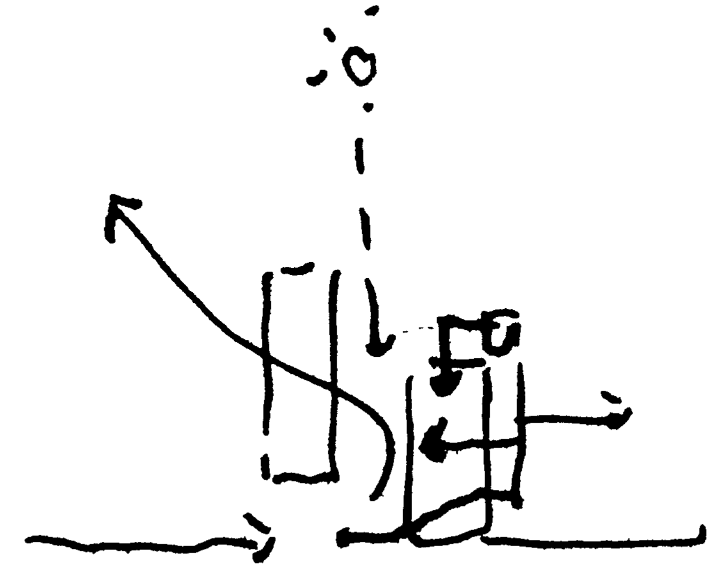
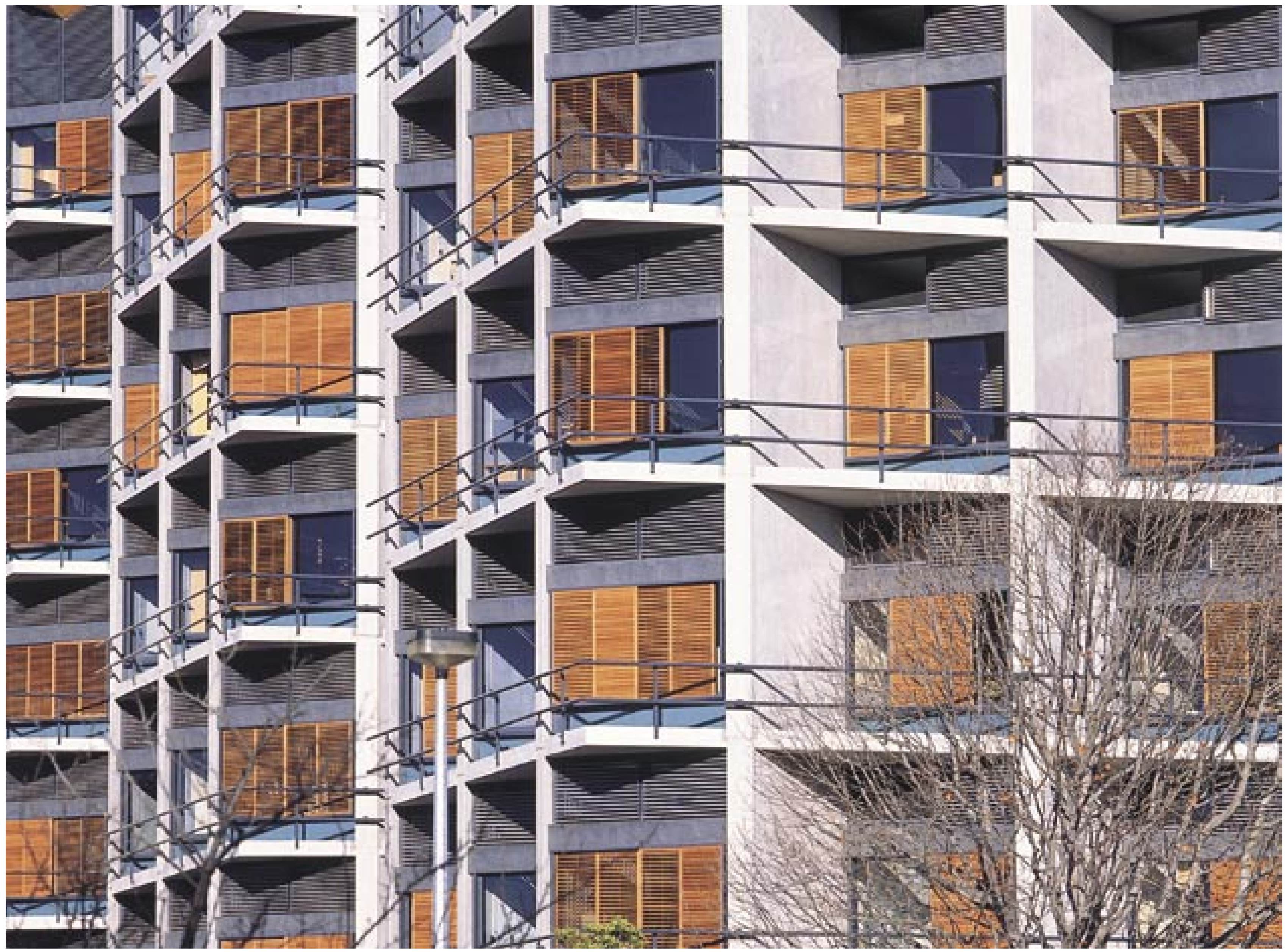
Mathematical formula

What is the formula behind the high user satisfaction and the successful environmental performance of the MSCS building at the University of Canterbury? Lindsay Johnston investigates.





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Mathematics, Science and Computer Science Building, University of Canterbury. Christchurch, New Zealand

Architectus. Architects
Lindsay Johnston. Review
Studio la Gonda & Duncan Shaw Brown. Photography

01 The rhythm of the office facades is a pattern of concrete and timber shutters.
02 The buildings are distinguished by their skewed fronts, angled north to catch the sun.

"Architectus' new Mathematics, Statistics and Computer Sciences Building for the University of Canterbury is a clear demonstration of the fact that distinguished architecture requires commitment from both client and architect. The thorough selection and consultation process, including a properly conducted architectural competition rather than a price dominated design-build submission, has resulted in an unusual combination of user satisfaction and courageous, richly layered architecture." Rory Spence in his review of the building for *New Zealand Architect*.

The name 'Architectus' is appearing rather a lot recently (*ar* 78). The practice was started in Auckland in 1987 by Patrick Clifford, Malcolm Bowes and Michael Thomson, all former students at the University of Auckland, after they had returned from a stint working in London with Terry Farrell and the Turkish-American architect Ilhan Zebekgoglu, a former student of Louis Kahn. The big breakthrough for Architectus in New Zealand was their success in a competition held in 1994 by the University of Canterbury for the master plan of the Science West Precinct of the campus and two new buildings – the Mathematics Statistics and Computer Science Building (MSCS) and the library for the Science Department.
Architectus, in association with Cook Hitchcock Sargisson and Royal Associates, won all three components of this competition. The MSCS is the first building to emerge from this competition and has given the practice an opportunity to demonstrate a strong design philosophy in a larger scale building. The New Zealand practice has, of course, recently joined forces with the Australian practice Travis McEwen, with Lindsay and Kerry Clare, under the Architectus name and has just been awarded the commission for the Queensland Gallery of Modern Art.
Christchurch is located one third of the way down the east coast of the South Island of New Zealand, at latitude 44˚S on the estuary of the River Avon. It is the capital of Canterbury province and is a small city with a population of under 200,000. The climate, which is 'rapidly changing', boasts more than 2000 hours of bright sunshine spread well throughout the year and temperatures are in the range –1˚C to +26˚C – a climate that offers good opportunities for low energy passive design.
The campus of the University of Canterbury is located in the suburb of Ilam. The terrain is flat and the site for the MSCS offers views to the north across the plains to the Southern Alps. The architecture on the campus, prior to this new intervention, has been described by Rory Spence as, on a positive note, "tough brutalist – orthogonally interrelated" and, on a more negative note, "dour pragmatic modernism". Either way it has celebrated the use of concrete, a Christchurch tradition based on abundant local resources of good gravel from the alluvial plain on which it sits. The MSCS Building imaginatively extends this. Architectus' master plan for the precinct uses the MSCS Building to form a southern edge to a space defined by two existing buildings, uncompromisingly orientated on a north-east/south-west axis. It will divide this space into two academic courtyards by the positioning of the new sciences library, when it is implemented.

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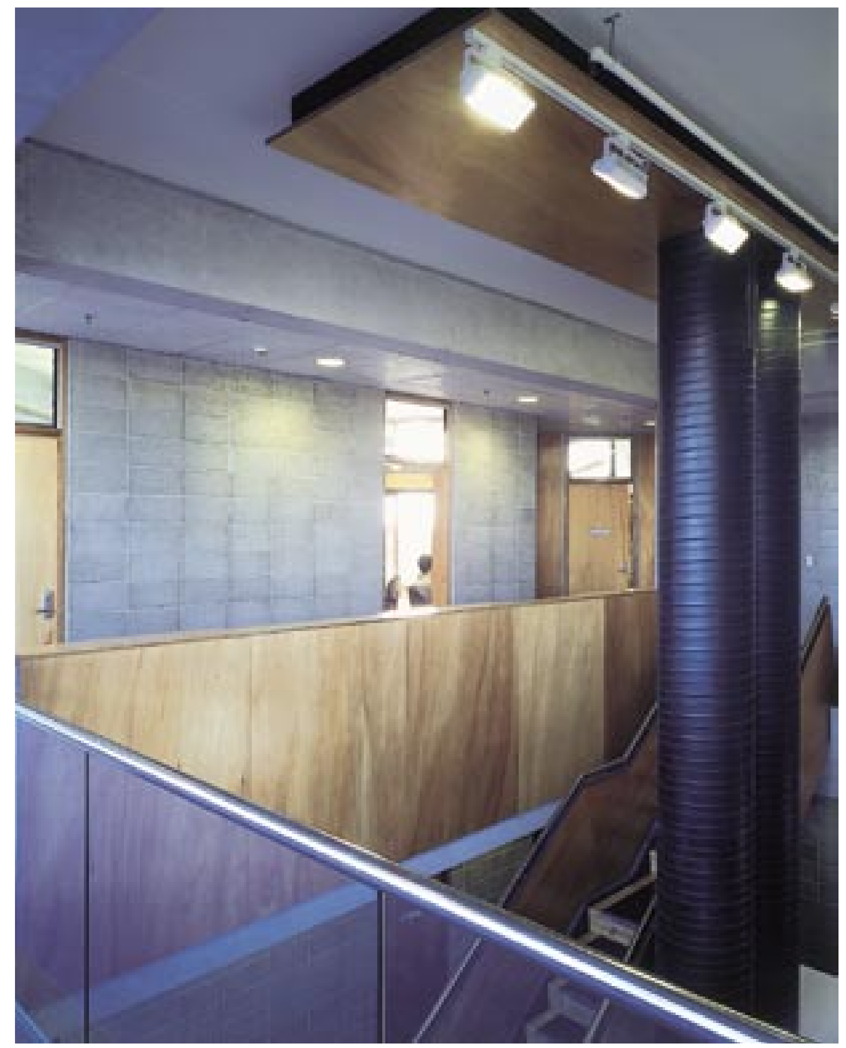
03 The central atrium contains the main vertical staircase and, as a key circulation area, is the scene for staff/student interaction.

04 Windows open from the teaching areas into the central atrium to provide ventilation and to subvert the need for air-conditioning.

The MSCS Building has a floor area of 11,550 square metres on a footprint of 1760 square metres and is an eight level structure with seven storeys over ground level, with lecture theatres and main computer labs at basement level. The upper levels provide 90 offices for staff and postgraduate research students and four levels of teaching spaces. The plan and section diagrams of the building respond literally to a stipulation in the university brief that staff and postgraduate offices should face north and the teaching areas should face south. A major driver of the diagram on plan is the skewing of the offices 45˚ off the orthogonal grid of the campus to face north, the introduction of the strong architectural element of blade walls separating these offices and the expression of these elements on the outside of the building as three distinct towers. This geometric 'gesture' yields the benefit of increasing the façade length, presenting its face to the valuable northern sun.
The section diagram has equal clarity with the offices sitting in a seven storey northern block, the teaching spaces located in a four storey southern block and the two separated by a multi-level atrium with a glazed roof. The main entrance to the building is between two of the office towers from the courtyard to the north; vertical circulation and toilets are located in seven storey overground cores at the east and west ends of the atrium zone with secondary entrances at ground floor level. Reviews of the building in New Zealand have cited the possible influence of Louis Kahn in the clarity and logic through the experience of two of the Architectus partners working with Zebekgoglu in London.
The most architecturally ingenuous elements of the building are the three office towers, which set up a clustering arrangement for staff and postgraduates in potential research groups. The 90 offices are in nine suites of 10 offices – three suites within each tower – on a two level 'maisonette' arrangement, with a shared double-height mini-atrium space serving five offices on each floor. Each one acts as a 'breakout' area for staff and research students, has its own internal staircase and has whiteboard tutorial space and a kitchenette. Internal walls are built in concrete blockwork (giving good acoustic separation) and use stack bonding (vertical joints) so that they can be more readily altered.
The teaching spaces are straightforward and pragmatic, contained in a 55 metre x 15.7 metre rectangle capable of arrangement in various configurations using lightweight steel-framed stud partitions – the only given is two plant-rooms on each level.
The 6.8 metre-wide atrium contains the main vertical circulation staircase and its glass roof creates the atmosphere of an external space spilling light into the middle of the building. The glass roof slopes up from the roof of the fourth floor of the teaching block to the ceiling of the sixth floor of the office towers – the internal mini-atrium in these allows access to the seventh floors. The glass roof, therefore, presents itself to the south-west sky and minimises the unwanted impact of direct solar gain in summer.
What is particularly interesting about this project is the post-occupancy evaluation (POE) that has been carried out to determine how the building is performing from thermal and energy points of view and to survey the satisfaction of its users. Many of



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05 One of the mini-atriums, which each serves 10 offices and acts as a 'breakout' space within each suite.
06 An informal study and research area.

A significant factor that has contributed to the success of the environmental performance of the building is the adequate time allowed for the design and documentation stages

the claimed and widely published 'green buildings', with apparently innovative environmental design strategies, remain unvalidated through lack of systematic performance review. Dr George Baird, of the University of Wellington Victoria, a recognised international authority on environmentally responsive buildings and author of the recently published book *The Architectural Expression of Environmental Control Systems*, has carried out a thorough evaluation of the MSCS Building and has published a research paper with his co-researcher Chris Kendall. The user satisfaction portion of the study has used what is called a 'PROBE' survey, developed in the UK by Adrian Leaman of Building Use Studies (BUS), which surveys occupants using a questionnaire of 63 questions under 12 headings (see www.usablebuildingsd.co.uk). The advantage of this internationally adopted survey is that a data-set is becoming available which allows comparative evaluation.

The survey of the MSCS Building has shown that user satisfaction is very high. Baird and Kendall's study concludes, "Overall, the results show that the building was rated highly by both staff and students, achieving a level of occupant satisfaction in the top five percentile of the 2001 BUS Benchmark data-set relevant to comfort (specifically noise, lighting, summer temperature, winter temperature and overall comfort)." This result reflects good thermal and lighting performance and the ability for users to interact with their own working environment.

The thermal conditions have been logged in winter and summer. The winter performance, albeit with radiator heating in operation from 6am to 9pm, showed internal temperatures, for example, in a range 15˚C to 24˚C, with external temperatures in the range –1˚C to +11˚C. The summer performance showed internal temperatures, in non air-conditioned areas, in a range generally 18˚C to 24˚C with external temperatures in the range 10˚C to 30˚C. Energy consumption – the annual energy use index (AEUI) – is at 143kWh per square metre per year, below the target of 150kWh per square metre per year set in the New Zealand National Energy Strategy for buildings of this nature (I calculate an Australian SEDA five star rating for office buildings in Sydney at 133kWh/per square metre per year). This energy use is apportioned 47 percent heating, 28 percent equipment (there are 660 computers in the building!), 15 percent lighting, three percent fans and pumps and seven percent miscellaneous.

So why is this building performing so well?

A significant factor that has contributed to the success of the environmental performance of the building is the adequate time allowed for the design and documentation stages – six months in each case –facilitating thorough consideration and resolution. A team approach, which is recognised as the only way to go to achieve a good integrated solution, involved liaison between Patrick Clifford and the architects in New Zealand and Dave Fullbrook of Ove Arup and Partners, the environmental consultants, then based in Bristol, England.

The construction extends the Christchurch tradition of massive precast concrete through the use of precast wall and floor elements, both of which have characteristics that are relevant to the thermal and energy performance of the building. The office tower walls are 'Thermomass' precast insulated sandwich panels 260 millimetres thick, consisting of 70 millimetres outer skin of concrete, 40 millimetres core of polystyrene insulation and an inner skin of 150 millimetres concrete.

Significantly, and correctly, the greater thermal mass is located on the inside of the insulation to maximise the potential to use this mass to moderate internal temperatures in summer and winter. The floors of the teaching block are intriguing and unique precast concrete units with a 'sine-wave' underside soffit forming an air movement duct within the floor depth. Fresh air, and in some cases air-conditioned air, is distributed through these voids and supplied to the rooms through round twist air registers in the floors. The inherent thermal mass in floors of this type allows them to absorb and store, from the distributed air, warmth in winter and 'coolth' in summer. The 'sine-wave' profile of the ceilings has the advantage of increasing the surface area of the thermal mass presented to the room, thus improving its effectiveness.

Thermal mass is of limited value unless used effectively and this has been done. The correct orientation of the office windows to the north allows good sun penetration onto the thermal mass in winter (heating up the building by passive means) and the overhangs and sunshades on these windows allow the elimination of unwanted summer sun penetration. Individually controlled windows and 'trickle vents' – small slot vents in windows with user controlled hit and miss registers – allow adequate natural ventilation for daytime use and, if used correctly, cool down the thermal mass at night in summer, taking advantage of the diurnal shift and cool night temperatures.

The main teaching areas at first, second and third floor levels are also non air-conditioned, with fresh air supplied through the ingenious precast floor slabs. Operable windows in these teaching areas open into the central atrium. The basement and ground floor lecture theatres, computer labs and offices are air-conditioned. The air-conditioning plants are located in the basement and on the roof over the two service cores in the teaching block.

Fresh air is supplied to the mini-atrium spaces in the office towers from roof mounted AHUs through large exposed round ducts. All south-facing windows are double-glazed to minimise heat loss in the winter. The main atrium is fitted with BMS (building management system) controlled vents at roof level to dissipate heat gains and drive natural stack effect ventilation, which draws fresh air in through natural 'leaks' associated with the entrances at ground level and out of the offices. Demand for artificial lighting is helped by the spill of light into the atrium with windows on both sides into the office and teaching areas. Heating of the building – minimised by the good orientation, insulation and thermal mass – is provided by a coal-fired campus district hot water heating system and radiators located under external windows in offices and teaching spaces. Cooling is obtained from a natural aquifer under the site from which water is drawn cold at 12.5˚C and returned at 18˚C.

Lindsay Johnston is a practising architect and specialist environmental consultant, and conjoint professor at the University of Newcastle.

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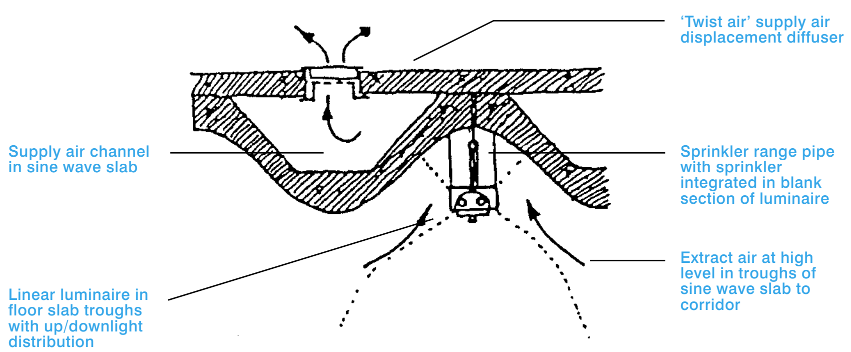
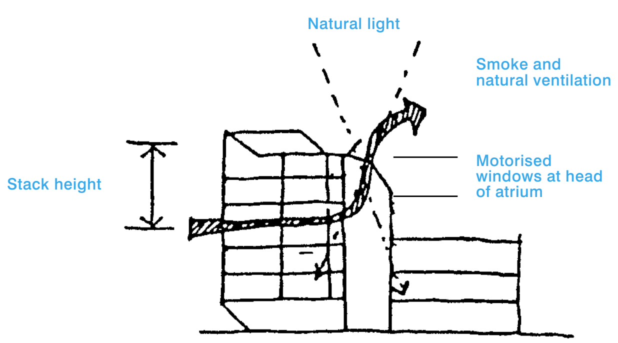
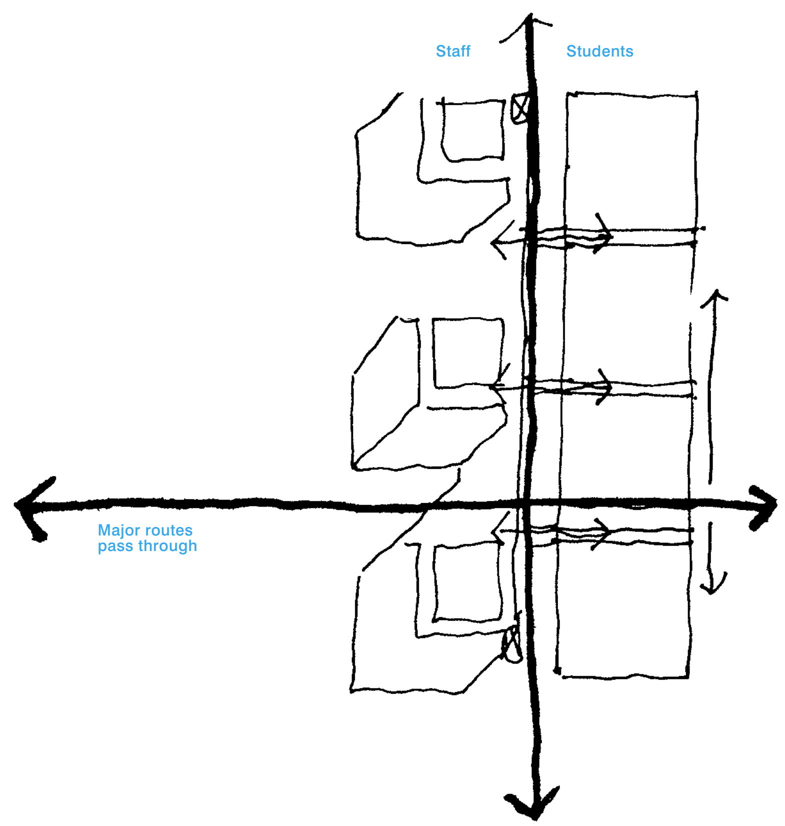


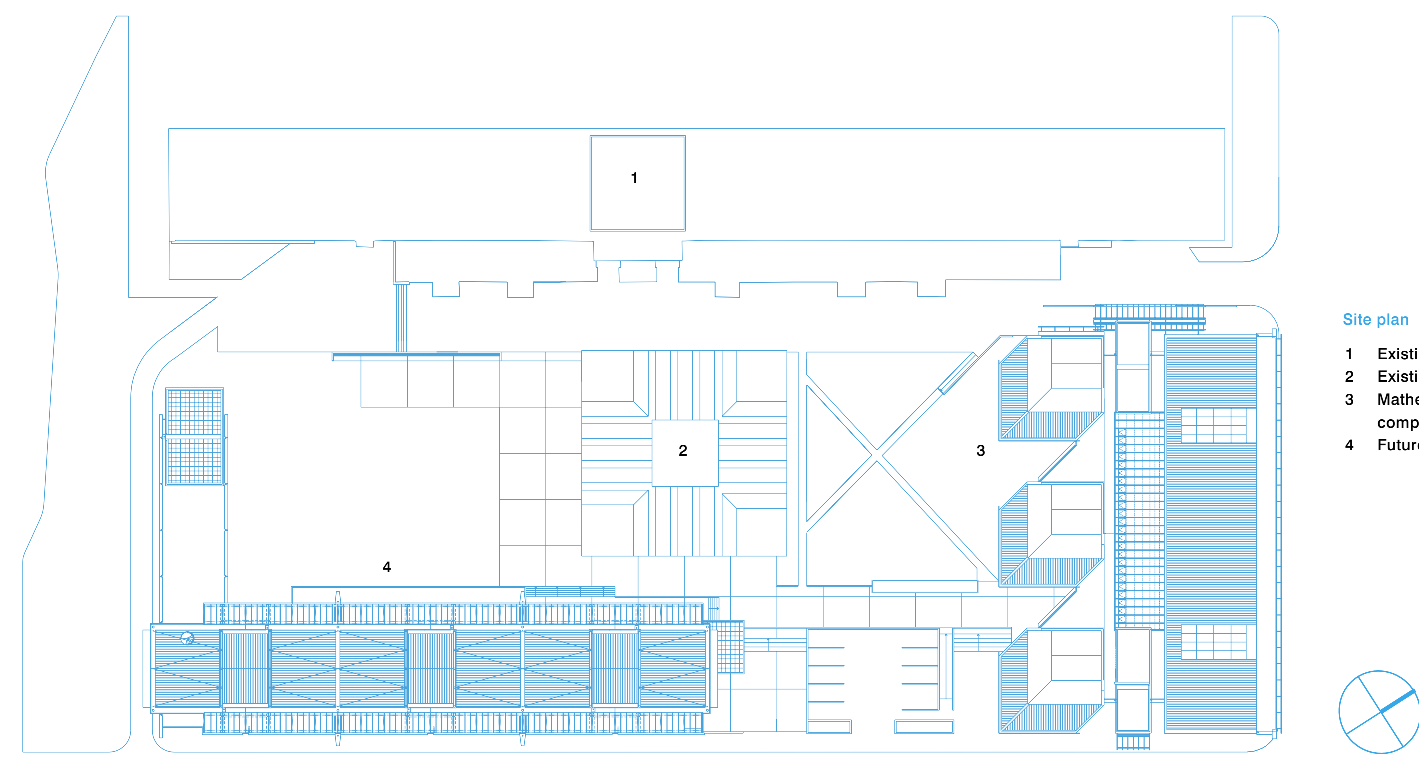
Cross section through pre-cast floor



Diagrammatic section



Circulation plan



Site plan

1 Existing physics and chemistry building
2 Existing physical sciences building
3 Mathematics and statistics and computer sciences building
4 Future sciences building

Project summary Mathematics, Statistics & Computer Science Building, University of Canterbury ■ **Principal architects** Architectus CHS Royal Associates ■ **Project team** Malcolm Bowes, Patrick Clifford, Michael Thomson, Jim Akehurst, Stephen Bird, Mark Campbell, Rachel Cook, Mahendra Daji, Philip Guy, Graham Hoddinott, Bruce McCartney, Blair McKenzie, Sean McMahon, Juliet Pope, Jane Priest, Tadek Rajwer, Giles Reid, Andrea Stevens, Shaun Thompson-Gray, Gerry Tyrell **Key contractors** ■ **Structural & civil** Holmes Consulting Group ■ **Electrical & mechanical** Ove Arup & Partners ■ **Acoustic** Marshall Day & Associates ■ **Quantity surveyor** Shipston Davies ■ **Project planning** Woods Harris Consulting ■ **Main contractor** Naylor Love Canterbury ■ **Client** University of Canterbury