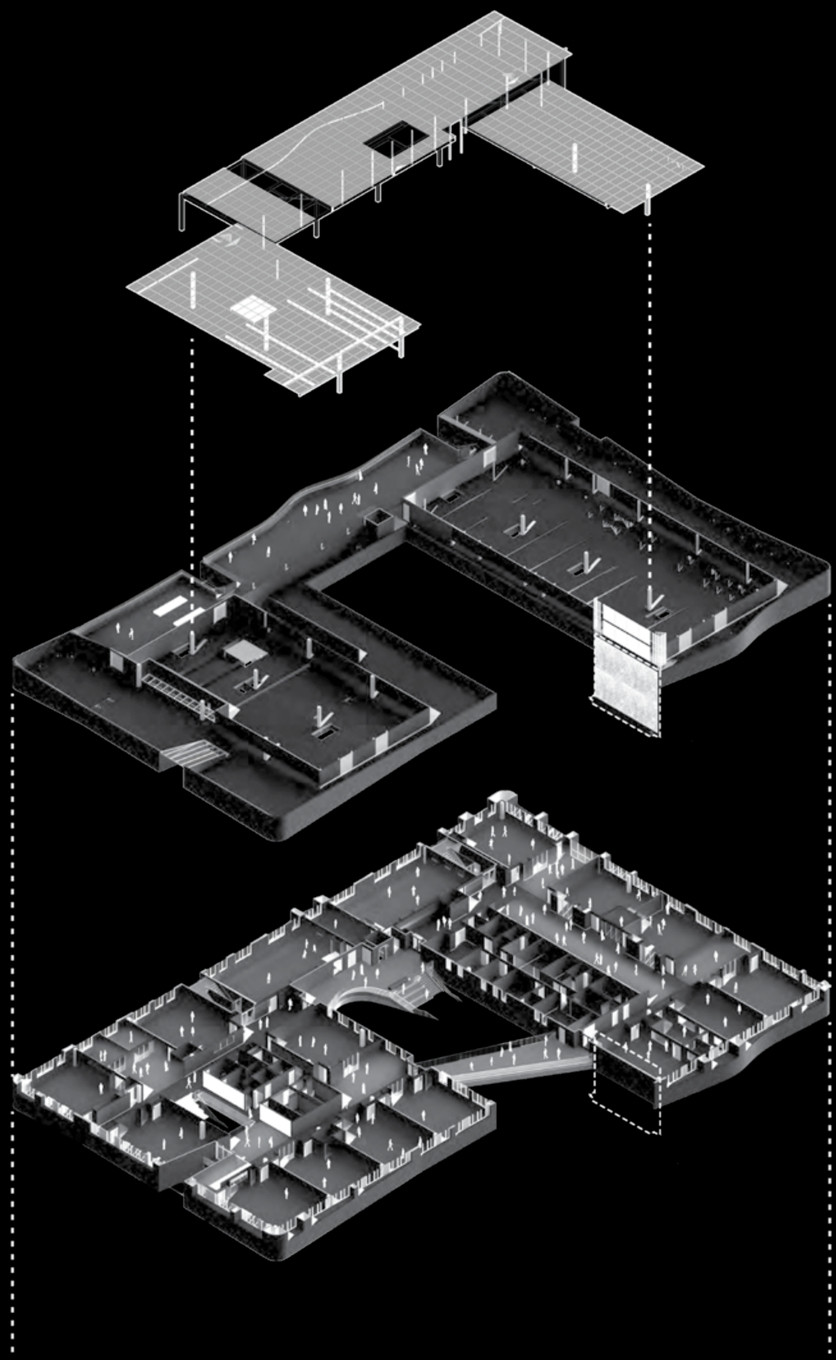
The A+D Museum
Los Angeles, California
December 6-8, 2018

councilonopenbuilding.org

OPEN BUILDING FOR RESILIENT CITIES CONFERENCE



THE COUNCIL ON
OPEN BUILDING

OPEN BUILDING FOR RESILIENT CITIES CONFERENCE

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PROCEEDINGS OF THE OPEN BUILDING FOR RESILIENT CITIES CONFERENCE

Los Angeles, California, USA, December 6-8, 2018

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OPEN BUILDING FOR RESILIENT CITIES

Proceedings

An International Conference Organized jointly by

The COUNCIL ON OPEN BUILDING

and

The CIB W104 OPEN BUILDING IMPLEMENTATION

A+D Museum, Los Angeles

December 6-8, 2018

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WELCOME.
WELCOME.
WELCOME.

As Chair and one of the founders of the Council on Open Building's first international conference "Open Building for Resilient Cities", I am pleased to welcome an extraordinary array of expert design professionals, developers, administrators and academics devoted to the design of buildings and urban environments for future change.

My co-founders, Stephen Kendall, Christopher French and I have invited you to Los Angeles – a city both of stereotypes and true diversity as it undergoes a profound metamorphosis. The Arts District, where the A+D Museum is located is a fitting setting for our conference because it epitomizes urban transformation. Like other rapidly evolving cities, LA has a pressing need for innovation, increased resilience and future proofing of buildings and infrastructure that need to anticipate and outlive rapid obsolescence and provide a lasting framework for a dynamic urban environment.

We encourage rigorous thinking, vigorous discussion and open minds for Open Building over the next few days. Welcome to the conference and welcome to Los Angeles!

JOHN DALE, FAIA

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VonRoll Library, University of Bern, Switzerland – Guiliani and Honger Architects

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Superlofts, Amsterdam Marc Koehler Architects

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Patch22, Amsterdam Tom Frantzen Architects

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Discovery Building, Santa Monica high School HED with MRY Architects and Planners

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MIT, Cambridge, MA

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Missouri Innovation Campus, Kansas City, Gould Evans with DLR Group

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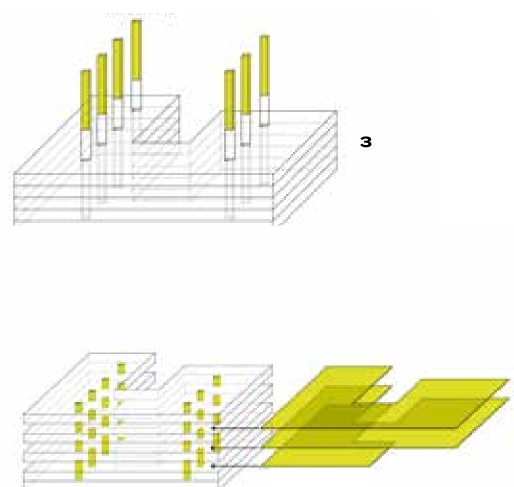

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JOHN DALE, FAIA

Chair, Open Building for Resilient Cities

As Chair of the Council on Open Building's first international conference "Open Building for Resilient Cities", I am pleased to welcome an extraordinary array of expert design professionals and academics devoted to the design of buildings and urban environments for future change.

My personal engagement in this incredibly important endeavor has not followed the straight-line focus that many of you have. Back in the 80's at MIT, Open Building founder John Habraken was my professor and thesis advisor. He taught me the fundamentals of Thematic Design (www.thematicdesign.org) and drew me into a National Science Foundation Grant project to create Design Games. Thematic design informed my Masters Thesis which focused on the transformation of the warehouse district at the Fort Point Channel in Boston. While I was somewhat aware of the international Open Building movement, already being nurtured and expounded upon by, among others, Steve Kendall. a PhD candidate at the MIT School of Architecture, I did not quite make the connection to what I was intuitively exploring.

Boston's Fort Point Channel warehouse district was a vast array of early 20th century brick and timber buildings acting as a distribution center connected to an intricate rail network and a grid of service lanes. The buildings were built incrementally but followed a logic dictated by the scale of the blocks, the logic of a timber structure forming an accommodating column grid encased in load bearing masonry walls that provided a dignified and in many ways graceful urban presence while ensuring adequate access to light and air. With the shifting patterns of freight distribution rendering the original purpose obsolete, these buildings, 80 years later, were taking on new uses. The first half of my thesis explored how to transform these buildings into multi-family residential complexes and support functions, adding layers to provide private outdoor spaces and comfortable pedestrian streets supportive of a 24-hour neighborhood. The second half of the study explored ways of extending the urban fabric into the abandoned lands of former railway yards along the harbor to the north. My focus was on developing the rules and patterns that could generate a diverse urban fabric that was not completely predetermined by a set program of functions. Unconsciously, the engineers, architects and developers had developed a nuanced, flexible but place specific building approach that to this day has ensured viable changes that have allowed this district to successfully evolve into something new and livable.

This was a great source of inspiration but not one I was able to directly explore in my subsequent work with Barton Myers Associates, an east coast firm recently transplanted to LA. In fact, my connection to the Open Building movement does not pick up again until a request in 2013-14 by John Habraken to publish some of my drawings from his Thematic Design courses in a book "Conversations with Form". In reconnecting with John, he suggested I should attend the International Future of Open Building conference in Zurich in 2015. I was immediately drawn into the detailed discussions led by Steve Kendall and others, invited to a tour of a pioneering 'open building' hospital complex in Bern and to dinner with US Military Medical experts who very much believed in the power of Open Building to shape and accommodate an evolving future of healthcare facilities. A year later, Steve invited me to a brainstorming session at the offices of HDR in Washington DC and subsequently asked me to join him as Co-Founder of the North American based Council on Open Building, with the goal of fostering a network of professionals collaborating to make the idea of design for change a normative part of our discourse and practices.

Not long after that, my firm HED, in collaboration with MRY landed one of the most important projects being launched by the Santa Monica-Malibu Unified School District: the Discovery Building at Santa Monica High School. With an overall capacity goal, a defined site and budget, the building was to contain a complex and varied program that was not yet completely defined. We suggested the District needed a loft building – an accommodating, flexible structure capable of change. This major undertaking has been an integrated collaboration between two architectural firms, engineers, an enlightened client and a proactive program management team. By clearly distinguishing between shell and core strategies, flexible infill systems (including raised floors) and lightweight, varied furnishings, this building is truly conceived of as a place to support shifting pedagogies and highly varied activities under one roof. Steve and I, together with colleague Chris French, have travelled the country over the last year and a half holding invited summits with hands on workshops and panel discussions from Greenbuild Boston ABX to Green Technology, the Committee on Architecture for Education and A4LE.

Perhaps the highlight of this year's Open Building venture was a trip Steve Kendall and I took to the Netherlands last February. In Amsterdam, we visited the contemporary open building projects of Mark Koehler, Tom Frantzen and others and spent two intensive days of discussion in Apeldoorn at the comfortable villa of the ever-gracious John Habraken. The transcriptions of our interviews and discussions will form the backdrop of a book of his collected short essays that we hope to publish in the New Year. We reflected on John's own journey to redefine and transform housing and how his dedication was the impetus to form a broader interdisciplinary body of experts around the world.

Now, as the recently formed Council on Open Building – a North American-wide network of professionals dedicated to the dissemination and implementation of Open Building principals across multiple sectors of the built environment, we are hosting our first international conference: “Open Building for Resilient Cities”. We have invited you to Los Angles – a city both of stereotypes and true diversity as it undergoes a profound metamorphosis. Office towers along the linear city that is Wilshire Boulevard are being converted into condominiums; South Park is filling in with high-rises and Downtown LA is being transformed into a lively 24-hour city. City agencies and developers alike are searching for more flexible approaches to programming and entitling large scale mixed use developments. The role of the private automobile is starting to shift in the context of high-density nodes and the City of Los Angeles Planning Department is looking for hybrid prototypes capable of accommodating shifting zoning requirements. The Los Angeles Unified School District and adjacent school districts like Santa Monica –Malibu are spending billions of dollars on infrastructure in the face of evolving demographics and shifting pedagogies. All this underlines the need for innovation, greater resilience and future proofing of structures that need to anticipate and outlive rapid obsolescence and provide a lasting framework for a dynamic urban environment.

So we encourage rigorous thinking, vigorous discussion and open minds for Open Building over the next few days. Welcome to the conference and welcome to Los Angeles.

What is Open Building?

Built environment has always been self-organizing. ...Despite our increasing ability to effect large-scale change and our escalating ambitions, built environment follows its own laws. ... Eventually, we must engage the environment's terms, not just our own intentions. ... The idea that a living environment can be invented is outmoded: environment must be cultivated. This requires proper use of levels, judicious articulation of territory, and creative applications of types, patterns, and thematic systems. It must also ensure well-modulated distribution of control, compatible with an increasingly mobile and informed humanity. After all, it is by the quality of the common that environments prosper and by which, ultimately, our passage will one day be measured.

John Habraken, from The Structure of the Ordinary: Form and Control in the Built Environment, MIT Press, 1998

Open Building is a term that was coined in the mid-1980's in the Netherlands (Open Bouwen in Dutch), some twenty years after John Habraken proposed the Support/Infill concept for housing, and after the initial development of design methods for housing based on that concept, worked out at the SAR (Stichting Architecten Research or Foundation for Architects Research). A number of successful experimental projects had already been built in Europe. By this time also, developments toward Open Building were taking place in Japan and interest in the theory and practice of Open Building had grown internationally. Research undertaken at the TU Delft by the Open Building group under the direction of Professor Age van Randen explored practical measures needed to fully implement the Support/Infill approach, focusing on technical, regulatory and financing issues.

The Support/Infill concept was based on the principle that housing would be sustainable and renewable only when a clear separation was made between what was shared (the Support) and what was decided per individual occupant (the Infill). The user, that is, needed a clear scope of control, and the community also needed a clear role.

The questions facing those using an Open Building approach were and remain:

1 **How do we design (as well as regulate, fund and manage) a coherent and resilient urban fabric, when individual building projects are initiated by independent actors and will change over time**

2 **How do we design (and regulate, fund and manage) buildings when decisions about uses and their floor plans are not known, and are usually decided by someone other than the building's architect, and will inevitably change?**

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The Council on Open Building

The Council on Open Building was launched in 2017 in the United States at the initiative of John Dale and Stephen Kendall. Like the CIB W104 at the international level, the Council is committed to the proposition that planning for change – during design and long-term – is a fundamental prerequisite for a resilient and sustainable built environment. The Council fosters the development of knowledge, methods and practices supporting implementation of the Open Building approach across all project types including residential, healthcare, educational facilities, and commercial.

The Council's leadership team now consists of John Dale, FAIA, HED Los Angeles, Stephen Kendall, PhD, Philadelphia, and Chris French, District Homes/Hickok Cole Architects, Washington DC. It's website (www.councilonopenbuilding.org) contains regularly updated information and resources.

The CIB W104
Open Building Implementation

In 1994, an organization was founded to bring synergy to many dispersed research and implementation efforts around the world under the umbrella of the CIB (International Council for Research and Innovation in Building and Construction – www.cibworld.nl). At an initial meeting in Tokyo, a number of individuals from several countries met to establish formal links among those who subscribed to "the Open Building approach." Stephen Kendall of the US and Karel Dekker of the Netherlands were appointed to be founding joint-coordinators.

Open Building encompasses a number of ideas including:

- The idea of distinct levels of intervention in the built environment such as urban planning, urban design, architecture, and so on
- The idea that built environment is in constant transformation, changing part-by-part, and that change must be recognized and understood
- The idea that users / inhabitants may make design decisions along with those representing various professions; the idea that, more generally, designing is a process with multiple participants
- The idea that the interface between technical systems allows the replacement of one system with another performing the same function

The organization's goals:

1 **To increase awareness of the principles of Open Building among researchers and professionals who shape the built environment, and among the people who live in that built environment**
2 **To support initiatives at national, regional and local levels that improve the efficacy of building construction and facility adaptation following Open Building methods**
3 **To be a platform for research and information dissemination among professionals committed to improving Open Building practices and methods**

Those advocating the Open Building approach agree that balancing permanence and change is important in both existing and new construction as well as the urban fabric. Open Building practices address both fine-grained and large-scope change, while respecting and reinforcing the value of stable and coherent places. Its methods are particularly effective in managing uncertainty and diverse values within a distributed decision-making process.

By 2018, an international network of more than 400 researchers and practitioners had developed, meeting every year in a different country to exchange information. Each conference has generated a peer reviewed proceedings of research papers. The network continues to meet yearly, under the direction of its two current joint coordinators, Jia Beisi (Professor of Architecture, University of Hong Kong and Director of BEA Hong Kong), and Amira Osman (Professor of Architecture, Tshwane University of Technology, Pretoria, South Africa).

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Discovery Building, Santa Monica high School HED with MRY Architects and Planners

2

Citti Academy - HED

3

BlackJack, Amsterdam Dirk Jan van Wieringhen Borski - BNB architects and Rene de Prie

3

The Open Building for Resilient Cities Conference Organizing and Scientific Committees

ORGANIZING COMMITTEE

John Dale, FAIA
——HED Los Angeles Conference Chair

Dr. Ewan Branda
——Woodbury University School of Architecture, Los Angeles

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——Executive Director, A+D Museum Los Angeles

Farooq Amen
——City Design Studio, Los Angeles

Dr. Stephen Kendall
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Dr. Jia Beisi
——University of Hong Kong (CIBW104)

John Dale, FAIA
——HED Los Angeles

Dr. Stephen Kendall
——Council on Open Building, Philadelphia

1

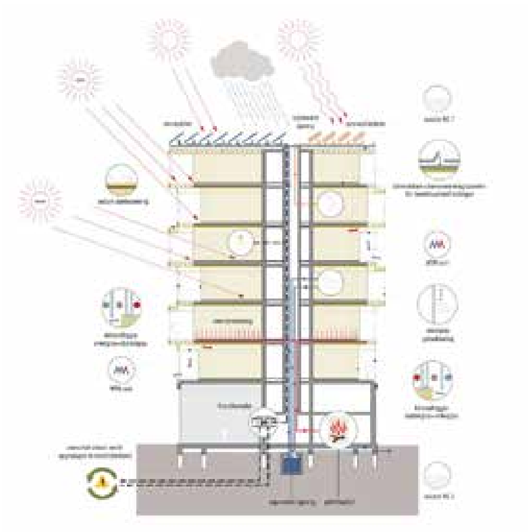
1

Patch22, Amsterdam
Tom Frantzen Architects

2

The Tila housing block, Helsinki, Arabianranta by Talli Architecture & Design

2



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The Conference Program

Open Building for Resilient Cities

Day 1 Thursday, December 6	**Welcome / Keynote**	**CONFERENCE OVERVIEW**	
5:00 - 7:30 PM	Conference Introduction	John Dale, Co-Founder, Council on Open Building	
	Presentation	**Engineering for Open Building - Work of ARUP - Murat Karakas, Simon Rees, Elizabeth Valmont,Irene Martin**	
	PechaKucha	Sharing case studies from around the world	
7.30 - 8.30 PM	*Reception*	*refreshments*	
Day 2 Friday, December 7	**Keynote / Panel**	**HEALTHCARE STRAND**	
8:00 - 8:30 AM	*Coffee / Networking / Registration*		
8:30 - 10:30 AM	Keynote	**Opening talk by Mehrdad Yazdani of Yazdani Studio, Cannon Design**	
	Panel Discussion	Stephen Kendall, Moderator with Mehrdad Yazdani, John Pangrazio, Nirit Pilosof and Bill Scrantom	
10:30 -10.40 AM	*Break*		
10:40-11:35 AM	Research Paper Sessions	Session 1a	**Building Industry / Building Performance**
		Pilosof	*Open Building in practice: a comparative study of hospital design strategies for future change*
		Dekker	*Methods and tools for defining usability quality, actual building performance and cost using the Open Building approach*
		Ross	*A methodology for quantifying adaptability of buildings using an analytic hierarchy process*
		Lamounier	*Adequacy level of Brazilian constructive systems to the Open Building: a research methodology*
11.35-12.30 PM		Session 1b	**Building Industry / Building Performance**
		Kim / Yang	*A study on the development of long-life housing supply model and field-test in Korea*
		Choi	*Lessons from remodeling aged apartment units in first-generation new towns around Seoul*
		Leibbrandt	*Architecture without Land. Secure land rental as an open development strategy*
12:30-1:15 PM	*Lunch*	*catered lunch*	
	Keynote / Panel	**HOUSING STRAND**	
1.15-3.15 PM	Keynote	**Jia Beisi, University of Hong Kong, Partner, BE Hong Kong Quality and capacity of architecture in three social-spatial levels – an analysis of the work of BEHK**	
	Panel Discussion	Otis Odell, Moderator with Jia Beisi, Tom Franzen and Brian Falls	
3.15-3.45 PM	*Break and Poster Session 1*	Frantzen, Abadi, French, JoonSoo, Ho Lim	
3:45-5:00 PM	Research Paper Sessions	Session 2	**Housing Experts on Open Building**
		Bar Abadi	*The Adaptable Unit building design methodology: Simplifying the steps necessary for OB implementation*

		Nadim	*Does Egypt embrace open building (OB) housing? Informal housing analogy to OB principles*
		Aggarwal	*Flexibility in Apartments: Examining feasibility of "Open Plan" housing in urban India*
		Frantzen	*PATCH 22 – A Case Study*
5.45 PM	Keynote	**California Perspective on Resilience: Chester Widom, California State Architect**	
7.30 PM	*Reception*	*refreshments*	
		Demonstration - Sustainable Building Council	
Saturday, December 8	**Keynote / Panel**	**EDUCATION STRAND**	
- 8:30 AM	*Coffee / Networking / Registration*		
- 10:30 AM	Keynote	**Opening talk by John Ruble, MRY Architects**	
		Open Building - The Architecture of Format	
	Panel Discussion	John Dale, Moderator with Kevin Greischar, James O'Connor and Carey Upton	
-11:15AM	*Break and Poster Session 2*	Sawano, Shin, Wiederspahn, Minami	
-12:45PM	Research Paper Sessions	Session 3	**The Architect's Role**
		Oostra	*The possible contribution of Open Building towards resilient and responsible architecture and urbanism*
		Osman	*The Elemental approach to residential architecture: is it Open Building?*
		Wilcox	*A case study of a 'hijacked' building in Johannesburg, South Africa*
		Sarmiento	*Towards An Adaptable Architecture*
		Wiederspahn	*Open Building and Future-Use Architecture – a comparison*
		Galle	*The architect's role in a change-oriented construction sector: a Belgian perspective*
-1:30 PM	*Lunch*	*catered lunch*	
	Keynote / Panel	**URBAN DESIGN STRAND**	
3.30 PM	Keynote	**Hybrid Zoning by Patricia Diefenderfer, City of LA Planning Dept.**	
	Panel Discussion	Farooq Ameen, Moderator with Christopher French, Patricia Diefenderfer, Dan Rosenfeld and Merrill St. Leger Demian	
4.00 PM	*Break and Poster Session 3*	Ross, Gola, Tirapas, Lee	
4:45 PM	Keynote	**Renee Chow, Chair, Department of Architecture, U.C. Berkeley**	
		Changing Cities: Challenging the Disposable City.	
5:30 PM	Panel discussion	Wrap-Up Session - Open Building Council Leadership with Renee Chow and Peter Wiederspahn	
7.00 PM	*Closing Reception*	*refreshments - MULTI-SHOW OPENING at A+D*	

THE CONFERENCE STRANDS

PANEL MODERATOR

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The Healthcare Strand

The only thing that lasts is change. Every day we are required to rethink our habits and change our minds. All built environment is subject to the question of “what must have priority” - performance or permanence, readiness or steadiness, change or stability, function or form, present or future. Nevertheless, planning should avoid that limiting “either/or” trap; it should support an “as-well-as” openness. Health care buildings are especially affected by this dilemma. In this expensive and dynamic project type, change and factual developments have led to environments that can hardly be perceived as pleasant. Nobody would disagree that a therapeutic environment is a key factor that any health care environment must offer to patients, staff, and the urban context. Nevertheless, hospitals have become “architectonic black holes.” Instead of being refined over time, what was built at a specific time, to a large extend, conflicts more and more with what ought to be. Dealing with change should become a fundamental aspect of how we perceive architecture, and consequently also how we conceive it. As long as time is not a guiding factor, the planning processes will be dominated by stress (from Giorgio Macchi's chapter "System Separation: ***A Strategy for Preventative Building Design" in Healthcare Architecture as Infrastructure***: Open Building in Practice, Routledge, 2018).

THIS PANEL WILL DISCUSS THESE ISSUES AND TENSIONS, AND SHARE APPROACHES TO DEALING WITH UNCERTAINTY IN PLANNING COMPLEX AND CONSTANTLY EVOLVING HEALTH CARE ENVIRONMENTS.

PANEL MODERATOR

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The Housing Strand

The residential building stock is the largest project use type, accounting for approximately 75% of total built floor space in the United States. Of a total of 136 million dwelling units in 2017, about 60% of which are detached houses, the rest some sort of attached dwellings with "shared" elements (many in HOA's or condominiums). This ratio has remained fairly consistent for decades.

These facts are important when we discuss Residential Open Building. The Open Building approach to residential architecture seeks solidity, energy efficiency and adaptability. The approach also seeks to make a clear distinction between the parts of a building that are common to all inhabitants, and the parts that are controlled autonomously per occupancy. This is the principle of technical and governance disentanglement, an essential basis for avoiding legal and technical conflict when one inhabitant's space use or layout changes (during design or over time). Autonomy of the individual dwelling unit (one reason single family detached houses are so attractive) is the goal of the Open Building approach in multi-family residential buildings. The goal is to assure gradual, unit-by-unit renewal of enduring and culturally-rooted buildings, with minimal disturbance and waste.

THIS PANEL WILL DISCUSS THESE ISSUES, POINTING OUT BARRIERS TO AND BENEFITS TO BE GAINED FROM IMPLEMENTING THE OPEN BUILDING APPROACH IN THE DEVELOPMENT OF NEW RESIDENTIAL PROJECTS AND IN ADAPTING AND UPGRADING EXISTING RESIDENTIAL AND NON-RESIDENTIAL PROPERTIES.

PANEL MODERATOR

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When we think of the extent to which school construction figures in the construction economy, when we think about how many of these facilities exist all over the country and the fact that school districts tend to do major replacements and renovations in 30-year cycles, it's a challenge. It's a problem that we have a stock of school buildings which are not really in harmony with the way pedagogy is evolving, the way teaching and learning take place, or need to take place, in our current context. Ideas about pedagogy are constantly changing and the approach to teaching and learning is constantly shifting. In this context, rigid buildings really don't make sense. School district are starting to move away from a one-teacher, one-classroom enclosed, internalized environment to a more fluid environment where people work in small groups, where they work in the classroom and also work outside the classroom. We're starting to see schools require more common areas, where different forms of learning can take place simultaneously.

THIS IS WHERE THE OPEN BUILDING APPROACH MEETS THE CHALLENGES OF DESIGNING 21ST CENTURY EDUCATIONAL ENVIRONMENTS – FOR K-12 PROGRAMS AND ALSO FOR UNIVERSITIES. DESIGNING FOR CHANGE. NO ONE HAS A CRYSTAL BALL, SO OUR CHALLENGE IS NOT TO DEVELOP NEW STANDARDS, OR TEMPLATES, BUT TO PLAN FOR THE UNFORESEEN. THIS IS FUNDAMENTALLY NEW, AND ARCHITECTS, PLANNERS AND EDUCATIONAL LEADERS NEED TO WORK CLOSELY TOGETHER TO ADDRESS THESE OPPORTUNITIES. PART OF OUR JOB IS TO STUDY AND LEARN FROM THE BEST EDUCATIONAL ENVIRONMENTS BUILT 100 YEARS AGO THAT STILL ENDURE – PRECISELY BECAUSE THEY COULD ADJUST TO CHANGING REALITIES.

The Education Strand

PANEL MODERATOR

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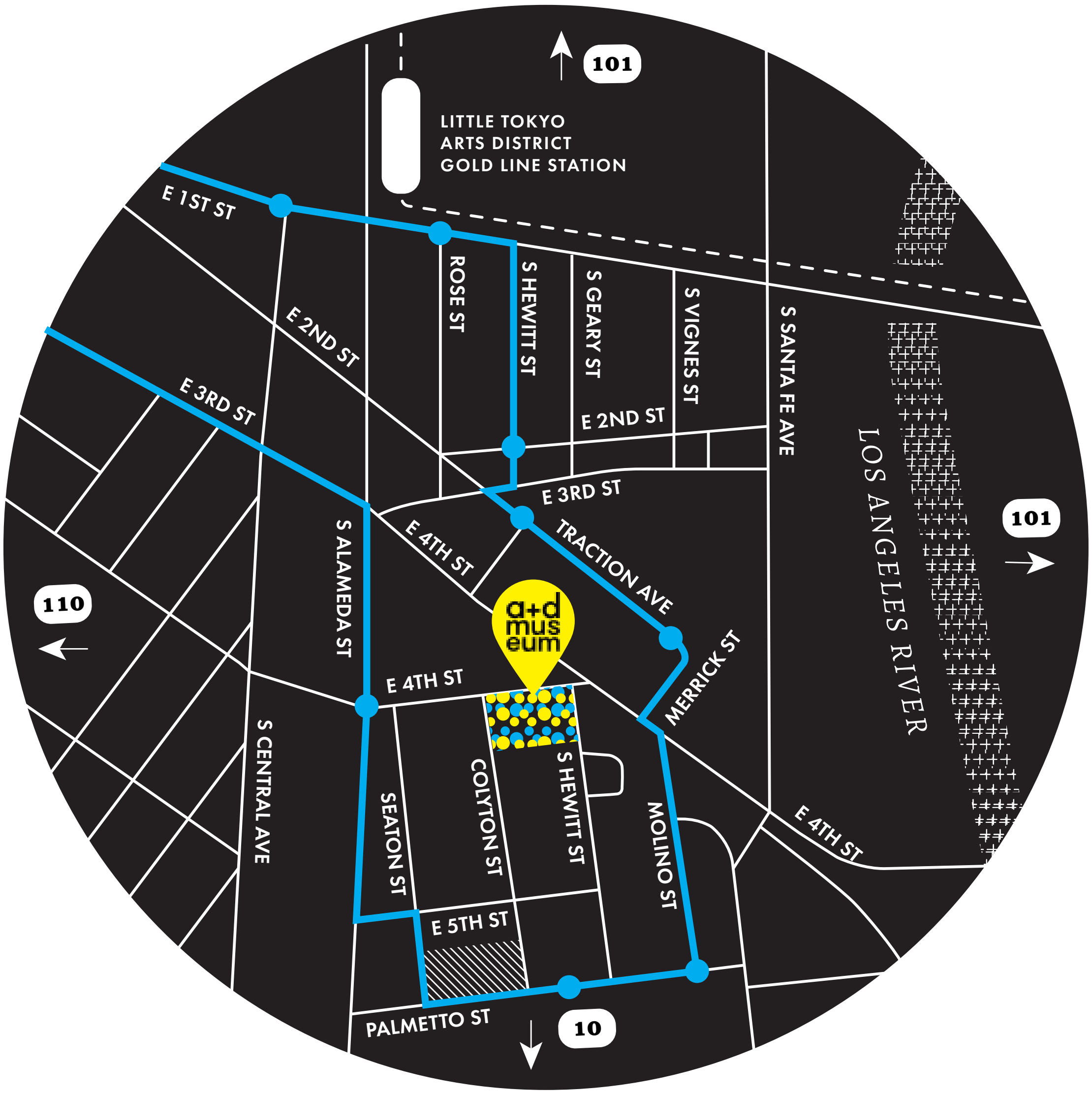
The Urban Design Strand

Urban Design is the level of intervention between urban planning and architecture. It is the level at which a stable stage is set by shaping public space and infrastructure, thereby setting out the themes and rules that will guide well-organized yet varied architectural interventions for a long time to come. Urban design is also the level of work that must anticipate that interventions at the next level – architecture – will be distributed among many firms and developers; it therefore has a built-in need for a governance structure to steer varied interventions while maintaining long-term resilience and spatial coherence.

THE CHALLENGE FOR URBAN DESIGN – WHETHER DRIVEN BY PUBLIC AGENCIES OR BY PRIVATE DEVELOPMENT – IS TO CREATE A BASIS FOR STRUCTURED GROWTH AND CHANGE, AS WELL AS OFFERING READILY AVAILABLE, SERVICED YET FLEXIBLE BUILDING PLOTS TO REALIZE NEW BUILDINGS REPLACING OLDER ONES. THIS REQUIRES STRATEGIC PLANNING TOOLS TO STEER DEVELOPMENT OVER TIME, TOOLS THAT ARE APPROPRIATELY UPDATED FROM TIME TO TIME IN LIGHT OF CHANGING REALITIES ON THE GROUND.

A+D Museum



ADDRESS

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900 East 4th Street
Los Angeles, CA 90013

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Los Angeles Ca 90013

A+D MUSEUM

SBC's ARCspace

METRO GOLD LINE

DASH ROUTE A BUS STOPS

JOHN HABRAKEN
APELDOORN, THE NETHERLANDS

Back to the Future

The Everyday Environment in a Phase of Transition

ORIGINALLY PUBLISHED IN LOOSE-FIT ARCHITECTURE/ DESIGNING BUILDINGS FOR CHANGE (GUEST EDITED BY ALEX LIFSCHUTZ) AD 05/VOL 87/2017

When I visited Dammam, Saudi Arabia, in 1985, I was taken to a neighborhood of some 20 identical high-rise apartment buildings standing in open space with carefully designed parking facilities, playgrounds, lawns and flowerbeds. The entire project looked as if it had been finished just yesterday. No inhabitants could be seen anywhere. I learned that it had been built a few years earlier to show the world that Saudi Arabia could do modern housing as well as Western countries could. When it turned out that no Saudi citizen wanted to live there, the project was fenced in and immaculately maintained to be proudly shown to foreign visiting professionals. Here was the ideal modern housing project, exactly as it had been designed and not marred by the inevitable tokens of everyday life: laundry hanging from balconies, dirty stairwells nobody feels responsible for, public lawns partly turned into private vegetable gardens or invaded by fast-food sellers, parking lots used to take apart and repair vehicles, and so on. This pristine example demonstrated the way designers like to think of their work.

Today, the architectural profession makes a living by designing not only housing, but also workplaces, schools, facilities for sports and recreation and many other kinds of buildings that together make our everyday environment. Anecdotal experience suggests a fundamental difference between the everyday environment as a living organism and the desire of architects to make art.

Early in the past century – under the pressure of entirely new ways of building and unprecedented demographic changes – the everyday environment became a 'problem' to be 'solved' by design. But when architects turned towards these tasks, they

Henk Reijenga, Westpolder Bolwerk, Berkel en Rodenrijs, The Netherlands

Example of a street within Reijenga's 1500 home residential extension of Berkel en Rodenrijs, with fine-grained distribution of design tasks and thematic architectural Variation. No two buildings are exactly the same.

Neighborhood near Hamamatsucho Station, Minato-ku, Tokyo, 2008.

An example of the countless state-of-the-art high-density everyday environment in the world that the majority of today's architects and urban designers depend on for a living.

did not change their ways of thinking and doing. Suddenly everything could be 'architecture'. They were driven by the rational functionalism of the Congrès internationaux d'architecture moderne (CIAM) and had a profound disdain for historic examples of urban fabric.

We now worry about the rigidity and coarseness of contemporary environments, discuss long-life loose-fit and aspire to 'sustainability', but remain largely unable to design for the social dynamics of the everyday environment. We have not yet learned how to do that.

It is true that, with the retreat of Modernist ideology, the architectural profession has slowly, albeit often reluctantly, tried to adapt its ways to a poorly understood reality. More explicit knowledge and particular skills are needed to successfully design attractive, healthy, adaptable and lasting urban environments. We are in the middle of a long period of transition towards a new professional role, and housing is at the heart of it.

In Renaissance times, Leon Battista Alberti first described the architect as the inventor of entirely new kinds of building, a person to be distinguished from the traditional master builder who was bound by customs and familiar typology. Andrea Palladio's genius most seductively applied this new attitude in his life-long practice. His oeuvre was unprecedented and free from local typology. It could therefore be published and followed by foreign practitioners on an international scale. Architecture became the product of a professional class. Modernism's belief in an 'International Style' had its origins in the 16th century.

After the Albertian emancipation of architecture from the everyday context, two professional cultures coexisted. The everyday environment remained the product of local vernacular. Architecture with a capital 'A' became an international phenomenon and dealt mainly with houses of worship, castles, palaces and monumental villas. This separation was mutually beneficial. Architects could occasionally be inspired by a vernacular in the way an artist can be inspired by nature, but the profession created its own history, one that has been carefully recorded as a major expression of art.

Modernism changed this peaceful co-existence. New techniques disrupted familiar ways of building, residential typology was considered outdated, and the emerging power of logistics and management developed in the Second World War to move and equip millions of soldiers promised efficient production at a very large scale. Soon the building professions decided that history did not offer any lessons for the new problems they faced. They aspired to design a New World. That aspiration was irresistible. It promised huge profitable projects. Never before had the design profession held such hubris. As an architecture student at TU Delft in the early 1950s

I remember one of our prominent teachers calling out in a public meeting that if we failed to succeed in our mission to shape the future, a Third World War might be inevitable. At the same time, however, housing was not considered real architecture and could not be the subject of a design studio. Our teachers, among whom were Jacob Bakema, Jo van den Broek and Cornelis van Eesteren, were busy doing large housing projects

Antonio Gaudi, Casa Mila, Barcelona, 1910.

Notable for its unconventional appearance, this building, also known as 'La Pedrera' ('The Quarry'), nevertheless fits thematically into the Architecture of Ilfedons Cereda's famous 19th-century plan for the extension of the city.

Sjoerd Soeters / PP HP (Pleasant Places Happy People), Sydhavnen, Sluseholmen Waterfront Renovation, Copenhagen, 2009.

View of the Sydhavnen neighborhood showing the thematic variation of the facades. Note also the public space on only one side of each block, the vaulted bridges breaking the cublic space, an entryway into a courtyard inside of a block with cars going down into the sub-courtyard parking, and pedestrians entering the courtyard on level.

that were never discussed in school. But designing a villa was considered a good task for beginners. I asked Van Eesteren to let me do a project for him, and he gave me a site, asking for a high- rise apartment on it. This was, of course, a design lesson, not a housing exercise. Only in the late 1960s were a few radical students permitted to graduate on a housing project.

Learning from the Past

Modernism's ideology allowed a romantic admiration for the coherent complexity of environments like Venice, 17th-century Amsterdam or Mediterranean hill towns. Aldo van Eyck's love affair with the Dogon settlements of Mali is legendary. However, this admiration did not lead to questions of comparison with contemporary practice. For instance, while architects generally admire the Georgian domestic fabric such as that at Bedford Square in London where the Architectural Association (AA) is found (see Clare Wright's article on the AA of this issue), the question of how eight former dwellings came to accommodate an entire professional school without disrupting the coherence of the local environment is seldom raised in discussions about loose-fit and flexibility. Modernist ideology kept us ignorant of specific qualities of the everyday environment. Some of those qualities are briefly mentioned in what follows.

Historic settlements could deal with partial change over time, allowing them to endure over centuries in a coherent manner. Function always was a variable in the life of an environmental fabric. Form did not follow it but had the capacity to accommodate functional change. Nevertheless, architectural education today takes it for self-evident that a studio task starts with a functional program. In short, the dimension of time is not part of architectural theory nor of education.

Several years ago, architect Andrés Mignucci and I ran an international workshop in Barcelona for young practicing architects and urbanists. As a warming-up exercise the class was divided into groups of five or six, and each given an urban block in the city's celebrated 19th-century urban expansion, which was built following Ildefons Cerdà's proposal. The students were asked to identify what the buildings in their block had in common. As they were trained to look for something special, this turned out to be an entirely new and bewildering experience for them.

We discussed how even Antoni Gaudí's famous Casa Milà ('La Pedrera'/'The Quarry') building (1910) shares many thematic features with the other buildings in the neighborhood, such as the typical access by carriage to an internal stairway leading to the main floor, space for shops and workplaces animating the pavement, the structural bay size and story heights. Built environments follow particular architectural values that we identify as types, patterns, themes or systems.

Yet today's dominant belief in invention and originality discourages designers from sharing these forms. Of course, refusing to observe an environment's thematic qualities is an accepted way of working, but to actually follow such qualities is not. Christopher Alexander's proposal to work with patterns in 1977 is still read by students, but did not trigger any additional theory about sharing form, except, perhaps, the 'form-based codes' movement in the US and its advocates elsewhere.(1) When the spontaneous desire to share types and patterns is absent, outside agencies seek to impose coherence by regulation, which in turn meets resistance by designers who dislike them.

Historically, thematic coherence was partly the result of a lack of technical alternatives, and local vernacular was the only language one could work with. In today's world, coherence of thematic variety does not come easily by itself. To achieve it, a deliberate choice must be made. We need to study how types, themes, patterns or architectural systems are shared, and must have the skills to apply that knowledge as part of normal practice.

The most striking difference between the urban fabrics that we make today and those of the past has to do with territorial markings. Gates and other means of territorial crossing abound in the historic fabrics of all cultures. They were important means of thematic architecture. Their absence today does not mean that territorial structure is no longer important. Indeed, the abundance of technical devices that protect and control 'our' space in the world, often deliberately kept invisible, is amazing. Contemporary territorial structure may well be different from any example from before the automobile was introduced, but that does not explain why it is no longer a basis for architectural elaboration and a means of social identification.

Sjoerd Soeters / PP HP (Pleasant Places Happy People), Sydhavnen, Sluseholmen Waterfront Renovation, Copenhagen, 2009.

Territorial control in the historic urban fabrics always led to minimal public space and maximal private space. The former was unsafe and expensive while the latter could be profitable. Buildings were put right at the edge of public space to make good use of backyard space, and to keep vegetable gardens and animals out of sight and well protected. This produced crowded public spaces and encouraged semi-public gated courtyards for social collectives, causing deeper territorial hierarchies. By contrast, contemporary designers like open space floating freely around buildings, and instinctively seek design control over the largest possible part of the earth's surface. (2)

Proper distribution of design control leads to variety. Shared typology, or patterns or systems, produce coherence. Control of all design decisions by a single party in a particular area soon results in repetition and uniformity. Partial change and variety come naturally when individual inhabitants control their own space. The question as to what can be decided individually and what should be held in common naturally arises. When we seek a neighborhood to settle in, we ask ourselves what we will share with our neighbors, and the answer to that question is often decisive. When many individual parties operate in a particular area without any sharing of values, incoherence will inevitably result.

Finding a proper balance in the distribution of design control and the sharing of thematic form makes coherent variation possible. All complex organizations distribute control on different levels. Traditional environments usually have public space, streets and squares, as the higher-level framework in which buildings find their place. Modernist urbanism distributed buildings into unshaped spaces and, if space was shaped, then this was only the by-product of the way that buildings had been located. Hierarchical clarity was lost, urbanists and architects found themselves making decisions on the same building for different reasons, causing confusion and design tension. On the other hand, advocates of bottom- up processes often fail to recognize the need for a higher-level party – be it one selected from among themselves or invited from outside – to shape and control a collective framework within which individuals 'can do their own thing'.

Everyday life seeks hierarchy. A commercial office building leaves the design of its interior space to the tenant's architect. The large 'building' becomes a two-level part of the continuous environmental hierarchy. The shopping mall is another example. Normally, increasing size and complexity trigger increased hierarchical depth. Contemporary residential construction ignores that rule. In present housing design, dwellings, or as they are mostly known 'units', have predetermined interior layouts. The layout defines the distribution of structural elements as well as of piping and wiring. It is also the basis of cost estimation and government approval. In other words, the floor plan must be there from inception to enable most other professions to play their part. Making all layouts the same saves work for everybody, whereas withholding the floor plan at the early stages of design disrupts a century-old professional culture and methodology.

In the Netherlands, this outdated philosophy was initially the result of revolutionary legislation in 1902 that made money available for low-income tenants via not-for-profit housing corporations. Governments, as well as investors such as pension funds, want to make sure their money is well spent and the inhabitant was not considered a reliable party. This heritage has shaped an entire building industry that argues that allowing the inhabitant individual control is more expensive. The opposite is true, as has been demonstrated by recent open building projects discussed by Stephen Kendall in this issue of AD.

Working with the Everyday Environment

The everyday environment tells us that we must be able to deal with change and make time the fourth dimension of design; to encourage designers to share thematic forms; to appropriately distribute design control; to understand the relation between complexity and hierarchical depth; to give the inhabitants or users their own level of intervention within the environmental hierarchy; and, finally, to understand territorial structure, the control of space, and how to design for it.

It is a tall order, but professionals are slowly beginning to meet these demands. The international Open Building Network promotes the idea of a level of intervention for residents or users in the environmental hierarchy. This network of academics and practitioners has about 350 members from some 30 countries. Kendall's article gives an overview of the most innovative projects over a period of four decades. It shows how in the last 10 years, initiatives in practice have come from clients who see economic advantage in the approach because short-term control by the user results in longer life and better long-term investment returns for a building. He also references Japan's Long-Life Housing Law of

2008, which recognizes the hierarchical nature of building construction.

In the Netherlands, a 'supervisory' architect is often appointed for the management of urban development to make sure his or her peers, who design the buildings, follow thematic forms to assure coherent variation in an entire neighborhood. There is also a trend to bring the user into the process. Some of these initiatives are taken by municipal governments, but many are taken by architects, developers, private investors and user groups. The trend is unmistakable, but poorly documented, which, in fact, is the traditional way for everyday environments to renew themselves.

Ultimately, well-informed and skilled designers will integrate several if not all aspects of the everyday environment into their projects. Henk Reijenga's ongoing low-rise, high-density Westpolder Bolwerk project – an extension of the town of Berkel en Rodenrijs, the execution of which began in 2005 – has 1,500 dwellings. No two buildings are exactly the same, but design and implementation were nevertheless organized in an efficient manner. Early on, a handful of building types were defined by Reijenga, and the architects under his supervision collectively selected the materials, colors and details. For all three phases, a team of four or five architects each did several designs of each of the defined house types. The distribution of these varied designs was then decided by the supervisor. The urban design also shows a thematic variation in the combination of well-defined urban elements like streets and canals of different kinds. The project was implemented within budget, and the first part was successfully occupied in the middle of the 2008 recession. (3)

Sjoerd Soeters and his firm PP HP (Pleasant Places Happy People) carried out the urban design for the Copenhagen Sluseholmen waterfront renovation, for which they deliberately reduced the amount of public space by surrounding urban blocks on two or three sides with open water and increased territorial depth by arranging houses around collective courtyard space over underground parking. As supervising architect for Sydhavnen, the southern part of this masterplan and the first part of it to be executed (in 2009), Soeters distributed the design of the facades for the terraced houses among some 30 architects, suggesting a few key thematic ingredients. To this day he still receives fan mail from residents. (4)

Challenging Academia

Until now, the development and endurance of human settlement in harmony with social reality has always occurred in an implicit way. Yet, given our professional involvement today, a more explicit approach must be possible. Without educational programs, more generally accepted theories and more research, our arrival at a harmonious professional engagement with the everyday environment will take a very long time. In closing, I mention the three most important academic tasks we need to pursue to successfully cultivate it: study the built environment as the living organism that it is; increase its hierarchical depth to include the autonomous dwelling unit; and teach the specific skills needed.

We must build a body of knowledge. We seek help from a medical doctor because we trust he or she knows how the body functions. The medical profession collectively improves that knowledge by experience, research and careful documentation. Similarly, lawyers share knowledge of the law and seek to improve it by experience, debate, social consensus and careful formulation. The design professions lack collectively maintained knowledge of the way the built environment behaves over time because they do not see it as a living organism with its own laws. We are the only profession that has no formally documented body of knowledge about the subject of its interventions. Yet we do intervene.

Henk Reijenga, Westpolder Bolwerk, Berkel en Rodenrijs, The Netherlands

Notes

1 Christopher Alexander, Murray Silverstein and Sara Ishikawa, A Pattern Language: Towns, Buildings, Construction, Oxford University Press (New York), 1977.

2 Sjoerd Soeters illustrates this trend by examining Colin Rowe's comparison of Le Corbusier's design for Saint-Dié-des Vosges (1945) with the historic fabric of the city of Parma, Italy. See his post from 4 April 2016 at: http://thematicdesign.orgsydhavnen sluseholmen-copenhagen-harbour renovation- project-2000-2009/.

3 For a detailed description by Reijenga of the Westpolder Bolwerk design process, see his post from 3 May 2016 at: http://thematicdesign.org/the westpolder-bolwerk-development project/.

4 For a detailed description by Soeters of the Sluseholmen waterfront urban design and the execution of the Sydhavnen project, see his post from 4 April 2016 at: http://thematicdesign org/sydhavnen-sluseholmen copenhagen-harbour-renovation project-2000-2009/

5 For a well-researched argument that the autonomous dwelling unit is a necessary condition for a sustainable built environment, see Frank Bijdendijk's keynote paper at the Open Building Network Conference, ETH Zurich, 2015, titled 'The Future of Open Building Resides in the Existing Built Environment' and available here: http://thematicdesign.org/the-future-of open building- resides-in-the-existing builtenvironment-6/.

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Four Decades of Open Building Implementation

Realizing Individual Agency in Architectural Infrastructures Designed to Last

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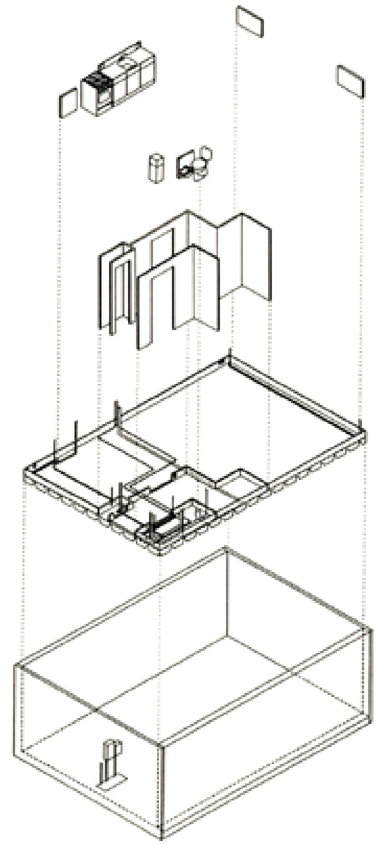
In the history of 20th-century architecture, two notable achievements were the advent of functionalism, and an unprecedented increase in large-scale, centrally controlled interventions into the built environment. In the 1970s, one of the responses intended to overcome the resulting rigidity, uniformity and lack of sustainability was 'open building' – a portfolio of design and decision-making methods originating in the thinking of John Habraken (see his article Back to the Future) and the work of SAR (Foundation for Architects Research) in the Netherlands, of which he was founding director.(1) Parallel investigations and building activity were emerging in Japan at around the same time. Open building methods recognize that sustainable built environment is never finished, that control of its transformation is distributed among many parties including inhabitants, and that observed cycles of change universally organize themselves on levels of intervention, akin to the way any man-made infrastructure system works.

Every year since 1996, an international Open Building Network, numbering more than 350, has met to exchange findings from realized projects and research. Open building is not new; it is implicit in office and retail developments everywhere, and increasingly in healthcare, housing and educational facilities, where change – rapid or slow – is a reality. These projects embody the general principles noted above, and in technical terms make an unambiguous separation between architectural elements and spaces expected to last a very long time (the 'shared' part of a building) from the parts and spaces with a shorter lifespan (controlled by or for individual households or occupancies). Open building makes all of this explicit, helping

Frans Van der Werf's competition winning Molenvliet-Wilgendonk housing in Papendrecht, the Netherlands



RPHS Architects; Patrimonius Woningen Renovation, Voorburg, the Netherlands, 1990-1993

to make methodical improvement possible. Two questions are resolved in each open building project: what distribution of individual and collective agency will yield a sustainable environment; and, when interventions are made, what decision-making flexibility is offered to those that follow? Such work is now being realized in many countries, in new constructions and in the reactivation of existing buildings. Each takes account of the contemporary forces at work in increasingly large, fast-paced and complex schemes where efficiency is critical, but where variety and capacity to accommodate change and user agency are equally important performance measures.

PIONEERING PROJECTS

The first significant open building project was Frans Van der Werf's competition winning Molenvliet-Wilgendonk housing in Papendrecht, the Netherlands (image to the left and above) (1977), in which a four-story base building principle is deployed as a continuous structure, forming streets and courtyards. It is fully within the Dutch architectural tradition with steep tiled roofs, courtyards for gardens, 'Dutch' doors opening to front stoops, and galleries that provide access to upper-level houses. Renters selected the location and size of dwellings and the layout of the interiors, as well as parts of the facade of their subsidized dwellings. It remains a vibrant mixed-use environment today, occupied by houses and a few offices and shops. After 40 years, this competition-winning project still attracts visitors from around the world. While only a small part of the competition-winning proposal, it is an outstanding example of a harmonious merging of urban design and architecture, skillfully balancing coherence and variety. (2)

Many hundreds of explicitly open building schemes followed, right up to the present day, in Japan, China, Austria, Finland, France, the UK, Switzerland, the US, Mexico and elsewhere, offering glimpses of a renewal of residential development practices and architectural possibilities. (3)

Another pioneering example in the Netherlands was a rental housing estate in Voorburg, owned by Patrimoniums Woningen, a housing association that intended to upgrade its portfolio of apartment buildings. (4) In 1993, the owner employed a new investment model enabling 'cellular renovation' developed by Karel Dekker (KD Consultants) and hired Matura Inbouw to install a an equally original Infill System using a technical solution developed by Infill Systems BV that used a certified zero-slope greywater plumbing system held in place by a thin tile laid on the leveled structural floor (Image above left), (5) helping to make one-dwelling-at-a-time renovation profitable and organizationally effective. This project was ahead of its time, employing a pioneering economic model for 'cellular renovation.'

The signal achievement of this early stage of open building implementation is Next21 (image next page), a mixed-use project in Osaka, Japan, initiated by the Osaka Gas Company and initially completed in 1993.6 It serves as a continuing experiment with energy systems such as hydrogen fuel cell technology, mutable interior fit-out components, adaptable facades, mechanical systems and introducing nature into urban environments. Professor Yositika Utida, who led the design team, originally invited 13 architects to each design

Yoshitka Utida /Shu-Koh-Sha Architectural and Urban Design Studio, NEXT21, Osaka, Japan, 1993- present

the fit-out of a dwelling, also using a selection from a facade kit of parts. Other architects have since been hired to redesign individual dwellings in the building, experimenting with new infill components and processes. This is an example of the unique capacity for government, industry and academia in Japan to partner in driving building innovation.

In Seattle, the Banner Building (images to the right), an award-winning condominium complex designed by Weinstein Architects and constructed in 1995, offered empty double-height spaces, each of which was custom-outfitted by its owners. This condominium/retail project broke new ground by offering completely empty spaces for sale and helped to spark the redevelopment of this part of Seattle. Other 'raw space' schemes (advertised as such by their developers) have since been built in cities across the US, demonstrating how open building can be implemented under local regulatory and financing constraints. These new-build projects are akin to the conversion of old industrial buildings to housing and other uses, a critical difference being that, to qualify as open building, the interior layout of each occupancy must be fully independent of the layout decisions of other dwellings in the building – a challenge for plumbing systems that usually penetrate into the ceiling of homes below, causing technical entanglement and legal conflict.

Another path-breaking project is the PlusHome 'Arabianranta' residential and mixed-used project in Helsinki (images on following spread) (2005) by architect ArkOpen. Together with Tocoman, a data management company, they pioneered solutions to the managerial and logistical aspects of open building to allow homebuyers to collaborate in the design of their dwellings, each of which is different in size and floor plan. The Sato development company was thus able to complete the project on budget and on time. Of special note is an 'upside-down' floor in the areas where bathrooms and kitchens were likely to be chosen by homebuyers, enabling piping and other systems to be accessible from the homes served. This residential for-sale and ground-floor retail project offered each dwelling owner a wide choice in the size and layouts of their homes as illustrated in the composite drawing above. The scheme won an award from the Finnish Steel Industry Institute and assured the investor of a profitable asset.

The building was constructed in part during the long winter months, made possible by the use of steel floor and wall assemblies made off-site and quickly erected by cranes on the building site. Each dwelling's large south-facing balconies can be made more private by moving sliding screens as needed.

There are now a number of award-winning 'raw space' projects throughout Finland, by architects including Tiuri & Lommi, and Talli, which designed the Tila housing block in 2009 and is now designing others like it. (7) Also built by Sato, at Tila each occupant bought a double-height space provided with finished bath/utility room (larger units have two) and completed the fi t-out on their own, including kitchens in various sizes and positions. A second, mezzanine level can also have a bathroom. Some owners completed their own infill in a do-it-yourself fashion, while others hired professional fit-out companies.

The Banner Building, Seattle, WA; Weinstein AU Architects + Urban Designers LLC

Inspired by PlusHome 'Arabianranta' and other open-building projects in Finland designed by Esko Kahri, Ulpu Tiuri, Talli and others, the Building Information Foundation – a national quasi-official organization – published guidelines in 2016 for housing based on general rules of open building and sustainability goals.

In Moscow, numerous 'free plan' apartment buildings have been initiated by developers and advertised as such. To obtain approval for the Catamaran House project (2000), (8) Vladimir Plotkin (Reserve Architects) submitted drawings showing dwelling floorplans (initially, 107 were planned). After consent, the architect deleted the approved floor plans, and the contractor built the empty base building. While construction was ongoing, owners hired designers and fitout companies to complete each dwelling according to individual preferences. Subsequently, the number of dwellings is different, some have changed hands, and some have been combined and their interiors altered.

Lingotto, a prominent Dutch development company, hired ANA Architecten to design Multifunk in the IJburg area of Amsterdam in 2006. The building was prepared for subdivision into offices, dwellings and/or student apartments and is making a profit for the owner. Also in Amsterdam, two schemes initiated by Frank Bijdendijk (as former director of the Stadgenoot housing corporation) have been built: Solids 1&2 in IJburg, Amsterdam, designed by Baumschlager Eberle (2010) (image right page), and Solid 11 in Amsterdam West by Tony Fretton (2011). Both were designed to accommodate virtually any function, and in fact do. Bijdendijk gave them the name Solids because he insisted that they be long-lasting, energy efficient and offer space for variable uses. They demonstrate the potential for long-term return on investment for at least a century. Both mimic the capacity of the city's historical building stock to accommodate changing functions.

Mark Koehler Architects (MKA), has developed a concept called SUPERLOFTS (image above right, 2016) and has built several in Amsterdam and other Dutch cities. In this new approach, MKA, also acting as developer, invites future residents to decide on collective facilities before construction begins. A personal design service – Homelab – is available with an on-line database to assist owners in designing their own homes.

Tom Frantzen Architects, designed PATCH22 in Amsterdam, built in 2017 and another is under construction adjacent to the first. This is a heavy timber project using Slimlines' 'upside-down' floor system, allowing access to all dwelling-related utilities from the space served. The project also pioneered legal agreements for a fixed ground lease with flexible positioning of functions within the building.

ANA Architecten and others in the Netherlands are designing successful open building projects in the Netherlands using state-of-the-art building methods and social media for sales promotion.

OPEN BUILDING ENTERS PUBLIC POLICY

In 1997, the Office for Real Estate and Public Buildings of the Swiss Canton of Bern (OPB) in Switzerland introduced a principle for facility acquisition called System Separation – a decision-making strategy aimed at assuring long-term asset usefulness by decoupling technical systems as far as possible according

The PlusHome 'Arabianranta' in Helsinki, by ArkOpen, 2005

to expected lifespan. (9) System Separation, now binding for all public buildings in the canton, has since been used to procure more than 20 projects (see Giorgio Macchi's article in this issue). In 2008, the Japanese government passed the Act for Promotion of Long-Life Quality Housing offering incentives for projects that can remain useful for two centuries. (10) The law includes guidelines for technical subsystems design (such as utility systems, structure and facades), enabling their resilience, replacement and upgrading – due to wear-and-tear or to serve changed user preferences – with minimum disturbance of other subsystems or occupancies. Owners of conforming dwellings are given tax breaks. More than 800,000 dwellings have been built in response. With a shift in priorities to a sustainable building stock, many companies in Tokyo now offer one-unit-at-a-time fit-out in the renovation of existing residential buildings, quietly, on time and on budget. The Haseko Corporation, one of a number of companies undertaking open building schemes (called 'skeleton-infill' in Japan) for both rental and sale, has also collaborated in a joint research project with Bridgestone (a tire and chemical company entering the construction products market) to develop a zero-slope grey-water plastic drainage piping system that allows wide variation in the placement of kitchens and is accepted by Japanese regulations.

In 2010, the Chinese government's Institute of Building Standard Design & Research (CBS) began building skeleton-infill projects containing tens of thousands of dwellings in several cities. It is also laying the groundwork for an 'industrialized' infill industry, with sophisticated companies now coming to market, one of which (Unity Tech Group) has delivered and installed more than 50,000 fit-out packages for both social and private housing and is now supplying infill for clinics and hospitals.In 2012, the US government Defense Health Agency began undertaking changes to its methods for acquiring and managing the many healthcare facilities in its portfolio to make them 'flexible'. (11) Other large public and private healthcare clients in both the US and Europe are now demanding and getting flexible facilities, pushing architecture and engineering teams to move beyond rhetoric.

THE NEXT STAGE

Projects such as those discussed here are appearing worldwide, often undertaken without any knowledge of similar developments in other countries and having no specific name by which to identify them. Though their architectural design, construction, financing and regulatory methods vary, the issues they address are similar and are – again without a common name – increasingly understood as a pragmatic extension of infrastructure planning into the design of buildings – separating long-lasting parts from those that change more frequently, and distinguishing shared (higher-level) and individual (lower-level) agency. Designers using open building approaches are not alone in moving beyond functionalism and supporting the distribution of control beyond the professions.

Advances in social media and digital tools are enabling decentralization, disintermediation, and new forms of community as well, responding to and stimulating innovative design and management strategies, building technologies, financing, regulatory/legal and policy measures. As important, emerging

The PlusHome 'Arabianranta' in Helsinki, by ArkOpen, 2005

Superlofts in Amsterdam by Marc Koehler Architects

The Tila housing block, Helsinki, Arabianranta by Talli Architecture & Design

design/build fit-out companies are pioneering novel means to deliver fit-out or infill services that offer sustainability, resiliency and user control. Further, the old notion that open building is too expensive is increasingly being exposed as fallacious, as social dynamics and new technologies force investors and clients to plan for change.

The path from the recognition of change and distributed control as key performance metrics of built environment intervention to widespread implementation of 'loose-fit' or open building architecture has not been smooth. Early housing experiments based on the separation of 'support and infill' were widely scorned in the architectural press; other visionary projects were never realized. But a shift from rigid functionalism to the use of capacity-for-change as a guiding principle, from centralized to distributed control, is nonetheless becoming evident. In this period of transition, open building or loose-fit should not be cast as a technical solution. Rather, the fundamental shifts in attitudes and practices lie in balancing stability and change and enabling and managing distributed agency with its related legal issues. The work ahead is to continue improving societal steering mechanisms in consonance with the real pressures facing the contemporary everyday built environment.

PATCH22 in Amsterdam, by Tom Frantzen Architects, 2017

Notes

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9 Stephen Kendall and Giorgio Macchi, Systems Separation: Open Building at the Inselspital Bern, INO Project, Stämpfli Verlag (Bern), 2008.

10 Kazunobu Minami, 'The Efforts to Develop Longer Life Housing with Adaptability in Japan', Energy Procedia, 96, 2016, pp 662–73.

11 Stephen Kendall et al, 'Healthcare Facilities Designed for Flexibility', in Romano Del Nord (ed), Healthcare Otherwhere: Proceedings of the 34th UIA/Phg International Seminar on Public Healthcare Facilities, Durban, South Africa, Tesis – University of Florence (Flor-ence), 2014.

PATCH22

The Tila housing block, Helsinki, Arabianranta by Talli Architecture & Design

Superlofts in Amsterdam by Marc Koehler Architects

The PlusHome 'Arabianranta' in Helsinki, by ArkOpen, 2005

The Open Building Conference Papers

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FLEXIBILITY IN APARTMENTS: EXAMINING FEASIBILITY OF "OPEN PLAN" HOUSING IN URBAN INDIA

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KEYWORDS

SUPPORT AND INFIIL (S&I)
FLEXIBILITY
OPEN PLAN
FEASIBILITY

ABSTRACT

India is witnessing an unprecedented growth in urban population leading to an inflating housing demand, which is primarily addressed with creating "ready to move-in" apartment towers. Although, this approach solves the problem of housing to a certain extent, it leaves many consumers and developers dissatisfied, because the end user prefers to alter these apartments to fit their lifestyle needs.

This research evaluates the feasibility of "Open plan - Support and Infill" as an alternative design approach, for urban housing in India. The first section establishes the need for a flexible design by evaluating the needs of the end user in urban India. The next section briefly critiques the N.J Habraken's "Open building concept", which suggests that decision making should be divided for different stakeholders - housing providers (builders and architects) and end user within a housing scheme, which can be done on the basis of understanding varied life cycle of different layers of a building. Section three introduces an evidence based framework to test the feasibility of the approach under three parallels- First, technological availability and construction industry analysis through two case-studies supplemented by literature study; second, regulatory obstacles and opportunities for execution of an "open plan" through interviews with selected practising architects, along with literature analysis and third cultural acceptability for the concept in Indian market through an online survey (n=100), spread across home-buyers, developers and architects over different cities. The study suggests, while India is technologically ready, there is a cultural inhibition towards "unfinished" apartments and the current housing regulations do not support of the design approach to full potential. After taking these factors into account, the research also provides recommendations on practical application of the approach in Indian market.

INTRODUCTION

The Urban housing sector is booming because people are migrating from every corner of India. And since people come from different cultural and social background, the standard housing options available to them frequently do not cater to the current needs as well as future aspiration of every individual. The dissatisfaction that is observed across the globe with the "ready-made apartments" is faced by the Indian users as well.

Designers predict behaviour of the users considering people not as individuals but as mass, and then providing standard defined designs for all. The result of this is that the user purchases this unit and often break down the "entire" house to re-design as per their unique needs, which is frustrating for the owner of the property and harmful for the building itself. As recommended by N. J Habraken, instead of predicting the future, design should accommodate the unforeseen, which means designing a house that facilitates the end user to build the apartment by themselves and make any "big modifications" like tearing down a wall, adding partitions etc. with ease. There is clearly a deficit of flexible and adaptable housing system in Indian cities.

1.0 HOUSING SCENARIO IN INDIA - AN OVERVIEW

As per Census 2011:

- According to estimates, around 600 million people are expected to make urban India their home by 2031, a whopping 59% growth over 2011
- The current housing deficit in India stands at 19 million units, which, in the absence of any meaningful intervention, is slated to double to 38 million units by 2030. 95% of this deficit is around the EWS (Economically Weaker Sections) and LIG (Low Income Group) segments (Times 2015)

To meet this housing demand, high density housing solution is required. With absence of adequate affordable land in cities, it is difficult for a regular individual to build their houses and hence, rigid "ready to move-in" apartment towers are mushrooming within the cities.

Indian cities are teeming with different cultures and though basic requirements for the residents maybe easy to determine, their treatment to the new home and intertwined spaces will vary. For example- a nuclear family, will require 2BHK flat, but the manner in which it will be occupied will differ from Bengali family to Gujarati family, because even though away from home their way of living is predominantly influenced by their cultural and social roots. The needs and desires of an urban family may vary in following ways

- **Multi-cultural households** – to accommodate spaces for some cultural rituals
- **Growth in family** – over the years, the family size may increase or decrease, for which house needs to accommodating
- **Short-term activities** – some relatives coming over, or in case of a wedding at home, requirement for more space to sleep
- **Changing weather** – from summers to winters, to match the living conditions, house needs to modify accordingly
- **Desires** – changing aspirations, from regular kitchen to "modern" open kitchen, adding a bathtub, etc.

To grasp a better understanding of the common requirements of a user in respect to their homes, an online survey was conducted between 100 random dwellers, spread across different cities in India and following were the findings.

While some of these modifications are easy to achieve, example changing the finishes of a wall, some do require the building itself to be conceptualized differently to accommodate the alterations, example in case a user wants to add a room.

As discussed in article - Flexible housing: opportunities and limits, 2005 by Tatjana Schneider and Jeremy Till, we can define flexibility as HARD and SOFT, on the basis of the kind of alterations a user requires. With the intention to provide "soft" flexibility to the user, the upcoming section briefly reviews the theory by N. John Habraken's theory on Open building.

The paper should be organized in chapters and sections consecutively numbered using Arabic numerals and decimals. Both chapters and sections (subsections) should be preceded with single blank lines.

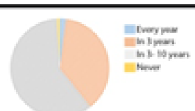
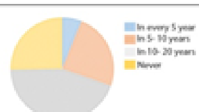
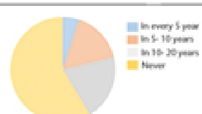
QUESTION	RESULTS	INFERENCES
How often do you need to - Re-paint		• Being a relatively simpler change, it can be undertaken in every few years. • Also the life-span of paint is low. • Mood changes and hence repainting may happen more frequentl
How often do you need to change - the floor tiles		• Taking the floor tiles down is a hassle as it requires masons for atleast 4-5 days. • Also the noise and debris created is another issue
How often do you need to change - add or divide a room ?		• This requires a lot of resource and time, and is often tedious because of neighbours objecting or the society not giving permissions easily. • People would rather move into a new apartment than add another

Figure 1: Survey results. Source: Author, 2017

SOFT	HARD
Wherein architect works in background and provides relatively indeterminate spaces for user to complete them	Wherein architect works in forefront and provides spaces that may have pre-determined uses and flexibility options

Figure 2: Survey results Source: Author, 2017

CUSTOMISABLE	FUNCTIONAL	TEMPORAL	ORGANISATIONAL	DIMENSIONAL	ADDITIONAL
An ability to choose finishes and some elements	an ability to change the function of a room	an ability to change the use of a room on the basis of time	an ability to change the order of the rooms.	an ability to change the dimensions or measurement of a room.	an ability to add more rooms

Figure 3: Types of flexibility listed from hard to soft (D'Souza 2013)

2.0 SUPPORT AND INFILL

Habraken, in his attempt to address the need of flexibility in housing promoted the concept of Open Building, and the proposed design approach to acquire flexibility was "Support and Infill". In order to accommodate for the unforeseen needs of future, he recommends segregation of different layers of a building to facilitate distribution of decision-making by different stakeholders. He calls them- Tissue, Support and Infill. The fabric of a town (tissue level) is at a higher level than the buildings, positioned within the town fabric. Buildings can be replaced and altered, while the town fabric remains the same. The buildings is divided in base building (support level) and fit-out (infill level) (Cuperus 2001). Jumping straight to the application- Support is the permanent and difficult element of a building which requires experts- architects, developers, etc., while Infill is the element that is directly dealt by the individuals and is governed by the quality of the support. The diagrams below, gives an overview:

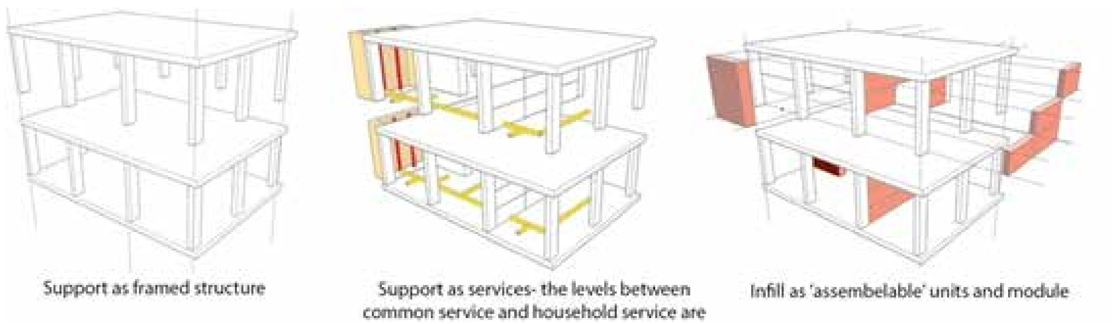


Figure 4: Support and Infill. Source Author 2017

The imperative expectation that the author holds is that an Infill industry can flourish in markets and trigger new products that are easily assemble-able and convenient to move around. What that also means is that, the ownership of the support is in the hands of a "site-holder" but everything else within the unit (preferably) is owned by the user them-selves and therefore if and when they move to new place, new Support system, their Infill can come with them to the place.

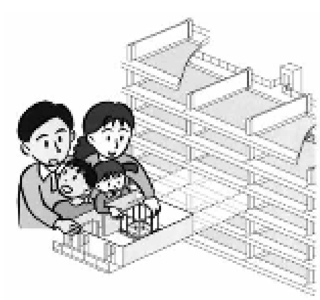


Figure 5: Source: Towards an open and user driven housing architecture Source: HUDC Japan

3.0 FEASIBILITY ANALYSIS

In order to bring the S&I in Indian market as an alternate design approach, the research fundamentally aims at addressing 2 main questions

- To what extend is it even feasible in India?
- Whyhasn'taconceptlikethisfoundits way into Indian housing market with full potential?

To determine the full potential of the scheme, one needs to investigate into the technological availability fundamental to S&I, regulatory obstacles and opportunities for an open plan that are prevailing in housing and cultural acceptability for S&I scheme for users and architect/ developers in terms of the new technology and alternate housing delivery system.

3.1 TECHNOLOGICAL FEASIBILITY

S&I demands technological advancement and the idea of industrialisation and use of standard modules to make different layouts is the fundamental principle of S&I. Therefore, to accept S&I in India, one first needs to answer the following:

1. What technological/ construction practices are required for this design approach?
2. Which technologies are commonly available in India?
3. To what extend it is used in Indian construction industry?

To address the first question, two case-studies are studied in detail -

- Case-study1-asuccessfulS&Iproject abroad – Tila Open Building housing, Helsinki, Finland
- Case- study2- a conceptual project in India- Wo77,-Shilpshree developers, Bangalore, India

CASE-STUDY 1

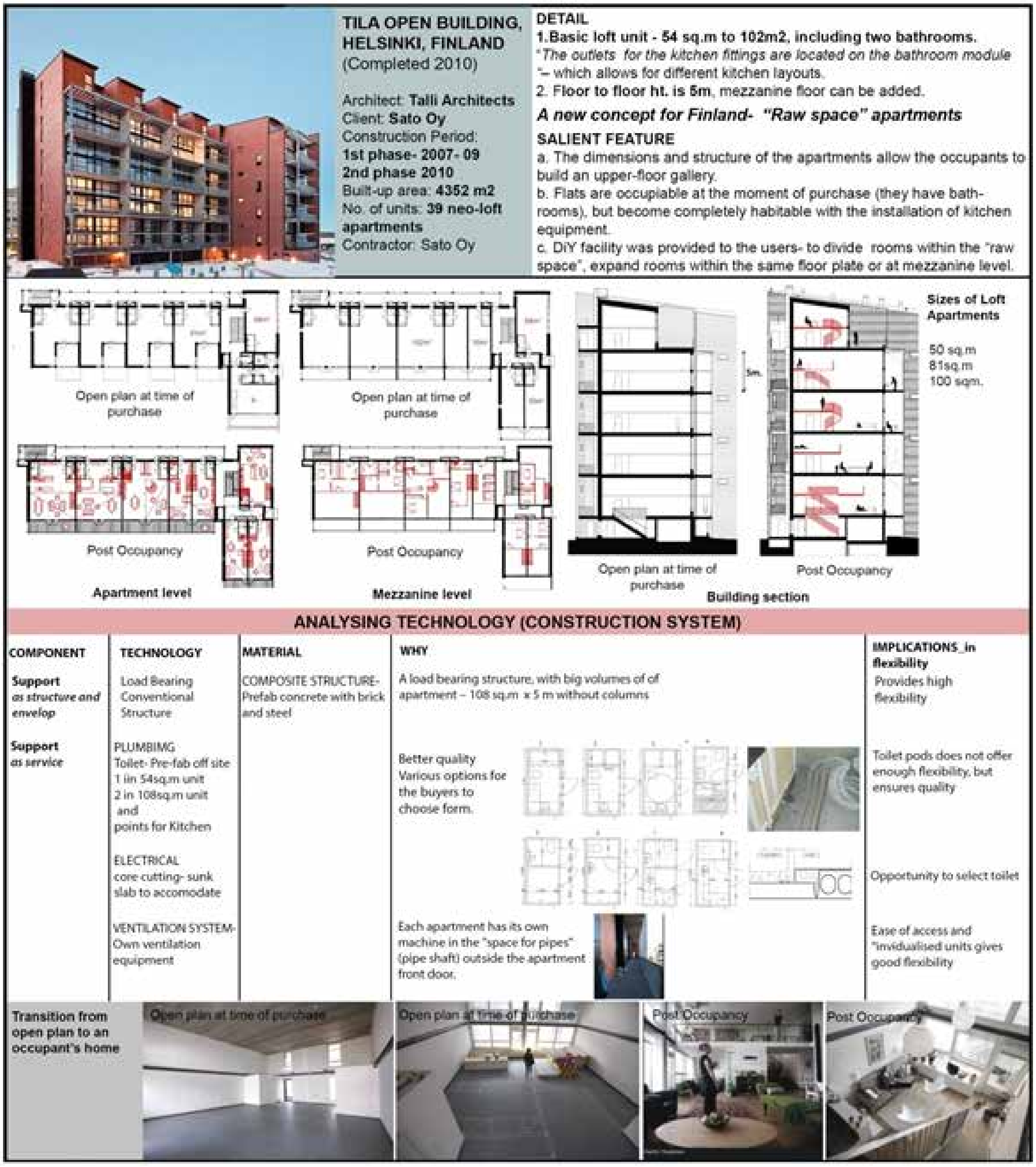
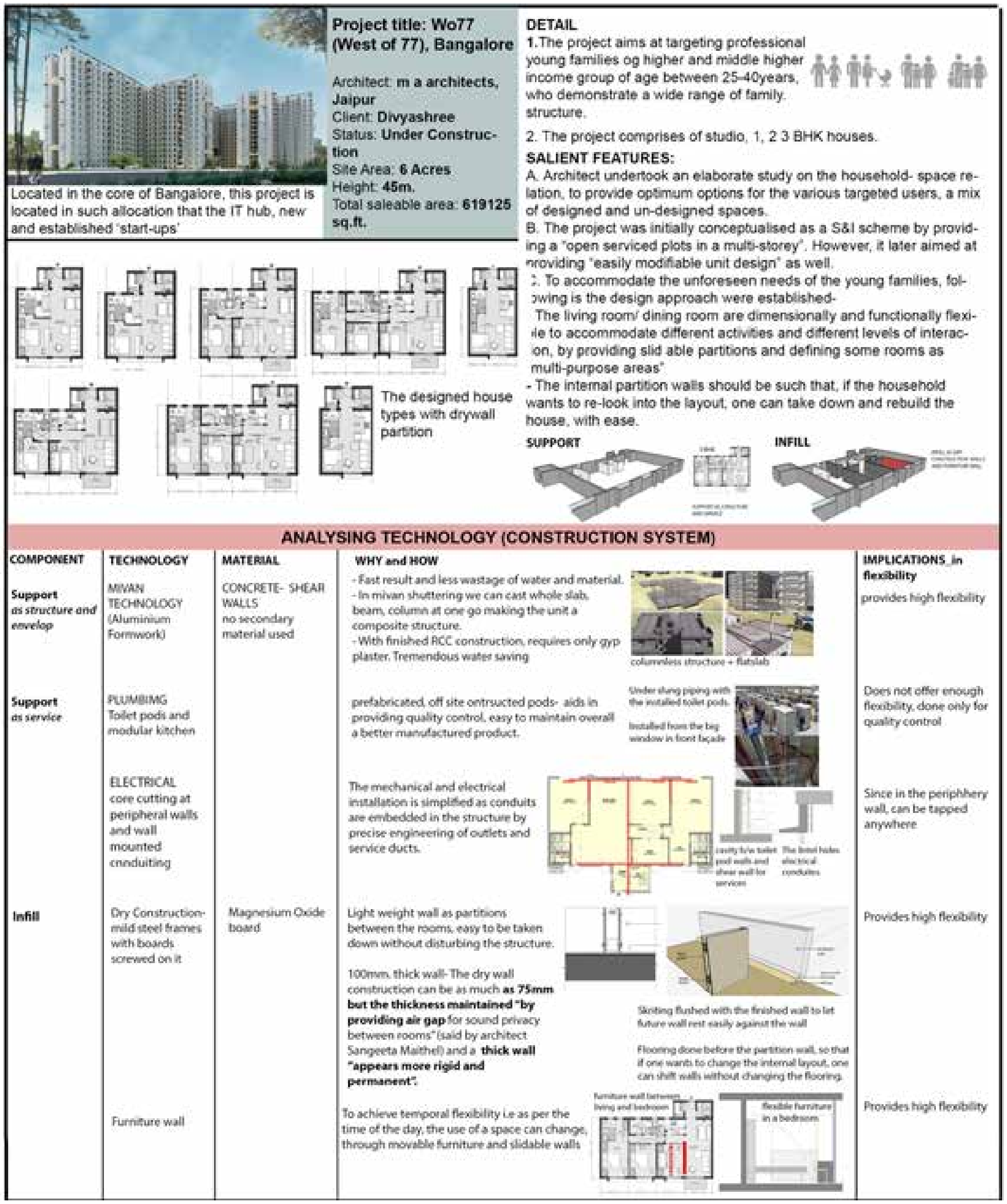


Figure 6: Support and Infill. Source Author 2017

CASE-STUDY 2



Project title: Wo77 (West of 77), Bangalore

Architect: **m a architects, Jaipur**
Client: **Divyashree**
Status: **Under Construction**
Site Area: **6 Acres**
Height: **45m.**
Total saleable area: **619125 sq.ft.**

Located in the core of Bangalore, this project is located in such allocation that the IT hub, new and established 'start-ups'

DETAIL

1. The project aims at targeting professional young families og higher and middle higher income group of age between 25-40years, who demonstrate a wide range of family structure.

2. The project comprises of studio, 1, 2 3 BHK houses.

SALIENT FEATURES:

A. Architect undertook an elaborate study on the household- space relation, to provide optimum options for the various targeted users, a mix of designed and un-designed spaces.

B. The project was initially conceptualised as a S&I scheme by providing a "open serviced plots in a multi-storey". However, it later aimed at providing "easily modifiable unit design" as well.

C. To accommodate the unforeseen needs of the young families, following is the design approach were established-

The living room/ dining room are dimensionally and functionally flexible to accommodate different activities and different levels of interaction, by providing slid able partitions and defining some rooms as multi-purpose areas"

- The internal partition walls should be such that, if the household wants to re-look into the layout, one can take down and rebuild the house, with ease.

The designed house types with drywall partition

SUPPORT

INFILL

ANALYSING TECHNOLOGY (CONSTRUCTION SYSTEM)

COMPONENT	TECHNOLOGY	MATERIAL	WHY and HOW	IMPLICATIONS_in flexibility
Support *as structure and envelop*	MIVAN TECHNOLOGY (Aluminium Formwork)	CONCRETE- SHEAR WALLS no secondary material used	- Fast result and less wastage of water and material. - In mivan shuttering we can cast whole slab, beam, column at one go making the unit a composite structure. - With finished RCC construction, requires only gyp plaster. Tremendous water saving (columnless structure + flatslab)	provides high flexibility
Support *as service*	PLUMBIMG Toilet pods and modular kitchen		prefabricated, off site ontrsucted pods- aids in providing quality control, easy to maintain overall a better manufactured product. (Under slung piping with the installed toilet pods. Installed from the big window in front façade)	Does not offer enough flexibility, done only for quality control
	ELECTRICAL core cutting at peripheral walls and wall mounted cnnduiting		The mechanical and electrical installation is simplified as conduits are embedded in the structure by precise engineering of outlets and service ducts.	Since in the periphhery wall, can be tapped anywhere
Infill	Dry Construction- mild steel frames with boards screwed on it	Magnesium Oxide board	Light weight wall as partitions between the rooms, easy to be taken down without disturbing the structure. 100mm. thick wall- The dry wall construction can be as much **as 75mm but the thickness maintained "by providing air gap** for sound privacy between rooms" (said by architect Sangeeta Maithel) and a **thick wall "appears more rigid and permanent".** (Skiting flushed with the finished wall to let future wall rest easily against the wall. Flooring done before the partition wall, so that if one wants to change the internal layout, one can shift walls without changing the flooring.)	Provides high flexibility
	Furniture wall		To achieve temporal flexibility i.e as per the time of the day, the use of a space can change, through movable furniture and slidable walls (Furniture wall between living and bedroom; flexible furniture in a bedroom)	Provides high flexibility

ACHIEVEMENTS

- The efforts taken by the architect in deriving details demonstrates that there is an ease for the user to make modifications in future. The fact that flooring is done before the erection of partition wall is an unconventional decision which gives an option of dismantling the wall without taking off the flooring, which gives a big advantage to the user.
- Also flat slab is another decision that facilitates flexibility of constructing drywall partitions anywhere within the "plot".
- Electrical service is thought of been taken through false ceiling, so that the points can be simply tapped down wherever necessary.

Through web search and personal exposure in architecture field, question 2 and 3 are addressed next. Now that we have established the technological (constructional) requirements for "Support" of a building- the structure and services and "Infill"- internal partition systems and various plug-in elements, next section will briefly provide evidences of availability and usage of some of these materials in other construction industry in India, apart from housing.

The construction techniques required for structure such as use of pre-fabricated RCC panels for exterior wall or in-situ load bearing construction, etc are already prevailing in multi-storey housing. Off site service elements such as plug-in toilet pods, assemble-able air ducts are available in the market but usually used largely in hospitality industry. The real shift in material selection is required in the infills, from wet construction to dry construction and elements "designed for dis-assembly".

Dry construction: The dry construction techniques such as gypsum partitions, MgO boards (Magnesium oxide boards),etc are available and used extensively in commercial buildings since many years. Used simply as separators, these partitions do not offer much performance. But now with the increasing regulations, various fire proofing and sound proofing techniques are becoming mandatory. The problem is observed in residential buildings, where it does not seem to have made its way. In fact the builders themselves have stayed away from bringing this alternative technology in residences, as there is a notion that dry construction is light weight and hence not very rigid or reliable and does not offer privacy that is required in residences. Says Samir Rasam, - a consultant of dry wall construction. 'How do we put unplanned load? Are the walls strong enough (since there is hollow knocking effect)?' are some of the typical questions raised by builders. (Rasam 2015)

Prefabricated products: The other identified technology in infills are the pre-fab elements, such as concrete panels used as the "envelope" of a housing, prefabricated balconies plugging into the structural system or internal DiY prefab partition systems. A few prototypal projects have found developed in the half a decade which have promoted use of prefab products as structure and partitions. However, these projects have not seen light of day. Example, India concept home by Kieran Timberlake (American Architect) and Lego like blocks to make ferro-cement assemblable blocks to make houses by Anupama Kundoo (Indian Architect).

From the above feasibility analysis of the technological availability, it can be concluded that, while there is an availability of the required technological advancement in India, the availability and usage of the DiY prefab products have not yet found relevant position in the market.

3.2 REGULATORY (LEGAL FEASIBILITY

Typically, for a residential (housing project, the approval from the municipality in India requires Architects to present habitable room sizes in the house and Define the occupancy of the room, along with providing tentative selection of specifications for interior finishes.

It is a mandate for a developer to acquire OC (Occupancy Certificate) in order to sell apartments and since S&I scheme, simply seen, is mostly a "serviced large room" house which is intentionally left unfinished for the future occupants to complete them as per their requirements, getting an OC might become an obstacle. Therefore, to accept S&I in India, one first needs to answer the following:

1 What challenges and obstacles do architects face from the regulatory framework for practical realisation of the project

2 What methods, "tricks" or improvisations have architects taken up to bring such housings to reality?

To address the above questions, the issues faced by the architects from the two case-studies covered in the Technological feasibility are elaborated along with their approach towards tackling with the issues.

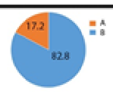
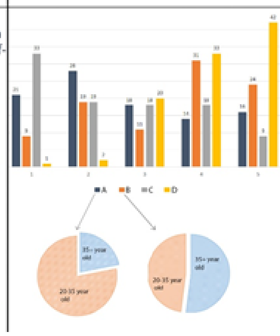
Table 8:Regulatory analysis of the case-studies

Project	Issue	Approach
Tila open building Project in Helsinki, Finland	Approval/ Inspection	• The idea of "what is habitable" had to be discussed with the building officials and lawyer in the early stage of the concept-design. • For "wet space" toilet and kitchen only plumbing points and water proofing was mandatory
	Further alterations (postoccupancy)	• To take care that if the "shareholders" make changes they have to contact the board of the housing company (which is like an HOME OWNER'S association of the dwellers with 3-4 representatives) to get permission,and take care of the building permissions from the City building department if needed. • While constructing bearing structures inside any apartment (like the gallery floor) one has to follow building regulations and hire architect/ supervisor (SATO- the client themselves) to arrange all the required building permits from the City building department for that. Officials inspect the construction also. • Architect made a booklet of instructions (negotiating with the City officials in the Building Department), showing how to follow the regulations.

Wo77, Bangalore	Approval/ Inspection	• All the internal partition walls are shown, but with dry construction, otherwise the sanction drawings follow the regular format. • For "wet spaces" the position was fixed such that ventilation shaft and service shaft was taken care of, which is necessary
	Further alterations (postoccupancy)	• Since, there is dry wall construction done in the finished apartments, it can be easily knocked down if needed by the users for which no prior permission needed
	Occupancy certificate	• In the recent development, the developers are trying to sell some "onlyshell (like an open serviced plot) to the users and are already working on convincing the authority to pass this housing scheme as CORE AND SHELL as done in commercial buildings. • This will be a new amend in the regulations if it happens.

Table 8:

Regulatory analysis of the case-studies

QUESTION	RESULTS	INFERENCES
If you are purchasing a new apartment, would you prefer- **A.** a fully finished, ready to move in apartment? **B.** a semi-finished apartment with scope to be modified. (or re-designed completely)		-A vast majority prefers a semi-finished apartment over fully finished.
Would you buy an apartment which only has toilet and kitchen and no room division, so that you can complete the house yourself?		-Even though an unfinished or semi-finished house is clearly in majority, but S&I type of apartment, which only has periphery walls and "wet spaces" is not appealing a vast majority. -Young people between 20- 35 accounting for 63% of the total 'yes' find the concept appealing
Rate the following apartment design approaches out of 5- as per your preferred house. **A.** an apartment with only toilet and kitchen, and making the partition walls on your own, using plug in prefab elements like lego blocks **B.** an apartment with only toilet and kitchen and making partition walls hiring an interior designer. C. A fully finished apartment where you can knock down the walls to make your modifications. **D.** Ask the developer to consider the alteration demands before-hand		Approach **A** has not received very good rating. However, it specifically mentions that for the users, "do-it-yourself" approach is not very welcoming The same approach seen in **B** seems to click with majority, as the interior designer will provide with desirable layout of the house Approach **C** is most undesirable, while **D** being offereing desirable layout at the time of purchase, is certainly preferable. Basis the responses for approaches **A** and **B**, ***people's acceptance and interest in S&I equivalent approach is seen. But the DIY does not seem to engage the Indians.*** Out of the few who prefer DiY, most are young adultscontributiong to nearly 78%.

From the above feasibility analysis, one can establish that India requires amendments in the current regulations during the approval stage, so that an open plan can be passed just like a commercial building get its approval done. There is also a requirement of leniency during the process of acquiring OC because only then this product can be truly viable.

3.3 CULTURAL FEASIBILITY

For any new product to work, its acceptability by the end user is the most critical aspect. It is key to understand, the expectations and requirement that users have towards a house type designed with the intension of creating flexible environment for the users. Also since the S&I encourages the users to engage in creating their own spaces through DiY products, enthusiasm for such an approach has to be evaluated. Hence, this section of research aims to address the following questions:

1 What is the users take on new flexible housing solution- S&I and equivalent concepts?

2 To what extend is the Infill market (DiY prefab elements and light dry wall construction accepted by the users to engage them in designing their own spaces?

To address the above questions, an online survey was shared by 100 applicants selected at random spread across different Indian cities with ages and gender and it also included practicing architects. Following are the results.

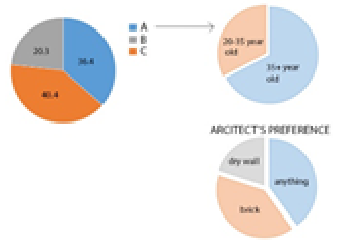
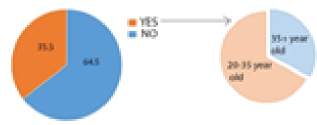
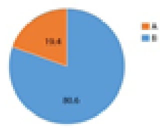
For the partition walls between your bedroom and toilets, what would you rather prefer- **A.** Brick walls (conventionally used, difficult to knock down) **B.** MgO board wall (light material, requires extra sound proofing, easy to be knocked down) **C.** I am okay with anything		Majority of the people have clearly preferred brick over dry construction techniques. • The common reason quoted is that it is sturdier and better for installing plumbing service. • Another common reason given was that they don't wish to make big changes, therefore they prefer brick. It is particularly, interesting that more architects have chosen brick over dry construction. • And the reason given by most is the need of extra insulation and therefore chose brick as it is cheap and reliable.
While making modifications in your house, have you used pre-fabricated wall panels, furniture (plug-in modules)?		Prefabricated market is not very popular yet in Indian market and therefore not a lot of people have used it yet. Amongst the ones who have used it, or are willing to use pre-fab products fall within 20-35 years old.
While making modifications in your house, would you rather **A.** Do it yourself, by purchasing pre-fab modules and assemble them like lego blocks? **B.** Hire a mason and pay him to make a wall, re-do flooring		As conclusion, majority of the surveyers confirmed that they would prefer conductio=ng modifications in their house using a mason, rather than 'doing it themselves'.

Table 9: Cultural analysis of the case-studies

The above survey confirmed, while there is excitement and a level enthusiasm towards flexible housing solutions equivalent to S&I, there is certainly an inhibition towards using new material which predominantly is light weight and requires people to handle the Infill materials on their own.

4 CONCLUSION

The research comes to an end, but with the aspiration that the study would be taken forward, by the future readers. The research analysed the feasibility of the concept in Indian market under three pretenses- technological availability, regulatory go-ahead and cultural acceptability. Following are the conclusions drawn.

Technological Feasibility

India is ready in terms of technology, but to an extent, lacks the managerial ability and awareness towards experimental usage of the technology.

Availability vs. Awareness

Through the 2 case-studies, the construction requirements were highlighted and later through web search and general know-how of the industry, it is understood that the technology required for "Support" is available and quite widely practised, the pre-fab type of elements for internal partitions especially are just coming up. Though these elements are used in commercial buildings extensively, the light-weight partition systems have not really entered much in the housing sector. These projects still opt for wet construction and relatively sturdier materials for partition systems. The biggest challenge lies in the inhibition that developers and builders have towards using the various available material in the housing sector.

Cultural Feasibility

India seems to be tolerant and welcoming to many ideas that are floating in the housing market which offers flexibility. But the lack of acceptability and inhibitions lie in the use of new or rather unconventional material.

Excitement vs. Inhibitions

From the analysis of the survey of approx. 100 people taken, almost a unanimous majority (83%approx) reflected that, instead of moving into a fully furnished space, they would prefer a semi-finished house. Also majority responded in favour of flexible housing design on new concepts like open plan, customise your space, multi-functional spaces converting from living room to bedroom within the course of the day through sliding partitions, etc. For particularly S&I scheme- that is an empty shell with no partitions, there is an eagerness and interest seen in people.

But the inhibitions for the users lie in the material use. Firstly, the market for DIY products seems lean. Only the youngsters and people from the construction industry are intrigued with the idea of DIY but that again not a vast majority. Secondly, there seems to be some inhibition amongst the users and surprisingly architects too, when asked to live or build a space with some "unconventional" materials or technology. The notion of "permanence" that is attached with brick wall is deep rooted in Indians, and even with all the awareness and exposure, many have not been able to shed off the 'false belief'.

Regulatory Feasibility

The main hindrance lies here, in the stringent and often unchecked rules and regulation that development authorities deliver.

Unquestioned rules: It was established that, it is difficult to get a plan like a shell and core approved in a residential typology because it is mandatory to define sizes and purpose of of habitable for getting municipality approval. But from the analysis of the two cases-studies, various tricks and approaches have been found that the respective architects have used to get their projects to reality. As Pia Ilomen (Principal Architect- Talli – architect for Tila project) says, the main question lies in understanding and communicating “what is habitable?” if this question can be truly understood by the designers and the regulation authorities, there might be scope for this concept to make its way in the Indian market.

The way ahead for the concept to enter Indian markets comes from the problems pointed out by various developers with the “ready to move in apartments” who were interviewed during the research. As one of the leading developers in city of Ahmedabad confesses, “the capital invested on a fully finished “ready to move in flats” is quite substantial. Developers face a problem when the user after possession, consider the house as ‘clean slate’ and change the entire layout. The walls might be taken down, flooring is changed, there might be drilling done in the column, so on and so forth. This is unhealthy for the structure and basically damages the property.” To avoid this response, developers often put strict regulations for the clients while drafting their contract, which is also a subject of difficulty for the users. Hence, the excitement showed by the developers towards “open plan” housing does put a positive light to the future of the concept in Indian markets.

The research would like to conclude with this thought for the architects and designer to ponder upon.

Invest in the facilities, amenities, structure and maintenance, which is permanent, why invest so much in the temporary elements like finishes, partition walls, etc.

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KEYWORDS

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METHODOLOGY

THE ADAPTABLE UNIT BUILDING DESIGN METHODOLOGY: SIMPLIFYING THE STEPS NECESSARY FOR OB IMPLEMENTATION

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ABSTRACT

Most ideas of Open Building (OB) are common to all applications: how to maximize a building lifespan, reuse and recycle building materials, give the power of choice to the users and enable division in the decision-making process. For the past 50~ years Habraken SAR and the OB organization have been developing and spreading ideas of planning for change through academia and exemplary projects. These ideas are increasingly relevant in today's growing environmental awareness, individuality and urban renewal design control issues.

However, when we try to implement the ideas in the individual countries' we are facing different needs, building methods, laws and regulations.

As practicing architects, in the process of realizing an OB project, we try to simplify the steps necessary for OB realizations for planners, searching for ways to convince the market to welcome change.

In this paper, we lay down the process of thinking and design that led to the development of the Adaptable Unit building, developed for the Israeli market in our previous research. We explore the architectural aspects, the construction method of the support, the systems and the infill, and follow through the steps that led to the specific choices, based on the building market study and work experience.

We also analyze the steps to be taken in reaching out the investors & contractors, municipalities and potential users, with a clear list of benefits, explaining how OB can simplify the building process.

In this process, we found that following a clear step methodology assists the process of realization. We hope that by introducing the process, step by step, along with its benefits, this paper will help promote the implementation of residential Open Building globally.

INTRODUCTION

The ideas in Habrakens' Support theory were simple yet revolutionary, providing the user with a support structure that allows the building of varied individual homes, allowing the user to take part in the important building process (Habraken 1961). Following this theme, the Open Building organization carried on, studying and developing ideas of residential adaptability. The theme has taken different forms depending on the different settings and countries in which they were built. The main goals shared by OB today are maximizing the building's lifespan, reusing and recycling of building materials, enabling division in the decision-making process and allowing the end user to make his own individual choices. In this paper, we lay down the process of thinking and design that led to the development of the Adaptable Unit building concept, developed for the Israeli market in our previous research. As we explore the architectural aspects, the construction method of the support, the systems and the infill, we follow through the steps that led to the specific choices, based on the building market study and work experience.

In the process, we first studied previously realized OB projects, comparing the settings, the concept of adaptability and the structural solution. To help us with the next steps of realization, we are also looking into the initiative and financing of each project.

1.0 OB PROJECT ANALYSIS

1.1 MOLENVLIET: PAPENDRECHT, NETHERLANDS 1977

Architect: Frans van der Werf. In the Netherlands in the 70-80 where Open Building was first introduced, there has been experimentation and research, supported by the gov't. This made it possible for a project at this scale, starting at the city planning level, making a clear separation in the decision-making process. The cool climate allows for large fenestration, making changes in the interior more convenient. A row house typology with changeable facades, the support is a tunnel-formed concrete structure. The infill includes removable partitions and the facades, made of wood and glass. The systems are centralized, pipes running vertically through the center of the building. The adaptability is internal introducing variety in the apartment size and layout. The initiative and funding is by the Gov't.

1.2 NEXT 21: OSAKA, JAPAN 1994

Architects: Mitsuo Takada, Kazuo Tatsumi. The concept of Next 21 (Osaka Gas Company, Japan) experimental sustainable project, introduces the principle of system separation, separating the support and its more permanent mechanical systems from the infill intended per fit-out. The typology is H form with 4 changeable facades. The support is made of a concrete skeleton structure, columns and beams. The infill includes removable walls and the façade made of aluminum sheet cladding. The systems include raised floor in the corridors and apartments. The apartments are adaptable both internally and externally. The initiative is governmental in this housing research project, financed by the Osaka Gas Company.

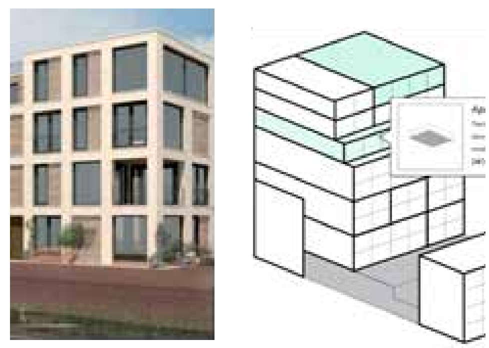
1.3 SUPERLOFTS: DELFT, NETHERLANDS 2016 (ONE OF 7 LOCATIONS)

Architect: Marc Kohler. The Superlofts is a hybrid co-housing concept, designed and marketed for organized groups of home buyers (acquisition groups). The buildings are composed of a combination of different apartment types that accommodate individual choices and designs, in a double height loft space. The typology is a block typology, each building differs depending on its location. The support is made of a concrete frame. The interior infill differs for each apartment, the facades are usually glass facades. The system run in raised floors. The adaptability of the buildings is internal, composed at the building stage with an ability for long term change. The initiative is by the architect, creating a web platform for the co- housing set up. The financing is by the group of buyers or private investors.

1.4 PATCH 22: NETHERLANDS AMSTERDAM 2009

Architect: Tom Frantzen. A 30m tall high-rise block typology building made of wood. The architect together with building-manager Claus Oussoren were the initiators of this sustainable outsized wooden building, hoping the wood structure will attract home buyers. The support is composed of a wooden structure and the facades are made of wood panels and glass. The infill is self-made by the users. The systems run in hollow floors connecting to the core. The building is adaptable at the initial building stage, and allows future changes, apartments can connect vertically. The initiative is private, the architect and building manager act as developers, the financing is also private. By looking at these 4 OB projects we can conclude that there are different options for building typologies and materials, depending on the settings. The buildings discussed above mostly allow internal adaptability, with the exception of the Next 21 in which the adaptability is also external, where the shape size and facades of the apartments may change. The last two newer projects are a private investment whereas the first two are gov't funded housing projects aimed to be more affordable. We can see that in the newer projects the Dutch architects at the financial crisis came up with innovative financing solutions.

Developing an OB project to fit our objective required trial and error. Our search for a process expressed in a simplified manner, resulted in our aim in this paper, to describe the process of development in simple steps.



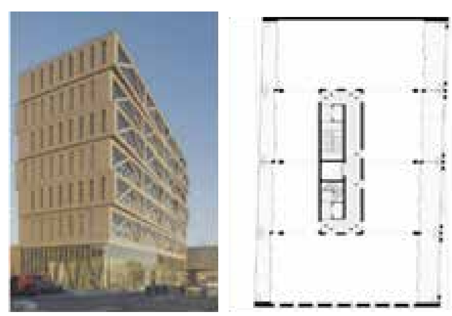


Figure 1: Molenvliet (Images courtesy of Frans van der Werf)

Figure 2: Next 21 (www.osakagas.co.jp)

Figure 3: Superlofts (www.superlofts.co)

Figure 4: Patch 22 (www.patch22.nl)

2.0 THE DEVLOPMENT OF THE ADUPTABLE UNIT (AU) BUILDING

2.1 MARKET STUDY

Our research and practice led us to search for an OB solution that would best fit the Israeli setting (Authors 2011). Israel's housing situation is identified by growth and development. An urgent need for affordable housing was amplified by the 2011 housing crisis. The building market is privatized with little-no gov't involvement, the result is a shortsighted building stock that often overlooks the individual long-term needs, in favor of the short-term financial benefits. Israel, unlike most European or Asian countries, has an average of three kids per family, requiring larger homes. Young families find it difficult to afford sufficient homes and are required to make many moves as the family grows. The majority of apartments are privately owned and there is no gov't housing or co-ops and organized management. There are however many laws and building codes to make sure buildings are designed according to the required standards.

2.2 TYPOLOGY - FORM AND STRUCTURE

The common typology for apartment buildings in Israel is H form with 4 facades to suit the warm weather and airflow requirement. The traditional construction method is based on concrete structural elements (floors, columns and beams) and elevator/stair core, façades and interior walls made of concrete blocks. A concrete bomb shelter for is required for each apartment making adaptability difficult to obtain. The infrastructure (pipes and wires) are commonly cast in the concrete and the concrete blocks. This causes an entanglement that is difficult to maintain and renovate, and as a result shortens the overall building's life span.

2.3 CONCEPT OF ADAPTABILITY AND THE DECISION-MAKING PROCESS

The theme (concept) developed for the AU building, based on our previous research, is an adaptable building that expands with the growing family. The support structure consists of a concrete frame with columns, an elevator/stair core and the completed floors extending to the buildings' edges. The concrete bomb shelters are centralized around the core for greater adaptability. Within this Base Building, a variety of units can be placed with varying size and configuration. The infill panels including the facades are removable and can be reassembled for gradual change over time. In this project involving the user in the decision-making process, is possible through carefully preplanned design options. There is a clear separation of the decision-making process between the planner/architect (acting for the investor,) and the users (who may also choose to acquire design and construction services).

2.4 TEST-FITTIN THE APARTMENT OPTIONS

The size of the building was determined according to the typical size for the construction method, a combination of concrete and blocks (taller buildings require more concrete). The building consists of 8 floors, four units per level, ranging from one level to a two-floor duplex. Using a methodology framed by Kendall (Kendall, 2006), the design process involved planning for varying family sizes and needs and test fitting the options in a "fixed" base building (or serviced shell). After test-fitting apartment plans, a basic 3-bedroom apartment and options of extensions to 4,5, and 6 room apartments was chosen. As a result, a modulation of the structure and panels was formed, followed by determining the placement of the infrastructure.

2.5 SYSTEM STRUCTURE AND INFILL DESIGN, METHODS OF CONSTRUCTION

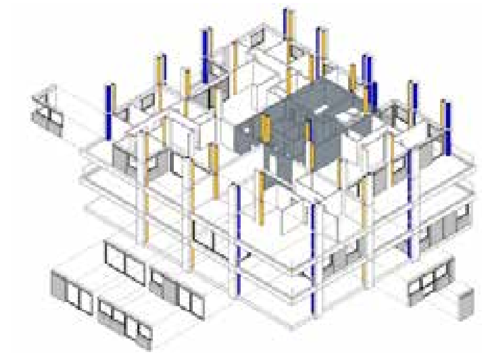
Part of simplifying the process involved choosing locally used materials and keeping down the costs. While a concrete structure was easily chosen for the support structure, with the intent to fit the market, the choice of infill required innovation. We focused on a façade design that can accommodate changeable dwelling unit sizes and layouts. The façade panels developed for this purpose in our previous research are made of steel frame panels and changeable finish surfaces (inside and outside). This Combined Method system was designed in collaboration with Mitek- light construction company. The panels are removable and reusable as a whole or in parts. When extending a floor area of a unit, these panels are removed and reassembled with weather-tight joint gaskets at the desired placement. Their siding and fenestration are then restructured according to the users wish. These panels can be topped with low cost stucco panels, which equivalents the price of the facades to a regular concrete block building.

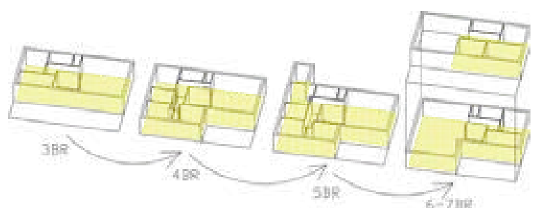
The utility infrastructure includes the mechanical, electrical and piping systems. The decision was to let the electrical and mechanical systems in the AU building run within the exterior steel panels and interior gypsum board walls. Placing the vertical piping adjacent to the columns every 6 m, running through pipe-sleeves in the cast-in-place concrete floors. The pipes are to be exposed for easy accessibility and replacement. As shown in figure 8, the yellow are sewage pipes placed throughout the building for varying connections to fixtures. In blue are the drainage pipes, draining roofs and terraces, of the open or closed terrace space.

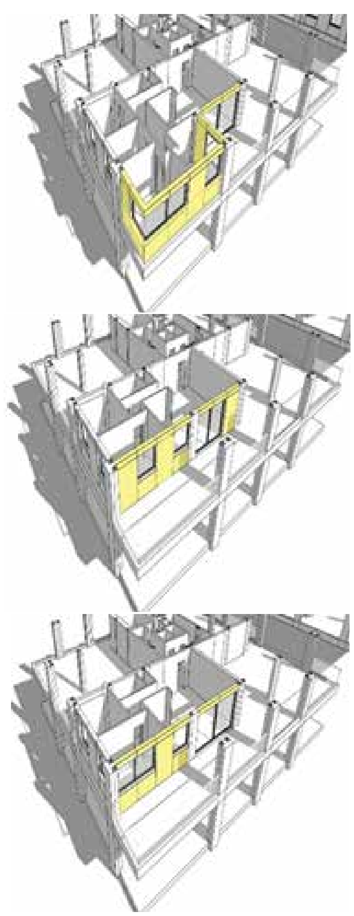
Figure 5: A growing and/retractable unit. Source: (Author 2017)

Figure 6: The different apartment types. Source: (Author 2017)

Figure 7: The user may choose from different façade panels options and reuse them to enlarge the unit. Source: (Author 2017)







2.6 APARTMENT OPTIONS AND INFILL CATALOGUE

In the AU building the investor and architect become the coordinators and "set the stage". They decide on the building scale and structural frame and preplan the apartment options and the installations belonging to each dwelling option. They also preplan the "library" of façade options, siding materials and fenestration options. When the building is marketed, the users purchase a complete floor area and an apartment type and size of choice. The apartment is than completed by the contractor. After the units are sold, the indoor - outdoor ratio and apartment size are changeable at any time along the buildings timeline. The additions can be self-made by the user, as long as they are part of the façade panel library.

2.7 THE CONTRIBUTION OF THE AU BUILDING

This project contributes by providing an additional approach to the separation of the support from the infill, it is an expandable solution that works within a specified floor area. Designed as an affordable building for the privatized ownership market. This prototype can adapt to varied contexts, it may function in many typologies as long as the separation of support and infill/façade panel is kept. The materials used may change depending on the local materials. The façade panels used in this example are aimed to keep the costs down and may change according to the climate to be more open or more enclosed. The façade panel system shown above may be used to replace other building methods such as cast in factory façade panels, giving a much better insulation solution. The building method may also be used as a base for do it yourself projects similar to the concept of the Half Built Houses by Alejandro Aravena for low cost housing. Another use for the infill system is in renovation projects where the exterior is torn down and needs to be replaced.

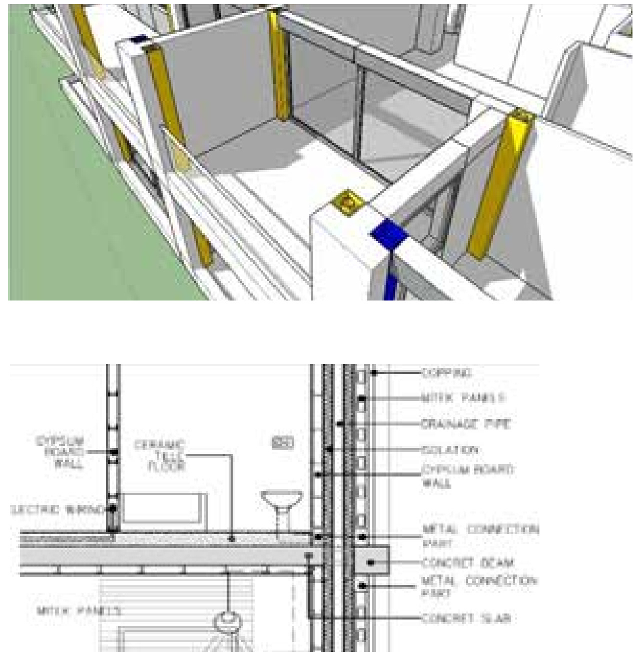


Figure 8: Infrastructure detail- Vertical piping run every 6 m. The horizontal pipes from the fixtures run in floor. Source: (Author 2016)

Figure 9: Façade panel library and apartment options. Source: (Author 2017)

3.0 REALIZATION ROUTES

3.1 LEARNING FROM PREVIOUS OB PROJECTS

Learning from the previous projects analyzed in this paper, leads us to form the realization diagram, shown in fig. 11. This diagram explains the options that are laid out for implementation and the different routes following each choice that is made. It shows the division of the decision-making process between the different parties. When designing an OB project, it is necessary to analyze the client profile and the budget of the project. Different budgets will obtain different types of adaptability depending on the choice of the infill and systems. The budget will determine if the solution will be raised floors, if the facades will be glass, wood, aluminum or stucco. It will also have an effect on the complexity of the support. If the user/ client is there at the initial stages of design as in the case with an organized group of buyers, the diversity can be determined in the early design stages. If the user gets involved at the last stages, as in the case of Israeli building market, the developer/architect will be designing for an unknown client, requiring changes only at the last stages of planning. In this case more options of design are required in a form of a library of plans, and a catalogue of changeable facades.

Figure 10: The AU Building image. Source: (Author 2017)

4.0 CONCLUSIONS

The OB residential building approach has many benefits. In the short term, it allows variety, answering the diverse users' needs and contributing to a rich and complex urban space. In the long term it provides adaptability, sustainability and long-term use, compared to that of conventional buildings. The OB approach simplifies the building process by making a separation of both building parts and the decision-making process.

When we look into the specific benefits for each of the parties involved, the authorities benefit from OB by being able to address long term environmental concerns, and by allowing for future function adaptability. This approach causes less disruption during renovations and potentially less administration because of the division of responsibilities.

Users may benefit by having more options available to them throughout the building's lifespan. This increases the possibility of staying in the same apartment longer, adapting it to changes as needed. The apartments are potentially easier to finance, providing more choice, more self-made solutions and user involvement.

The investor benefits from sharing the responsibilities, leaving the finishes to the user, reducing the risk and investment. They may also have an easier time selling apartments with a potential of fitting diverse users. The benefit of the architect is to think in a broad open manner, creating options and libraries of choice, rather than finished products. Or as Tom Frantzen says in the Patch 22 website1, "Not because that was what was required but because that is what ought to be done". Taking responsibility, being a stage setter, having concern for all parties considered, doing what is right.

In the process of doing the research, we tried to develop a clear step methodology. We found that it assists us in the development stages of the project. We intent to follow the next stages laid in this paper, to the realization of the AU building, writing about it as we go along. We hope that by analyzing the process, the research will assist in promoting future implementation of residential Open Building.

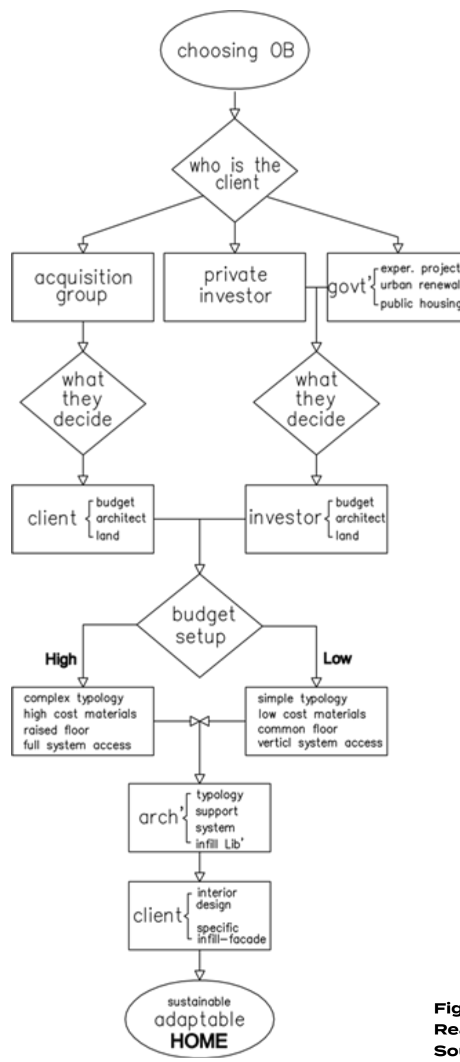


Figure 11: Realization diagram. Source: (Author 2018)

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Endnotes

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KEYWORDS

AGED APARTMENT
REMODELING
RENOVATION
NEW-TOWN

LESSONS FROM REMODELING AGED APARTMENT UNITS IN FIRST GENERATION NEW TOWNS AROUND SEOUL

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ABSTRACT

The aging of apartment units, which were quickly and massively supplied in the New Town Development of Seoul Metropolitan Area during the first half of 1990s, is becoming a major social issue. This research systematically surveyed a total of 328,944 aged apartment units built in this period, in order to (1) identify the best prototypical apartment unit plans representing the majority of the aged apartments, and (2) to suggest extension remodeling solutions for them. The survey was based on the detailed factors such as apartment complex composition, apartment block type and unit plans. Five representative types were identified which account for 49.8% of the surveyed units. The 5 representative types are distinct in terms of building types, number of bays, number of rooms, core types and unit area. The first type, accounting for 19% of all the units, has 60-85m² area, 2 bays and 3 bedrooms in a flat-type apartment block. The second type, accounting for 16.1%, is a unit with more than 85m², 3 bays and 4 bedrooms in a flat-type apartment. The remaining 3 types account for 14.7% of the total, and differ in terms of area, core type, and number of bedrooms. Two remodeling plans were developed. The suggested plans with an area increase of about 30-40% reflected the needs of residents by surveying changes in family structure and the preferences of current residents. It turned out that the load-bearing interior walls are the biggest problem. They limit the flexibility and adaptability of the unit plan, while they are very costly to remove or partially modified for the changes of unit plan. For the future apartment design, support and infill system would be a good alternative for the flexibility and adaptability of unit plan changes along with extensive remodeling.

1 STUDY BACKGROUND AND PURPOSE

In the early 1990s, South Korea developed first-generation new towns such as Bundang, Ilsan, Pyeongchon, Sanbon, and Jungdong to address the housing shortage in the Seoul metropolitan area. Over 5 years, a total of 292,000 apartment units were supplied. Those apartment units, which were built within a short period of time, are now 25 years old and require measures to restore their housing performance. Aged apartment units can be addressed either by reconstruction, where the existing buildings are dismantled and new ones are built, or by remodeling, where the spaces and utilities of the existing structures are repaired. Since 2014, the South Korean government has allowed vertical expansion in remodeling in order to encourage remodeling and discourage new construction. The latter requires dismantling costs as well as huge concrete wastes. Vertical expansion remodeling involves adding three floors to aged apartment buildings with 15 or more floors. The number of newly added apartment units is limited to 15% of the number of current apartment units, and the newly added units are available for general sale. This reduces the shared cost of existing residents and improves the business feasibility of remodeling.

The vertical expansion remodeling needs to be technically verified and demonstrated before its massive start across the nation, especially in terms of structural stability and economic and social feasibility. Accordingly, a research group called "Vertical Extension Remodeling Research for Aged Apartment" was established with the Korean Government R&D fund. Their goal is to develop technologies required for design, structure, and business and to apply the technologies to actual housing complexes. Among their efforts, a three-floor vertical expansion remodeling technology is being developed that would save 15% of the construction cost and deliver over 90% residential satisfaction compared to new construction.

The aim of the present study was to derive remodeling floor plan designs that can be applied to more than 50% of aged apartment units in the first-generation new towns, which represent the majority of apartment units older than 15 years and are now in need of remodeling. This paper first presents the derivation of the representative apartment types supplied by the first-generation new towns. Remodeling criteria for the derived representative types are presented, and corresponding remodeling alternatives are proposed. Lessons learned during the research process are also presented for designing flexible and adaptive residential buildings in the future.

2.0 DERIVATION OF REPRESENTATIVE APARTMENT TYPES IN FIRST- GENERATION NEW TOWNS

2.1 ANALYSIS SCOPE AND METHOD

The first-generation new towns refer to five cities developed in the early 1990s to address the housing shortage problem in the Seoul metropolitan area. As presented in Table 1, these towns have a total of 328,907 apartment units in 4,529 buildings in 670 complexes. The units have similar floor plans because they were supplied in large quantities within a short period of time. The representative apartment types of the first-generation new towns were extracted through a complete enumeration survey, and the floor plan characteristics were identified.

The representative types were derived based on apartment complexes, buildings, and units in accordance with previous studies. With regard to apartment complexes, the supply type and parking lot were considered. Because the residential environments of apartment units and complexes have different architectural characteristics depending on the suppliers, the supply type was classified as public or private. The parking lot was selected as an analysis parameter because existing complexes subject to remodeling require the creation or extension of underground parking lots, and parking lots are becoming a major remodeling issue (Choi, Lee, and Park, 2006).

With regard to the apartment buildings, the building type, circulation type, and number of floors were considered. The building type, either flat or tower type, significantly affects the floor extension of the remodeling unit and the construction scale. As shown in Figure 1, the circulation type can be classified mainly as corridor or stair type. Many older small- and medium-sized apartments have corridors, which causes problems with privacy and natural lighting. In addition, many changes to the stair type have recently been made. The number of floors is closely associated with the possible number of floors for vertical expansion remodeling. Three floors can be added to buildings with 15 or more floors, but two floors can be added to buildings with 14 or fewer floors.

With regard to the apartment units, the unit area, number of bedrooms, and number of bays were considered. The unit area was classified as <50 m2, 50–60 m2, 60–85 m2, and >85 m2. These ranges were chosen because a unit area of 59 m2 is the most common, and 85 m2 is the national housing standard (Kim & Yoon, 2010). The number of bays is a particularly important remodeling element in terms of horizontal extension and room configuration. Effective remodeling floor plans need to consider existing bay structures since loadbearing walls cannot be demolished. The number of rooms was selected as an analysis parameter because it is closely related to changes in household composition.

Table 2 presents the parameters adopted for the complete enumeration survey and the classification standards of each parameter. Figure 2 shows how the characteristics of each unit were typified according to the classification standards. All units were classified based on the seven planning elements except for the numbers of floors. For example, a unit supplied by the private sector in a tower-type building with corridor-type circulation, area between 50 and 60 m2, three bedrooms, two bays, and a surface parking lot can be coded as S2T2C1A2R3B2P2. All units were coded, which resulted in 271 types. The most common types that represented 50% or more of all units were derived.

Table 1: State of first-generation new town apartments older than 15 years. Source: (Author 2016)

New Town	Apartments older than 15 years		
	Apartment complexes	Apartment buildings	Units
Bundang	127	1,332	88,964
Ilsan	134	1,026	72,998
Pyeongcheon	190	958	74,385
Jungdong	97	509	38,402
Sanbon	122	704	54,128
Total	670	4,529	328,907

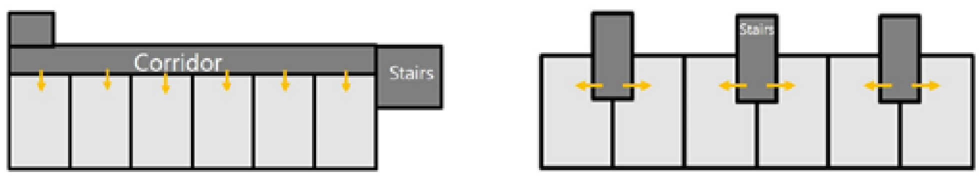

Figure 1: (a) corridor type and (b) stair type. Source: (Author 2006)

Table 2: Selection of the analytical framework. Source: (Author 2016)

Spatial Hierarchy	Classification Criteria	Characteristics
Complex	Supply type	Public, Private
	Parking	Underground, Surface, Mixed
Building	Building type	Flat, Tower, Mixed
	Circulation type	Corridor, Stairs, Mixed
	Floors	<14, >=15
	Pilotis	Present, Absent
Units	Unit area	<50 m^2, 50–60 m^2, 60–85 m^2, >85 m^2
	Number of bedrooms	1, 2, 3, >4
	Number of bays	1, 2, >3

2.2 ANALYSIS RESULTS

The detailed characteristics of the aged apartment units in the first-generation new towns revealed that 93% of the buildings were the flat-type. With regard to the circulation type, 76% of the units had stairs, and 23% had corridors. The typical unit area was between 60 and 85 m2, and the typical number of bedrooms was three. With regard to bays, 53.4% had two bays, and 23.4% had three bays. Figure 3 shows the floor plans for the five most common unit types, which represented 49.8% of the aged apartment units in the first-generation new towns. They were supplied by the private sector in flat-type buildings with underground and surface parking lots.

Table 3 lists the characteristics of the representative types. The first representative type accounted for 19.0% (62,564) of the units. These units were in flat-type buildings with stairs, an exclusive area of 60–85 m2, two bays, and three bedrooms (Code S2T1C2A3R3B2P3). The second representative type accounted for 16.1%. These units were in flat-type buildings with stairs, an unit area exceeding 85 m2, three bays, and four bedrooms. The third representative type accounted for 5.4%. These units were in flat-type buildings with stairs, an exclusive area between 60 and 85 m2, three bays, and three bedrooms. The fourth representative type accounted for 4.8%. These units were in flat-type buildings with corridors, an exclusive area between 50 and 60 m2, two bays, and two bedrooms. The fifth representative type accounted for 4.5%. These units were in flat-type buildings with stairs, an exclusive area between 60 and 85 m2, two bays, and three bedrooms. Among the top five types, four had stairs, and one had corridors. Three types had two bays, and two types had three bays. The unit area and number of rooms varied depending on the types.

3.0 PROPOSED EXPANSION REMODELING PROTOTYPES

This section suggests the major criteria for deriving remodeling prototypes and proposes the remodeling plans for the two-bay and three-bay prototypes.

3.1 MAJOR REMODELING CRITERIA

As presented in Table 4, the major remodeling criteria can be largely divided into structural, plan, and other criteria. The structural criterion is to minimize the demolition of loadbearing walls. This can reduce the cost of structural reinforcement while promoting structural stability. In addition, it considers economic efficiency and the environment by reducing the construction period and waste.

The plan criteria are to apply stair-type circulation and to secure storage spaces and ancillary rooms. One of the largest problems with aged apartment units is infringement on the privacy of each unit and the lack of natural lighting in the rear rooms because of corridor-type planning. To address these problems, stair-type circulation must be applied. In addition, aged apartment units lack storage spaces and ancillary rooms, such as bathroom and dress room within master bedroom, and pantry, compared to the latest apartment units.

The survey results on preferences of the residents living in the representative type apartments were also considered in proposing prototype remodeling unit plans. Also, some alternatives, especially with regard to the extended floor area, were made in order to meet various resident needs and preferences.

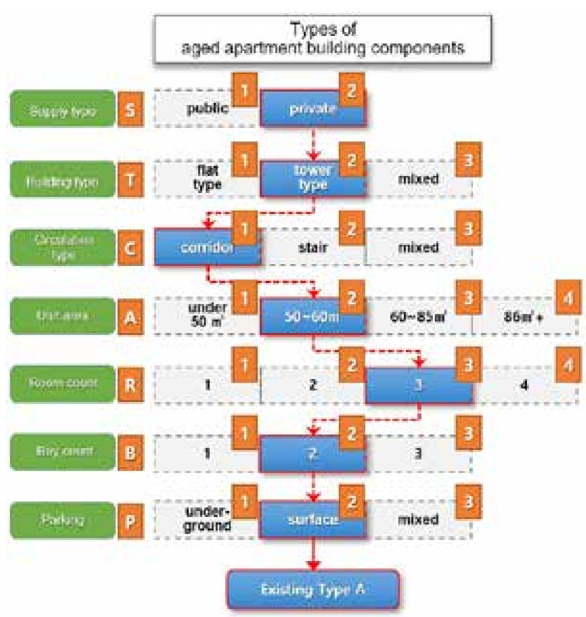

Figure 2: Classification of aged apartment building types. Source: (Author 2016)

Table 3: Representative apartment types of the first-generation new towns. Source: (Author 2016)

Rank	Code							Unit (#)	Ratio (%)
1	S2T1C2A3R3B2P3	Private ·	Flat type ·	Stairs ·	60–85 m2 ·	3 BRs ·	2 bays	62,564	19.0
2	S2T1C2A4R4B3P3	Private ·	Flat type ·	Stairs ·	>85 m2 ·	4 BRs ·	3 bays	53,025	16.1
3	S2T1C2A3R3B3P3	Private ·	Flat type ·	Stairs ·	60–85 m2 ·	3 BRs ·	3 bays	17,778	5.4
4	S2T1C1A2R2B2P3	Private ·	Flat type ·	Corridor ·	50–60 m2 ·	2 BRs ·	2 bays	15,660	4.8
5	S2T1C2A2R3B2P3	Private ·	Flat type ·	Stairs ·	60–85 m2 ·	3 BRs ·	2 bays	14,926	4.5
Etc.	Others							164,991	50.2

Table 2: Selection of the analytical framework. Source: (Author 2016)

Table 4: Major criteria for remodeling

Category	Parameter	Criteria
Structure	Loadbearing walls	1. Minimize loadbearing wall demolition
Plan	Circulation (core)	2. Apply the stair-type core
	Interior layout	3. Secure storage space and ancillary rooms
Others	Survey on resident preferences	4. Reflect the survey results on resident preferences for the representative types

The two-bay floor plan has a unit area of 58 m2 and three bedrooms. Its most distinct characteristic is the corridor-type core. This corridor offers poor privacy to units compared to stairs and insufficient natural lighting to the rear rooms. In addition, there is only one bathroom. Now it is a norm to provide two bathrooms even in the smallest apartment units, and an extra bathroom should be provided. There are three bedrooms. The two options are available. Each of the three bedrooms can be bigger after remodeling, or there can be a fourth bedroom. The first option is selected considering the demands of the current residents and the household structure. With regard to the structural characteristics, most of the walls are loadbearing. Not only the wall between units but also the wall between the living room and master bedroom are loadbearing. The wall between the kitchen and small bedroom is also loadbearing. Because the walls around the bathroom are not loadbearing, they should be used to improve the floor plan.

The three-bay floor plan has a unit area of 129 m2, a stair-type core, and four bedrooms. The front section has the bedroom–living room–bedroom configuration, while the rear section has the bedroom–kitchen (dining area)–bedroom configuration. It offers a larger space and more comfort than the two-bay floor plan, but its ancillary spaces (e.g., the dressing room, utility room, and pantry) and the storage space are insufficient compared to newly built floor plans with the same unit area. In addition, because the shared bathroom is adjacent to the kitchen, the overall space layout is degraded. The unit should be remodeled so that the shared bathroom is moved to a more proper position and additional ancillary spaces are created. The structural characteristics indicated that most of the walls in the top–down direction are loadbearing, while those in the left–right direction are not. Because most of the walls of the bathrooms and utility room are not loadbearing, the internal floor plan can be improved through remodeling. In addition, because the wing walls are not loadbearing except for the kitchen section, the floor plan can easily be extended to the front and rear. Some spaces have the column structure. The remodeling needs to reflect all these characteristics.

3.3. PROPOSED REMODELING PLANS

The government regulates that, through remodeling, floor plans with an area of less than 85 m2 can be expanded 40%, and floor plans exceeding an area of 85 m2 can be expanded 30%. Figure 5 shows the proposed plans based on the most commonly applied vertical expansion remodeling. In this case, half of the expandable area was allocated to existing units, and the other half was allocated to the vertically added units.

For the two-bay type remodeling plan, staircases are installed instead of the corridor-type core. This secures natural lighting in the rear section and the privacy of the residents. In addition, a shared bathroom, ancillary space in the master bedroom (dress room), and storage space are added to increase resident satisfaction. The living room and kitchen are enlarged to reflect the resident preferences for large shared spaces. Because of the extensions to the front and rear, the middle has dead space. Ancillary spaces that do not require natural lighting (e.g. the shared bathroom, master bathroom, storage space, and dress room) and facility spaces (e.g., pipe ducts (PD)) are placed in the middle. Alternative 1 maintains the existing loadbearing walls and installs the core in the rear section to minimize the demolition of loadbearing walls. Alternative 2 reduces the core width and increases the natural lighting performance by adjusting the direction of stairs, but it requires demolishing more loadbearing walls

The three-bay type remodeling plans focus on minimizing the demolition of loadbearing walls and securing ancillary spaces such as the dressing room, pantry, and utility room. The plans try to secure proper room areas and balanced balconies. Alternative 1 secures large areas for the living room and kitchen while maintaining the existing floor plan. The living room, kitchen, and dining area are integrated by moving the bathroom toward the main entrance. Alternative 2 moves the kitchen and dining area to the front section. This integrates the living room, kitchen, and dining area to facilitate natural communication between family members. PD is installed at three positions in alternative 1 and at two positions in alternative 2. Alternative 2 is more effective in terms of PD planning.

Figure 4: Representative floor plans: (a) two bays (58.14 m2; M complex in Bundang) and (b) three bays (129.56 m2; H complex in Bundang). Source: (Author 2018)

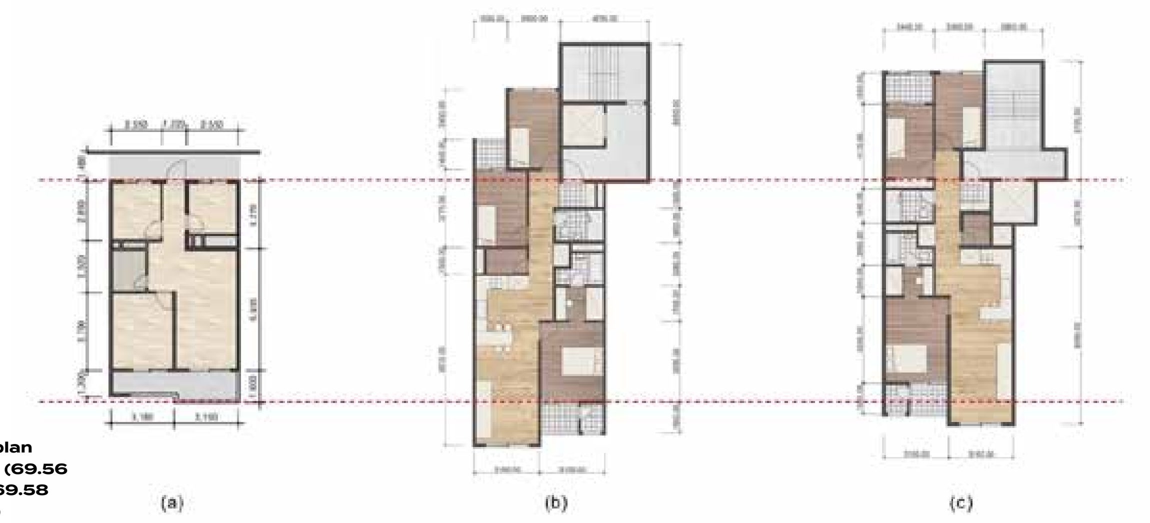

Figure 5: (a) Existing floor plan (58.14 m2), (b) alternative 1 (69.56 m2), and (c) alternative 2 (69.58 m2). Source: (Author 2018)

Figure 6: (a) Existing (129.56 m2), (b) alter (148.99 m2), and (c) (148.99 m2

4.0 CONCLUSION: LESSONS LEARNED FOR FLEXIBLE AND ADAPTABLE RESIDENTIAL BUILDING SYSTEM

4.1 LIMITATIONS IN THE REMODELING OF APARTMENT UNITS WITH LOADBEARING WALLS

Because aged apartment units are mostly composed of loadbearing walls, flexible floor plans and facility plans for remodeling are difficult. Because loadbearing walls are installed between units, the floor plan has to be improved within a limited scope, as shown in Figure 7. In this study, only the front and rear sections were extended, which made the inside of each unit deeper. There were huge reductions in natural lighting and ventilation, and many loadbearing walls inevitably had to be demolished. For flexible floor plan changes, it is sometimes necessary to install doors in loadbearing walls. For this reason, the structural engineering team of the fore-mentioned research group is currently developing technologies for the partial demolition and reinforcement of loadbearing walls. Figure 8 graphically describes the technologies involved in this.

Most apartment buildings in South Korea have loadbearing walls. The reason was that the building regulations related to the distance between apartment building, natural lighting, and right to enjoy sunshine limits the building height substantially. Although the Rahmen(or rigid frame) structure has benefits in terms of variability and flexibility, its application was excluded because of the high floor heights associated with the beam/girder depth, as shown in Figure 9. For newly built apartment units, the Rahmen structure should be applied because of its better variability and flexibility compared to loadbearing wall structures. It should also be encouraged through the relaxation of regulations on volume and height limits or through another forms of incentives.

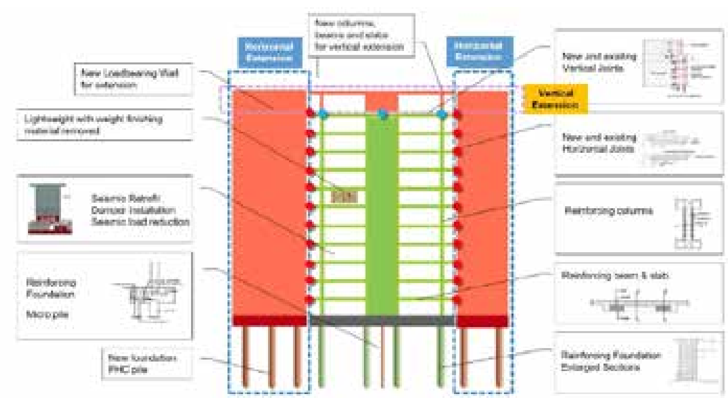

Figure 7: Dead space caused by the inability to demolish loadbearing walls. Source: (Oh, S 2006)

Figure 8: Structure concept diagram for extension remodeling. Source: (Author 2018)

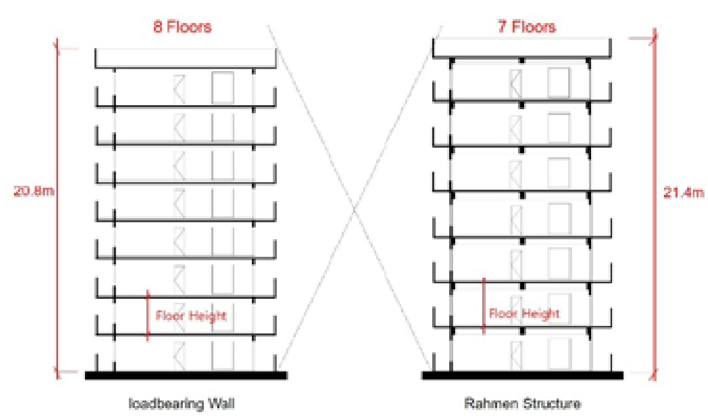

Figure 9: Comparison between the loadbearing wall and Rahmen (slab/beam) structures.Source: (Author, 2018)

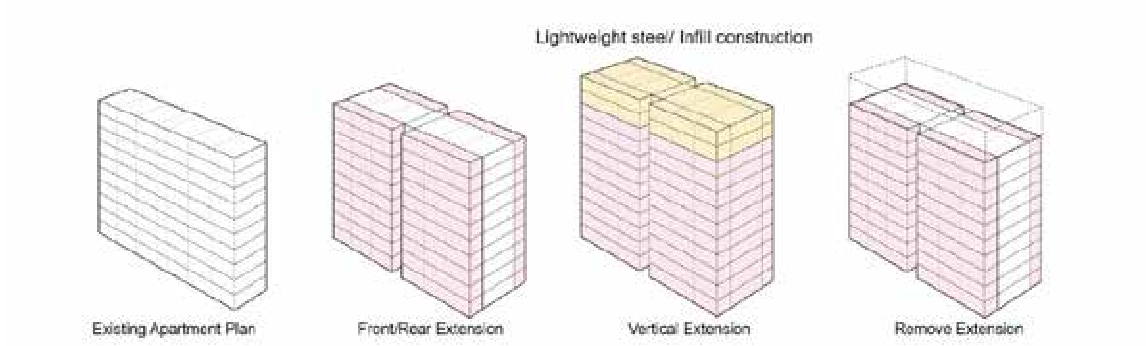

Figure 10: Lightweight steel construction. Source: (Author 2018)

Figure 11: Remodeling for small-sized apartments. Source: (Author 2018)

4.2. PROPOSAL FOR SECTIONS OF VERTICAL EXPANSION: APPLICATION OF LIGHTWEIGHT STEEL STRUCTURES AND INFILL STRUCTURES

A response to the population decline and changes in the housing market is necessary. As shown in Figure 10, lightweight steel structures and infill structures can be applied to newly constructed sections in vertical expansion remodeling. Although three new floors can currently be added vertically, there may be no demand for expansion sections in 20–30 years because of population decline and changes in residential environments. It is necessary to predict such changes and plan with lightweight steel structures and infill structures that can easily be constructed and demolished, such as that shown in Figure 10. In addition, PD links with lower units are essential because additional facility floors are required if the PD plan of the vertically expanded section does not match the PD plan of the existing units.

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DESIGN AND CONSTRUCTION PLAN FOR THE PRACTICAL USE OF INFILL IN LONG-LIFE HOUSING

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ABSTRACT

While the percentage of apartments among the housing units in South Korea soared from 37.5% in 1995 to 59.9% (9.8 million apartments) in 2015, the service life of the apartments in South Korea is considerably shorter than that in advanced countries like Europe or USA. As such, there has been a need for long-life-housing to secure a sufficient number of high-quality housing units and to save resources and energy and to increase each individual's property value and to reduce the housing maintenance costs from the national level.

Accordingly, “Development of the Technology for Long-Life Housing with Durability and Variability” was carried out as a national research project from 2005 to 2010, and the long-life housing certification system was enacted with the amendment to the Housing Act in December 2014.

However, when we looked at 220 certifications, they were all in the ‘general’ category. It is only passive application. One of the major reasons for this negative certification level was the rise in construction costs.

The purpose of this study is to propose a cost - saving design and construction plan for Infill as a way to build long-life housing at the basic construction cost level of existing apartments. We will refer to the way in which ceilings and floors are first installed on each floor and the dry panel walls are later constructed (one-shot construction). We also derived a rough cost savings. It is my first attempt in Korea.

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KEYWORDS

OPEN BUILDING

LCC

KEY PERFORMANCE INDICATORS

WHOLE-LIFE PERFORMANCE

USER REQUIREMENTS FOR USABILITY VERSUS BUILDING PERFORMANCE AND IMPACT ON COSTS

Methods and Tools for Defining Usability Quality, Actual Building Performance and Costs Using the Open Building Approach

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ABSTRACT

This paper describes a research project about lessons from 12 years user-centered (CfPB) research into requested 'functional qualities' for governmental working environments. These qualities are structured following the new Dutch NEN 8021 and the EN 15221. It also includes a calculation model with which economic consequences of choices in quality levels can be weighed.

The paper describes a 5-step approach for the evaluation of existing office buildings and defining strategies for improvement. Both for the quality of the work environment and usability of the facility.

The theory of the Open Building approach has been used to relate the different building parts (with different life times for primary, secondary and tertiary systems) to corresponding building parts to be renovated. A classification scheme for 10 levels of renovation has been developed.

The research team defined a series of 114 'functional qualities' for usability structured according the subjects defined in NEN 8021. Comparing the requested functional quality levels with the corresponding properties and performance of an existing building gives the gap between demand and supply.

A method has been developed to translate this gap to cost consequences both for investments as for exploitation costs.

The paper concludes with an evaluation of the process and product innovations used in this research project and makes recommendations for improving decision-making for adapting the existing building stock to provide a better working environment and usability of office facilities.

1 FUNCTIONAL QUALITIES FOR BUILDINGS

1.1 BACKGROUND

In the past, several attempts have been made to describe the quality requirements for real estate in order to compare a housing need / demand with the available supply. A new standard, NEN 8021: 2014 nl, published on 01-02-2014, describes the qualities of buildings in an unambiguous way. More than 20 parties from the real estate world, including the Government Buildings Agency, have in the past period been busy drawing up this new standard on the basis of which the use value of buildings can be determined in an objective and transparent manner. This new standard NEN 8021 will remain an important starting point in the quality and cost aspects of the next chapters.

On the website of NEN the following is written about the new NEN 8021: "With the introduction of the NEN 8021, comparing buildings is made easier, more transparent and, above all, more objective. This contributes to better choices and clear accountability".

NEN 8021 gives more transparency. With the NEN 8021, utility buildings can be really objectively assessed on different performance criteria. This makes it possible to assess different objects uniformly on the basis of the same verifiable performance.

The required quality can be set on a level 1 to 5. The accessed quality of an existing building could be defined also between 1 to 5. The way the cap between demand and supply was the big challenge to solve in the FWR Cost-Quality Model.

2 EXPLAINING THE FWR MODEL FOR COSTS AND QUALITIES

2.1 BACKGROUND AND INTRODUCTION

2.1.1 EXPLAINING FWR

FWR stands for the "Fysieke Werkomgeving Rijk", (Physical working environment for governmental offices)

The FWR model for Costs and Qualities is part of the studies for an integrated strategy for the transformation of governmental office buildings to efficient and attractive work environments for users. After setting the norms for quantities for office lay-outs, the FWR committee has been defined 144 functional qualities for an efficient and attractive environment for office workers.

2.1.2 RELATIONSHIP BETWEEN QUALITY REQUIREMENTS AND COSTS

A direct relationship between quality requirements and costs cannot be made. There will always have to be relations between quality requirements, the resources needed to achieve these qualities and the costs involved with those resources. For that reason, we are working with new construction reference data. This reference data can be derived from a theoretical building model such as the PARAP model, but also an existing building, of which sufficient data is available, can be used as a reference model.

Interventions in existing buildings are, as much as possible, related to the theoretical reference building. In this way, the relative costs of the proposed interventions can also be compared with the costs of analogue new construction elements, using the levels of Open Building, and building-related operating costs. The FWR Quality and Cost model combines renovation and operating costs and makes it possible to draw up business cases based on Total Cost of Ownership.

2.1.3 STATUS OF THE FWR COST-QUALITY MODEL

The model has been demonstrated several times in the prototype phase and discussed with experts. The essence of the cost model is to intervene in the existing stock of governmental buildings, which have to accommodate for the new way of organization-oriented and time and place independent work. This assessment involves the following 5 steps.

1. The search for a suitable new-build reference to compare building interventions
2. The assessment of a logical procedure to compare the existing building with minimal technical requirements. This has a strong relationship with partial depreciation of building parts and the age of the building. Choosing the technical level of renovation (see 2.3.3)
3. To compare the desired functional quality of the building with the accessed quality of the existing building. The new standard NEN 8021 and EN 15221 have been used for this assessment
4. Comparing the list of basic qualities drawn up by the FWR, which have a direct relationship with the FWR objectives and with the previous qualities according to step 3
5. Combining the data and showing the calculation results In addition, it was considered to what extent the method could be made suitable for the assessment of the whole "strategic stock of governmental office buildings".

Responsible use of this model can only be practiced by persons with a reasonable cost expertise.

2.2 COMPONENTS OF THE FWR CALCULATION MODEL QUALITY AND COSTS

The calculation model consists of several parts:

1. Input modules
   - a Model NEN 8021 (as a separate model)
   - b Functional qualities NEN 8021
   - c Functional qualities EN 15221
   - d Intervention levels for renovations
2. Scenario data for control
   - a Choice of intervention strategies
   - b Choice of priorities
3. Data data
   - a Data reference project (investments and operating costs)
   - b Data NEN 8021 (Resumé from separate model NEN 8021)
   - c Data List with FWR functional qualities
   - d Data Renovation interventions in 10 classes
4. Calculation models
   - a Calculation model NEN 8021 (separate workbook
   - b Calculation model Investments for functional qualities according to NEN 8021
   - c Calculation model Investments for functional qualities according to EN 15221
   - d Calculation model Renovation interventions and investment costs
   - e Calculation model exploitation costs for functional qualities according to NEN 8021
   - f Calculation model exploitation costs for functional qualities according to EN 15221
5. Output
   - a Investment results
   - b Results exploitation
   - c Graphs

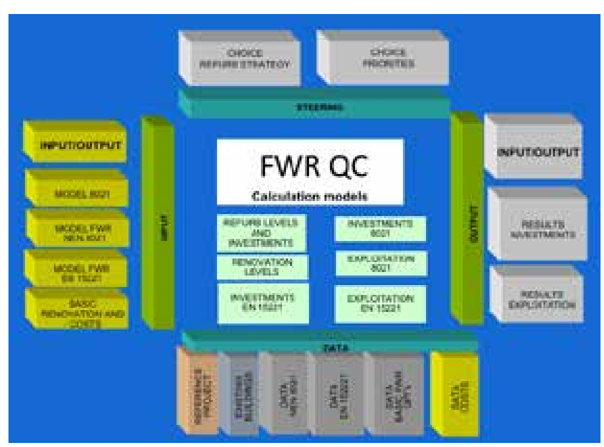


Figure 1: Clickable menu of the FWR Cost-Quality model

2.2.1
APPLICATION OF NEN 8021

The NEN 8021 helps to visualize the choices for desired qualities versus the offered qualities of a building. The offered quality aspects can be assessed on the basis of the existing condition of a building. Both the required demand score and the supply score for the assessment of an existing building are indicated. The user further indicates the importance of the relevant quality requirement. In next sections the results from this assessment can be used to perform the calculation rules in the model. For NEN 8021 accessing is also a web app for the iPad available.

2.2.2
CLASSIFICATION IN LEVELS AND OPEN BUILDING

Specifying the relationships between the individual quality requirements with parts of the building that needs to be adjusted requires a further classification of these building components. These are divided into different levels according to the principles of "Open Building". In the FWR report "Flexibility of the internal physical environment" this distinction in levels is explained in greater detail (Albers, Dekker et al., 2011).

This distinction in levels makes it possible to make a clear link to the lifespan of the various building parts and therefore also to the depreciation periods.

1 Destination level
2 Tissue level - urban tissue
3 Primary systems - basic building without layout
4 Primary systems, subdivision - vertical and horizontal distribution
5 Secondary systems - all structural and installation parts for the fit-out
6 Tertiary systems, interior and equipment for usability of the office

This classification has been used in the calculation model to divide the costs of the reference in such a way that they are comparable to the renovations and the influences of the different functional quality requirements.

2.2.3
CLASSIFICATION IN 10 RENOVATION CLASSES

To be able to say something about the nature and investment costs of building interventions, a classification has been made in 10 basic renovation classes from very light to complete demolition and new construction. This Quick Scan Renovation has recently built into the PARAP model in order to be able to calculate reference renovation consequences. This method is also used as an integral part of the concept "FWR calculation model" Quality - Costs discussed in this paper. The basic renovations are divided into ten standardized renovation classes from very light to very far-reaching. The relative costs of these standardized intervention levels have been calculated in relation to a corresponding new reference building (Dekker, Gerritse, & Pullen, 2006). For the purpose of use in situations where the standard intervention levels are not tailored, for the building campus case, three free entry options have been added (11, 12 and 13).

	Standardized renovation profiles	Support incl. installations for base building				Parcellation		Infill		Tertiary system	
0	No renovation strategy	Fund. & Casco	Schil	Opwekking	Prim. Distr.	stijgpunten	Vert. transp.	Bouwk.	Installaties	ICT	Interieur
1	Very small change of infill						0%	30%	10%	30%	30%
2	Adaptation 80% infill						20%	60%	60%	60%	60%
3	Adaptation 100% infill + 50% elevators						50%	100%	100%	100%	100%
4	Adaptation 100% infill + installations			100%	100%		100%	100%	100%	100%	100%
5	100% infill + installations + 75% envelope		75%	100%	100%		100%	100%	100%	100%	100%
6	10% skeleton + 75% envelope + all other elements	10%	75%	100%	100%	100%	100%	100%	100%	100%	100%
7	20% skeleton + 100% envelope + alle other elements	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%
8	60% skeleton + alle other elements	60%	100%	100%	100%	100%	100%	100%	100%	100%	100%
9	New building upon existing foundation	80%	100%	100%	100%	100%	100%	100%	100%	100%	100%
10	Total demolishment and new building	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
11	RVB Strategy 1 (short term)	0%	0%	0%	0%	0%	5%	50%	30%	30%	50%
12	RVB Strategy 2 medium term)	0%	20%	20%	10%	5%	15%	50%	30%	100%	100%
13	RVB Strategy 3 (long term)	0%	70%	80%	80%	50%	50%	100%	100%	100%	100%

Figure 1: Clickable menu of the FWR Cost-Quality model

2.2.4
INFLUENCE ON THE INVESTMENT COSTS PER QUALITY ASPECT

Determining the impact per quality aspect on the renovation costs of the perceived quality difference between supply and demand according to NEN 8021 is a first task. The functional quality requirements described earlier are provided with a valuation in relation to the NEN 8021 and, moreover, a priority setting. The rating of the requirement runs analogously to the NEN 8021 from 1 to 5. The prioritization is indicated from 1 to 3

1 = of limited importance
2 = of interest
3 = of great importance

In the above table 2 of the calculation model we also see how the data from the application of the NEN 8021 model and the list with the FWR functional quality requirements are included. This shows the gap between the demand side and the supply side to be determined. (In this case 2). The chosen priority in model NEN 8021 and in the list with the FWR functional quality requirements is also included here (in this case 3). Moreover, this priority can be easily adjusted in the calculation model.

Of each quality aspect, the experts first determine the relationship between the quality aspect and the building parts on which this affects. In the example below in table 3 the KPI flexibility.

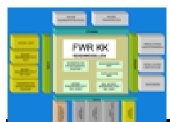
Data in table subtracted from model NEN 8021 and from FWR quality lists											
QPI	code	Requirement 8021	FWR list	calc value	performance after basic renovation	gap	priority 8021	priority FWR	adapt ?	calc value
Flexibiliteit	4.1.1	3	5	5	3	2	3	3		3
Flexibiliteit	4.2.1	5		5	3	2	2			2

Table 2, Data extracted out of the cost quality model showing the cap between demand and supply

In table 3 a relevant relationship between lay-out flexibility (4.1.1) with the infill (secondary systems) and the infill-installations can be seen.

A next step is to determine the impact of this aspect on investment in a renovation case. In this example again, the KPI flexibility. (See table 4)

Results assesment NEN 8021 + FWR quality and consequences for investments



which lists are relevant?		Impact of quality at building parts											
from model NEN 8021 and from FWR quality lists		Environ ment		Support & prim. Installations				Parce-lations		Infill		ICT	furni ture
QPI	code	Environment	Urba fabric	Base structure	Envelope	Ressorces iHVAC & Electra	Primary isribution	Staircases etc	elevators and core's	Construction	Installations	ICT	Furniture & equipment
Flexibiliteit	4.1.1									1,0	1,0		
Flexibiliteit	4.2.1			0,5	1,0			0,5					

Table 3, Relations between the KPI flexibility and the relevant building parts.

In table 4 the maximum impact of the KPI for extra flexibility on the costs of these building parts is estimated by experts at 10%. Further in this example the highest requirement is set on number 5). The existing building offers a rating of '3' in this case. The difference between the demand and the supply now becomes 2. The relative cost influence in this case is calculated at 2/4 x 10% is 5.0% of the costs of the relevant components. The reference investment costs for these components are 23% + 17% = 40%. The cost influence in this case is 5% of 40% is 2%.

QPI	code	requirements	existing quality	gap	priority			A Capital Costs (appiciation) (incl. replacement.reserve)	B Tax etc	C Insurance	D Mainten ance	E Adaptations	F Use of energy and water	G Con trol + renters maintenace	H Interest		max. impact on: capital and maintenance costs	max impact on: other operation costs
Flexibility	4.1.1	5	3	2	3			+0,55%	+0,04%	+0,02%	+0,10%	-1,50%			+0,88%		4,07%	30%
Flexibility	4.2.1	5	3	2	2			+0,26%	+0,02%	+0,01%	+0,05%	-1,50%			+0,42%		1,95%	30%

Table 4, impact of the KPI for extra flexibility on the costs

2.2.5
INFLUENCE ON THE OPERATING COSTS PER QUALITY ASPECT

An analogous method has been established for the relationship between the quality requirements and the operating costs. A reference is also required for operating costs to enable comparisons. Data from the PARAP model can be used here but for the reference in this case the data from the Bouwcampus in Delft has been used. These reference costs have been used to compare the impacts of the quality requirements. The operating costs are classified according to NEN 2699 (New standard for investments and exploitation costs).

Of each quality aspect, the experts first determine the relationship between the quality aspects and the operating components to which this affects. In this example again, the KPI flexibility. In the example below (see table 5) there is a relevant relationship with costs of future transformations. In this screen dump of the calculation model we also see how the data from the application of the NEN 8021 model and the data from the list with the FWR functional quality requirements have been taken over. As a result, the cost effects can be determined in a subsequent step.

QPI	code	requirements	existing quality	gap	priority		A Capital Costs (appiciation) (incl. replacement reserve)	B Tax etc	C Insurance	D Maintenance	E Adaptations	F Use of energy and water	G Control + renters maintenace	H Interest		A Consumtions (not in this code)	B Risc management (not in this code)	C Cleaning costs	D Moving costs (not in this code)	E Document management (not in this code)	F Waste management (not in this code)	G Several services for owner and renter	ICT (separate column)	External facilities	Facility Management		1 Profits landuse	2 Profits building project	3 Profits operating costs
Flexibiliteit	4.1.1	5	3	2	3		1	1	1	1	-2,0			1														1	1
Flexibiliteit	4.2.1	5	3	2	2		1	1	1	1	-2,0			1														1	1

A next step is to determine the impact of this aspect on the operating costs after a renovation. In this example again, the KPI flexibility. In the table below, the maximum impact of this KPI for additional flexibility on the costs of these exploitation items is split into two parts.

1 The impact on fixed costs for housing, which depend on the corresponding investments.

2 The impact on the other operating costs. In this case estimated at 30%. The calculations are analogous to the relative investments.

In table 6 is the screen dump of the relevant part of the cost model. In this case, the costs of future transformations in the building are lower, due to the chosen flexibility level.

Table 6, Relations between the KPI flexibility and the relevant operation costs

QPI	code	requirements	existing quality	gap	priority			A Capital Costs (appiciation) (incl. replacement reserve)	B Tax etc	C Insurance	D Maintenance	E Adaptations	F Use of energy and water	G Control + renters maintenace	H Interest		max. impact on: capital and maintenance costs	max impact on: other operation costs
Flexibility	4.1.1	5	3	2	3			+0,55%	+0,04%	+0,02%	+0,10%	-1,50%			+0,88%		4,07%	30%
Flexibility	4.2.1	5	3	2	2			+0,26%	+0,02%	+0,01%	+0,05%	-1,50%			+0,42%		1,95%	30%

2.3
TOTAL OVERVIEW CALCULATION OF RENOVATION COSTS

In figure 2, the input-output screen gives an overview of all calculations. The input for an easy use of the model is restricted to only 4 items. The influence on the total renovation costs is related to the next 4 choices:

1. Choosing the building (in this case The Bouwcampus)
2. Define the technical level of renovation (1-12), (in this case level 2)
3. Choice of the priority level (1-3)
4. Defining the use of the functional quality lists

The results of these 4 choices is given in the overview for investments and the impact on different Key Performance Indicators.

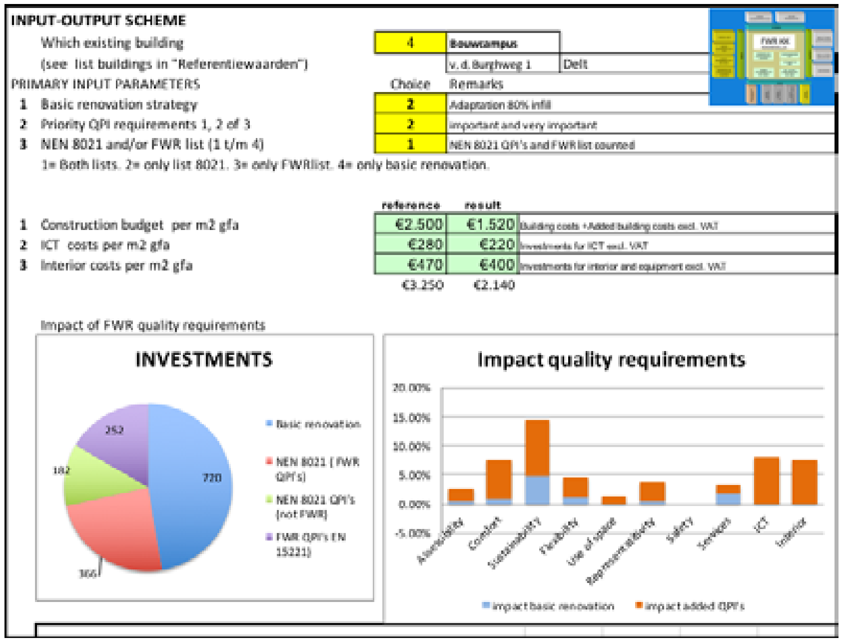


Figure 2: Example of the input-output overview of the renovation costs for refurbishment level 2, the choice for the quality aspects =1 (all lists included) and choice 2 for the priorities, "both of interest and of great importance".

3 APPLICATION FWR COST-QUALITY MODEL

Responsible use of this model can only be practiced by persons with a reasonable cost expertise. The most valuable use of this instrument is in the exploration and initiation phase of projects. It can be a strong tool for weighing the relationship between the desired level of quality and the effects on budgets for renovation.

In addition, it was considered to what extent the method could be made suitable for the assessment of the whole strategic stock of government office buildings

In that case, it is important that a "standardized demand profile" is drawn up for all buildings to be considered. The inventory of the existing quality of the buildings to be assessed must primarily take place. This can also be done with a small team of experts.

Resume the steps in use of the Cost – Quality instrument:

1. Choose of the building to evaluate strategies for renovation
2. Visit and Evaluate the existing building with the NEN 8021 web tool
3. Building a relevant reference model using the PARAP model
4. Choosing a basic technical refurbishment level (1-10)
5. Choose relevant priority level for KPI's (1-3)
6. Get results of calculations depending the kind of functional requirements (1-4)

Evaluation and comparing the results with the FWR Cost-Quality model with traditional cost instruments and methods has been carried out and the differences were within a margin of 5%.

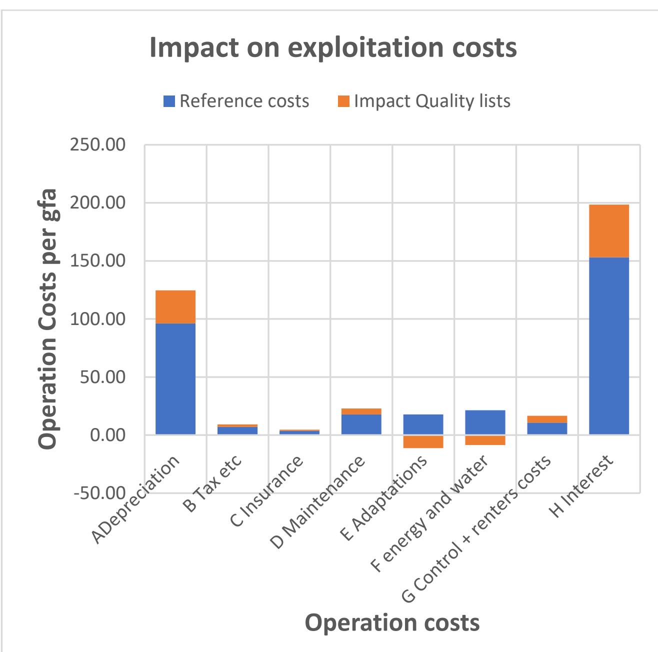


Chart 1: Example of the impact on operation costs. Adaptations and energy are lower thanks the choices for flexibility and energy saving.

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KEYWORDS

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THE ARCHITECT'S ROLE IN A CHANGE-ORIENTED CONSTRUCTION SECTOR: A BELGIAN PERSPECTIVE

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ABSTRACT

Over the past decades, a growing awareness of the built environment's ecological impact has increased the interest in the long-term value of buildings in Belgium, like in many other countries. Central to the idea of long-term value is the search for buildings that stay relevant after the requirements that shaped them have changed. Consequently, little by little, the principles of Open Building gain ground once more.

In the context of a renewed interest in Open Building's principles, concurring with the transition towards an economy of closed material loops, new policy guidelines and client requirements are introducing changing demands for architectural designers. Sometimes these demands are perceived as an opportunity, sometimes as "yet another constraint". To understand this duality, we reviewed the added-value and agency of architects in and beyond ongoing transitions.

Our review is based on the observation of two panel debates we organized in the context of the research project Bâti Bruxellois, Source de nouveaux Matériaux. During these debates, participating architects and consulting engineers were invited to take position against several hypotheses, illustrating that position by their own projects. In this paper, we present the outcome of these debates as three reflections, focusing on the responsibility, skills and position of the architectural designer.

Our findings highlight new and renewed opportunities for architectural designers. They demonstrate the potentially significant role architects can play in the construction sector during and after the transition towards a sustainable building practice. We conclude by illustrating why this review requires also the involvement of sector organizations, academics and policy makers.

CONTEXT

In Belgium, characterized by an unsustainable urban sprawl, dependent on the import of several construction materials and on the export of construction and demolition waste, the awareness and understanding of the built environment's ecological impacts has grown rapidly (OVAM 2014). To act on that awareness, regional policy agencies have been initiating waste and material management programmes and introducing sustainability assessment methods (Debacker et al. 2017). An exemplary initiative has been the signing of over 100 Green Deals, which are declarations of commitment between policy agencies and individual organizations to create lasting, sustainable impact in construction and other sectors (LNE 2017; Circular Flanders 2017).

One of the themes introduced by these policy initiatives is the long-term value of buildings. Central to the idea of long-term value is the search for buildings and building components that stay relevant after the requirements that shaped them have changed. This search has brought with it a renewed interest in the principles of Open Building. In Belgium, the revival of Open Building principles can be identified at different scales (Circular Flanders 2018; Be.exemplary 2018) and includes, amongst others, references to Levels and the interaction between a building, its surroundings and its users, the Support-and-Infill principle and the idea of shearing layers of change, as well as the need for Capacity and a Functional-economic sustainability as defined by Kendall and Teicher (2000, 31).

Note that, in the Flemish region, the term Design for Change is used more often than Open Building or flexibility. Design for Change is an umbrella term for design and construction strategies acknowledging that the needs and requirements of our built environment will always change; the aim of Design for Change is to create buildings that support change more efficiently (Galle and Herthogs 2015). The term was introduced as part of a common language commissioned by OVAM to facilitate communication between stakeholders (Debacker et al. 2015), and has now become a recurrent theme in design assignments and debates in Belgium.

1 PROBLEM STATEMENT AND METHOD

1.1 PROBLEM STATEMENT

In the context of a renewed interest in Open Building's principles, concurring with the transition towards an economy of closed material loops, new policy guidelines and client requirements introduce changing demands for architectural designers. For example: demolitions must be preceded by reuse-audits without project delays; during refurbishments as many components as possible must be preserved while fulfilling new standards; and, new buildings should integrate materials in a reversible way (Be.exemplary 2018). On some occasions, such demands are perceived as an opportunity to reduce the project's (environmental) cost and increase the building's long-term value. This is for example the case for projects characterized by a long-term developer responsibility (e.g. DBFO-projects, see 2.1.). On other occasions, such demands are perceived as "yet another constraint", such as during very competitive public design calls (Sivunen et al. 2015).

The position of the architectural designer towards the demands that are introduced by the transition to a sustainable built environment, including principles of Open Building and Circularity, is not unimportant. Of course, the implementation of such principles depends on their adoption by designers and contractors. But, the survival of the built environment professions, including architects, is dependent on their response to the challenge of sustainability, argue Bordass and Leaman (2013). Hence, we must understand the apparent duality between architects' acceptance and rejection of Design for Change and the related Open Building principles. Therefore, we reviewed the agency and added-value of architectural designers in and beyond the ongoing transitions. The next section explains our method.

1.2 METHOD

To clarify the identified duality, we reviewed the agency and added-value of architects in the ongoing transition towards a change-oriented construction sector in Belgium. Our review is based on the observation of two panel debates we organized in the context of the research project Bâti Bruxellois: Source de nouveaux Matériaux (BBSM, or in English: Brussels' Buildings, a Source of new Materials). During these debates, the participating architects and consulting engineers were invited to take position against several hypotheses, illustrated by their own projects (Table 1). In this paper, we present the outcome of these debates as three reflections.

The first reflection reviews the responsibility and tasks of the architect. Design is the way buildings are shaped. A building's shape determines how it can and cannot be used, and thus how fast it will become obsolete. Complementary, design is the way materials are used. It determines how easily they can be recovered, what their residual value will be, and if it will be feasible to reuse them. The second reflection identifies several skills and tools as an architect's asset. Insight into the complexity of both society and construction, the ability to imagine and depict future values and needs, and the skill of discussing and negotiating all indicate that architects could play a key role in the implementation and transition towards a change-oriented construction sector. And during the third reflection, the position of the architect is restated in the context of the present discussion. A shift in short and long-term engagements, as well as in direct versus indirect design services, opens ways to a renewed role of the architect in construction.

Focusing on the demand side of the architectural discipline in the first analysis, and on the supply side in the second, allows us to attempt to rephrase the relevance of the architectural discipline at a moment it is under pressure, i.e. a saturated market of architects, producing buildings of questionable quality, societal relevance and ecological sustainability while being faced with new demands. The third reflection touches upon the operational (business) model of the discipline, proposing some suggestions as to how the architect's new role could become economically viable too.

1.3 STATE OF AFFAIRS

Most international publications related to Open Building discuss the strategy's principles and review how they have been adopted in various situations (ICONDA 2018). But what does it mean to be an actor of Open Building? A cursive review of the abstracts of the hundreds of papers presented at the most recent Open Building conferences shows that only a few authors touched on the question before. For example, van den Brand, Quanjel and Zeiler (2001) discuss the practical implementation of Open Building as a design approach, and Schwehr and Plagaro Cowee (2011) present a specific method that architectural designers could adopt. Cuperus (2004) and Galle, Vandenbroucke et al. (2014) explore the related design process, while Oostra (2015) shifts the perspective away from construction professionals writing that "more and more people are eager to actively influence and shape their own environment" (Oostra 2015). However, what seems to be missing is a critical review of the added-value and agency of architectural designers in relation to Open Building.

Participating architect (Affiliation)	Presented projects (Location)	Current use (construction type)
Johan Anrys (51N4E)	Buda factory (Kortrijk) Grootkapel (Beersel) Peterbos (Anderlecht)	Art center (refurbishment, extension) Care homes (new-built) Social housing (refurbishment)
Olivier Breda (Dzerostudio)	Tomato Chili (Brussels) City Gate project (Anderlecht)	Greenhouses (reclaimed components) Plug-in offices (reclaimed components)
Pieter Walraet (KPW Architecten)	Gandhi neighborhood (Mechelen) Hoogbouwplein (Zelzate) Oude God (Mortsel) Berg ter Munt (Tervuren)	Social housing (new-built) Social housing (new-built) Youth center (new-built, reclaimed c.) Youth center (new-built)
Jorden Goossenaerts (CONIX RDBM)	Multi, former Philips tower (Brussels) Keyhof (Huldenberg)	Mixed use (refurbishment, reclaimed c.) Care homes (new-built)
Geert Verachtert (Van Roey)	SportOase (multiple locations)	Sport center (new-built)

Table 1a: Architects participating and design projects presented during the first BBSM panel debate (BBSM 2018a).

Participating architect (Affiliation)	Presented projects (Location)	Project type
Maarten Vanderlinden (BAST)	Wiegenlied (Oostende) Ten Dries (Sint-Denijs)	Child care center (new-built) Youth care center (refurbishment)
Simone Valerio (KADERSTUDIO)	ASPER (Gavere) Learning from Tubize (Tubize)	Single dwelling (new-built) Mixed use (urban redevelopment)
Kathleen Van de Werf (BUUR)	Potterij (Mechelen) Circular Care Campus (Antwerp)	Living Lab (refurbishment) Hospital campus (urban redevelopment)
Jan Laute (Dear Pigs, AAC)	Au ReTour (Brussels) AAC own offices (Brussels)	Urban intervention (reclaimed components) Office interior (reclaimed components)

Table 1b: Architects participating and design projects presented during the second BBSM panel debate (BBSM 2018b).

2 REFLECTIONS

2.1 REFLECTION ON THE RESPONSIBILITY OF THE ARCHITECT

Since architects provide a wide set of services, their work involves a high degree of responsibility towards their clients and society (Schoenmaekers 2010, 45). Because of that responsibility, the profession of architect is regulated in its own specific way, in Belgium by the Architects Act of 1939. The Act introduces a protected title that formally distinguishes the architects' design task from the contractor's commercial activities. That distinction is designed to guarantee that architects advise their clients independently (Schoenmaekers 2010, 212–13). The Act further specifies that an architect's involvement is mandatory for "the design of the plans" and - exceptional in Europe - the "supervision of the execution of the works" (Belgian Gazette 1939), effectively establishing a monopoly for trained architects for such tasks. Today, the responsibility of the architect is challenged by, on the one hand, a broadening task and, on the another, new collaborations in construction.

In practice, the architects' monopoly does not cover all regular tasks of an architect, which also include construction planning, estimation and expertise (Schoenmaekers 2010, 214). Moreover, regulations require architects to implement knowledge on specific themes such as energy and water use or building safety and health. While some architects flourish in these fields, and others found ways to delegate specific expertise, the broadening task of the architect often results in economically unviable working conditions and is perceived by architects as the most serious threat to their profession (NAV 2016; Van Tornhaut 2016).

Additionally, the legal responsibility of the architect is also challenged by DBFM (Design Build Finance Maintain) and IPD (Integrated Project Delivery) projects, or concepts such as 'early contractor involvement' in the United Kingdom and 'best value procurement' in the United States. Internationally, such collaboration formulas are becoming increasingly popular and have proven repeatedly to be useful and efficient (Hardin and McCool 2015). However, because of the Architects Act, there is no legal ground for such collaborations in Belgium. In these collaborations, the client enters into a contract with a team of construction professionals through one leading party (Van Tornhaut 2016). However, the Architects Act strongly disadvantages architects in such agreements, as they legally cannot establish contracts with contractors. "As a result, financially and in terms of content, the architect is always in a weaker position compared to other construction partners" (Van Tornhaut 2016).

Putting pressure, these challenges requires us to review the added-value and agency of architects. Therefore, let us start with a broadening perspective on agency in the built environment. According to Habraken, being an actor of the built environment means to have "the ability to transform some part of that environment" (Habraken 1998, 8). Consequently, the search for the architect's agency, legally defined as "the design of the plans", or more generally making design choices, is turned into a reassessment of his or her ability to transform the built environment. Moreover, studying the architect's role in a change-oriented construction sector, our interest extends to his or her ability to enable transformations. That ability was discussed earlier by a series of academic discussions and has been confirmed by the projects that participating architects presented during the panel debates. It relates to two kinds of design choices and three design tasks.

First, design is the way buildings are shaped. A building's shape determines how it can and cannot be used, how easily it can be adapted, and thus how fast it will become obsolete (Iselin and Lemer 1993; Thomsen and van der Flier 2011). That is illustrated for example by the work of BAST Architecten (BBSM 2018b). Their study for the refurbishment of the youth care center Ten Dries in the municipality of Sint-Denijs shows how introducing generality facilitates future transformations. However, being general is no guarantee that the building's enduring value will be positive. That is aptly illustrated by the structure currently in place: spatially generous, but detested by the local community because of the troubled history of the center. This emphasizes that in addition to functional changes, also the meaning and expression of a building in its environment should be designed to evolve over time.

Second, design is the way buildings are materialized. It determines the initial performance and durability of the building, as well as how easily its components can be recovered and reconfigured (Addis and Schouten 2004; Durmisevic 2006; Glogar 2011). That is illustrated for example by the collaboration between KPW Architecten (BBSM 2018a) and academic researchers (Paduart et al. 2013; Debacker et al. 2015). The life cycle analyses they made in the context of the redevelopment of the Gandhi neighborhood in Mechelen and the refurbishment of a social housing block in Zelzate show that alternative design solutions adopting Open Building principles can reduce the (environmental) cost of future transformations. Nevertheless, the analysis outcomes strongly depend on the solutions' technical characteristics (including reversibility and durability) and implementation strategy (which can be idealistic or more realistic).

Consequent to the reviewed responsibility of the architect, also three tasks were highlighted during the panel debates. First, like every design, change-oriented design requires rigorous research. Conventional design parameters remain important even if new demands are introduced, such as the accessibility of spaces and technical services, or net-to-gross floor area ratio (CONIX RDBM Architects in BBSM 2018a). Second, like every design strategy, the implementation of Open Building principles requires conception. After all, because the spatial, technical and financial context of every project is different, a one-size-fits-all solution does not exist (KPW Architecten in BBSM 2018a). And third, transmitting information and insight into the design's long-term value to the future user is indispensable too (Van Roey BBSM 2018a).

2.2 REFLECTION ON THE SKILLS THE ARCHITECT

Heijne and Vink stated that, in the conventional sense, "designers have been trained along functionalist lines [...] with a clearly described brief", but that the need to address change introduces a context where "both the future use and its users are largely unknown" (Heijne and Vink in Leupen, Heijne, and Van Zwol 2005, 65). Accordingly, in a change-oriented construction section, a designer's skills, including methods and tools, need to be much broader than the mere articulation of space. Some of those requirements have been identified by Kendall when educating architectural designers in the United States; they include the ability to recognize levels, design with constraints, conceive without program and implement research (Kendall 2001).

The need for new or altered skills was also discussed during the BBSM debates. Some were identified as an opportunity for architects in and beyond the changing sector, such as the need for insight into the complexity of both society and construction (cf. research task), the ability to imagine and depict present and future values, needs and solutions (cf. conception task), and the skill of discussing and negotiating the solutions at the table (cf. transmission task). Aside from opportunities, the panel discussion also highlighted risks. Both are illustrated by the following conclusions of the debates:

- Designing according to Open Building principles challenges architectural designers to answer current and future needs by using existing spaces and structures. Yet, in Belgium's refurbishment-oriented practice, architects are skilled to manage that constraint (Dzerostudio in BBSM 2018a).
- Open Building requires designers to think in systems of decision making and building components. Today, they already design with products and elements; not with raw materials. Using systems creatively must therefore be capitalized as the architect's asset (KPW Architecten in BBSM 2018a).
- When seeking long-term value, life cycle thinking is crucial. It is exactly the architect that has the skills of supporting and encouraging a well-considered management of the building: they can depict future needs, enable dialogue, and build alliances (CONIX RDBM Architects in BBSM 2018a).
- Currently, architects have been relying increasingly often on contractors for material issues and construction techniques. However, in order to be able to conceive innovative Open Building and Circular design solutions, architects will have to improve their knowledge about materials and construction (51N4E in BBSM 2018a).

Further, in the early history of Open Building, designers showed great interest in specific methods and tools enabling relevant skills. Referring to the work of SAR, Kendall explains: "to handle the complexity of levels of intervention, distributed control and change, Open Building practitioners apply particular design methods. These include capacity analysis in the design of supports or base buildings; the use of zones and margins as a means of describing the limits of variation in spatial terms; and dimensional and positioning grids to facilitate communication between different parties each responsible for different building elements" (Kendall 2015). During the two panel debates, we observed also the interest in emerging methods and tools of participating architects. Those methods and tools are illustrated by the following issues raised during the debates:

- Projecting divergent scenarios, plausible as well as surprising, allows evaluating the resilience and robustness of the design proposal at the table (Galle 2016). Designers must therefore imagine divergent user-paths and adopt the Scenario Planning method (KPW Architecten in BBSM

2018a, KADERSTUDIO in 2018b).

- Data-driven methods are indispensable to handle the complexity introduced by Open Building and Circularity principles (CONIX RDBM Architects in BBSM 2018a). For example, to scout second-hand materials and to assess their reusability, such tools can be vital (Denis 2014). Therefore, construction professionals should look at methods as BIM and Blockchain to ensure transparency and quality in the construction process; even managing that data could be a business case (Van Roey in BBSM 2018a).

2.3 REFLECTION ON THE POSITION OF THE ARCHITECT

After analyzing the responsibility (see 2.1) and skills (see 2.2) of the architectural designer, this section finally raises some points regarding the discipline's operational (business) model, identifying options to make a renewed engagement for architects economically viable. In literature and the during the panel debates, that viability was identified as an issue slowing down sustainability frontrunners (Vandenbroucke et al. 2013; Galle, De Troyer, and De Temmerman 2015). Nonetheless, if the whole economy transforms towards a circular one, it is conceivable that the architect's position in the value chain of construction must change too (BBSM 2018a).

Today, architectural designers are applying an increasing number of expert domains and methods (cf. first and second reflection). However, in the already saturated market of architectural professionals, that work is not rewarded financially (Rutgeerts 2015 in Van Tornhaut 2016). Looking at the value chain of construction, that might be explained by the fact that architects' engagement represents only a short period relative to the long-term impact of their choices. During the panel debates, several initiatives in other construction disciplines were nevertheless identified as opportunities to change also the architect's position in that value chain. Concretely, we identified two dimensions along which new business models are emerging: shifts in short and long-term engagements, and shifts in direct versus indirect (design) services.

First, as implied by the Belgian Architects Act (see 2.1), designers deliver a design and support only the construction process. However, rather than handing over all knowledge at the end of the construction phase, a designer could profit from the developed insights throughout the buildings' service life (CONIX RDBM in BBSM 2018a). In Belgium and elsewhere in Europe, long-term engagements of contractors, such as in DBFM projects, and service providers adopting performance-based contracts for energy refurbishments and technical service are being established (cf. RenoWatt 2017; GuarantEE 2018). Moreover, consultancy firms propose to offer guidance "through the entire real estate life cycle" (Borpo 2018). They seem to fulfil a need that was identified by Heijne and Vink: "Flex-buildings require active management. Besides the day-to-day business of upkeep and repair, there needs to be a policy for the building's fit-out. This includes deciding which users and uses are desirable and in which proportions, and fixing the requirements for user representation in the façade" (Heijne and Vink in Leupen, Heijne, and Zwol 2005, 66). This seems to imply that a part of the design responsibility - including research, conception and transmission tasks - is shifting from the design phase towards the operational phase of a building's service life.

Second, a conventional Belgian client would be both the investor and the future user of a building. However, in a circular and service-based economy, or a built environment with fully implemented control distribution, that fact is no longer evident. If infrastructure is shared, components rented or materials leased, the owner will not necessarily be the user, let alone the facility manager. Each of these positions can be taken up by different entities, each with their own objectives and needs. One future position for architects might be to align those objectives and needs. After being the master planner, the architect could become the master connector, linking together flows of people, experiences and materials, offered as a service to the investor (BUUR in BBSM 2018b). Alternatively, the architect might take the position of developer and manager of general infrastructures and adaptable infill systems according to Open Building principles; this would be an indirect design service - though direct design consultancy will likely still be necessary for implementing such systems in their context. Today, some Belgian practices already demonstrate this shift. Some architectural offices have been developing specific skills, such as disassembly and resell of construction components (Rotor Deconstruction 2018) or expert knowledge of a specific construction technique, for example the design and construction of rammed earth elements (BC materials 2018). However, considering the boundary conditions set by the Architects Act, such engagements are not obvious.

3 CONCLUSION AND DISCUSSION

In the context of a renewed interest in Open Building's principles, concurring with the sustainability transition towards an economy of closed material loops, policy initiatives and client requirements introduce changing demands for architectural designers. Because the survival of built environment professions, including architects, is dependent on their response to the sustainability challenge and vice versa, we reviewed the role of architectural designers in and beyond the ongoing transitions. Our review, structured in three reflections, is based on two panel debates with frontrunners among Belgian architects and consulting engineers.

First, enabling future transformations of the built environment was identified as a key responsibility of architects that are actors of Open Building. Therefore, research, conception and transmission could be identified as complementary design tasks. Second, the added-value of architectural designers is not limited to "the design of the plans". Their insight into the complexity of both society and construction, their ability to imagine and depict present and future needs, and their skill of discussing and negotiating the solutions at the table are of great value during the innovative implementation of Open Building and Circularity principles. And third, a shift in short and long-term engagements, and in direct versus indirect design services, sets the solution space of a renewed, more viable position of the architect in the value chain of construction. All together, these findings demonstrate the potentially significant role architects can play in the construction sector during and after the transition towards a sustainable building practice.

Our findings could be a starting point for a more exhaustive discussion about the renewed agency of architectural designers, involving not only architects, but also academics, sector organizations and policymakers. After all, changes in legislation, business models, professional skills and attitude must be reviewed too. For the architect of today, designing with and for reuse, or according to Open Building principles, is based in experimentation. During the BBSM debates, finding the right project setting - exploiting opportunities and mitigating risks - was identified as crucial attitude towards experiments and learning. For that setting, creativity, temporality, revival, independence and alliance are key ingredients. Accordingly, if architects will need to experiment more, they need to be taught the skills and insights necessary to shape change-oriented buildings; so far, many of the existing examples relied however on the individual experience and interests of the involved designers. For that reason, the transfer of insight and experience, for example through academic education or sectorial learning networks, could be crucial to profit from the identified potential. Simultaneously, policymakers could work with and learn from front-running architects, understanding and acting upon the necessary legal adaptations in relation to a changing architectural profession, especially to safeguard economic feasibility and fair competition.

While this paper certainly did not cover all possible needs, opportunities, risk and threats related to the role of the architectural designer in a change-oriented construction practice, the presented observations could serve as a starting point to better understand the apparent duality between architects' acceptance and rejection of Design for Change and the related Open Building principles: a state-of-affairs collecting insights of frontrunners, allowing more architects to get inspired to rethink their role and practice.

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KEYWORDS

WOOD
FLEXIBILITY
SUSTAINABILITY
DEVELOPMENT

PATCH22: A CASE STUDY

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ABSTRACT

The aging of apartment units, which were quickly and PATCH22, a 30m tall high-rise in wood, was one of the successful projects in the Amsterdam Buiksloterham Sustainability Tender in 2009. We, an architect and a building-manager, wanted to achieve independently what we had never been able to when working for our previous clients: an outsized wooden building with a maximum degree of flexibility, striking architecture and a high level of sustainability.

We developed PATCH22 on our own account and risk during the crisis years of 2009-2014. The project incorporates numerous innovations in the technology and application of technical rules, all maximizing flexibility. Examples include hollow floors with removable top floors, the absence of shafts in apartments – drains and cabling are connected horizontally to central shafts in the core – and special ground lease contracts that allow for flexible positioning of different functions within the building.

Division walls between apartments can be added and removed; apartments can be subdivided or merged at any future moment. The building can be converted from residential to commercial and vice versa without any changes to the structure.

Patch22 is a case study showing that reorganizing the architectural practice into an architectural development company allowed us to be unconventional and to come up with truly open and flexible building solutions without making compromises.

INTRODUCTION

In the autumn of 2009 the Dutch city of Amsterdam tendered four plots in the Buiksloterham, an industrial area in the northwestern harbor of Amsterdam, to convert it into a mixed working and living area with a strong emphasis on sustainable building solutions. Therefore the tendering criteria were based on sustainability scores instead of financial criteria. This raised an opportunity for non-institutional developers with more ideological motives to enter the tendering procedure and to reorganize our conventional consultancy practices into a design & development practice. We, architect Tom Frantzen and building manager Claus Oussoren, started Lemniskade Projects to participate in the tender and were selected with our proposal Patch22. The design received the highest sustainability score and introduced the use of wood as a circular building material for the main structure and flexible floor plans for future-proof sustainable building. In the following development process the urge grew for even greater flexibility than originally designed and we developed more radical solutions. We came to understand that our design attitude was rooted in the history of participatory building in the Netherlands and the work of John Habraken in particular. In this paper we will focus on the context of Patch22, position Patch22 in the open building architectural history and propose criteria to evaluate flexibility. We will show how Patch22 was conceived, address the constraints of building with wood in the Netherlands and go into innovations in techniques and costs. Finally we will speculate on the lessons learned for the future application of these principles by others.

1.0 DESIGN AND DEVELOPMENT

1.1 THE ARCHITECT AS DEVELOPER

Winning an (inter)national architectural competition can be the short cut to fame for architects. However the chance to win one is small and the investment in time and money can be huge. When we entered the Stockholm City Library competition in 2005 we found ourselves amidst 1050 competitors. We would have had a 0,1% chance winning the competition, but the odds to real success, building a winning project, would even be 50% lower, down to 0,05%. It is common knowledge that a lot of building initiatives, even winning projects, never get to be built. Having invested €30.000 in the competition we concluded it wasn't a smart business model. So we decided to invest our yearly competition budget in developing real estate ourselves and to become our own client. After we did some relatively small but financially and architecturally profitable projects we heard in 2009 that the city of Amsterdam was tendering plots on sustainability scores instead of financial biddings. That enabled us to compete with the usual suspects, the big Dutch development companies such as BAM, Heijmans and Strukton. We decided to try our luck.

1.2 THE AMSTERDAM BUIKSLOTERHAM SUSTAINABILITY TENDER 2009

The tender called for proposals for four different plots in the Buiksloterham, an industrial area in Amsterdam North. We developed a 5000m2 mixed housing and working building for plot 22, measuring 2000m2. We designed a good-looking building but esthetics was not part of the criteria. Only sustainability scores, calculated with the GPR system (a Dutch governmental Benchmark sustainability scoring system) that focused mainly on energy efficiency were taken into account. The 2009 design for Patch22 won the tender with a GPR score of 8.9/10 and an EPC of 0.2. The roof of the energy-neutral building is covered with PV panels. Rainwater is reused in a grey water system. CO2-neutral pellet stoves, fueled on compressed waste wood from the timber industry, generate heating. But to our opinion energy efficiency is not the only important aspect of sustainability. To achieve the high GPR score we had to rely on high end installations, that were given high scores. But 2009 installations will be old-fashioned twenty years later. Therefore we decided to introduce circularity and we designed a building that could prolong its life span by being able to accommodate unknown future use. We decided to use the renewable, circular, building material wood for the main structure and we designed the building to be a very flexible 'open building'.

Figure 1: The Buiksloterham in 2009, plot Patch22 in red

1.3 AN UNTAPPED NICHE MARKET

From 2009 to 2014 the Dutch real estate market suffered from the worldwide credit crunch and had almost come to a complete stop. It was hard for the general public to receive mortgages and there were plenty of the average 100m2 apartments available on the market. We had to aim for another kind of buyer to be successful. While the other developers offered minimized and more affordable 40-50m2 apartments we decided to adopt Tesla's marketing strategy: to sell a sustainable product to the upscale market first. We were convinced that it would be easier to attract twenty weird buyers than 40 regular or 80 low budget buyers. We offered 200 m2 apartments, a size almost unavailable in Amsterdam. By offering casco (Support) apartments with complete freedom in the layout we attracted buyers with a free mind and spirit, essential for pioneering in the (until then) unpopular Amsterdam North. The fact that Patch22 is a wooden building raised exclusiveness and when we went on sale late 2013 our strategy proved to be a success.

What also helped is that we increased the flexibility of the building in our final design compared to our initial design. We started with 200m2 apartments with load bearing division walls but decided that we needed a financial exit-strategy for our buyers in case the Buiksloterham would not become popular. A straightforward 200m2 apartment would then be unsellable, so we made it possible to divide them into smaller affordable apartments. Thanks to the lack of structural division walls, the generous floor height of 4m and the high floor load of 4kN, the six timber floors that playfully shift in and out can be used as large lofts up to 540m2 with huge balconies, as up to eight smaller apartments or as open office space. Apartments can be subdivided or merged, and the division into apartments will remain flexible in the future. This convinced our buyers to move to the yet undeveloped industrial area Amsterdam North in the middle of a financial crisis.

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Figure 2: Patch22 as seen from the southwest

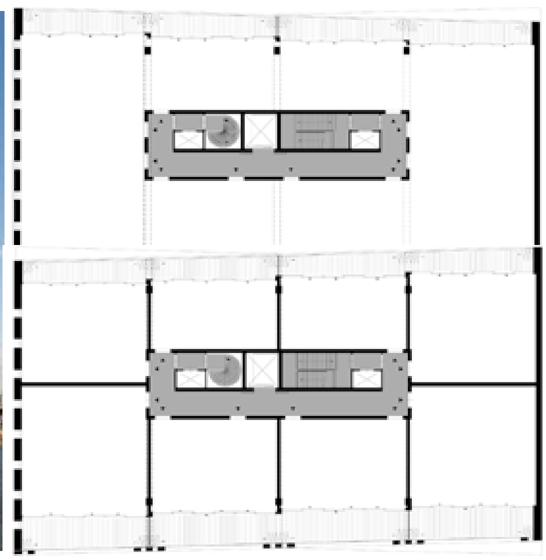

Figure 3: level 4 without division walls and level 5 with the maximum number of division walls (final design)

1.5. THE ARCHITECT AS EDITOR

In conventional housing buildings the architect is the dominant organizer of the inhabitants' interior. In a project that aims at stacking villa's it is tempting to become the sole designer of all those high-end private apartments. Already combining the roles of project developer, real estate agent and architect we refrained from being the almighty interior architect as well. Our office FRANTZEN et al architects did not design all interiors but instead coached all inhabitants in designing their homes themselves, just reflecting on their own designs and pointing out regulatory requirements and spatial enhancements. Some used interior architects; some used just drawing paper and pencil. When all the designs were finished, FRANTZEN et al converted them into working draw¬ings so the general contractor could install drains and wiring in the hollow floors during construction. This was technically not necessary but it compressed the total building time. After completion of the casco building inhabitants could start executing their own interiors with their private contractors. When compared to journalism you could argue that the inhabitants took on the role of journalists writing their own articles while we as architects took on the role of the editor and supervised, suggested improvements or detected possible conflicts to fit all the contributions to an optimized overall product.

1.6 FLEXIBILITY EQUALS SUSTAINABILITY

Recycling is an appreciated sustainable strategy but wouldn't it be better to use artifacts over and over again? The UNESCO world heritage historic center of Amsterdam is a perfect example, the 450 years old canal houses were originally used as warehouses, were converted into private houses, subdivided or merged, turned into museums, banks, offices and hotels while the city center remained almost the same. That's also sustainable! In Patch22 the high-rise section of the 5400m2 building can be converted from commercial to residential and vice versa without any changes to the structure. The apartments offer complete layout flexibility because the occupants are able to install drains and wiring in the hollow floors with removable top layer to their own demands.

1.7. EVALUATING FLEXIBILITY

Flexibility can range from one time only to over and over again and anything in between. In reality all buildings can be modified and are therefore flexible, designing a building to be flexible just makes it easier to modify them. To simplify we like to distinguish one time flexibility and repeated flexibility in different gradations.

The difference between the two is the level of integration of installations and structure, which is of great importance in the Dutch context. In the Netherlands the majority of dwellings are build as apartment buildings and it is common to build the structure in (prefab and semi-prefab) concrete with electrical facilities integrated in the structural walls and ceilings (as part of the prefab part of structural floor), water integrated in the structural floors and walls, heating and drains integrated in the in situ concrete part of the structural floors. Strict regulations for the integration of fire alarms in the ceilings of different rooms reduce freedom of room layout dramatically.

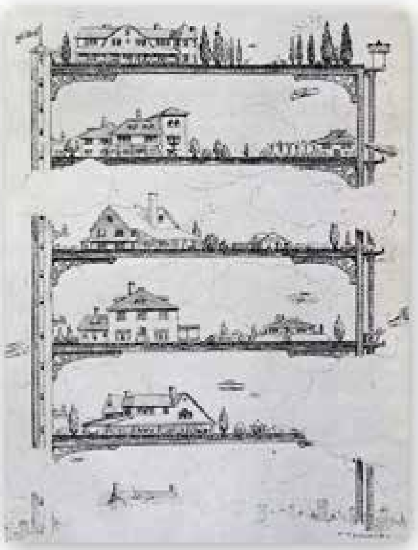

Figure 4: The skyscraper as a structure for stacked villas, drawing by A.B. Walker 1909

Figure 5: Apartment Van Langh / Stakenburg on level 6 and 7, note the bathtub on the loggia balcony.

Offering buyers an open building with the possibility to design their own interiors inside a shared structure would therefore mean that the design (ideally) has to be finished before the production of the prefab concrete starts. Inhabitants must be committed early in the building process because making choices in later stages reduces the flexibility of the position of all the installations. In this approach the general architect of the shared part of the building has to capture everything on building permit drawings. We would like to describe the flexibility as mentioned above as one time only. Modifications can of course be done later in the lifetime of the building but would be part of a renovation.

In Patch22 we aimed at an over and over again flexibility, which meant that we could not rely on regular building techniques. We wanted inhabitants to be completely free in the layout of the apartment during the buildings' complete lifespan. Therefore we introduced shaft-less floor plans with removable division walls and innovative hollow floors in which drains and wiring can be installed almost independently of the load bearing structure. In a first draft for comprehensive flexibility evaluation criteria Patch22 would end up in the very flexible category.

1.9 PATCH22 AND THE PARTICIPATION MOVEMENT

Dutch architect John Habraken is known for his 1961 manifest Supports , in which he proposes the separation of Supports, the structure, from Infills. He aimed at increasing user participation in the design process of residential construction with an architecture of lively variety as a visual result. Although early experiments, such as the 1971 Diagoonwoningen by Herman Hertzberger in Delft show a division between support and infill, later Dutch examples of user participation such as Amsterdam Scheepstimmermanstraat and Almere Homeruskwartier show the visual lively variety but are mostly a collection of very traditionally built and commissioned single family homes. They lack flexibility and have no division between structure and infill.

In Patch22 we were not interested in inhabitants expressing themselves visually on the exterior of the building, which had to serve as a first urban landmark for the yet undeveloped neighborhood. In Patch 22 inhabitants share the architecture of the building as a whole but are extremely free to design and built their own interior. Not just the first inhabitants but also the next and the next...Our goal was to build a sustainable structure that repeatedly can be internally modified to ensure that the structure, containing a lot of precious materials, will remain useful to future generations, even if we don't know what their future demands and desires will be.

2.0 THE DO'S AND THE DON'TS

2.1 FACILITATE EXPERIMENTS: CIRCULAR BUIKSLOTERHAM

After the sustainability tender in 2009 stakeholders drafted and signed the Circular Buiksloterham Manifest to establish Buiksloterham as an experimental city development area to facilitate experiments. Amongst the stakeholders were the city, developers, Electricity Company (Al)liander, the public water companies and city heating supplier NUON. In several meet-ups these stakeholders consulted each other if an experimental approach was needed and exemptions to existing rules and regulations had to be facilitated.

2.2 A WOODEN BUILDING, CONSTRAINTS AND OPPORTUNITIES

The main material for the structure and façade of Patch22 is wood. According to the cradle2cradle philosophy it is OK to use mate¬rial excessively when nature provides us with it repeatedly. With this in mind we solved the fire resistance issue that obviously arises when building a high-rise in wood. We simply added 80mm extra timber to the structure so it would take the obligatory 120 minutes before a fire would affect the structural qualities of the building. We were able to keep all the wood in plain view, which was essential to maintain the exclusive look and feel of building with timber. It also turned out to be cheaper to build a post and beam construction than load bearing walls in timber because the overall surface and the amount of extra fire resistance timber protecting the structure would be less. In a post and beam structure division walls can be added and removed later, improving flexibility. The possible heavy wind loads on the façade and structure caused a second problem, a wooden building would simply be to light in combination with the typical Amsterdam soft soil layers, basically a swamp. In Amsterdam buildings are build on 20m long piles to reach the first solid sand layer. To prevent the building from being lifted up and out of the ground during a perfect storm we had to add weight to the structure. Therefore we choose to replace the timber floors of the initial design by a hybrid steel-concrete flooring system and constructed the ground floor structure in solid prefab concrete. But we still used relatively lightweight parts and managed to build with lightweight cost-efficient mobile cranes. For the architectural design building with timber offered a lot of morphological freedom, because so called cold bridges, which are so problematic in concrete structures, do not occur. Our real estate agent was surprised to find out that the use of wood proved to be a marketing advantage in the difficult credit crunch real estate market, to convince buyers that Patch22 was an extra ordinary building. A third constraint of wood structures is the fragility when it comes to sound insulation. Because there is no mass to absorb sound, the structure has to be carefully built in different sound-independent layers. It is easy to make building errors or to influence the total structure by errant additions. Having inhabitants executing their own interiors in a wooden structure increases the risk of sound related issues.

2.3 NO LOAD BEARING DIVISION WALLS

A post and beam structure with lightweight division walls is more flexible than a structure with load bearing division walls that fixate the size of different units. Lightweight division walls can easily be built or removed at any moment in time. In Patch22 a maximum of 8 units per floor are possible. Multiple units can be divided or merged to apartments measuring 540 m2. By superimposing regulations for housing and offices, a generous floor height of 4 m and floor loads of max 4 KN, the wooden structure can be subdivided into six independent office floors or maximum 48 apartments.

2.4 FLEXIBILITY FOR DUMMIES

In the Dutch building industry that is dominated by prefabricated and fully integrated building concepts we found it hard to facilitate flexibility. Regular building components are aimed at solving regular requirements and integrate rules and regulations for regular apartments for a regular public in a highly cost-efficient way. But when flexibility and changes are required to these regular building components they tend to get very expensive and require a lot of design planning and management. Therefore, we decided to dis-integrate structure and services and to build as dumb as possible. Paradoxically the overall design still has to be very smart because all possibilities have to be foreseen so the casco (Support) building does not impose restraints on the later infill of the interior. A major contribution to the dumbness of the individual apartments was that we managed to organize all the technical meters and obligatory ventilation appliances outside of the units, so the end-users only had to focus on the spaces for living in and not on the invisible

Table 1: evaluation criteria for the flexibility of interior layouts in shared structures

	Installations fully integrated in the load bearing and apartment-dividing structure.	Installations partly independent of the load bearing and apartment-dividing structure.	Installations fully independent of the load bearing and apartment-dividing structure.	Division walls coincide with the load bearing structure	Division walls independent of the load bearing structure
Non-flexible / one time flexible	X			X	
Slightly flexible		X		X	
Flexible			X	X	
Very flexible		X			X
Max-flexible			X		X

2.5 NO SHAFTS

Shafts are the invisible organizers of floor plan layouts. In conventional housing, meter cabinets, kitchens and bathrooms will always be executed close to the shaft to minimize the length of the drains and the floor dimensions that have to accommodate the needed inclination for the drains. In Patch22 shafts would never be in the right place for an inhabitants' floor plan. We didn't know which units would merge into a single apartment and therefore it made no sense to have shafts vertically through all the units. So we designed two shafts in the central core and pre-installed drains, water and electricity to just behind the front door, where the inhabitants could have these extended to the desired position in the apartment. To make sure that there was enough height for the inclination of the toilet-drain we positioned an imaginary toilet in the outmost corner of the building and determined the necessary floor dimensions. We figured, if somebody would be crazy enough to have the toilet in front of the window, it should be possible. And some did!

2.6 NO METERS INSIDE THE APARTMENTS

Because we were not building regular shafts in Patch22 we had to develop alternatives for positioning meters in apartments with the Circular Buiksloterham stakeholders. Together with (Al)liander we created a shared room with all meters and main switches together on ground floor and secondary fuse boxes installed inside the apartment, horizontally connected to the central shafts.

2.7 HOLLOW FLOORS WITH REMOVABLE TOP

Due to the necessary inclination of the toilet drain to the central shaft the floor dimensions became 50cm high. So it made sense to make hollow floors and we decided for the Slimline system , which is a combination of 36cm perforated steal beams and a 8cm concrete bottom slab. After installing drains and other facilities the floor is topped with a Lewis profile sheet and 8cm anhydrite screed with floor heating. Because the top floor is part of the sound barrier between two apartments we define this solution as partly independent of the load bearing structure. Opening up the floor completely will require some demolition work but is very easy to repair. By making strategically placed holes in the floor the cavity of the floor can be entered and alterations inside the floor can be made. Initially we wanted inhabitants to be able to disassemble the top floor in original components, but that turned out to be more complex and more expensive than the anhydrite top floor and therefore practically and economically less flexible.

Figure 6: level 3 & 7. Very different layouts on identical floors. None of the layouts have any shafts running through.

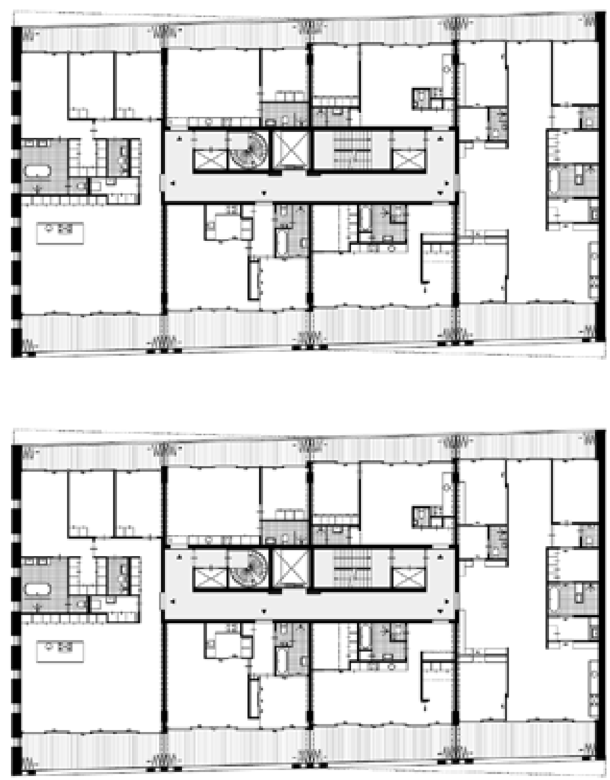

Figure 7: hollow Slimline floor system with free positioning of drains and wiring.

2.8 COSTS, OPEN BUILDINGS ARE NOT CHEAPER

It is not necessarily cheaper to build without interiors. When structure and services are integrated the volume of the building can be smaller compared to a non-integrated building, which needs extra space for raised top floors, lowered ceilings and retention walls. It takes more building material and labor and the dimensions of the façade, the most expensive part of a building, increase. Given the fact that (in a Dutch context) interiors in regular projects are often finished extremely cheap we ended up spending €1200,-/gross m2 on Patch22 while in 2014 €1050,-/ m2 was the standard for a finished building with comparable sustainability scores. Our buyers invested another €800,-/net m2 to complete their (high end) interiors.

2.9 LEGAL ISSUES

In the Netherlands property owners don't own an apartment in a shared building, they own the right to use and trade certain legal units of a building. All owners are members of the Property Owners Association (POA) that owns the building. In Amsterdam the POA doesn't own the ground underneath the building but has a land lease contract. In Patch22 we divided each floor into 8 legal units and bigger apartments are a combination of multiple legal units. Although this is permitted in Dutch law, it was not permitted in regular Amsterdam land lease contracts. It was even more difficult to arrange permission to legalize a flexible use for housing and working in each legal unit, because Amsterdam charges different lease fees for different functions and wants to keep control. But when we started selling we didn't know how big the apartments were going to be, where they would be located exactly and how they were going to be used. That was supposed to be flexible! It took us two years of negotiation with the city to draw up a new kind of land lease contract that would not impose paper restrictions on our very flexible building. Ideally one would divide a building in as much legal units as possible and have apartments that are combinations of a number of legal units. Even more ideally would be if the legal units would not have a specific function, f.e. working or housing, assigned to them. It is not even necessary that all legal units can be accessed individually and possibly turned into individual houses. Having more legal units than apartments would make it possible for apartments to grow or shrink over time, by combining legal units or by splitting up an apartment into it's smaller legal units.

CONCLUSION

To improve the circular sustainability of apartment buildings it is wise to design flexible buildings, to separate structure and infill. Flexibility improves with dis-integration, when division walls and installations are build independent of the load bearing structure. Flexibility and freedom of layout improves even more when hollow installation floors allow for the vertical shafts and larger installation appliances to be located outside the apartments. But when building flexible buildings is not the norm and more expensive than regular building, flexibility is only suited for a niche market, for inhabitants that want to express themselves in their own interiors, not necessarily inhabitants that are interested in sustainability. Designing flexible open buildings demands the architect to take up another role, to shift from the almighty designer to a more coaching role. This does not imply that the exterior has to be neutral however; in Patch22 the iconic exterior was much appreciated for the shared identity. When developing open buildings generosity is required because literally more space has to be given to inhabitants. Open building should not just be an architectural issue, to improve flexibility in buildings a lot of effort has to be made to decrease legal restrictions.

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[3]http://www.slimlinebuildings.nl

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KEYWORDS

OPEN BUILDING
OPEN ROOM
HOSPITAL
HEALTHCARE
ENVIRONMENTS
FLEXIBILITY

FROM THE OPEN BUILDING TO OPEN ROOMS: A DESIGN APPROACH FOR FUTURE HEALTHCARE ENVIRONMENTS

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ABSTRACT

In recent years, many studies have revealed the increasing rate of hospital obsolescence: this fact is a reflection of the fast pace at which contemporary society and medical knowledge evolve. The main challenge is to realize flexible healthcare facilities able to update their services in time.

Objective. Starting from the Open Building design approach, the current development of prefabricated technologies in construction industry and the application of Plug-In users' rooms in hotel facilities, a multidisciplinary research group (coordinated by the authors) develops a new approach in flexibility in hospital wards with the Open Room, predisposed to respond to several functions.

Methodology. The design approach is structured into three areas: Primary System, the structural framework in which the modules are plugged; Secondary System, through the Plug-In approach, represents the prefabricated sub-structures that host the skeleton with all the implants and needs for all the typologies of hospital rooms; Tertiary System, that features both the furniture and all the finishing elements, that allows to quickly transform the room.

Outcomes. The resulting product is a prefabricated room, transportable in three parts and able to accommodate a variety of fit-out changes: the interior is defined by a series of customizable wall panels with foldable furniture and integrated functions; the tripartition of the sub-structures provides the possibility of removing the room and repurpose the building.

Conclusion. The research work started as a concept and it was developed for giving rise to a new approach in design that overcome the old utopic concepts of plug-in architecture. Thanks to the technological developments it provides intrinsic flexibility that allows care quality improvement directly empowering the hospital to update its services during time.

1.0 INTRODUCTION

Current hospitals lifespan is decreasing at a very high rate. Obsolescence rises from the inability of health facilities to embrace changes and it does not allow modifications in time to happen without disrupting the daily routine of patients and hospital staff (Capolongo 2012). The challenge of hospitals and socio-sanitary facilities, as complex constructions, is to be resilient in order to cope with the constant changes that society, medicine and technology are going through. Resiliency is important both at the town planning level and at the architectural level because all the process phases of design, build and management have to be aligned and oriented to the same objective, especially when it is far in the timespan (Fawcett 2011; Allison et al. 2015; Franck 2016). Recent studies in the US healthcare market sector highlight the need of constant refurbishment and repurpose of several spaces even in new facilities, just as an intrinsic condition of the system (Allison et al. 2015). Therefore, one of the main strategies that architects, planners and managers have to consider when approaching new projects, is flexibility.

In design scenario, flexibility can be defined as the capacity of a building to adapt to changing spatial, operational or usage demands whether in short, medium or long term (Capolongo 2012).

It is the adaptability of a system, capable to respond to both technological and structural changes as well as spatial and functional ones (Schmidt and Austin 2016). These changes must face also the issue of being neither disruptive nor needy of demolition since they may also happen during healthcare activities execution (Capolongo et al. 2016).

There are several approaches to satisfy the demand for flexibility and they can be defined as:

- Design flexibility, which consists in planning several design options to satisfy from the beginning many different needs;
- Flexibility of use, which allows the possibility to modify the way space is exploited if new needs arise and may involve short to long-term modifications
- Flexibility of space, which consists instead in making possible changes in the set-up of a room, reconfiguring it over time (Astley et al. 2015)

Those strategies are embedded in two main spatial frameworks:

- Variable Surface Flexibility: the shape and dimension of the building can be increased or expanded vertically or horizontally, acquiring also new volumes
- Constant Surface Flexibility: the volume and dimension of the healthcare facility do not change, so any change happens inside it. This model, which might include the idea of reconversion at the end of life of the structure, addresses the creation of an ending strategy which increases the residual value of the building, since the asset can be used afterwards for different purposes not strictly connected to the previous activities

Open Building (OB) is a design strategy that permits to deal with Constant Surface Flexibility and has been developed since the Eighties by J. Habraken and P.M. Van Raden (Mills et al, 2010). The concept has been widely applied both at the urban scale and at the architectural one with commercial buildings, office buildings and retail buildings but also residential and educational ones.

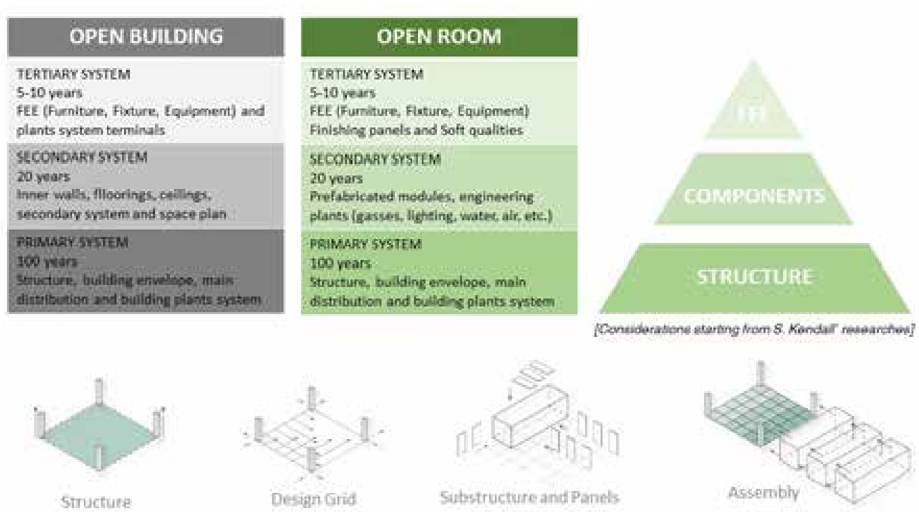
A great challenge is represented by the transaction of OB concepts to healthcare facilities that, due to their intrinsic trend to evolve and change during time, can actually benefit from this approach. In front of several spatial and functional redistributions, there is the attempts to design inner spaces with a high level of adaptability; by reducing excessive and useless dependencies and entanglements among the different components of the project, it is possible to ensure their operation without interference or damage to the others. At the theoretical level it is important to assess a preliminary distinction between durable elements and those that are more prone to be changed and allows easier, quicker and low-cost actions with a greater level of customization (VV.AA. 2011; Davies et al. 2007). Sometimes, this kind of approach can be useful when dealing with quickly changing regulations and strict bureaucracy that does not suit the long timeframe of the designing and constructing process of complex structures (Smith 2011), such as healthcare facilities.

The application of OB approach to this building typology, consists in defining the three traditional OB systems with respect to the possible lifespan and implications for the services held in the spaces, as prof. Kendall (1999) stated:

- The Primary System, also known as Mother System or Base Building, is the long-lasting part, the least changeable one, as encompasses the structure, main entries, staircases, elevator shafts, and so on
- The Secondary or Fit-Out System which is fairly more changeable without disrupting the base building and includes the size of internal spaces, piping, medical gases, etc.;
- The Tertiary System which includes all the fixtures, medical and non-medical equipment and various finishes that intrinsically suffer from the shortest lifespans and need to be changed or upgraded in time

These three levels may also be thought as levels of decision-making processes, allowing managers and hospital managers to have always good choices since they are not predetermined by the container itself, designing a building in which the Fit-Out cannot be allowed to determine the Base Building, but one in which the Base Building is prepared to accommodate a variety

Figure 1: Conceptual evolution from Open Building approach to Open Room features starting from Kendall' researches. Sources: (Authors, 2018) and (OPEN BUILDING group, 2016).



2.0 OBJECTIVE

Currently the State of the Art lists several international case studies that merge the concept of hospital design and flexibility in healthcare, such as Martini hospital in Groningen with a lifespan of 40 years thanks to its drytechnology - design approach, and/or technological solutions in prefabrication by several companies (i.e. Cadolto, HT Group, etc.). As Astley et al. (2015) highlighted, it is necessary a flexible approach because layout changings of healing spaces is a constant prerequisite that should be guaranteed for improving performances and organizational aspects. Starting from the OB approach and the current development of prefabricated technologies in construction industry, a multidisciplinary research group developed and proposed a new approach in flexibility in hospital wards with the concept of Open Room (OR), a hospital room predisposed to respond to several functions.

The objective of the paper is to describe the research project and the results achieved underling the advantages that such innovative approach can assure to the building industry and to the contemporary healthcare real estate market. Through the development of a conceptual design of a hospital room, the research team investigated the multiple possibilities of functional and spatial settings of a prefabricated module able to be implemented into a specific designed structural skeleton. Indeed, the OB approach has been considered as grounding theory for the implementation of a room-scale project (Fig. 1). The current trends have been deepened in terms of technology and application with the objective of a meta-design proposal.

3.0 METHODOLOGY

In order to provide a flexible and industrialized design solution for a hospital inpatient room based on the OB approach, three phases have been carried on within an iterative and responsive multidisciplinary process: a Preliminary (investigation), an Intermediate (exploration) and an Advanced (evaluation) phase (Tab. 1).

In the preliminary research phase, a deep literature review has been undertaken. Through a deep analysis of scientific literature, books and papers, the State-of-the-Art and the current trends of healthcare environment have been clarified. In particular three topics were investigated with specific keywords: i) Theoretical background on OB research and development; ii) Prefabricated rooms design and construction with reference to technological development and innovation in prefabrication; iii) International case studies of built and unbuilt hospitals have been covered with visits on the field (when possible) and in-depth analysis based on OB approach.

In the intermediate phase, the design of the room has been developed considering the Primary, Secondary and Tertiary System issues, descending from OB to OR at a room dimensional scale. The design embeds issues related to structure, architecture, layout, finishing and services, keeping the end-users (patient, visitors, medical staff) at the core of the strategies. This phase has been supported by a series of intensive reviews and focus group with experts, scholars and practitioners in the field of healthcare architecture, industrialized technology and interior design.

In the advanced phase assessment and evaluation activities have been approached with reference to possible construction scenario of the room.

Phase	***Preliminary phase***	***Intermediate phase***	***Advanced phase***
Activities	State-of-the-Art analysis (investigation)	Design development (exploration)	Design assessment (evaluation)
Topics	- Open Building - Flexibility - Prefabrication - Trends in Healthcare Design	- Structure; - Architecture - Layout - Finishing - Services	- Construction process - Evaluation - Scenario
Outcome	Overview of existing needs and trends	Open Room meta design proposal	Future research lines of development

Table 1: Methodological phases. Source: (Authors, 2018).

4.0 OUTCOMES

The research investigates the relationship between design, construction and management in healthcare settings throughout the development of a conceptual proposal for a prefabricated room, the Open Room, able to host different hospital functions during time. The outcome is indeed a prefabricated room, transportable in three parts (Fig. 2) and able to accommodate a variety of fit-out changes (Fig. 3): the interior is defined by a series of customizable wall panels with foldable furniture and integrated functions; the tripartition of the sub-structures provides the possibility of removing the room and repurpose the building (Gola et al. 2017).

Figure 2: Open room subdivided into three modules. Source: (Brambilla 2016).

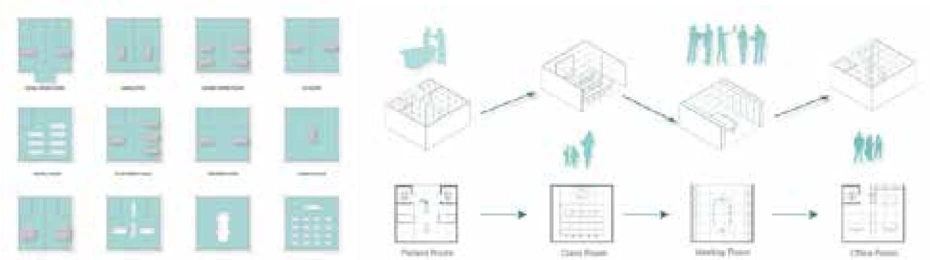


Figure 3: Possibilities of room layout modifications based on OR module. Source: (OPEN BUILDING group, 2016).

This approach grounds on seminal research and design milestones in the history of architecture such as Archigram and Metabolist experimentations from the Seventies but involves a more pragmatic approach, going beyond the radicalism of unbuilt proposals and considering the available technology as one of the main drivers of innovation. Recently, different sectors embraced technological innovation while facing radical market changes and adapting to new demand trends. Therefore, several companies are developing new modular design and construction strategies for example in the hospitality market, such as instant temporary buildings with the so-called *Plug-In approach* of rooms, conceiving the building just as a consumer good which can be easily installed and disassembled (Di Pasquale et al. 2015). This is easy recognizable in container hotels, tubo-hotels, or sleep-box facilities, but also in residential housing market as Kasita start-up demonstrates.
Currently, in hospitals, this approach is adopted mainly for punctual functional units such as operational theatres, sterilization areas or entire prefabricated facilities offering acceptable solutions, as well as the installation of prefabricated bathroom for inpatient wards. Practices show that completely factory-made box with plumbing and equipment can be installed with a significant reduction of time. Starting from those considerations, the design embeds the three OB systems and translate the approach into a room scale as described below (Fig.4).

4.1. Primary System

Also known as the "base building" or "core and shell" (Kendall et al. 2014) in commercial market, the primary system is the decision level with the longest utility value. It includes the bearing structures, the main distribution and the building plant system. It can last up to more than 100 years and it is possible to evaluate its cost incidence between 10 and 15% of the total investment. According to prof. Kendall' studies, the main goal is to assume that the Primary System can accommodate a variety of floor plans and equipment layouts over time. It means that the structure should not be dependent on the secondary system such as the design of a highway is not dependent on any specific vehicle.

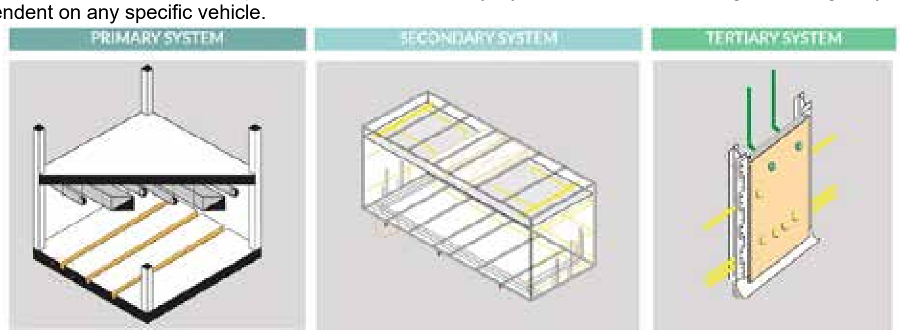


Figure 4: OR Primary, Secondary and Tertiary Systems: it is possible to see how the structural frame (Primary) can host the sub-structural module (Secondary), which is the skeleton of multipurpose panels (Tertiary). Source: (Brambilla, 2016).

In order to apply these concepts to a specific design proposal, many case studies have been analyzed. Starting from the cases described by different scholars and experts of Open Building (Capolongo et al. 2016), the allowable dimension for a structural grid in order to accommodate flexible layouts have been chosen between 7.00 and 9.00 meters. Among the case studies selected for their flexibility strategies, it is important to mention the INO Hospital in Bern, Switzerland (8.40x8.40m), Martini Hospital in Groningen, The Netherlands (7.50x6.00), Humanitas Institute in Milan, Italy (7.20x7.20m). The hospitals have been compared also in terms of functions included into the structural grid. Afterwards, the data have been used to create a structural frame model into the parametric plug in Grasshopper for Rhino using the Mc Neal's Rhinoceros 3D modelling software. Through the parametric approach, it has been possible to create an abacus of possible combinations between the structural grid, the space for the room and the functions allowed inside.
Another important issue faced during this phase was the definition of the design module. It was necessary to define a basic dimension to use as parameter for all the design phases and, in particular, for production. Indeed, many interviews with leading companies in the prefabrication and healthcare real estate field underlined how having a basic module is a fundamental starting point for a successful operation. It should not be neither too small for production and assemblage time waste, nor too big for logistic issues. The analysis of several hospital furniture and spaces led to the choice of a 120 cm module with exceptional submodules of 60 cm. In this way in each space, it is possible to ideally accommodate an infinite variety of furniture and functions keeping a compact and non-fragmented feeling of the space. The combination of those two basic elements helped to define the structural frame as a rectangle of 7.20 x 7.80 m in which several healthcare environments (low and medium care) between 28 and 56 square meters can be hosted.

4.1. Secondary System

The Secondary System, known as "Tenant work" or "Fit-out" (Kendall et al. 2014) is the decision level that generally includes partitioning, ceilings, floor layers, etc. Several scholars suggest specific attention to the provision of Secondary System components that can be rapidly removed, repositioned or replaced with minimal disruption to the Primary. In the same way, the changes made in the tertiary system (upgrades, replacements, substitution) should not disturb or modify excessively the Fit-out level, which usually lasts for about 20 years. This level is the Component level and, in a radical perspective, should include the entire healthcare environment module. The attractive idea of having a single complex component completely built in factory and delivered on site in very short time has been investigated and questioned. Although there are some examples in the hotel design, the concept of a Plug-in hospital is still far for being feasible in the close future. The main issues are the transportation, the logistics of assemblage, the technologies and the implants. The experiences related to the so-called "Container-approach" are constrained by the fixed standard dimension of a single unit which are related to the maximum allowable transportation dimensions (2.55 m width x 12.00/16.50/18.75 m length x 4.00 m height in Europe). On the contrary, the proposed design uses the imposed limits as a resource combining them with the design grid described before.
This process led to the definition of three identical light sub-structural frames with dimension: 2.40 m width x 7.80 m length x 3.60-4.00 m height. These modules assume the role of a secondary system with the predisposition of all the possible implants (Fig.5) such as water, air, electricity, gases, etc.
These modules, in addition, assume the role of a secondary system with the predisposition of all the possible implants such as water, air, electricity, gases. The frame is made of IPE and UPN steel elements dimensioned according to a preliminary load of 1.5 kN/m^2.

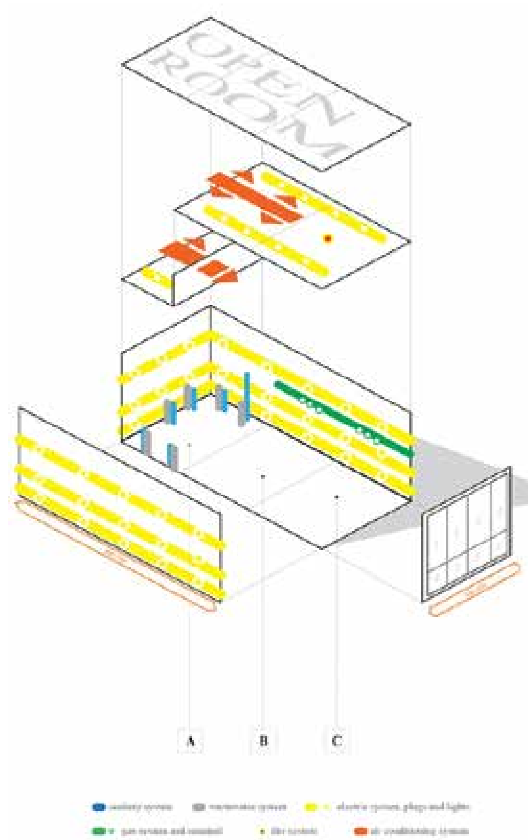


Figure 5: OR – Secondary System, with all the possible installations. A, B and C are the three half-modules. The other halves can host a second room as shown in Fig.2. Source: (Brambilla 2016).

4.3. Tertiary System

The Tertiary system is generally called Equipment and includes all the elements that in the commercial market are defined as FF&E (Fixtures, Furnishing and Equipment) or IO&T (Initial Outfitting and Transition). It includes all the items that, due to an intensive use or the rapid technological upgrades, can last no more than 5 to 10 years. In the specific case, the design solution proposed to address the highest level of flexibility starts from the panel approach studied into during the analytical phase. Using the 120 cm design module is possible to create finishing elements which embed several different functions according to the required performances and general layout.

4.4. Building scenario: innovation in the construction site and module transportation

Starting from the previous considerations and this new approach, focusing the attention on the building scenario, the construction site will be very different from the usual one.

The solution proposed wants to exploit, in the best way, all the advantages that prefabrication and dry technologies determinate: in fact, the three modules prefabricated will be brought by road transport to the construction site (Verderber 2016). After having placed a module on a temporary wheeled support a crane will lift it and slide it into the predisposed Primary System. Once the module has been placed inside the structure the wheeled support will slide out and the workers can start joining the first sub-structure, with its pipes and implants, to the hospital structure in safety environment. The second module can now be lifted and put in place like the first one as the workers continue the joining process, also between the different modules themselves, and, at the end, the process is repeated a third and last time.

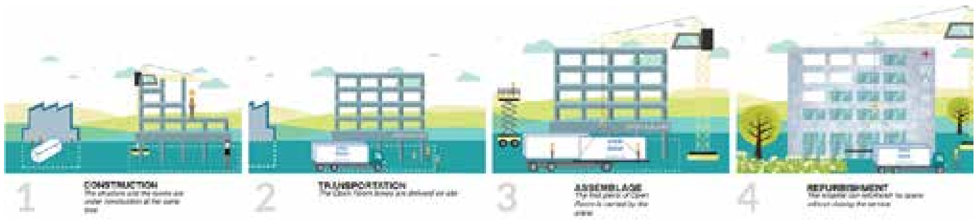


Figure 4: Conceptual representation of the overall OR construction process. Source: (OPEN BUILDING group, 2016)

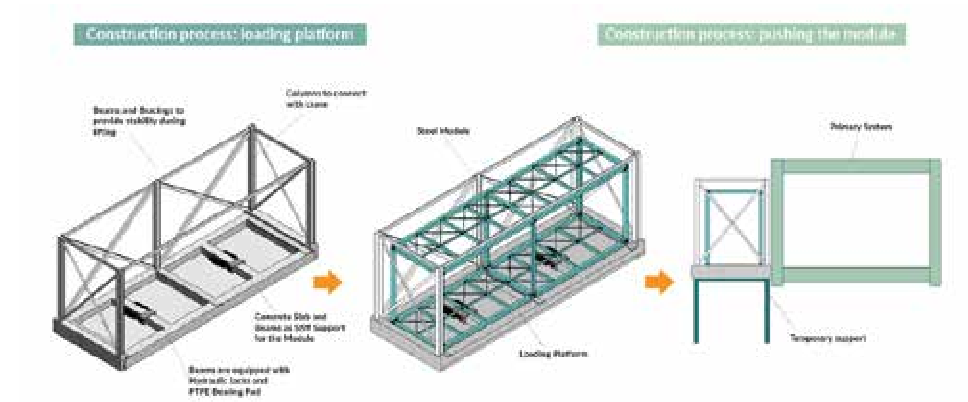


Figure 5: Technical features of the loading platform and the pushing-the-module phase in the Open Room construction process. Source: (HOS.T group, 2018)

It is clear that the modules will arrive at the construction site ready to be plugged-in, that means panels will be already present inside the substructure but some of them will not be jointed if some operations underneath or behind have to be performed (e.g. plugging the gas and water pipes, joints with the structure, air conditioning ducts to be joined, and so on). This building approach has been chosen for mainly two reasons: the first one is a significant decrease in the construction times, which was inspired by the growing tendency of placing prefabricated bathrooms in healthcare facilities; the second one falls directly behind since it involves an increase in the safety of the work environment since the majority of the building operations are performed in the controlled environment of an off-site industrial facility.

5.0 CONCLUSIONS

The Open Room presented throughout this research paper tries to give rise to a new research stream for enhancing flexibility in the future healthcare environment. Merging together different competencies it was possible to achieve a result where technology, layout considerations and soft qualities contribute to a final product easy to realize, fast to assemble and well-integrated into the hospital life cycle, giving also the opportunity to extend its lifespan by means of changing internal functions. Indeed, based on the OB conceptual framework, the OR approach faces the hospital obsolescence issue by drastically increasing the rapidity of construction.

Open Room enhances operational sustainability and allows fast and safe changes in space and functions either in the short and in the long-term period. For short term changes (updates) the flexibility is addressed by the Tertiary System thanks to the easiness of replacing panels. On the other hand, for long term scenarios (changes in functions), the room composed by the three boxes can be unplugged from the Primary System and quickly substituted by a new one or even completely recycled at its end-of-life. In this way, it is possible to achieve what prof. Kendall envisaged talking about the idea of Capacity in Open Buildings*:*

> those making decisions about a capacious container (Primary System) will design it so that those making decisions about what goes inside have good choices. Not only one good choice and several not-so-good choices! (Kendall et al. 2014).

5.1. Future Developments

Eventually, at this stage of development, the project must be further investigated back and forth from academy to industry, in order to define and test different prototypes and implementations in an industrialized production process. Indeed, it is important to investigate the relationship that the Open Room has with different hospital ward layouts. In this direction, it is interesting to evaluate which are the constraints to consider while designing a hospital to host an Open Room system.

The study of interfaces between system levels does not consider that only one single company will deliver the design of OR: in fact, substitutes at each level will be important (i.e. competition) to drive innovation, cost and risk reduction, etc. Therefore, next steps in research will benefit also from assuming distributed control and studying the consequences of that. Collaborations with companies are welcome.

Finally, a further line of research might elaborate and deepen the advantages and disadvantages of designing a whole Open Room line of production into the current Healthcare Real Estate market, taking into account production costs and selling margins (Goulding et al. 2015). In fact, since this new building approach that exploit fully wet technologies is going to be surely more expensive than traditional construction techniques (in short term), an analysis of the returns in terms of saving in scheduled and unscheduled maintenance and overall managerial impacts should be performed in the long term (Olsson and Hansen 2010).

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QUALITY AND CAPACITY OF ARCHITECTURE IN THREE SOCIAL-SPATIAL LEVELS – AN ANALYSIS OF DESIGN BY BEHK

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ABSTRACT: Despite the transformation of urban density into a hot topic in architectural research, and the concept of sustainable city having been long implemented as part of the city policy, in-depth research on the theoretical understanding on the new form of urban complexity or its impact on the spatial quality based on the study of newly built cases has remained lacking. Hence, this paper introduces a theory of Open Building and Infrastructuralism in Architectural practice. The observations are based on the classification of three social-spatial levels with focus on the performance of public space, adaptability of the buildings and interactive with users. After introducing and formulating the research objectives and methodology, this paper investigates three recent completed projects, carried out by Baumschlager Eberle Architects (BEA) Hong Kong. As a participatory research, the paper analysed the quality and capacity social interactive spaces in three different scales, public spaces, building and interior refurbishment. The paper addresses the importance of the atmosphere as design quality and interactive procedures in the design process. The research concludes that a typological difference among the capacity of built environment in different levels. In the urban public space, the high capacity addresses the importance of safety and comforts with identity of community. On the building level, a neutrality of plan is important to accommodate a diversity of occupancy groups. On the infill level, interaction and operable instruments are the keys to fulfil and stimulate both multiple programs and temporary identities.

KEYWORDS: Sustainable Architecture, Open Building, Infrastructure, Capacity, Interaction

INTRODUCTION

Sustainable urban complex needs to address at least two issues beyond programs and energy efficiency:
The issue of time: To ensure that a building can last as long as the physical structures allows, it has to be flexible and adaptable enough to accommodate changes of uses, circumstances, and as many as unforeseeable matters as possible, arising from the building's service period.

The issue of people: the real people beyond any statistics, function or program of use made by programming. If pluralism is the word characterizing the conceptions and behaviors of the people of today, no building can ever be satisfactory without interaction by everyday use. People collectively and individually look for opportunities to change and adapt to their environment.

As early as the 1960s, N.J Habraken considered two lines of development for housing. On the one hand, the occupant had to be reintroduced as an actor in the building process in order to restore the natural relation between the user and the dwelling (Jia 2001): "Dwelling is after all doing something; it is the sum of human actions within a certain framework, within the protective environment created by man…" (Habraken, 1972: P18 a) As he continued in the book, "Supports: An Alternative to Mass Housing", the dwelling is indissolubly connected with the building; the building and the dwelling together comprise the notion of man housing himself: "Dwelling is building". (Habraken, 1972: P18 b) On the other hand, in the contemporary world, technical solutions had to evolve to give households the opportunity for full control over his/her environment. A building production process, both rational and industrially based, should develop in such a way that the occupant can choose and directly show interest to the producers. Open Building is the concept and practice along with the understanding above, but not extended the concept into Architecture – not constraint within residential buildings.

For Habraken and Open Building, the issues are not only technical but social. The built environment should be understood as territories controlled by different powers. A territory means a space, or an arrangement of spaces, that is under control of one power (Habraken, 1983: P29). And by using "power", Habraken gives people in any built environment, or any person or group of persons, the ability to change the physical reality of the territory (Habraken, 1983: P15). The territory is never homogeneous. Instead, there are physical hierarchies responding to the impact of the people. For instance, a building can be understood as Support or base building, and Infill. "Typical support elements include building structure and facade, entrances, staircases, corridors, elevators and trunk (main) lines for electricity, communications, water, gas, and drainage." (Kendall and Teicher 2000: 33). Habraken mentioned a group of infill examples, including external wall elements, internal partition elements, floor elements, storage elements, doors, kitchen elements, bathroom elements, and so on. (1972: P 63) Age van Randen provided four categories:

1. The spatial layout of the house and
2. Its necessary elements such as inner partition walls, frames, doors etc.
3. Equipment found in the kitchen, sanitary fittings and appliances and, last but not least,
4. The part of the installation determined by the layout. (1992: P.82)

These two opposing, strategic directions – Infill development and Support development not surprisingly, are based on the same understanding of the diverse and changing needs and circumstances of our world today. Both recognize that it is the responsibility of the architectural profession to take this diversity and change into consideration. (Jia 2007:9-10)

The base building or Support is the platform where varieties and changes and interaction with people in the life time of the building can take place. According to the theory of Open Building, the quality of base building includes, if not limited to, architectural and tectonic quality, permanency, adaptability, simplicity, public spaces, energy saving service systems. Among them the architectural and technical quality, and the design of the pubic space requires design skills partially borrowed from traditional architectural discipline. (Jia 2010) "As a result, it will become far easier for architects designing Supports to refocus on traditional; aspect of architectural; for and public space, on the building's tectonic qualities, spatial experience, facade and definition of public space and urban character." (Kendall and Teicher 2000: 191)

The building understood as combination Support and Infill. There is another level called urban tissue representing and controlled by common value and service of community. There are elements such as streets, plazas, pedestrian network, shopping mall, community center, drainage system and power supply etc – they are civilized infrastructure. Stan Allen summarized 7 characters of infrastructure, with which he believe new architecture interventions can corporate (Allen, 1999, p.54-55). Infrastructure prepares the ground for future building and creates the conditions for future events. The provision of services to support future programs; and establishment of networks for movement, communication, and exchange. They are flexible and anticipatory. Infrastructure work recognizes the collective nature of the city and allows for the participation of multiple authors. Infrastructure creates a directed field where different architects and designers can contribute, but it sets technical and instrumental limits to their work. Infrastructures accommodate local contingency while maintaining overall continuity. Although static in and of themselves, infrastructures organize and manage complex systems of flow, movement, and exchange. They create the conditions necessary to respond to incremental adjustments in resource availability and modify the status of inhabitation in response to changing environmental conditions. Finally, infrastructures allow detailed design of typical elements or repetitive structures, faciliting an architectural approach to urbanism.

However, Infill, Support or Infrastructure does not answer quality of perception of space. we develop a sense of the space largely from visual perception. Atmosphere is concept of the perception of a space. Although an urban space is a highly complex web of many individual components, we usually absorb it immediately and with all our senses: when we step into the space of a street or a square, we form an intuitive impression of its appearance and scale, which triggers a subconscious chain of associations without having consciously grasped every detail. Atmosphere involves a mix of sensory perceptions, i.e. hearing, smelling and touching etc. This preconceived mood will often determine whether we use it intuitively relaxed and feel comfortable in relation to it. All these is based on a sensory code, through which we communicate with the space. (Eberhard,2015 p36)

Infill, Support and Infrastructure are conceived as three levels of Architecture. Each independent from the upper level has its own quality and design principles. It allows changes and diversity of use in the lower level. The following paper introduce three latest projects in China designed by Baumschlager Eberle Hong Kong Ltd, in which both authors plays key role. Baumschlager Eberle Architectes (BEA) originated in Austria 1985. It has been recognized as leading company in Architectural design of sustainable buildings, in which the longevity, flexibility, passive energy and high quality of user-friendly design are the important components.

1.0 INFILL – A SHOWROOM OF 300 SQUARE METER

The project accomplished multiple quality of a showroom to highest standards. The showroom of 400 sq.m. accommodates a high complexity of exhibitions and information in simple, intimate, comfort space. It is also credited for integration of multiple interactive digital technology for presentation. The visitors are encouraged to participate into the presentation from touching screen, interactive 3D imaging, to operable partitions which combine and divide the space. The sliding exhibition panels motivate the architectural space into a Time-Space: the spatial experience changes with the theme of exhibition and movement of visitors. The atmosphere of simplicity and high-level comforts were achieved by sensitively implementation of adjustable lighting, acoustically sound material, and thermal insulation of double layered envelope which helps also in saving energy. A "mini bar" - a sliding cabinet make the ending of the visit become of party, or a small social event. The project promotes traditional Chinese and Japanese architectural characters with movable screen walls and permeable space. It also makes exhibition room into a social place by using operative and interactive presentation technology.

Figure 1: The atmosphere and the interactive partitions

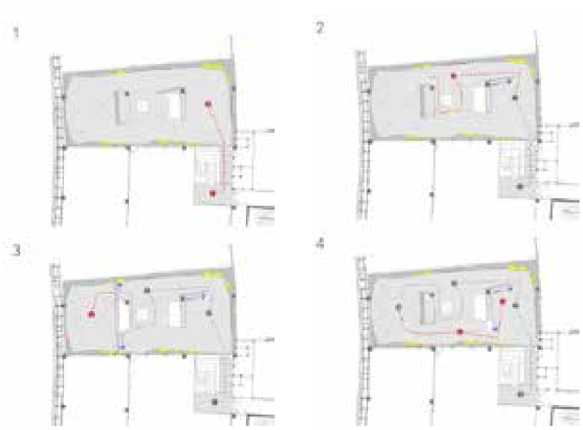

Figure 2: Infill components in the existing building

2.0 SUPPORT – ENGINEERING FACULTY IN 9400 SQUARE METERS

This project follows the overall concept structure of the campus, integrated in pedestrian flow and the topography. As the landmark of the northwest campus, the massing emphasizes the architecture integrity. The engineering school has 2 U-shaped courtyards, which have openings towards 2 hills at the southwest with landscape successfully utilized. Overall, the unleveled roof, which is lower at east/south and higher at west/north, fully reflects the consideration of terrain and the respect to context.

The design fully reflects the dignity, simple and economic features of the university architecture. However there are nine departments in the faculty. Each of them had an intension to accommodate the research lab, administration, and professor number with assistant ratio based on their own chose. However, at design stage none of them could actually a concrete program. On the technical aspects, the research labs are very different from one department to another. The project adopted an neutral based building system, efficient floor plan, sufficient service cores for research labs, but open for varieties of layout. During the design process, the constant changes of requests raised by departments could easily integrated and accommodated. Among the four projects carried out approximately the same time, the Engineering Faculty run most smoothly. Actual final build-up will be exactly the same as initial competition project at the very early stage. Thanks for the strategically laid-out base building.

Through careful design of every detail, the project not only fulfills a highly diversified research labs, and constant changes of the faculties, but also considers the humanity design principles by the well elaborated indoor and outdoor space and green architecture strategies.

Figure 3: Base building shaping with surroundings

Figure 4: Base Building plan and the atmosphere of research lab.

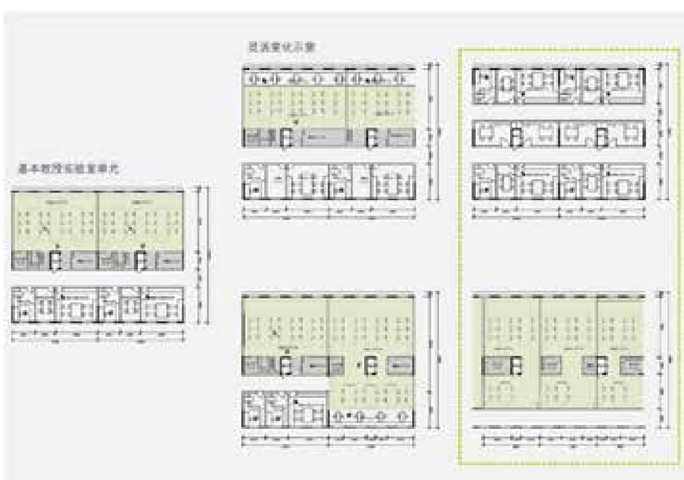

Figure 5: Variety of floor layouts

3.0 INFRASTRUCTURE – A HIGH DENSE URBAN COMPLEX IN 370,000 SQUARE METERS

Given the prominent location of the site along a major traffic axe to Wuhan city centre, facing to a park and its proximity to the Yangzi River to the North, and large new housing development to the South and east, the design proposal emphasizes the middle and lower income neibourhoods of iron and steel industy in the area. It is characterized by the flowing open space offering multiple possibilities of dynamic functional arrangement and unobstructed movement.

With its soft curved lines and bold volumes, the “InCity” city reveals strong formal and spatial characteristics which clearly distinguish it from other developments and parts of the city and durably imprint it in the memory of residents, users, visitors and by-passers. The formal innovation in design was one of the factors leading to selection of the project in a limited competition (Figure.6) .

Preliminary and foreseeable study of the project of clients resulted in integrated and high dense development concepts before the architecture completion was invited. These concepts were further enhanced by the Architectural design concepts. The project is required to be integrated into the city. The multiple levelled and smooth flow of pedestrian and open spaces connects and opens to surroundings in various directions, including the Pease Park in the north. The distribution of open areas results out of the profound analysis of the surrounding neighborhood. The outdoor space takes up major existing axes and creates a carefully staged movement network on the site. Continuously flowing, it opens towards the Wuhan Peace Park and extends the green belt into the site, while it varies in width between the single buildings to form a sequence of exiting spaces with different character, ranging from large plazas to intimate secluded gardens.

Figure 6: Urban tissue and partial floor plan showing urban space network

The formal quality of the design was also required and objected in the conceptual design. Divided by the open and green public areas, the retails space introduces a new shopping concept. The shopping mall is not any more, as otherwise usual, an introvert mega structure. On the contrary, it stretches out and over the outdoor areas and merges with the surrounding. The commercial complex divided by open and green public spaces, and connected by bridges and pedestrian networks, is an ideal solution for the business of the retails and quality of public life. Retail shops are open and easily accessible from outside to inside, and from inside and outside. Multiple levelled bridges take the pedestrian flow of the ground and elevate it in the vertical. Playfully connecting the different volumes, the maze of bridges interlaces the in- and outdoor space, turning the architecture into a thrilling background for public space. The characteristic public space shaped by the retails on multiple levels invite people to stay.

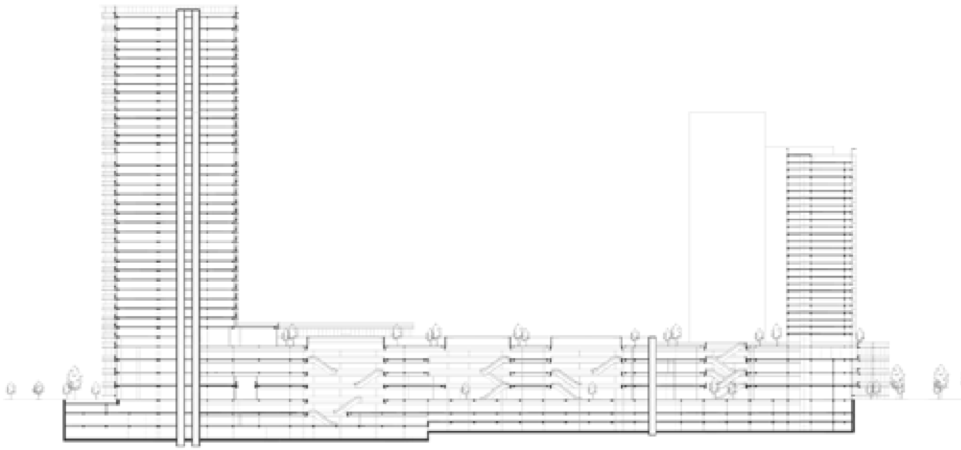

Figure 7: Section of the urban complex

The long-term flexibility which was both required by the clients and encouraged by the architects is also implemented in the conceptual design. One of the dynamic concepts creates an “alive” building - not only because of the interlaced in- and outdoors spaces, built and natural environment, but mostly because of its flexibility and openness towards future requirements. The open floor plans based on a rationally gridded load-bearing structure allow the buildings to easily adapt to and adopt changes such as adjustment of size or function. On functional level, the retail space could easily turn into office or public building, the residential tower into office or vice versa.

Figure 8: Views and atmosphere of indoor and outdoor urban spaces

4.0 CONCLUSION

Open Building concept opens up a new horizon to achieve sustainable future in Architecture. It responds the changes of social needs, diversity of demands in the design process and life-long of the buildings. By understanding the building in three levels, the designers can focus the specific property of the building and uphold both quality and capacity.

However, in practice Open Building service as both conceptual tools and construction tactics, it is not generalized purpose. The three cases introduced in this paper represent specific needs and context. Only by addressing the specific of each project, can the concept and techniques achieve the coherent unity which is architecture of high quality.

Open Building in practice is more than a design strategy. Good architecture is about human scale, the identity the local community, and relaxation of pedestrian movement, the attractive place where people can stay, the protections from climates, and most importantly, the surrounding activities where people can participate. The atmosphere and activities both contribute to the quality and liveliness of a place.

ACKNOWLEDGEMENTS

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EFFECTS OF THE KEP ADAPTABLE INFILL FOR AGING RESIDENTS

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ABSTRACT: The author reports the results of the post occupancy survey of the aged residents who have been living in KEP housing in Tama UR housing estate in the western suburb of Tokyo. From 1973, the Ministry of Construction and the Japan Housing Corporation (now known as the Urban Renaissance Agency) initiated the research and development of the Kodan Experimental housing Project (KEP), which developed moveable partitioning and storage systems to allow residents to alter their living environments themselves. The previous surveys were first conducted in the next year of its completion of the housing in 1982 and were followed in every ten years after. This paper reports on the survey that was implemented from December 2017 to January 2018. The author found the aged residents have renovated the infills to make their lives comfortable and allow them to live as long as possible as they wish.

KEYWORDS: Adaptability, Infill, Housing, POE

INTRODUCTION

The author investigated the housing estate "Tsurumaki -3" of Tama New Town in the west suburb of Tokyo. It was the first experimental project, named KEP (Kodan Experimental housing Project) which Japanese Housing Corporation started in 1973 in order to research and develop the flexibility and adaptability of housing. Because the average years to be rebuilt of housing in Japan used to be almost 30 years, the government and private sectors started the research and development projects to design and build longer life housing with adaptability in time, such as KEP (Kodan experimental housing project) and CHS (Century housing project) [*6, *8]. The author has analyzed the outcomes of those experimental projects to examine the attempted adaptability have worked or not in these thirty-five years after people lived in.

1.0 POE of KEP Housing

1.1. Research purposes

In the last survey implemented in 2015 [*7, *9], the author realized that the aging residents in "Tsurumaki -3" of Tama New Town have many problems to continue to live and decided to study their problems in December 2017 and January 2018 which was 35 years later after the first residents started to live. The most important object of this research is to investigate how residents have adopted the design concepts to suit their individual needs and how they have adapted their living environments to changes in their lifestyles over time by remodeling rooms and changing the position of partitions, especially that of KEP movable partitioning system (Figure 1).

1.2. Research methods

This paper tries to find out the effectiveness of the movable building elements with flexibility and adaptability by Post Occupancy Evaluation (POE). First, the author developed a questionnaire survey for the residents. We asked the res-idents if they had altered the room arrangement by changing the position of the KEP movable partitioning system or by using a conventional partitioning system. Similar investigations were performed in 1982 (just after the completion of the estate) by Prof. Hatsumi and Housing and Urban Development Corporation, Japan, and in 1995 by Prof. Hatsumi. The author and the students of Shibaura Institute of Technology have conducted the similar surveys in 2005 [*1], 2014 and 2015. The author has analyzed the transformation of the room layout of each unit through more than 35 years by comparing the results of the studies made in 1982, 1995, 2005, 2014 and 2015.
In the Tsurumaki -3 estate, there are 192 units in four-story flats and 29 units in two-story terrace houses to own (Table 1, Figure 3,4). There are three main types of plans for units in the estate: A, B and C. Type A can be subdivided into types A1 - A3, Type B into types B1 - B5 and Type C into types C1 - C4, for a total of 12 types of units. Type C units are not equipped with the KEP movable partitioning system. Figure 1 and 2 show the plans and the location of the movable partitioning system in A3 and B4 type of unit.

1.3. Attributes of residents

63 households living in the apartment of “Tsurumaki -3” answered the questionnaire in 2014. 56% of them was in their 60s or older than that (78 out of 140 residents). In 1983 one year after than people started to live in the estate, only 4 residents out of 516 residents who live in the apartment were in their 60’s or older. In 1983, 49% of the residents were in their twenties or younger than that (254 out of 516 residents), but in 2014 only 12% were in their twenties or younger than that (17 out of 140 residents). The aging of the residents is obvious. 36 families out of 63 families which answered the questionnaire in 2014 were the households of couples which have no children to live with.

38 families in the apartment and 9 families in the terrace house answered the questionnaire in 2018. All of them own their property and most of them have been living since they bought their house in 1982 or 1983. Almost all residents who answered the questionnaire have willingness to live in their house as long as possible but some aged people are not sure it is possible in their future.

1.4. Changes in the room arrangement

As children grew, and when they left home, many families used the KEP partitioning system to adjust the room arrangements to fit the changes in their lifestyles. The KEP system appears to have worked the way it was planned to more than thirty years ago.

Figure 5 shows an Example of layout changes and renovation of a terrace house. The family bought this unit and renovated all infills before they started to live in 2005. The wife opens cooking classes six times a month so she designed an open and wide kitchen. The designed the house as open as possible while their child is young and renovated the second floor again to have a separate room for parents and more storage space in 2017 when their son became 10 years old as they planned at the beginning.

Figure 2 shows an example of layout changes and renovation of a unit in the apartment. The residents have been living in this unit since 1982 and renovated all interior finishing in 2002 immediately after their children left home. The move the KEP movable storage and make their living room wider. They change the KEP movable partition wall which divided rooms in north to solid stable wall at that time.

2.0 Renovation of infill

Figure 6 and Figure 7 show the history of renovation works in each dwelling unit from 1982 to 2017 entered by year period. Each row shows the dwelling unit renovation history of one household. The white part shows residency period of the first family, and the grey parts show the residency periods of the second or third families. In years indicated by the symbol "◆", renovation work was done, and the letters of the alphabet in the table indicates the contents of renovation works. We can find that when new residents moved in, they often renovated the infills regardless how old their units were. The renovation was necessary for new family to adjust their unit for their life style. We can also find that the sanitary spaces such as bathroom, toilet and kitchen have been fixed and renovated in every ten to fifteen years both for the units in apartment and terrace houses. This might be because of the changes of the lifestyles in Japan in these three decades.

By conducting the interviews to the residents last winter, the author found some of the aged residents have little willingness to renovate the infills of their units because the apartment has no elevator in its common space. The apartment has several steps to climb up even for the first floor units so it has no sense to renovate the interior of their units for the wheelchair. One of the aged residents who lives in the terrace house experienced the difficulty to use steps in front of her entrance when she suffered pains in her knees. The aged residents think they will move out to the apartment equipped with elevators when they become hard to use staircases. Even though, the author found infill renovations to improve the life of aged residents have been conducted in some units such as adding handrails to corridors, toilet and bathroom, deleting the gap of the floor finishing, changing the material of floor finishing from slippery wood floor to non-slippery carpet, widening the width of the door to the toilet and changing the toilet door to sliding door. All these small renovations help the aged residents to live comfortably and continue to live in their house as long as they wish before they finally move to the other apartment equipped with elevator or to the aged people’s house with care.

Table 1: Information about surveyed housing Source: (Author 2018)

Name	Tsurumaki -3 of Tama New Town
Address	3 Choume Tama, Tame- city, Tokyo
Site Area	27700m2
Building Type	4 stories apartment and 2 stories terrace house
Time of Occupancy	1982 (apartment), 1983(terrace house)
Structure	Reinforced Concrete Structure
Number of Units	192 units (apartment), 29 units (terrace house)
Average Area per Suite	87-89 m2(apartment), 99-106 m2 (terrace house)

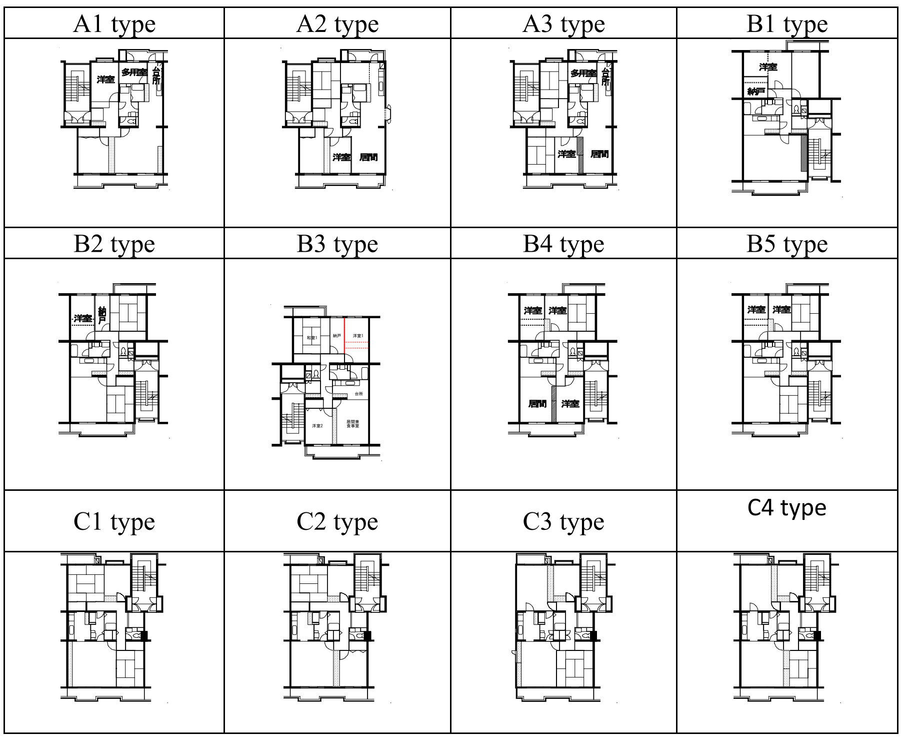


Figure 1: The plan of each type for the four stories apartment Source: (Author 2018)

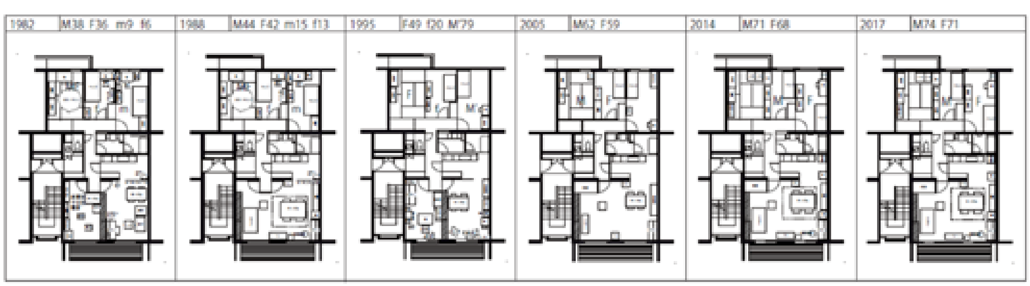
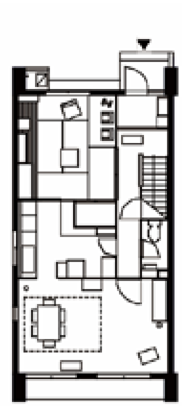
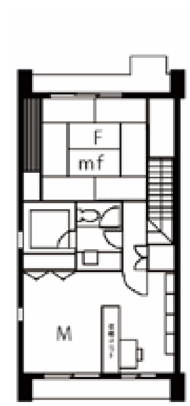
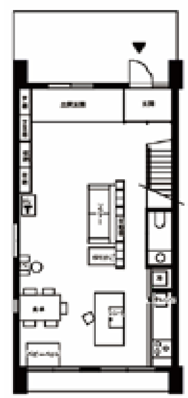
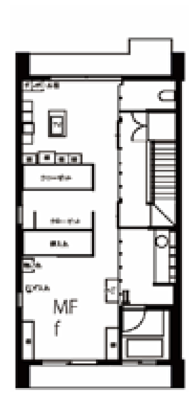
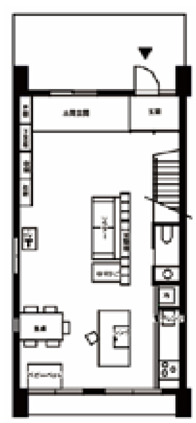
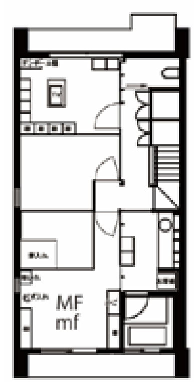


Figure 2: An example of layout changes and renovation of a unit in the apartment Source: (Author 2018)

Figure 3: The four stories apartment
Source: (Author 2017)

Figure 4: The terrace house Source: (Author 2017)

Figure 5 (Right): An Example of layout changes and Renovation of a terrace house
Source: (Author 2018)
The alphabetic letters entered on the dwelling floor plans shown indicate the family members using the rooms as bedrooms or as private rooms. The upper-case letters indicate the head of the occupying family and the head's spouse, while the lower-case letters indicate their children. A male is indicated by "M" or by "m", while a female is indicated by "F" or by "f", and the numbers following the letters indicate age.

	1st Floor	2nd Floor
1983		
2006		
2017		

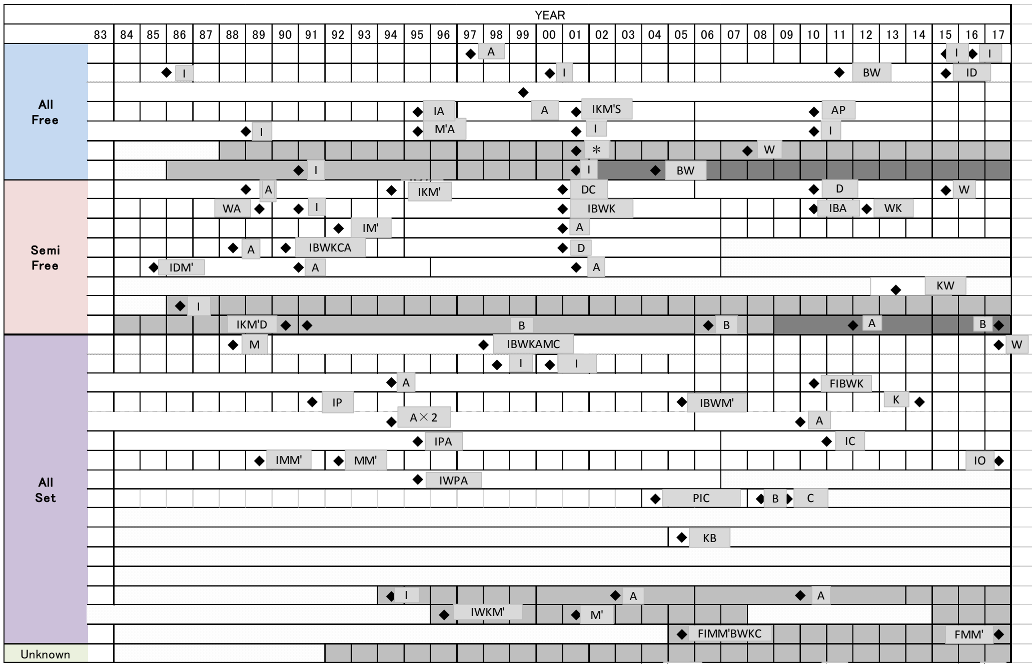
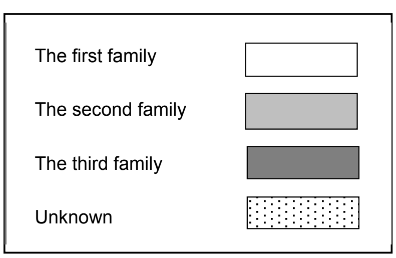


Figure 6: History of renovation works in each dwelling unit in the terrace house from 1982 to 2017 Source: (Author 2018)

Index for Figure 6 and Figure7

W: Toilet, Washroom
B: Bath
K: Kitchen
C: More storage, Less storage
I: Replacing flooring, tatami, Repapering windows, Recovering wall, Ceiling, Interior finishing
S, M: Change of room layout
P: Removing Japanese room
F: Comprehensive renovation of exclusive use areas
O: Water heater
D: Repair of doors



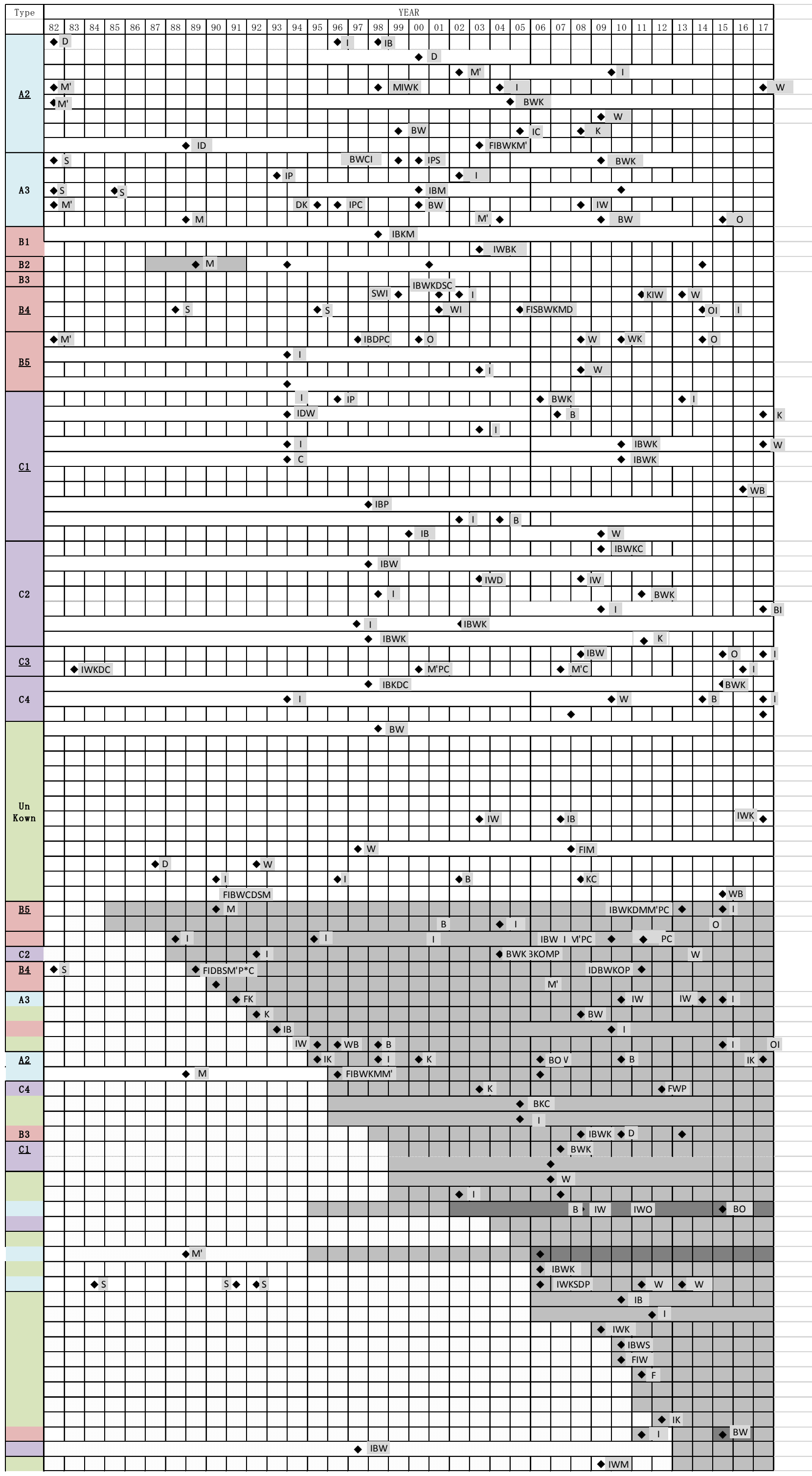


Figure 7: History of renovation works in each dwelling unit in the apartment from 1982 to 2017 Source: (Author 2018)

Table 2: Renovation in the past 35 years Source: (Author 2018)

Contents of renovation		Number of Cases: Apartment	Terrace house	Total	Contents of renovation		Number of Cases: Apartment	Terrace house	Total
Sanitary	Toilet Washstand room	57	14	71	Change of room layout	Movable KEP Storage unit	17	0	17
	Bath room	50	11	61		Fixed Storage unit	0	0	0
	Kitchen	39	10	49		Movable KEP Partition wall	14	6	20
Interior	Reflooring	52	22	74		Fixed Partition wall	15	11	26
	Replacing tatami	6	1	7	Transform Japanese tatami room to western style room		14	4	18
	Replacing wall paper	56	17	73	Transform western style room to Japanese room		0	0	0
	Windows	5	1	6	Complete Interior renovation		10	3	13
	Ceiling	32	10	42	Hot water supply		5	3	8
	Interior finish	11	5	16	Doors		18	5	23
Storage		15	5	20					

3.0 New technologies for infill

3.1 Relocatable kitchen and movable partitions

A number of recent technical innovations show the potential for even greater flexibility in both new and existing housing stock [*2, *4, *10]. Mitsui Real Estate has sold six units of apartments in Akabane-nisi in which division storage walls can be installed and moved by residents in the same manner as furniture. Although bathrooms are fixed, the remaining space is free for the residents to plan. The idea of the movable partition and storage is basically the same as of the KEP infill system. Even kitchens can be relocated to any of seven optional positions including in the center of the apartment by preinstalling the gray water pipes in the raised floor. The wheels under the kitchen units allow them to be relocated in seven alternative places in the room. The cooker hood on the counter draws away cooking smells and returns cleaned air back to the apartments. The author visited the units and found some of the families move the movable storage walls once in a while to easily make a temporary bed room for their guests.

3.2 Zero slope gray water drainage pipe

Three companies – Nomura Real Estate, Haseko Corporation and Bridgestone – have developed a zero-slope gray-water drainage system to permit flexible positioning of apartment kitchens and have sold an apartment in Mitaka, Tokyo in March 2018 followed by several different types of projects. These companies continue their R&D and applied their zero-slope drainage for the bathrooms and washing machines in the new apartment for the workers of Bridgestone company in Totsuka, Kanagawa prefecture which is expected to be finished in March 2019. In the zero-slope siphonic drainage system, soil pipes run horizontally, allowing a much greater range of locations for bathrooms and kitchens. Traditional soil pipes are larger in diameter and require falls, taking more sub-floor space and restricting spaces for kitchens and bathrooms to be located close to vertical pipe shafts.

The height of each floor of this project is 3020 mm which is a bit higher than that of ordinary Haseko housing which is 2970 or 2920 mm. The diameter of the zero slope pipes is about 20 mm and pipes are installed in the raised floor whose height is about 150 mm. The finished floor is 200 mm above the structural floor slab which has 200 mm thick. The raised floor system is made of low-cost material such as plywood panel supported by steel posts and hard rubbers. The rubbers absorb the sound and vibration transmitted form the upper floor to the lower floor. The length of the steel posts can be easily adjusted to make the finished floor flat even if the surface of the structural concreate slab is not very flat. Contrast to the gray water pipes which could be located freely in a unit, the black water pipe is located at the fixed place in the middle of a unit. In their early stage of R&D, three companies used the disposer to grind the kitchen waste but now they do not use disposer. Instead they use some filter to separate kitchen wastes. Developers tend to reduce the height of apartments to minimize the cost of construction. Also we have regulations to control the maximum height of buildings in residential areas. From this point of view, reducing the height of apartments by only 50 mm is important for the developers. In Japan, we have a large number of old housing which need to be fixed and renovated [*3, *5]. Almost all of them have limited floor heights, and this new technology that enables to layout pipes freely helps us to renovate the existing apartments.

CONCLUSION

The author found some residents renovated the all infill of their units by using the KEP movable partitions and storage systems and some residents did not. As children grew, and as they left home, some families used the KEP system to adjust the room arrangements to fit their changing lifestyles.

The infill system for housing must be adaptable to changing lifestyles of residents and must be easily fitted and removed. The infill needs to be as simple as furniture, easily to be built on site and can be replaced easily by the residents and users. One resident said that he bought his house 35 years ago because that KEP movable partition walls and movable storage system would help his family to change the layout of their units in order to adjust their life style easily. In fact, his family has not moved KEP partition walls or KEP storages, but knowing the easiness to move them he came to think his family’s future life would be flexible. He said the architects should realize this effect which the architect originally planned.

The author thinks the continuous research and development of adaptable housing in Japan from KEP, CHS (Century Housing System), KSI (Kodan Skelton Infill) to the establishment of the long fife housing law and the recent development of the zero slope gray water drainage system by the collaboration of the government, private companies and research institutions have been one of the most essential forces for the development of adaptable and sustainable housing in Japan.

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A STUDY ON THE DEVELOPMENT OF LONG-LIFE HOUSING SUPPLY MODEL AND FIELD-TEST

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ABSTRACT: This research was undertaken as part of a national R&D research project on “development of cost effective long-life housing and construction of field test.” The aim of the research is to investigate long-life housing certification systems as well as construction expenses and technologies associated with long-life multifamily housing units, and then to verify the findings through field test. The achievements made in the research can be utilized to establish related design guidelines, law amendments, and technological advancements to be applied in the industry. Long-life housing model was developed for apartment houses in Korea, which considers space use Korean’s characteristics. Currently, the design of the long-life multifamily housing supply model has been completed, and construction of 2 buildings (116 units) for field test of verification purposes is underway and scheduled for completion in 2019. This paper provides an overview concepts of long-life housing, as well as contents regarding supply models and cost saving designs. Further the construction of buildings for field test has also been included. The following research topics were included in this study. First, an overview of the concept and conditions of long-life housing, and an explanation regarding long-life housing certification system the concept of developing cost effective, long life housing are provided. Second, based on the long-life housing certification system supply models its performance goals for each grade are proposed. And the cost and performance levels associated with Good Grade models that meet the goal of saving costs are reviewed. Third, the designs and applied technologies for long-life housing units for field test ware explained.

KEYWORDS: Long-life housing, Supply Model, Field-Test

INTRODUCTION

A long life-housing in Korea means a house with high durability, flexibility, and maintainability that can be accommodated for a long time (ex 100 years) due to easy replacement and change of the infill while maintaining the performance of the support for a long time. In Korea Housing Act, "long-life housing" means housing which has a durable structure that can be maintained and managed for a long time, whose variability allowing easy alteration of internal structures as residential demand and ease of repair are excellent.

However, in Korea, long - life housings were not built to fit these definitions. Through the study, basic concepts and some mock-up housings were constructed, and houses with only low performance levels of durability, flexibility, maintainability and were built. In Korea, it is not being built in the housing market because of the perception of housing industry decision makers that "long-life housings will have higher construction costs due to higher levels of performance." Although some infill parts and technologies have been developed for long-life housings, there are not many areas that actually apply to the site because of the high cost. In recent years, the Korean government has recognized that it is necessary to expand the supply of long-life housing in order to improve energy efficiency and resource conservation at the global level, improve housing performance, maintain housing stock and improve people's quality of life.

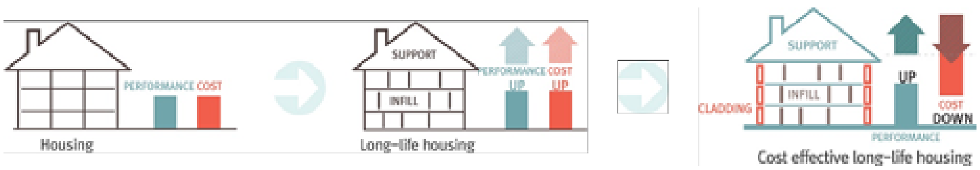
1.0 Direction of cost-saving long-life housing development

The final paper should not exceed 4000 words or a total number of 8 pages maximum, including abstract, references, endnotes, figures and captions. File size is strictly limited to 5mb. Authors should optimize graphics (i.e. size and resolution appropriate for this format). Graphic resolution should not be any lower that 150 dpi for print quality. Separate images may be requested for the production of the proceedings.

Based on the current situation and problems of the Korean multifamily housing, we have set up the following direction for developing the supply model of the long-life housing.

First, based on the situation of the multifamily housing market in Korea, we apply the concept of long-life housing and the necessary technology to solve problems after identifying characteristics and problems from the viewpoint of longevity, apply the concept of long-life housing and necessary technology in order to solve the problem. Second, we propose a model plane plan to reduce the construction cost while satisfying the conditions of the long-lived housing approval system. Thirdly, based on the proposed model plane, we study the implementation design applying technologies usable in South Korea, propose improvement plan through demonstration construction, and disseminate results.

Table 1: Development of cost-effective long-life housing model



Definition : Housing which has a durable structure that may be maintained and managed for a long time and whose flexibility allowing easy alteration of internal structures as residential demand and maintainability are excellent (Article 2 of the Housing Act)	Development of long-life housing technology at the level of general housing construction cost.

2.0 Characteristics and problems of Korean apartment housings

From the point of view of long-life housing, the characteristics of apartment in Korea are as follows.

First, the concepts of distinction and separation between support (such as structures and common facilities) and infill (such as private equipment and interior parts) does not applied in apartment housing design. That is, the concept of Support and infill has not been established and it entangled such as structural system, toilet piping system, position of common piping shafts, piping and wiring buried in structure and light weight concrete, wall joining method difficult to dismantle and move etc.

Second, Korea's new apartment complexes are generally 20-30 floors, and high-rise houses higher than this are increasing. Nevertheless, the structure of apartment housing is bearing wall and slab system. Most of the inner wall that divides the room of the unit and the outer wall consist of concrete bearing walls. Therefore, housing has a limit in that it has a uniform spatial structure that cannot accommodate various life styles or life cycle of residents. In other words, there is a lack of space flexibility in response to the diverse and changing needs of residents. Since the interior of the unit is a structure with almost no built-in lightweight walls, the development of the infill parts industry like a wall is a cause of delay, and it acted as a cause not requiring the development of a movable lightweight wall.

Third, it is a wet type construction method that put concrete on site. It inhibits the development of dry type infill parts and construction method. Office buildings in Korea are being constructed in column and beam type, and internal partition walls in dry type. However, almost all apartment houses in Korea have a generalized bearing wall and slab system. Since the structure system of the apartment house is generalized as the bearing wall and slab system, there is no need of dry wall. When the structure construction is completed, the construction work ends with wall paper finishing. However, in recent years, a dry wall system has been partially introduced to some walls in order to change architectural construction conditions and partially change the room.

Fourth, a construction method of burying piping and electric wiring in a structure or lightweight concrete has been generally used. Ondol heating piping, which is a unique floor heating system in Korea, is also embedded in lightweight concrete. These construction methods have the problem of making it difficult to maintain inspections, repairs, exchanging, etc. of piping and wiring and to increase the cost of remodeling.

Fifth, common piping space is located inside the unit, or there is no check point and access door for common piping. This has limitations in maintenance. Sixth, upstairs toilet piping system (sewage, drainage) is located in the lower floor ceiling, which has a limitation on the arrangement of the toilet space and the influence of the noise on the lower level unit.

3.0 The concept of long-life housing and comparison of existing housing

3.1. Concept of long-life housing

It is possible to realize a long-life housing through SI distinction and separation design. “S” means support and

“I” means Infill. It is a kind of open building concept. Open building concept is a distinction between Support and Infill with different characteristics. We start by physically separating Infill from Support and designing it. Support has a long lifespan, such as a structure and common facilities that is a social and common parts. Infill has a short lifespan, and personal, and easy-to-change parts, like interior parts and private facilities. In some cases, Cladding is separated from infill. A long-life housing is a house that has been designed to maintain the performance of Support for about 100 years and to be able to easily change and replace the infill, which is sensitive to social and functional changes. Key performance factors of long-life housing include durability, flexibility, and maintainability.

Durability refers to the ability to exist for longtime without significant deterioration of a structure. In the case of reinforced concrete multifamily housing, it requires to the excellent performance of quality concrete and sheathing thicknesses of the steel reinforcements.

Flexibility refers to spatial performance in terms of the capacity to change and diversity. That (changes and diversity) means responsiveness of change of family compositions, family life cycle and life style, and residents. It shows variation or level of responsiveness to spatial changes of space layout according to user needs. Maintainability refers to performance regarding the ease of repairs and maintenance of facilities of common areas and private areas, as well as changes in future demand and diversity. In this study, cost - saving long - life housing means to reduce the construction cost of long life. In other words, it starts at a level that is comparable to that of a general multifamily housing in Korea.

4.0 Long-life housing certification system and supply model

4.1. Overview of long-life housing certification system

The long-life housing certification system, which began in December 2014, has established long-life housing construction and certification standards under the Korean Housing Act (Article 38) (Enforcement September 14, 2018). In the certification system, "long-life housing" refers to houses certified by checking performance on durability, flexibility, and maintainability. The certification level is divided into four grades: outstanding, excellent, good and normal grade. The performance evaluation items are 7 durability, 9 flexibility, and 11 maintainability (6 items in the common part and 5 items in the exclusive part). There are 4 grades for each performance evaluation item, and scores are determined by the grades. The total score of these three performance evaluation items is 100 points. A score of 90 or higher is outstanding, a score of 80-89 is excellent, a score of 60-79 is good grade, and a score of 50-59 is a normal grade. By acquiring outstanding and excellent grade, we provide incentives to mitigate the coverage ratio and floor area ratio in accordance with the local government ordinances within the range of not exceeding 115/100. Housing complexes supplying more than 1,000 housing units are required to achieve a grade of normal or higher.

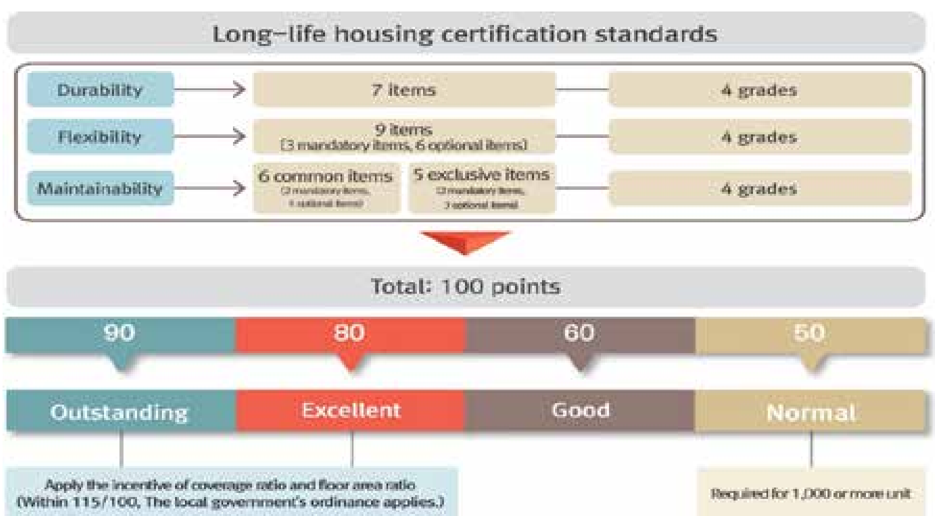


Figure 1: Long-life housing certification standards

4.2. Reflecting the certification system in the supply model

The supply model proposed three grade unit design considering the rating of certification system. Since it is important for the supply model to provide various examples to the housing industry, we proposed a floor plan design for an area of less than 40 ㎡, 59 ㎡, 84 ㎡, and 120 ㎡ based on three grades. For the demonstration construction, 59 ㎡ which is the most important area in Korea recently was selected and designed. For each area, the sub-items of the three evaluation items -durability, flexibility, and maintainability- were listed and the supply model was examined by repeating the design elements to be applied to the grade-excellent, excellent, and good grade.

5.0 Reflecting cost reduction measures for long-life housing supply model

Long-life housing R & D (Technology Development for the Long-life Housing with Durability and Flexibility; 2005-2010) showed that the construction cost of long-life housing increased from 108% to 130% compared to general multifamily housings (wall and slab type housing).
The goal is to match the construction cost of the good grade model to the level of the wall structure. This was an important reason why long-life housings were not widely available in Korea.
Since the general apartment house in Korea is a wall-type structure, but it makes the pilotis on the first floor, it is necessary to construct a structural transfer layer between the first and second floor, and there is facility pit floor instead of parking spaces in the lower basement of the building. This is a major reason for the increase in the cost of construction of existing apartments, and it was unreasonable in terms of construction costs.
We have found that if we overcome these problems, we can reduce support costs through rational design while adopting long-life housing. In other words, it is found through calculations that it is possible to reduce the construction cost by adopting the pilotis through the column method, eliminating the structural conversion layer, and designing the parking section in the underground.
In addition, we focused on simplifying the shape and form of the house, optimizing the block layout in connection with the underground space, and reducing costs by matching the column modules in the underground parking lot of the apartment complex. In addition, infill companies' technology development and cost reduction of some products have increased the possibility of cost reduction.
Also, in the field of structural planning, cost reduction was achieved by using the outer concrete wall of the column type structure as the structural member, applying the flat plate structure of the underground parking lot, introducing the seismic performance design, and utilizing the underground pit layer as the parking lot.
Through this process, the design model is reviewed through the development and application of cost reduction technology.
We got the result that it is possible to construct at a level where the level rising by 3.5% compared with the existing apartment building in the case of good grade, if the outstanding and the excellent grade are 7-10%. Based on this, additional research is being carried out to enable construction at a level similar to that of existing apartment houses through additional technology development and application at the construction stage.

6.0 Cost-effective long-life housing model unit plan (outstanding, excellent, good grade)

The supply model for long-life housing construction is designed by combining the concept, the certification system, and the cost reduction measures described above. This section describes the good, excellent, and outstanding grade models developed based on the 59 ㎡ type.

6.1. Design principles

The design principles of cost-effective long-life housing supply model can be explained in 4 stages.
First, on the premise of SI separation, we have developed plan that can accommodate various life changes (life cycle and life style and life stage). It is a simple plan form, but it is planned as a flexible design that can accommodate various variations.
Second, the structural plan is based on the (long span) column structure and the principle is to simplify the column and beam (column and flat plate). Inside the unit, the non-slab-down structure is designed to have a high flexibility. In order to increase the utilization of the underground parking lot and to rationalize the structure of the interior space of the unit. In addition, the structure is designed without a transfer layer.
Third, the development of the facility plan aimed at saving costs while separating common facilities with private facilities within the existing areas for facilities. The basic purpose of facility planning is to separate the common

from the private facility area and horizontal- facilities were not buried in the structure and spare space was prepared. The facility plan is to be able to respond to future spatial changes and is planned as a facility space that is easy to maintain (check, clean, replace). Toilet piping system uses on slab piping system to prevent noise and easy maintenance.

Finally, the infill plan is based on the development of a construction method that can improve the ease of development and application of dry infill, and the modular coordination design and cost reduction of infill. Since the housing module dimension is 30Cm, the infill dimensions are composed of 30, 60, 90, and 120Cm. Application of movable partition walls, dry Ondol floor system is used partially.

6.2. Long-life housing supply model for construction

The durability part reinforces the thickness of the reinforced concrete and improves the quality of the concrete to make a strong and durable structure which is the basic condition of a house which goes to 100 years.

The flexibility part improves the variable performance by using the column type structure and the dry wall and the movable light wall which are easy to construct the joint part of the wall / floor / ceiling so that it can be changed in five ways according to the lifestyle of the residents. Toilets are equipped with an on-slab wall type piping system and allow the movement of kitchens and toilets through provision of spare shafts. We have planned a spare shaft so that two families can separate each unit.

In the maintainability part, the private / common PS can be separated and maintained. In the common PS, check holes are provided for easy inspection and repair, and piping wiring is prohibited from being embedded in the structure (application of toilet floor layer wall piping). Also, double piping and drywall which can easily repair and replace piping wiring are applied.

6.3. Outstanding grade units

The following is a 59 ㎡ type long-life housing demonstration model designed to meet the requirements of outstanding grade. A private(exclusive) area of 59 ㎡ is one of the typical area that is currently most commonly applied in multi-family housing units in Korea. In consideration of various lifestyles, the plan adopted 4 bay-type capable of modifications into several different types.

In Outstanding Grade, plan variation (house division) is higher than Excellent grade, individual performance grade is higher, and the level of infill is higher. Therefore, the cost is also increased. Compared to ordinary buildings, construction costs rise by more than 10%.

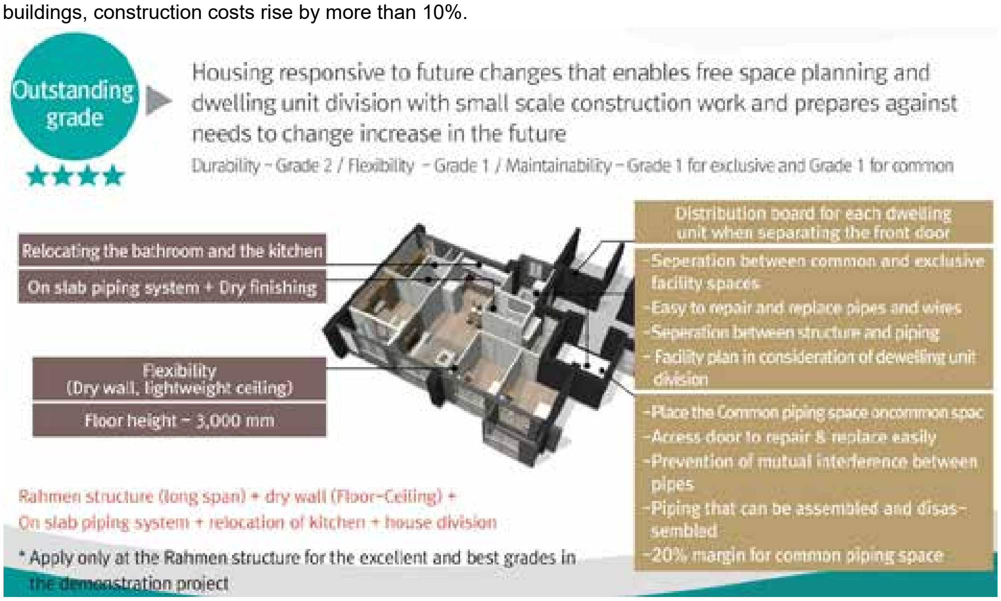


Figure 2: Outstanding grade long-life hosing model

6.4. Excellent grade units

Excellent grade has more applied technology than Good grade, and individual performance grade is higher. For example, Excellent grade is more flexible because there is no column inside the unit. We planned independent entrance and facilities to allow partial lease.

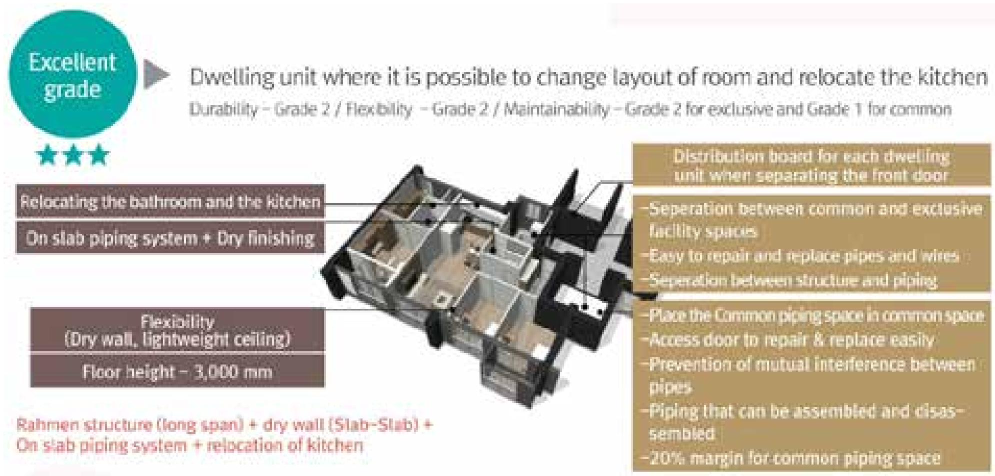
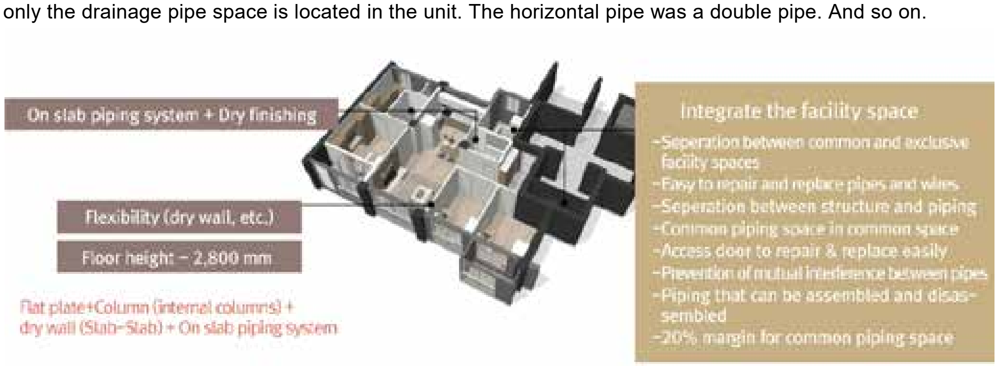


Figure 3 : Excellent grade long-life hosing model

6.5. Good grade units

The following is a 59 ㎡ type long-life housing demonstration model designed to meet the requirements of good quality. In order to reduce the cost, the columns are arranged inside the unit, but some degree of plan change is possible. Considering ease of maintenance, the common facility is placed in the common part and only the drainage pipe space is located in the unit. The horizontal pipe was a double pipe. And so on.



Column + flat plate (column : arranged in the unit interior and exterior)
Front: 4 bay, 3 rooms and living, back : dining, kitchen, two toilet and bathrooms
Separation of private piping shaft and common piping shaft
Common piping shaft arrangement in the common area
Floor plans incorporates flexible scenarios →dry zone (Number of rooms not using water and size changes etc.)

Figure 4: Good grade long-life hosing model

7.0 Construction of long-life housing test bed for technology, cost, system verification

Based on the long-life housing supply model, we are constructing 116 households in two buildings, and are carrying out verification studies on technology, cost and system. Construction of the structure has been completed, and construction of the infill has started. We will monitor the technology, cost, and system during the construction process and seek ways to improve it.

7.1. Demonstration construction contents

The outline of the construction of the three grade models is the construction of the good, excellent and outstanding grade models, the two buildings each have 15 floors, total 116 households, and the household area is 59 ㎡.

The purpose of construction is as follows.

First, it is a role model that shows actual cases of long-life housing construction and grade differences.

Second, it examines the technology, cost, and certification system for long-life housing.

Third, finding problems and improvements to long-life housing technology.

Fourthly, to provide a direction for the spread of long-life housing in Korea comprehensively.

It is a rented house, and after 10 years it is converted into a condominium.

One building is excellent grade and best grade with frame structure (Column and Beam) and the other one is good grade with column and flat plate slab system.

Table 2: Outline of long-life housing field-test

- Location: Sejong Metropolitan Autonomous City Administrative City
- Number of units: 59 ㎡ (stairway type) 15th floor 2 buildings 116 units, of the total 1080 housing units,
- 906: Frame structure (outstanding of 30 units + Excellent of 28 units)
- 905: Column and flat plate structure (58 units of good grade)

CONCLUSIONS

This study is part of a study to establish the concept of long-life housing that meets the characteristics of Korea on the extension of the open building theory, starting from the characteristics and problems of the multifamily housing in Korea and to expand the long-life housing.

Although there were some previous researches, it was difficult to expand the supply in the housing market due to the insufficient system and the increase in the construction cost. For this reason, a long-life housing certification system has been created, but no studies have been conducted to reduce costs and no real-built housing has been fitted to the long-life housing certification system. This study started from this background.

This study first examines the results of long-term housing research conducted in Korea, and then develops a model of cost-effective long-life housing that meets the certification system while reducing construction costs. In addition, the developed model is verified through construction and the results are distributed to the housing industry.

To do this, we designed a cost-saving long-life supply model for each grade, reviewed the design and cost based on the plan, and obtained the possibility of the long - term construction cost of existing apartment and construction cost.

Based on this, we are currently constructing 116 units, and construction of the structure has been completed and infill works are being started. We will continue to monitor the contents of technology, cost and institutional aspects, and the research will be completed with the corporation in the next four years.

This achievement is expected to serve as a starting point for the dissemination of long-life housings in Korea

ACKNOWLEDGEMENTS

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SCRIPT: THE STRATEGY OF PROGRAMMING CODES FOR THE DEVELOPMENT OF RESIDENTIAL ENVIRONMENTS

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ABSTRACT:

Manifesto: Process is more
Currently, the profession of the architect is transforming, and a multifactorial design approach is actual. A living environment is a process. Urbanization and transformation are the main challenges today. The role of space is significant, but equally important is the temporal factor. Design of the architectural environment and its scenarios should become a norm. The process reality of living environment is the main theme of this paper.

Strategy: S.C.R.I.P.T.
The approach that I form and use in my residential urban block project is called S.C.R.I.P.T - programming codes for the development of residential environments. The main principles of this strategy are:

S – Structure: General block structure, capillarity and fine-grained block's organization of the territory [LOT and PLOT concept], high density and middle-rise development, a complex hierarchy of public spaces.
C – Core: Universal Urban Unit, Adaptive capability of "UUU" to design a morphology of the residential tissue.
R – Rule: Mechanism of interaction for "long" and "short" transformations.
I – Infill: Typology of adaptable apartments.
P – Programming: Scenarios of development.
T – Transformation: The ability to transform and preserve the original urban tissue.

The residential block project includes programming of the architectural, social and economic potential of the environment. The structure and generated space of the project is a tool for spatial flexibility. The strategy for programming of the living environment is an attempt to put into the project scenarios for its development. It is important to make a residential quarter capable for self-adapting to the challenge of the future.

KEYWORDS: Script, Strategy, Urban Structure, Transformation

INTRODUCTION

Residential development in Russia is experiencing a time of change. The capitalist society has matured, consequently different are demands for the quality of residential environments. In parallel, the profession of the architect is transforming and a multifactorial design approach is becoming topical. Residential development and living environment have always been an indicator of any social, economic and political changes in Russia. Therefore, the importance of sustainable adaptability of housing to the time factor grows.

A living environment is dynamic, not static. Urbanization and transformation are the challenges of a modern age. If we continue complying to the logic of the architectural slogans "Less is More" (Mies van der Rohe) [1] and "Yes is More" (Bjarke Ingels) [2], we can as well choose a new slogan for the modern age – "PROCESS IS MORE". The role of space is important, but equally important is the time factor. Designing the scenarios for residential development including its architecture should become the norm.

1.0 SCRIPT: THE APPROACH AND THE STRATEGY

The approach that the authors propose and use in their residential urban block project is called S.C.R.I.P.T - programming codes for the development of residential environments. In this case the goal of the residential project is programming of architectural, social and economic potential of the living environment. Therefore, the tool for spatial flexibility is the structure of the space and its future generated potential. [3]

The SCRIPT approach includes following principles:

S. Structure

C. Core

R. Roadmap

I. Infill

P. Program

T. Transformation

For the first time this approach was used in the residential area project at the 1st Russian Youth Architectural Biennale. The project was awarded a Silver Prize and generated a great interest in the professional community. [4] 29 finalists were selected from 377 applications from many Russian cities that submitted their residential block projects to the Biennale. The main goal of the competition was to discover novel approaches to the development of residential environments.

Fig.1 Photo of the SCRIPT model. Source: www.krnv.pro (N.Koreneva 2017)

1.1 S. Structure

The main challenge of the last decade for architects and urban planners in Russia was the focus of the residential unit structure. This happened due to the fact that over the last hundred years the quarter has grown so large that it has lost its former importance. [5]

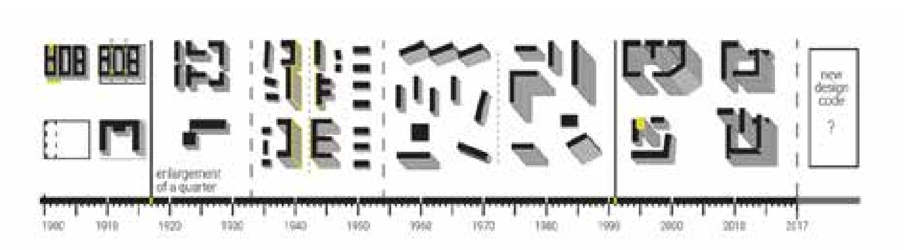

Fig.2 Evolution of the morphology of living environment tissue (N. Koreneva, 2017)

For the developers of the residential quarter, the priority was the size of a residential quarter as a territorial unit.

For the project site the Biennale has chosen a territory of 240x240 meters designed as an Urban PLOT (Unit) of the larger quarter. The main planning solution was the division of these plots into 9 RESIDENTIAL UNITS 60 * 60 meters (Residential Urban LOTs).

The connectivity and permeability typical for the capillary structure, which disappeared in the 20th century, has obvious advantages both at the city planning and at the architectural levels. [6] The main architectural and city-planning principles of the residential structures in Russia, identified in the analysis, are the relatively high density (23000 m2/ha) and low rise (4-6-8 floors) development, a complex hierarchy of public spaces, and the ability to transform and preserve the nature of the initial tissue.

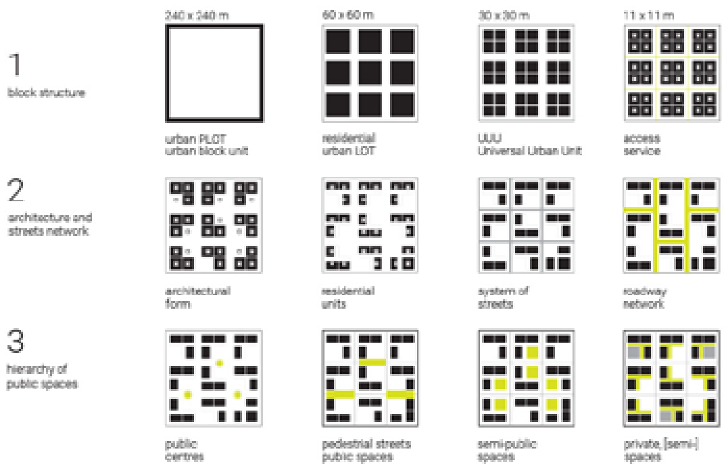

Fig. 4. Structure. (N. Koreneva, 2017)

1.2 C. Core

Core, unchangeable components, constant layer.

A Universal Urban Unit 30*30 m (UUU) is an unchangeable, stationary component. In the center of the unit, there is a ladder-elevator cage and a belt of engineering blocks. Possible unit modifications and combinations make it universal in the formation of the morphology of the urban tissue. The foundation and networks for the constructive engineering system are laid in each block, creating reserves and flexibility for further adaptive development.

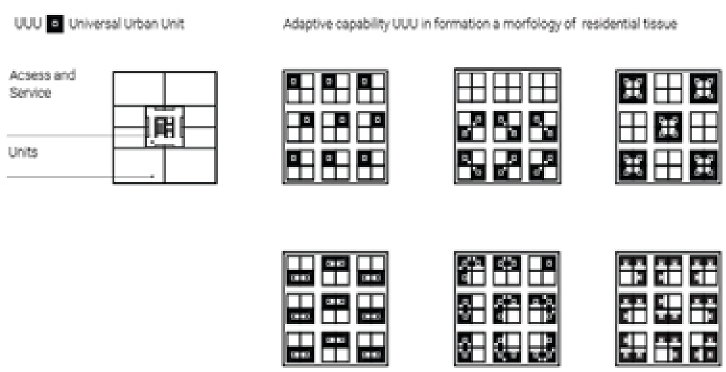

Fig. 4. Core. (N. Koreneva, 2017)

1.3 R. Rules

I propose a model for interaction mechanism at the level of the city planning and distribution of responsibility and control in the transformation management.

The core of the interaction regulation and a tool for managing transformations is the SCRIPT LAB (Bureau of Urban Transformations) - a center for research and design.

Short transformations concern changes in private and semi-private public spaces, as well as the generation of internal unit spaces. A resident can make an application to the SCRIPT LAB and obtain professional answers to his changing needs in the form of ready-made variable adaptive solutions. The cataloging of variable solutions and the centralized production of modular elements for interior spaces of a UUU and elements of improvement are envisaged.

Long transformations refer to the level of public and semi-public spaces, where exists a complex mechanism of interaction with different structures. For this purpose, we developed a course of a civil expert within the laboratory, providing qualified assistance in understanding the role and the boundaries of resident's responsibility in transformation of their residential quarter and a city.

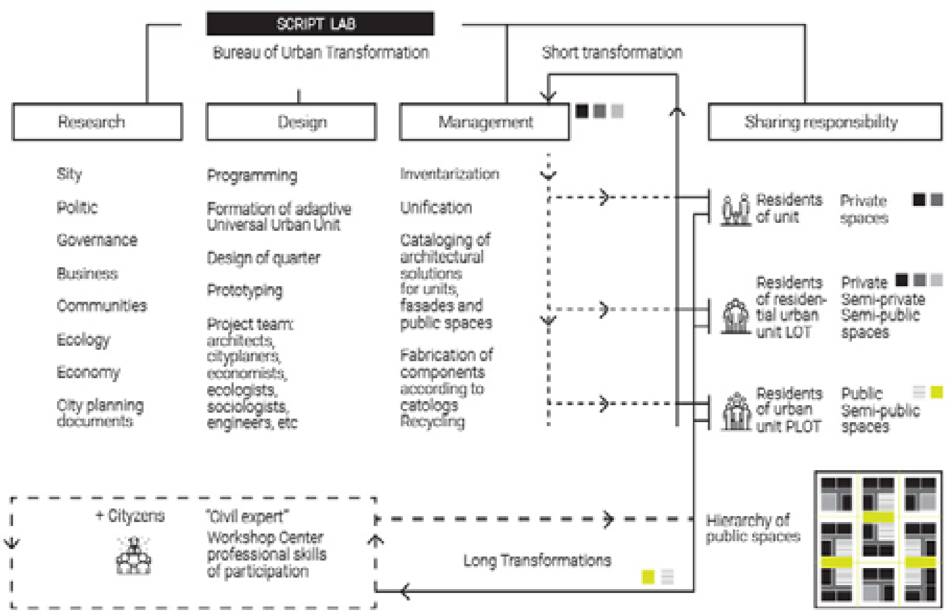

Fig.5. Rules. (N. Koreneva, 2017)

1.4 I. Infill

Filling. Variable components. Generated spaces. Free spaces.

The project has three types of unit sizes that are traced so that each has an outdoor engineering service block, embedded in the engineering ring in the UUU. Structurally, the unit consists of two levels, but can be transformed into two single-level units. At the level of the environment organization, the public spaces in the UUU configuration structure become the filling.

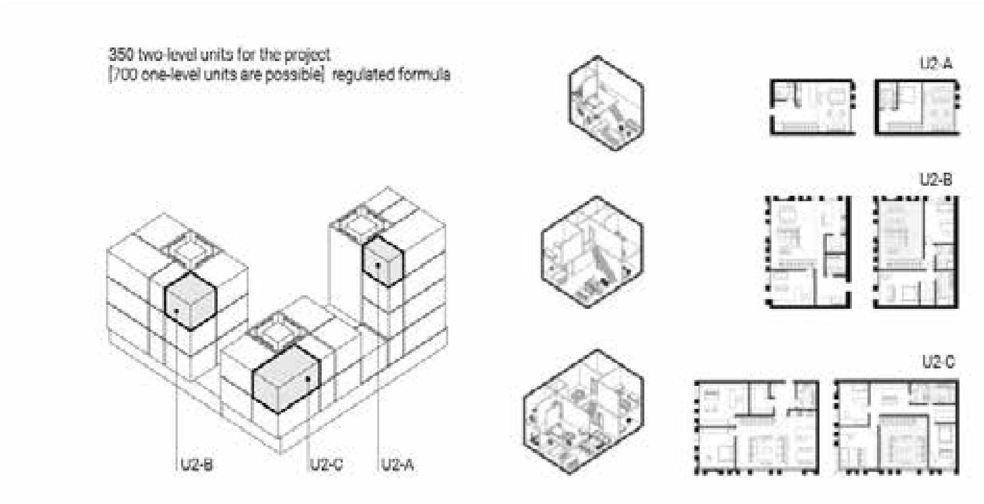

Fig. 6. Infill. (N. Koreneva, 2017)

1.5 P. Program

Programming of living environment is an attempt to lay into the project the scenario for its future development. We cannot predict the future, but after researching some previous paradigms of the organization of the residential environment and practices of strategic planning, we can build some hypotheses in programming the living environment. In this sentence, the hypotheses are rather conditional and abstract. It is crucial to make a residential quarter capable of self-adapting to the challenges of the future. Important is the attempt to preserve the nature of the urban tissue, even in the conditions of increasing density.

Three time scales are considered in the project:

Short-term perspective (1-5 years): changes at the level of a single unit, yard spaces and common areas.

Long-term perspective (100-200 years): changes in the tissue of urban environment and the effect of such changes on a living quarter, transformation hypotheses.

Medium-term (buffer) (10-50 years): other changes that become a transitional scenario between the strategy of small and long-term changes.

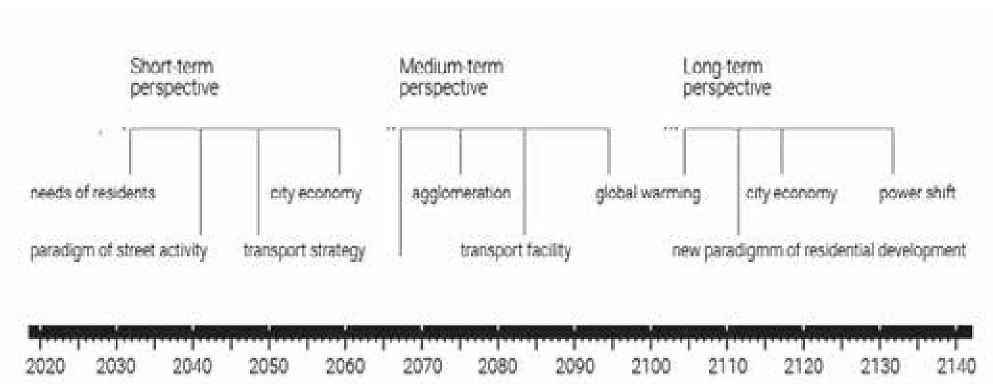

Fig. 7. Programming. (N. Koreneva, 2017)

1.6 T. Transformation

Architectural solutions for the above scenarios. Cataloging adaptive modular solutions.

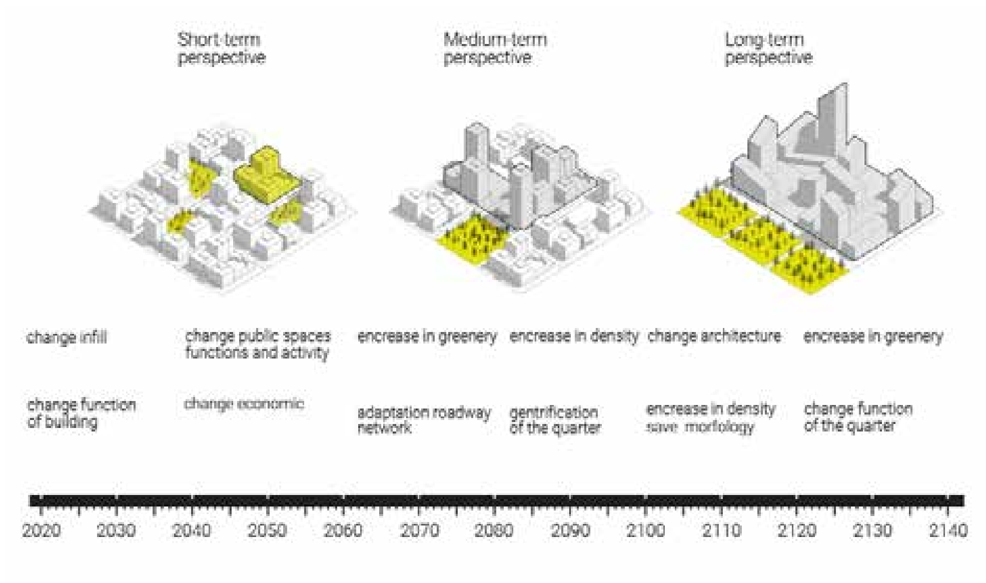

Fig. 8. Transformation. (N. Koreneva, 2017)

In opposition to the traditional approach, I propose an architectural project with a scenario for changes in its residential structures. The importance of adaptive architectural and city-planning solutions in the creation of residential environment and the programming of scenarios for its future development are first in line.

2. A CASE STUDY

In Russia it is still difficult to implement such an approach in full, because of outdated building codes, spatial and legal restrictions for plots as well as customer's requirements for a certain number of square meters of housing and apartment types.

In this paper, the author analyzes an actual project from his architectural practice through the prism of SCRIPT algorithms. The project of residential quarter No. 5 in the residential area "Salavat Kupere" [SK5] in Kazan, is carried out by the KRNV architectural studio in collaboration with Ilya Korenev, for the State Residential Fund of the Republic of Tatarstan. The size of the quarter is 10 hectares while the area of the housing stock is 132,000 m. An important limitation in this project is the valid Territory Planning Project, the document regulates the functional zoning of the entire microdistrict and technical and economic indicators of the territory but does not meet actual requirements any more. For example, this document includes standard quarter units of 10-15 hectares, as well as uneven distribution of social and transportation infrastructure throughout the district. These factors deprive the possibility of quarter self-organization independently from the district development as a whole. Flexibility at the level of master planning has not been initially included, that worsens the adaptive qualities in the development process.

2.1 Structure

The size of the project site (plot) is 10 ha. The connectivity and permeability of the quarter is ensured through the allocation of automobile and pedestrian arteries. One of the features of the project is a landscape corridor, a public space connecting adjacent quarters and a park of regional significance. Taking into account the specifics of the site and existing functional restrictions of the territory, three morphological types of residential urban units were designed. The concept is based on the principle "yards without cars", where the yard is not designed for the movement of personal vehicles. Each yard and attached to it residential block, has a different type of accessibility depending on the morphotype. Morphotypes of the residential quarter units are the following:

1. Semi-closed morphotype with a semi-private courtyard spaces LOT 1 (1 ha), LOT 3 (1 ha), LOT 5 (1.5 ha)

2. Semi-open morphotype LOT 2 (0.5 ha) with a semi-public yard space

3. Open morphotype LOT 4 (0.8 ha) with a public yard space

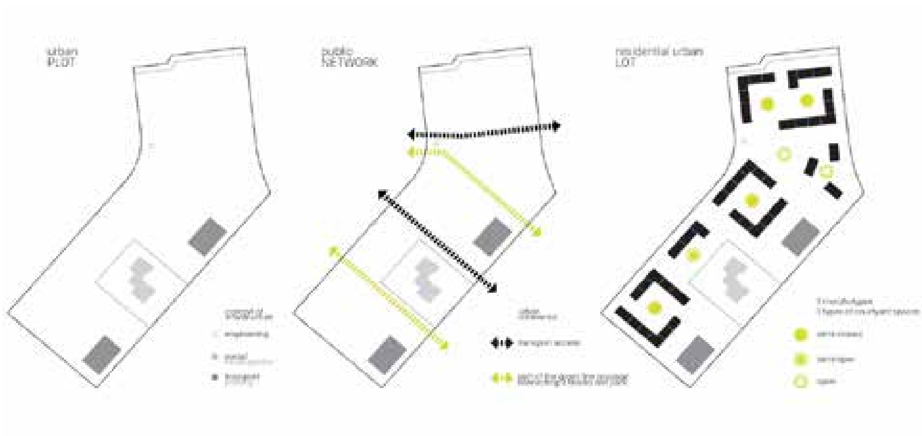

Fig.8. Formation of SK5 quarter structure. (N. Koreneva, I. Korenev, 2018)

2.2 Cell

70% of the housing stock of the proposed project is in the social housing sector. Therefore, the economic feasibility of design solutions is a very important issue. Most of the constructive and planning decisions were adapted to the possibilities and restrictions of panel housing construction. The high-tech panel housing construction has not yet reached the level of broad optimization and remains cost-intensive for Russia. Planning flexibility is achieved through the standardization of building structures, the use of one transverse pitch, single ladder-elevator unit and the universal location of sanitary units. An important economic factor reducing the cost of construction is the implementation of the re-use houses, projects for multiple uses. Standard series of panel housing construction of the Russian Soviet period are worn out and outlived its usefulness. [7]

At present, the errors of the urban planners of the socialist period are reinterpreted by the society and architects, and the diversity principle becomes an important requirement for the modern living environment. Therefore, in this project, architects set the task of customizing project solutions, combining standardization and diversity. The houses with a universal orientation were developed with consideration of the insolation requirements. This allowed for the flexible use on other territories while forming the living environment tissue of various morphotypes.

Fig. 9. Formation and customization of residential tissue SK5. (N. Koreneva, I. Korenev, 2018)

2.3 Rules

The interaction mechanism presented in the SCRIPT strategy requires consistent changes and reforms in the sphere of the Russian standard for design and management practices.

In this project, we propose the flexibility of use of the first-floor spaces for quarter residents. It is assumed that 70% of free-use spaces will be rented for public centers and small business residents on special terms. This may increase the economic and social stability of the residential quarter.

2.4 Infill

According to the preference of customers, the layout of the residential buildings has a certain number of one, two and three-room apartments. Legally, apartments of social housing cannot be sold by universal free lots. Unlike the comfort and premium housing, where a free plan apartment is popular, the social sector includes the finishing of the apartment interior. Potential flexibility of apartment floor plans is possible due to the standardization of the design solutions at the planning level in case the project is reused.

2.5 Programming and Transformation

In the short term, the project supposes programming and transformation of the first floors and public spaces. The long- and medium-term development prospects are aimed at changing the socio-economic situation of the whole neighborhood.

At the moment the district is built up with almost identical 19-storey houses and has an unfavorable, marginal environment. Such segregation of residential areas on the economic basis exists in almost all Russian cities and generates major social problems. In contrast, new architectural solutions for social and affordable housing can contribute to the process of neighborhood gentrification, raising the status and capitalization of the territory.

CONCLUSIONS

Testing of the SCRIPT approach in the social housing sector does not demonstrate all possibilities due to the strict regulation of the building codes as well as engineering and structural features of panel housing construction. In order to implement all aspects of the SCRIPT strategy, we need an experimental site independent of Russian legislation, or consequent changes in Russian architectural and town planning regulation.

In general, Russia is undergoing positive changes in the field of residential development. The economic crisis had resulted in the reduced demand in the housing market and inspired developers to improve the quality of the residential environment in the competitive struggle. Parallel to this, in recent years the Ministry of Construction of Russian Federation has initiated many professional competition aimed at developing of new solutions in the field of domestic architecture in order to identify bottlenecks and make possible adjustments in the standardization of built environment and planning approaches. Therefore, the opportunities for SCRIPT implementation are growing.

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ADEQUACY LEVEL OF BRAZILIAN CONSTRUCTIVE SYSTEMS TO THE OPEN BUILDING: A RESEARCH METHODOLOGY

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ABSTRACT: The Open Building approach has been broadly considered in several countries while little investigated in Brazilian building production processes, architectural research or teaching. Exploring the theory from its technological aspects, this paper presents a research methodology proposal whose objective is to evaluate Brazilian building systems, subsystems and components adequacy to Open Building principles, through gathering, processing, crossing-checking and analysing mapped data on such elements. These building elements are organized by layers – site, structure, façade, roof, internal closure, services and furniture – based on Duffy, Brand and Geraedts' proposals, considering their behavior as support and/or infill. This information will constitute a database that will feed a research tool, allowing different combinations, and enabling people to develop a multiple-criteria analysis through some evaluation parameters and architectural categories. Inspired by Prins, the evaluation parameters will be cost, lifespan, building execution time, compatibility with other systems (measured by their modularity and connectivity), execution complexity, modification and reuse potential. The categories will be attributes such as architectural types, finishing standards and development scales of construction companies operating in Belo Horizonte, Brazil. Finally, a dynamic digital graphic interface might be created from this research to assist architects, researchers, entrepreneurs, developers, contractors and autoconstructors in making decisions on flexible and adaptable buildings.

KEYWORDS: Brazilian building systems. Building layers. Multiple-criteria analysis methodology. Open Building. Modularity and connectivity. Digital interface.

INTRODUCTION

Brazilian studies have criticized the standardized and mass production of housing carried out in the country, from small to large scale, by public or private agents, for lower or higher income classes (MORADO NASCIMENTO & TOSTES 1998a; ANITELLI 2011, 2015; LAMOUNIER 2017). Furthermore, surveys also reveal a contingent of dissatisfied people, living in spaces that do not meet their changing housing needs at that time (PRAXIS-EAUFMG 2014; LAMOUNIER 2017).

This article, which is the result of ongoing research[1], aims to propose alternatives to the problematic spatial rigidity and the consequent lack of possibilities for dwellers regarding space. The investigations presented here are based on N. J. Habraken's *Theory of Supports* and *decision-making levels* from Open Building, as well as the multi-criteria analysis method.

More specifically, the research in Brazil has investigated systems, subsystems and constructive components which are suitable for the Open Building approach in terms of its technological aspects enunciated in the 4th Principle of the movement, which proposes:

> the interface between technical systems allows the replacement of one system with another performing the same function. (such as different fit-out systems applied in a given base building) (KENDALL 2004)

The LabFlex Group[2] has developed a tool to evaluate the adaptive capacity of these elements, i.e. their degree of flexibility. This text presents a research methodology that investigates the proposition of this tool. It is intended for architects, engineers, property owners, builders, entrepreneurs, auto-constructors, researchers, professors and students in the decision-making process for the production of adaptable residential buildings.

The research on constructive systems from the Open Building perspective is justified exactly because of the proposal of the distinction between the levels of decision-making, both collective and individual, as being the differential of the theory. Such levels are fundamentally political in nature, but are represented physically in the parts of a building, through support (elements of long durability and less changeable) and infill (separable units with shorter useful life).

The majority of the research which has been developed with a presupposition of this separation between the levels of decision-making focuses on design strategies, constituting a logical approach to the production of open buildings which is extremely relevant. Geraedts et al. (2014; 2015; 2016a; 2016b), who propose the FLEX method, and Osman et al. (2011), who propose the Adaptability Assessment Tool (AAT), are some examples. Such research is intended to evaluate (and examine in detail) the adaptive capacity of, as a priority, preexisting buildings, from the analysis of spatial attributes that refer to strategies or design characteristics. However, such strategies are closely related to the technology used in the projects and the present research focuses on this aspect.

The tool proposed here differs from those previously mentioned because it is currently restricted to the evaluation of physical constructive components per se. While it is a future research goal to establish correlations of technology with design strategies, such connections are not addressed in this article. In this sense, the tool can be applied to the analysis of constructive systems, or part of them, present in preexisting buildings, as well as new buildings to be produced in the future.

The criteria, or evaluation parameters, of the components were created in the light of the *Theory of Supports* and Open Building. In other words, it is important to know the extent to which each constructive component meets the requirements of open architecture, enabling and facilitating the physical separation between different decision-making levels and thereby promoting flexibility – either *adaptation*, *expansion* or *rejection* (Geraedts & Prins 2014).

In Brazil, this is a fertile field of investigation precisely because this country does not boast production that considers the issue of spatial flexibility and the participation of the dweller as an active agent in the process. However, the research in development that deals with the subject does not associate these issues with technological investigations on constructive systems.

1.0 THE TOOL

1.1. Decision level, building Layers and elements

Duffy (1992), Brand (1994) and Geraedts & Prins (2015a) propose, with different but similar objectives, that a building be divided into layers, due to its different functional, technical and economic (cost) life cycles (Figure 1). Duffy (1992), for example, asserts that "our basic argument is that there isn't such a thing as a Building [...] a building properly conceived is several layers of longevity of built components", since its object of analysis is the use of the building at that time, made possible by its transformations.

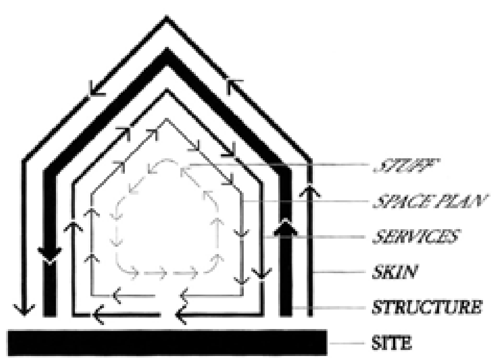


Figure 1 – Building Layers. Source: (Brand 1994)

In light of the distinction between the decision-making levels proposed by Habraken, layered logic has been used in this research in order to develop the aforementioned instrument to evaluate the adaptive capacity of a constructive component, or its degree of flexibility. It was adopted the concept of *adaptive capacity*, first defined by Hermans (2014) and consequently adopted by Geraedts et al. (2014; 2015a; 2015b; 2016):

> The adaptive capacity of a building includes all characteristics that enable the building to keep its functionality through changing requirements and circumstances, during its entire technical life cycle and in a sustainable and economic profitable way. The adaptive capacity is being considered as a crucial component when looking into the sustainability of the real estate stock.

By analogy with the procedures adopted by Duffy (1992), Brand (1994) and Geraedts et al. (2016), seven layers were created for this research: site, structure, roof, façade, services, internal closure and furniture (Table 1), in order to structure, locate and group the mapped constructive systems, subsystems, elements and components. For some layers it was necessary to define certain types of sub-layers, referred to as *elements* - a term based on Lopes, Bogéa and Rebello (2006). In the first phase of the research, the focus was on the investigation of the *structure, façade* and *internal closure* layers, albeit in the last only the *partition* element was considered, as highlighted in Table 1.

Table 1 – Building layers adopted by this research. Source: Authors, based on (Duffy 1992; Brand 1994 and Geraedts & Prins 2015a)

DECISION LEVEL	SUPPORT ◄ ——— ▷ INFILL								
LAYER	SITE	STRUCTURE	ROOF	FAÇADE	SERVICES	INTERNAL CLOSURE	FURNITURE		
ELEMENT	SLAB	PILLAR	BEAM	FRAME WALL	CLOSURE	WINDOW FRAME	PARTITION	RAISED FLOOR	LINING	SHAFT CLOSURE

Table 2 and Table 3 below illustrate the *structure* layer and the *closure* element of the *façade* layer, added hierarchically to the next features of the constituent elements of a constructive system, as well as the *components* family. This categorization has also been investigated in terms of modes of *production* (*on-site* or *prefabricated)* and types of *materials* (concrete, steel, ceramics etc.).

Table 2 – Subdivision of the *structure* layer. Source: (Authors 2018)

ELEMENT	PRODUCTION	MATERIAL	COMPONENT
SLAB	IN LOCO		SOLID
SLAB	IN LOCO		MUSHROOM
SLAB	IN LOCO		RIBBED
SLAB	IN LOCO		PRESTRESSED
SLAB	IN LOCO		STEEL DECK
SLAB	IN LOCO		OSB
SLAB	PF.		ALVEOLAR
SLAB	PF.		PRECAST
PILLAR	I.L.	CONC.	SOLID
PILLAR	I.L.	CONC.	REINFORCED MASONRY
PILLAR	PREFABRICATED	CONC.	PREFABRICATED
PILLAR	PREFABRICATED	STEEL	CIRCULAR HOLLOW
PILLAR	PREFABRICATED	STEEL	RECTANGULAR HOLLOW
PILLAR	PREFABRICATED	STEEL	LIPPED CHANNEL
PILLAR	PREFABRICATED	STEEL	HOT ROLLED H
BEAM	I.L.	CONC.	SOLID
BEAM	PREFABRICATED	CONC.	PREFABRICATED
BEAM	PREFABRICATED	STEEL	CIRCULAR HOLLOW
BEAM	PREFABRICATED	STEEL	RECTANGULAR HOLLOW
BEAM	PREFABRICATED	STEEL	LIPPED CHANNEL
BEAM	PREFABRICATED	STEEL	HOT ROLLED H
FRAME WALL	IN LOCO	CE.	MASONRY
FRAME WALL	IN LOCO	CONCRETE	SOLID
FRAME WALL	IN LOCO	CONCRETE	MASONRY
FRAME WALL	PF.	CONCRETE	PREFABRICATED
FRAME WALL	PF.	ST.	STEELFRAME

PF: PREFABRICATED, I.L.: IN LOCO, CONC.: CONCRETE, CE.: CERAMIC, ST.: STEEL

Table 3 - Subdivision of the *closure* element of the *façade* layer. Source: (Authors 2018)

ELEMENT	CLOSURE									
PRODUCTION	IN LOCO				PREFABRICATED					
MATERIAL	CE.	CONCRETE								ST.
COMPONENT	MASONRY	MASONRY	CELLULAR	SOLID	PRECAST	AUTOCLAVED	PREFABRICATED	PREFABRICATED W/ CE.	ALVEOLAR	FRAME W/ CEM. BOARD

CE.: CERAMIC, ST.: STEEL

1.2. Evaluation parameters

Taking into consideration the distinction between Habraken's decision-making levels and the Open Building approach, associated with the concept of adaptive capacity, and to some parameters defined by Prins[3] (1992), as well as to other important attributes that must be taken into account in choosing a constructive system for a particular work, it was noticed that the multi-criteria analysis procedure would be very useful in the construction of this tool. As Bryman (2016, p.153-154) explains, the adoption of multicriteria analysis methodology, or multiple-indicators,

> 'is a recognition that there are potential problems with a reliance on just a single indicator:
> 1. it is possible that a single indicator will incorrectly classify many individuals. […]
> 2. A single question may need to be of an excessively high level of generality and so may not reflect the true state of affairs for the people replying to it. […]
> 3. You can make much finer distinctions."

Thus, an attempt was made to define the evaluation parameters for specific constructive components that considered all the factors that could influence their adaptive capacity.

For this research, 7 general parameters of flexibility assessment of a particular constructive component were defined, with some variations (or 'sub-parameters'). No weight differentiation has yet been established for the parameters exhibiting such variations. All sub-parameters received the same weight as the general parameters, thus it was defined a total of 10 parameters: [1] average cost; [2] lifespan; [3] work execution time; modularity and connectivity in their attributes of [4] minimum module, [5] maximum measure and [6] connection type; execution requirements such as [7] the level of labor or company to be contracted – manpower and [8] necessary tools or equipment; besides [9] reapproval potential and [10] modification potential.

Costs for components, inputs or services in civil construction vary greatly in terms of unit of measurement. They can be by area, length, volume, weight, piece, unit sums etc. After consultation with specialists, manufacturers and suppliers and in order to interrelate the costs of each component installed, a scale of values in percentage terms of the total cost of the work was established (Table 4). An explanation of this conversion follows in the next section.

The average lifespan of the building components has been defined in years, based on consultation with several Brazilian manufacturers and suppliers, which is largely in line with the lifespan of the Open Building approach (support level – 100 to 200 years; house allocation – 25 years; infill level – 10 to 20 years).

As for the work execution times, Coutinho et al. (2012) warn that the execution time of civil works depends on some important factors: season of the year – whether winter/dry or summer/rainy – in the case of Brazil, as well as building area, total cost of the work, operational capacity of the company, type of service (whether construction or renovation), among others. In general, short execution times are considered as *the best* (scale 4), just as very extended times are regarded as *the worst* (scale 1). Just as in the *cost* parameter, a range of scale for *execution time* was defined that varies in percentage times of the total work time. The calculations made for the definition of the *execution time* ranges of each element considered the average between the times spent in the respective services of a more industrialized or more manufactured form. A residential work with a total time of 2 years and an average variation of 30% for each service, whether more manufactured or more industrialized, was considered as a reference.

In the case of the connectivity and modularity parameters, the definition of the grading scale for *minimum* *modulus* was based on the Brazilian Technical Standard for Modular Coordination for Buildings, NBR-15,873, whose standard minimum modulus for buildings is 10cm, and on the *tartan* band grid (of 30cm =10cm+20cm) developed by SAR[4] in the 1960s and which has become the standard for modular coordination adopted in construction throughout Europe.

With regards to maximum measures, surveys were carried out with several Brazilian suppliers and measurements were established in meters. The type of connection varies from *monolithic*, which practically prevents substitutions, to *direct*, without the necessity of a third piece, being connected and disconnected more immediately.

The complexity of execution was defined in terms of the degree of specialization of the labor or company required to execute or install the component, and the type of tool or equipment necessary. The first parameter varies from D.I.Y (Do It Yourself) as being *the best*, to *the worst* when it would be necessary to hire a specialized company. The second varies from the *domestic* tool, being *the best*, to the *exclusive domain*, as *the worst*.

The potential for reapproval refers to the possibilities of reuse, recycling or reduction of resources, offered by a specific component. The more possibility of reapproval in similar situations (with the same function or not), the better the component will be evaluated.

Finally, the potential of modification of a given component refers to the degree of modification required in the other components and layers. The less disturbance it causes in the preexisting elements, the better it will be evaluated.

Therefore, a numerical scale ranging from 1 to 4 was defined for all the evaluation parameters, corresponding to the four qualitative evaluation levels: *worst* (1), *bad* (2), *good* (3) and *best* (4). Thus, the aim was to generate a scale with an even number of scores, either positive or negative, revealing a clear tendency of the component to an evaluation consistently above or below the average.

Table 4 – Assessment values per parameter and per element. Source: (Authors 2018)

ELEMENTS	SCALE				MODULARITY AND CONNECTIVITY			CONSTRUCTION COMPLEXITY			
		01. AVERAGE COST (% OF BUILDING TOTAL COST)	02. LIFESPAN (DURABILITY IN YEARS)	03. WORK EXECUTION TIME (% OF BUILDING TOTAL EXECUTION TIME)	04. MINIMUM MODULE (cm)	05. MAXIMUM MEASURE (m)	06. CONNECTION TYPE (BEST PERFORMANCE)	07. MANPOWER (LOWEST LEVEL OF SPECIALIZATION REQUIRED)	08. TOOLS/ EQUIPMENT (LOWEST LEVEL OF SPECIALIZATION REQUIRED)	09. REAPROVEMENT POTENTIAL (% OF REUSE, RECYCLING OR REDUCTION)	10. MODIFICATION POTENTIAL (DISTURBANCES IN OTHER SYSTEMS)
SLAB	1 - Worst	> 8%	< 60	> 10%	Other or none	< 3	Monolithic	Specialized company	Exclusive domain	None	Unfeasible
	2 - Bad	6% to 8%	60 to 100	8.5% to 10%	Multiple of 5	3 to 6	Not planned	Skilled labor	Specialized and locable	< 30%	In various layers
	3 - Good	4% to 6%	100 to 200	7% to 8.5%	Multiple of 10	6 to 12	By third piece	Some experience	Specialized and purchasable	30% to 70%	In the same layer
	4 - Best	< 4%	> 200	< 7%	Multiple of 60	> 12	Direct	D.I.Y.	Domestic	> 70%	None significant
PILLAR	1 - Worst	> 13%	< 60	> 5%	Other or none	< 3	Monolithic	Specialized company	Exclusive domain	None	Unfeasible
	2 - Bad	10% to 13%	60 to 100	4.2% to 5%	Multiple of 5	3 to 4.5	Not planned	Skilled labor	Specialized and locable	< 30%	In various layers
	3 - Good	7% to 10%	100 to 200	3.5% to 4.25%	Multiple of 10	4.5 to 6	By third piece	Some experience	Specialized and purchasable	30% to 70%	In the same layer
	4 - Best	< 7%	> 200	< 3.5%	Multiple of 60	> 6	Direct	D.I.Y.	Domestic	> 70%	None significant
BEAM	1 - Worst	> 18%	< 60	> 5%	Other or none	< 3	Monolithic	Specialized company	Exclusive domain	None	Unfeasible
	2 - Bad	14% to 18%	60 to 100	4.25% to 5%	Multiple of 5	3 to 6	Not planned	Skilled labor	Specialized and locable	< 30%	In various layers
	3 - Good	10% to 14%	100 to 200	3.5% to 4.25%	Multiple of 10	6 to 12	By third piece	Some experience	Specialized and purchasable	30% to 70%	In the same layer
	4 - Best	< 10%	> 200	< 3.5%	Multiple of 60	> 12	Direct	D.I.Y.	Domestic	> 70%	None significant
FRAME WALL OR STRUCTURAL WALL	1 - Worst	> 31%	< 60	> 10%	Other or none	< 3	Monolithic	Specialized company	Exclusive domain	None	Unfeasible
	2 - Bad	24% to 31%	60 to 100	8.5% to 10%	Multiple of 5	3 to 4.5	Not planned	Skilled labor	Specialized and locable	< 30%	In various layers
	3 - Good	17% to 24%	100 to 200	7% to 8.5%	Multiple of 10	4.5 to 6	By third piece	Some experience	Specialized and purchasable	30% to 70%	In the same layer
	4 - Best	< 17%	> 200	< 7%	Multiple of 60	> 6	Direct	D.I.Y.	Domestic	> 70%	None significant
CLOSURE	1 - Worst	> 9%	< 30	> 9.75%	Other or none	< 3	Monolithic	Specialized company	Exclusive domain	None	Unfeasible
	2 - Bad	7% to 9%	30 to 60	7,3% to 9.75%	Multiple of 5	3 to 4.5	Not planned	Skilled labor	Specialized and locable	< 30%	In various layers
	3 - Good	5% to 7%	60 to 100	6.8% to 7.3%	Multiple of 10	4.5 to 6	By third piece	Some experience	Specialized and purchasable	30% to 70%	In the same layer
	4 - Best	< 5%	> 100	< 6.8%	Multiple of 60	> 6	Direct	D.I.Y.	Domestic	> 70%	None significant
WINDOW FRAME	1 - Worst	> 9%	< 30	8.3%	Other or none	< 3	Monolithic	Specialized company	Exclusive domain	None	Unfeasible
	2 - Bad	7% to 9%	30 to 60	7.05% to 8.3%	Multiple of 5	3 to 4.5	Not planned	Skilled labor	Specialized and locable	< 30%	In various layers
	3 - Good	5% to 7%	60 to 100	5.8% to 7.05%	Multiple of 10	4.5 to 6	By third piece	Some experience	Specialized and purchasable	30% to 70%	In the same layer
	4 - Best	< 5%	> 100	< 5.8%	Multiple of 60	> 6	Direct	D.I.Y.	Domestic	> 70%	None significant
PARTITION	1 - Worst	> 5,5%	< 25	> 6.85%	Other or none	< 3	Monolithic	Specialized company	Exclusive domain	None	Unfeasible
	2 - Bad	4% to 5.5%	25 to 50	5.8% to 6.85%	Multiple of 5	3 to 4.5	Not planned	Skilled labor	Specialized and locable	< 30%	In various layers
	3 - Good	2,5% to 4%	50 to 75	4.8% to 5.8%	Multiple of 10	4.5 to 6	By third piece	Some experience	Specialized and purchasable	30% to 70%	In the same layer
	4 - Best	< 2,5%	> 75	< 4.8%	Multiple of 60	> 6	Direct	D.I.Y.	Domestic	> 70%	None significant

1.3 Adjusting process of the average cost parameter

Whilst in the process of defining the scales of scores of the respective elements, it was noticed that the *cost* parameter had to undergo an adjustment, which is common in the methodological construction by analysis with multi-criteria. As stated earlier, the costs of the various building components reported by manufacturers, suppliers and specialists vary greatly from their unit of measurement – cost per square meter; per cubic meter; per piece; by weight etc.

With the practical impossibility of directly converting the costs of each specific component into percentage values of the full cost of the work as described in the scale of notes of Table 4, it was decided to carry out the conversion from the simulation of a simplified constructive volumetric model (Figure 2). In order to perform the operation, at least two different types of generic components (*elements*) were chosen for the study layers (*structure*, *façade* and *partition* for the *internal closure*). As a prerogative, two quite opposite combinations were chosen regarding to the degree of adaptability generated in the construction models: [1] a monolithic structure, which, by definition, offers a very low degree of flexibility; and another, [2] an independent structure that offers a greater degree of flexibility.

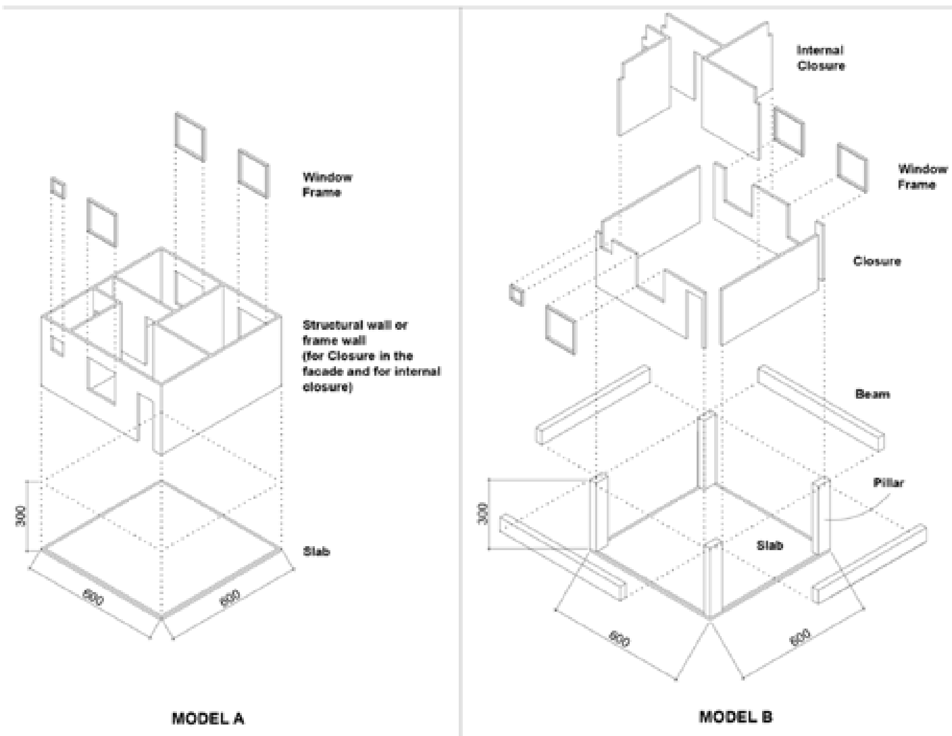


Figure 2 – Diagrams of the constructive models. Source: (Authors 2018)

Model A combines a type of slab cast on-site with structural wall for the *structure* layer. The structural wall also forms the *closure* element for the *façade* layer and the *partition* element for the *internal closure* layer. The model also presents the *window frame* as an element of the *façade* layer.

Model B combines a type of slab, beam and pillar more prefabricated (industrialized) for the *structure* layer. The *façade* layer has the windows frames as in model A. Furthermore, the *closure* elements of the *façade* layer and *partitions* of the *internal closure* layer are independent of the others.

The two models have the same final dimensions (6mX6mX3m), which makes possible to convert the cost of each element (generic component) in the way it is practiced in the market (per square meter, per cubic meter, by weight, etc.), in cost per square meter of construction. For this first conversion, the costs per square meter of construction defined by CUB-Sinduscon[5] was used as reference maintaining the average percentage values per *layer* or *element* as defined in Table 4. For example, the cost of the *structure* layer corresponds in average to 30% of the total cost of the work; the cost of the *closure* element of the *façade* layer corresponds to 7% and that of *window frames* 13%. This is regardless of the specific component chosen.

1.4 Assessment and weighting values

As well as for the evaluation values (assessment) defined in section 1.2, a scale with 4 levels was also defined for the weighting values: [1] unimportant; [2] slightly important; [3] important; [4] very important (Table 5). The tool under construction will present a score for all the constructive components under study, but proposes that the user assigns weighting to the parameters, precisely because in each context and depending on the decision-making criteria, some parameters may weigh more than others, even if the adaptive capacity of the building is desired.

Table 5 – Evaluation parameters, assessment and weighting scales, and scores per specific constructive component. Source: (Authors 2018)

EVALUATION PARAMETERS	ASSESSMENT (A)				WEIGHTING (W)				SCORE
	01	02	03	04	01	02	03	04	
01. AVERAGE COST									
02. LIFESPAN									
03. WORK EXECUTION TIME									
04. MINIMUM MODULE									
05. MAXIMUM MEASURE									
06. CONNECTION TYPE									
07. MANPOWER									
08. TOOLS/EQUIPMENT									
09. REAPROVEMENT P.									
10. MODIFICATION P.									
FINAL SCORE (S)									

The final score (S) of the component relative to its degree of flexibility or adaptive capacity in the building will be, for each user and scenario studied, calculated by the sum of the multiplication of the evaluation value (A) by the assigned weight factor (W) attributed to each parameter.

$$S = W1xA1 + W2xA2 + W3xA3 + W4xA4 + W5xA5 + W6xA6 + W7xA7 + W8xA8 + W9xA9 + W10xA10$$

2.0. DATABASE

This research has mapped, built and structured, within a database, several Brazilian constructive components employed or capable of being employed, in housing production, with any standard of finishing. For each component, the systematization of information is restricted to the 10 parameters of evaluation of its flexibility. Table 6 illustrates this mapping with the drywall component of the *internal closure* element. The majority of the information has been sought from the respective manufacturers and suppliers, or from experts in the field.

Table 6 – Example of evaluation parameters to the drywall component. Source: (Authors, 2018)

LAYER	ELEMENT	COMPONENT	PRODUCT	PRODUCER	AVERAGE COST	LIFESPAN (YEARS)	WORK EXECUTION TIME
INTERNAL CLOSURE	PARTITION	DRYWALL	DRYWALL STANDARD	KNAUF	110BR/ m2	FRAME: ≥ 100 BOARD: ≥ 30	10% TOTAL TIME

MINIMUM MODULE (cm)	MAXIMUM MEASURE (m)	CONNECTION TYPE	MANPOWER	TOOL/ EQUIPMENT	REAPPROVEMENT POTENTIAL	MODIFICATION POTENTIAL
MULTIPLE OF 20	3,6	THIRD PIECE	SKILLED LABOR	SPECIALIZED AND PURCHASABLE	< 30%	UNFEASIBLE

In order to initially feed the database, structural components more commonly used in Brazilian housing production were chosen, such as: [1] *on-site* cast concrete structures (pillar and beam or wall-concrete systems); [2] structural masonry (with ceramic or concrete blocks); [3] metallic structures (sections with shape H, tubular or rectangular, in addition to steel frame); [4] precast concrete structures (square, rectangular and circular section, in addition to concrete structural walls); [5] *on-site* cast slabs: solid, mushroom, ribbed or pre-stressed; and prefabricated slabs with beams, lattice work, trellised or alveolar panels.

In the case of the components of the other layers, the most utilized systems in the construction of non-residential buildings, but which could be adopted for such a function, have also been mapped.

In the case of *façades*, different types of *prefabricated* concrete, ceramic, metallic or *on-site* walls and panels have been classified. Similarly, research has also been performed on various *internal closure* components for *partitions* (internal masonry walls with various materials, dry wall or wood frame), *linings*, *raised floors* and *shaft closures* in the most diverse variations of materials and modes of execution.

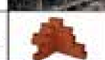
The database under construction will include a selection of the main components available in Brazil, for all layers of the building, except for *terrain* and *furniture*. All the components will include scores attributed by the tool under construction and refer to the parameters of evaluation. This will enable the user in the decision-making process, to cross-reference, assigning weight to the most important parameters for the scenario being studied.

3.0. CASE STUDY: PARTIAL VERIFICATION PROCESS AND APPLICATION OF THE TOOL

In order to test the tool in development, verify its partial validation and compare the degree of flexibility of some constructive components of the same function, there was an attempt to apply it to some known cases.

To exemplify the procedure, the specific components were chosen as shown in Table 7. It should be emphasized that the evaluation of a specific constructive component is not, at this moment, linked to its combination with another component, nor to a specific scenario. Thus, scores were assigned from the database under construction and according to the scale of scores previously presented in Table 4. These are as shown in Table 7, below.

Table 7 – Application example of the tool in development. Source: (Authors 2018)

ELEMENT	PRODUCT	PRODUCER	PICTURE	01- AVERAGE COST	02- LIFESPAN	03- WORK EXECUTION TIME	04- MINIMUM MODULE	05- MAXIMUM MEASURE	06- CONNECTION TYPE	07- MANPOWER	08- TOOLS/ EQUIPMENT	09-REAPROVEMENT P.	10- MODIFICATION P.	SUBTOTAL
SLAB	PRECAST CONCRETE	INCOBRAZ		4	4	2	1	2	2	3	3	1	1	23
	ALVEOLAR CONCRETE	PRECON		4	4	4	1	4	3	2	2	3	2	31
PILLAR	PRECAST CONCRETE	PRECON		2	4	3	3	4	3	2	2	2	3	27
BEAM	PRECAST CONCRETE	PRECON		2	4	3	3	4	3	2	2	2	3	27
FRAME WALL OR STRUCTURAL WALL	SOLID CONCRETE	IN LOCO		4	4	4	1	1	1	1	1	1	1	19
CLOSURE	CERAMIC MASONRY	BRAÚNAS		2	3	2	1	3	2	3	3	1	2	22
	AQUAPANEL W384	KNAUF		1	2	4	4	4	4	3	3	2	4	31
WINDOW FRAME	PRÁTIKA STEEL LINE	SASAZAKI		3	2	3	3	1	2	2	3	3	2	24
	SOLUTA LINE	KAWNEER		1	3	3	4	4	4	2	1	3	3	28
PARTITION	CERAMIC MASONRY	BRAÚNAS		2	3	2	1	3	2	3	3	1	2	22

Considering the scores assigned in Table 7, and considering as an example of application of the tool an equal weighting factor for all the evaluation parameters, it appears that the *alveolar slab* presents a higher score than the *prefabricated slab*; the *precast structure* receives better evaluation than the *concrete-wall structure*; the *Aquapanel closure* has better flexibility performance than *ceramic masonry* and the *Kawneer Soluta window frame* line is also more flexible than the *Sasazaki line*. That is, the more independently the components behave in a construction (Model 2 in the Figure 2), allowing their easier replacement, more adaptable in time the building will be.

Since the weighting value will be assigned by the tool-user, logically the final score of each component can be changed according to the weight given to each evaluation parameter. For example, the parameters 4 to 10 can be seen in a more direct relation to the component's flexibility performance, due to its physical, structural, functional etc. nature. However, other parameters such as *cost*, *lifespan* and *work execution time*, may or may not influence the final evaluation, depending on other aspects of user demand.

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It should be noted, however, that *cost* and *lifespan*, while apparently not determining parameters of the high flexibility performance of a specific constructive component, should be analyzed together, depending on the *future value* inherent in the adaptive capacity of the buildings.

CONCLUSIONS: RECOMMENDATIONS AND NEXTS STEPS

As presented earlier, this article was an important step in the development of an instrument to evaluate the adaptive capacity of Brazilian constructive components.

The following steps are to be taken:
- Better develop and structure the *layer*, *element, component* and *product* concepts, refining the description of the evaluation criteria of the adaptive capacity of Brazilian constructive components;
- Make necessary adjustments in the scales of the parameters evaluation and their variations, in the assessment and weighting scales;
- Simulate calculations to define classes of final scores for the parameters;
- Complete the structuring of the database;
- Study more complete and complex scenarios, seeking to better represent reality, thus better illustrating and discussing the applicability of the tool;
- Associate the tool with design strategy for flexibility.
- Discuss and evaluate the methodology together with potential users;
- Develop a digital graphic interface for consultation on database, tool application and visualization of results;

In the end, the research results will allow describe better about the adaptability of Brazilian constructive systems available nowadays. The tool is expected to offer the target users greater resources in the decision-making process towards the production of more adaptable buildings.

ACKNOWLEDGEMENTS

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ENDNOTES

[1] "Systems, subsystems and construction components adhering to the Open Building methodology" of the group LabFlex, based at the Centro Universitário Metodista Izabela Hendrix (CEUNIH), Belo Horizonte, Minas Gerais, Brazil, coordinated by Professor Rosamônica da Fonseca Lamounier. Participating in the project are Professors Ana Maria Ferreira Saraiva and Carolina Albuquerque de Moraes, researcher Rodrigo Rocha de Freitas and students Edésio Rocha Júnior, Ruben Gonçalves do Vale, Henrique Nogueira Pereira and Júlia Cristina Carneiro. The project has partnerships with Architecture and Urbanism Course of UFOP, with a research group supervised by professors Dr. Clécio Magalhães do Vale and Ms. Giselle Oliveira Mascarenhas, and PRAXIS-EA/UFMG group, led by Professor Denise Morado Nascimento.

[2] LabFlex Group is a research group of CNPq, created in 2018, based at CEUNIH, Belo Horizonte, Minas Gerais, Brazil, coordinated by Professor Rosamônica da Fonseca Lamounier. The central objective of the LabFlex is investigate the housing production in Brazil under the bias of the spatial flexibility, adaptive capacity of the buildings, being in this imbricated the decision power of the dwellers.

[3] Matthijs Prins, in his Doctoral Thesis (1992), defines a series of useful terms for the development of a system to support decision-making in design processes that involve flexibility and costs. His work has been useful in understanding the importance of parameters such as lifetimes (technical, economic or use-oriented) as well as costs related to both flexibility demand and its supply. The author also discusses the types of flexibility (re-allocation, re-use, replacement and repair) associated with the life of the building components.

[4] Stichting Architecten Research (Foundation Architectural Research), created by Habraken and some researchers, investors and industrialists in The Netherlands in 1960's.

[5] The Basic Unit Cost of Construction (CUB) is a monetary indicator of the construction sector that is calculated by Civil Construction Industry Unions throughout Brazil per federal state. It determines the overall cost of the work for legal compliance purposes. The costs per square meter are calculated monthly in different scenarios, considering use, formal architectural typology, scale and standard of finishing. For the year presented here, the values considered were those calculated for Minas Gerais in the base month June 2018, from the weighted

average of the values presented for residential uses, considering different typologies (individual, with 4, 8 and 16 floors, in addition to projects of social interest) and standard of finishing (low, medium and high). The value per square meter found for the cost of each component was divided by this average to arrive at the cost of each component in percentage terms of the total cost of the work.

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A STUDY ON A FLATNESS TEST OF LONG-LIFE HOUSING INFILL FLOOR

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ABSTRACT: Long-life housing is attracting attention as a future-oriented residence in Korea, where there are limitations to securing living space. This study is significant in conducting performance tests on the dry floor and verifying its performance among the infill, which consists of ceilings, walls, floors, toilets, wiring, and piping. Among the various performance items on the floor, this study performed a performance test and verification on the flatness. The flatness (smoothness) of the floor system is a performance that affects the aesthetics and installation of furniture and goods, and the opening and closing of doors. Therefore, this study performed a flatness test on the dry hot-water *ondol* panel system by selecting an evaluation basis of 7 mm or less per 3 m, which is the standard value of flatness of the concrete-finished surface. This study applies the “flatness test method for the floor of residential facilities” proposed in the “Development and Application for Floor Heating System in Apartment Housings” as the flatness test method for the infill system floor. As a result of the flatness test on the floor, it is considered to be suitable for use as the floor of residential facilities. The results of this study can be used as the basic data to increase the reliability of replacing wet floors with dry floors, and are considered to be suitable for proposing future infill performance criteria and evaluation methods.

KEYWORDS: Long-life Housing, Performance, Infill Floor, Adaptation, Disentanglement

INTRODUCTION

This study was designed to establish the infill performance criteria as part of the demonstration study of Long-life Housing. The Long-life housing research group is working on the design guidelines for Long-life housing, the demonstration project for construction, and the policy system for Long-lived Housing. In Korea, apartments are built using concrete as a wet method. Because the wetting method is performance that should be satisfied, there are no standards, so the dry technique of infill may not be satisfied. Therefore, performance criteria for infill are necessary.

1.1. Study Background and Purpose

Long-life housing is attracting attention as a future-oriented residence in Korea, where there are limitations to securing living space. Existing houses consume tremendous resources by repeating the demolishing and rebuilding process of buildings in a rapid cycle. The support for long-life housing is designed to last for more than 100 years, and the infill can be planned to be changeable and easy to repair as desired by the residents. However, there are limitations to realizing the concept of long-life housing by the conventional wet construction method. Therefore, the concept can be realized by actively using the dry construction method. However, the standards for the infill are insufficient. This study intends to establish the performance items and criteria for the infill.

1.2. Study Method and Content

This study is significant in conducting performance tests on the dry floor and verifying its performance among the infill, which consists of ceilings, walls, floors, toilets, wiring, and piping. Among the various performance items on the floor, this study performed a performance test and verification on the flatness. Since wet floors are leveled during construction, the flatness is moderately flat. However, dry floors are made up of multiple layers and bonding materials, which reduce the reliability of the flatness compared to wet floors. The flatness is a performance item that must be satisfied. If the flatness is not suitable, phenomenon such as the lifting of the floor finishing materials and height imbalance during furniture installation may occur.

2.0 Theoretical Consideration

2.1. Construction Sequence of Infill

The main factors of infill are variability and ease of repair, as well as the interior and dedicated facilities depending on the residents (Hwang, 2003). Among them, the floor infill, unlike the conventional wet construction method which buries the heating piping XL pipes, can be easily repaired through disentanglement if the pipe is damaged. This corresponds to the ease of repair, which is a key element of long-life housing. For the adaptation to long-life housing, the dry floors must be fully installed before the walls are built within the household. The residents can change the location of the wall in the future through this construction method. This corresponds to variability, which is a key element of long-life housing. If the walls are built before the floor is constructed, the floors need to be dismantled in order to change the wall. Therefore, the construction method is a very important factor.

3.0 Infill Floor Flatness Test

3.1 Experiment Overview

The flatness (smoothness) of the floor system is a performance factor that affects the aesthetics, installation of furniture and goods, and the opening and closing of doors. Considering the safety, cleanliness, and aesthetics concerns of the residents, there is a recent trend of not installing a door frame within the household around apartment houses In addition, if the conventional floor finishing materials are replaced with floorboards, the degree of finishing depends greatly on the flatness (smoothness) of the background. In addition, as residents experience great inconvenience and anxiety when the floor finish is not smooth, it is important to secure flatness (smoothness) in the dry hot-water *ondol*[1] panel system. Therefore, this study performed a flatness test on the dry hot-water *ondol* panel system by selecting an evaluation basis of 7 mm or less per 3m, which is the standard value of flatness of the concrete-finished surface.

3.2 Test Specimen Construction Method

The floor systems to be applied in the infill system are the 2 types of the G2 and G3 dry hot-water *ondol* panels. Test specimen G2 is a dry hot-water *ondol* panel type in which the steady rest serves as a support but is not a floating structure as shown in Figure 2. Test specimen G3 is a dry hot-water *ondol* panel type in which the steady rest serves as a support and consists of a floating structure with an empty space of 20 mm at the bottom (see Figure 2). However, the final finish for both test specimens is a magnesium board (thickness 12 mm).

Figures 1 and 2 show cross-sectional drawings and outlines of test specimens G2 and G3 to be applied to the floor system of the infill system.

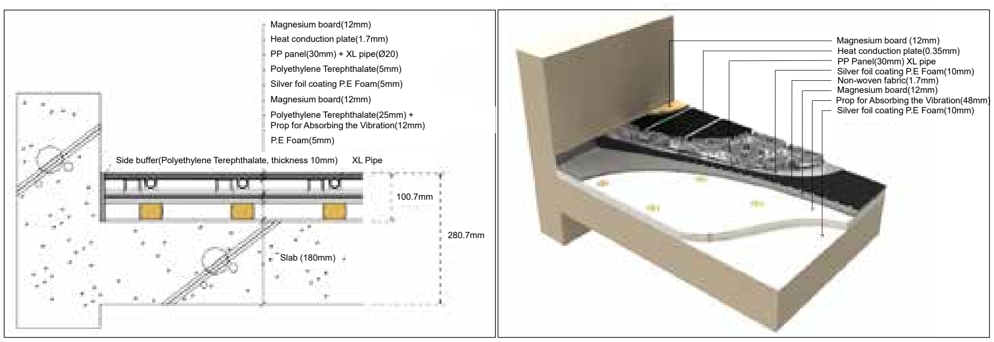

Figure 1: Cross-section and outline of G2

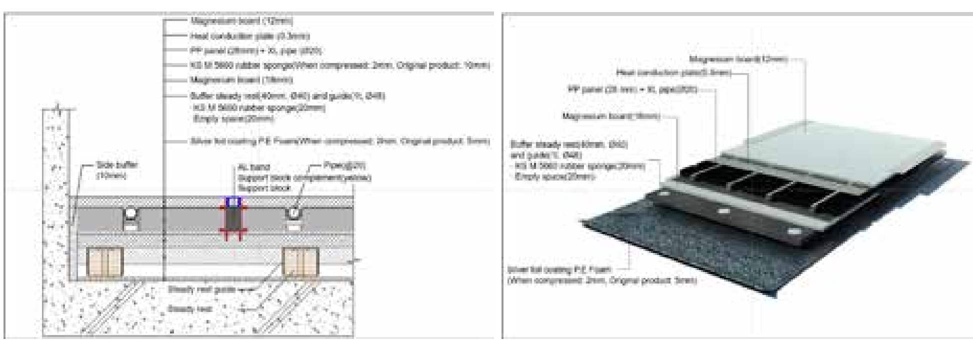

Figure 2: Cross-section and Outline of G3

3.3 Experimental Conditions and Method

This study applies the “flatness test method for the floor of residential facilities” proposed in the “Development and Application of Floor Heating System in Apartment Housings (Korea National Housing Corporation, Ministry of Construction & Transportation, 1998.12.)” as the flatness test method for the infill system floor. The most important thing before installing the test specimen is that the concrete structural slab should be flat. It is recommended that thin layers of sand be tested on top of concrete before this experiment. The overview of the test method is shown in Figure 3, and the test procedures are as follows.

① Mark 25 joints (intersecting points at intervals of 0.5 m within a 3 m x 3 m grid) between the boards of the measured test specimens (G2, G3).
② For each measuring point, place the tripod equipped with a steel ruler (indicating a measurement up to 0.5 mm) horizontally using a circular level.
③ Read and record the gradation of the steel ruler in 0.1 mm increments with a level installed in a designated place.
④ Obtain the maximum level difference by calculating the relative displacement (level difference) for the 25 measurement points.

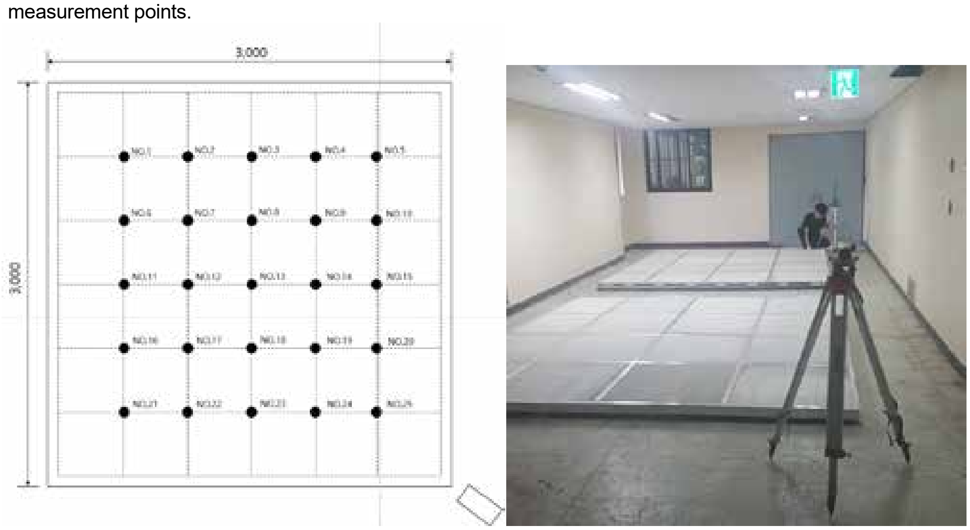

Figure 3 : Measurement points and test photo

4.0 Experimental Results

4.1 Applicable Standards

Since there are no performance standards established for the infill floor flatness (smoothness) in Korea or other countries, this test applied the “standard value of flatness of concrete finish” of the standard specifications for construction work and the “standard value of flatness of concrete finishing surface specified by the ACI[2]
Figure 1 shows the standard values of flatness for concrete finishing surfaces as specified in the standard specifications for construction work by the ACI

Table 1: Flatness standard values of concrete-finished surfaces as specified in the standard specifications for construction work by the ACI

Standard specifications for construction work		ACI		
Standard value	Surface finish method	Slab exterior material	Slab	
		Standard value	Standard value	Grade

-	-	Less than 1/4 in per 20 ft	Less than 1/8 in per 10 ft	A
Less than 7 mm per 3 m	-Exposed concrete -Extremely thin finish thickness	Less than 1/4 in per 10 ft	Less than 1/4 in per 10 ft	B
Less than 10 mm per 3 m	-Finish thickness less than 7 mm	-	-	-
-	-	-	-	-
Less than 10 mm per 1 m	-Finish thickness over 7 mm	-	Less than 1/4 in per 2 ft	C
-	-	-	-	-

Although these values refer to the final finish condition of the concrete surface, there will be no problem applying them to the dry hot-water *ondol* floor. This is because the background of enactment includes the securing of the aesthetic or structural safety of the surface and the influence on the precision of construction of internal and external finishing materials. However, in order to understand the validity of the standard values of flatness (smoothness) above, it is necessary to thoroughly review existing studies related to each regulation. However, since the data is currently insufficient and difficult to obtain, it is rather difficult to apply these standards directly to this test. Therefore, the flatness (smoothness) standard values presented in the relevant standards shall be applied to evaluate the infill system floor flatness (smoothness). This will also be in consideration of the problems caused by insufficient flatness (smoothness) in actual dry hot-water *ondol* floors such as the effects on the aesthetics, construction of floor finishing materials, installation of furniture and goods, and the opening and closing of doors.

4.2 Results Analysis

Table 2 shows the flatness (smoothness) test results of the infill system floor test specimens G2 and G3.

Table 2: Flatness standard values of concrete-finished surfaces as specified in the standard specifications for construction work by the ACI

Test specimen G2			Test specimen G3		
Measuring position	Level (mm)	Maximum level difference	Measuring position	Level (mm)	Maximum level difference
No.1	-0.79	1.1	No.1	-0.05	1.21
No.2	-1.06		No.2	-0.07	
No.3	-0.73		No.3	0.00	
No.4	-0.91		No.4	0.22	
No.5	-0.72		No.5	0.42	
No.6	-0.61		No.6	-0.39	
No.7	-0.06		No.7	-0.35	
No.8	0.04		No.8	-0.30	
No.9	-0.31		No.9	-0.08	
No.10	-0.85		No.10	0.71	
No.11	-0.72		No.11	-0.01	

No.12	-0.23	No.12	-0.20
No.13	0.00	No.13	0.00
No.14	-0.27	No.14	0.02
No.15	-0.66	No.15	0.73
No.16	-0.82	No.16	0.01
No.17	-0.37	No.17	-0.10
No.18	-0.23	No.18	-0.02
No.19	-0.31	No.19	0.10
No.20	-0.61	No.20	0.82
No.21	-0.61	No.21	-0.05
No.22	-0.62	No.22	-0.28
No.23	-0.67	No.23	-0.33
No.24	-0.68	No.24	-0.15
No.25	-0.35	No.25	0.00

[Note] The measurement results are based on setting No.13 point as the reference (0.0 mm).

In general, the flatness (smoothness) of wet *ondol* floors finished with relatively thin materials, such as double-layer flooring or vinyl sheets should be evaluated by applying the standard specifications for construction work "when the concrete is exposed concrete finish or when the finish thickness is very thin, or when other good surface conditions are required (less than 7 mm per 3 m: resin-painted floor, wear-resistant floor, trowel-finished floor)" or conforms to ACI grade B (less than 1/4 in per 10 ft).

As a result of measuring the flatness (smoothness), the maximum level difference for test specimen G2 was 1.1 mm, and 1.21 mm for test specimen G3. These results are equivalent to the standard specifications for construction work "when the concrete is exposed concrete finish or when the finish thickness is very thin, or when other good surface conditions are required (less than 7 mm per 3 m: resin-painted floor, wear-resistant floor, trowel-finished floor)" and equivalent to ACI grade B (less than 1/4 in per 10 ft), which indicate that the flatness (smoothness) of the test specimens G2 and G3 applied to the infill system floor is suitable for use as the floor of residential facilities.

CONCLUSION

The results of conducting a performance test by deriving the major performance items required from a structural safety, durability, and livability perspective for each part of the infill system of long-life housing are as follows.

As a result of conducting a flatness (smoothness) test on the floor, the maximum level difference within the (3 m x 3 m) grid was 1.1 mm for test specimen G2, and 1.21 mm for test specimen G3, which are equivalent to the standard specifications for construction work "when the concrete is exposed concrete finish or when the finish thickness is very thin, or when other good surface conditions are required (less than 7 mm per 3 m: resin-painted floor, wear-resistant floor, trowel-finished floor)" and equivalent to ACI grade B (less than 1/4 in per 10 ft), which indicate that the flatness (smoothness) of the test specimens G2 and G3 applied to the infill system floor is suitable for use as the floor of residential facilities.

The results of this study can be used as the basic data to increase the reliability of replacing wet floors with dry floors, and are considered to be suitable for proposing future infill performance criteria and evaluation methods. However, it is difficult to determine whether it can function as a floor solely by the flatness data. Therefore, various performance factors, such as load resistance and impact resistance, must be verified.

ACKNOWLEDGEMENTS

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ARCHITECTURE WITHOUT LAND. SECURE LAND RENTAL AS AN OPEN DEVELOPMENT STRATEGY

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ABSTRACT
The ownership of urban land in South Africa is highly contested while its considered development is key, as the majority of low-cost housing is currently developed on inexpensive land on the urban periphery. Secure land rental can, with the provision of infrastructure, mediate between land required by the urban poor and land that they can afford. Fixed ownership projects stagnate urban development, whereas rental facilitates appropriation and unit flexibility, so that tenants can alter their dwellings to suit their economic ability.

This paper, titled *Architecture without Land* proposes tenure without the promise of ownership of land. This approach suggests access to land that fosters compact resilient development and the reduction of wasteful and inefficient building stock particularly in previously disadvantaged, and poorly developed, neighborhoods.

The paper will critique current, and relevant, land tenure approaches in South Africa and will investigate land access opportunities, characterized by a process of continual redevelopment within strict urban boundaries and multiplicity of use. These investigations will be made through approaches aligned with Open Building discourse which best conveys the possibilities of functional change, heightened with anchors of stability such as infrastructure, and resilience thinking where continual redevelopment is enhanced, and high adaptive capacity, networks and scales increase the flexibility of urban life.

KEYWORDS: Land, Development, Tenure
South Africa, Dependency.

1.INTRODUCTION

“Architecture without land” is a proposed strategy to deal with land acquisition in urban areas without the possibility of ownership. Gonzalo Lizarralde[1] (2015) highlights that land is a powerful means to guide development and economic growth, ultimately becoming a political instrument. The land question is deeply rooted in South Africa’s history, visible in the 1913 Native Land Act, 1950’s and 60’s forced removals supported by the Group Areas Act that formed part of the Apartheid legislation, and current evictions, often violent, by government and private developers. The question of land acquisition has, recently, become integral with the recent campaign of Radical Economic Transformation. In December 2017, the African National Congress (ANC, ruling party) elected Cyril Ramaphosa as its new leader and vowed that Land Expropriation without Compensation will become a reality, this view being supported by opposition parties such as the Economic Freedom Fighters (EFF) led by Julius Malema, a former ANC youth league leader. The EFF and Black First Land First (BLF) political parties are well known for their radical behavior and land grab actions. Previously land expropriation focused on rural and agricultural land, but this has recently shifted to urban land and housing. As a result of segregated spatial planning there has been biased development and allocation of resources (Commey 2015) and as South Africa has an urbanization rate of 2,43% (CAFH 2015), the need for affordable housing, both rental and purchase, and economic capacity building is sorely needed.

But land acquisition and financial resources cannot be separated. Professor Malcolm Keswell[2] (Fisher 2017) argues that “land reforms are ultimately about changing the distribution of wealth in our country”. The urban land question can be defined as the right to, use of and benefit of land. Land use policy should enable all residents equitable access to services and livelihood opportunities. Spatial transformation is fundamental to this discussion but is challenged by decisions about who the rightful owners are and to whom land should be restored (Joseph 2014). The South African government is currently hosting a series of public discussions around the question of amending Section 25 of the Constitution which deals with land expropriation. This has provided the opportunity to debate the question of land with residents, professionals, politicians and academics.

This paper focusses on secure access to land, and adaptive development potential, in critical neighborhoods which are in well-located previously disadvantaged areas or informal settlements, currently being inappropriately redeveloped by city authorities and private developers.

2. CURRENT LAND TENURE AND HOUSING MODELS IN SOUTH AFRICA

Research conducted by the Centre for Affordable Housing Finance in Africa (CAFH) indicates that only 32% of South Africans will be able to afford the cheapest house ($ 28 650) built by a private developer in South Africa in 2017. In 1994, as a response to the housing crises and apartheid spatial planning, the first democratic government introduced the Reconstruction and Development Program (RDP) subsidy. South African residents with a household income less than R 3500 ($ 255) per month and are eligible to receive, free of charge, a freehold title 40m² house on a 180-250m² stand. RDP, reimagined as the Breaking New Ground (BNG) program in 2004, promoted the 'one house, one erf' approach often on peripheral land, which exemplifies reductive design principles. This has resulted in mono-functional environments in low density areas, lacking well-defined urban spaces and hindering the basics of urban life (Low 2015). In 2011, 1.5 million homeowners of the RDP/BNG scheme had inaccurate or outdated title deeds and 5 million homeowners lived in RDP/BNG houses with no title deeds. Tenure insecurity is a key legacy of apartheid city planning and results from a lack of legal and formal government structures, coupled with the vulnerability of the poor (the Conversation 2017). Well located-land is scarce and cannot satisfy current demand, as it is not realistic to extend title deeds to all in any reasonable time. Title deeds will, also, not sufficiently disentangle the question of land as they tend to stagnate the process of continual redevelopment while limiting development to single uses and increasing inefficient land use. Mono-functional static land parcels do not respond to shifting needs without capital investment and risk becoming symbols of wasted financial resources. All of this results in decreased quality of urban space. South African cities cannot support poorly structured housing tenure solutions as land is a finite resource and efficiency is crucial for urban functionality (Joseph 2014).

The current provision of housing in South Africa can be described as varying levels of household dependency on government. The RDP/BNG program is the most dependent, residents only being accountable for water and electricity costs. Social Housing, supported by city authorities, is provided mostly to families with a household income between R3500 - R 7500 ($245 - $520) where they are responsible for monthly rental, water and electricity payments. Affordable rental housing and affordable bond housing are mostly developed by private developers with limited subsidy. FLISP (Finance Linked Individual Subsidy Program) aids first time qualified home buyers with a once-off down payment to those that have secured mortgage finance for residential properties thus reducing the initial home loan amount and monthly instalments.

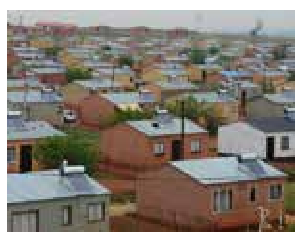

Figure 1: Typical RDP Housing. Source: (Image by Yandisa Monakali, in Dlamini 2017). Figure 2: RDP Housing. Source: (Dhlamini 2014). Figure 3: Springfield Terrace Social Housing. Source: (Tonkin 2008).

The standard application of the abovementioned government housing models limits the household's self-help ability and opportunities to adapt the dwelling for income generation such as home businesses, typical in an informal setting. One opportunity that does exist is the presence of "backyarders". They rent land, most often informally, from home owners, frequently sharing with other backyarders, resulting in overcrowded conditions. Backyard units are typically free-standing timber structures clad with corrugated sheet metal. Backyarders are currently exploited by high rentals, land insecurity, lack of access of basic services, subsequently being forced to use the home owners' facilities (ASF-UK DAG 2017). The City of Cape Town developed a policy in 2017 for backyarders with a focus on provision of infrastructure. This resulted in larger municipal service connections from main lines to one erf, accommodating multiple households, with the provision of split power prepaid meters and water connections (Pretorius 2017). Blikkiesdorp, originally a Temporary Relocation Area (TRA) established as emergency housing in 2008 in Delft, Cape Town, is 25 km from the city centre, and is well hidden from tourists. It currently consists of 1600-2000 households that have been living in tin shacks for the last 10 years. The urban structure is a bleak image, with a rigid urban grid, lack of vegetation and no defined public space. The City of Cape Town moved residents to Blikkiesdorp to 'clean' the streets for the 2010 football World Cup and this approach is a common theme in housing provision in South Africa. Residents explain that Blikkiesdorp structures are leaking, with four families sharing one tap and one toilet in unhygienic conditions (Bohatch & Hendricks, 2017). With the current high demand for land use in South Africa it becomes almost impossible for any temporary housing not to become permanent. The current TRA model is unacceptable in the South African condition as

temporality does not excuse undefined and undignified spatial conditions.
Blikkiesdorp, once a temporary location, is now permanent showcasing the importance that temporary architecture must be designed with permanence as a potential spatial condition.


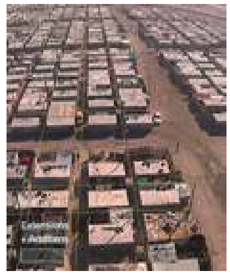


Figure 4: Parkwood, Cape Town Backyarders. Source: (Huffington post 2018). Figure 5: Blikkiesdorp, Cape Town Source: (South African Townships by Drone 2015). Figure 6: Blikkiesdorp, Cape Town. Source: (Google Maps, 2018)

3. SECURE LAND RENTAL
The preceding summary of housing provision and land tenure in South Africa highlights the ‘opportunity of land’ to provide a legal framework for economic opportunity and capacity building. This is necessary for continual redevelopment within strict boundaries, multiplicity of use, secure access, resilient compact city development and a reduction in urban sprawl and inefficient land use. Secure land rental can strengthen this process, by enabling shared authorship, supporting the development of resilient livelihoods. Land rental can, with the provision of infrastructure, mediate between land required by the urban poor and land the urban poor can afford. But the risks of gentrification, uneducated residents, urban decay, unstable provincial land parcels necessitate the removal of land from the market as a protection measure, to limit the commodifying effect. Land rental is often unstable, and informal, exploiting the urban poor and foreign nationals.

Secure land tenure is an urgent need in the South African context to reduce economic and social vulnerability. The general perception is that government is slow with informal settlement upgrades, often opting for a top down approach. A common concern of the community, in terms of private developers, is the quality of work as the perception is that development is driven by profit. Community Land Trust (CLT) is an example of an approach that mediates between grassroots and top down developments. The CLT is a community non-governmental organization, consisting of a tripartite governance of residents, city council and professionals (Klug 2017). The main objective of the CLT is to provide access to land for previously excluded, to address the risk of urban decay and lack of urban management. (Zhang 2012). The CLT takes the role of the developer, guides the overall governance and maintenance of the shared infrastructure, with a focus on low income households to rent land for housing, establish small business and sustainable urban agriculture. The operation of the proposed CLT land rental approach is similar to the buy-rent strategy developed in the Netherlands by Frank Bijdendijk in 1988; where the tenants rents vacant space in a building, from the developer, and purchases the interior fit-out. This approach allows tenants to adapt the unit to suit their current needs, reducing the need to relocate to alternative housing and increasing the stability of both the building and the neighborhood (Kendall 2000). Rental enables the tenants to be clients and not state-dependents, which translates to the opportunity, to either be part of the governing body, working along with city officials and professionals or keeping the CLT legally accountable. Decision clusters and sub-committees will oversee various elements of the building such as services, tenants, land composition and neighborhood integration, enabling tenants to shape their own support infrastructure. A clear division of the shared and individual is key, yet the two are interdependent. John Habraken (2002) describes housing as partially the production of buildings, but rather the cultivation of a process. The support environment is continually adjusted to fit the needs of the current tenants, maintaining affordability and security, economic diversity and local access to services.

Secure land rental is a flexible strategy that has potential to adapt to urban and economic fluctuations while adaptive land use approaches are essential for resilient city planning. It is vital to redirect future growth by adopting strategic planning measures as it is difficult to retrofit or ‘fix’ issues such as Blikkiesdorp (Lasser 2015). David Salt[3] defines resilience as the ability to absorb change, while resilient built forms enhance dynamic fluctuations in urban environments (Applegath 2012). Urban resilience also provides a contextual and integrative method to enhance the positive properties of city systems so that they are prepared for, and can adapt to, changes in climate, collapse of economic, cultural and political systems (Peres & Du Plessis 2014) or daily changes such as informal appropriation, or temporary tenants. Social-ecological resilience is defined as the amount of disturbance a system can absorb and remain within the same state. It considers the degree the system is capable of self-organization and the system's ability to build and increases capacity for learning and adaptation, strengthened by governing structures such as CLT's (Wilkinson 2010; Brand 2007). Land rental, articulated as an open system, responds to current political and economic disruptions, expecting change, disturbances and self-help. The adaptive cycle is central to resilience thinking such as adaptive co-management with user participation in decision making, as supported by Open Building principles.

4. INFRASTRUCTURE PROJECTS

Secure land rental and the 'opportunity of land' necessitates a flexible and adaptable architecture, the origins of which can be found in the 1960's. Approaches were then influenced by cybernetics, artificial intelligence and information technology. Cedric Price[4] articulated the concept of anticipatory architecture by arguing for time-based interventions, as environment with variations. His proposal for the "Fun Palace is a process of continual construction, dismantling and reassembly" (Kolarevic 2015:3). Yona Friedman[5] (1964) argued that architecture as infrastructure must strengthen urban growth suggesting a 6m by 6m grid to allow for multiple functions. Villa Spatiale is a manifestation of infrastructure for compact urban growth, elevated above past areas of the city, retaining land use as a post war critique of unwanted expansion and urban sprawl. The intention is to expand the city within boundaries to limit demolition. Friedman suggests simple technologies, multiplicity of space, and mobile architecture designed by the occupant (Pinder 2011). The work of Price and Friedman focused on plug-in host structures as infrastructure to strengthen the process of change. This is similar to the "backyarder" city policy of Cape Town that emphasizes the importance of serviced land and the recent Cape Town property bylaw (2017) which allows residents to build a second dwelling to increase the multiplicity of land. The current definition of permanence, or temporality, limits adaptability and urban development and can rather be framed in terms of stability and change. Stability refers to stable built fabric, less likely to change, but which has the potential to change or be manipulated. Change refers to the shift between tenants, function and appropriation, the time of change varying from a day to 5 or even 50 years.

5. SUPPORT ENVIRONMENT

Open Building principles best convey the intention of functional change, heightened with anchors of stability such as infrastructure. Jo Noero's[6] Table House (ongoing) in Cape Town (Melvin 2017), for example, has been designed to provide the urban poor with a permanent low-cost structure that can be extended vertically and laterally to aid the process of incremental change and ordering growth. Similarly, Torre David, in Venezuela was an uncompleted concrete frame office building, which became an unintended open building host to 3000 residents. Occupants built their homes between columns, only requiring walls, as the floor and roof existed. The tower is a vertical composition of urban life and a framework for organic form such as the appropriation of the lobby into a basketball court (figure 2) while each floor has a barber, church and other services (Baan 2013). Torre David follow the notion of a dominant structural grid and the provision of horizontal levels, each level treated as flexible with housing and streets, accommodating density within a single erf. Designing for density and growth supports resilient city ideology while density reduces the cost per person, particularly the capital cost of infrastructure and urban and building management. Density is a keystone for resilience resulting in energy reduction and the possibility of multiplicity of use.


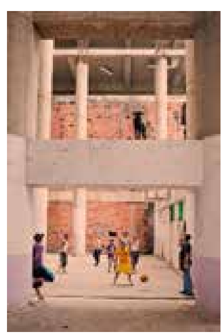
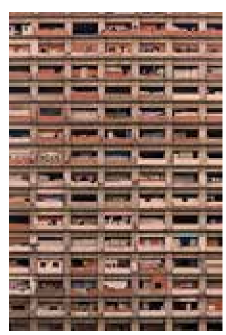

Figure 7: Table House by Noero Architects Source: (Melvin 2017). Figure 8: Torre David Lobby. Source: (Baan 2013).
Figure 9: Torre David Elevation. Source: (Baan 2013).

Continual redevelopment is enhanced when the open system strategically encourages and restricts development, by predetermining structure, service, urban boundary and open space. This maintains internal functionality and environmentally responsive conditions. Resilience thinking highlights urban conditions as inherently unpredictable, demanding acknowledgement of uncertainties (Wilkinson 2010).

5.1 STRUCTURE

Open system structures order development and stable built fabric and they predict future changeability and growth by encouraging and limiting development. Column and beam systems are both appropriate and flexible, with the potential of the base building being able to extend to meet development requirements. A column system, as opposed to a shed or outer shell, supports symbiotic relationships between stability and change and support and infill, whereas shed typologies cultivate parasitic relationships. The base structure mediates between existing and future neighboring contexts, as changes in these environments must be acknowledged. Typically, the context of critical neighborhoods in South Africa is single story but expected future developments should consider scales of four-story walk-ups, as regulation requires a lift for five and higher stories.

A wasted opportunity of government housing projects is the lack of acknowledgement of the family. Is the family headed by a single parent, does the extended family live with them, are they employed or dependent on home business? Housing tenure solutions in South Africa habitually provide a single solution for all families, failing to understand the end users, their spatial requirements (for example family size) and economic capacity, including future fluctuation in family's' economic capability. Land rental as open strategy enables families to insert, expand, subtract and manipulate their infill-built form dependent on fluctuations in economic capacity. The support and stable environment respond to the abovementioned variations with the provision of a scaled approach between facility (functional room such as public ablutions) and a connection point (service point).

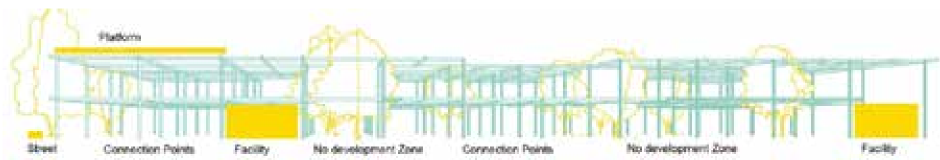

Figure 10: Proposed support environment. Source: (Leibbrandt 2017)

5.2 SERVICES

Services such as power, water and sewage can be ordered in a central spine, combined with a main circulation route and secondary, perpendicular, services lines (like an urban block), encouraging development to maintain the system logic. Service connections and lines can then be expanded. The strategy enables limited service development to these predetermined lines. It is not realistic, effective or logical to grid the entire land parcel with services. The restriction of services to a central point also enhances flexibility.

5.3 URBAN BOUNDARY

The provision of a structural grid and services cannot, alone, sustainably host the urban condition. Boundary is required to effectively ground the project and acknowledge layers of dependency. The urban condition therefore becomes a construct of a strict predetermined boundary, strengthening compact city ideology. Compact city development increases investment in utility and social infrastructure contributing to a level of convenience and service (Dewar, 2004). The compaction of urban form is vital for improving performance and operations as the single house on one erf consumes space (Dewar 2004). Stable built form reinforces boundary with previously mentioned facilities as anchor points, acting as interfaces between public and development. Secondary boundaries are perforated, and flexible, in a continual negotiation of space between the Community Land Trust (CLT), tenant and neighborhood that shifts dependent on need, such as 'lending' space to the urban environment.

5.4 OPEN SPACE

'No-development zones' are similar to courtyards and open spaces, providing shared outdoor space, accessibility and the potential of temporary use which does not require built fabric. These 'no-development zones' are predetermined breaks in the erf, acting as a courtyard to allow for daylighting and ventilation, as it is not sustainable to fill the entire land parcel.

6 TENANT AND INFILL DEPENDENCIES IN OPEN BUILDING

Change is further enhanced when the support environment accommodates various levels of tenant dependency. Stephen Kendall[7] (2006) describes Open Building as a number of levels being urban, support, infill and furniture. John Habraken[8] (2002) argues that uniformity is not efficient and has slowed development, 'Architecture without land' argues for both the infill and support level to be expanded into various options to accommodate diversity of tenants. The support environment is articulated with the scaled approach of facility and connection point. The infill responds accordingly with the following infill typologies, listed below, accommodating individual preference (figure 5).

1. Insert: A tenant sorely requires a service connection point, independent on structure and typically a

prefabricated unit.
2. Infill: A tenant is dependent on both connection point and structure, typically a panel system and dry construction, such as walls, floors and roofs.
3. Fit-out: A tenant requires a weatherproofed room provided by the support environment.
4. Furniture: A tenant require a finished room.
5. Use: Typically, of a homeless person, refugee or limited interaction of a pedestrian.

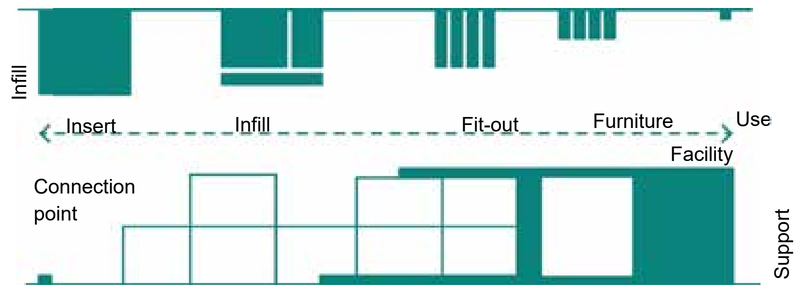

Figure 11: Diagram of scaled understanding of support and infill diversity. Source: (Leibbrandt 2017)

Habraken (2002) motivates that change itself must improve over time while technologies used today will most likely be inefficient in a few years. A community land trust (CLT) governed by tenants allow for the interdependencies between support and infill and change to gradually improve, in a sense giving freedom to lower levels as explained by Habraken in his description of the hierarchical organization of levels, in his paper titled *The Uses of Levels*. Typically, alterations in the support environment will affect the infill, but changes in the infill level will not affect the support level. This enables the infill to adapt and appropriate the support environment, attributed to the owners of the infill governing the support environment.

The intention of 'Architecture without Land' is to balance these dependencies on a single land parcel with predetermined anchor points (abovementioned service facilities) and flexible regions, influenced by decision clusters managed by the CLT. Secure land rental is similar to the Two Step Housing of the 1980's in Japan, the first step providing infrastructure as social overhead capital and the second step accommodating infill from local and informal construction companies. This strategy is also applied in current core-housing developments such as the Half Good House by Elemental (Botha 2010). Secure land rental takes into account changes and disturbances past the initial engagement with built form. It is a system that considers the change of tenants and built fabric with a focus on the development of a family, a cluster of families and business over time if the family should decide to move. Secure land rental explores the idea of the base building being open, changeable and removable at end of use. This is articulated in four phases (refer to fig. 5) (1) the buildup phase, (2) development of architecture (infill), (3) disassembly and (4) the redevelopment of land

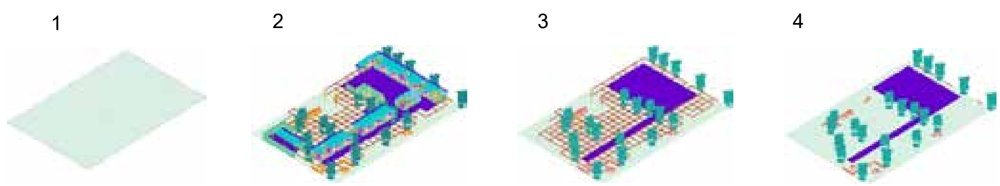

Figure 12: the four possible development stages of land. Source: (Leibbrandt 2017)

Inefficient and wasteful land uses burden city structures, aggravating the contested land debate while vacant urban land or abandoned buildings create unsafe, deterring and polluted voids in the urban fabric. The condition of the property at end of use must be considered and the architecture must contribute to the urban environment, past its initial use, and ownership, to facilitate redevelopment by defining space for future development or temporary appropriations. The permanent built fabric (the left-overs after disassembly) can be considered as an urban park, aligned with public use, deliberately limiting fixed forms such as foundations and floors to accommodate land-based uses such as urban agriculture or recreational activities.

Change is determined by the effort and need required, financial or physical. Dry construction offers the potential of disassembly and change, albeit that a scale of permanence of materials should be acknowledged.

It is less likely that a dry stacked brick wall will be removed, compared to a lightweight sandwich panel wall system. Although Open Buildings are inherently planned and designed for external changes, adaptability and flexibility, it is important to note that both stability and change are integral realities of contemporary built fabric and should be incorporated in the design.

Figure 13: A potential scenario of Architecture without Land. Source: (Leibbrandt, 2017)

7. CONCLUSION

Insecure land tenure aggravates residents' social and economic vulnerabilities. Current South African government housing models, like the RDP/BNG model, fail to address multiplicity and variation of space, promoting inefficient and mono-functional land uses by following the 'one house, one erf' strategy. 'Architecture without land' proposes an adaptable, open design and implementation strategy to increase the effectiveness of one erf so that it can aid multiple families and land uses over time; strengthening the interdependency between the support environment and infill. 'Architecture without Land' motivates for a CLT with high resident involvement and self-organization, with the support of professionals and city authority.

Secure land rental is best facilitated through a dialogue of stability and change, accommodating various levels of dependency articulated in a scaled understanding of facility and connection, that can support compact city form. Stability and change best articulates the opportunity of land, which is characterized by continual redevelopment within strict urban boundaries and multiplicity of land use, strategically encouraging, and restricting, development to enable occupation of land rental. Access to land is vital for spatial transformation, and this paper has highlighted the potential of Open Building principles and resilience thinking for the creation of various scales of development in critical neighborhoods in South Africa. Architecture can be developed "without" land.

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A RESEARCH ON THE HOUSING NEEDS OF THE AGED

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ABSTRACT: The ageing population is a prominent issue that affects countries all over the world. Compared with other countries, this problem is worthy of close attention in China because its population of elderly citizens is already very large and is growing rapidly. However, most urban housing is inadequate in terms of serving their habitation demands properly, so it is considered that this study is of great necessity.

This article is based on an investigation of 61 ageing families in Jinan, China. It examines the housing needs of the elder occupants through their comments about their current living environments and their intentions and ideas for change, and subsequently suggests refinements to design strategies. Using the principal of LEVELS in Open Building theory, the research has two themes: (1) On the Support level, the investigation concentrates on the public space inside the building, and the general features of the private suites, specified as orientation and ventilation. It reveals that the width of public corridors is commonly criticised, while improving this has a significant influence on the living experience of the aged; (2) On the Infill level, the study focuses on the layout of individual suites. It provides the elders' desire for their areas to be extended and demonstrates that dining room, bathroom and kitchen are common areas for complaint and that this clearly correlates with people's evaluation of the whole suite.

The objective of this research is to reveal to what extent the existing housing satisfies the older citizens' living demands, and to discover the design strategies which ought to be improved.

KEYWORDS: housing needs, the elderly, Support, Infill

INTRODUCTION

'Ageing in place' is one of the most prominent issues all over the world and the research on the housing needs of the elderly and the corresponding design strategies is of significant necessity. Compared with other countries, China has two special situations: firstly, it has a very large population of aged citizens and this is growing rapidly. It was revealed at the end of 2016 that about a quarter of the world's aged population is Chinese and by the middle of this century, one-third of Chinese citizens will be aged over 60. The second unique element for China is that the great majority of nationals are accommodated in mass housing and their personal preferences are liable to induce inevitable refurbishments, which aggregate pollution and reduce the building's service life. As a consequence, both the common and the individual housing needs of the aged should be studied as a matter of urgency.

This research is based on the investigation of 61 ageing families in Jinan, China, most of whom are over 60 years old. Using the principal of LEVELS in Open Building theory, Support is separated from Infill as follows: 1) The Support level in this research refers to the common spaces of a residential building that cannot be changed by the individual, with the focus on the shared corridors adjacent to the suites' entrance, as well as the unchangeable features of the suites which are specified as orientation and ventilation; 2) The Infill level refers to the private living spaces, which individuals can change, albeit with great sacrifice in most cases, and concentrates on the living area, the suite layout and main rooms.

1.0 THE PROCESS OF THE INVESTIGATION AND DATA COLLECTED

The investigation was conducted during the July and August 2018 and followed three steps. The main findings of the first two steps are included in this article.

The investigation began with free discussions with some of the elderly citizens. On the Support level, the interviewees were asked to comment on their living environment, especially with regard to the public corridors, and to explain the factors that contributed to their evaluation. Meanwhile, on the Infill level, particularly close attention was paid to their evaluation of private space and demands for change. Both the possible factors influencing people's comments and the way they proposed to achieve the changes were recorded as items that warranted further study.

Secondly, a questionnaire was designed based on the information acquired in the first step, and put up on the website with the result that 68 citizens aged over 60 responded. After eliminating five repeated samples, one with contradictory answers and one from a district outside Jinan, there were ultimately 61 valid samples for the primary study. From these responses, the current living experience of the aged was learned, the performance of the existing housing was generally evaluated and the unsatisfactory points were revealed.

The aim of this step was to explore in broad terms how the existing housing satisfies the living demand of the old citizens and to reveal the design strategies that should be studied at the next stage.

Thirdly, with the approval of 58 citizens and 31 families, the public space and the private dwellings were visited and the layouts of shared corridors and individual suites were recorded, with the related dimensions being measured. The information was abstracted into design patterns and parameters. Based on the research in the second step, conclusions were drawn about the unsatisfactory designs elements and improvements were tentatively proposed. This element of work is still in progress and is not included in this article.

2.0 THE GENERAL INFORMATION OF THE 61 SAMPLES

The 61 samples cover the six main districts of Jinan city and are distributed mainly in the three neighborhoods of Shizhong, Lixia and Licheng. The responders comprise obvious variations in age, family size and health situation: more than half of the responders had only just entered the aged phase and 11 cases were people aged over 70, of which five responders were over 80. The main element of the samples were old-couple families, while 23 families in the investigation accommodated children or grandchildren; in addition, amongst all the responders, six of them have to limited mobility and have to depend on walking sticks or wheelchairs (Fig. 1).

The year of construction of the residential buildings in this investigation is distributed evenly in the scope between 1985 and 2016. The minimum length of residence by the respondents was two-years, so it was expected that comprehensive and all-around comments would be gathered. The area of the dwellings involved ranges from 40 to 221 ㎡ with the mean 116.4 ㎡ while the number of bedrooms ranges from 1 to 4, with the mean of 2.85. It is revealed by the scatter diagram that the dwellings involved mainly have a floor area of 60 to 160 ㎡ with two or three bedrooms (Fig. 2). Besides, the per-capita living area of the studied dwellings is 41.24 ㎡, effectively equal to the average living standard in Jinan, which is 40 ㎡ per capital.

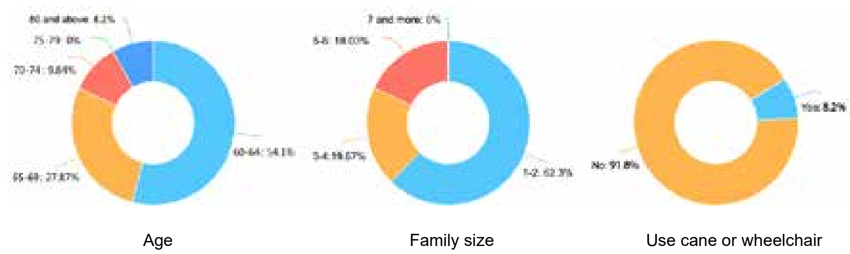

Fig 1: The age, family size and health situation of 61 samples.

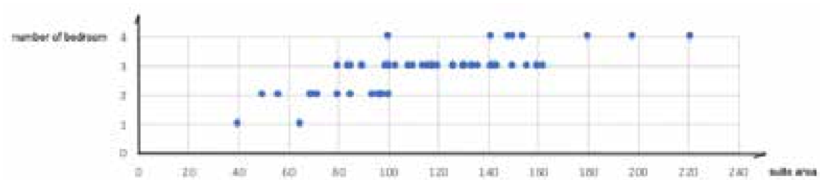

Fig 2: Scatter diagram of dwelling size and number of bedrooms.

3.0 ANALYSIS AND FINDINGS ON SUPPORT LEVEL: PEOPLE'S EVALUATION OF SHARED SPACE AND INTERIOR LAYOUT

Generally, the current living environment on Support level received positive comments. This was specified as the public spaces, including staircase and corridors, as well as the general features of the suites, focusing on orientation and ventilation.

3.1. Public space

In this investigation, it was found that 39 responders were satisfied with the public spaces in their residential buildings, six of which appraised it as very good. However, four responders described their public space as not good, while two reported terrible (Fig. 3).

With a 5-grade marking system, all of the five selected factors, which are liable to influence the quality of public space, were graded above 3. The item of 'convenient connection with staircase or lift' received the highest average score of 4.31, while the item 'appropriate width of corridor' received the lowest mean of 3.89. Besides, the items 'no occupation of sundries', 'natural lighting', 'without mutual interference of adjacent entrance doors' got 4.15, 3.9 and 3.9 respectively (Fig. 4).

The correlation analysis indicates that among the five possible influential factors, 'appropriate width of corridor' and 'convenient connection with staircase or lift' have the most obvious effect on the users' evaluation of the public space. This indicates the necessity of further study on the design strategy for these two items, especially on the former, which receives the lowest score. In addition, it is revealed that responders who live in housing with elevators close by are far more satisfied with their public space than their counterparts who are further away from a shared elevator. This phenomenon indicates that 'whether the lift is available' has a significant influence on the elderly's degree of satisfaction. This finding suggests that it is necessary to add lifts to existing housing, not only proving the validity of a policy that was initiated by the Chinese government in the 2010s, but also suggesting that the adaptable design is particularly relevant to low-rise building which had been customary to build without elevators in the original design (Fig. 5; Fig. 6).

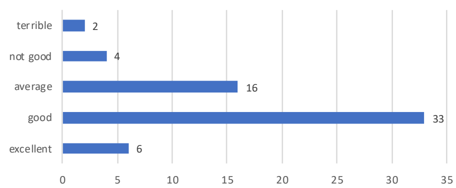

Fig. 3: The responders' evaluation of shared space

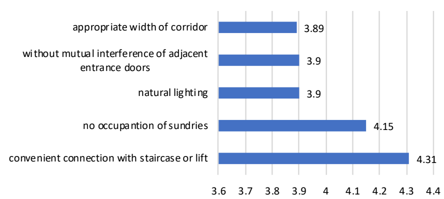

Fig. 4: The responders' evaluation of selected factors of shared space

Fig. 5: An investigated dwelling which was added an elevator this year.
Fig. 6: An investigated dwelling with a long and narrow staircase which is criticized by the interviewee.

3.2. General features of suites

The general features of the suites were appraised by 46 families, with six of the responders describing their suites as excellent. However, there were also five dwellings where responders complained that they were ‘not good’ or ‘terrible’ (Fig. 7). In the scoring of related items, ‘natural lighting’ and ‘ventilation’ received the highest scores, at 4.39 and 4.34 respectively (Fig. 8). The result may be attributed to the fact that the great majority of dwellings involved in this investigation are located in slab-type buildings. In addition, it seems that the responders’ evaluation is obviously affected not just by these two factors, but by the elements on the Infill level.

4.0 ANALYSIS AND FINDINGS ON INFILL LEVEL: PEOPLES’ INTENTION OF CHANGE

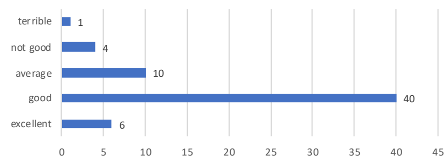

Fig. 7: The responders’ evaluation of the suites.

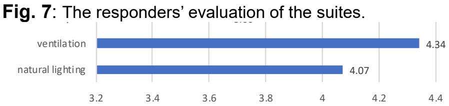

Fig. 8: The responders’ evaluation of selected factors of the suites.

The investigation on Infill level concentrates on people’s evaluation of individual suites and the refurbishment intentions of both the suite area and each main room. It was found that the existing suites meet the elderly respondents’ basic habitation demands although some complains were generated.

4.1. Suite area

In this investigation, two-thirds of the responders said that their suites have an appropriate area, while the remainder severely criticised this item. The correlation analysis reveals that this significantly affects the living experience of the elderly respondents.

It was revealed that some members of the unsatisfied group have strong aspirations of change and that all of them expect an area extension, rather than compression. This finding conflicts with the conclusion drawn from the Australian research[1]. However, the change of family size seems to have no obvious influence: although 15 families said they would tend to shrink in the next ten years, due to children or grandchildren moving out, they still expressed a demand for more living space. Consequently, it can be concluded that the old citizens’ demands to extend their suite area is aroused by reasons other than the fluctuation of family size.

In the investigation, two reasons could be attributed to peoples’ desire for area extension, the first of which was to reserve a bedroom for occasional use. Plenty of interviewees advised that an extra bedroom would be necessary to use when the children or grandchildren returned to visit and many even said even once the second or third generation had moved out entirely, they would reserve a bedroom for them. The second reason was to extend certain functional space: for example, a number of families were unsatisfied with a narrow bathroom or kitchen and believe that an extension of this space would be necessary to provide better use. Furthermore, it was found that several families expected to enlarge their bedrooms to accommodate activities such as watching TV or practicing calligraphy.

4.2. Interior layout and main rooms

It was revealed in the investigated that the layout of private suites had a significant influence on the responders’ comments about their living environment. However, people’s satisfaction rate for this item was merely 60% (Fig. 9) with the average score being 3.66. The correlation analysis reveals that the dissatisfaction of the whole suite is specifically expressed in the responders’ complaints about the main rooms, especially the bathroom, dining room and kitchen, and subsequently in the desire for change. As a result, a more detailed study of the elder citizen’s comments on the main rooms is necessary.

When the responders were asked to grade the main rooms in their private suites, the bedroom received the highest average score of 4.07, followed by the living room, balcony, dining room and kitchen; while the bathroom was given the lowest average grade of 3.3 (Fig. 10). Meanwhile, peoples’ plans for refurbishment concentrated on the following in order of popularity: bathroom, balcony, living room, kitchen and dining room (Fig. 11). Comparing with the two results, it can be deduced that people’s intention of change has some connection with their complaints, or in other words, the refurbishment activity of the elderly is generated mainly by their dissatisfaction about a specific space.

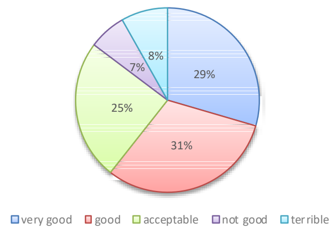

Fig. 9: Peoples' satisfaction rate of suite layout.

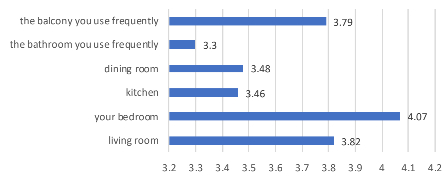

Fig. 10: The responders' evaluation of the main rooms in their suites.

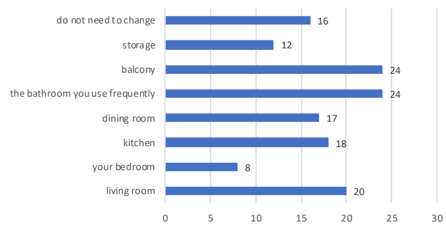

Fig. 11: The conceived change of the main rooms in the suites.

The specific changes that were proposed by the responders mainly involve extending the area of some rooms, but some also involve a change of location, improvement of ventilation or insulation. The conceived changes can be summarized as follows:

1) Bathroom: 24 responders believe that the bathroom needs to be changed, among which 12 wished to extend the area and eight propose to improve the ventilation performance by creating new windows. A few responders also wish to maintain the current area but adjust the proportions or to modify the position of sanitary appliances or doors (Fig. 12).

2) Balcony: 24 propose changes related to the balcony. Ten responders show a consistent demand to extend or add a kitchen balcony, but peoples' attitude towards balconies connected with the bedroom or living room is variable. Some suggest that the area of these balconies should be extended for entertainment or storage, while others insist that the bedroom balcony should be removed to improve the insulation performance of the bedroom or that the living room balcony should be moved to another place to avoid guests seeing their clothes hanging out to dry (Fig. 13).

3) Living room: 20 responders wish to make some changes to their living room, half of whom propose extending the area. Other than eight families living in an outdated type of dwelling with a 'minimal living room and maximum bedroom', there are still 12 families hoping to extend the width of their modern-type living room. In addition, a few responders mention a change of orientation, relative location, and the proportion of space.

4) Others: It is found that 18 responders propose to enlarge the existing kitchen; 17 responders suggest changing the dining room, 10 of which suggest an increase of width; 12 people wish to increase storage space; eight suggest increasing the bedroom area or improving its insulation performance.

 

Fig. 12: An investigated family wishes to change the position of door and sanitary appliances so that the family members can use different appliances in the bathroom in the same time.
Fig. 13: An investigated family has only one balcony inside the dwelling, which is connected with the kitchen. It is used as storage room and for drying clothes. However, since the oil smoke in the kitchen always pollutes the clothes in the balcony, the family wishes to have the other balcony in the suite.

Although plenty of refurbishment plans are conceived, only a few are likely to be executed. According to statistics, while 45 families out of the 61 valid samples propose some changes to their dwellings, only 15 responders have a refurbishment plan. Consequently, it seems that the great majority of the aged are destined to endure the unsatisfactory elements of their dwellings. On the one hand, this phenomenon demonstrates the precedent conclusion that the aged have less intention of complicated refurbishment when compared to the middle-aged people[2]. On the other hand, it demonstrates the significance of appropriate suite layout and the necessity of research on the negative comments about the space.

CONCLUSION

Based on the investigation of 61 families with elderly residents using the Open Building method, this study is aimed at revealing how the existing dwellings satisfy the housing needs of the aged and explores design strategies to be improved.

On the Support level, it was found that both the public space and the general features of private suites received largely positive comments. People's main complaints focus on the width of the corridors in the public spaces, which is proved by correlation analysis to have a significant influence on the living experience of the aged.

On the Infill level, the suite area and the main rooms were appraised in general by the responders, with certain complaints being noted as well as the desire for refurbishment. The most common desire was to extend the area of both the whole suite and specific rooms, particularly the dining room, bathroom and kitchen. The improvement to these areas are expected to have a positive effect on the elderly residents' levels of satisfaction.

Based on the results detailed above, a study of the design strategies that have a close connection with people's complaints is being analysed.

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EFFECTS OF THE KEP ADAPTABLE INFILL FOR AGING RESIDENTS

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ABSTRACT: The author reports the results of the post occupancy survey of the aged residents who have been living in KEP housing in Tama UR housing estate in the western suburb of Tokyo. From 1973, the Ministry of Construction and the Japan Housing Corporation (now known as the Urban Renaissance Agency) initiated the research and development of the Kodan Experimental housing Project (KEP), which developed moveable partitioning and storage systems to allow residents to alter their living environments themselves. The previous surveys were first conducted in the next year of its completion of the housing in 1982 and were followed in every ten years after. This paper reports on the survey that was implemented from December 2017 to January 2018. The author found the aged residents have renovated the infills to make their lives comfortable and allow them to live as long as possible as they wish.

KEYWORDS: Adaptability, Infill, Housing, POE

INTRODUCTION

The author investigated the housing estate "Tsurumaki -3" of Tama New Town in the west suburb of Tokyo. It was the first experimental project, named KEP (Kodan Experimental housing Project) which Japanese Housing Corporation started in 1973 in order to research and develop the flexibility and adaptability of housing. Because the average years to be rebuilt of housing in Japan used to be almost 30 years, the government and private sectors started the research and development projects to design and build longer life housing with adaptability in time, such as KEP (Kodan experimental housing project) and CHS (Century housing project) [*6, *8]. The author has analyzed the outcomes of those experimental projects to examine the attempted adaptability have worked or not in these thirty-five years after people lived in.

1.0 POE of KEP Housing

1.1. Research purposes

In the last survey implemented in 2015 [*7, *9], the author realized that the aging residents in "Tsurumaki -3" of Tama New Town have many problems to continue to live and decided to study their problems in December 2017 and January 2018 which was 35 years later after the first residents started to live. The most important object of this research is to investigate how residents have adopted the design concepts to suit their individual needs and how they have adapted their living environments to changes in their lifestyles over time by remodeling rooms and changing the position of partitions, especially that of KEP movable partitioning system (Figure 1).

1.2. Research methods

This paper tries to find out the effectiveness of the movable building elements with flexibility and adaptability by Post Occupancy Evaluation (POE). First, the author developed a questionnaire survey for the residents. We asked the res-idents if they had altered the room arrangement by changing the position of the KEP movable partitioning system or by using a conventional partitioning system. Similar investigations were performed in 1982 (just after the completion of the estate) by Prof. Hatsumi and Housing and Urban Development Corporation, Japan, and in 1995 by Prof. Hatsumi. The author and the students of Shibaura Institute of Technology have conducted the similar surveys in 2005 [*1], 2014 and 2015. The author has analyzed the transformation of the room layout of each unit through more than 35 years by comparing the results of the studies made in 1982, 1995, 2005, 2014 and 2015.

In the Tsurumaki -3 estate, there are 192 units in four-story flats and 29 units in two-story terrace houses to own (Table 1, Figure 3,4). There are three main types of plans for units in the estate: A, B and C. Type A can be subdivided into types A1 - A3, Type B into types B1 - B5 and Type C into types C1 - C4, for a total of 12 types of units. Type C units are not equipped with the KEP movable partitioning system. Figure 1 and 2 show the plans and the location of the movable partitioning system in A3 and B4 type of unit.

1.3. Attributes of residents

63 households living in the apartment of “Tsurumaki -3” answered the questionnaire in 2014. 56% of them was in their 60s or older than that (78 out of 140 residents). In 1983 one year after than people started to live in the estate, only 4 residents out of 516 residents who live in the apartment were in their 60’s or older. In 1983, 49% of the residents were in their twenties or younger than that (254 out of 516 residents), but in 2014 only 12% were in their twenties or younger than that (17 out of 140 residents). The aging of the residents is obvious. 36 families out of 63 families which answered the questionnaire in 2014 were the households of couples which have no children to live with.

38 families in the apartment and 9 families in the terrace house answered the questionnaire in 2018. All of them own their property and most of them have been living since they bought their house in 1982 or 1983. Almost all residents who answered the questionnaire have willingness to live in their house as long as possible but some aged people are not sure it is possible in their future.

1.4. Changes in the room arrangement

As children grew, and when they left home, many families used the KEP partitioning system to adjust the room arrangements to fit the changes in their lifestyles. The KEP system appears to have worked the way it was planned to more than thirty years ago.

Figure 5 shows an Example of layout changes and renovation of a terrace house. The family bought this unit and renovated all infills before they started to live in 2005. The wife opens cooking classes six times a month so she designed an open and wide kitchen. The designed the house as open as possible while their child is young and renovated the second floor again to have a separate room for parents and more storage space in 2017 when their son became 10 years old as they planned at the beginning.

Figure 2 shows an example of layout changes and renovation of a unit in the apartment. The residents have been living in this unit since 1982 and renovated all interior finishing in 2002 immediately after their children left home. The move the KEP movable storage and make their living room wider. They change the KEP movable partition wall which divided rooms in north to solid stable wall at that time.

2.0 Renovation of infill

Figure 6 and Figure 7 show the history of renovation works in each dwelling unit from 1982 to 2017 entered by year period. Each row shows the dwelling unit renovation history of one household. The white part shows residency period of the first family, and the grey parts show the residency periods of the second or third families. In years indicated by the symbol "◆", renovation work was done, and the letters of the alphabet in the table indicates the contents of renovation works. We can find that when new residents moved in, they often renovated the infills regardless how old their units were. The renovation was necessary for new family to adjust their unit for their life style. We can also find that the sanitary spaces such as bathroom, toilet and kitchen have been fixed and renovated in every ten to fifteen years both for the units in apartment and terrace houses. This might be because of the changes of the lifestyles in Japan in these three decades.

By conducting the interviews to the residents last winter, the author found some of the aged residents have little willingness to renovate the infills of their units because the apartment has no elevator in its common space. The apartment has several steps to climb up even for the first floor units so it has no sense to renovate the interior of their units for the wheelchair. One of the aged residents who lives in the terrace house experienced the difficulty to use steps in front of her entrance when she suffered pains in her knees. The aged residents think they will move out to the apartment equipped with elevators when they become hard to use staircases. Even though, the author found infill renovations to improve the life of aged residents have been conducted in some units such as adding handrails to corridors, toilet and bathroom, deleting the gap of the floor finishing, changing the material of floor finishing from slippery wood floor to non-slippery carpet, widening the width of the door to the toilet and changing the toilet door to sliding door. All these small renovations help the aged residents to live comfortably and continue to live in their house as long as they wish before they finally move to the other apartment equipped with elevator or to the aged people’s house with care.

Table 1: Information about surveyed housing Source: (Author 2018)

Name	Tsurumaki -3 of Tama New Town
Address	3 Choume Tama, Tame- city, Tokyo
Site Area	27700m2
Building Type	4 stories apartment and 2 stories terrace house
Time of Occupancy	1982 (apartment), 1983(terrace house)
Structure	Reinforced Concrete Structure
Number of Units	192 units (apartment), 29 units (terrace house)
Average Area per Suite	87-89 m2(apartment), 99-106 m2 (terrace house)

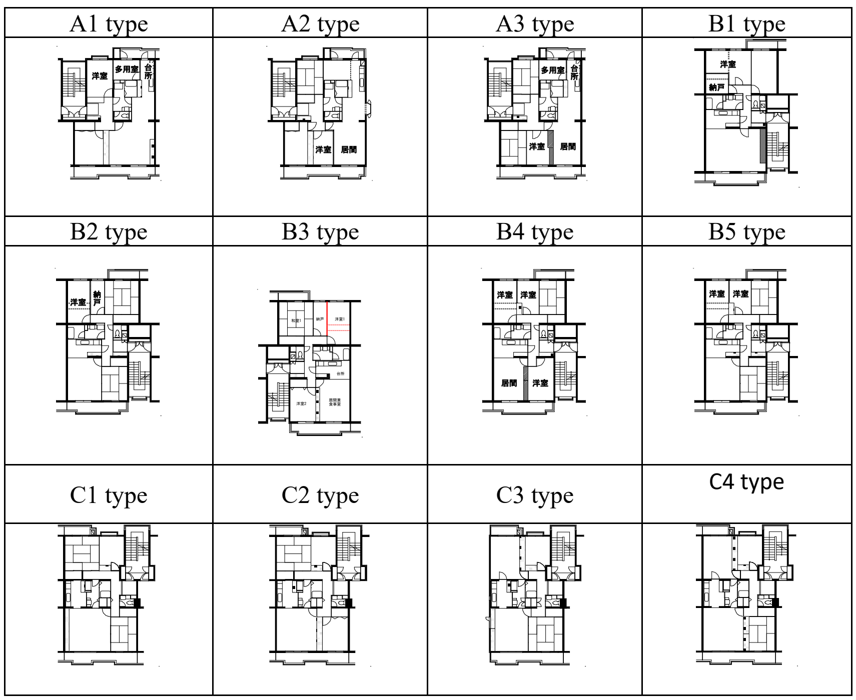

Figure 1: The plan of each type for the four stories apartment Source: (Author 2018)

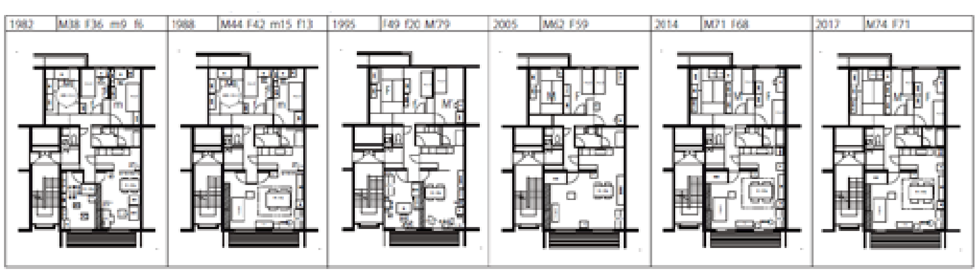

Figure 2: An example of layout changes and renovation of a unit in the apartment Source: (Author 2018)

Figure 3: The four stories apartment
Source: (Author 2017)

Figure 4: The terrace house Source: (Author 2017)

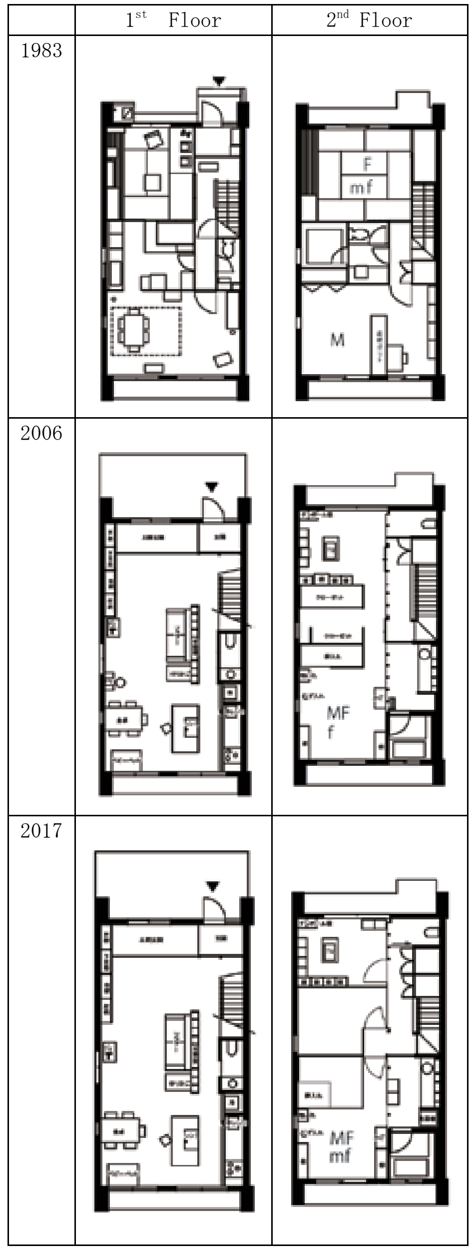

Figure 5 (Right): An Example of layout changes and Renovation of a terrace house
Source: (Author 2018)
The alphabetic letters entered on the dwelling floor plans shown indicate the family members using the rooms as bedrooms or as private rooms. The upper-case letters indicate the head of the occupying family and the head's spouse, while the lower-case letters indicate their children. A male is indicated by "M" or by "m", while a female is indicated by "F" or by "f", and the numbers following the letters indicate age.

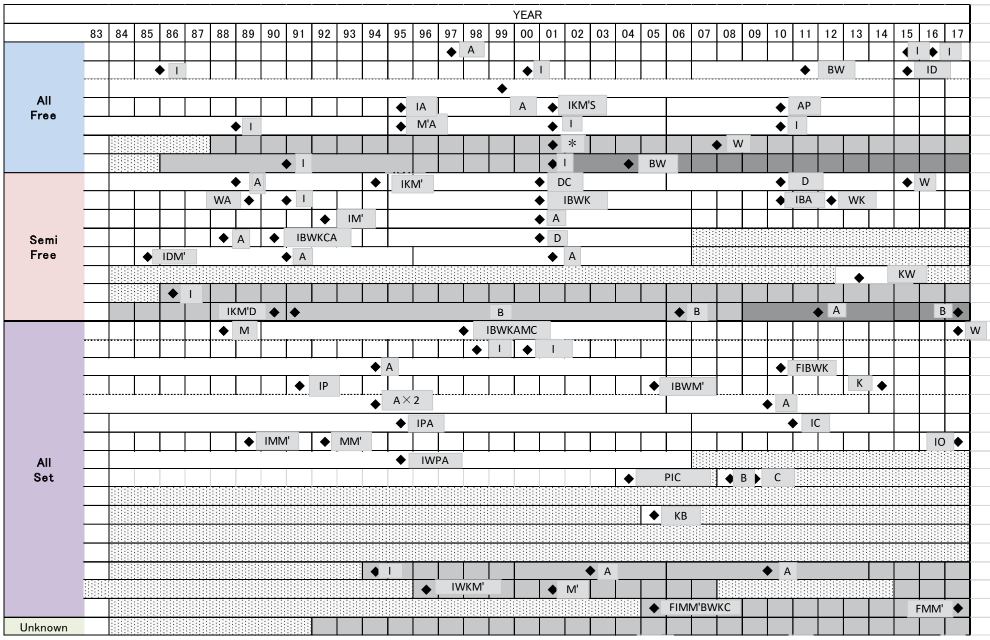

Figure 6: History of renovation works in each dwelling unit in the terrace house from 1982 to 2017 Source: (Author 2018)

Index for Figure 6 and Figure7

W: Toilet, Washroom
B: Bath
K: Kitchen
C: More storage, Less storage
I: Replacing flooring, tatami, Repapering windows,
Recovering wall, Ceiling, Interior finishing
S, M: Change of room layout
P: Removing Japanese room
F: Comprehensive renovation of exclusive use areas
O: Water heater
D: Repair of doors

The first family
The second family
The third family
Unknown

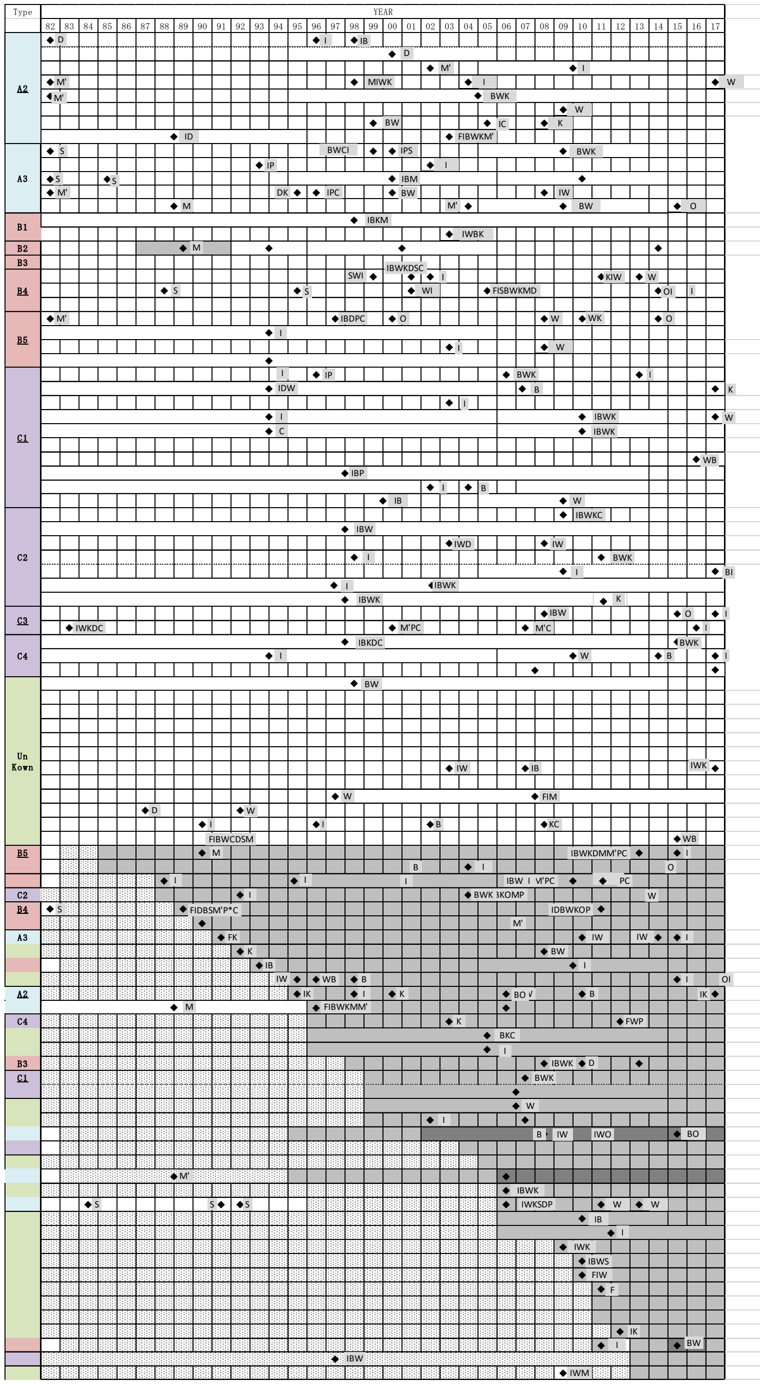

Figure 7: History of renovation works in each dwelling unit in the apartment from 1982 to 2017 Source: (Author 2018)

Table 2: Renovation in the past 35 years Source: (Author 2018)

Contents of renovation		Number of Cases: Apartment	Number of Cases: Terrace house	Number of Cases: Total	Contents of renovation		Number of Cases: Apartment	Number of Cases: Terrace house	Number of Cases: Total
Sanitary	Toilet Washstand room	57	14	71	Change of room layout	Movable KEP Storage unit	17	0	17
	Bath room	50	11	61		Fixed Storage unit	0	0	0
	Kitchen	39	10	49		Movable KEP Partition wall	14	6	20
Interior	Reflooring	52	22	74		Fixed Partition wall	15	11	26
	Replacing tatami	6	1	7	Transform Japanese tatami room to western style room		14	4	18
	Replacing wall paper	56	17	73	Transform western style room to Japanese room		0	0	0
	Windows	5	1	6	Complete Interior renovation		10	3	13
	Ceiling	32	10	42	Hot water supply		5	3	8
	Interior finish	11	5	16	Doors		18	5	23
Storage		15	5	20					

3.0 New technologies for infill

3.1 Relocatable kitchen and movable partitions

A number of recent technical innovations show the potential for even greater flexibility in both new and existing housing stock [*2, *4, *10]. Mitsui Real Estate has sold six units of apartments in Akabane-nisi in which division storage walls can be installed and moved by residents in the same manner as furniture. Although bathrooms are fixed, the remaining space is free for the residents to plan. The idea of the movable partition and storage is basically the same as of the KEP infill system. Even kitchens can be relocated to any of seven optional positions including in the center of the apartment by preinstalling the gray water pipes in the raised floor. The wheels under the kitchen units allow them to be relocated in seven alternative places in the room. The cooker hood on the counter draws away cooking smells and returns cleaned air back to the apartments. The author visited the units and found some of the families move the movable storage walls once in a while to easily make a temporary bed room for their guests.

3.2 Zero slope gray water drainage pipe

Three companies – Nomura Real Estate, Haseko Corporation and Bridgestone – have developed a zero-slope gray-water drainage system to permit flexible positioning of apartment kitchens and have sold an apartment in Mitaka, Tokyo in March 2018 followed by several different types of projects. These companies continue their R&D and applied their zero-slope drainage for the bathrooms and washing machines in the new apartment for the workers of Bridgestone company in Totsuka, Kanagawa prefecture which is expected to be finished in March 2019. In the zero-slope siphonic drainage system, soil pipes run horizontally, allowing a much greater range of locations for bathrooms and kitchens. Traditional soil pipes are larger in diameter and require falls, taking more sub-floor space and restricting spaces for kitchens and bathrooms to be located close to vertical pipe shafts.

The height of each floor of this project is 3020 mm which is a bit higher than that of ordinary Haseko housing which is 2970 or 2920 mm. The diameter of the zero slope pipes is about 20 mm and pipes are installed in the raised floor whose height is about 150 mm. The finished floor is 200 mm above the structural floor slab which has 200 mm thick. The raised floor system is made of low-cost material such as plywood panel supported by steel posts and hard rubbers. The rubbers absorb the sound and vibration transmitted form the upper floor to the lower floor. The length of the steel posts can be easily adjusted to make the finished floor flat even if the surface of the structural concreate slab is not very flat. Contrast to the gray water pipes which could be located freely in a unit, the black water pipe is located at the fixed place in the middle of a unit. In their early stage of R&D, three companies used the disposer to grind the kitchen waste but now they do not use disposer. Instead they use some filter to separate kitchen wastes. Developers tend to reduce the height of apartments to minimize the cost of construction. Also we have regulations to control the maximum height of buildings in residential areas. From this point of view, reducing the height of apartments by only 50 mm is important for the developers. In Japan, we have a large number of old housing which need to be fixed and renovated [*3, *5]. Almost all of them have limited floor heights, and this new technology that enables to layout pipes freely helps us to renovate the existing apartments.

CONCLUSION

The author found some residents renovated the all infill of their units by using the KEP movable partitions and storage systems and some residents did not. As children grew, and as they left home, some families used the KEP system to adjust the room arrangements to fit their changing lifestyles.
The infill system for housing must be adaptable to changing lifestyles of residents and must be easily fitted and removed. The infill needs to be as simple as furniture, easily to be built on site and can be replaced easily by the residents and users. One resident said that he bought his house 35 years ago because that KEP movable partition walls and movable storage system would help his family to change the layout of their units in order to adjust their life style easily. In fact, his family has not moved KEP partition walls or KEP storages, but knowing the easiness to move them he came to think his family's future life would be flexible. He said the architects should realize this effect which the architect originally planned.
The author thinks the continuous research and development of adaptable housing in Japan from KEP, CHS (Century Housing System), KSI (Kodan Skelton Infill) to the establishment of the long fife housing law and the recent development of the zero slope gray water drainage system by the collaboration of the government, private companies and research institutions have been one of the most essential forces for the development of adaptable and sustainable housing in Japan.

ACKNOWLEDGEMENTS

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DOES EGYPT EMBRACE OPEN BUILDING (OB) HOUSING? INFORMAL HOUSING ANALOGY TO OB PRINCIPLES

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ABSTRACT: With more than 96 Million inhabitants, Egypt is unable to meet the increasing housing demand in terms of quantity, quality, and affordability. This has led to the emergence and expansion of informal housing. While these informal interventions have helped in responding to people's basic needs vis-à-vis access to housing and creating job opportunities; the resultant housing lacks the basics for a healthy and quality living. Since the 1970s several initiatives in collaboration with international agencies have been launched to ensure access to affordable housing and combat the expansion of informal interventions. These, however, were unsuccessful as they either did not respond to households' socio-economic needs and/or resulted in the so-called substandard quality of housing; thus, were discontinued. This has left Egypt with a cumulative housing gap opening the door for the unprecedented (still) expanding informal housing. This paper uses a triangulated approach to capitalise on potentials for future housing in Egypt[1]. The qualitative approach defines past housing initiatives lessons learned. The quantitative approach uses a case study to investigate the extent to which informal housing in Egypt associates with OB principles and further contrast these with international cases from Japan and Germany that applied OB strategies. Informal housing in Egypt applies a distorted version of OB principles. A mechanism for an OB building-system that responds to various socio-economic needs is needed to govern and ensure the quality of the building; and consequently, the quality of living. Nevertheless, to mainstream OB principles, the Egyptian Government should consider lessons learned, support national OB industry, provide appropriate financing schemes, facilitate training, technical assistance, and close supervision.

KEYWORDS: building systems, Egypt, informal housing, open building

1.0 HOUSING CHALLENGES AND INFORMAL INTERVENTIONS IN EGYPT

Housing provision challenges are not new. Since the 1950s, housing was considered one of Egypt's main responsibilities towards the poor and low-income households; hence public housing was sought (Sims, 2010). The very first public housing project in Egypt dates back to 1948 providing unit areas ranging between $45m^2$ and $65m^2$. These were mainly dedicated to low income families and low-ranking Government employees for a marginal rental fee (Sims, 2010). Nevertheless, Egypt could not meet the increasing housing demand; particularly that Governments over two decades were pre-occupied with the development of heavy industries in the late 1950s and early 1960s, followed by the wars in 1967 and 1973. As a result, formal urban development has halted, due to the shift to the war economy where all the resources were reserved. This has resulted in the emergence and the expansion of informal settlements which mainly take place on agricultural land and on state owned desert land (Sims, 2010)

In response to the unprecedented pace of informal housing expansion (Nadim et al., 2016a), Egypt launched the National New Towns policy in 1977. Nevertheless, these have failed to attract the targeted capacity of inhabitants (Sims, 2010). Meanwhile informal interventions continued to expand/develop and have become too mature in the early 1990s which rendered them difficult if not impossible to be dealt with While informal interventions have the benefit of accommodating various household's social and financial capabilities; they also have the disadvantage of being congested, unhealthy, and unsafe in some areas (Sims, 2010; (Un-Habitat, 2007).

Informal interventions are extra-legal urban developments that completely lack urban planning or building control measures (Sims, 2010). In this context, informal areas lack definable street patterns, have no public spaces, and have rarely public services such as schools, clinics, or youth centres, etc. Furthermore, streets are very narrow (two to four meters wide) with small plots averaging between 80 to $150m^2$(Sims, 2010); resulting in high population densities which reach 50,000 inhabitants/km^2 in Cairo (CAPMAS, 2016). Existing

[1] This work is part of a funded research project by the Egyptian Science and Technology Development Fund (STDF) under the German Egyptian Research Fund scheme to investigate future housing in Egypt.

‘formal’/government supplied housing transformation is another form of informal interventions in Egypt. This is performed by the users in order to adapt mass provided dwellings to fulfill individual needs and the specific way of living. It is argued that the greater the mismatch between what is provided and what is needed, the stronger the urge to change the living environment; and thus, the more difficult it is to control (Kardash, 1993). In Greater Cairo, for example, a study investigating five-storey apartment blocks in both Helwan and Medinet Nasr, revealed that occupants managed to extend, by co-operating amongst themselves and engage specialised contractors to build stacks of rooms attached to the ‘parent’ building. Through a combination of internal alteration and outward extension, they could increase their living spaces by more than 75%. Thus, transformation increased floor space per person by up to $10m^2$; and consequently, kept occupancy rates down to 1.2 persons per room (Tipple, 1996).

Positive aspects documented to informal multi-storey apartment blocks extensions included a) considerable increase in dwelling area amounting to more than 100% of the initially provided area in some cases, b) extensions are carried out through social/economic organisations which consists of a group of users in addition to a builder/contractor; thus, promote self-governance, and further, c) allow business generation (contractors/commercial). Nevertheless, negative aspects to informal transformation have also been documented to include a) poor quality of living spaces, b) cross room circulation and privacy infringement, c) overloading the infrastructure, d) jeopardy of structural integrity and environmental performance (Kardash,1993). Another form of informal interventions is mixed-use that further change the unit from residential to non-residential e.g. commercial or industrial workshops. This has further perplexed the housing challenge; however, may have the added benefit of creating job opportunities which is another challenge that should also be considered when addressing the housing provision challenge (Nadim et al., 2014).As a result of informal transformations and the consequent alarming increase in density, public spaces are infringed, crowding has increased, and poor environmental conditions prevailed in and around dwellings. The consequences of which are negatively affecting not only the physical but also the mental health of individuals. While there are no empirical studies evidenced within the Egyptian context; several international literatures documented the impact of the built environment on both the mental and physical health of individuals (Evans, 2003; Guite et al., 2006). For example, the number of persons per room and noise may elevate psychological distress, hypertension, high blood pressure, heart disease, hearing impairment, increased stress levels, reduced ability on concentration, and disturbed sleep (Stansfeld and Matheson, 2003; Evans, 2003). Furthermore, malodorous air pollutants intensify negative impact, and some toxins (e.g. lead and solvents) may cause behavioural disorders such as self-regulatory ability and aggression (Stansfeld and Matheson, 2003; Evans, 2003). In addition, insufficient daylight is strongly associated with increased depressive symptoms (Evans, 200; Guite et al. 2006).

2.0 EGYPTIAN HOUSING INITIATIVES

Governments arguably intervene to produce affordable housing as housing market competition may leave poorer households unable to afford to buy their necessities. It is anticipated that society’s welfare may be improved if minimum standards could be achieved by all households (Whitehead, 2007; Turner, 1980). Government housing initiatives either take the form of complete apartment blocks or incremental self-help initiatives (World Bank, 2007).

2.1 Incremental housing (self-help)

Self-help housing dates back to 1918-29 in Europe and the then Soviet Union before it was promoted in the developing World (Harris, 1999). This was in response to severe housing shortages and political unrest after the First World War. Self-help was then called for the developing World in the 1970s (Rakodi, 1989), to ensure affordability of housing units (Harris, 1999). Assisted self-help housing denotes that households would receive external support to build their homes and take the form of the provision of land and services, core-houses on plots within the land and services scheme, technical assistance and micro-financing schemes (Bredenoord and Lindert, 2010). Major drivers for the interest in self-help included the rising unemployment rate and low income in the 1930s and severe housing shortages after the First World War. This was perceived as an effective way of producing large numbers of homes in a relatively short period of time (Harris, 1999). Different stances towards self-help were recorded between developed and developing countries. In developed countries, governments would restrict through enforcing building regulation, while in the developing countries, households were left unsupervised with no means of control Harris (1999). Yet, self-help has not been welcomed by all Governments and local planners in developed countries due to technical and political criticism. In the UK, e.g. self-help was criticised as ‘antagonising the building industry and trades’, being unattractive, in addition to being called for and promoted by some anarchists. In Germany it was described as ‘Wildsiedlungen’ i.e. wild settlements (Harris, 1999).

The most substantial self-help projects were reported in the then Soviet Union, where incentive schemes were offered e.g. plots where offered to those who build their own home, 2% incentives to those who could provide a down payment of 30% in cash or labour, and even 10-year tax exemption was also offered (Harris, 1999). In addition, a number of prominent international architects supervised unskilled labourers in self-help projects. In Stockholm, a municipal scheme of standardised houses called the ‘Magic House’ was offered, using prefabrication, required that homebuilders accept close supervision, and to build to a definite time schedule. In Canada, in 1949-50 ‘Build-your-own-home’ policy was launched under which technical assistance, including construction courses together with on-site inspections and guidance were provided (Harris, 1999). Further success factors for implementing self-help projects require design to accommodate environmental, cultural, technical, and socio-economic needs (Bredenoord and Lindert, 2010). Self-help is perceived by supporters as a means to ensure the production of appropriate housing; and thus, help develop a sense of community identity and self-governance (Rakodi, 1989). It is further suggested that design, that would facilitate progressive and incremental expansion and improvement over time, is an important key factor to affordable housing Mukhija (2014). Nientied and Linden (1988) attributed Government’s failure to provide affordable housing initiatives in the developing World to the attempts to apply Western solutions to local urban housing problems, and Egypt is no exception.

2.2 Incremental housing in Egypt

Incremental housing was launched in Egypt in the late 1970s and early 1980s in order to provide lower-income groups with land and basic home that they can expand, finance over a period of time, and maintain (Goethert, 2010; World Bank, 2007). The scheme comprised plots on which a core is built, usually a bathroom and kitchen unit (wet core), in addition to one room, that is given to households along with financial loans (Goethert, 2010; Abdel-Kader and Ettouny, 2015). Fundamentally, the concept of incremental housing is the phasing of development and consequently, the phasing of cost. This was anticipated to allow households to prioritize their living needs and expand according to their financial capabilities (Abdel-Kader and Ettouney, 2010). Two main types for incremental housing were implemented in Egypt, namely horizontal and vertical ‘Core Housing’. The horizontal core housing, the land and services scheme, subdivided plots are furnished with utilities for households to extend horizontally and vertically. Plot sizes were determined according to households’ sizes, needs, and financial ability. The process of allocation was distributed to families through public lottery (World Bank, 2007). The vertical core housing, on the other hand, provided low-income households with externally finished and internally (undivided) open plan unfinished units in apartment blocks. These were also supplied with utilities. Households were then expected to incrementally subdivide their apartments and finish these based on their needs and financial abilities (Abdel-Kader and Ettouney, 2012).

While there were successful international incremental housing projects; incremental housing in Egypt was unsuccessful (Sims, 2010; Nazmy 2011; Abdel-Kader and Ettouney, 2010; Abdel-Kader and Ettouney, 2015). Challenges to incremental housing could be categorised under four main categories, namely a) Financial and economic, b) management, c) design, d) urban. With regards to the financial and economic aspects it was concluded by several studies that units were unaffordable to the targeted low-income households even with government subsidy and the financial scheme offered. From the management perspective, the inability of Governments to supervise, monitor, and guide the construction phases allowed the informal adaptation to the units. With regards to the design issues, while providing plot sizes of 90 – 200 m^2, households were required to build on only 50% of the plot; i.e. having a smaller footprint ranging from 45-100m^2 (World Bank, 2007). Thus, rendering the units unaffordable and socially unsuitable to the average size of a family of 4.5 members. From the planning perspective, the absence of infrastructure, basic services, and transportation further burdened the financial abilities of households; and thus, discouraged targeted households from participating in the scheme. As a conclusion, incremental housing scheme in Egypt did not meet the socio-economic needs of targeted households and ended up transforming into informal housing, the exact opposite to the intention of the incremental housing scheme which was to combat the informal housing expansions (Sims, 2010; Goethert, 2010; Abdel-Kader and Ettouney, 1989; Ettouney and Abdel-Kader, 2003; Nazmy, 2011).

2.2 Mixed-use Housing in Egypt

Mixed urban uses of living, moving, and mobility is arguably an old model for the traditional life in cities prior to industrialisation, stressing density, use, social and cultural diversity (Kaur, 2010; Trading-Economics, 2015). Zoning and segregation of land uses have been criticised to work against the proper growth of a community (Rowley, 1996). Therefore, should mixed use not be ‘divorced’ from cultural priorities and lifestyles. Mixed uses can occur on four different levels, namely on the district and neighbourhood level, within streets and public spaces, inside building blocks, or even within individual buildings (Kaur, 2010). Main benefits identified for mixed uses are reducing the need to travel, allow urban diversity and vitality, preventing crime and promoting security (Trading-Economics, 2015). While some activities have been concluded as not suitable for mixing such as heavy industries (Trading-Economics, 2015); however, may be accepted, if building codes are applied (Dolan, 2012). Egypt embarked on mixed-use developments such as [Herafeen] artisan or craftsman zone, but were also not successful (Sims, 2010). The reasons for the projects’ failure were investigated by the research team, since no reasons were evidenced in extant literature. The development consisted of five floors with the ground floor reserved for workshops servicing cars. The upper floors were residential comprising units of areas around 60/70 m^2 accommodating two bedrooms, a small reception, small bathroom, and a kitchen. From a cultural and social perspective, the project; has however, been criticised for not being suitable for females in the family as the area was industrial in nature. From the design and urban perspective, the unit areas were relatively small; thus, not suitable for large families, cheap finishing material that deteriorated, and no availability of nearby vocational institutes to support the community, no occupational health and safety measures, or health centres in the vicinity in case of emergencies. In addition, streets width was not enough to accommodate serviced cars on both sides of the street, and thus, streets get blocked particularly on working days. Since the offered mixed use units did not meet targeted households needs, households made informal alterations to their residential units, or moved and sold their apartments to be used as storage for the workshops on the ground floors. Thus, rendering the project unsuccessful as those working there are not necessarily those living there as was initially planned (Nadim, 2019).

3.0 INFORMAL HOUSING in EGYPT

A case study in an informal area in Greater Cairo was investigated to define the characteristics of household and assess the living environment on the level of the housing unit, as well as the direct urban context (Nadim, 2016a; Nadim, 2016b; Nadim, 2019). 500 questionnaires were administered with a response rate of 91%. Family members median was five members (28%).

The unit areas in the case study were relatively small, however, larger unit areas were also available. The majority of floor areas (60%) were less than 70m^2. With regards to the size of units occupied in relation to the size of families, it was found that families up to of five and even 6 members as well could reside in areas ranging between 30-50m^2 and 50-70m^2 with much fewer families residing in areas of 90-110m^2. 55% of respondents lived in units with two bedrooms resulting in a high occupancy rate for a family of 6 members (Nadim, 2016b; Nadim, 2019). That is higher than the official rate of 1.12 (CAPMAS, 2017). 66% of respondents found their unit area suitable to most of their needs as opposed to 25% who found the unit area not suitable to their needs. Where families of 6 members were mostly those who were less satisfied followed by families with five and four members. Nevertheless, irrespective of the number of family members, and irrespective of suitability of housing unit (whether suitable or unsuitable) transformation to units has always taken place in a form of horizontal and/or vertical upward extension (Nadim, 2016b; Nadim, 2019). With regards to the structure; 33% of respondents lived in blocks which walls were loadbearing; whereas 64% of respondents lived in buildings with concrete skeletal structures. Major problems that were facing the buildings were cracks (56%), deteriorated façade (20%), and differential settlements (18%) due to the proximity to the Nile and the high-water level in the area. Generally, inhabitants never carried out maintenance (45%), or rarely carried them out (25%), or only when necessary (21%), whereas only 4% carried out maintenance more frequent. In case of maintenance was carried out, it encompassed painting façade, plumbing, or extra structural support mainly for load bearing structures (Nadim 2016b; Nadim, 2019).

From an economic point of view with regards to housing affordability, housing units in the area were generally affordable (Nadim, 2016b; Nadim, 2018). 63% of respondents spent less than 25% of their income on rent, whereas 27% spent between 25-35%. Furthermore, from the mobility perspective, 74% spent less than 10% of their income on transport (Nadim, 2017). The majority (77%) of respondents' work was within proximity to their home. They either had their work within a walking distance (44%); used at least one means of transport to get to work (22%); or work was in the same block where they lived (11%). With regards to the housing typologies, the case study encompassed mixed-use typologies; where non-residential activities were mainly commercial (58%) and workshops (18%). Major problems associated with mixed-uses recorded were noise (63%), lack of parking place (18%), bad odor (20%), and waste generated 8%. Other problems included disrespect and no consideration to tenants. Generally, respondents either agreed (18%), or agreed with condition (46%) to mixed uses, whereas 36% did not agree to mixed uses. Agreement, however, was with the condition that mixed uses would increase income to both tenant and owner and generate jobs (Nadim, 2016b; Nadim, 2018). It may be thus, concluded that informal areas allow various forms of flexibility which render these areas more popular than mass housing. Mansour (2017), concluded and categorized the nature of flexibility in informal housing in Egypt, under personalisation/identity, extendability/affordability, multi-functional space, mixed-use typologies, diversification of structures, services flexibility, and multiple material use for façade.

4.0 HOUSING FLEXIBILITY AND ADAPTABILITY

In order to ensure successful housing provision, housing should be holistic to respond to the different socio-economic needs (Turner, 1980; Nadim, 2018). There is, however, debate in extant literature on housing needs and the constituents of a 'good housing design (Franklin, 2001; Ytrehus, 2001; Ahmed, 2012). Ytrehus (2001) for example, investigated the extent to which the size of a dwelling and its spatial characteristics is corresponding to household needs. In this context, needs are advised to be studied within social, historical and cultural settings; and consequently, should consider change according to time, place, topography, climate, social environment, and context (Ytrehus, 2001). Franklin (2001) further suggested the need for a more fluid, sophisticated and interdisciplinary conceptualisation of the connections between social processes and spatial forms. In the same context, Friedman (2012) argued that the dynamics of a typical household characteristic and structure is changing in response to socio-economic and demographic transformations. This would require some sort of building adaptation to take place (UN-Habitat, 2012). Weaknesses of housing design, layout and environmental insensitivity have been criticized for negatively affecting the general level of residents' satisfaction (Worthington, 1971; Hajdu, 1982). The importance of creating a diverse urban environment as well as allowing flexible use of space within an individual residential unit to ensure a distinctive identity of the individual home has been subject to research after the World War II (Hajdu, 1982).

From an economic perspective, it is argued that adaptable buildings may decrease the whole life cycle costs by allowing change to take place during occupancy (Kendall, 1999; Slaughter, 2001; Friedman, 2012). This being said, unadaptable buildings would make buildings obsolete; and thus, would impose extra costs on household due to the continuous renovation needed to accommodate the changing needs (Spiegel, 1971; Iselin and Lemer, 1993). From a psychological perspective, it is argued that the inability to control space one is living in may result in anxiety, distress, and discomfort. Thus, three different types of flexibility could be identified, namely spatial, functional, and aesthetic flexibility. Where spatial flexibility referred to the capacity of change in the spatial structure of a building; functional flexibility, referred to the capacity of the infill to allow different functions to be accommodated, and aesthetic flexibility referred to the capacity of altering the form, façade arrangement and identity of the building (Sinclair et al., 2012; Fulwood, 1987; Dhar et al., 2013; Friedman, 2012; Gijsbers, 2014). This concept of flexibility may be an overarching concept to include ‘extendability’; where users would start by occupying a small space/unit with the intention to extending it later to achieve more space in response to changing needs (Fulwood, 1987). This may further be considered as a means for achieving housing affordability (Kuang and Li, 2012, Blok and Herwijnen, 2006; Groak, 1992; Manewa, et al., 2016; Nadim, 2016b). A distinction could be made between ‘active’ flexibility and ‘passive’ flexibility. Where the first referred to the ability to actively respond by changing, reacting or adapting; whereas, the latter does not require active interference due to sufficient tolerance and capacity of space (Blok and Herwijnen, 2006). In this context, spatial characteristics of space would allow the passive flexibility and the structural characteristics of a building would allow the active flexibility where extendibility of the structure would be governed. The concept of flexibility/adaptability resonates well with the Metabolist movement advocating flexible and evolving architecture; which would be directly responsive to the changing needs. Metabolism is inspired by the model of human organism which produces cells when needed and subsequently allows them to die and be replaced (Schittich, 2005). In this respect, staged replacement of parts was deemed compulsory; and growth or directed expansion beyond the initial form was perceived as an option (Daniell, 2008).

5.0 OPEN BUILDING PRINCIPLES

Housing is a bulky consumer-oriented commodity; yet, at the same time it embodies a jointly held social asset. Nevertheless, housing has arguably never achieved the straightforward match with consumer preferences achieved by other industrial products. Traditional housing provides limited options for diverse users over time. As market demand, demographics, and life styles shift over time such predetermined models are unlikely to respond to the changing needs due its inflexibility. The breakdown of housing elements into distinctive layers has attracted attention since the 1960s in an attempt to explore means to respond to mass housing needs considering speed of construction and the ability to change to accommodate occupants changing characteristics. In this context, the physical structure has been broken down into structure and infill (Habraken, 2002). This distinction was aimed to allow greater freedom to the users to determine their own floor plan. The support could arguably be built in rigorous repetition as a single project; whereas the infill for each unit may differ (Habraken, 2002).

Open Building (OB) has gradually emerged in response to evolving social, political, and market forces that require effective and responsive measures (Kendall and Teicher, 2000). The intention was to structure interfaces of parts and that of decision makers to improve responsiveness of buildings to end users while increasing efficiency, sustainability and capacity for change. By doing so, it is anticipated that the useful lives of buildings can dramatically be extended (Kendall and Teicher, 2000). OB principles require structured subdivision of technical, aesthetic, financial and social decisions into distinct levels of decision-making. To reinstate the natural relationship or process within built environment, it was advised that residents should be able to make autonomous dwelling decisions rather than to be provided with units of housing. Dwellers would still settle within a three-dimensional structure; nonetheless, they remain free to transform their homes. By doing so, neighbours arguably remain unaffected by the change initiated by their neighbours such as renovation or even total demolition of abutting dwellings. In this context, OB projects are designed with change in mind to allow the retrofitting of outmoded housing stock in an efficient but inhabitant-oriented way, obviating the need for new construction of whole buildings as a result of untimely obsolescence of the building’s parts or units (Kendall, 1999). Openness of the building system (Sarja, 2005) should be manifested in various aspect such as: free design to accommodate varying requirements, free competition between contractors and suppliers, facilitating future changes in the use, and further allowing reuse and recycling. Kendal (1999) identified major benefits of OB to the different disciplines to include urban, architectural, public housing agencies, product design and manufacturing, contracting and construction management, finance and development, facilities management, and sustainability.

While there have been numerous OB projects realised in the industrialised Western World, and in Japan, many countries started to abandon these kinds of projects. This has been attributed to supports, while demonstrating economic viability, no economic viable fit-out systems could be achieved. This was very clear in the Metastadt project by Richard Dietrich, where the project had to be demolished rather than renovated. Further challenges facing OB implementation were documented to include land ownership and household control (Kendall, 1999; Hilpert, 2015; Spiegel; Stegemann, 2014; Bergdoll and Christensen; 2008; Schneider and Till, 2007; Hajdu, 1982; Bauwelt, 2012; Kim et al., 1993; Sasakura, 2005; Mansour 2017). The following table (Table 1) uses the different OB levels/benefits and project these on three different OB projects from Japan (Next 21) and Germany (Metastadt) and Wohnbau Genter Strasse. These selected projects provide alternative implementations visa-vis support and infill in terms of materiality of support, ability to extend, and thus, the extent of flexibility provided by these projects. The table is complemented by Egypt formal and informal housing to gauge the extent to which there are (dis)similarity with OB principles; and thus, to highlight major weaknesses/strengths within the Egyptian housing context to inform future successful housing projects that would respond to the socio-economic needs of households through their openness and inherent flexibility.

6.0 DISCUSSION AND CONCLUSION

Housing provision in Egypt has been a challenging proposition since the 1950s due to increase in population, rural urban migration, lack for financial resources, inability to monitor and control housing initiatives, and poor workmanship. This has led to the unprecedented informal interventions which has becoming popular as opposed to Government provided housing. The popularity of informal housing is largely attributed to its capacity to provide housing typologies that accommodate the different socio-economic needs of households. This is achieved through the ability to offer various unit areas, allow incremental building, allow mixed-uses; and thus, help create job opportunities, albeit informal. Both approaches for housing provision in Egypt whether mass housing or incremental housing have been unsuccessful insofar that mass housing has eliminated inhabitants from the housing process; thus, denying individuality and uniqueness; whereas the latter produced substandard housing that negatively affect not only the public infrastructure; but also, the physical and mental health of the society.

Open Building evolved in response to societies' changing needs to re-engage households' in the housing process and reinstates the autonomous decision to change/adapt their dwelling. Building on OB principles, this paper analyzed three different OB projects in terms of levels and the extent and nature of adaptation that may take place by the inhabitants to allow responding to the changing socio-economic needs and by further making benefit from technological advancements to ensure speed in construction and adaptation with no or limited disruption to neighbors. Building on OB principles, it may be concluded that housing in Egypt whether formal or informal undergo change that is not solicited. By doing so, inhabitants could expand their living space, can achieve personalization to their units externally and internally, and include mixed-uses. Furthermore, inhabitants can change the location of the bathroom and kitchen, by simply surface mounting plumbing stacks on the façade etc. These adaptations may jeopardize the parent building structure (through upward and external horizontal extensions) and may further cause disruption and annoyance to neighbors.

As a conclusion, Egypt already embraces a distorted version of OB principles which reinforces the need for flexibility in housing in Egypt to accommodate the various socio-economic needs. OB is indeed important for Egypt to help meet the increasing housing demand, ensure affordability of units, and ensure quality of outcome. However, in order to mainstream the proper OB principles in Egypt's housing sector and for not to repeat mistakes, OB application in Egypt should accommodate the specifics of the Egyptian culture, consider national standardization of interfaces (rather than layouts) to ensure elements fit together, ensure the easy assembly and fitting of elements in order to compensate for the lack of skilled labour. This may further require certified building systems that encapsulate various levels of flexibility and adaptability; however, should ensure adaptation is carried out within a framework to govern the quality of the final product the building, and consequently the quality of living. In the same context, Egypt should revise regulations and building processes to allow mainstream OB building. Furthermore, the Government should support OB research and development to ensure a feasible and successful OB business model.

Table 1: Open Building Principles projection against Egyptian formal and informal housing

OB Levels	**Next 21** (Osaka oil company) 1994	**Metastadt** (Dietrich Friedrich) 1974	**Wohnanlage Genter Strasse** (Otto Steidle) 1972	**Formal housing (Egypt)**	**Informal Housing (Egypt)**
Urban	- standalone building - mixed use on ground floor	- residential complex - mixed use on ground floor	- residential, emphasising relationship between house, street, courtyard, access & communication structures	- mainly residential, - ground floors are informally commonly transformed into non-residential	- mixed use
Support	- precast grid 3.6x7.2x3.6m. - upper floor grid smaller than ground floor grid - not extendable	- steel structure - volumetric grid (4.2x4.2x3.6m) - extend horizontal/vertical	- precast concrete structure - grid 5.4 – 7.2m - exposed structure can be filled at later stage	- skeletal construction	- various. Combination of load bearing structure and skeletal structure
Infill	- dry connection for facade	- dry connection for façade	- dry connection for facade	- brick wall for façade/internal partitions] - various material for informal extension	- brick wall for façade and internal partition - various material for informal extension
Services	- separated in zones in raised floors or suspended ceilings (utility trench)	- separated and located in raised floors of 45cm	- wet areas fixed	- imbedded into slabs and walls and exposed on exterior walls	- imbedded in slabs/ walls & exposed on exterior walls - wet areas may re-location
OB impact on various disciplines					
Architecture	- Flexible - Support designed by one architect, and units (internal+façade) designed by 13 other architects	- Flexible open plan for flexible enclosures	- Structural connection at every half level allow split levels and double height spaces - Raw space that can be claimed as internal or external space	- Fixed floor plans - Informal physical vertical/horizontal extensions (burdening initial structure) - no personalisation allowed	- Floor plans adjusted according to needs - Allow personalisation - Poor quality spaces
product design & manufacture	- Customisable finished or ready to assemble for infill shifted to offsite	- Customisable (push button) for infill shifted to offsite	- Customisable for infill shifted to offsite	- Fixed infill (brick wall)	- Fixed infill (brick wall) depend on financial ability
contracting & construction management	- Mechanical and utility system shifts toward infill - Support is simple/repetitive - Reduce coordination needs	- Mechanical and utility system shifts toward infill - Support is simple/repetitive - Reduce coordination needs	- Mechanical and utility system shifts toward infill - Support is simple & repetitive - Reduce coordination needs	- Fixed design	- Depends on financial ability
finance and development	- Combe onsite and offsite controlling life cycle cost	- Combine onsite and offsite; controlling life cycle cost	- Combining onsite and offsite; thus controlling life cycle cost	- Only for doors and windows and sanitary fixtures	- Doors/windows/ sanitary fixtures
public housing agencies	- Help build with respect to budgets and preferences	- Help build with respect to budgets and preferences	- Help build with respect to budgets and preferences of households	- Units built are not affordable	- cater for different financial abilities
facilities management	- Systems entangled with no/ minimum disruption	- Systems entangled no or minimum disruption	- Systems are entangled no or minimum disruption to others	- Systems imbedded. - Disruption to other units	- Systems imbedded. - Disruption to other units
- sustainability	- Built environment that is able to accommodate change with least destruction	- Built environment that is able to accommodate change with least destruction	- Built environment that is able to accommodate change with least destruction	- n/a	- n/a

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TECHNOLOGICAL INNOVATIONS IN BRAZILIAN HOUSING PRODUCTION ORIENTED BY OPEN BUILDING METHODOLOGY

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ABSTRACT: Between 2006 and 2007, and from the launch of *Minha casa Minha Vida* (My Home My Life) Program in 2009, Brazilian housing production was greatly stimulated, made possible by the Federal Government's resources and its articulation with the civil construction business facing the country's housing shortage - in particular, social interest. Thousands of houses were built, during this period. However, in this production there is a predominant use of rigid housing solutions in form and in processes, which do not match the reality of 85% of the Brazilian families that self-produce their dwellings. Self-production is part of the artisanal construction scenario, where spatial flexibility strategies are often demanded and used, as examples, layout changes, small renovations and room additions, - showing a great openness to the Open Building (OB) methodology. In order to deal with the "technological backlog" associated with the construction sub-sector of the Brazilian civil construction, the *Sistema Nacional de Avaliações Técnicas* – SINAT – (National Technical Assessment System) was implemented. SINAT evaluates and certifies new constructive technologies, such as pre-fabricated structural panels, lightweight wood systems and lightweight fences. Understanding that these technologies foster new design and constructive arrangements, this article aims to test and evaluate - from the classification of support and filling and connectivity among the elements of the building layers - the potential for adequacy of some SINAT products to the design strategies guided by the OB guidelines and the Brazilian reality. The results indicate that the SINAT solutions have characteristics compatible with the OB methodology with a view to the self-production of housing.

KEYWORDS: Flexibility. Housing Production. Brazilian Constructive Technology. Open Building.

INTRODUCTION

In Brazil, civil construction is an important branch of the industrial sector, which includes, among other activities, residential real estate production. This predominantly labor-intensive production is characterized, above all, by manufacturing and craft arrangements.

Manufacturing is an intermediate productive process, situated between crafts and industry. In this stratum there are two organizations: the first one, the serial manufacture, is determined by the result of the final amount of internal work at the construction places, promoter of the largest public, private and institutional building; The second, the heterogeneous manufacture, is characterized by the assembly of prefabricated elements (FERRO 2006, 113). Since the opening of the capital of construction companies between 2006 and 2007 and the launch of the *Minha Casa Minha Vida* (My Home My Life Program) (PMCMV) in 2009, the production of heterogeneous manufacturing has shown significant growth in the economic segment, also known as “housing social market”. This term is adopted by Shimbo (2010, p.100) to designate dwellings produced by builders and incorporators for families with up to ten minimum salaries. The production of PMCMV is guided by a standardized typology (with an area of less than 45 m² or 484,3 ft²), replicated uncritically throughout the country, in which Ferreira (2012, 89) points out:

> (...) it turns out that the massive production of large construction companies has imposed technological standardization incompatible with regional specificities. Parameters such as thermal comfort, performance and material efficiency are often overlooked due to economies of scale.

In the craft also two different organizations coexist: the first one can be understood as official, because it is based on the legality and availability of different resources, financial or access to certain knowledge, easily verified in the housing of the middle and higher classes, which produce them according to their needs and wants. The second, although numerically preponderant, is sometimes treated as an informal production - by the illegality of the activities performed in the occupation of the territory in the face of the rules conducted by the State - identified in the self-production of dwellings. Autonomy, an inherent characteristic of informal artisanal production, points us to a close link between this constructive reality and the Open Building methodology, since in both the inhabitant is a fundamental agent in the decisions that fit the construction of the dwelling (MASCARENHAS 2015).

Today, in Brazil, 85% of the families that have already built or reformed are part of the scenario of self-production of housing (CAU / BR-DataFolha 2015). Self-production forms part of the artisanal production of civil construction, where the residents themselves make all the decisions regarding the composition of their dwelling - from the choice of the land, through the purchase of materials to the execution of the work – it means that, they don't have the technical support or interventions of the public power. In addition, about 70% of this production is self-built, which means that the user effectively builds with their own hands, often with the help of friends and family. In this reality, users often demand and employ strategies of spatial flexibility autonomously; from layout changes, through minor renovations to the addition of rooms and larger interventions in the building. According to Lamounier (2017, 67) a "Self-construction is present in various levels of intervention, from the internal spatial rearrangement or change of finishes of a housing unit, through renovations that include extensions, to total self-construction, starting with choice of the ground". Self-production, which also incorporates self-built, although it is not exclusive to the needy population, is the most expressive example of handicraft of those who have few resources and live in precarious housing in the peripheries and slums (favelas).

In Brazil, we have on one side the reality of the production of social housing market, accomplished with the participation of construction companies and professionals in general marked by exclusion dweller in their production decisions, by heteronomous fragmented construction processes, by constructive inflexibility, by the imposition of peripheral location and by great environmental impact throughout its production chain. These, among other negative characteristics, are inherent in the constructive processes engendered by capital.

On the other side, we face the self-production of villages, slums and precarious subdivisions, often linked to the occupation of illegal and risky areas. In this condition, the absence of specialized technical and / or technical assistance by architect or engineer confers a series of problems on self-produced and / or self-built realities, among which we highlight: unhealthiness, constructive insecurity, precarious aspects of spatial mismanagement of financial and material resources.

In front of the exposed scenario, the constructive technologies available, coupled with the strategies developed by the users to execute their own house, show a context propitious to the incorporation of the Open Building (OB) methodology in Brazil. In addition, we find that Brazilian families increasingly assume different compositions, as shown in Figure 1 and Ferreira's passage (2012,97):

> Families grow up, people get older: an apartment for the composition of four residents, two adults, a teenager and a baby, in the space of a few years may be a couple with a child, and in the future, a couple, or a new family, the next generation.

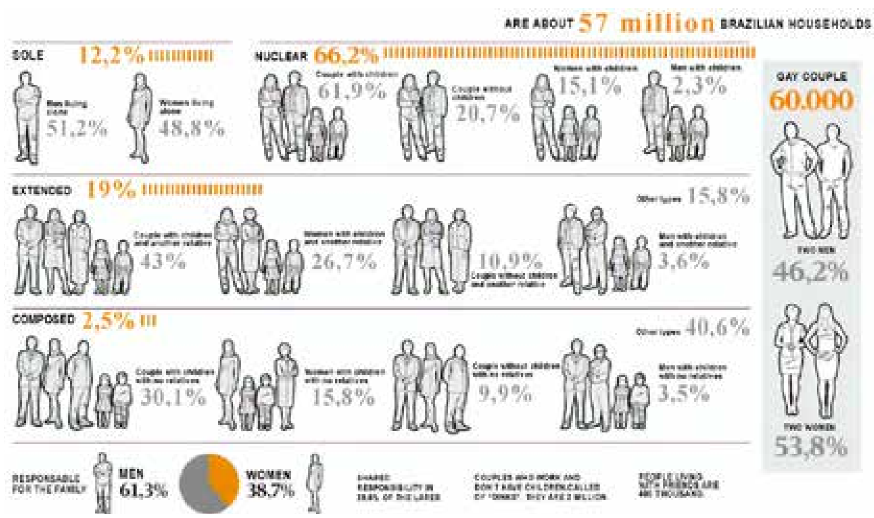

FIGURE 1- Brazilian family composition. Source: (AUTHORS from IBGE 2010 data)

The family profile, with the common practice of self-production, confirms the need to design housing that is flexible to change and open to shared decision-making between technicians and users.

1. INNOVATIONS IN THE CONSTRUCTION SECTOR: Change or maintenance in housing production?

Due to its predominantly manufacturing characteristics, the "lack of progress of the productive forces" or the "technological backwardness" are themes frequently associated with the building sub-sector of Brazilian civil construction. It is in this context that the *Sistema Nacional de Avaliações Técnicas (*National System of Technical Assessments) - SINAT is implemented that bases its discourse on "improving the quality of habitat and on the productive modernization" in the country (BRASIL, Ministry of Cities, 2018).

SINAT is part of the Programa Brasileiro de Qualidade e Produtividade do Habitat - Brazilian Habitat Quality and Productivity Program - (PBQP-H), an instrument of the Federal Government, developed by the Ministry of Cities, through the National Housing Secretariat. SINAT grants Technical Assessment Documents (DATec) that look for evaluate products, (materials, elements, systems and / or construction components) in order to grant a certificate issued by ITA's, provisionally. The ITA's are composed of legal entities treated as "research, teaching and research institutions, and / or laboratories for the testing and technological control of civil construction products" (BRASIL, Ministry of Cities, 2018).

SINAT describes that any product that does not previously obey a normative structure, and includes characteristics and specifications of manufacture and execution, is considered a constructive innovation. The main objectives announced by SINAT (2018) are:

> I - stimulate the process of technological innovation in Brazil, increase the range of technological alternatives for the production of building and sanitation works, and promote a competitive equilibrium in the related productive sectors;
> II - to reduce risk in the decision-making process by promoters, developers, builders, insurers, financiers and users of innovative products and construction processes in terms of technical suitability for use, fundamentally considering safety performance requirements, habitability, durability and environmental suitability;
> III - guide producers, manufacturers and builders regarding the requirements and performance criteria applicable to the product or process, specifying them in technical documents defined in the SINAT Rules; and
> V - promote trade between countries or trade blocs, as long as the guidelines and procedures defined for SINAT are consistent with others defined in other countries, continents.

Therefore, SINAT is promoted as a tool to apply new techniques, systems or constructive materials for building improvement. The DATec is seen as a fast and viable solution for companies that wish to have a legitimized construction product, since it is a certification focused exclusively on civil construction.

However, more than promoting a "breakthrough" in the construction sector, SINAT presents itself as an opportunity for companies and for the use of their "constructive innovations" in an even more profitable type of production, such as housing of the PMCMV. The importance of the search for technical evaluation and consequent legitimacy of products is mainly because that, without technical reference or standardization, construction systems cannot reach financing for large-scale housing programs. Since 2010, companies wishing to have access to funding to promote PMCMV housing must meet the standards set by the PBQP-H Technical Assessment System (Siac). In this way, SINAT presents itself as an alternative to the Brazilian Technical Standard (NBR), which aims to promote products that seek to increase productivity in the civil construction sector. This strategy of legitimating the performance of non-standardized companies in the construction market indicates that it is effectively the focus of this System. SINAT was intensely demanded, because of the construction companies invested in the management of construction processes as a way to optimize their profitability. Consequently, construction technologies were rethought or increased (MASCARENHAS 2015).

Table 1, below, shows all DATecs referring to constructive sealing elements or structure issued by SINAT since its implementation (2007). There are 30 products validated by the document until this moment.

TABLE 1 - DATec issued by SINAT. Source: (AUTHORS from PBQP-H 2018 data)

Nº DATec	PROPONENT COMPANY	PRODUCT
001	SERGUS Ltda.	Concrete walls molded in metal type forms "banche"
002	SULBRASIL Ltda.	Reinforced concrete walls molded in loco
003	Viver	Walls made of solid pre-cast reinforced concrete panels
004	TENDA S.A	Reinforced concrete walls molded in loco
005-B	HOBRAZIL Ltda.	Solid in-molding walls made of lightweight polymer concrete and fiberglass reinforcement protected by polyester
006-A	TECNNOMETTA Indústria e Comércio Ltda.	Lightweight reinforced concrete walls molded in loco
007-A	ROSSI Residencial S.A.	Solid precast concrete panels for walls
008	JET CASA Industrial Ltda.	Precast concrete mixed concrete panels and ceramic blocks for walls
009-B	CASA EXPRESS Construções e Empreendimentos Imobiliários Ltda.	Precast concrete mixed concrete panels and ceramic blocks for walls
010	Bairro Novo Empreendimentos Imobiliários S.A.	Reinforced concrete walls molded in loco
011	Construtora Carrilho Ltda.	Reinforced concrete walls molded in loco
012	PRECON Engenharia S.A.	Prefabricated panels.
013	Construtora DHARMA Ltda.	Walls consisting of mixed precast concrete panels and ceramic blocks
014-B	SAINT-GOBAIN do Brasil Ltda.	Light Steel Frame
015	LP Brasil Ltda.	Construction system in Light Steel Frame and closing in OSB sheets coated with vinyl siding
016	LP Brasil Ltda.	Construction system in Light Steel Frame and closing in Smart Side Panel

017	GLOBAL Housing International Brasil Ltda.	Walls made of PVC panels filled with concrete
018	GIASSI construtora e incorporadora Ltda.	Construction system consisting of pre-fabricated reinforced concrete panels
020	TECVERDE Engenharia Ltda.	Light Wood Frame
021	MOREFÁCIL Construtora e Incorporadora Ltda.	Pre-cast panels in masonry and reinforced concrete
023	CASA EXPRESS Construções e Empreendimentos Imobiliários Ltda.	Precast masonry panels with ceramic tiles and reinforced concrete (DATec 009-B revised technology)
024	DPB Soluções Tecnológicas para Construção Civil S.A	Prefabricated reinforced concrete panels for walls
026	Tecnometta	Structural lightweight reinforced concrete structural walls
027	Queiroz Galvão Desenvolvimento Imobiliário S.A	Internal vertical seal in non-structural masonry of gypsum blocks
028	PREMIERE Construtora Ltda.	Pre-cast ceramic and reinforced concrete block panels for walls
029	Sem identificação	Solid precast concrete panels for walls
030	LP Brasil Ltda.	Light Steel Frame Construction System and OSB sheet closure
031	Laccheng Engenharia Ltda.	Mixed precast concrete panels and ceramic blocks with no structural function
032	Construtora Altiare Ltda.	Precast reinforced concrete structural panels
035	MRV Engenharia e Participações S.A	Molded Concrete Walls Reinforced with Glass Fiber

Among the technologies homologated by SINAT we verified five groups: the concrete walls molded in loco (denominated wall-concrete); prefabricated structural panels; pre-fabricated panels without structural function; Light Wood Frame and Light Steel Framing systems. Among the 30 certified products, 25 are manufactured in concrete, demonstrating that the certifications issued by SINAT are indicative of the preponderance of structural and sealing systems based on cementitious materials, as is already recurring in Brazilian housing production. Structural masonry (conventional system already widely used in Brazilian civil construction) and concrete walls represent the most used solutions by builders and developers for social housing in the country. The predominance of concrete walls is an option because it allows greater agility in the execution of the tasks, with an impact on the time of return of investments. When analyzing the production conformed by concrete walls, Lamounier (2017, 193) points out:

> The problem discussed here is not the adoption of technology, but the way it has been used in the production of the projects, making it even more difficult, or definitely preventing any spatial modification that involves (...) much more than the rigidity of a masonry structural approach, until now, historically applied in this type of housing production.

Initially, we verified that SINAT promotes the research and the use of new materials and construction systems with potential of incorporation in the production guided by the concepts of Base Building and Fit-Out of the OB. In this article, we investigate, on the one hand, through a case study, how one of the technologies homologated by SINAT is today adopted in social housing developments. On the other hand, considering that these technologies foster new design and constructive arrangements, we also test and evaluate - from the classification of support and infill and connectivity among the elements of the building layers - the potential for some SINAT products to adapt to employment in design strategies guided by the OB guidelines, considering the Brazilian reality.

2. CONSTRUCTIVE RATIONALIZATION AND REPRODUCTION OF A HOUSING MODEL: A CASE STUDY

Prefabrication has been getting space in housing construction, especially in the area of social interest. We selected therefore for case study, a prefabricated building component approved by SINAT.

For ease of access to product information, as well as being widely used in PMCV projects, we opted for the analysis of the innovative system, composed of **prefabricated reinforced concrete panels for walls** of the company DPB with DATec issued by SINAT in 2016. In the evaluation of the DATec, in reports and on the company website, we can see that DBP's projects adopt 140 mm thick panels for the construction of structural walls of buildings with a maximum of five floors (Figure 2). The other (non-innovative) parts of the construction system are composed of prefabricated massive slabs, foundations in grade beams or radier slab and composite roofing of wood structure or metal structure and ceramic or fiber cement tiles.

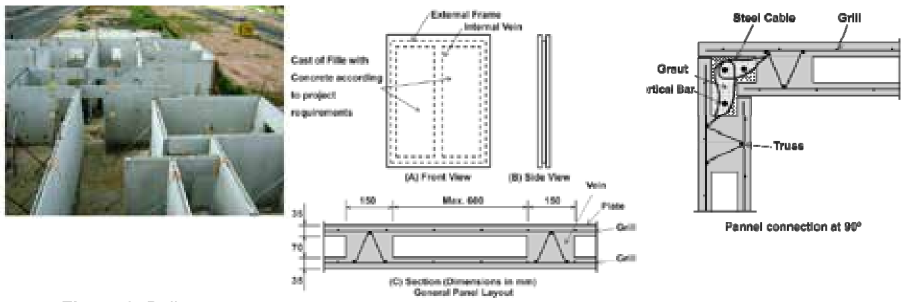

Figure 2- Built Panels on construction site and constructive details of the system Source: (BRASIL 2018)

For a better understanding of the use of the panels in projects executed by DPB, we analyzed one of his works, the Residencial Monterrey I, composed of 896 housing units located in the State of São Paulo / Brazil, where the company produces buildings for the PMCMV (FIG.3).

Figure 3- Buildings using mixed sealing prefabricated panels. Source: (CICHINELLI 2015)

The company offers only one standard typology in the enterprise analyzed, as shown in Figure 4. The typology has an area of 48m² (516.6 ft2), consisting of two bedrooms, a bathroom, integrated living and dining room and kitchen and service area also integrated. There are four units per floor, with kitchens and bathrooms concentrated and organized in blocks of five floors.

Figure 4- Residential Monterrey I: floor plan type (left) and plant type unit (right). Source: (DPB 2018)

According to Cichinelli (2015) "Because it is a structural panel, any modification in walls and slabs, as opening spans and tears for hydraulic and electrical installations, must be previously agreed with the manufacturer in the design phase of the building." Therefore, there is no possibility of future modification in the property, excluding the resident of the decisions on the composition of their dwelling. In addition, we find that the floor of each building is composed of an "H-type floor plans", in which vertical circulation is centralized and followed by four standard units at the ends. Even if the system allows changes, this layout of the floor does not allow for any room for future additions and makes significant layout changes difficult. In addition, Ferreira (2012, 95) points out other negative aspects of this model:

> The "floor plan H", with housing units on the ground floor, widely adopted in current production, although optimizing the use of vertical circulation in a minimum space that serves four apartments, presents major problems. (i) Whenever the building is implanted on the north-south axis, one of its facades will not receive natural light, (ii) Compromises cross ventilation because it is not implanted on pilotis, which prevents upward currents of air.

It is important to mention that all decisions about base building and also about filling are given in advance by the company, which is based on a generic family profile, composed of a couple with two children. In this production, the residents do not participate in any decision on project or construction work, contradicting the self-production profile of a large part of the Brazilian population. The possibilities of internal alteration to the units, with variation in the arrangements of the rooms for adaptations necessary to each family profile, become very impaired, if not suppressed. We understand that the residents are unable to make substantial changes in the new house, since there is a heteronomous conception, which, consequently:

> It installs a hidden crisis, since the resident is unable to adapt his home to the immediate needs of the family, as he suffers, over the time, directly from a problem whose roots he does not even understand. (LAMOUNIER 2017,62).

In practice, the use of the rationalized and innovative construction system analyzed does not contribute to an effective modification in the conformation of the housing units. Prevails a pattern of buildings similar to the highly employed in the other developments of the PMCMV.

In this case study we realized that, instead constructive flexibility and constructive design decisions shared and widely discussed - OB postulates - market dwellings in Brazil increasingly tend to heteronomous solutions, rigid in form and in processes. Among the several consequences of this model, we highlight the impediment of new spatial configurations and the promotion of an inadequate production to its public. Here we also identify that technological innovation, when treated within the reproductive logic of the same housing market model does not necessarily follow and promote new spatial and decision-making organizations. Therefore, we try to investigate the adequacy of SINAT technologies to the use of architectural strategies previously oriented by the OB methodology.

3. ADEQUACY OF THE DPB SYSTEM / PREFABRICATED REINFORCED CONCRETE PANEL TO THE OPEN BUILDING METHODOLOGY

Although the current formal production of Brazilian housing does not incorporate and even seem to impede the exercise of OB principles, we believe it is possible and necessary to rethink constructive and design practices. As a main step towards an adaptation to the open architecture, we can mention the division of the constructive decisions through support and infill.

The approach to an open architecture assumes that both users and professionals can make design decisions, considering that the parts of collective definition should be clearly distinct from those of individual competence. It also requires that the interface between technical systems allow its replacement, with a view to maintenance or updating (Kendall, 2003). For an adaptation of the DPB system to the OB methodology, we work with the existing pavement-type and with the inherent limitations of its volume, including the current arrangement of facade openings and the distribution of vertical and horizontal circulations of shared use. From this decision we propose the reallocation of the kitchen and bathroom cores (part of the support-base building), so that these new positions suggest different spatial occupations. Some internal walls were maintained to make use of the slab panels, whose spans should not exceed 4.0 meters or 13,12ft. From five new positions of hydraulic cores, plus the original option proposed by the construction company (type I), new spatial organization alternatives are generated, which allows users to design their dwelling spaces (Figure 5).

Figure 5- Floor-type of the Residencial Monterrey I with adequation to the OB. Source: (Authors 2018)

For BDP system, sewage pipes shafts are embedded in the tank, sink leads are apparent and the sink is embedded in filler under the worktop. The bathroom and the kitchen water pipes are embedded in a fake lining, while the sub-extensions of the sink, lavatory and tank are allotted in mortar filler run on the panels (Figure 6). The gas pipe is external to the walls, positioned superimposed on the facade.

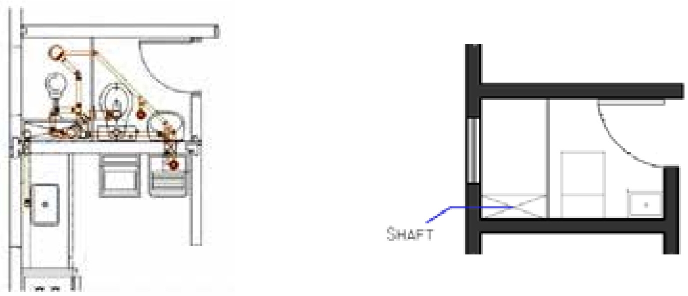

Figure 6- Hydrosanitary plan connections. Source: (Authors 2018)

The relocation of the wet cores will not demand a new shafts distribution. We assume the enterprise solution. In this way, there is a superposition of the hydraulic cores, but with variation of the spatial organization. We believe that it is not necessary, in the studied case, to adopt raised floors for greater spatial flexibility.

The raised floors, common in the solutions that use the OB methodology – for example, Solids Projects, Keyenburg and Next 21 (TOKYO NATIONAL CONFERENCE BOARD 2005) – are, in Brazil, marketed by companies focused on corporate buildings. This system is expensive and economically unviable for use in popular residential buildings. Although they provide a high degree of flexibility in spatial organization, it is still necessary to think of alternative solutions in the Brazilian reality.

The new layouts (infill), developed from the new allocation of bathrooms and kitchens, present the possibility of typological variations of one, two or three bedrooms, therefore, more coherent with the different profiles of dwellers (Figure 7).

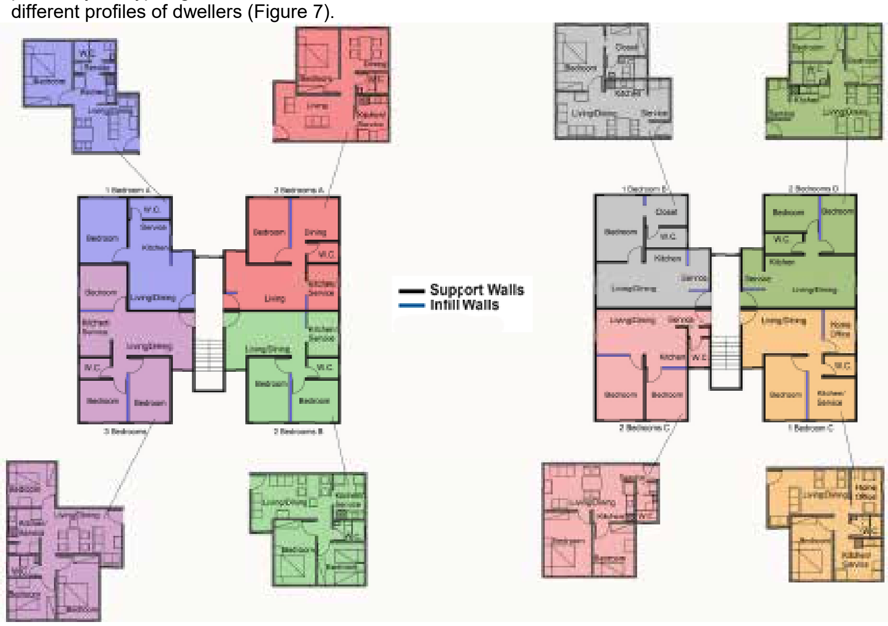

Figure 7- New possibilities of layout from the adjustment of the system. Source: (Authors 2018)

In general terms, the adequacy of the construction system of SINAT to the OB methodology has the following characteristics regarding the base building:

- black walls are prefabricated concrete panels (support-base building);
- blue walls are light prefabricated panels (filler);
- hydraulic cores consisting of sanitary installation and kitchen in prefabricated concrete panels, with built-in shafts.

As for the infill, the local market offers components that allow the resident to self-produce, whether advised or not by specialized labor, in which we highlight the closures in modular panels of plaster, wood, drywall, fibro cement , among others. Other components and finishing materials are available in the market, with wide range of options.

CONCLUSIONS

From this exercise of adapting a constructive system - traditionally applied inflexibly by the real estate market - to the possibilities of an open architecture, we understand that the constructive components approved by SINAT mostly understand elements of systems that can be interpreted as part of the support (base building). This prior division would agree on an arrangement of models capable of harboring different infill (fit-outs); besides not compromising technical and economic decisions by the State and the construction companies. Thus, industrialized-scale production (based on market logic) and the definition of other systems (such as closures, facilities, etc.) at the filling stage of the fit-out are not compromised.
Constructive solutions of construction companies employ a minimal variety of elements and components. By allowing the use of lightweight and interchangeable components as infill, capable of replacement or removal without major efforts and damage to the support of the building, the autonomy of the dwellers is stimulated as to the decision about their living spaces. The use of different components and systems is a fact that already happens in the technologies approved by SINAT, as already demonstrated in the system used by the company DBP (use of prefabricated elements in conjunction with concrete panels), being a recurring solution mentioned in the other DATec. This point is a decisive factor in the possibility of executing different fillings, since the use of rigid and inflexible components is an aggravating factor in the possibility of changes of layouts.

The feasibility of producing social housing, in the Brazilian case, according to the logic of supports and fillings, is a real and viable alternative to current production. Although studies in this sense should be more comprehensive - such as that of Lamounier (2017), which analyzes this viability in its political, economic, financial, legal, cultural and technological aspects - the technical-design side contributes to the understanding of how the flexible housing can be equated.

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ENDNOTES

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THE POSSIBLE CONTRIBUTION OF OPEN BUILDING TOWARDS RESILIENT AND RESPONSIBLE ARCHITECTURE AND URBANISM

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ABSTRACT: Our attitudes, business models, products, services and actions related to the design, build, maintenance and transformation of our built environments have to change fundamentally. New build, renovation and restoration projects increasingly focus on energy efficiency, renewable energy generation, sustainable building, water management and resource efficiency due to the emerging implications of a growing global population and rise in living standards. More and more resources will be necessary to meet global demand. What does this mean for architecture and urbanism? What exactly are the challenges we are facing? What can Open Building contribute to meet those?
Conclusions are based on the presentations, workshops and discussions during the RRAU18 conference held in Groningen, the Netherlands on April 10-12, 2018. Contributions came from countries like Egypt, South Africa, Indonesia, Philippines, China, Iraq, Syria, Algeria and the Netherlands. This conference was organised by CIB, platform Urban Energy, IEREK and the Hanze University of Applied Sciences.

KEYWORDS: resilience, architecture, urbanism, Open Building

INTRODUCTION

Our attitudes, business models, products, services and actions related to the design, build, maintenance and transformation of our built environments have to change fundamentally. New build, renovation and restoration projects increasingly focus on energy efficiency, renewable energy generation, sustainable building, water management and resource efficiency. This is not so strange when you consider the implications of a growing global population and rise in living standards. More and more resources will be necessary to meet global demand. What does this mean for architecture and urbanism?

For a long time, we have treated natural resources as if they were infinite and the use of toxic substances as something of little significance. Those times now seem to be well and truly over. From studies towards major turnarounds in our society by economists we know that major transitions occur when structural social changes meets major economic developments and new disruptive technology. Recent financial crises, a major increase of world population, growing resource usage, changing demographics (e.g. ageing & urbanization) in combination with the possibilities created by disruptive information and communication technologies is an indication that we are currently on the threshold of such a period in history. This presents major challenges to our society, the current built environment and consequently to architecture, urban planning and the construction sector.

The built environment has a major impact on how we experience the quality of our daily life. With a world population that is predicted to grow considerably, the demand for energy and resources is likely to increase and not diminish. Since the construction sector is currently responsible for 40% of energy consumption, 40% resource usage and 40% of waste globally, it is one of the most important sectors in which a real impact can be made to improve our ecological footprint. This means architecture and urbanism are facing a major challenge. But then still, finding answers in designing and realising green objects and sustainable urban only will not be enough. Addressing these issues successfully can never be done without considering how man experiences the quality of the built environment. More than ever architecture and urbanism has the responsibility to include issues important to ordinary people, e.g. the affordability of housing, the accessibility of the urban environment for elderly, healthy and comfortable places to live, safe working conditions, new jobs and maintaining quality of life in regional areas with a shrinking population. This demands an interdisciplinary approach for architects as well as urban designers and an integrated supply chain to execute the developed plans.
In Groningen, the Netherlands on April 10-12, 2018, a conference was organised to discuss what we can do as architects, urban planners and researchers interested in resilient and responsible architecture and urbanism. RRAU18 provided a comprehensive view of the latest developments related to resilient and responsible interventions to our buildings, towns and regions on different continents both by professionals and communities.

Aim of this conference was to exchange knowledge and experience in ramping up the future-proofing of new and existing dwellings and communities with an eye for the users of the built environment. Papers and keynotes were presented by professionals from different angles of the globe representing 17 nations: Indonesia, China, Japan, Sri Lanka, Malaysia, Philippines, Afghanistan, Iraq, Syria, Lebanon, Egypt, Algeria, South Africa, Argentina, Italy, the UK and the Netherlands.

The purpose of the conference was to stimulate discussions of new ideas and find new perspectives in traditional methods, approaches, tools and conditions to be considered while future-proofing.

1.THEORY

Point of departure for the conference was that we seem to be living in a period were major changes are taking place in our society. These changes will put major challenges to society, the built environment and as a consequence to architecture, urban planning and the construction sector. First this paper will examine the magnitude of change we are talking about. In this section attention will be given to what Rifkin (2011) considers the starting point of improvements for the coming decades: value. After that Living Buildings and Regions are described, new concepts introduced in construction based on the value perspective. Finally Open Building is introduced, before it is tested as possible approach to help to structure implementation of value concept that transcends construction and planning.
First an introduction of two important notions of the conference: resilience and responsibility.

Resilience
Resilience is often seen merely as the capacity of a community to ‘bounce’ back, retaining a state of equilibrium after a situation of crisis. This however, is too limited (Horlings, 2017). Resilience is a dynamic process of transformation towards a more desirable trajectory, which can be captured in the notion of evolutionary resilience (Davoudi et al., 2013; Boschma, 2015). Disturbances, such as gas extraction in Groningen in the Netherlands, can push systems to thresholds at which adaptations are no longer sufficient (Horlings 2018) but may require an energy transformation towards a gas-free province (see also Magis, 2010, p.404). This is a critical perspective, including not only sustenance and renewal, but also the adaptive and transformative capacity to regenerate a place beyond its current state (Franklin, 2017). Conditions for evolutionary resilience are preparedness (learning capacity), adaptability (being flexible), persistence (being robust) and transformability (being innovative) (Davoudi et al., 2013, p.312).
Resilience is also associated with robustness. The dictionary definition of robustness includes terms such as ‘‘strong’’, ‘‘tough’’, and ‘‘sturdily built’’. How to define robustness depends on the broadness chosen. Robustness in the built environment is often related to material, components (e.g. Jelle e.a. 2014), and/or buildings structures (e.g. Canisius, 2011; ABCD, 2016). Then the definition of robustness helps to evaluate the durability and resilience of a building and its components. However, robustness refers to more than mechanical properties, materials and solutions having a high resistance against failure (e.g., moisture problems), being constructed according to specifications and a raisonable service life of the materials and solutions. Also resistance to damage from climate load and energy robustness are mentioned (e.g. Jelle ea. 2014). A broader definition could also be chosen, which includes e.g. a building’s economical, social or political robustness.
Planning for the future, like in urban planning, is regarded as inherently risky. In most systems, exogenous driving forces affect any strategy's performance (Goodings Swartz ea, 2013). These driving forces are generally categorized as economic, social, political, technological, and environmental (Zegras 2004). Uncertainty about the state of those driving forces requires strategies that perform well in the face of a range of possible, even improbable, future conditions (Goodings Swartz ea, 2013). Robustness in urban planning is therefore related to the need to leave all alternatives considered viable to be open, and to minimize the possibility of surprises, the allowance to make early decisions in a time-phased sequence that still keep viable alternatives as options. Robustness is therefore about increasing the flexibility and to minimize uncertainties of the planning process, which allows for a better and more reliable decision making (Deogratias e.a., 2003).

Responsibility
According to the dictionary: if you have **responsibility** for something or someone, or if they are your **responsibility**, it is your job or duty to deal with them and to take decisions relating to them (Collins English dictionairy). Responsibility in architecture and urban planning is related to the UN Sustainable Development Goals. The goals are:
the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. The Goals interconnect and in order to leave no one behind, it ís important that we achieve each Goal and target by 2030. (UN, 2015)

1.1. New paradigm

From studies of economists into changing societal systems and transition management we know that management of major turnarounds takes place when changes in different societal systems meet and strengthen each other. As the history of industrialisation shows, technology alone is not responsible for the fundamental changes in our society (e.g. Arthur, 2002; Arthur, 2013; Freeman et al., 1997). Technology needs to be embedded before it can make a difference. Arthur therefore describes theses changes of the economy as an evolving complex system: combining economical change with new emerging technology and social systems. As a result, not only the structure of organisations, technology and the economy changes, but society as a whole transforms. Because of this correlation, technological, economic and sociological trends together cause long-term waves in the economy (Freeman et al, 1997). Complete new areas for business can emerge and blossom. Seizing the new opportunities is no easy task since the technology has to be developed and embedded in on-going organisational and economic transformations, which requires considerable effort.

The American economist Jeremy Rifkin (2011) argues industrial revolutions take place when three important systems of society are changed: communication, energy and mobility, thereby affecting construction in all sort of ways. Since we are living in an era with a major increase of world population, changing demographics, growing energy and resource usage and disruptive information and communication technologies, we appear to be on the threshold of such a period in history. For the implications from a transition from the 2nd to the 3rd industrial revolutions as described by Rifkin a translation has been made of the characteristics important for the built environment (see table 2).

	Characteristic for 2nd Industrial Revolution	**Characteristic for 3rd Industrial Revolution**
Central focus for improvement	Process and production efficiency	Customer value, customer experience, with additional data-based services and the measurement of performance through analytics
Dwellings	Spawned flat suburban tracts constructed with industrialised standardised components	Customised dual purpose dwellings: habitat and micro-power plant
Attitude in business	Self-interest an adversarial relationship between sellers and buyers	Shared interest and cooperation
Information concerning product and performance	Enclosed & proprietary information	Transparency, openness and collective trust
Business model	Autonomous transaction-based business models directed at delivering products. Competitive business operations in siloed markets to focus specifically on the market niche were the company can create its competitive advantage	Business models directed at delivering a specific (guaranteed) performance and an excellent customer experience. Cross-sector networks and peer-to-peer business practices in flexible supply chains in order to meet specific client needs.
Organisation model	Top-down organised, scales hierarchal	Distributed & collaborative relationships, nodally structure, scales laterally, and favours distributed and collaborative business practices that work most effectively in networks
Financial arrangements	Autonomous transaction-based business models, clients buy cash, on credit or rent	Performance contracting and shared savings ventures in the service and experiential sectors, just-in-time access to goods and services in networks, purchased in the form of leases, rentals, timeshares, retainer agreements, and other kinds of time allotments.
Ownership	Centralised capitalism	Distributed capitalism
New scientific domains	Chemistry, electronics, industrial agriculture, pharmaceutics	Artificial intelligence, robotics, the Internet of Things, 3-D printing, nanotechnology, biotechnology, materials science, and quantum computing
New products	Cars, pesticides, construction materials, drugs, synthetic fibers, plastics	Robots, wearables, smart products, autonomous vehicles, energy storage, photovoltaics

Table 1. Characteristics of the second and third industrial revolutions based on Rifkin (2011) important for the built environment (Oostra 2017)

1.2. Living Buildings and Regions

In the keynote presentation of Harry Vedder (2018) the developments around the concepts of living buildings and regions were presented. In this day and age, according to Vedder, we need strategies that are based on new value flow systems, not only strategies just based on money. There are many more values to build upon in the built environment than just money alone. Jonkers and Hennes de Ridder laid the basis for this approach with a concept for buildings that facilitate change; The Living Building Concept (De Ridder, 2006). De Ridder (2011) explained how this could be effectuated with tailor made industrialised manufactured components. It first sight it might seem an incompatible contradiction. Nevertheless, De Ridder states that the crisis in the construction sector is not only caused by the economy, but goes much deeper and is structural. Cars, computers, televisions, planes: these products are the result of decades of accumulated knowledge and experience. Their shape is constantly changing and the performance is constantly improving, but their structure is still the same and the continuously improved parts are produced in series. Construction, on the other hand, still works in a pre-industrialised manner. As if it is about reinventing the wheel every time. Prof. dr. Dr. Ir. Hennes de Ridder advocates in this book that construction should work with taylor-made components, that are developed evolutionarily on the basis of experiences with already realized structures. These components should be easily adaptable to allow for changing use. With this the performance of the sector could improve enormously.

Extending on the concept of living building concept, Vedder (2018) pleads for flexibility on an urban scale as well. He wants to also apply it to city development. He stresses that it is important that clients start demanding these new strategies so that suppliers will come with new offers.

1.3. Open Building

Ideas and techniques that make it possible to respond to individual requirements and desires are not new. In 1932 Le Corbusier drew his plan Obus for Algiers. This plan consisted of a mega-bearing structure in which, as a matter of speech, individual and unique houses were inserted. This plan was never realized, but the plan of Le Corbusier L'Unité d'Habitation in Marseille, designed on the same principle, was. It took until the 60s, until the end of the mass housing was announced by John Habraken (Habraken, 1961). Habraken developed his ideas further with the SAR research at TU Eindhoven in the Netherlands under the name Open Building. They developed a support and infill structure, in which it was possible for various stakeholders, including occupants, to develop their own knowledge, expertise and preferences. End-users were made part of the decision-making and therefore organized on specific levels. These ideas were picked up and applied worldwide, for instance in Japan, Finland, USA, and also in unexpected countries like Russia and South Africa. Habraken continued his developments from MIT. To realize this goal disentanglement of technical systems and the development of plug-and play principles proved necessary. Since the '90s these ideas were mixed with principles and techniques from lean and mass customization (Kazi et al., 2007).

Industrialization coupled with ICT and supply chain integration opened up the possibility of providing end- users with greater quality and more transparent choices using a top-down approach. This is done by taking a rational approach to construction and offering prefab solutions that can be applied in several combinations, mass-customization. Components are manufactured under controlled conditions, instead of being produced in adverse weather conditions at the construction site. This leads to better quality products. Platform-based buildings allow parts of buildings that end-users and clients have no need to influence to be standardized, which is also done in the car industry (Halman, 2004). After all, why would you, as a client, want to be bothered by the building's foundation or the wiring and plumbing? By providing options that matter, building companies can give clients a tailor-made choice. Although this choice is limited in scope, the process is made more transparent for clients because the options are explained as well as how they impact budget, energy consumption or the maintenance bill. Depending on requirements and budget, the client is free to weigh up the pros and cons and choose between the alternatives on offer.

Building companies and architects have used the possibilities offered by Open Building and mass-customization to supply end-users with better quality products and greater transparency in terms of choice (Oostra et al., 2007; Engström et al., 2007). A lot has happened in mass customization in the past few years. Catalogue homes have become a well-known phenomenon and many building companies are focusing on supply chain integration and mass-customization. Famous examples in the Netherlands include the Van Dijk Group's Customised Housing designs and Nijhuis' Trento concept. Abroad there are other interesting developments for example NCC in Sweden (high-tech mass customization combined with indoor building site), Sekisui in Japan (home-buying marketed as a total experience), and Bensonwood Homes in the US (passive house solutions based on Open Building principles).

The ideas of Open Building are still developed further, even today. Configurators allow future residents to make up their own property. This is made possible by technology, the developments in the fields of lean, mass-customization and IT in particular. Recently, initiatives emerging around the adaptation of buildings and homes go even further. The development of tools accessible via Internet, facilitate people in composing the set-up of their own home. These platforms can at the same time assemble the outcomes of a group of candidates in order to plan the transformation of existing buildings (Pool, 2013). Other projects start from a more individual architect-to-client basis. These kinds of projects are in fact a variation on the principle of support and infill, as proposed by Habraken. The Tetterode complex in Amsterdam was in fact the first of its kind, followed by the Solids, which have been realized in 2011 (Platform31, 2013). The current developments in IT and manufacturing will allow users to take a more active role in the design and production process. The challenge now is to search for various possible scenarios for the transformation of existing buildings in which the right balance between the ultimate freedom for the end-user is combined with the observance of the conditions and limitations of the particular object being transformed and its effects on the environment. What does this mean for construction? How will it influence the role of the architect? And what will happen with the roles of other professionals in construction?

2 METHODOLOGY

The aim of the conference was to determine: What exactly are the challenges we are facing? What does this mean for architecture and urbanism? What can Open Building contribute to meet those?
In this paper we will analyze what different aspects of responsibility and resilience can be derived from the contributions of the conference and how Open Building can contribute. For this an analysis was made of the different papers submitted to the conference and outcomes of discussions during the sessions.

3. ANALYSIS

3.1. Challenges for Architecture & Urbanism

When looking at developing countries it becomes clear that the challenges we face are enormous. Wafaa Nadim (2018) gave us an impression about the urban and architectural challenges Egypt started witnessing since the 1950s. This was largely due to the industrialization and heavy industry policy at that time that was mostly taking place in cities. This has resulted in the rural-urban migration; and thus, increasing city populations beyond their planned capacities. Cairo with its current 20Mill inhabitants, for example, has been declared to have already exceeded its planned capacity back in the 1970s. The inability of successive Governments since to meet housing demand in addition to the war back in 1973 that has consumed all resources has further compounded the problem resulting in the emergence and expansion of informal/illegal housing. Informal housing may entail a whole neighborhood or community, or can be also in the form of illegally adapting government provided housing. While informal housing respond to basic human needs and are affordable in comparison to government provided housing; thus, more popular to Egyptian, they may represent a burden on existing infrastructure and may also have negative impact on the physical as well as mental health of people. Given the changing characteristics of the population in terms of socio-economic and demographic needs, it is time to act quickly to help achieve housing that is affordable and adaptable to accommodate the changing needs. An investigation into the popularity of informal housing in Egypt revealed the following characteristics of favored housing, namely affordability, phased construction or extendibility, mixed uses, flexibility of spaces, personalization of facades, hybrid building systems and finishes, and flexible building services. These characteristics, to a large extend, match open building principles; an indication that open building may play an important role in solving the chronic problem of housing that has never been solved to-date in Egypt.
Amira Osman (2018) presented in her keynote the urban and architectural challenges in modern South Africa. Other challenges were presented in the paper sessions.

In table 1 the different challenges are indicated as emerged from the different paper contributions and presentations to the conference.

Table 1: Design level, challenge and paper topic

Design level	Challenge	Paper topic	Origin authors
Landscape & regional design	Resilience – security	Building security against terror attacks with landscape elements	Beirut, Lebanon
	Resilience - ecosystems	The role of natural landscape elements in traditional city concepts Nuwara Concept – interwoven between myth and reality. Natural landscape elements such as mountains, rocks, hills, water, trees, forests and topography all had a major role in shaping the city form, architecture and built elements, directing spirituality for the life of people to recognize the ideal understanding of place	Sri Lanka
	Resilience - water	Dutch resiliency under sea-level	Delft & Enschede, the Netherlands
	Resilience -	Elimination of pollution using urban solutions and	Tébessa, Algeria

	water	sustainable development	
	Resilience - water	Monuments to be protected from flooding	Delft, the Netherlands
	Responsibility - governance	Opportunities for new forms of public-private partnerships in the Groningen Earthquake zone	Groningen, the Netherlands
Urban design	Responsibility - governance	From un planned city development with informal city infill to tools for spatial decision making	Kabul, Afghanistan
	Responsibility - governance	Case study of the developing villages close to Nantong. In the past a water conservancy project has been implemented that proved to be a good basis for a resilient growth, now the fast developments impact special spatial and ecological environments.	Nanjijng, China
	Responsibility - governance	Rurban design in-between rural and urban design	China & Tokyo, Japan
	Resilience - water	Campus design & flooding - Mitigation, preparedness, response and recovery	Philippines
	Resilience - water	City climate scan	Groningen & Leeuwarden, the Netherlands
	Resilience - water	City climate scan	Groningen & Rotterdam, the Netherlands
	Resilience - resource efficiency	Allowing for circular flows of water, food, waste and energy - vertical farming, decentral biological water purification – integration in a historical city centre of Groningen gives rise to new public spaces, like a recessed and multi-layered urban fields than a glass floored town garden	Groningen, the Netherlands
	Resilience – societal change	Streetscape (re-)design based on community participation. Design can enhance the environment, social conditions and supporting urban economic development What has been lacking recently is greenery, safety as well as historic atmosphere Focus-groups as a method of discussions with several stakeholders to provide innovative design ideas in the development of streetscape that has meaning in sustainable urban development	Surabaya, Indonesia
	Responsibility - governance	Accessibility to upgrade Urban poverty areas and develop affordable and adaptable housing	Egypt
	Resilience - ecosystems	Greenways development to safeguard ecosystems in the raid development of urban areas	Wuhan, China
	Resilience – energy	Future solar potential in high density urban areas	Mendoza, Argentina
City block design	Resilience – climate adaptation	Climate responsive courtyard dwellings in hot-humid climate - What are the consequences for daylight quality and energy performance. Also heating load is neglected only cooling load is considered nowadays	Beijing, China
	Resilience – climate adaptation	Designing sustainable buildings starts from early stages of city blocks in urban design. The effects on outdoor thermal comfort in the semi-arid regions.	Duhok, Iraq
	Resilience – societal change	Change of authority symbols into inherent part of open-spaced city design	Java, Indonesia
Architecture & technology	Resilience – climate adaptation & energy	New technologies for adaptive architecture Bioclimatic architecture – able to adapt form, shape, colour or character responsively (via actuators), reflecting the environmental conditions around them	Palermo, Italy
	Resilience – climate adaptation	Data for a new local thermal comfort standard for buildings	China & Syria
	Resilience – climate adaptation	Mosques as emergency shelters. Islamic theology - how to provide social and welfare services to the community	Malaysia
	Resilience – energy	Business case small-scale hydrogen storage for a 5-person household	Arnhem, the Netherlands
	Resilience – energy	High concentration solar systems	Arnhem, the Netherlands
	Resilience –	Dielectric-metal nanoshell plasmonic metamaterial for	Wuhan China & Syria

	climate adaptation	filtering and protection. Filtering specific frequencies of visible light – to protect antiquities in museums	
	Resilience – water	The Hanseatic Waterwall - Vertical water storage on building facades	Groningen, the Netherlands

3.2. International trends in construction

On top of the challenges in architecture and urban planning Wim Bakens' keynote (2018) gave an overview of the 16 mega trends and impacts on building and construction:

SOCIETY
1 Going East
2 Getting old
3 Being rich
4 Living in cities
5 Preventing and expecting climate change
6 Preparing for threats
7 Working international
TECHNOLOGY
8 IT and other technologies
BUILDING AND CONSTRUCTION
9 Market: Maintenance vs Extension
10 Process: Integration vs Fragmentation
11 Design: Sustainable vs Fashionable
12 Production: Offsite vs Onsite
MAKING A DIFFERENCE
13 Attract quality people
14 Co-develop and own
15 Find new ethics
16 Re-define the Industry

4.0. SYNTHESIS

4.1. Theme's to address in architecture & urbanism

In the presentations different aspects of resilience and responsibility were addressed. These can be summarized in the following categories:

Resilience - energy
An enormous challenge exists for our built environment across the globe, as a result of the Paris Agreements to reduce global carbon emissions. Since the built environment is responsible for 40% of energy consumption, the EU e.g. has committed itself to a domestic reduction of at least 40% in greenhouse gas emissions compared to 1990 in an agreement on the 2030 climate and energy framework (EC, 2015). The EU is also committed to become the world leader in renewable energy. Additionally the EU has set a target of a share of at least 27% renewable energy in 2030 (EC, 2015).
Resilience – resource efficiency
Also material consumption is rising as a result of aspirations of citizens worldwide to adopt a western lifestyle. Again 40% of material usage is linked to the built environment (EC, 2011; OECD, 2013). Since the built environment is responsible for major energy and material usage, it is here we can have a real impact to improve quality of life, and to improve our ecological footprint. These are of course Worldwide a lot of effort has been put in research and development to retrofit buildings towards net-zero.
Resilience – water
Due to climate change even regions with moderate climate are threatened by extreme weather events. This may be periods of drought and forest fires but also periods with torrential rains causing flooding.
Resilience – climate adaptation
Climate change also means temperatures during summer can become more extreme and humidity may increase. Architecture and urban planning can anticipate increasing human comfort levels.
Resilience – security
Polarization between people from different nationalities, race, religion or gender can lead to violence. With the increase of threats people will feel the need to include design features in architecture and urban planning that helps to improve (feelings of) security.

Resilience – societal change
The values and needs of people change over time. This has consequences of what they expect functionally and symbolically from their buildings and built environment.
Resilience – ecosystems
People are not the only species on the planet. The built environment can offer a lot to house other species and embed ecosystems.
Responsibility – governance
Architects, urban planners as well as governments at different levels have the responsibility to take decisions that see to the interest of the society as a whole in the present as well as in the future.

4.2. Possible contribution of Open Building
The challenges we face seem overwhelming when looking at the inventory made during the RRAU18 conference. This may result in feelings of despondency by professionals, resulting in apathy or in deliberately ignoring a large part of the challenges to be met. Especially when departing from the assumption that efficiency is key. With the insights of Rifkin we may ask ourselves if the new ara we seem to be at the brink of still demands us to depart from this precondition. It seems as if the time now demands a new point of, departure: value. Then the questions becomes what kind of value am I able to create as an architect, urban planner, client or contractor seen the conditions I have to operate in? What possiblities and principles can I put to use that allow me to create additional value for different individual stakeholders or society as a whole? When pondering these questions the principles of Open Building can be put to good use since it anticipates the need to change or adapt buildings and urban structures during its lifetime, in line with social or technological change. Open building design also helps to co-ordinate inputs from different stakeholders, not only professionals, but also clients and users of buildings, and interests associated with locality and the local community.

This will ask something of professionals, as Clements & Krabey (2018) concluded in their presentation:
…future architects [and urban planners] need to acquire new research and design skills to (1) open up innovative areas of expertise and (2) experiment with unprecedented spatial solutions to these complex urban questions.

CONCLUSIONS
Future architects and urban planners need to include a wide range of matters related to resilience and responsibility as we have seen in this paper, because of major challenges and changes we face. Since we are at the brink of a new era the paradigm of efficiency in which most of us were brought up is no longer valid, our values, attitudes, business models, products, services and actions related to the design, build, maintenance and transformation of our built environments have to change fundamentally. New build, renovation and restoration projects should take energy efficiency, renewable energy generation, sustainable building, water management, resource efficiency and embedding ecosystems as a pre-condition due to the emerging implications of a growing global population and rise in living standards. Besides this all sorts of social issues need to be addressed, poverty, inequality, tensions and violence in order to arrive at inclusive solutions. This means different facets of resilience and responsibility need to be addressed by architects, urban planners, clients and contractors to actually fulfil the ambitions that come with a quest for resilience and the ambition to meet the 17 sustainable development goals as formulated by the UN. This may seem an invincible burden and might require professionals to start from the other end, not to focus on the burden, but on the purpose: the responsible creation of a resilient built environment, which has value and meaning for us all.

This is however not a challenge for professionals in construction only. Although we can expect a lot of architects and urban planners to come up with creative solutions that include a wide myriad of valuable considerations, architects and urban planners are not able to look in the heads of end-users, nor are they able to look into the future. To create the value, adaptability and flexibility we aim for as a society we need to adapt the principles of Open Building on much profounder way as we thought we needed to foster a dynamic and liveable future. This has of course consequences for education for future generations of architects, urban planners and other building professionals.

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THE ELEMENTAL APPROACH TO RESIDENTIAL ARCHITECTURE: IS IT OPEN BUILDING?

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ABSTRACT: Aravena has designed numerous noteworthy projects with various programmes in various contexts – however, he is mostly known for his significant contribution towards re-thinking housing for the poor in well located city sites through a partnership (a “do-tank”) known as Elemental.

The basic principles of Open Building are summarised as: “…the way a building is “put together”, how buildings are assembled in terms of long- and short- life components and how the interface between building components allows for disassembly, replacement and upgrading with no disruptions to other building systems or components.” (Osman, 2015).

Could Aravena’s approach be considered Open Building? The process delivers “part of the house”. Yet, the house is not separated into Open Building levels. Aravena asks “which part should one construct?” which implies an engagement with the concept of a primary support system. Aravena also asks “how can one set the rules of the game” which implies a positive concern with allowing maximum user control within set parameters.

The multiple sources of finance used for the construction are not used to deliver different components of the project based on long and short life elements. Rather the funding has been used to deliver buildings that are to a great extent conventional. The Elemental experiments grapple with the concept of “capacity” – but they have not investigated the idea of mixed income, mixed functions or mixed typologies within the same development.

Many aspects of the projects are rooted in similar conceptual underpinnings as Open Building thinking, however, a deeper engagement with its core principles would have added much value, to an already valuable experiment.

KEYWORDS: Elemental, Aravena, Housing, Open Building

INTRODUCTION

Alejandro Aravena was celebrated in 2016 and the Pritzker Prize jury explained in their citation that: “He has a deep understanding of both architecture and civil society, as is reflected in his writing, his activism and his designs. The role of the architect is now being challenged to serve greater social and humanitarian needs, and Alejandro Aravena has clearly, generously and fully responded to this challenge." (Franco, 2016)

News of Arevena being awarded the 2016 Pritzker has been reason for some controversy amongst architectural professionals – and judging by social media in SA, there are reservations from SA architects around the award with some even mentioning other architects who were perceived to be more worthy of the award. Aravena has designed numerous noteworthy and fine projects with various programmes in various contexts – however, he is mostly known for his significant contribution towards re-thinking housing for the poor in well located city sites through a partnership (a “do-tank”) known as Elemental.

Perhaps the most notable South African reflections on the matter came from Thorsten Deckler, who questions the “myth of creative genius” while still celebrating the fact that someone from a developing context was recognised as generally “mainstream architectural media drowns out work like this.” (Deckler, 2016). In other media, Aravena is described as “radical” probably referring to the manner in which his practice is able to engage with more socially conscious design problems through a: “.. Robin Hood structure [which] runs throughout Elemental’s work, split three ways between social housing, urban planning and more lucrative commercial contracts.” (Wainwright, 2016).

1.0 THE SOUTH AFRICAN HOUSING SITUATION

South African cities have been deliberately and carefully engineered to enrich some and disadvantage others. Apartheid spatial planning still perpetuates, almost 25 years after the transition into democracy, and the housing debate is right at the centre of this reality. The built environment professions were complicit in the implementation of policies that aimed to “assert control over space”. (Campkin, Mogilevich, Ross, 2014) After 1994, South Africa experimented with various housing policies and subsidy systems, with a belief that the right to adequate housing is a socio-economic right which is enshrined in the universal declaration of human rights, tha African charter on human rights as well as in the national constitution (SAHRC, n.d., p3).

Despite many years of debate around the role of governments in housing delivery, and despite the constant call for government to be more of an enabler rather than a provider, in South Africa, the state continues to be “at the centre of delivery - either as a developer (for low-income subsidised BNG-type housing), property manager (for about 50000 rental housing units) or as an investor/financier (in the form of social housing) for subsidised housing.” (Kumar, 2018) This condition has led to housing programmes being highly ineffective in actually reducing housing backlogs and has not encouraged other role players to participate in addressing the gaps in the housing market: “The word “delivery” in and of itself captures the relationship between the state and its citizens in the current body politic paradigm: citizens expect services to be delivered and provided on demand, and the social compact between the citizen and state provides the citizen with an illusory access to power, when in fact, waiting for delivery is a disenabling state of being.” (Makeka, 2013, p16)

South Africa, like many African countries is facing massive urbanisation. People are not only moving to urban areas in large numbers, but it is also important to consider that the populations of African countries are also very young and mobile (Muggah, 2018). The infrastructure and housing demands that need to be met to manage this increasing population are daunting. The current sprawl, fragmentation and high levels of informality are apparently extremely expensive for the residents of cities on the continent: “According to the World Bank, African cities are 29% more expensive overall than non-African cities with similar income levels. Locals pay a whopping 100% more for transport, 55% more for housing, 42% more for transport and 35% more for food.” (ibid)

Location remains the key challenge in housing in South Africa to combat the inherited fragmented city conditions and also to develop higher density, compact and mixed residential settings which would help alleviate some of the costs that come with the current sprawl. Indeed, the argument that there is no well-located land for affordable housing has been met with anger. In Cape Town, this anger has led to occupation of some well-located buildings in protest (McCool, 2017).

In 2009, South Africa reviewed housing approaches and found that a shift had not yet been achieved with regards to a change in approach and with regards to delivered housing products and their locations (housing continues to be delivered through top-down decision making and in peripheral locations). (South African Cities Network, 2014, p6-7) Government programmes were expanded to include the Upgrading of Informal Settlements Programme (UISP), which promoted incremental, phased, approaches to informal settlements. (ibid, p7) Other funding instruments such as the Neighbourhood Development Partnership Grant (NDPG) and the Urban Settlements Development Grant (USDG) were intended to facilitate integrated design and development at a local level. (ibid, p7) The significance of these approaches was the shift away from the focus on the individual subsidy, and the individual complete house on a plot, delivered as a full project by a developer, to thinking at the nighbourhood level and considering the house as constantly evolving as opposed to a finished product. While these have been commendable shifts in thinking and policy instruments, they have failed to address demand and housing backlogs continue to rise.

The informal sector is stepping in to fill the housing gaps and provide more affordable and viable housing options. Much of this happens as infill projects and what is referred to as “backyard rentals”: “Urban informality cannot be construed as a problem, but rather an asset and sign of resilience and agility. When exploring innovative financing solutions, the task for city planners and investors is maintaining the virtues of informality (demand responsiveness, job creation and self-sufficiency) while reducing its vices (unsafe conditions, low-quality services, unfair labour practices, and at times inefficiency and high costs for consumers).” (ibid)

Government needs to find a way to harness the benefits of informality, change its role from that of provider to enabler and better use the massive resources which it invests in housing. In order to address the future housing needs in South Africa, and in order to achieve that with dignity, access to opportunity and equity in mind, a major shift in thinking needs to happen. South Africa therefore takes note when housing solutions are found in similar socio-economic contexts globally.

2.0 AREVENA AT THE WORLD CONGRESS ON HOUSING, PRETORIA, 2005

Aravena spoke as a keynote speaker at the 2005 World Congress on Housing which was hosted at the University of Pretoria. At the time, the Quinta Monroy project (2001-2004) had started to create some ripples in the field – an architect engaging differently with urbanism and poverty, generating debate on these topics in a profession that has generally tended to distance itself from the "messiness" of informality and affordable housing in cities. Aravena presented on how a hybrid model of funding was used in the project, subsidies, savings and loans. He explained how the subsidy – which needed to include land, infrastructure and architecture – at the time allowed for 30m2 of built space – which was built with the intention of the users themselves expanding the residential unit to 72m2 after occupation.

This talk came at an opportune time when South Africa's Breaking New Ground policy was just adopted (2004) under Lindiwe Sisulu's leadership of the then newly re-named Department of Human Settlements. The name-change implied a re-focus from "house" to "human settlements", Aravena's explorations into high density urban configurations which still managed to address issues of overcrowding, circulation, light and ventilation as well as allow for future expansion by the residents managed to generate some interest from the audience. These topics had great resonance, especially as the project retained the community on the site and did not remove them to an isolated location.

What Aravena proposed was a set of buildings that managed to create a strong urban presence and spatial definition as well as a method by which to negotiate and manage the relationship between the individual and the collective through built form. Indeed, Elemental focus strongly on the "urban" and perceive "architecture as an artful endeavour... meeting socio-economic challenges"... asking the question "If Chilean architecture is so good, why is social housing so bad." (Franco, 2016).

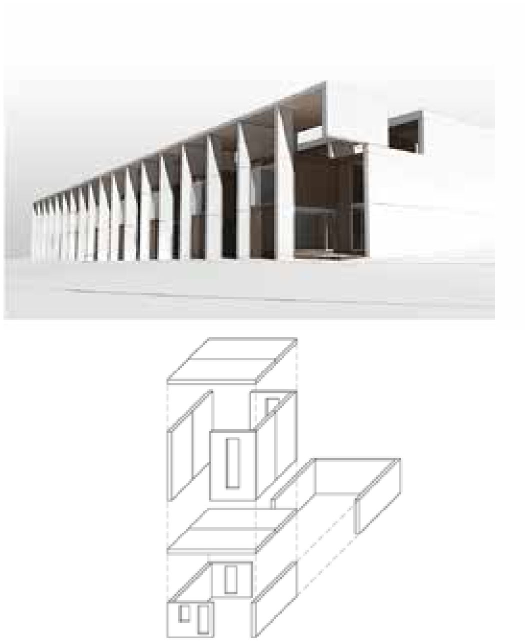
3.0 ARAVENA AND ELEMENTAL SINCE 2005

Since 2005 and the Pretoria Congress, Aravena has been involved in numerous projects, many of them residential, replicating the system devised in earlier projects – delivering an estimated 2500 units, some which have increased in value (5 fold) since construction (Wainwright, 2016). All the projects have similar configurations to the earlier Quinta Monroy project and have a fixed structure delivered upfront and the option for expansion by the residents. While highly replicable, the built form has been adapted to different sites – and one can only imagine that the project process and negotiation and interaction with the various resident bodies and local authorities and clients must have been very diverse. There have been experiments with multi-storey buildings as well as higher quality single family homes.

Some of the principles underpinning the work of the practice were made more evident in the Milano Triennale of 2008, where an Elemental house was installed as 10 prefabricated panels assembled in 24 hours. It was explained that the structure/finishes ratio was inverted so that the structure absorbed almost 80% of the total cost. The focus on replication, repetition of components and chain production was also key to the design concept. The concept of "half a house" implies achieving a smaller house rather that a fully finished house. The finished project has an interesting characteristic where: "half the houses are identical and the other halfs are completely unique." (Zilliacus, 2016) (All information and images below are obtained from http://www.elementalchile.cl, n.d.)


Figures 1 and 2: Monterrey, Mexico 2008 and Paraisopolis, Sao Paolo 2008 (elemental, n.d.)

Figures 3 and 4: Anto Fagasta 2008 and Villa Verda in Constitucion (date?)(Elemental, n.d.)



Figures 5 and 6: Elemental House at Milano Triennale 2008 and En Sully, Geneva 2010 (Elemental, n.d.)

Elemental defines five design conditions for incremental housing. Good location is considered to be the first principle, followed by harmonious growth in time, urban layout, provide enough structure for the final scenario of growth and finally what they call a "middle-class DNA" which aims for a final scenario of 72m2 or four bedrooms. (Elemental, nd) The projects aim for low-rise, high density, without overcrowding and with the built in possibility for expansion.

4.0 ARAVENA AT THE BIENNALE ARCHITECTTURA 2016

Aravena's curating of the Venice Biennale in 2016 was the next key event that further highlighted his approach to the profession. This was an ideal platform for Aravena to demonstrate the ethos which guides his professional practice. Titled, REPORTING FROM THE FRONT, he stated: "We believe that the advancement of architecture is not a goal in itself but a way to improve people's quality of life… Our curatorial proposal is twofold: on the one hand we would like to widen the range of issues to which architecture is expected to respond, adding explicitly to the cultural and artistic dimensions that already belong to our scope, those that are on the social, political, economical and environmental end of the spectrum. On the other hand, we would like to highlight the fact that architecture is called to respond to more than one dimension at the time, integrating a variety of fields instead of choosing one or another." REPORTING FROM THE FRONT aimed to look "for new fields of action, facing issues like segregation, inequalities, peripheries, access to sanitation, natural disasters, housing shortage, migration, informality, crime, traffic, waste, pollution and participation of communities." (Aravena, 2016)

5.0 THE HISTORY AND PRINCIPLES OF INCREMENTAL/EVOLUTIONARY HOUSING AND ELEMENTAL

Habraken has stated how he believes that "dwelling is first and foremost a relationship between people and environment" (Habraken, 2011, p21). The absence of this "natural relationship", as it is referred to by Habraken, in housing projects means that these projects are based on "a chain of guesses" which replaces the "impulsive variation, all everyday inventiveness, all spontaneity, the whole growth of testing and searching for more and better" which would characterise the "natural relationship" between people and environment (ibid, p23). Uniformity thus becomes the symptom of the disruption of this "natural relationship" (ibid, p25) as there is an attempt to "forecast what will happen" ((ibid, p50). Indeed Habraken argues that we should rather "try to make provision for what cannot be foreseen." (ibid, p50)

This exploration of centering people in housing processes has been tackled by numerous people and projects over time. Turner believed it was a problem of definitions of the term housing, as well as a problem of the different value systems that underlie the issue of housing standards. He explained how housing could be a noun, a commodity or product, or a verb, a process or activity. (Turner, 1972, p151) By planning for and providing for people's housing, Turner argues that people are turned into consumers or passive beneficiaries. (ibid, 154)

Kroll has explained the benefits of this approach as follows: " Preliminary participative consultation and later contacts prepare the inhabitants to put down roots more easily, to get to know each other and to discover how to act together upon their environment. In view of this we take trouble to leave space for future extensions and to organise the rules of the architecture (both constructionally and culturally) to encourage such initiative. It is as much the readiness to believe as the readiness to get involved which allows a neighbourhood to regenerate itself by itself, and to develop quickly into a vital urban organ." (Kroll, 1997, p103)

The case for incremental housing was further emphasised by Cities Alliance in 2010 where they presented six arguments for governments to support participatory incremental housing (Wakely, Riley, 2010, p2). They argue that governments do not have the necessary resources to delver complete dwellings while even poor households are able to raise significant savings for investment in housing. This process then also allows governments to focus on what households cannot deliver for themselves – that is the assembly of land and the provision of trunk infrastructure and services. Incremental housing strategies also offer an opportunity to better manage informal housing activity and a means to establish decentralised decision-making and governance structures. From a socio-economic perspective, incrementality is seen to be a catalyst for development, social solidarity and local enterprises. (ibid, pp1-3)

Incremental housing demands a different approach to finance, design and implementation. International precedents demonstrate that initial developments intended as incremental projects have evolved into fully functioning urban settlements, integrated within city contexts – and most importantly, these settlements continue to evolve as the built environment is in constant change and never static. This is an important principal which needs to guide the planning for housing and human settlements.

It can be seen that the elemental approach is rooted in a long history of engagement with the topic of adaptation and change of residential units as well as user participation in the decision-making. Elemental have therefore made a significant contribution towards translating the principles into implemented projects.

6.0 RE-VISITING THE BASIC PRINCIPLES OF OPEN BUILDING AND CONDUCTING A COMPARATIVE ANAYLSIS

The seminal work by Habraken which was first published in 1961 (Habraken, 2011) is referred to in order to extract the key principles which have gone on to constitute the concepts adopted by Open Building practitioners, thinkers and researchers today. These are presented as quotes in a table as are some of the principles of Elemental with comments by the author:

ELEMENTAL PRINCIPLES	HABRAKEN'S PRINCIPLES	AUTHOR COMMENTS
1. a fixed structure delivered upfront; the option for expansion 2. highly replicable; built form can be adapted to different sites 3. structure/finishes ratio inverted; structure absorbs 80% of the total cost	"This does not mean… that our independent dwelling is necessarily a freestanding one… we must find a way to build independent dwellings on top of each other." (p63) "We must make constructions which are not in themselves dwellings or even buildings, but are capable of lifting dwellings above the ground; constructions which contain individual dwellings as a bookcase contains books which can be removed and replaced separately; constructions which take over the task of the ground, which provide building sites up in the air, and are permanent like streets." (p70) "A support structure is quite a different matter from the skeleton construction of a large building… A support structure… is built in the knowledge that we cannot predict what is going to happen to it." (p72)	While the Elemental approach provides a basic structure which can be adapted and expanded by the residents over time, it does not at all study the creation of independent support structures as conceptualised by Habraken. However, some of the qualities of the "half a house" do resemble the envisioned qualities of support structures as the offer a level of permanence, high quality and give structure and spatial and formal identity to the site in question.
4. "half a house" concept; half the houses are identical and the other halfs are completely unique	"…our civilisation is by no means confined to the activities of a number of more or less talented architects… civilisation is first and foremost rooted in everyday actions of ordinary people going about their business." (p13) "…we should not try to forecast what will happen, but try to *make provision for what cannot be foreseen*." (p50) It is "…much more important to understand how a dwelling comes about than what it looks like." (p14)	The Elemental approach makes excellent attempts at leaving some of the decision making to the future residents. It determines and delivers 50% of the design upfront and the rest evolves through the actions of the residents within strict set parameters.
5. harmonious growth in time	"…it is the process which must occupy us, not the architectural problem or production or design questions." (p7) "For is it not impossible to predetermine requirements which can only become apparent through the activity of the individual to be housed?" (p12) "To arrive at better housing we must begin by refusing to separate town and population, for the form of one determines the form of the other, and consequently the form of one cannot exist before that of the other." (p33) "The test of the ability of a town to cope with time lies in its ability to adapt to change, to assimilate the new, to alert part by part, and yet maintain its identity, and to ensure its existence and that of its inhabitants without overly severe shocks."	To some extent, the Elemental approach occupies itself with process rather than product, however, the delivered product (half a house) does not fully explore the potential for maximum adaptability and change as it offers residential units rather than a support structure which would have more capacity for being used in different ways, including, but not restricted to residential units.

	(p41)	
6. a "middle-class DNA"	"…interwoven with human happiness and human dignity…" (p11) "The relationship between man and dwelling, formerly the exclusive privilege of its better situated members, must become a universal right." (p49)	The intentions to restore the "natural relationship" and offer increased choice, dignity and involvement to end users are shared in both approaches.

7.0 THE ELEMENTAL APPROACH TO RESIDENTIAL ARCHITECTURE: IS IT OPEN BUILDING?

Habraken stated that Modernsim failed to acknowledge the complexity and multiple decision-makers and the management of different levels in the built environment (Habraken, 2004). Habraken further illustrates this concept through the study of historical contexts in "The Structure of the Ordinary", emphasising how cities have developed as a "fine-grained living fabric" with no single party controlling the whole and where control is "hierarchically structured". (Habraken, 1998)

The basic principles of Open Building are summarised as follows: "...the way a building is "put together", how buildings are assembled in terms of long- and short- life components and how the interface between building components allows for disassembly, replacement and upgrading with no disruptions to other building systems or components... [it] also implies the interface between building level and urban design level and between spaces within and outside of buildings and how people manage their relationships within the built environment through negotiation, transaction and deal-making." (Osman, 2015).

Could Aravena's approach be considered an Open Building approach? The incremental/evolutionary nature of the Elemental designs allow for increased user involvement through the lifetime of the building – the options of unit growth are quite defined (probably due to the nature of the sites and the higher densities achieved) and not allowing for multiple growth paths or options as the internal layout variation would be quite limited because of the small size of the spaces and the urban settings would also pose some constraints externally.

The process delivers "part of the house" and not the complete house. Yet, these are not necessarily separated into Open Building levels with varying life spans. Aravena asks "which part should one construct?" which implies an engagement with the concept of a primary SUPPORT SYSTEM. There is an awareness that the primary structure needs to have strong urban presence and needs to be of a high quality and robust nature – refer to the Milano experiment and the greater expenditure on the structure. With the Anto Fagasa project, the Elemental website states: "The housing unit is defined by structural 3 floor high partition walls. All complex items (firewall, facilities, circulation and structure) are associated to the wall. This system generates a triple height interior void, in which families can do spatial modifications." ("http://www.elementalchile.cl," n.d.)

Aravena also asks "how can one set the rules of the game" which implies a positive concern with allowing maximum user control within set parameters – thus ensuring that individual actions do not infringe on the collective good. However, it is not implicitly stated that many times users are unknown and that the physical structures would have to allow for unknown clients and needs.

While some Open Building practitioners state that the architectural configuration should allow you to "be the boss behind your own front door" (acknowledgement to Karel Dekker of the Netherlands), in the Elemental case, the facades are also open to adaptation and construction by the residents.

The multiple sources of finance used for the construction are not used to deliver different components (or Open Building levels) of the project based on long and short life elements and the ownership model has not allowed for different forms of ownership (perhaps split into one agency owning the "supports" while the users own the "infill"). Rather the funding has been "put into one pot" as it were – to deliver buildings that are to a great extent "conventional" in that there is no strict system separation between the built environment levels – in Open Building terminology.

"The products of Open Building thinking usually have great "capacity"... think beyond "cosmetic, surface and facade" variation to spatial and functional variation that adds value and quality to the day-to-day experience of users. This also allows for the possibility of cost variation and rental/ownership diversity within the same development – thus avoiding solutions that perpetuate difference between people with diverse income levels..." (Osman, 2015) The Elemental residential experiments most certainly grapple with the concept of "capacity" – perhaps to the extent of "overkill" in the case of the "Make it Right" house they developed for New Orleans which has a massive porch for future expansion by the residents – but as far as is evident, they have not investigated the idea of mixed income, mixed functions or mixed typologies within the same development.

CONCLUSION

Was Aravena's work deserving of the recognition and what can be learnt in South Africa? Is it Open Building?

The work of Elemental and Aravena is most significant. It has brought aspects neglected in mainstream architectural debates to the forefront and while many of the projects are repetitive in solution (housing is in many ways repetitive!) there is no doubt that there were diverse and unique processes behind each project solution and the repetitive structures are devised in such a way to allow for a degree of variation in the long term. South Africa needs to celebrate the Aravena award and to use it as a way to motivate for further experimentation in housing – which is seriously lacking.

The attempt to balance between uniformity and choice in the built environment is an aspect that has great resonance with Open Building thinking and practice, as is the attempt to involve many decision makers in the design and construction process. While many aspects of the Aravena projects are rooted in similar conceptual underpinnings as the Open Building approach, it is believed that deeper engagement with Open Building core principles would have added much value, to an already highly valuable, experiment.

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Information on the Elemental projects as well as the images of projects was downloaded from the Elemental website. Four examples of incremental housing are freely available on the website.

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OPEN BUILDING IN PRACTICE: A COMPARATIVE STUDY OF HOSPITAL DESIGN STRATEGIES FOR FUTURE CHANGE

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ABSTRACT: The Open Building approach, which recognizes different life spans of building elements and distributed decision-making processes, and proposes to design buildings by “system Separation,” can be realized in different design solutions and strategies for future change. While some studies investigate Open Building projects, only a few analyze and compare the implications of the design strategies on the resilience and flexibility of the building. This study documents two hospital buildings that were constructed in recent years in Israel. The Sammy Ofer Heart Center at the Tel Aviv Sourasky Medical Center, and the Joseph Fishman Oncology Hospital & Eyal Ofer Heart Hospital at the Rambam Health Care Campus in Haifa. Both buildings hold a similar medical program of cardiovascular and oncology units, yet their design is significantly different. The Tel Aviv hospital building was designed as a ‘base building’ with a horizontal division of units and shell floors for future completion, while the Haifa hospital building was designed as a cluster with a vertical division of units and a shell structure for future fit-out. This comparative case study analyzes the design strategy of the two buildings and their evolution process over time. The results illustrate the impact of the design strategy on the flexibility of the building to future change and evolvement. The typology of the building defined the affordance to make changes during the design process, construction and occupancy phase. While the Open Building approach was implemented in both projects, the different results demonstrate the greater influence of healthcare policies and infrastructure funding models on the architecture and flexibility of hospitals.

KEYWORDS: Open Building, hospital architecture, design strategy, building typology.

Figure 1: Architectural images of the hospital buildings: (1) The Sammy Ofer Heart Center at the Sourasky Tel Aviv Medical Center, and (2) the Joseph Fishman Oncology Hospital & Eyal Ofer Heart Hospital at the Rambam Health Care Campus in Haifa. Source: (Sharon Architects & Ranni Ziss Architects, 2008; Mochly-Eldar Architects, 2015)

INTRODUCTION

Sustainable healthcare architecture requires a design strategy for change. While hospitals need to be designed for highly specialized functionality they also need to be designed for flexibility to account for the constant and rapid transformations taking place in medicine, technology, and sociology. The Open Building theory addresses the conflict between functionality and flexibility and argues that hospitals should be designed to accommodate a variety of functions in order to gain value over time. The theory, developed initially for housing and later implemented in the healthcare sector, recognizes the different life spans, investment and decision-making processes related to the built environment, and proposes a method of system separation between what is relatively stable and what is relatively changeable. This approach can be realized by different typologies and design strategies for future evolvement and change.

While some studies have investigated the Open Building theory, only a few have documented the impact of the design strategy on the implementation of the theory and how it stand in practice over time. Previous studies have revealed that some hospitals designed to be 'infinitely' flexible and dynamic, based on an approach similar to the Open Building, did not fulfill their original vision (Putievsky Pilosof 2005). Other studies revealed that the Open Building approach of system separation enabled the design of a variety of changing functional spaces, and enhanced the management and coordination of the design process (Putievsky Pilosof and Kalay 2017). This study proposes to explore and compare different design strategies of Open Building in the context of two recently constructed Israeli hospitals.

1.0 OPEN BUILDING FOR HEALTHCARE DESIGN

The Open Building theory distinguishes between levels of intervention in relation to the hierarchical structure of the built environment. This approach is often represented by the terminology of 'base building' and 'fit-out' or 'support' and 'infill'. The theory was developed as a response to the rigidity of a 'whole' design solution, a departure from the conventional functionalist thinking and architectural management practices (Habraken 1972). The recognition that certain "clusters" of building elements have variable life-cycle values led to the definition of three levels of systems: Primary level of the "base building" (structure, envelope, public circulation, and mechanical and supply systems), Secondary level "fit-out" (function, interior walls, service systems), and Tertiary level of FF&E (furniture, fixtures and equipment) (Kendall 2017). The primary level is expected to last 100 years and should be designed to provide capacity for a changing combination of functions. The secondary level in expected to be useful for about 20 years, and the tertiary level, for 5-10 years. Because the life expectancy of each level differs, and control over the different levels is distributed over time among different stakeholders and planners, the decision making process should be sequential rather than an "all-at-once".

2.0 RESEARCH METHODS

In order to explore the Open Building approach in the context of different design strategies for future change, the study compared two hospital buildings in Israel: (1) The Sammy Ofer Heart Center at the Tel Aviv Sourasky Medical Center, and (2) The Joseph Fishman Oncology Hospital & Eyal Ofer Heart Hospital at the Rambam Health Care Campus in Haifa. The study was based on primary data collected from the hospital and the architecture firms, including architectural drawings, programming documents, and reports. The design and construction process was analyzed based on expert interviews including the hospital management, chief architects, project managers, and consultants. Survey information was also obtained by site visits and observations of the buildings construction and performance-during-use from 2005-2018. The study documented, analyzed and compared the two hospitals by seven main categories: (1) the building typology, (2) design strategy, (3) program, (4) funding, (5) design process, (6) construction by phases, and (7) change in practice. The comparison of the hospitals by these categories in the discussion leads to conclusions regarding the impact of each subject on the flexibility of the buildings to change and evolve.

3.0 COMPARATIVE CASE STUDY

3.1. The Sammy Ofer Heart Center, Tel Aviv Sourasky Medical Center

3.1.1 Building typology

The Sammy Ofer Heart Center at Tel Aviv Sourasky Medical Center, designed by Sharon Architects and Ranni Ziss Architects opened in 2011. The building, located in the center of Tel Aviv, was designed as a monolithic cube clad in glass with prominent red recessed balconies (Fig. 1). The building was designed to connect to an adjacent, historical 'Bauhaus' hospital building through an atrium. The 70m (230ft.) high building consists of 55,000 m^2 (592,000 ft^2) and includes thirteen medical floors of 3,100 m^2 (33,300 ft^2) per floor and four underground parking floors designed with the possibility of conversion to an emergency 650-bed hospital. The 15,000 m^2 (161,400 ft^2) underground "sheltered" floors were designed to be resistant to chemical and biological warfare. The building was designed by system separation of three main levels: The primary system which consists of a 7.6m x 7.6m structural grid, central core, distributed MEP shafts, and the building envelope. Secondary system includes the MEP systems and the interior non-loadbearing walls, and the tertiary system consists of the ward equipment, including medical devices and furniture (Fig.2).

3.1.2 Design strategy

The main objective of the Tel Aviv Sourasky Medical Center in the design of the building was to construct the largest structure possible to enlarge the hospital built area for future development. The hospital management decided to maximize the building area and height by applying pressure on the municipality planning guideline limitations. This objective led to a design strategy aimed to build a “container with capacity” for future infill of unknown medical programs. As a result, the building was designed as a base & envelope with seven shell floors for future fit-out completion, implementing the Open Building method of system separation.

3.1.3 Program

The building that was defined and designed as a Heart Center has changed its functional program considerably since it was constructed (Putievsky Pilosof and Kalay 2017). The cardiology division, initially programmed to relocate all the hospital cardiac units, clinics and surgery units, occupies less than 30% of the building on three main floors. After the building opened in 2011, the hospital management decided to relocate their oncology division to the new building in order to centralize the cancer treatment in one location, to enhance hospital efficiency and patient-centered care. The change in plans can be explained by changing needs since cancer became the number one cause of death and statistically surpassed cardiac diseases. Also, the hospital management decided to relocate other functions to the building since their previous locations required renovation or extension, or because they received funds to reconstruct a specific medical unit. Consequently, the building has evolved to include neurology, dermatology, internal medicine, outpatient clinics and research labs (Fig. 3).

3.1.4 Funding

The construction of the Sammy Ofer Heart Center was made possible through the donation of the Sammy Ofer family to the Tel Aviv Sourasky Medical Center in 2005. The private donation supported the construction of the building, including its base & envelope and the fit-out of the cardiology center on floors 0-2. The other medical units that were constructed in the shell floors 3-9, after the building opened in 2011, including the oncology division, were made possible through additional donations made to the hospital by private donors.

3.1.5 Design process

The design process, which began in 2005, reflected a variety of concepts to deal with the tight budgetary, regulatory and environmental constraints. The design team used a method of developing design options and capacity studies to support decision making by the hospital management. The long design process of over thirteen years involved many different professionals and decision makers. Many of the hospital medical managers were replaced, resulting in reconsideration of the design and requests for alternative design options. The development of the project by phases, using system levels, allowed the architects to divide the workload between the two collaborative offices and to control the development of the project by different design teams, project managers and consultants.

3.1.6 Construction by phases

The Sammy Ofer Heart Center was constructed in five main phases: (1) the underground emergency hospital, (2) core and envelope of floors 1-10 including a mechanical roof floor, (3) interior fit-out of floors 0-3, (4) interior fit-out of floors 4-6, and (5) interior fit-out of floors 7-10 (Fig. 3). The phasing stages, divided by the floors in the building, created a process of fit-out from bottom upwards. Although this process of deferred completion of secondary and tertiary systems was planned in advance, it still created a challenge both for the construction and the operation of the running units.

3.1.7 Change in practice

In a study of the evolutionary process of the building in the years 2005-2018, the author documented the changes that were made to the building during the design process, construction phases, and occupancy (Putievsky Pilosof and Kalay 2017). The study illustrates the significant change in medical functions on the upper floors of the building, transforming the Heart Center into a multi-disciplinary medical center including an oncology division, neurology, and other medical programs. The hospital also added two shell floors to the building just before construction began, which required redesigning the buildings’ primary system including the structure, MEP systems, and facades and caused a delay of a few months in the design and construction process. Most of the changes were made upon completion of the secondary and tertiary levels, while the primary level was changed only before the construction of phase 1 (Fig.3).

Figure 2: Architectural drawings of the hospital buildings illustrating the division to two units per floor: (1) The Sammy Ofer Heart Center at the Sourasky Tel Aviv Medical Center, and (2) the Joseph Fishman Oncology Hospital & Eyal Ofer Heart Hospital at the Rambam Health Care Campus in Haifa. Source: (Sharon Architects & Ranni Ziss Architects, 2008; Mochly-Eldar Architects, 2018)

3.2. The Joseph Fishman Oncology Hospital & the Eyal Ofer Heart Hospital, Rambam Health Care Campus in Haifa

3.2.1 Building typology

The Joseph Fishman Oncology Hospital & the Eyal Ofer heart Hospital at Rambam Health Care Campus in Haifa were designed by Mochly-Eldar Architects. The building was designed as a cluster of two connected structures, while in fact, it is one structure with two separate medical centers (Fig. 1). The two centers, divided vertically, were designed and constructed in separate phases. The Joseph Fishman Oncology Hospital was opened in 2016, and the Eyal Ofer Heart Hospital is still under construction in 2018. The building consists of 24,000 m^2 (258,300 ft^2) and includes eight medical floors of 2,500 m^2 (26,900 ft^2) per floor, and three underground floors with four linear accelerators for radiation therapy, part of Rambam's' underground fortified emergency 2000-bed hospital.

3.2.2 Design strategy

The design strategy of the building evolved from the west-campus development plan that specified the possibility to build only one building on the hospital site. The hospital urgent needs to develop two new medical centers: one for cancer and one for heart treatment, led to the decision to locate both of them in the same building. The vertical division of the building was an attempt to create an image of two separate buildings to attract different donors to finance the project. The administration explains that most donors want their name on a tower in honor of their donation. Consequently, the management even insisted on creating two separate entrances, but the architect managed to convince them otherwise due to lack of space, and designed one main entrance leading into two separate lobbies with separate circulation systems. To support the construction of diverse medical programs, the architects implemented the Open Building method of system separation. Reflecting on the design process, the project manager stated that the main challenge was to design the primary system to support the secondary and tertiary systems of different functions on each floor, including hospitalization rooms, outpatient clinics, and research labs (Brumberg 2015).

3.2.3 Program

The two centers were programmed separately in different periods of the project. The Joseph Fishman Oncology Hospital was designed to offer comprehensive cancer treatments, including linear accelerated chemotherapy, radiotherapy, and brachytherapy, complementary medicine, and outreach programs for prevention and early detection of cancer. The Eyal Ofer Heart Hospital was programmed to consolidate all cardiovascular diagnoses, treatments, research, and disease risk-reduction programs, including cardiac and vascular surgery, interventional cardiology, electrophysiology, advanced cardiovascular imaging, and cardiac intensive care (Fig. 4). The main concept of the two programs was to create a central division to implement integrated medical care models and to enhance patient-centered care.

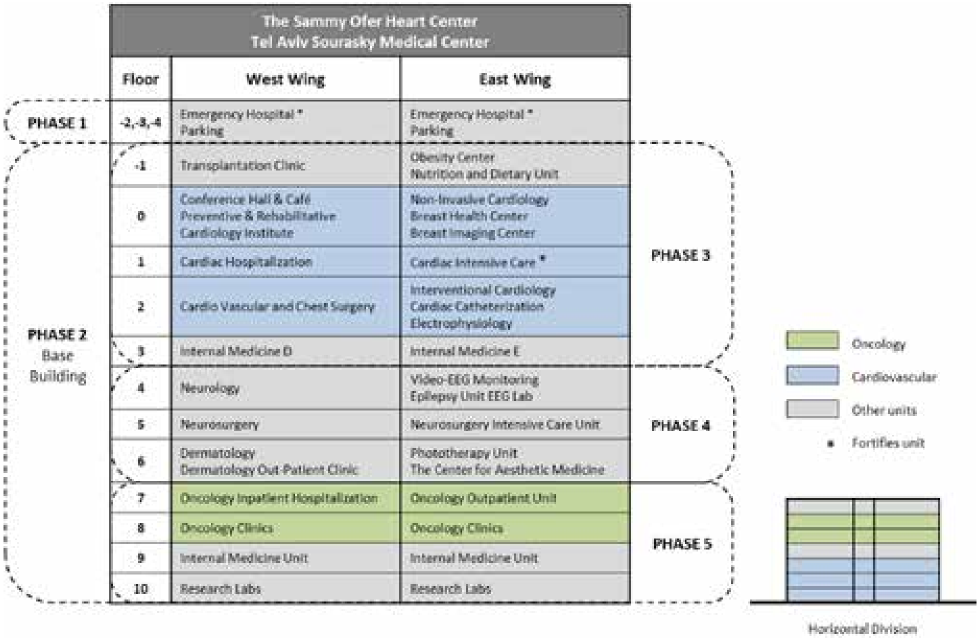

Figure 3: Diagram of the Sammy Ofer Heart Center in Tel Aviv Sourasky Medical Center illustrating the medical units on each floor and wing, location of fortifies units, and the phases of construction, with a schematic diagram of conceptual horizontal division. Source: (The author, 2018)

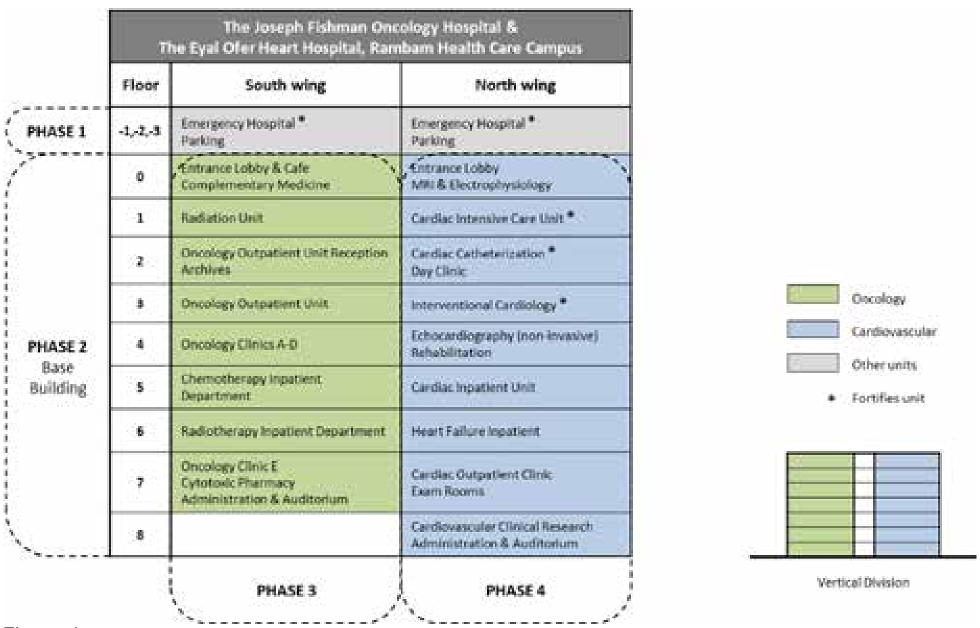

Figure 4: Diagram of the Joseph Fishman Oncology Hospital & Eyal Ofer Heart Hospital at the Rambam Health Care Campus in Haifa illustrating the medical units on each floor and wing, location of fortifies units, and the phases of construction, with a schematic diagram of conceptual vertical division. Source: (The author, 2018)

3.2.4 Funding

The construction of the building was made possible through two significant donations. The first donation of Joseph Fishman and his family supported the construction of the oncology center. To maximize the donation, the hospital decided to construct the complete base building including both south and north wings, in addition to the construction of the envelope and interior of the oncology center on the south wing. The donation of Eyal Ofer and his family, years later, supported the realization of the cardiovascular center on the north wing of the building including its exterior façade and interior units. The hospital continues to seek additional funds to finance the completion of all the medical units and to purchase new equipment. For example, two floors of radiotherapy were completed by additional fundraising in 2016, after the oncology center had already opened.

3.2.5 Design process

The conceptual division of the building lead to two separate design processes for the oncology center, and years later, for the cardiovascular center. The two design teams, which included different architects, hospital managers, and consultants, worked in different periods of time and schedules. The conceptual division is apparent even in the architect's presentations and drawings, graphically illustrating the building as two separate projects. The design process took over eight years and dealt with many limitations and constraints. The underground, sheltered hospital that was constructed five years earlier restricted the design of the structure, the location of the core, columns, and shafts. Also, the decision to build the complete base building at an early phase, years before there was even a program for the cardiology center on the north wing, challenged the team to decide where to locate the cardiac units that needed to be fortified according to the Israeli civil defense unit. This decision had massive implications on the design of the base building and the cardiovascular center. Previous research also demonstrated that fortified structures restrict the units' future potential to expand, change function or move to other locations (Putievsky Pilosof and Kalay 2017).

3.2.6 Construction by phases

The Joseph Fishman Oncology Hospital & The Eyal Ofer Heart Hospital were constructed in five main phases: (1) the underground emergency hospital, (2) base building including the two wings, (3) completion of the south wing including its envelope and interior fit-out of floors 0-7 of the oncology center, (4) completion of the north wing including fortifying the structure of the 3rd floor, construction of an additional 8th floor, and interior fit-out of floors 0-8 of the cardiovascular center (Fig. 4). The construction phases, divided mostly by the buildings' wings, created a process of vertical evolution. Although this process caused fewer interruptions in the operation of the running units, it affected the image of the building. When the oncology center on the south wing opened in 2016, the north wing was still a construction site with only a concrete core structure.

3.2.7 Change in practice

The changes made to the building during the design process, construction phases, and occupancy were primarily a result of the design strategy to divide the building vertically into two units. The changes included modifications in the cardiovascular program to fit into the structures' limitations, as the base structure of the north wing was already constructed. To fit the extended program of the oncology division, the hospital management decided to build an additional 8th floor on top of the existing north wing structure and to fortify the 3rd floor to include another interventional cardiology unit. The hospital management also changed the program of the oncology center during phase 3 to add an outpatient clinic on the 7th floor of the south wing for future needs.

4.0 DISCUSSION

The two hospital buildings have a very similar typology, program, and vision. Both buildings were constructed in 2011-2018 in Israel by local architecture firms. They have a similar architectural configuration, scale, and style (Fig. 1 & 2). Both hospitals accommodate similar medical programs of oncology and cardiovascular care and provide service as part of the Israeli health system, dealing with similar challenges of health policies and demands. Both projects were designed by a multidisciplinary team and were realized through private donations of funds raised by the hospital. The two projects had a long design process and were constructed in phases, supported by the Open Building method of system separation. Despite these similarities, they significantly differ in their design strategy for evolutionary development and change. The Tel Aviv hospital building was designed for horizontally oriented development, and the Haifa hospital building was designed for vertically oriented development.

The difference in the design strategy – horizontal vs. vertical evolution – had a major impact on the design of the buildings, their design process, phases of construction, funding models, and change over time. The horizontal strategy led to the design of a monolithic cube with interior shell floors for future infill of functions, and the vertical strategy led to a cluster of two structures with separate functions and images. Each strategy caused limitations to the design and use of the building. The horizontal strategy defined a process of fit-out from the bottom upwards, challenging the operation of running units in the building. The vertical strategy resulted in fewer interruptions, but maintained an exterior image of a construction site. The horizontal strategy also created a challenge of placing similar medical functions on adjacent floors, while the vertical strategy limited the options of placing collaborative medical functions on the same level to enhance efficiency, orientation, and flexibility of use. For example, the registration of the oncology outpatients unit is located on the 2nd floor while the treatment units are on the 3rd floor, resulting in staff inefficiency and confusion for the patients.

The design strategies had an impact on the flexibility of the building to change and evolve. Both strategies limited the buildings option to grow and expand. Their exterior form was determined in advance leaving only shell spaces for future completion that were all occupied in a few years. The limitations of the building area demanded compromises on the building program. For example, neither hospital included the hematology department with the oncology division even though the building was programmed as a comprehensive cancer center. One of the greatest limitations of the vertical strategy, according to its architect, is the deterministic size of the units within each wing. The horizontal strategy, on the contrary, enabled changes of unit's sizes and forms. Accordingly, the only area in the Haifa building that connects the two wings behind the service core became a space for negotiation between the oncology and the cardiology units on the same floor, to share and use during different hours. This finding indicates how inner-politics between division and medical specialties influence the design and the use of the building.

While the horizontal strategy supported a significant change in its medical programs, the vertical strategy limited the building potential to change its medical programs to only oncology and cardiovascular units. This limitation is significant since researchers predict that new technologies of personalized and precision medicine will improve cancer treatment protocols and have a substantial impact on occupancy rates of future patients. Such changes were disregarded in the program and the design of the buildings. Another missed opportunity was the option to plan for change in the connections between different medical units as new models of care are developed to treat multi-morbid patients. For example, cardio-oncology is an emerging medical specialty that focuses attention on preventing heart damage caused by cancer treatments, such as radiation therapy and certain chemotherapy drugs that carry a risk of hypertension and bold clots (Herrmann et al. 2014). This new model of medicine is not supported by the hospitals, although they both integrate cardiology and oncology in the same building. The program and the design of the buildings focused on separating and distinguishing the two medical specialties, for economic and policy reasons, and missed an opportunity to engage a collaborative effort to advance patient care.

The architectural image of the two buildings represents the design strategy approach to the Open Building concept. The monolithic cube in the Tel Aviv hospital was designed to express its flexibility to enable changing functions by not revealing its interior use. The conscious decision to complete the exterior glass façade at an early phase while the interior was still under construction reflects the motivation to create an illusion of a complete "whole building." The cluster of the buildings in the Haifa hospital is similar. The building was designed to emphasize the separation of the two medical centers as two complete buildings. The fact that the northern wing of the cardiovascular center was left as a base building with no exterior cladding for a few years was only due to lack of funds, with no intent to represent the flexibility of the architecture. Furthermore, the Haifa hospital exterior was designed to distinguish certain functional floors, such as the top floor of the oncology center that was designed for research labs. The floor program later changed to an additional outpatient clinic, but the exterior accentuated design remained.

5.0 CONCLUSIONS

The results illustrate the impact of two design strategies, horizontal oriented evolution vs. vertically oriented evolution on the form, function, and use of the buildings. The result demonstrates how each design strategy defined the affordance to make changes during the design process, construction and occupancy phases. While the Open Building approach was implemented in both projects, the different results demonstrate the greater influence of organization policies and funding models on the architecture and flexibility of the projects.

The Open Building approach of system separation and distributed design management is evident in both projects. Although the approach was not explicitly stated by anyone in the design process, its methods implicitly supported the construction of the projects in phases, enabled changes in different phases, and enhanced the coordination of various consultants, designers, and contractors during the long design processes. While system separation was used in both projects, the reason for its implementation was different. The Haifa hospital used it only as a method for gaining financial support and subsequently phasing the construction and the fit-out of the two wings. This approach is evident in the unsystematic configuration of the MEP shafts that were located according to the specific needs of each unit with superposition between the floors, without consideration of future changing needs. The Tel Aviv hospital also used it as a method for phasing the project, but the primary purpose was to defer the decision on the uses of seven of its eleven floors for later consideration. The need to design shell floors for an unknown function led to the configuration of a systematic structural grid of columns and MEP shafts. This finding is also evident in the architects' reflection on their designs. In the vision of the architect of the Tel Aviv hospital, the building was designed to be flexible and to provide optimal space for future advances in medicine (Sharon

2012), while the architect of the Haifa hospital declared that his design was not designated for future change. He explained that the limitation of the site, the hospital requirement to design the building as two separate buildings and the extended program demanded that they create a “tailor-made” solution.

The study demonstrated how the hospital's evolutionary plans were driven by forces of economics as well as internal and external organizational politics. As most hospitals in Israel are in need to find immediate solutions for their inadequate infrastructures in the face of growing demands and advances in medical technology, hospital directors attempt to maximize the potential for financial support. The dependency of hospitals on private donations to initiate the design process and construction of new buildings has significant implications. In the case of the Tel Aviv Sourasky Medical Center, it was clear from the start that the hospital would construct the largest structure possible to maximize the donation. In the case of Rambam Health Care Campus in Haifa, the hospital management supported the request of the donor to name an oncology tower, leaving the cardiovascular center that was designated to be located at the same building for future financial support. These policy decisions defined the design strategy of the two buildings and resulted in many limitations, not only in the planning and design of the new projects, but also in the potential of the hospital to change and evolve over time. Eventually, it even affected the medical care models of the hospitals.

This study compared two hospital buildings with different design strategies. Further work is needed to evaluate other design strategies and building typologies. The study also documented changes over the last thirteen years during the design process, construction and occupancy phases of the two hospitals. While this time frame is significant, further work is needed to evaluate healthcare facilities over their full life-cycle period. Further research on healthcare facilities’ change over time from different environmental, cultural and economic context will enhance the knowledge base needed for the successful design of sustainable healthcare architecture.

5.0 ACKNOWLEDGMENTS

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A METHODOLOGY FOR QUANTIFYING ADAPTABILITY OF BUILDINGS USING AN ANALYTIC HIERARCHY PROCESS

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ABSTRACT: While adaptable building design is an area of increasing interest, there is a dearth of published empirical evidence regarding which physical characteristics of buildings are most effective at facilitating adaptation. This paper outlines a methodology for identifying physical characteristics that facilitate or impede adaptability; the methodology uses expert elicitation (survey) to empirically measure the "adaptability" of different buildings. The survey asks about hypothetical adaptations to buildings on the Clemson University campus. Participants are presented with a series of pairwise comparisons of buildings and asked to rate the relative attractiveness of the buildings for the hypothetical adaptation projects. They are also asked to compare the buildings based on the relative presence of general adaptability strategies (such as *long life* and *loose fit*) in their designs. Four case study buildings, resulting in six pairwise comparisons, are utilized. In this manner, expert evaluations are grounded in real-life buildings with the intention of producing meaningful results. An analytic hierarchy process (AHP) is used to formulate the survey, process the data, and determine quantitative rankings of adaptability. Results of the study (forthcoming) will be used to confirm the efficacy of design strategies recommended by other authors, and to provide quantitative comparisons on the effectiveness of these strategies on adaptability.

KEYWORDS: adaptability, flexibility, AHP, resilience, expert elicitation

INTRODUCTION

"A building is not something you finish. A building is something you start." This pithy line from Stuart Brand sums up the thesis of his seminal work on building adaptability, *How Buildings Learn* (Brand 1995). As technology, politics, business, and user demands are changing ever more rapidly, it is becoming more and more apparent that for our buildings to remain relevant they must be able to adapt to new circumstances. In recent years, organizations and researchers have developed design-for-adaptability (DfA) guides that present strategies for making new building designs more adaptable (Schmidt and Austin 2016; Kestner et al. 2010). However, there is a lack of empirical data demonstrating how effectively these strategies create more adaptable buildings. What's more, a consistent theme in recent technical literature on the topic has been the need for methods to measure the adaptability in new designs (Rockow et al. 2018; Heidrich et al. 2017).

The current paper presents a new methodology for ranking adaptable designs and ranking the relative effectiveness of different DfA strategies. The methodology uses expert elicitation and an analytic hierarchy process (AHP) and is a jumping-off point for future quantification of adaptability in buildings.

As research in sustainable building design has increased and matured, the issue of embodied energy has emerged as a primary consideration. Buildings are often demolished well before the end of their physical lifespans, leading to waste of embodied energy (O'Connor 2004). This end-of-life waste can even outweigh lifetime energy savings produced by efficient systems and design (Wilkinson and Langston 2014). Therefore, sustainable building designs must consider not only the immediate future of the building, but the eventuality of the building becoming obsolete. Fig. 1 shows the life cycle of a typical building (Rockow et al. 2018). As the building ages, it eventually ceases to meet user needs and is either demolished or adapted. This study focuses on the "Initial Design" stage of the life cycle; the objective is to quantify the impact of initial design decisions on future adaptability. In other words, can design features included at the outset lead to an increased likelihood of later adaptation? If so, which ones, and to what extent? To address these questions, the proposed methodology has been developed to exclude contextual (e.g. social, political, historical) factors and focuses solely on design features. Though physical features are not always what precipitate the decision to adapt or demolish a building, they are the only aspect of the building that can be influenced by the designers. Other studies have performed surveys and developed tools for measuring the adaptability in general (Geraedts 2016; Conejos et al. 2013), but this study is distinct in that it focuses solely on physical features.

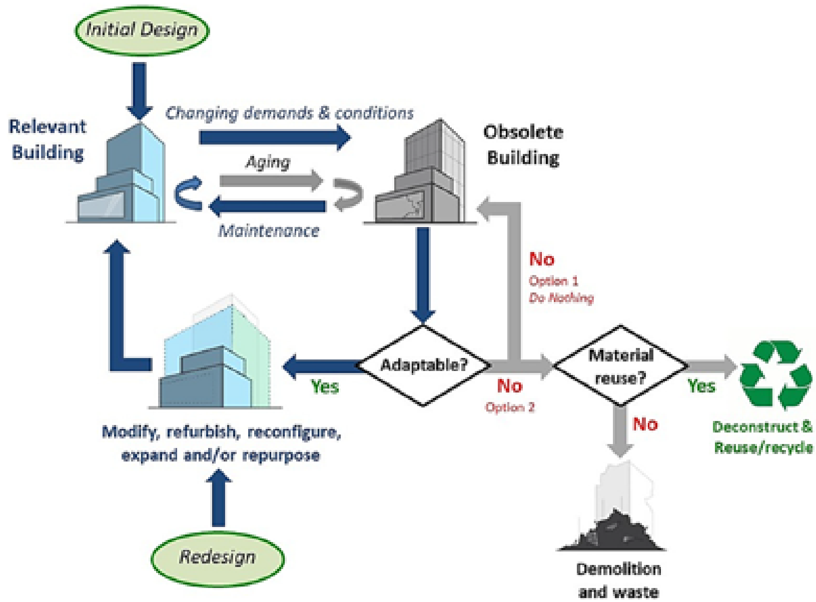

Figure 1: Building life cycle (Rockow et al. 2018).

At time of writing, the proposed methodology is being deployed. Experts are rating the importance of four dimensions of adaptable building design: *long life*, *loose fit*, *simplicity*, and *layer separation*. They are also judging the adaptability of case study buildings through pairwise comparisons. These responses will be aggregated to "score" the adaptability of different buildings. This paper describes the methodology being used to obtain these scores.

1.0. BACKGROUND

1.1. Definition of terms used in the current paper

Definitions must be clarified for *adaptability* and *adaptation*. According to Dolnick and Davidson, a building *adaptation* is a rehabilitation or renovation of an existing building or structure for any uses other than the present ones (1999). *Adaptability* is the ease with which buildings can be physically modified, deconstructed, refurbished, reconfigured, or repurposed (Ross et al. 2016). In this paper, an *adaptation* is a significant change to a building's space plan, envelope, services, or structure, beyond an aesthetic update or rearrangement of furnishings. Specifically, this paper focuses on *design-based* adaptability, which refers to that adaptability that is due to the physical design of the building. Contextual features such as market demand, social issues, and historical status are not a part of design-based adaptability. According to Ross et al. (2016), design-based strategies are "aspects of a design that can be manipulated to increase the potential for adaptability". There are numerous physical characteristics that can influence adaptability. For this study these characteristics have been condensed into four general dimensions: *long life*, *loose fit*, *simplicity*, and *layer separation*. These dimensions are defined below and are included in the instructions given to experts participating in the study.

- *Long life*: The usable lifetime of a building can be extended through overdesigning the structure, using durable and high-quality materials, and through designs that slow the physical aging of a building (Ross 2017).
- *Loose fit* refers to openness in the floor plan and building section, and the ability of space to perform multiple functions with minimal adaptation (Council on Open Building 2018).
- In individual systems and buildings as wholes, *simplicity* indicates the use of regular, repetitive, easily understood parts or spaces with minimized unique conditions (Ross 2017).
- *Layer separation* is the physical and functional separation of building layers (i.e. space plan, envelope, structure, services) such that one can be modified or removed with minimized effect on other layers (Brand 1995).

1.2. Previous work in quantifying the adaptability of buildings

As previously mentioned, quantifying the adaptability of buildings has been an area of increasing interest to many researchers. A few of the most relevant works are reviewed here. A more comprehensive review of methods for modeling and measuring adaptability can be found in Rockow et al. (2018).

Ross et. al. identified eleven design-based “enablers,” or strategies, for creating adaptable building designs (2016). Experts were asked to rate these enablers according to their relative importance in determining the adaptive potential of buildings. In a later paper, Ross sorted the eleven enablers into four general adaptability dimensions: *long life*, *loose fit*, *layer separation*, and *reduce uncertainty* (2017). These dimensions were used in the Learning Buildings Framework (LBF), a tool for calculating an adaptability score based on the physical features of a building. The current paper’s four dimensions are similar; however, the current paper omits *reduce uncertainty* and adds *simplicity*. A future work will compare results from the methodology in the current paper to scores from the LBF (Becker 2019).

Another rating tool, FLEX 4.0, developed by Geraedts, was designed to assess the adaptive capacity of buildings based solely on physical features, or flexibility key performance indicators (FKPIs) (2016). Geraedts identified 44 FKPIs. The tool utilizes default weighting factors for the FKPIs, or the user can alternatively assign their own weighting factors.

Based on previous work, the proposed methodology will feature four dimensions of adaptability. The dimensions chosen (*long life, loose fit, simplicity,* and *layer separation*) are broad enough that the more specific DfA strategies found in literature fall into one or more of the dimensions. Thus, any aspect of a building’s physical design can be sorted into one of those dimensions. The authors chose to focus on four general dimensions rather than more specific aspects in order to make the survey manageable for participants.

1.3. AHP and previous uses in building design studies

This study will use an AHP-based survey of building design professionals. The analytic hierarchy process (AHP) is a decision-making tool that was developed by Saaty (Saaty and Alexander 1981). AHP simplifies complex decisions by decomposing them into a hierarchy of pairwise comparisons between alternatives and between criteria. The first step is to identify criteria and develop a criteria importance weighting vector through pairwise comparisons. Second, the alternatives are compared on the basis of each criterion. The results of these two steps produce a final weighting vector for the alternatives, giving the relative attractiveness of each alternative based on the presence of the criteria. AHP is commonly used for group decision-making because group members’ answers can be aggregated (Saaty 2008). The proposed methodology uses AHP to calculate the building adaptability scores in two ways; these processes are explained in detail in the next section.

Though AHP has not been used previously to study building adaptability specifically, AHP has been implemented in other aspects of building design. Alwaer and Clements-Croome used AHP and expert elicitation to develop a model for rating the level of sustainability in sustainable intelligent buildings (2010). Wong and Li used an AHP and expert surveys to investigate the relative importance of selection criteria that are judged when designing intelligent building systems (2008). Bhatt and Macwan surveyed experts in India using an AHP-based questionnaire to determine which sustainability parameters were most important for buildings (2011).

The three studies described above each had experts complete an AHP-based survey and then used the results to develop importance weightings for certain parameters. This is similar to the current study’s objective to use expert elicitation and AHP to develop rankings of the importance of physical factors that contribute to adaptability.

2.0. PROPOSED METHODOLOGY

In summary, critical information from four buildings was condensed into case study packets, which are reviewed by experts prior to their taking of the survey. The experts use that information to complete a 102-question survey in which they are asked to perform pairwise comparisons of the buildings (thus, performing six comparisons among four buildings). For each comparison, the experts answer twelve questions about potential adaption projects, and four questions about the presence of the four dimensions of adaptable design in each building. Finally, the experts are asked to rate the relative importance of the four dimensions. Each question is answered using a simple point-assigning system to express the level of the expert’s preference for one option over the other. Once the survey data are collected, a two-part AHP will be used to calculate relative adaptability weightings for the buildings and dimensions.

2.1. Case studies

The researchers chose four buildings on Clemson University's campus for the case studies. Each case study summarized the building's physical features in a 10-15 page document. A summary table of the building features can be seen in Fig. 2. Below is listed the rationale used for selecting buildings for the study.

- All buildings were of a similar size (i.e. floor area).
- All buildings were low rise.
- All buildings were built within the last thirty years.
- Buildings had varying current uses, including: art/architecture studio building, student center, dormitory building, and office/classroom building. This was done purposefully to provide different original building designs for the experts to compare.
- Buildings have varying structural systems, footprint shapes, and envelope materials. Again, this was done purposefully so that no two buildings were too similar in their physical aspects.

Figure 2: Summary of case study buildings.

2.2. Survey questions

A purpose-made spreadsheet was created for survey completion by participants and for AHP analysis. The survey questions were written in accordance with questionnaire design guidelines by Brace (2008). On the participant side, the spreadsheet has seven pages; one page for rating the importance of the dimensions, and one page for each pairwise comparison between the buildings. The pairwise comparison pages are all duplicates of each other except that each page compared different pairs of buildings (A vs. B, B vs. C, etc.). The survey asks twelve "adaptation scenario" questions and four "dimension" questions per pairwise comparison (examples below). These questions are identical between the six comparisons.

Example adaptation scenario question: Which building is most suitable for conversion into office space?

Example dimension question: Relative to one another, to what extent does each building exhibit long life?

All questions, regardless of type, use the same answer format. Participants are prompted to distribute eleven points between the two given options; higher point values indicate that an option is preferred for the question at hand.

2.3. Recruiting experts

At the time of writing this paper, fifteen experts have been engaged in the study. The target is to have participation across various disciplines in the design and construction industry. The following numbers are used as approximate recruitment targets: six architects, three structural engineers, three façade engineers, three mechanical engineers, two electrical engineers, two geotechnical engineers, and three project managers, for a total of twenty-two participants.

2.4. AHP design

The analysis used in this methodology contains multiple steps, some of which are parallel. One strength of the proposed method is that it produces results that can be used to crosscheck each other. Broadly speaking, the experiment seeks to answer the question, "Which case study buildings are most adaptable?" This question is answered using two different parts and is based on aggregate responses of the experts. The explanations below go in order of the steps required in analysis, not in order of the appearance of questions in the survey tool itself. The rating vector calculation method used in this paper is recommended by Saaty and Hu (1998) for accurate results.

2.4.1. Part 1

Part 1 functions as a typical AHP. First, the expert performs pairwise comparisons between the buildings, comparing the relative presence of each dimension. Take for example the expert comparison of "long life" in buildings A and C. Building A receives 3 points and C receives 8 points, indicating that the expert believes that C exhibits significantly more "long life" than A. The expert repeats this for all building combinations, and their numerical responses populate a "building comparison matrix" (Fig. 3, left). (Note the 3/8 value at the intersection of "Bldg A" and "Bldg C," corresponding to the expert's scoring. Also note that the diagonal of the matrix is made up of 1's because there, the buildings are compared to themselves. Values on either side of the diagonal are mirrored because they represent the same comparison, only done in the opposite order, e.g. "A vs. C" and "C vs. A.") A *dimension presence vector* for each dimension is calculated via matrix math, expressing the relative presence of that dimension in each building (Fig. 3, right). In this example, building D exhibits the most "long life" with a presence rating of 0.38, which is approximately three times as much as Building B, which is rated at 0.12.

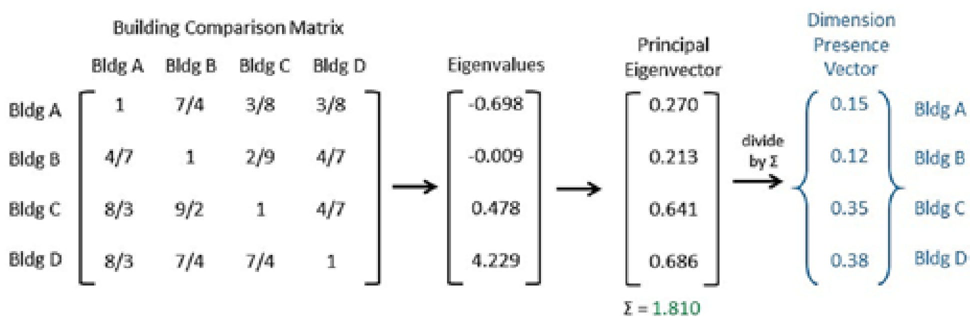

Figure 3: Calculation of dimension presence vector for "long life" (Part 1 of method).

The four *dimension presence vectors* are assembled into the *dimension presence matrix* (Fig. 4, left). Then, the expert performs pairwise comparisons between the dimensions themselves, rating the relative importance of each dimension to adaptability. For example, the expert compares "long life" to "loose fit" and gives each a score, and so on, until they have compared all four dimensions to each other. The procedure for this step is exactly like that used in Fig. 3, except dimensions are being compared, not buildings, and the result is a *dimension rating vector* (Fig. 4, center). Finally, the matrix and vector are multiplied to produce an *adaptability rating vector* (Fig. 4, right). This expresses the relative adaptability of each building. In this example, building C at 0.309 is the most adaptable. Building C is approximately twice as adaptable as building B, which has a score of 0.143. These numbers are hypothetical and are used as an example; they will be replaced by expert responses for the study.

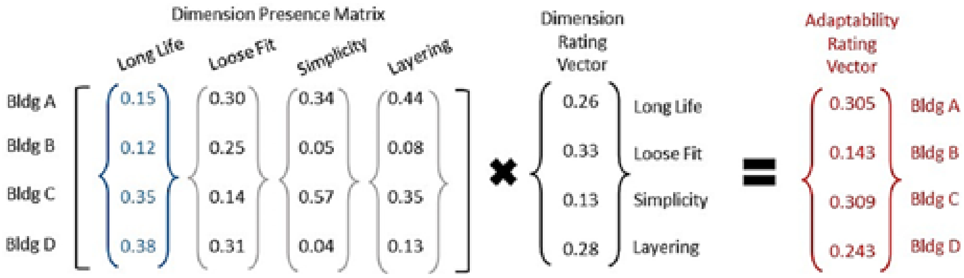

Figure 4: Calculation of adaptability rating vector (Part 1 of method).

2.4.2. Part 2

The end result of Part 2 is also an *adaptability rating vector*. However, in Part 2 adaptability is not computed based on dimension presence and importance but is generalized from a range of questions addressing hypothetical adaptation scenarios for the buildings. First, the expert performs pairwise comparisons between the buildings, like in Part 1. However, this time, the buildings are compared based on their relative attractiveness for a given adaptation scenario. For example, the expert compares all four buildings based on the question, "Which building is more suitable for conversion into office space?" The pairwise comparisons populate a *relative adaptability matrix* (Fig. 5, left), from which a *specific adaptability rating vector* is computed (Fig. 5, right), which give the relative score for each building.

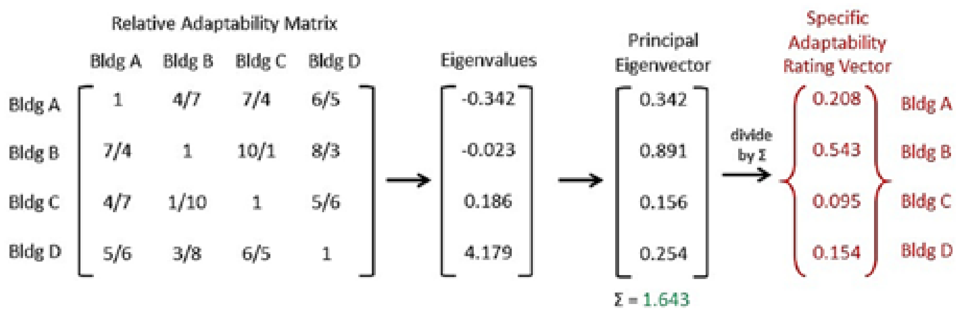

Figure 5: Calculation of specific adaptability rating vector (Part 2).

One specific adaptability rating is calculated for each scenario. In order to make the final adaptability ratings generalizable across all facets of adaptability, the expert is asked the make the same pairwise comparisons based on twelve adaptation scenarios, addressing changes to the structure, envelope, foundation, space plan, and services (Brand 1995). The twelve *specific adaptability rating vectors* are aggregated to produce a final *adaptability rating vector* that expresses the buildings' relative general adaptability, according to that expert.

Because the twelve adaptation scenarios address various aspects of building design, a given expert may not have the experience and/or expertise to answer each question with confidence. To account for this, each adaptation scenario question is followed by a request for the expert to rate their confidence in their answer, and their answers will be weighted accordingly. Also, for all calculations based on the experts' pairwise comparisons, a consistency ratio is calculated (Saaty and Alexander 1981) to check that the experts' answers within each pairwise comparison are internally consistent. If inconsistency is detected, the researchers will contact the expert to clarify their answers.

2.4.3. Comparison between results of Parts 1 and 2

For each individual expert, both parts produce an *adaptability rating vector* that, theoretically, represents the overall relative adaptability of each building. The vectors from both parts will be compared to observe whether both methods lead to similar results for the same expert. Next are listed some possible conclusions that may be drawn based on observed similarities or differences between the vectors.

If one expert's two final rating vectors have similar values: The expert's judgments about the relative importance of the four dimensions of design-based adaptability are consistent with their judgments about adaptability in real-life scenarios. This is evidence that the experimental method reliably determines which dimensions most affect the expert's decision-making.

If one expert's two final rating vectors have dissimilar values: The expert's judgments about the relative importance of the four dimensions are not consistent with their judgments about adaptability in real-life scenarios. This means that one or both of the methods may not accurately reflect the reasons behind the expert's decisions in adaptation scenarios. One possibility is that questions for Part 1 are too theoretical and do not reflect the opinions behind the expert's scenario-based responses to Part 2. Another is that the adaptation scenario questions may be too specific and, together, are too limited to reflect the full scope of possible adaptation projects.

2.4.4. Group comparisons

The analysis described earlier in the paper is completed for each expert individually. Then, following established methods, the experts' results will be aggregated (Ossadnik et al. 2016; Forman and Peniwati 1998). The data can be aggregated and compared in multiple ways; results can be compared by individual, by expert group, or can all be aggregated together. The consistency of the results can be compared within expert types and across all the experts to observe whether the methodology produces consistent results, and to judge whether it is feasible to obtain objective judgments of a building's adaptability from expert elicitation.

CONCLUSION AND NEXT STEPS

The methodology presented in this paper uses AHP to answer the question: "What physical design features lead to adaptable buildings?" The method uses expert elicitation to derive ratings for: the adaptability of building case studies, and: the relative importance of the four major dimensions of adaptable design features. At the time of writing, the survey instrument and analysis method have been developed by the researchers, and initial surveys are underway.

Once sufficient responses have been collected, the researchers will perform the AHP analysis to obtain weightings for the four case studies and the four adaptability dimensions. These weightings will be compared to adaptability scoring systems from other literature (Ross 2017; Geraedts 2016; Conejos et al. 2013). Following the US-based study, the researchers aim to expand the survey to include international professionals whereby commonalities and differences between views on adaptability can be evaluated.

ACKNOWLEDGEMENTS

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TOWARDS AN ADAPTABLE ARCHITECTURE

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ABSTRACT:
What is an open building? Does the term 'open' is only related to the particularity that its interior can change in time? Are these buildings with rigid skeletons that allow some kind of variability in their interior? Could it be that the term 'open' (adaptable) can also transcend all areas and then buildings become organisms, as if they were living beings, which can be totally transformed according to the needs of its inhabitants and the conditions of their environment? This work gathers a research and application experience in relation to these concerns, through a couple of invention patents, some writings and a professional practice of the author.

This article reflects on the way in which we build our habitat on the planet and makes an appeal about important aspects the author considers convenient for our days, such as lightness, adaptability and sustainability in construction. The way in which these three themes are addressed, is through reflections and examples that the history of architecture teaches us in different places of the planet, and at different times. Finally, the author shows these principles applied to his own professional practice through some architectural designs and built works.

KEYWORDS: Lightness, adaptability, sustainability.

INTRODUCTION

Never before has humanity had such a rapid population growth, nor so concentrated, as in our time. In the last century the population of the planet has multiplied by six, from 1,200 million inhabitants to 7,000 million, and 75% of people live in cities. The disproportionate growth of the population has resulted in a predatory consumption of the planet's natural resources, an unbridled demand and supply of products and services. This growth has intensified pollution and led to an increase in the temperature of the globe. The largest consumption of world energy is represented by the construction sector (41%), followed by industry (31%) and transportation (28%).

The environment and populations conditions are changing, technological advances allow us to connect and move with more ease and speed, however we continue to occupy the land with the same criteria as hundreds of years ago: we build slowly, rigidly and heavily, in an era that demands agility, adaptability and responsibility with the environment. What to do about it? Nowadays, it is necessary to think that we must live and inhabit the planet in a different way that allows us to live with nature in a responsible way. We could build lightly, with renewable and reusable materials, considering natural energies (sun, water or wind), habitats that can be adaptable to the environment, and the lives of the inhabitants.

These reflections are part of a wider research and development process that this author has been working on several years, through the academic and professional practice he has had in Spain and Colombia, from which he has obtained a pair of invention patents, several publications, as well as a lightweight and adaptable construction system that is being implemented in his own company (www.sistemaensamble.com).

1. LIGHTNESS

"How much does your building weight, Mr. Foster?" was the unexpected question that Buckminster Fuller asked Norman Foster after flying over the Sainsbury Center for Visual Arts.[1] The surprising question led Foster to investigate the real weight of his work, and to realize that the greatest weight was destined to the less interesting parts of the building. But behind Fuller's provocative question hides a perceptive inquiry: Can we build more lightly? The answer would be given by Fuller himself, who proposed buildings that were transported by air, as in the sketches he made for the 4D Tower (1928) (Fig. 1), which was carried from one place to another by a zeppelin, and whose idea seemed to be more appropriate coming from a comic or a science fiction magazine. But Fuller was able to realize this dream with the geodesic domes he designed for the US Army, which were transported by helicopters to accommodate the troops in their land displacements.

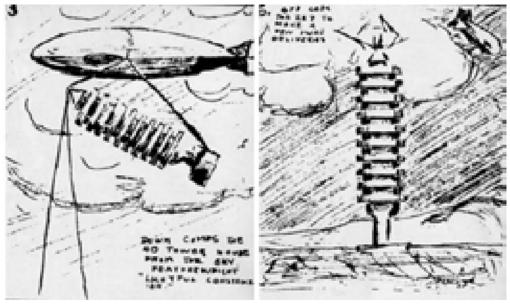

Figure 1: Sketches of the 4D tower transported by a Zeppelin (Buckminster Fuller, R., 1928)

On occasion the idea of lightness is mistakenly associated with little durability, fragility or even insecurity in cases of earthquake. Contrarily it is demonstrated that many light constructions are safer than heavy constructions. 1910, on January 12th, an earthquake measuring 7.3 degrees on the Richter scale occurred in Haiti, leaving 316,000 dead people and the capital devastated. Two weeks later, on February 27th, another earthquake occurred in Chile with 8.8 degrees, 788 dead people and fewer damaged buildings. How can we explain that similar situations produce such different results? No doubt it was due to the type of construction prevailing in each place. In Haiti the buildings are mainly built heavily , with cement blocks joined by mortars and reinforced concrete structures; while in Chile constructions are built primarily with light wooden elements. The heavy constructions represent a greater risk of collapse due to the mass displacements, while the light constructions have a better capacity to respond to seismic movements.

Weight and lightness are also associated with misconceptions of durability and permanence in time. The most important ancient buildings, those that were dedicated to kings or gods, were generally built with huge stones; for example the Greek temples, the city of Machu Picchu in Peru, or the pyramids of Egypt and Mexico. These are unique buildings designed to survive unshakable through time; they were conceived for posterity, for *eternity*. With the passage of times, it has been seen that constructions tend to decrease their thickness, and therefore their weight. Lets think about the transformations that were happening from the thick stone walls of the Romanesque period; the appearance of the slenderness, the ribs and the stained glass windows during the Gothic period; up to the prefabrication of fine metal pieces mixed with glass sheets in the large European railway stations, the North American skyscrapers in Chicago and New York, or the huge exhibition halls like the Crystal Palace (1851)[2] during the era of industrialization. More recently, with the development of new materials, it has been possible to build unimaginable buildings, such as the United States Pavilion for the Universal Exhibition in Montreal (1967)[3], a geodesic steel and acrylic dome designed by Buckmister Fuller; as the House in a plum orchard by SANNA (2003), whose walls are 16 mm thick metal plates, or the New headquarters for Apple in California (2018) by Norman Foster, whose large circular roof rests over structural glass.

The idea of perpetuity and immobility is also changing with the times. Some old buildings of great architectural value have had to adapt by changing their use or modifying their shape. Recall the Museum d'Orsay adaptation in Paris, previously railway station (S.XIX) and now an art gallery (1986); The Tate Gallery in London, which from a power station (1963) became the British National Museum of Modern Art (2000); or the enlargements of the Louvre Museum in Paris (1793-1989). There are few ancient buildings that remain unchanged in time. Population growth, cultural changes and technology development are appealing for the renovation of highly culturally representative spaces.

Progressive research in new materials and development of technologies allow us to have more durable, thinner and lightweight materials.The evidence can be seen in parallel fields such as industrial design or automotive industries. Nowadays we manufacture cars with aluminum chassis that weigh less, and therefore have lower gasoline consumption and are faster, than the cars produced by Henry Ford. Racing bicycles are made of titanium alloys or carbon fibers, which means less weight and better performance than the wooden or iron ones. Aircraft designers seek to alleviate their weight and achieve greater distances using lightweight and resistant materials, with alloys of metals such as aluminum, copper, magnesium or titanium. The discovery of composite materials has facilitated the decrease in size and weight of everyday objects, such as home appliances, computers and mobile phones; now we have mini computers like 'Tablets' and 'smartphones' that we carry and connect us with the world. Portability has become one of the contemporary attributes.[4]

And what about lightness and portability in the construction field? They are introduced in a slower way than in the other industries. Maybe it is due to cultural conceptions or prevailing market interests. Lightness, in the construction field, also entails a series of significant advantages, such as the considerable reduction of foundations, and the decrease in time and costs of execution; that's because the materials size and weight in transportation and placement in the building are reduced. Nevertheless, the concept of lightness in architecture and construction is still to be explored and developed thoroughly, representing a great challenge for researchers, academics and professionals community. Let's consider Fuller's insinuation: we can build in a lighter way.

2. ADAPTABILITY

If the use of buildings changes sometimes, then so do the families occupying the houses, if mobility is an ever more prevailing contemporary condition, then why do we keep on building rigidly, as if we were still designing buildings for eternity? From architecture and construction, from conception to full use, we are dedicated mostly to design and build inanimate objects, *finished* and non-moving things. How then to attend to and be in harmony with this changing world, with the great demographic explosion in the last centuries, with the fluid and fluctuating condition of our time?[5]

Rather than conceiving and building finished objects, it is convenient to create and produce *systems*, sets of parts that are related to each other, with the ability to change throughout the time. Nature is an inexhaustible source of examples of survival and adaptation to changing environmental conditions. Think of the honeycombs, the water bubbles formed by the sea foam, the anthills, or a pineapple peel. This concept, explains the French philosopher Edgar Morin about Systems Theory:

> In principle, the field of Systems Theory is much broader, almost universal, because in a sense all known reality, from the atom to the galaxy, passing through the molecule, the cell, the organism and society, can be conceived as a system, that is, as a combinatorial association of different elements. (Morin 2011, p. 41)

After the first period of the Modern Movement, from the 1950´s through 1970´s the work on systems became a constant occupation for architects. As examples, the Plug-in-City (1964), a city in permanent change made of containers transported in the air (inspired in the Fuller's portability precepts), by the English group Archigram; the Nagakín Tower (1972), a residential complex with prefabricated modules connected to a shaft, like a tree, a sample of the Japanese group Metabolists; the Spanish Pavilion for the Brussels Exhibition (1958), was like a forest made of umbrellas, by Corrales and Molezún team; the Municipal Orphanage in Amsterdam (1960) by Aldo Van Eyck; the housing complex Habitat '67 (1967), like a mountain range made of stacked houses in Montreal, by Moshe Safdie; or the Free University in Berlin (1973), a 'carpet building' designed by Candilis-Josic-Woods. All these buildings demonstrate how the main architects concern by that time was no longer to propose totally defined and finished forms, but rather to present sets that could be modified or easily adapted to the land, the inhabitants, or use conditions throughout time.

Regarding these system buildings, in particular the Free University in Berlin (Fig. 2), it is convenient to read the text written by Alison Smithson, *How to reconnize and Read Mat-Bilding*, from which it was generated the 'Mat-Building' term. She alluded to buildings that, like a net, had the capacity to extend or modify in the territory.

> Mat-building can be said to be the epitome to the anonymous collective; where the functions come to enrich the fabric, and the individual gains new freedoms of action through a new and shuffled order, based on interconnection, close-knit patterns of association, and possibilities for growth, diminution and change (Smithson 1974)

Figure 2. Free University in Berlin, aerial view. (Candilis-Josic-Woods, 1973). Google Earth.

Due to the war, population growth, and huge migrations from the countryside to the city, the collective housing had a leading role during the twentieth century. Industrialization made it possible to produce large housing complexes, but also the standardization of components led to repetitive and tiresome solutions, which meant that, in some cases, users modified their homes claiming for identity and differentiation from the others. It is worth to remember what happened with the houses for workers at *La Cité Frugès* (1924), in Pessac, designed by Le Corbusier; many of the residents denied the neat appearance of the facades and decided to modify the rationalist language by changing 'the long windows' or the appearance of their homes. "Life is right and the architect is wrong," Le Corbusier would say when he saw the changes that the owners made in their homes (Cohen, p. 29). In the end, the French government decided to recover and preserve the original appearance of the houses. In any case, these inhabitant's dissatisfactions faced a dilemma between building in large quantities with standardized systems, inducing certain uniformity in the users, or seeking the identity of the people through differentiations in their homes.

To solve the uniformity problem and user's dissatisfaction in housing, recently there has been talk about *customization*, which means a certain capacity for variation and adaptability that has to do with the inhabitant's tastes and possibilities. The architects Stephen Kieran and James Timberlake, in their book *Refabricating Architecture* (Kieran and Timberlake, 2003), they refer to how the failure of the modern industrialized housing dream consisted, precisely, in the massive and repetitive production of the components, without taking into account the differences between the inhabitants. According to them, through contemporary technological advances we can count on a greater variety and solve the massive housing problem. The book also takes up the concept system as an answer to find variety, and it also refers to change the process of building with fixed and immovable materials by using components that can be removed and reinstalled, that is, to assemble instead of building.

The system also entails a state of malleable entity, modifiable according to the environment´s conditions. That means the system can be a resilient body, with the capacity to respond to adversities and remain in time, as if it were a living organism. We can ask ourselves why, if buildings shelter living beings, with the capacity to move, grow and reproduce, these life containers do not also have the capacity to transform themselves according to their inhabitants. Buckminster Fuller formulated years ago, in his Standard of Living Package and Skybreak Dome (1948), that houses could be like minimum boxes containing and deploying the devices for essential human activities such as eating, sleeping or grooming. The Archigram group had imagined buildings with legs, as if they were spiders, moving on the ground. Today we can talk about sensitive membranes that change with cold or heat, expand or contract, transpire or close to the environment.[6]

Regarding the sense of adaptability, it is worth it to remember experiences made by designers who conceived elements that were installed according to the needs of users, in the manner of a Lego set, such as modular furniture or buildings, such as the Packaged House System (1942), by the German architects Walter Gropius and Konrad Wachsmann (Gilber 1984), the Modulli System (1968) by Kristian Gullichsen and Juhani Pallasmaa in Finland, or the Espansiva System (1969) by Jorn Utzon in Denmark. The great value of the Danish architect consisted in designing some cells (bathrooms, bedrooms, kitchens, etc.) that, by their activity and size, could be assembled and combined with each other, in a multiplicity of almost infinite forms.

Other avant-garde proposals, still unrealized, were designed by the British architect Cedric Price in the Fun Palace (1972), where he proposed a versatile theater, adaptable to the situations generated by the audience inside, a space that interacted with its visitors, made of industrial components; or the proposal of the *Ville Spatiale* (1959) by the Hungarian architect Yona Friedman, who tells us about the possibility that man has to manipulate his own environment, of buildings that move according to the wishes of its inhabitants (Friedman 2014).

> 'Who is important? The people who live there and how they can adapt to the environment, but mostly how the environment, how the manmade environment, adapts to them (…) So I was interested in how you manipulate your own residence, the public buildings, the city itself… so simply like you can manipulate a chair.

3. SUSTAINABILITY

Why is it fashionable to talk about sustainability? Have not sustainable constructions existed before? Was not sustainability a previous architecture goal? In fact, good architecture, such as the one made by modern masters, always had sustainability among its inherent conditions, always considered the implantation place, orientation, or material; it is adequate to see the care in which Mies van der Rohe used to place his buildings (Gastón 2005), the studies in which Le Corbusier oriented his buildings with respect to the sun, the use of the place materials and the buildings implantation in the landscape that made Frank Lloyd Wright or Alvar Aalto. So, why is this topic being talked about so much that it seems new and has become a current obligation? Perhaps because we have realized that natural resources are not inexhaustible, because we feel in our own skin the climatic changes of the earth, or because good architecture and construction are uncommon. The truth is that we are acquiring a new awareness about the way we inhabit the planet.

But what is sustainability? Much is said about sustainability in environmental terms, care for the land, energy consumption, that is, physical aspects, but little is said about other factors that are part of an integral situation.

There are authors who maintain that sustainability involves the environmental, social and economic features (Jiménez 2010); and for this to be achieved there must be a balance between the three aspects. The word sustainable is also related to the care we take now for the well-being of future generations; in this sense sustainability is almost an appeal to the survival of the planet earth and the human species.

There are extreme positions between those who argue that the most sustainable thing is to do nothing -not to build anything new-, and others that wield to give ourselves entirely to technology, to the point of making us depend exclusively on it. It would be convenient to move in intermediate positions in which technology is not an end that subordinates man, but a tool that allows the human species to advance. Nowadays, it is possible to talk about *low technology*, technologies more friendly to the environment and to humans, for example self-construction systems with basic tools in which man has even greater interference and ability to mediate.

In between these parameters works the Australian architect Glenn Murcutt, for whom the basic topics of solar orientation, natural ventilation and respect for the place are still fundamental issues in his professional job, but his work also relies on advanced aspects of technology such as industrial processing of materials, light construction, or the induction of air through mechanized chimneys (Fig. 3). The Marika-Alderton House (1994) is a reference of how to assemble a good home in an isolated place, with very few resources, for a specific community. It is all an example of sustainability.

Figure 3. Fredericks / White House (Murcutt 1982). Sarmiento 2008.

4. APPLICATIONS

Taken from more extensive research about light construction systems, the author of this article has written a series of articles related to the subject of industrialized construction with some flexibility (Sarmiento 2017), composed a couple of invention patents, as well as participated in academic and professional practice in his own company, whose brand is *Sistema Ensamble* (www.sistemaensamble.com).

The aforementioned aspects of lightness, adaptability and sustainability are immersed in these practices and seek to offer concrete solutions to real problems, especially the housing deficit suffered in Colombia, where he has proposed mass housing solutions (Fig.4).

Figure 4. Social Housing design. (Sarmiento 2017)

The author is also working on transportable or modifiable buildings according to the users needs, such as progressive homes, which allow expansion based on the growth or inhabitants requirements (Fig. 5).

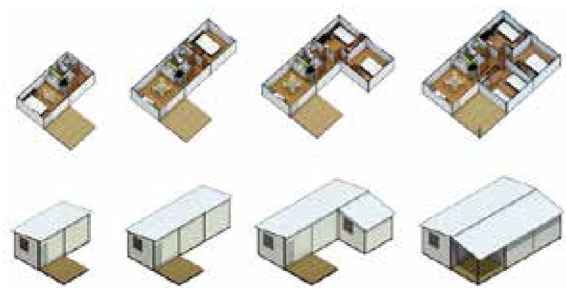

Figure 5. Progressive House with capacity for growth and adaptability (Sarmiento 2017)

Here are introduced other private homes examples, such as the *Foreman's House* (Fig. 6) or the *Ecoestudios* (Fig. 7), a building that includes six small apartments -inspired in the activities kit proposed by Fuller-. Both assemblies, thanks to their modularity, adapt to the inclined topography; due to their lightness and low weight they were built in a short time and required very little groundwork.

Figure 6. Foreman's House, side view, 2016. (Sarmiento 2016)

Figure 7. *Ecoestudios*, foreshortened view, 2015 (Sarmiento 2015)

Another case of social housing is also presented, this time for the field, such as the *Tropical House* (Fig. 8), a farmhouse inspired by the concepts that the French engineer Jean Prouvé would apply in his own Tropical Homes, like minimal impact on the ground, cross ventilation and portability. Our design has a minimum of underpinning (only 6 basis) and the possibility of being transported and built with manual means, in places where there are no roads or electricity. It is a very own home for the return of displaced farmers, after the armed conflict that Colombia has suffered.

Figure 8. *Tropical House*, design (Sarmiento 2017)

The *Sistema Ensamble* was examined over a seismic test platform at the EAFIT University in Medellín, Colombia, where its efficiency could be verified in cases of earthquake (https://www.youtube.com/watch?v = c92Lno9LcM4). [7] The prototype, with its own weight of approximately 100 kgf/m2 (20.5 lbf/ft2), was able to support an additional live load of 300 kgf/m2 (61.4 lbf/ft2). This demonstration shows that the system is light and resistant.

This research and development work has generated questions and answers, but above all it represents a search for new constructive systems, towards an adaptable architecture.

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[1] This is also the title of a documentary film about Norman Foster's professional career (https://www.youtube.com/watch?v=woHc6-Py3Mw). Foster refers to the movie title generated by Buckminster Fuller's question.

[2] The Crystal Palace was originated in the London World's Fair contest (1851), which was declared void by the juries at the beginning, since the delivered proposals failed to meet the planned deadlines and costs. It was Joseph Paxton, specialist in gardens and greenhouses, who managed to materialize a pavilion that was built in record time and a smaller budget. The building was disassembled later and moved to another place, confirming its virtues in its serial and light manufacturing.

[3] The United States Pavilion for the Montreal World's Fair in is the largest geodesic dome ever built. It is 76m (250ft) in diameter, and 63m (206ft) height, made with a light steel structure and an acrylic membrane.

[4] An example of this is the promotional slogan to release the iPods: '1000 songs in your pocket'.

[5] Zygmunt Bauman coined the term "Liquid Modernity" (Bauman 2003), referring that the constant of our time is change, that the only certainty is uncertainty: "Today the biggest concern of our social and individual life is how to prevent things from being fixed, that are so solid that they can not change in the future" (Barranco 2017)

[6] See for example the exhibition *Another Generosity*, in the Nordic Pavilion for the Venice Architecture Biennale 2018. [https://www.metalocus.es/es/noticias/another-generosity-una-experiencia-inmersiva-pabellon-nordico -for-the-biennial-of-architecture-of-venice-2018]

[7] The sample was submitted to the maximum effort and movement of the platform, remaining standing without substantial damage.

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A STUDY OF BANGKOK SHOPHOUSE FACADES FOR ADAPTIVE POSSIBILITIES: A CASE STUDY OF KLONGSAN DISTRICT

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ABSTRACT: In Thailand, especially, Bangkok, the shophouse is one of the well-known mixed-use and multi-functional buildings: residential and commercial use. With its diverse uses, the users have modified shophouses' appearances to accommodate the purposes of uses based on residents' and owners' conditions, and business opportunities. However, the designs, constructions, and materials of its appearance have never been considered to adapt for new building purposes. This causes difficulties of adaptation and reuse of the buildings. The adaptive concepts and typology study are applied to understand the building type. The former study of shophouse are also employed and reviewed to depict the pattern of building uses. The study aims to present the variety of shophouses' appearance pattern to generate a common understanding of façades' designs, constructions, and materials. In addition, a survey of the residents' attitudes and requests for adaptable facade opportunities is done. The study mainly focuses on Klongsan district area where a new development is rapidly occurring due to the new expansion of the city and its potentials of waterfront developments. The area is in an urgent need for adjusting itself for the new developments to come. A survey of 100 shophouses of 3 story in height or higher and 3.5 - 4 meters in width are explored. An expected result is to illustrate the possibilities for shophouse façade adaptive design and structure. This can improve the shophouse façade appearances, shophouse usages, an image of the community, and a future of the sustainable city development.

KEYWORDS: Bangkok, Shophouse, Facade, Adaptive, Possibility

INTRODUCTION

In the recent years, Bangkok development have been impacted by new sky train and subway lines. This causes many new high-rise condominiums and apartments evolving along the lines. This happens in Klaongsan District where there are new 3 subway lines and a sky train line running through the district. With the district location, next to the Choapraya River and opposite to the CBD and historical area of Bangkok, it is a new prime location for new city developments. To strengthen its potentials, National Innovation Agency, one of government agencies, aims to develop this district to be one of the innovation districts in Bangkok. As a result, Klongsan District is now become a new city expansion area. The new developments cause concerns on local daily life and developments, especially, living lifestyle and images of the areas. Furthermore, a gentrification of the area become a major concern to the communities in the district.

However, one of the common housing types in Thailand is shophouses. The shophouses, in residents' perspectives, are very good in supporting walkable street and livelihood of the area (Tirapas and Suzuki, 2014). It is also commonly known by the local of its diverse uses; residential and commercial use. This unique character also supports the Innovation District policy. In addition, with the numbers of them, the appearance of the shophouses have created an image of the city or the area. With different purposes of use, people change the shophouse's appearances according to their preferences and conditions. However, shophouses' design, structure, materials, have never been considered to serve its adaptation. Therefore, with its increased degrees of shophouses' adaptation, the local atmosphere and developments can grow along with the new developments from the developers.

Thus, this study aims to survey the existing shophouses' facades in Klongsan District to understand their designs, constructions, material usages and patterns. Furthermore, the survey presents residents' concerns on shophouses' renovations. The results can address and suggest possibilities of shophouse facade designs, constructions and material usages in order to increase the degrees of adaptability to respond to the new urban developments.

1.0 SHOPHOUSE AND INNOVATION DISTRICT DEVELOPMENT

1.1. Shophouse and Klongsan innovation district development

One of the Thai government policies is Creative Economy which intends to drive the country from merely manufacturing industries towards innovative and creative industries (NESDB, 2016). Thus, science, technology, research, and innovation are the main tools to achieve the goals. In order to encourage innovation, especially, the urban and main regional developments are significantly focused. Therefore, National Innovation Agency (NIA) which responds to drive this policy, funded many researches and activities to gear the policies to increase economic abilities for both urban and reginal areas (NIA, 2018).

The innovation district concept is a world trend to encourage knowledgeable, innovative, and creative people to join and share their ideas in order to create innovations which lead to the economic value increasing. Katz and Wagner (2014) state that to facilitate the innovation ecosystem, there are 3 major keys involving economic, network, physical asset. The economic asset involves firms, institutes or organizations that drive and enrich innovation environment. Network asset is the relationship between those key players in innovation. There can be tied or loosen relationship; same and different professions. As they meet and exchange, ideas can be created and generated.

Figure 1: Bangkok map and Klongsan district area.
Source: (https://commons.wikimedia.org/wiki/File:Thailand_Bangkok_location_map.png; https://www.google.com/maps/place/Khlong+San,+Bangkok+10600/@13.7221144,100.484931,14z/data=!3m1!4b1!4m5!3m4!1s0x30e298e8dba300b3:0x30100b25de24ea0!8m2!3d13.7187489!4d100.5014909)

The physical asset is the major concern. Especially, the urban area where high-tech companies, universities, institutes, business incubators are the keys to motivate the innovations. The area should provide facilities and environment to encourage creative people e.g. mass transit systems, network wireless and offers variety of activities, mixed-use housings and buildings, and retails (Katz, B. & Wagner, J. 2014). The idea is served very well with the nature of the shophouse which is a mixed-use type of urban housing in Thailand.

1.2. Open Building and shophouse adaptable façade

The study bases on the Open Building concept. The idea aims to increase an efficiency of building uses, business opportunities, construction procedures, and material technologies via a design of “support” and “infill” (Kendall, S. and Teicher, J. 2000). This increases degrees of building flexibility and adaptability over time.

The shophouse is a mixed-use building; however, it has not been designed for adaptation. Often time the residents or owners adapt it with common ways of renovation. The Open Building can enrich the possibilities of adaptive use of the shophouses in many levels; for examples, spatial and apparent adaptations. According a study of Tirapas and Suzuki (2015), the shophouse residents and owners view that the shophouse’s components have different degrees of change and adaptation. The results show that the structure (columns and beams) is the most difficult components to modify; while the façade is rather easier for the residents and architects to modify when they want. However, the process of modifications of the shophouses’ facades is not convenient for the residents and owners.

To understand the shophouses’ façades, the typological study by Habraken (1988) is applied. The idea is to distinguish a building type into 3 main parts; spatial, physical and stylistic characteristic. Habraken (1988) suggests that the spatial characteristic is viewed by certain configuration, positions between inside and outside, public and private classification. The physical characteristic is viewed by their physical shapes and sizes and relation between each other in the space. The stylistic characteristic is viewed by what kind of windows and doors used, how they placed, and decorative elements applied on the facade. With this approach, the results can guide shophouse façade adaptabilities.

Furthermore, Habraken (1998) addressed the hierarchy of control of the physical elements. This study states the level of dominance and the dependence of the level of control (hierarchical control). The level concept explains the controlling ability to adjust and transform physical elements based on restrictions of the higher level. At the same time, the physical elements of the lower levels are moved or changed according to the restrictions given by the higher-level elements. This idea is applied to study the physical components of the shophouses in order to understand the impact of the facade physical components.

2.0. METHOD

The survey focuses on Klongsan District where it is aimed for the innovative district development. As the shophouses are mostly built along the streets, the survey then focuses on the shophouses, located on the main streets. The 100-shophouse samples are 3 story in height or higher and 3.5 - 4 meters in width. These are a typical shophouse. The survey of the 100 shophouse façades and the questionnaires are distributed on 8 main streets; Krung Thonburi (2 bldg.), Charoen Nakhon (northern and southern of Taksin Bridge) (36 bldg.), Somdet Chaophaya (6 bldg.), Tha Din Dang (5 bldg.), Itsaraphap (15 bldg.), Somdet Prachao Taksin (12 bldg.), Chareonrat (18 bldg.), and Lat Ya (7 bldg.) (see Fig. 2).

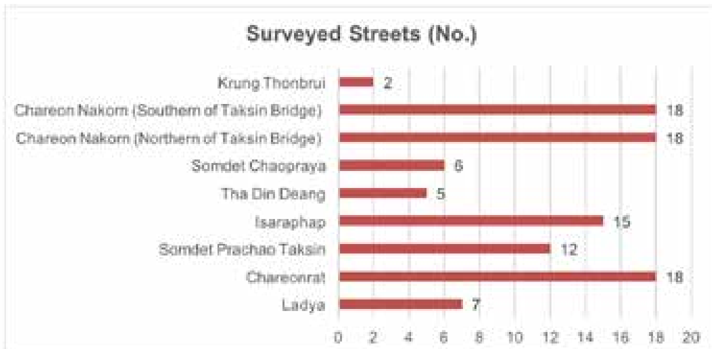

Figure 2: Numbers of surveyed shophouses in 8 streets in Klongsan District.

The questionnaire survey focuses on the residents' attitudes towards the façade modifications. The survey then inquires the participants to answer 3 main issues; the reasons why they need to improve or modify the façade; their concerns about façade renovation; the needs of assistance for renovation. Furthermore, the questions inquire them to rank the top 5 issues from the most important to the least important according to their aspects.

The results of the questionnaires and facades' photos are compared and analyzed in order to depict the patterns of the shophouses' modifications by the residents or owners. This reveals ideas of residents towards what they concern and need to support their facades' modifications.

3.0. SURVEY RESULTS

3.1. Basic information

According to the survey, as shown in Fig. 3, there are 55.7% of female and 44.3% of male. The age of participants is shown in Fig. 4, which are 3% of 20-25 years old; 8.9% of 26-30 years old; 14.9% of 31-35 years old; 18.8% of 36-40 years old; 18.8% of 41-45 years old; 10.9% of 46-50 years old; 4% of 51-55 years old; 9.9% of 56-60 years old; and 10.9% of more than 60 years old. The income of the participants is shown in Fig. 5, which are 13% of lesser than 15,000 baht; 37.7% of 15,001-30,000 baht; 17.4% of 30,001-45,000 baht; 8.7% of 45,001-60,000 baht; 8.7% of 60,001-75,000 baht; 4.3% of 75,001-90,000 baht; and 10.1% of more than 90,000 baht.

In addition, the ownership of shophouses are shown in Fig. 6. There are 27.8% of self-owner; 15.6% of parent's belonging; 26.7% of rental building; 17.8% of long-term leasing; and 12.2% of others. The type of building use is also shown in Fig. 7 which are 24.6% of commercial building; 3.1% of residential building; 72.3% of mixed-use building. Among the surveyed shophouses, Fig. 8 shows that there are 51% of participants who have experienced in adapting the shophouse facades; there is 49% of participants who have never experienced in adapting the shophouse facades.

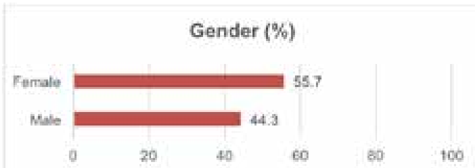

Figure 3: Gender of participants.

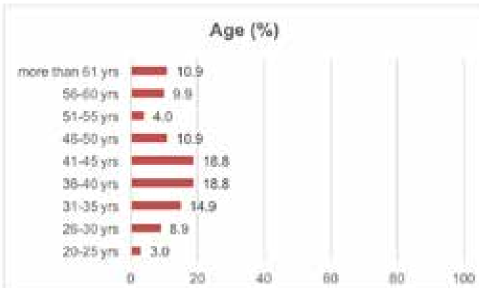

Figure 4: Age of participants.

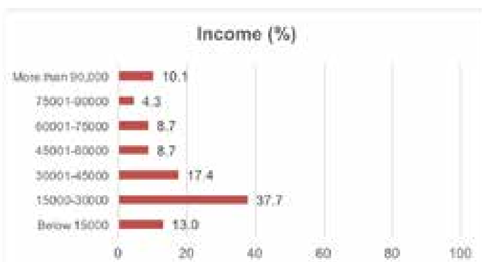

Figure 5: Income of participants.

Figure 6: Building ownership of participants.

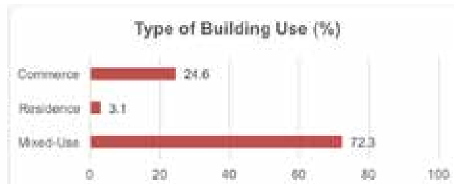

Figure 7: Percentage of type of building use.

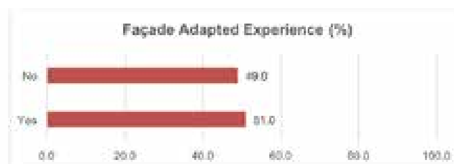

Figure 8: Percentage of façade adapted experience of participants.

3.2. Shophouse facade patterns

The study of the shophouse façade patterns is based on the typological study by Habraken (1988). The designs, structures, and materials are also explained. In term of the spatial characteristics, the façade can be seen as two portions; ground and upper level. The space on the ground level is defined by the terrace or concrete shading of the mezzanine or second floor above (see Fig. 9 (a)). In addition, in order to protect the sun heat, a canopy is extra installed which extends the front space of the shophouse (see Fig. 9 (b)). This spatial definition is ubiquitously problematic. It is unclear of public or private space. The residents normally occupy this area by displaying goods, renting to venders, planting pottery, etc. (see Fig. 9 (c)). However, the Bangkok government has recently taken over the space for pedestrians.

On the upper floors, there are terraces, balconies, or shading devices. It is 0.80 – 1.00 m. in width with the same length of the front façade. For the terraces, the space is used for hanging clothes, placing the air-con, planting pottery, etc. (see Fig. 9 (c). The roof deck is the most variation in use as the residents often extended the space. The extension can be a roof for the rain and sun protection; a steel case to cover to burglary protection; or a room (see Fig. 9 (d) and (e)). Some units extend the room over the terrace (Fig. 9 (f)).

Physically characteristic of shophouse is quite simple. The shophouse structure is simply reinforced with concrete column and beam with 4x4 m. the dimension of span. The floor is the precast concrete plank floor system. For the façade, the ground level is widely open for many wall materials; aluminum frame, steel fold door, rolling door, etc. On the upper level, the brick wall with cement plaster is commonly used.

The design of shophouse façade is a given by the designers. The analysis of the physical study, based on the "control of hierarchy" by Habraken (1998), shows that the shophouse façade is one of the upper level which control and impact on the lower physical element in the shophouse (Tirapas and Suzuki, 2013). As mentioned above, the façade is considered as easily modifiable (Tirapas and Suzuki, 2015). This addresses a chance for detaching the structure and façade from each other to enhance the façade adaptability.

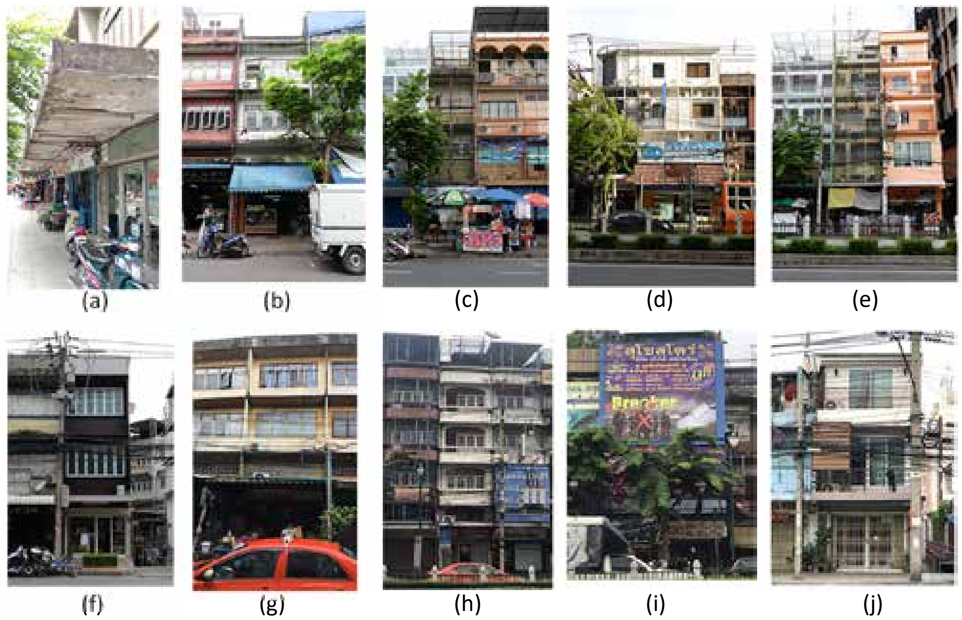

Figure 9 : A front façade of shophouses. (a) the space in front of the shophouse with the shop signage hanging on the concrete ceiling or put on the beam on Chareon Nakorn; (b) the fabric canopy installed to protect the heat on Chareonrat; (c) a vendor rents the front space of shophouse on Tha Din Dang; (d) The room extension of shophouse on top of the roof deck on Ladya; (e) the steel case covers the whole front façade and roof deck on Ladya; (f) Balconies have been covered to a full room on Somdet Chao Praya; (g) the small windows are placed over the front door to allow daylight to get inside on Isaraphap; (h) The balcony hand rail is brick wall and precast concrete ornament on Somdet Prachoa Taksin; (i) a huge fabric advertising board covers the whole façade on Somdet Prachao Taksin. (j) a residential house with a modern design on Chareon Nakorn.

For stylistic characteristic of shophouse, the shop signage, made of aluminum, plastic, or plastic light box, is hung from the concrete ceiling or attached to the concrete beam or brick wall at the front door (see Fig. 9 (a)). The door on the ground level has different designs. Mostly the door will be widely opened for business purpose such as welcoming customers or displaying goods (see Fig. 9 (f) and (j)). The door types and materials are steel folding door, aluminum-rolling door, glass aluminum frame, and wooden folding door. Above the front door or canopy, there is a window for ventilation or daylight purpose (see Fig. 9 (g) and (h)). For the upper levels, there is very common to have a door on each level to access to the terrace or balcony; however, without a door, a window can also be used as well. The common door materials are color or oil painted wooden, color painted steel, or normal or black-color aluminum (see Fig. 9 (f) and (j)).

The window materials are also similar to the door. However, one to four sets of window on each floor are common. The windows are designed with a very simple pattern to suit the common shophouses (see Fig. 9 (f) and (g)). There are also different types of opening; awning, fixed, casement, or sliding window type. In addition, the handrail is also often as part of the balcony. There are many materials of handrail; cement blocks, steel, precast concrete, brick parapet (see Fig. 9 (c), (e), (h) and (j)).

The advertisement boards or signage are often seen on the shophouse façades. The different scales and positions of the façade are varied. The shop signage, on the ground level, appears over the front door or a graphic sticker on the glass of the aluminum frames (see Fig. 9 (a), (d), and (h)). On the upper level, the billboards are put as banners on the mezzanine level to the upper floors or cover over the whole façade (see Fig. 9 (i)). The signage is made of many materials; fabric, plastic, or aluminum.

3.3. Shophouse façade adaptation opportunities

3.3.1. Intentions of shophouse façade improvement

The results of the top 5 important reasons for the façade improvement or renovation are shown in Fig. 10: Decadent Building (4.20), Structural Safety (3.54), Noise (3.31), Attractive Building (3.19), Business Promotion (Signage/Bill Board) (3.05). From the first two reasons; Decadent Building and Structural Safety, these can be seen that the safety and strength of shophouses structure is a very important for the participants. The surveyed shophouses in Klongsan District are rather old; thus, the physical conditions are needed to be repaired. In addition, most of the surveyed shophouses are on the streets, therefore, the noise from cars is one of their major problems.

Figure 1 0 : Participants' reasons for improving and renovating the shophouse

Attractive Building and Business Promotion (Signage/Bill Board) are ranked 4th and 5th. There is a possibility for the shophouse facade to adapt in order to serve the business purposes. The participants improve and adapt the façade mostly for business advertisement and to attract customers; therefore, a beautiful, clean, new painted, modern façade are needed.

In addition, Heat Protection (3.00) is also ranked as high as Business Promotion. This is because of a comfortable living concern resulting from the hot-humid climate. However, when the advertising board has been built, it effects on the poor living quality in the shophouses; daylighting, energy usage, ventilation, and air quality. This could be dissolved without an inclusive façade design. On the other hand, Increase Property Value for Leasing or Sale (2.08) is ranked quite low. This results from the lack of budget and the ownership. The participants who rent, do not want to invest or not allow to do so. The lowest rank is Meet Function Needs (2.02) which presents that the façade is less concern to them for the functional changes.

3.3.2. Concerns of shophouse façade renovation

The concerns of the participants when they renovate the shophouses' façade are shown in Fig 11. The list can be categorized into 3 major groups; pre-renovation, renovation process, and impacts during the renovation. The first group shows the top 5 concerns which are: Structural Strength (4.03), Budget (3.82), Impacts on New/Old Systems (3.81), Renovation Period (3.24), Professional Level of Designer (3.00), and Professional Level of Contractor (2.78). These are similar to the reasons when participants want to do the facade renovation. They highly concern on the safety and strength of the structure since the buildings are old. Most of these concerns are related to the pre-renovation of the façade. Therefore, a clear and well-plan method and process of renovation can encourage the residents and owners to be certain of their renovations.

The second group is Unknowledgeable of Material Usages (2.72) and Permission Process (2.60). These seem to be concerns during the process of renovation. These concerns relate to the renovation process. The third group of concerns are Unsatisfied Function (2.47), Maintenance Cost (2.39), Difficult Process of Permission (2.27), Safety of Residents During Renovation (2.20), Impacts on Nearby Units (2.00), Business Interference (1.83), Daily Life Interference (1.81). The third group concerns about the impacts of the renovation. However, the building renovation permission somehow can be illegally done; therefore, the minor changes of the façade will be less concerned.

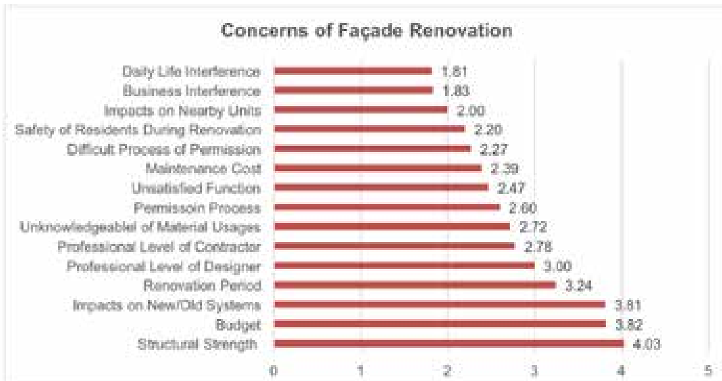

Figure 1 1 : Participants' concerns on renovating the shophouse facades.

Many major concerns can be solved by introducing and applying the Open Building. When a detachment of the shophouse structure and façade components are done; the idea of "support" and "infills" can be applied to assist the residents or owners to advance their design and renovation plan. By applying "support" and "infills"; as a result, it finally saves the renovation time consume and budget. However, the concept has been rarely known and widely practiced in Thailand.

3.3.3. Needs of shophouse façade renovation assistances

The results show the most wanted assistances are; Design Consultant (3.54), Construction Consultant (3.37), Contractor Provider Firm/Org. (2.83), Material Consultant (2.70), One Stop Service Firm/Org. (2.60) (see Fig. 12). The results are synchronized with the concerns of professional designer and contractor. The participants need design and construction consultant to advice on the designs the most. This shows that the participants might lack of knowledge of design and construction. Therefore, this can be an opportunity to contribute professional services to the shophouse residents and owners.

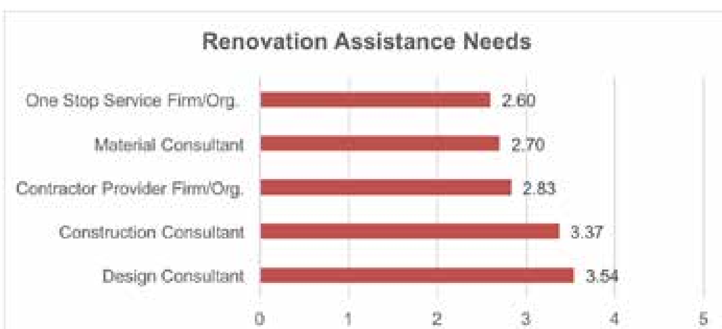

Figure 1 2 : Participants' needs on the shophouse facade renovation assistances.

CONCLUSION

In general, the façades of the shophouses can be seen as a variety of variation. The ground level is more variety of design. However, it is mostly aimed to encourage business opportunity. While the upper level facade is more rigid in changing. Observing the ground level, the front door is more widely open to adapt and change;

light weight and dry process. This offers quick an installation, budget saving, less maintenance. These benefit the commercial aspects. On the other hand, the material use of the upper level, brick wall with cement plaster, seems to be a typical construction. This construction rarely supports façade's adaptability. Therefore, a substitution of the facade materials, with easily adapted materials responding to functional and business changes, can be an approach. In addition, detaching the concrete frame (column and beam) from the façade components can greatly assist in adaptability. This is an opportunity to enhance the dry wall system to encourage more adaptable shophouse façade.

The questionnaires have shown an opportunity to approach the adaptable façade. The intentions of adapting the façade address that the concern of commercial use is more important than the residential use. Therefore, the high results are focused on the façade attraction rather than the quality of living. The concerns of adapting can be dissolved by the pre-conceptual design of adaptable façade. It is also a common skeptical for the construction process for those who are not the experts or involved in the professions. Hence, a professional consultant for design and construction is obviously needed.

Finally, to encourage the adaptable shophouses' facades, the Open Building should be implemented. Thus, the Open Building can be approached in two ways; soft and hard approach. The soft approach is to create a professional consultant service for design and construction which respond to the concerns and requirements of the participants. This service includes the adaptable façade design to respond the functional needs (residential and commercial use) and maintenance; and to encourage living quality of shophouse; daylighting and ventilation. The hard approach focuses on the "support" and "infill" idea. By detaching the structure from the façade components, an application of dry wall system and light-weight materials must be tested and researched for future applications.

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OPEN BUILDING AND FUTURE-USE ARCHITECTURE: A COMPARATIVE ANALYSIS

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ABSTRACT
The foundational concepts of the Council on Open Building and the 2017-2019 AIA Latrobe Prize winning team's concepts of Future-Use Architecture are well aligned. This paper is a comparative analysis of their origins, overarching principles, commonalities and differences at multiple scales: the scale of the city; the scale of the building; and the scale of the user. Because both sets of underlying principles promote greater incorporation of the temporal dimension in the design of the built environment, and they share the conviction that provoking change within the profession is imperative to better manage the resources devoted to the built environment over the long term, a comparative analysis of the two can expand the strategies and tactics to produce durable architecture and resilient cities.

KEYWORDS
Temporal; Long-term; Durable; Adaptable; Flexible.

1.0 INTRODUCTION

The foundational concepts of the Council on Open Building and the 2017-2019 AIA Latrobe Prize winning team's concepts of Future-Use Architecture are well aligned. This paper is a comparative analysis of their origins, overarching principles, commonalities and differences at multiple scales: the scale of the city; the scale of the building; and the scale of the user. Although their intellectual foundations were generated at different moments in time and contexts, the confluence of Open Building and Future-Use Architecture is not surprising given the underlying mandate that each set of principles apply to the practice of architecture. In short, both promote greater incorporation of the temporal dimension in the design of the built environment.

The implications of thinking of time as a design factor commensurate to form, performance or use is potentially a profound disruptor of current practice in architecture and its interrelated professional disciplines, such as engineering, construction, planning, and finance. But unlike the current trends toward new digital systems focused on expedited design and construction processes increasingly being applied to the AEC industry by new tech start-ups and established giants of Silicon Valley (Caulfield 2018, 44), Open Building and Future-Use Architecture look towards the long-term implications of how we react to the architecture and urban fabric of the past, how we build in the present, and how designing with time impacts the long-term future of the built environment.

2.0 OPEN BUILDING

The Council on Open Building is an international association of design professionals from the allied building disciplines, including "policy makers, designers of all disciplines, investors, product manufacturers, builders and property management experts working across scales" (*Mission Statement* 2017). The historical genesis of the Open Building concepts is the work of the Dutch architect and theorist John Habraken. Habraken first developed housing planning paradigms counter to the predominant housing solutions in Europe in the post-war era in his polemic 1961 book, *Supports: An Alternative to Mass Housing* (Habraken 1972). His focus on mass housing implicitly addresses multiple scales of design simultaneously: the scale of the individual dwelling units, the scale of the architecture containing the living units, and the urban scale of the community generated by housing so many people in concentrated districts. The pressure in post-war Europe to produce housing for millions of people was intense, and each nation had its government-run programs to solve the housing shortages as quickly and inexpensively as possible (Kendall and Teicher 2000, 29). *Supports* was Habraken's reaction to the "top-down" planning that had produced large-scale housing projects in the 1950s and 1960s that were derived from CIAM strategies and other modernist agendas (Habraken 2017). Hs critique is evident in this scathing assessment:

> What happens today is nothing but the production of perfect barracks. The tenement concept has been dragged out of the slums, provided with sanitation, air and light, and placed in the open (Habraken 1972, 13).

At the urban scale, this is a denunciation of the modernist "towers-in-the-park" schemes that neither create nor interact with a traditional urban fabric of dense housing, streets and other legible public spaces.

Habraken did not stop his barrage on mass housing production with the object of design, i.e., the architecture itself. He also challenges the very process of design that produces what he saw as, and what history has since demonstrated, an alienating architecture that does not adequately address the needs or desires of the inhabitants. He targets the "top-down" bureaucratic systems that produced a myriad of monotonous mass housing districts by advocating for an inclusive process where the users design and redesign their own dwelling over the life of the building. He accomplishes this by distinguishing the permanent building shell, which he calls *supports*, from an everchanging and more mutable interior *infill*. This relationship to what is logically fixed in architecture being articulated as distinct from what can possibly change in the interior opens up the opportunity for the ultimate user to have more control on their personal environment instead of spatial configurations being predetermined by an architect at the conception of the building. Habraken discusses the interrelationship between the supports and infill like musical themes in jazz that provide an overall organizing structure for the individual improvisations (Lüthi 2013). Alex Lifschutz summarizes Habraken's book as follows:

> He argued that the external form of a building should be decoupled from its interiors, which should be 'possessed' and altered by its users at will (Lifschutz 2017, 8).

Habraken himself continues to actively advocate for these same principles he started in the 1960s. In 2013, he provides a clear synopsis of his ideals:

> Proper distribution of design controls leads to variety. Shared typology, or patterns or systems, produce coherence. Control of all design decisions by a single party in a particular area soon results in repetition and uniformity. Partial change and variety come naturally when individual inhabitants control their own space (Habraken 2013, 21).

The primary tenets of Habraken's alternative philosophy of participatory design, supports and infill has been followed by many of his contemporaries and students, albeit in evolutionary forms. His protégés Stephen Kendall and John Tiecher published a book in 2000, called "Residential Open Building," that focuses on Habraken's ideas as applied in particular building cultures for the production of housing in the Netherlands, Japan, and elsewhere. Kendall and Teicher provide a clear and nuanced taxonomy of Habraken's interrelated concepts of *levels*, *supports*, *infill*, *unbundling*, and *capacity*. Levels refer to the hierarchy of decision makers in a design process. To Habraken and his ideological descendants, the changes made in a building over time is also a record of changing regimes of control (Kendall and Teicher 2000, 31). Supports are the common building elements, including "building structure and façade, entrances, staircases, corridors, elevators, and trunk (main) lines for electricity, communications, water, gas, and drainage" (Kendall and Teicher 2000, 33). Infill is the mutable interior fit-out, preferably in the form of a coordinated system of components. As Kendall and Teicher explain, infill becomes the democratizing element for control of a living space (Kendall and Teicher 2000, 4). Supports and infill have different time horizons: supports are "intended to accommodate and outlast infill changes, to persist largely independent of the individual occupants' choices, while accommodating changing life circumstances" (Kendall and Teicher 2000, 33). Unbundling suggests that distinct building systems should be kept spatially apart so each one can be maintained or changed without affecting the other. The authors use this concept as a critique of highly integrated buildings where the close coordination of building systems can unduly intertwine systems impeding their potential future flexibility (Kendall and Teicher 2000, 37). And directly related to unbundling is capacity, the ability of buildings to accommodate multiple uses over time. Capacity becomes yet another challenge by Kendall and Teicher to common tropes of design thinking, where program is usurped by adaptability: "In Open Building practice, capacity replaces the set program and its functional specificity during initial design" (Kendall and Teicher 2000, 38).

Habraken's ideas are also still very much evident in contemporary architectural practices globally. One example is West 8's adaptive reuse of a former docklands in Amsterdam, called Borneo Sporenburg. Planning parameters insured that a fine rhythm of unique forms of architectural expression and individual input would create a vibrant variety of the overall urban block fabric (Machado 2006). Multiple architects and their clients designed individual townhouses within non-stylistic, dimensional and configurational mandates. Integral to the overall urban plan where medium-sized multi-dwelling buildings and large-scaled housing blocks. The different housing types could appeal to a large range of household incomes, so the overall effect is an urban district of significant architectural and socio-economic variation.

One of the most recent and clearest expressions of the support/infill strategy is the SuperLofts concept by Marc Koehler Architects (Koehler 2018). A base building of double-height loft spaces served by the necessary systems provides a platform for the individual design and layout of each dwelling unit. At the other end of architectural necessity is the work of Alejandro Aravena. Starting in 2003 with the Quinta Monroy Housing project in Iquique, Chile, and as described in his *Incremental Housing and Participatory Design Manual*, Aravena devised a strategy to provide a basic architectural framework for low-income housing that could be filled in by the inhabitants over time as their economic situation allows (Aravena 2016). The temporal dimension is particularly evident in a number of projects he has built throughout Latin America using an initial A-A-A-A rhythm of positive enclosed spaces and negative interstitial spaces, which allows for more spontaneous infill of the negative spaces.

Figure 1: Haus 2226, Baumschlager Eberle. Source: (Author 2016)

3.0 FUTURE-USE ARCHITECTURE

"Future-use architecture embodies a tectonic and performative intelligence that facilitates long-term use and persistent change of buildings." This is the introductory sentence to the 2017-2019 AIA Latrobe Prize winning team's proposal. Explicit in it are the essential elements of this design polemic: that uses over the life of buildings will change; that the organization of buildings can impact usability over time; and that buildings systems can be conceived to possess a latent potential to continually adapt. Implicit in this introduction is another series of concepts that are of equal importance: that time must become an integral design dimension; that the architect must consider uses for the present and the future equally; and that buildings will either continually adapt or become obsolete, thereby losing their value.

Future-Use Architecture is practiced as a pedagogical tool at Northeastern University in the context of the ultimate undergraduate design studio, *Comprehensive Design*. This studio is directly coordinated with the concurrent building technology course, *Integrated Building Systems.* Together, these courses invite the students to weave their spatial and experiential proposals with a deep exploration of building systems as a source of invention of innovative performative building systems and their resulting creative expression (Wiederspahn 2013). There are three primary conceptual domains that are basis of this pedagogy: *physical systems*; *architectural order*; and *cultural value*. each domain has sub-categories to more finely define design attributes of Future-Use Architecture.

3.1 PHYSICAL SYSTEMS

Physical systems pertain to the material and tectonic attributes of Future-Use Architecture. Within this domain are material, structural, enclosure, and service systems. Material systems are primarily focused on design considerations for the life cycle, embodied energy, carbon footprint, and durability of material choices at the detail and building scale. Material choices also have a strong impact on the psychology of a building's inhabitants (Kellert, Heerwagen, and Mador 2013).

Of all of the building systems, structural systems have the most direct impact on spatial configurations that define levels of openness and adaptability over time. Given that architectural design is a process of the studied anticipation of a building's performance, it is in the design process, versus the subsequent construction or occupation phases, that the future usability of a building will primarily be determined. To provide the most adaptable spaces, minimizing the presence of vertical structure is crucial. Naturally, the depth of the horizontal structure is directly related to the distance between vertical points of support, so an optimal balance of dimensions must be found for each construction type.

Enclosure systems define the boundary between the exterior and interior of buildings, so, they becomes the locus of multiple technical and cultural design factors, including durability, climatological response, thermal resistance, moisture control and water management, energy capture, the architectural image, and the contextual fit to the site. These systems want to be an integral part of the architecture so they do not become obsolete as uses change. For example, the fenestration pattern needs to accept wide variations of internal spatial subdivision and interior partitions.

Service systems, including the environmental systems and mechanical chases, vertical circulation, and building maintenance systems, are closely coordinated with enclosure systems due the roles both perform to insure interior comfort. Each wants to be designed to maximize passive strategies in order to minimize active, energy-consuming processes. Some service systems are inherently fixed, such as vertical circulation and plumbing cores. They, like vertical structure, must be designed not to encumber new spatial configurations while still serving the life safety and convenience of its users. Other service systems, such as partition, mechanical, electrical, and lighting systems are more flexible as long as easily accessible and frequently placed service chases are planned to accept changes over time.

Stewart Brand's *Shearing Layers of Change* diagram identifies that different systems have different time horizons. He stipulates that the site is unchanging, structure is the most long lasting, and in temporal descending order are skin, services, space plan, and stuff (Brand 1994, 13). We have come to learn in the era of climate change that the site is less static than Brand suggests. An alternative to the concept of layers is the integration of systems such that each serves multiple performative roles to create a systems synergy. For example, when the building envelope is also the vertical structure, interior spatial encumbrances are reduced providing greater spatial flexibility.

3.2 ARCHITECTURAL ORDER

In Future-Use Architecture, architectural order pertains to design factors at the scale of building configuration. A building's external orientation and shape relative to the climatic and contextual conditions of the sun, wind, water, and site can have a profound effect on building performance. Strategies for solar and wind energy capture, creation of micro-climates, and storm-water management directly mediate a building's environmental footprint. Internally, configuration can also greatly enhance building performance as well as the sense of well-being of its inhabitants. The dimension of the floor plan and the aspect ratio of section, for example, can insure that all building users have good access to natural light and air. Tall ceilings can more easily accept a greater variety of uses and the intervention of new systems, and multi-level spaces can serve numerous performative roles. For instance, sky-lit naturally-ventilated atria can provide daylighting in the center of a building footprint and natural convection for passive ventilation using the stack effect while serving as a catalyst for social connection and well-being.

Architectural order is dependent on what systems are fixed and which are flexible. Fixed systems such as structure and enclosure persist over the long term, while the flexible components must be able to change without substantively affecting the base building. Balancing qualities of formal specificity and neutrality is similarly critical. A highly specific correspondence of architectural-form-to-program risks obsolescence when uses change, thereby reducing a building's value in the future. Yet, generic architectural form risks stripping architecture of that which makes it unique and memorable. Kendall and Teicher warn against making a completely generic building in the name of flexibility when they write:

> "The form need not be neutral to optimize useful capacity. Totally 'flexible' multi-purpose space—space devoid of columns, walls, changes in section or qualities of light—offers no architectural definition for dwelling" (Kendall and Teicher 2000, 39)

A Future-Use Architecture, therefore, strikes an equilibrium between stability and change, and distinctiveness and openness. The enduring elements of an architecture must be of a sufficient quality to become timeless, while the mutable elements must transform with ease and without evidence, maximizing use and minimizing resistance. Additionally, it is doubly important for a long-term architecture to perform sustainably since its energy profile will be extended deep into the future. Alex Gordon's prescient 1972 appeal for an architecture of "long life, loose fit, low energy" is even more imperative now that we are fully cognizant of the impact the built environment has on the global environment (Lifschutz 2017, 8).

3.3 CULTURAL VALUE

Cultural value is perhaps the most difficult domain in Future-Use Architecture to define, yet it is critical to the longevity of a building. The only forces that threaten the longevity of a building equal to environmental degradation are cultural forces. If an architecture has the attributes to facilitate adaptability and be symbiotic with its environmental, economic, and cultural contexts, it generates value. The greater the value an architecture has, the more likely that it will be maintained and protected by the society which it serves. Dietmar Eberle looks to history to explain what qualities create a lasting architecture. He states:

> History teaches us that buildings need to be robust. Robust refers to the materiality of the building and its simplicity, but also to the architectural qualities of the building: arrangement and dimension of the rooms, daylight–the ability to provide comfort and well-being. This type of robustness guarantees a long life for the building instead of assigning the users a kind of compulsory happiness (Eberle and Aicher 2015, 166-167).

Figure 2: Haus 2226, Baumschlager Eberle. Source: (Author 2016)

Dietmar Eberle's Haus 2226 in Lustenau, Austria, provides an excellent precedent for a Future-Use building (Fig. 1). The exterior walls are also a quintessential integrated system. They provide vertical structure, thermal resistance, and natural light and ventilation that is so highly tuned to its environmental context that it supersedes the necessity for any additional mechanical systems (Fig. 2). The interior structural floor spans from exterior support to interior core, thereby creating quadrants of open space on each floor. There is a raise-floor cavity and floor access panels ringing the central core for ease of installing new electrical and plumbing services anywhere in the floor plan. The building has a diversity of uses creating a hub of activity across the full diurnal cycle. It currently houses professional offices, private residences, a gym, and an art gallery. The exterior projects a robust and stately architecture, one that remains constant even though there is such dynamism within.

Cultural value also operates at the urban scale. Buildings that possess good urban responses, such as defining and socially animating street and public spaces, providing a good mix of public uses, and respecting the scale of neighboring architectures, create good cities. Eberle reinforces this notion when he states, "For the long-term value of the building, what counts is public acceptance" (Eberle and Aicher 2015, 169). When buildings with Future-Use Architecture attributes are aggregated into urban form, whole urban districts collectively become highly desirable places to live. Most modern cities have post-industrial districts of warehouses and manufacturing buildings that are no longer needed for their original purpose, such as Fort Point in Boston, River North in Chicago, and the Pearl District in Portland, OR. Since the buildings have ample fenestration, open floor plans and high ceilings, they have easily accommodated new uses. Often such buildings have a great variety of uses on different floors of the same building creating diverse neighborhoods of mixed residential, commercial, and cultural uses. These historically industrial districts prove that the principles of Future-Use Architecture do create a persistent architecture and urbanism that is socially vibrant, economically strong, and culturally valuable.

4.0 COMPARISONS

Because Open Building and Future-Use Architecture share the conviction that provoking change within the profession is imperative to better manage the resources devoted to the built environment over the long term, a comparative analysis of the two can expand the strategies and tactics to produce durable architecture and resilient cities. At the scale of the building, the principles of both identify a necessary balance between the logically fixed and the possibly flexible elements in the design of enduring buildings. But there are differences in how each seeks a balance between flux and fixity. Open Building subdivides building components to supports and infill where the base building is designed by an architect with a sufficient capacity for individual users to configure their interior fit-out, perhaps with the aid of a pre-established infill system. Open Building also advocates for separating service systems to facilitate their separate and subsequent changes. Future-Use Architecture is more invested in the fixed systems, be they separately articulated or highly integrated, that operate passively to the greatest extent possible. But it does not project precisely how architects over generations will choose to infill the open spaces. Neither set of principles are stylistically determinant. However, Open Building is deliberately antagonistic to repetition and uniformity, advocating instead for variety and individual expression within the architectural frame. Future-Use Architecture, on the other hand, finds the regularity of structure as liberating for possible interior uses, and the repetition of fenestration as responding uniformly to solar orientation, natural ventilation, and variable interior subdivision.

At the scale of the city, Open Building and Future-Use Architecture both embrace the concept that the aggregation of enduring buildings into an urban district creates resilient, economically vibrant, and desirable urbanisms. Open Building, however, looks to the post-war mass housing with its comprehensively planned districts and anonymous architecture as a paradigm to overcome. In contrast, Future-Use Architecture emulates post-industrial urban districts comprised of buildings with open floor plans, abundant natural light, and culturally significant architectural expression as a paradigm of urban resiliency. Both, however, embrace a participatory design ethos that engages the individual in the design of their own interior space within the stable architecture of a base building.

Most critical, however, is that Open Building and Future-Use Architecture both promote design processes that incorporate the temporal dimension into professional practice with full consideration for the life-cycle of material, architecture, and urbanism. Lifschutz captures the essential value of designing with time when he states:

> "The key to appropriate building design is an understanding of time, a predisposition towards buildings in continuous flux rather than as static lumps. In this light, the role of the architect is to facilitate change, and to liberate users to achieve their destinies. Simple plans and sections, generous volumes and structural capacities are at the heart of that liberation" (Lifschutz 2017, 17).

Habraken correctly laments that we take "as self-evident that a studio task starts with a functional programme. In short, the dimension of time is not part of architectural theory" (Habraken 2017). For Open Building and Future-Use Architecture, the program is not a list of functions, but instead is the performance of architecture over time.

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A CASE STUDY OF A 'HIJACKED' BUILDING, JOHANNESBURG SOUTH AFRICA

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ABSTRACT

1994 was a significant year in South African history. It signified the change from an Apartheid Government to the Democratic Republic of South Africa. Although this democracy signified freedom and diversity, this transition came with significant social challenges. Today, 24 years after democracy, South African Cities are still confronted by the repercussions of historically segregated Cities. Post 1994, Inner City Johannesburg experienced great transformation. Racially segregated zoning laws were lifted and more black people started to reside in the previously 'white only' spaces that surrounded the CBD. This change resulted in a large migration of white people leaving the Inner city and moving to lower density suburban areas north of Johannesburg.

The case study in this research paper is based on a medium density residential block just outside the Johannesburg CBD. This block was built in 1956 in a historically middle income Jewish Suburb. Over a 62 year period, its story evolved into being a high density, informally occupied or 'hijacked' building.

This paper is an exploration of an informal building in transition. The analysis of the changes that have taken place in the building will be based on architectural drawings, analysis sketches and interviews. The overall concept of these studies will be based on open building principles of spatial transformation and communal design decision making. The existing community have experimented with a series of modifications that have attempted to improve the sustainability of this particular building. These systems could be used in order to improve the longevity of various other 'hijacked buildings' in inner cities.

This case study also documents the resilience of a building that has endured significant demographic changes. It will reflect on the significance of the buildings design and will comment on the socio-economic and socio-political adaptation 'hijacked buildings' to further comment on the current state of inner city housing and explore ideas of the future development of resilient spaces and resilient cities.

Interactive Session: The Presentation of this Paper will include an Interactive session that demonstrates architecture as a blank canvas, and adaptations that arise according to socio- economic, socio-political and cultural transformation.

KEYWORDS: Resilience, Sustainability, Transformation, Architectural History, Social Layering

INTRODUCTION

The post- apartheid constitution of 1996 introduced new concepts of democracy, diversity and the right to access adequate housing for all people in South Africa. The abolition of the Group Areas Act if 1950[i] meant a total shift in Post-Apartheid Cities. In the case of Johannesburg, it signified the relocation of white people and a substantial number of influential corporates from the Johannesburg CBD to the Northern Suburbs, leaving the Johannesburg CBD as an "empty shell" for black South Africans to live in. This "empty shell" also became the home for a number of African foreign nationals which has also posed a point of tension for the inner city. (Smith 1992) (Dewar 2000) (Tomlinson, R. et al 2003)

The Apartheid laws of area based racial segregation were abolished in 1994. 24 years later, segregation is now based on socio-economic status (Tomlinson 2001) (Osman, Sebake 2010). This condition is also highly influenced by historically white owned land being based within close proximity to the CBD, and black owned land being located extensively large distances from the CBD. This legacy has resulted in two outcomes; Firstly, low income populations spending up to 35% of their income on transportation costs (Kerr 2015), and secondly the creation of informal settlements in and around the economic hubs of South Africa. A typical case of informal settlements within the CBD includes that of hijacked buildings[ii].

This paper examines a case study of Josanna Court.[iii] This is a hijacked building in close proximity to the Johannesburg CBD and forms a case study on spatial adaptation and the significant transformation of inner city housing in Johannesburg post-apartheid. Hijacked buildings are a contentious issue on an international scale, although the majority of these environments do not provide ideal living conditions, hijacked buildings are synonymous with the high rate of urbanization within the African continent, Johannesburg is no exception.

The case study will discuss 'disentanglement' in relation to the sustainable support systems and participatory processes that have been put in place. It will also explore the life cycle of a building, in relation to Time Based Architecture (TBA) in order to understand a model of affordable inner city housing within Johannesburg that could hopefully impact policy, existing structures and frameworks around rehabilitating inner city buildings for affordable housing purposes.

1.0. SUPPORT LEVELS OF JOSANNA COURT

The sustainability of Josanna Court, the community it houses and the longevity of the building is dependent on the existing governing structures and community participatory structures.

1.1. Location, Government and Private Sector Support

The initial drivers for the residents of Josanna court is based on a lack of affordable well located housing within the country. Many of the residents of Josanna court moved to this location, to have access to job opportunities with affordable rentals as seen in table 1. The residents of this building informally inhabited this building from approximately 2001 until present. Some of the residents have been living in this building for up to 21 years. Governing laws and the Prevention of Illegal Evictions Act (1998)[iv] is a primary level support, nationwide that has enabled the residents of Josanna Court to reside there for up to 21 years. Josanna Court is owned by the city of Johannesburg, and although the residents of the building are not paying any form of rent or levies, they are legally pardoned to stay within the building until alternative accommodation is made available to them. The building is also protected from any demolition as it is over 60 years old and in now a protected heritage building. The governing laws of the country have made it possible for the residents of Josanna Court to remain here, but the City of Johannesburg officials have notoriously harassed these inhabitants, threatening eviction. Although the PIE Act has protected these residents, it has also challenged existing development goals of city development.

The location and medium density typology of Josanna Court is in line with new affordable housing development policies in South Africa, Breaking New Ground (BNG)[v], the building is situated on extremely valuable, well located, and high density zoned land. The buildings typical unit sizes of 84sqm, 2 bedroom dwellings are much larger than standardized subsidized housing that has typically been pegged at 40 sqm, 2 bedroom dwellings. The city has argued for the demolition and redevelopment of this land to provide more efficient housing, but due to the extreme housing crisis, the municipality has no place to move all 76 residents to, whilst developing this land. This has brought development on this site to a stalemate, and has stagnated any future development/ investment into the building from the state.

Table 1

Reasons why residents moved to this building

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Employment opportunity	23	59.0	**60.5**	60.5
	To be closer to family	2	5.1	**5.3**	65.8
	Affordable rent	12	30.8	**31.6**	97.4
	Was evicted	1	2.6	**2.6**	100.0
	Total	38	97.4	100.0	
Missing	System	1	2.6		
Total		39	100.0		

Source: Field Data, 2018

1.2. NGO and Resident Participation

The PIE Act has provided 76 of the buildings residents with accommodation for up to 21 years, but the secondary support level was provided to the residents by NGOs such as Plan Act, SERI[vi] and the ICRC[vii] . These NGOs provided access to information to all residents around their rights. Prior to 2003 the residents of Josanna court were constantly raided and harassed by police officers. In 2003, the building residents partnered with NGOs that informed them of their rights, the police harassment came to an end, and subsequently the residents began to take ownership over the building. (Melta 2017)

These NGOs gave the residents access to legal information and representation. They also provided support around creating governing structures, strengthening relationships and leadership structures between residents which resulted in more sustainable management structures being put into place.

2.0. LIFE CYCLE OF JOSANNA COURT

Lukez comments on how built environments can be treated as living systems. Time Based Architecture (TBA) (Lukez 2009) can be applied to Open Building theories, particularly pertaining to physical, financial and management implications of a building. (Osman, Sebake 2010). The Life Cycle of Josanna Court will be discussed in relation to its developments in forms of tenure, qualities of built form, recycling of built materials, building diversity as well as financial and management structures.

2.1. Evolution of Tenure, Density and Financial Structures

The timeline of tenure for Josanna court has evolved from a privately owned middle income, medium density building, built in 1956 within a white, predominantly Jewish suburb to that of a middle and low income, medium density, predominantly black housing around 1995 (1 year after the end of apartheid) and 21 years later, in 2018, the building has become a relatively high density, low income, with a mix of 55% South African and 45% foreign African nationals in the building. This pattern is consistent with the demographic change post-apartheid as seen in Figure 1a.

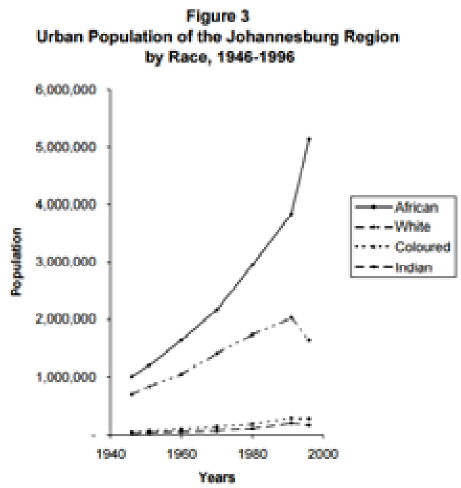

Figure 1a: Urban population of Johannesburg region by race (Crankshaw & Parnell, 2002)

Prior to 2001, the residents of Josanna court were paying for rent as well as water and electricity. Figure 1c demonstrates a change of tenure. The payment of water and electricity came to a halt when the residents started experiencing water cuts, power cuts and police raids. This brought awareness to the fact that their former landlord was not paying any rates of bills and that the building had been bought by the City of Johannesburg. There was no communication between the residents and the city around this change. In the last 15 years the residents have not paid formal rent (apart from where subletting has taken place) and have resorted to illegal service connections in the form of water and electricity.

The lack of levies/ rental system also meant that the general upkeep of the building fell below par. In 2003, with the assistance of the NGO Plan Act, a leadership structure was established. This leadership structure enabled the building residents to organize weekly cleanup sessions and weekly meetings. This progression in residents taking ownership over the building also established systems where the residents put together money to install a security gate, paint the building and repair a number of windows in the building as seen in Figure 1b (Melta 2017).

Figure 1b: Photograph of new security gate funded by residents and new glass panes fitted by tenants (Photos by author, 2017)

There is currently no formal financial arrangement for rental within the building. The building committee has established a formal agreement with all residents in the building that establishes their right to the room they stay in. When residents move out of the building, these agreements are usually forwarded to a close friend/ relative to the person moving out, and encourages the community remains intact. People without direct references to the building are not typically allowed to stay in the building.

Between the years 2001-2003, the building was at its highest occupation rate with living rooms being utilized to house short term tenants. This also resulted in the highest crime rates that have been experienced within the building. With assistance of the NGOs, short term tenures in living areas was put to an end, and crime was drastically reduced. Many of these short term tenants were residing in the communal living areas. These communal living areas became grey areas of ownership, and because of this it was difficult to control/ keep track of the short term tenants which typically resulted in petty crime incidents. These incidents initially sparked xenophobic tensions in the building, as many of the short term tenants were foreign African nationals, but with time the residents discovered the petty crime issues were more a result of short term tenancy than the presence of foreign national tenants.

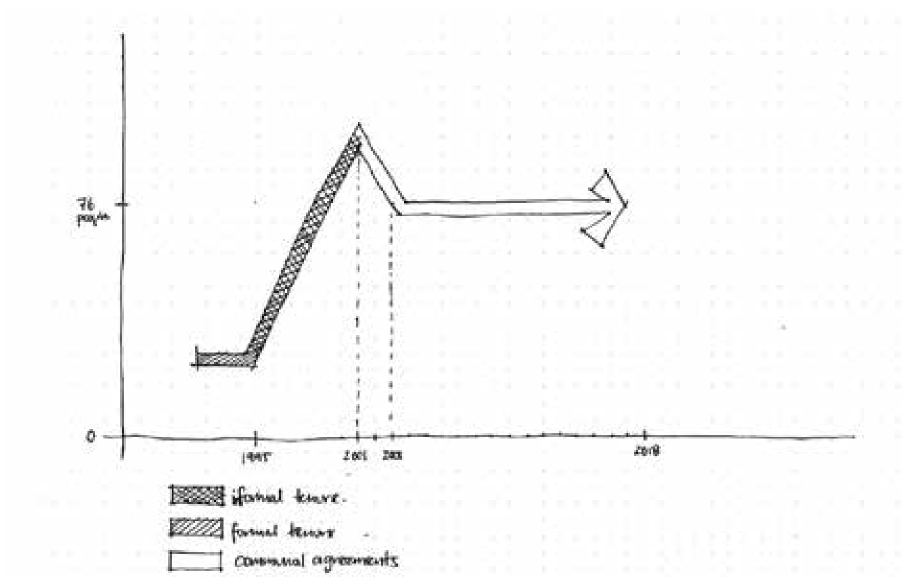

Figure 1c: Approximate number residents of the building vs forms of tenure 1995-2018 extracted from interview (Melta 2018)

2.2. Structural and Spatial Qualities of Josanna Court.

According to Durmisevic (2006), the degree of disassembly is determined by independence and exchangeability. "The first is a measure of their entanglement, the latter determines the reversibility of the connections." (Osman& Herthogs, Davey 2011, 3)

Josanna Court was built in 1956, its architectural characteristics are typical of Post War modernism in Johannesburg, with an emphasis on horizontality, utilitarian planning and a flat concrete roof. The structure is made of concrete slabs and supporting brick core walls, strategically located to create central ducts.

The permanence of the buildings appearance suggests that adaptation was not at the forefront of its conception. This is clear in the usage of in situ concrete and masonry wall materials that were typical of the buildings period as seen in Figure 2a.

Although the building is not a prime example of an adaptable building, it is success lies in its "robustness" and "resilience" factor. The flat concrete roof, short spans and over engineered foundations have allowed for future expansion/ extending of the building. The longevity of this building could also be based on the choice of masonry materials. During the timeframe of 2001-2003 various steel elements and waterproofing was stolen from them building as seen in Figure 2c. This is typical of the petty crime in the Johannesburg CBD, and should always be considered when designing for open building purposes in this context. Steel is a popular commodity, and can be sold for high returns for people who have no other sources of income. In situ concrete slabs and columns alongside masonry walling with mortar should be used as a preferred medium when building structures within the Johannesburg CBD.

The residential units range in size, largest being 84 square meters and smallest being 8 square meters. The larger units could accommodate internal adaptations due to the generous sizing of the rooms. Figure 2b has shown the number of households over a 62 year period, based on the experience of the most long term tenants in the building.

Figure 2a: Building Perspective from street (Field Data, 2018)

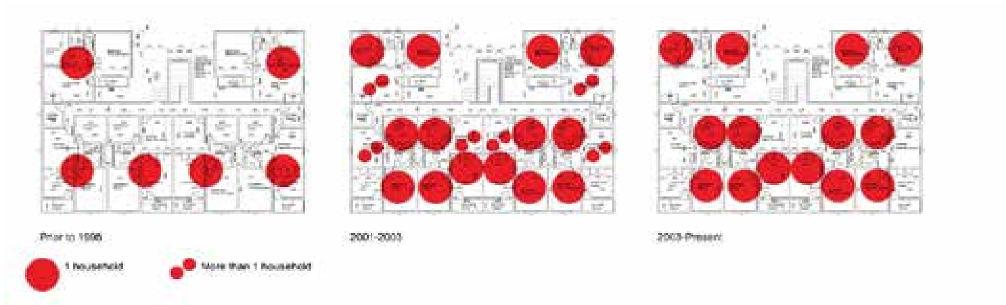

Figure 2b: Change in number of households, typical floor plan 1994-Present (diagram by author)(Melta 2018)

Figure 2c: Image of flat concrete roof. Waterproofing was removed between 2001-2003.

The layout in figure 2b could allow for units to be connected, however the choice of material-brick would make it more challenging to alter as opposed to using a more semi-permanent materials .i.e. dry walling/ timber etc. Plumbing cores being placed central to layout allows for freedom of movement and change.

2.3. Sustainability, Recycling of Building Materials, Theft, Informality and Building Adaptability

Theft is a large issue of hijacked buildings in Johannesburg. The gap in ownership structures of the early 2000s in the building resulted in washing troughs and bitumen waterproofing on the roof being stolen from the building as seen in Figure 2b. The in situ concrete slab without bitumen waterproofing has caused substantial water damage to the building. These items were stolen and relocated outside the building. This resulted in a very costly need for waterproofing within this building.

Through this state of transition, the flat roof acquired a layer of river sand up to 250mm thick, this has been speculated to be resultant of silting, or the remnants of residents' construction in the 3rd floor. This layer of sand has brought an alarming reaction from civil and structural engineers that stress that this sand needs to be removed, as it forms a sponge during rainy periods and adds considerable loads to an already vulnerable concrete slab. The reinforcing of the slab has been eroded at numerous points.

Although this sand is cautioned around its addition to live loads its irregular building detail as seen in Figure 3 has resulted in the sand playing a useful role in concealing illegal electrical wiring on the roof, thus protecting residents and children from live/ informally connected wiring.

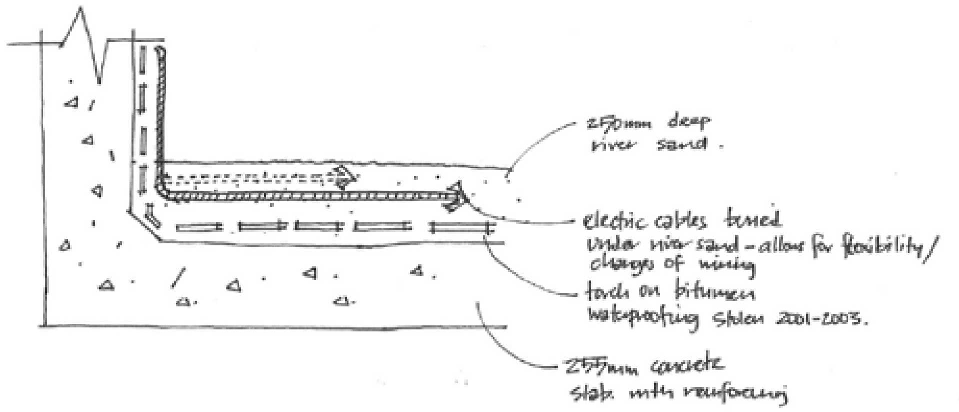

Figure 3. Detail of roof slab by author

2.4. Building Diversity

Open building can also be used as a restructuring tool (Osman& Sebake 2010). The informality/ flexibility of tenure has allowed for mixed use land use as well as a diverse range of South African and foreign African nationals within the building, living together and working together for the betterment of the building.

2.4.1. Mixed Use Land Use

The informality of tenure/ flexibility of tenure allows for informal businesses to take place within a building that is zoned for residential use only. The home based enterprises as seen in Table 2, breaks norms from conventional affordable rental housing models and allows for economic opportunities, and social gatherings through the mixed uses of the building.

The informal tenure of the building has also incited an informal enterprise initiatives to create alternative uses of rooms within the building. It could be argued that if more formal regulations had been enforced, the car mechanic and general dealers would not have been established. These informal conditions/ alternative and organic regulatory processes have allowed for the betterment of livelihoods in the building. It should also be noted that two alternative uses of the building were a result of location of units. The ground floor, street facing units, resulted in the founding of a mechanic and convenience store.

Table 2:

Non-Residential Land Use of Units					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Church	1	2.6	**3.1**	3.1
	Convenience shop	5	12.8	**15.6**	18.8
	Shebeen-Beer distributer	2	5.1	**6.3**	25.0
	Other	8	20.5	**25.0**	50.0
	Not applicable	16	41.0	**50.0**	100.0
	Total	32	82.1	100.0	
Missing	System	7	17.9		
Total		39	100.0		

Source: Field Data, 2018

2.4.2. Diverse Range of Tenants

The informal nature of tenure allows for more inclusive, diverse income groups and residents with various cultural backgrounds/ various nationalities. This process is more informally conducted through a first come first served basis that has been community lead, allowing form organic human intervention/ “emergence” to occur.- this open building principle of diversity is consistent with South African constitutional aspirations, as well as aspirations of inclusive housing , part of the Breaking New Ground housing policy aspirations.

The range of tenants in 45% foreign African nationals and 55 % South African residents (Field Data 2018). A number of residents do not have formal legal residential status in South Africa, but the informal nature of tenure has allowed for these foreign nationals to find well located and affordable housing. The majority of these foreign nationals are men, and are typically artisans that can add value to the building. Through trial and error it was a community driven decision that foreign African nationals could only be tenants on a long term basis.

2.5. Management

User participation in decision making within this building is a democratic processes and decisions have been steered through the discourse of human interaction with the built form. The leadership structures, and management structures put into place by the NGOs have been an integral part of the success of this building in comparison to other hijacked buildings (Melta 2017). Many other hijacked buildings within the Johannesburg CBD have fallen into squalor due to a lack of management systems, and a lack of ownership from the residents of the buildings. The management structures put in place have allowed for the residents to be in this building for up to 21 years. This has also lead to negotiations with the city of Johannesburg, discussing possible formal title deeds, with respect to existing tenants having full ownership over their units.

CONCLUSION

There are various challenges that the residents of Josanna court have experienced since 1995, the biggest issue being around forms of tenure and management structures. This building hit the all-time high of crime and overcrowding when management structures were at an all-time low. This all-time low lead to various items and waterproofing being stolen from the building and being the source of long term waterproofing issues. This reinforces the importance of robust, resilient building materials being used for all sustainable, time based architecture within this context.

Through the assistance of partnering NGOs, these management structures have been developed into an organized building leadership structure, based on community meetings and democratic voting processes. This management system, has failed in many state driven corporative housing models. The reason why this process works here is because of the long term tenure of the residents, the value of the building due to its robust materiality and convenient location that offers minimal transportation costs and access to jobs.

The organic, long term building of community leadership in this building has also allowed for a harmonious relationship between foreign African nationals and South Africans within the building, which has come about as a result of trial and error and it is now understood that crime is not necessarily associated with foreign African nationals but rather short term tenancy patterns.

The semi-formal/ flexible tenure within the building has also allowed for examples of affordable housing with mixed use land use, particularly on the ground floor. This could be perceived as a pilot in order to understand how allowing for mixed use/ flexible zoning within affordable housing schemes could be revolutionary in allowing for home based enterprises to grow and in doing so uplift the overall livelihoods of the people within these mixed use areas.

The nature of a hijacked building within Johannesburg has begun to symbolize, squalor, poor spatial layouts and badly maintained buildings. It has suggested that informality cannot result in good living conditions. This case study signifies that with good policies/ legal guidance, management guideline assistance from NGOs, democratic participatory processes and long term investment of residents in their place of residence, informality can allow for new economic opportunities and a space that encourages changes over time. This also allows for opportunities for diverse income levels and nationalities to live and work together for the betterment of their environments.

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[i] The Group Areas Act if South Africa, No. 41 1950 was an Apartheid law that spatialized racial segregation. The result of this law ensured that during Apartheid, the economic hubs of South Africa was a predominantly white spaces, the law also produced residential areas that segregated race and tribes of South Africa.

[ii] Hijacked buildings refer to existing buildings that have been informally occupied, in most cases, for residential use. The inhabitants of these buildings typically do not pay rent and are not guaranteed any basic services i.e. access to electricity/ water.

[iii] The information that has been documented in this paper is from findings taken from an ongoing Community Based Project by the University of Johannesburg's Housing and Urban Environments Architectural Design Elective.

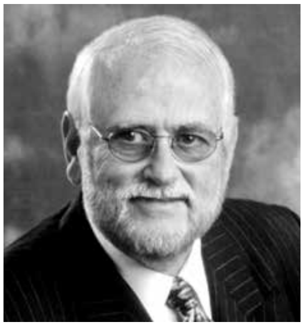
[iv] the Prevention of Illegal Evictions Act (1998) was also a direct response Apartheid forced removals, this act ensured that forced removals cannot take place, unless the people who are being evicted are provided with alternative accommodation.

[v] Breaking New Ground is a new comprehensive plan for providing sustainable human settlements within South Africa. Some of the principles include densification, diverse, mixed use and inclusionary housing.

[vi] Socio-Economic Rights Institute of South Africa

[vii] Inner City Resource Centre

Keytonoter Speakers



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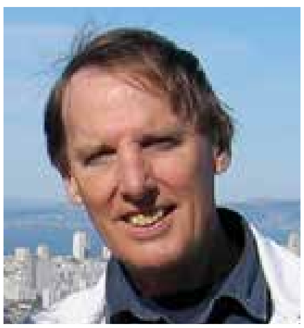

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Nirit Putievsky Pilosof is a registered architect, a Ph.D. candidate at the Faculty of Architecture and Town Planning at the Technion - Israel Institute of Technology, and the Israeli representative at the UIA Public Health Group. Nirit practiced architecture at leading architecture firms in Israel and Canada, specializing in healthcare design. Nirit holds a Post-Professional Masters of Architecture from McGill University and has gained international awards including the prestige's AIA Academy of Architects for Health award, the American Hospital Association (AHA) graduate fellowship, and the Azrieli Foundation fellowship.

DR. BRANDON E. ROSS

Assistant Professor, Glenn Department of Civil Engineering, College of Engineering, Computing and Applied Sciences, Clemson University, Clemson, SC

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Brandon E. Ross is the Cottingham Associate Professor in the Glenn Department of Civil Engineering at Clemson University. His research focuses on three overlapping areas: experimental evaluation of reinforced and prestressed concrete, design of buildings for future adaptation, and low-cost technologies for housing in developing communities. Dr. Ross earned his BS and MS degrees from the University of Wyoming; his PhD is from the University of Florida. Prior to embarking on an academic career he worked as a consulting structural engineer in the Pacific Northwest. Dr. Ross is a licensed Professional Engineer in Idaho.

JAIME SARMIENTO

Professor Universidad Nacional de Colombia, Medellín, Columbia

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Jaime Sarmiento Ocampo is an Associate Professor at the Universidad Nacional de Colombia, and director of the master's degree in architecture. He was Titular Professor at La Salle Schools of Architecture in Barcelona, where he obtained his doctorate. He has been invited as speaker at several universities in Latin America and Europe, with publications in international books and magazines. He has also worked as architect designer and builder in Colombia and Spain. Now Mr. Sarmiento is researcher in sustainable social housing, inventor of a lightweight modular construction system

ALBERT SAWANO

Principal Architect, Synchronis
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Albert Sawano has applied his 30 year's experience on major building projects to converge upon a design approach that sets aside traditional polarities such as functional vs. aesthetic, or architectural vs. structural, in favor of design that is holistically-approached, integrative, and synchronistic. Prior to founding Synchronis in 2017, he has been in the unique position of holding a Principal Architect or project leadership role on several landmark Los Angeles projects since 2001 including Constellation Place, 2000 Avenue of the Stars, USC Village, The Vermont, Circa, Metropolis, and Century Plaza Towers.

CHAMNARN TIRAPAS

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Dr. Chamnarn Tirapas is a full-time lecturer at School of Architecture and Design (SoAD), King Mongkut's University of Technology Thonburi (KMUTT) in Thailand. In 1999, he received the Bachelor in Architecture from SoAD, He received Master of Architecture from Ball State University in 2004. He received Master of Engineering and PhD. of Architecture from Kyoto Institute of Technology, Kyoto in 2015. His interests are urban housing and urban living, especially, shophouse and its diverse usages. Currently, he is the head of the Graduate Program of Design and Planning, SoAD.

PETER WIEDERSPAHN

Associate Professor of the School of
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Peter Wiederspahn is an associate professor at Northeastern University, Boston, MA, and principal of Wiederspahn Architecture, LLC. His research and pedagogical foci are on architectural design, production, performance, and systems. He has been awarded the 2017-2019 FAIA Latrobe Prize and a Graham Foundation grant, and his architectural practice has received numerous design excellence awards. He earned his Bachelor of Architecture from Syracuse University and his Master of Architecture from Harvard University.

AFUA WILCOX

Lecturer, University of Johannesburg,
South Africa

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Afua Wilcox is a professional architect and a design lecturer at the University of Johannesburg. Afua has worked as an architect for the past five years in a practice largely focused on affordable housing design, sustainable urban environments and related policies. She is also a director at the African Architects Collaborative, a non-profit company that strives to make architecture more accessible to previously disadvantaged communities. Her academic architectural work has led her to pursuing research within the field of housing and African identities.

Paper + Poster Session Presenters

BONGJAI SHIN

Architectural Designer at Harley Ellis Devereaux and Research Lead at Labot

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Bongjai Shin is an architectural designer at Harley Ellis Devereaux. He is interested in design automation especially for space planning and has developed software with his personal research team, Labot.co. His professional experience includes a couple of the biggest mix-use projects in LA, Metropolis and Century Plaza Redevelopment, as well as an innovative K-12 project, Santa Monica High School Discovery Building. He holds a Master in Architecture degree from Harvard.

Healthcare Panel

STEPHEN KENDALL

Emeritus Professor of Architecture, Ball State University Council on Open Building / Infill Systems US LLC, Philadelphia, PA

sk@infillsystemsus.com

Dr. Kendall is a registered architect and holds a PhD in Design Theory and Methods from MIT. His career in architecture, research and education spans more than 35 years. His research focuses on the Open Building approach, needed to make buildings more adaptable, easier to customize to meet changing preferences and thus more sustainable. He is author of more than 50 papers, co-author of Residential Open Building (Routledge) and editor of Healthcare Architecture as Infrastructure: Open Building in Practice (Routledge)

MEHRDAD YAZDANI

Design Principal, Yazdani Studio, Cannon Design Los Angeles, CA

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Mehrdad Yazdani's design philosophy is focused on maintaining an environment of exploration, tempered with a realistic sense of each client's needs and pragmatic details. As a design principal at CannonDesign's national practice and the director of the Yazdani Studio of CannonDesign, he possesses deep experience designing complex design work across the globe. His buildings are responsive to context, climate and culture, while achieving enduring value with a conscientious respect for client budgets and schedules.

JOHN PANGRAZIO

Consulting Partner, NBBJ Seattle, Washington

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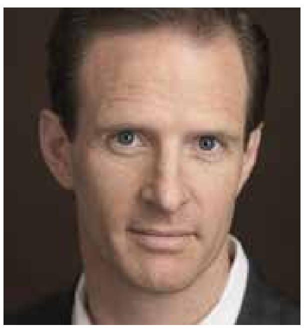
John Pangrazio is a consulting partner at NBBJ. In a 40-year career devoted to designing buildings that promote health and healing, John has been instrumental in shaping NBBJ's internationally recognized healthcare practice. He has designed more than 100 healthcare projects, establishing precedents for quality and innovation. He is a former president of the AIA American Academy of Healthcare and the American College of Healthcare Architects (ACHA) and a recipient of the ACHA Lifetime Achievement Award.



BILL SCRANTOM

Principal, Healthcare Business Leader for Arup in the Americas, Los Angeles, California

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Bill Scrantom is Arup's LA Buildings Practice Leader, the Americas Region Healthcare Business Leader and sits on the regional board. Bill has 30 years of experience in the industry working with owners, architects, and contractors to develop sustainable design solutions that reduce resource consumption and improve operational cost. He has touched virtually every aspect of the project lifecycle – from design to delivery – with a strong focus on design and project management. He believes that integration and collaboration are key to every project's ultimate success. As a hands-on leader, Bill maintains significant involvement on the design side of his projects, championing strategies which improve owner outcomes.

NIRIT PILOSOF

PhD Candidate, Architect, Technion Faculty of Architecture, Faculty of Architecture and Town Planning, Technion - Israel Institute of Technology

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Nirit Putievsky Pilosof is a registered architect, a Ph.D. candidate at the Faculty of Architecture and Town Planning at the Technion - Israel Institute of Technology, and the Israeli representative at the UIA Public Health Group. Nirit practiced architecture at leading architecture firms in Israel and Canada, specializing in healthcare design. Nirit holds a Post-Professional Masters of Architecture from McGill University and has gained international awards including the prestige's AIA Academy of Architects for Health award, the American Hospital Association (AHA) graduate fellowship, and the Azrieli Foundation fellowship.

Housing Panel

JEROME OTIS ODELL

Sector Leader, Harley Ellis Devereaux (HED) Los Angeles, California

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Otis brings over 30 years of experience, with multifamily housing projects nationally. He excels at client relationships and project over-sight, and has been the Principal-in-Charge for a wide variety of assignments including market rate, high-rise, affordable, and senior housing. Otis's expertise includes facilitation of community meetings and neighborhood forums. Most recently, he has worked on multiple affordable housing developments in LA and a large scale residential mixed-use development in the City of Pasadena.

BEISI JIA, PHD

Associate Professor,
Department of Architecture,
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Jia Beisi studied at the Nanjing Institute of Technology (NIT China) and the ETH Zurich where he earned a PhD. He is an Associate Professor of Architecture at the University of Hong Kong, where his students have won more than 30 design competitions. He is the joint coordinator of W104-Open Building Implementation (CIB) and has published 4 books and 53 papers in international and/or national journals. He is also the Director and Partner of Architectural design office Baumschlager Eberle Hong Kong.Ltd.

TOM FRANTZEN

Lemniskade Projects / FRANTZEN et al architects

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Tom Frantzen started his career as an independent architect shortly after graduating Cum Laude at the Technical University of Eindhoven in 1995. Since then his office "FRANTZEN et al" won several competitions and completed a number of high quality buildings. In 2009 Tom founded "Lemniskade Projects" together with building-manager Claus Oussoren to develop architectural projects from initiative to completion as an architect-developer. In 2018 Lemniskade was awarded the Golden Pyramid 2018, the biannual Dutch state prize for excellence in commissioning work in the spatial disciplines.

BRIAN FALLS

VP Development, Palisades,
Los Angeles, California

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Brian is the VP of Development with Palisades, a design-driven real estate development and investment firm based in L.A. Brian has 20-years of development experience on large mixed-use projects ranging from Playa Vista, The Bloc, NBC Universal and Campus El Segundo to small infill developments in Hollywood. Palisades has 8 projects under development including 1111 Sunset, a 5.5-acre residential, hotel, retail and office complex. Brian has a Bachelor of Science in Civil Engineering with a minor in Architecture (Building Science) from the University of Southern California and a Master of Real Estate Development from USC's Price School of Public Policy.

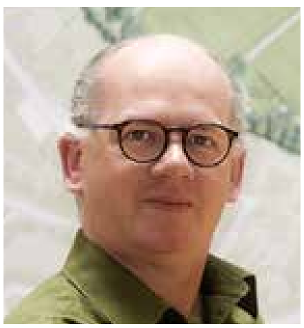
Education Panel

JOHN DALE

Pincipal, Pre-K12 Studio Leader, Harley Ellis Devereaux (HED), Los Angeles, CA

jdale@hed.design

John has been designing educational environments for over 25 years. In 2007, he was named a Fellow of the American Institute of Architects (AIA) for this focus. By defining small learning communities which boost student achievement and galvanize community involvement, he creates high performance, sustainable learning environments. He was 2016 Chair of the AIA's Committee on Architecture for Education. He is currently a member and Past-President of the Board of Directors of the A+D (Architecture and Design) Museum,LA and Co-Chair of the North American Council on Open Building.



JAMES O'CONNER

Moore Ruble Yudell Architects and Planners, Santa Monica, CA

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James O'Connor, FAIA received the AIA Young Architect Award and was cited as "a virtual ambassador for American architects, he brings excellence, humanity, and honor to his profession." James entered Charles Moore's Master Studios at UCLA as a Fulbright Scholar from Ireland. Now, as Principal-in-Charge at Moore Ruble Yudell, James provides design leadership for residential, academic and mixed-use urban projects. International work includes housing and planning projects in Sweden, Philippines, Japan, China and Ireland. James has taught design studios, lectured, and been invited as guest critic to universities around the world.

CARY UPTON

COO, Santa Monica Malibu Unified School District, Santa Monica, California

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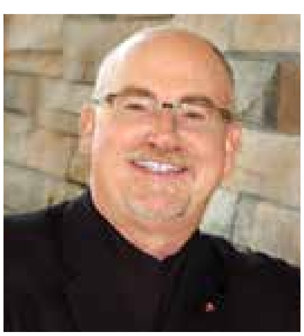
Carey Upton is the Chief Operations Officer with the Santa Monica – Malibu Unified School District where he oversees all Facility Departments, including the bond construction program. His unconventional path has led through a theatre career where he directed, designed, produced, and stage managed over 400 theater productions at major regional theaters. His teaching career includes University of Maryland, College Park where he co-directed the Whole Actor Research Project and Artist-in-Residence in middle and high schools.



KEVIN GREISCHAR

Principal, DLR Group, Overland Park, Kansas

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Kevin has practiced architecture in the Midwest for 35 years and is responsible for designing almost 10 million square feet of educational space PreK-16. His last 12 years has been spent leading the Southeast Region of DLR Group PreK-12 from his Kansas City, Missouri office. After a devastating tornado in 2011 destroyed the high school in Joplin, Missouri he led the team to recreate an interim school for 1100 students in 55 days. This was an experience of a life time and in 2012 awarded the coveted A4Le McConnell, the top honor for international PreK-16 design.

Urban Design Panel

FAROOQ AMEEN

City Design Studio, Los Angeles, California

farooq@cityDesign-Studio.com

Farooq Ameen is the founding principal at City Design Studio, an architecture and urban design practice dedicated to revitalizing communities. He has lectured widely including the Bauhaus, Harvard and Columbia. Ameen is the author/editor of publications such as "The South Asian Paradigm", "50 Under 50: Innovators of the 21st Century", and the forthcoming "deCoding Asian Urbanism". Current projects include urban design plans for 15 communities along the LA County West Santa Ana Transit Corridor and the Shanghai Zizhu High-Tech TOD Center. He received a Master of Architecture from UCLA.

CHRIS FRENCH

District Homes / Hickok Cole Architects, Washington, DC

chris@districthomesllc.com

Chris is the founder of District Homes, and an Open Building guide working to help Hickok Cole Architects streamline the multifamily residential design process and prepare for the coming revolution in off-site fabrication. District Homes' first patent, "Reconfigurable Residential Unit," incorporates Open Building principles as part of a new way of building mixed-use rowhouses and other missing-middle scale development projects, and creates a framework for increasing choice, variety, resilience, and economic empowerment and autonomy in American communities. District Homes currently has pilot projects underway in DC and St. Thomas, USVI.

MERRILL ST. LEGER DEMIAN, AICP CUD, LEED AP

Principal, Urban Design and Planning, SmithGroup, Washington, DC

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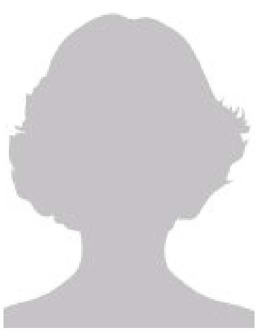
Merrill St. Leger is a Principal and Urban Design and Planning studio leader in SmithGroup's Washington, DC office. Merrill collaborates with municipalities, developers, and institutions to shape the future of cities through the design of beautiful, sustainable, and connected places. Merrill currently serves as Secretary-Treasurer of the APA Sustainable Communities Division and is involved in ULI Washington's Sustainability Initiative Council and TAP Committee.



PATRICIA DIEFENDERFER, AICP

Senior City Planner, Los Angeles Transit Neighborhood Plans, City of Los Angeles Planning Department

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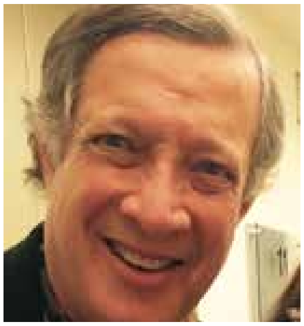
Patricia Diefenderfer is a City Planner with Department of City Planning of the City of Los Angeles. Currently, she oversees the Department's long range planning efforts for Downtown Los Angeles. She is one of two people in the Planning Department leading interdepartmental and inter-agency coordination of the High Speed Rail project in Downtown Los Angeles on behalf of the City. Her most recent project has included working with stakeholders to prepare design guidelines for the Broadway Theater and Entertainment District. She has 10 years of urban planning experience as a planner with the City of Los Angeles.



DAN ROSENFELD

Real Estate Investor
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Dan Rosenfeld is a real estate investor who alternates between private and public sector service. In the private sector, Mr. Rosenfeld served as a senior officer with The Cadillac Fairview Corporation, Tishman-Speyer Properties, and Jones Lang LaSalle. Mr. Rosenfeld is currently developing and managing real estate in Los Angeles and Seattle. In the public sector, Mr. Rosenfeld served as Director of Real Estate for the State of California and City of Los Angeles, and as a Senior Deputy for Economic Development with Los Angeles County. Mr. Rosenfeld is a graduate of Stanford University and the Harvard Business School.

The Future of the Council on Open Building Panel

RENEE CHOW, PHD, RA

Chair, Department of Architecture
University of California, Berkeley

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Renee is Chair of Architecture and Professor of Architecture and Urban Design at University of California Berkeley as well as Principal of Studio URBIS. Renee has developed analytic and generative tools for integrating urban and architectural systems across sites and individual buildings. To re-shape the discourse of urbanism, she has written Suburban Space: The Fabric of Dwelling (UC Press, 2002) and Changing Chinese Cities: The Potentials of Field Urbanism (University of Hawaii Press, 2015).

STEPHEN KENDALL

Emeritus Professor of Architecture, Ball State University Council on Open Building / Infill Systems US LLC, Philadelphia, PA

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Dr. Kendall is a registered architect and holds a PhD in Design Theory and Methods from MIT. His career in architecture, research and education spans more than 35 years. His research focuses on the Open Building approach, needed to make buildings more adaptable, easier to customize to meet changing preferences and thus more sustainable. He is author of more than 50 papers, co-author of Residential Open Building (Routledge) and editor of Healthcare Architecture as Infrastructure: Open Building in Practice (Routledge)

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CHRIS FRENCH

District Homes / Hickok Cole Architects, Washington, DC

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Chris is the founder of District Homes, and an Open Building guide working to help Hickok Cole Architects streamline the multifamily residential design process and prepare for the coming revolution in off-site fabrication. District Homes' first patent, "Reconfigurable Residential Unit," incorporates Open Building principles as part of a new way of building mixed-use rowhouses and other missing-middle scale development projects, and creates a framework for increasing choice, variety, resilience, and economic empowerment and autonomy in American communities. District Homes currently has pilot projects underway in DC and St. Thomas, USVI.

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