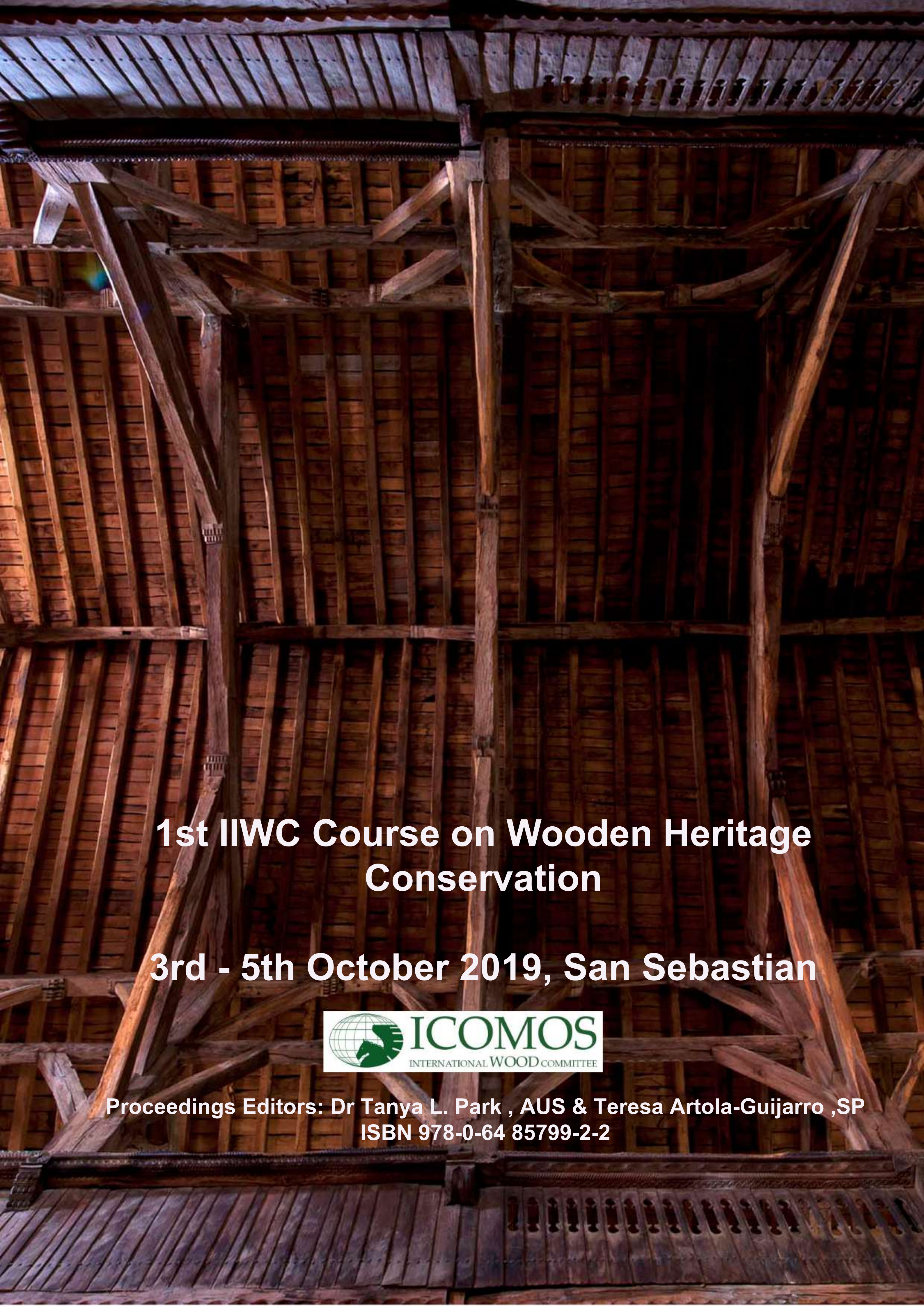


1st IIWC Course on Wooden Heritage Conservation

3rd - 5th October 2019, San Sebastian

ICOMOS
INTERNATIONAL WOOD COMMITTEE

Proceedings Editors: Dr Tanya L. Park , AUS & Teresa Artola-Guijarro ,SP
ISBN 978-0-64 85799-2-2

Preface

Since the ICOMOS International Wood Committee (IIWC) was established in 1975, the need for a set of conservation principles has been a continuous theme in the Committee's ongoing discussions and activities.

In the of the 19th General Assembly of ICOMOS held in Delhi on 15th December 2017 the new IIWC 'Principles for the Conservation of the Wooden Built Heritage' were adopted as ICOMOS doctrinal text. These new 'Principles' replace those adopted previously in 1999.

Last year, the 21st IIWC Symposium held in York was a multidisciplinary forum for the interchange of experience, ideas, and knowledge of 'New Horizons' in the conservation of wooden built heritage as embraced in the new ICOMOS 'Principles' adopted in 2017.

This year we want to take a step further with the organization in the Basque country of a symposium and a course that amplifies the progress made in York and focus on the holistic approach to wooden heritage conservation that extends beyond structures to include its complex intangible side together with the materiality of wood construction. The scope of the Symposium and Course will include the diversity of professions involved, possible approaches and processes from a global perspective, and their adaptations to the conservation of local wooden heritage.

We are hoping to create a forum to reveal, exchange and discuss different theories, including processes, methodologies and intervention techniques in wooden heritage from different points of view through different disciplines but with a common goal which includes every specialism involved (carpenters, engineers, architects, archaeologists, historians, wood scientists, administrators and stakeholders).

The 22nd IIWC International Symposium, Wooden Heritage Conservation: beyond disciplines was held in Bilbao from the 30th September to the 2nd October 2019 and the 1st IIWC Course on Wooden Heritage Conservation was held in San Sebastián from the 3rd to the 5th October 2019. It was organized by IIWC (ICOMOS International Wood Committee) within the program of the summer courses of the University of the Basque Country (UPV/EHU) responsible for the academic accreditation. It was financed by several institutions, including the 3 Provincial Councils of the Basque Country, the Spanish ICOMOS Committee, the GPAC heritage research group and Baskegur, a professional association of the Basque wood sector. I would like to thank all the contributors for their support.

Both events consisted of 98 participants from 21 different countries from Europe, America, Oceania and Asia. During these 6 days, a full program was prepared with approximately 260 hours of speeches and discussions. The schedule was divided between lectures, questions and answers and field visits. Two days were spent on an excursion where we visited some of the most interesting cultural wooden heritage sites in the Basque Country; including the Añana Salt Valley.

The participants' evaluation and the organisers' experiences are discussed in the following report.

Mikel Landa
Vitoria, Spain, December 2019

Table of Contents

New Considerations in Conservation Theory

Gustavo Araoz

Past President of the International Council of Monuments and Sites

At the General Assembly in New Delhi two years ago, ICOMOS adopted the Charter on the Conservation of Wood structures that had been presented by the Wood Committee after some years of reflection. The Charter is very up to date in that it captures most of the thinking that has emerged from the ever-changing appreciation and understanding of what constitutes heritage as they have evolved over the last few decades.

What I have been asked to do today, and at the risk of sharing with you knowledge that you may already possess, is to provide a summary of the context from where these ideas emerged and continue to emerge, and to do that, we need to look back at the way the modern preservation movement has developed by responding to evolving social, cultural, political and economic needs.

Even though the need to protect certain places that hold shared value for communities because of the beauty, communal symbolism, spiritual meaning or the shared memories they contain has been a permanent fixture of all human societies, the modern preservation movement did not come together until the accelerated destruction of such places by the French and the Industrial Revolutions was perceived as a public threat in Europe.

Over the course of the 19th century and the first half of the 20th many theories about the best way to preserve heritage places developed in Europe, often in direct contradiction with each other. In spite of these differences, the one common trait that was shared by all the conservation approaches was that the value of all these places rested exclusively on the material elements that were inherited from the past and that provided the visual and tactile form of the heritage place. These were the character-defining elements that merited conservation, and it was about these concerns that conservation science and theory were born and evolved.

We don't have the time today, nor would it serve any purpose to go into the rich history of the modern heritage movement between 1810 and 1960.

The important thing to point out is that the results of the reconstruction of historic centers and buildings in Europe after WW2 were so varied and erratic that an international agreement was reached on the need to define one proper and ethical approach to conservation. Under the aegis of UNESCO, this is what the Venice Charter of 1964 accomplished; using the brilliant, but strictly Eurocentric ideas of Cesare Brandi, Roberto Pane and others, the Carter reconciled the polarized views about reconstruction and the use of new materials that had emerged from all of these opposing trends and unified them in a shared concept of what heritage is, the values it holds, the treatments it deserves, and the role it plays, and even though strictly based on European heritage needs, it was assumed to be universally applicable to all cultures.

What, then, are the principal characteristics of the Venice Charter's Eurocentric concept of heritage and its conservation?

1. Heritage places, at least conceptually, are commonly-held public properties that should be accessible to all because they contribute to the public good. For that reason, government, as the best guardian of the public interest, is responsible for their inventory and preservation

2. Because their significance rests on its design and materials, heritage places are non-renewable resources that belong equally to past, present, and future generations. For that reason, each generation is considered not an owner, but a temporary steward or trustee of the authenticity of their material forms.

3. A place transcends into heritage as a result of two types of values being attributed to it: historic or documentary values, and artistic or aesthetic values that are directly related to and reside in its material and spatial components which cannot be irreversibly altered

4. The 4th assertion that the Venice Charter made was that the purpose of conservation was to prevent any change in the material and spatial components where the values attributed to the place were known to reside. In this sense, the nature of heritage places was assumed to be basically static even though there were concessions made to urban areas and the modern use of heritage buildings.
5. And finally, the Venice Charter implied that understanding the full nature of historic and/or aesthetic values is a scholarly process that can only be fulfilled by specially trained professionals. Consequently, only specialists know the conservation treatments that will respect these values.

These were the five perfect truths that were believed to be immutable in that perfect world of the mid 1960s, when the Venice Charter neatly wrapped heritage as a coherent paradigm at the very same time that ICOMOS was created, and when the idea of a World Heritage Convention first emerged.

To this day, the Venice Charter still provides the appropriate approach to certain monumental structures, especially those built of durable materials or whose significance rests on their aesthetic values or as witnesses of highly valued historic figures or events. This approach is what Julian Smith of Canada has called the Curatorial Approach to conservation, which remains valid for certain types of heritage places in certain cultural contexts, such as in buildings that are so precious that they must be treated as museum objects to avoid material changes at all cost. Like museum objects, at times, these monuments are placed inside glass cases.

However, contrary to the expectations at the time, the ideas and concepts about cultural heritage were not frozen by the Venice Charter. Over the last 50 years the concept of heritage has evolved and been enlarged, and the principles of the Venice Charter that once were thought of as immutable and universally applicable have been challenged repeatedly by the emergence of new heritage categories built with ephemeral materials and especially in Asian countries who were unable to reconcile the principles of the Venice Charter with their ancestral heritage concepts and conservation practices. Thus, our theoretical foundations have been in a constant process of transformation and expansion for the last 50 years and the means through which we protect our cultural heritage has continued to evolve. The consequence, as I will explain, is that a new heritage paradigm has emerged that coexists alongside the traditional curatorial one.

This new paradigm illustrates what Julian Smith has termed as the ecological approach to conservation that stands in stark contrast to the curatorial one. AS WE SHALL SEE, the resulting heritage duality between what the French *call monuments historiques* and *patrimoine,* has yet to be properly studied and codified in the doctrinal theories that should guide our practice. Since each paradigm demands different conservation approaches, it is imperative that those in charge of conservation and documentation know which cultural heritage paradigm they are dealing with.

Let’s look at the characteristics of the ecological heritage paradigm

The first explanation for the emergence of the new paradigm has to do with the appropriation of cultural heritage by their stakeholder communities who demand a say in the identification of its values and how it will be treated and used. This was a complex task that used to belong to erudite specialists, who relied on a strong set of disciplines to define significance and proper treatments. Stakeholder communities, however, Identify their heritage not necessarily through rigid intellectual processes but pragmatically through shared emotions, memories and opinions. In retrospect, this phenomenon was inevitable in an increasingly democratized world. But we also must bear in mind that our sustained emphasis on the principle that heritage is a communal property was instrumental in the drive towards the appropriation of heritage by communities. The process was further accelerated by the many programs intended to foster greater public awareness and support for conservation. In short, be careful of what you wish for….

The issue of local residents as stakeholders and caretakers is now prevalent in most societies bu it can be problematic, especially under the migrations, social mobility and the rapid demographic changes that characterize the world today. For instance, the local population surrounding the royal tombs of France in the Cathedral of St Denis in the north of Paris consists of underprivileged immigrants from Northern Africa who come from very different cultural traditions, who feel discriminated against and who do not identify with this place as being a significant part of their historic trajectory or their cultural identity. How can they be expected to be proper caretakers of this place?

The surge on community participation and empowerment is rooted in the Burra Charter, a document developed and periodically amended by Australia ICOMOS, which called for community or stakeholder consultation and input in identifying the places that are heritage and determining why they are significant, and to whom. This practice rapidly expanded beyond Australia and has become relatively commonplace even in Europe, where it was originally rejected by many old-line conservators who perceived it as a travesty of traditional conservation principles as well as a threat to their professional authority.

The question of who is a valid stakeholder with the right to participate in the decision-making process can be both unclear and politically explosive. According to most, valid stakeholders include the creators of a site or their descendant communities. Does this mean that since the Hitler regime built the concentration camps, the neo Nazis are a stakeholder group in Auschwitz with a right to participate in defining its significance and the way it is preserved?

The recognition of the right of communities over their heritage has as its corollary the recognition that there usually are multiple stakeholder communities for any individual heritage site, and that often the values each of them attributes to the place are different and even in conflicting opposition. This has become particularly poignant as the concept of a dominant culture in a society has been replaced by the acceptance that all societies are to a lesser or greater degree made up of multiple cultures that coexist side by side and who hold different values and histories.

With the growing hostility to ethnic minorities and immigrant communities in Europe and the United States and the tendency to ethnic cleansing in many Asian societies, this is proving increasingly problematic, with some suggesting as a solution that all heritage places must continue to be treated according to the Eurocentric curatorial model and values. In the Western Hemisphere the heritage of the European settlers is now being claimed by the descendants of enslaved African and abused indigenous people who were the actual builders of these places

Perhaps no site better exemplifies the shift towards multicultural societies, the multiplicity of values and the rising role of once ignored stakeholder communities than Uluru or Ayres Rock in Australia. Originally inscribed in the WH list as natural heritage for its particular geology, Australia later requested the re-inscription of the site as mixed natural-cultural to recognize and respect the sacred nature of the place in the beliefs of the Anangu, the local Aboriginal people. As a result, a new management plan that takes into consideration the taboos of the Anangu had to be drawn up. Climbing the rock and photographing certain restricted areas are now strongly discouraged and restricted.

The second characteristic of the ecological heritage paradigm is the creep or expansion in the range and nature of values that can be used to designate a place as cultural heritage and that go beyond the two types that prevailed in Europe for a century and a half and that were officialized by the Venice Charter. This shift can also be traced principally to the Burra Charter that articulated social value as a justification for heritage designation.

Abetted by the increasing demand by communities with relatively short histories to identify their own heritage and define its use and treatment without any clearly adopted discipline, many previously commonplace places have emerged as new heritage. In other words, heritage has begun to be valued for reasons than in the past had been unacceptable for such designation.

A good example of this are the movie houses of the 1950s that are determined to be important mostly by those who lived during that period and for whom these places bear important memories of their youth. Thus, they are not places inherited from ancestors, but significant in the living memory of a living generation.

Social values being an elastic and inexact term, they opened the door to a range of other community-held values, at times more economic and political in nature, and that in some cases, as we have seen with the movie house example, places that serve the interests of the current generation rather than those inherent in the continuum of the inter-generational contract that obligates us to transmit our heritage to those who follow us with the same potential, integrity and authenticity with which we received it from our ancestors. In fact, the questions to ask are: Are we defining our own legacy for the future? will this heritage be valued by the same generation or is only valuable to the current generation because of the memories it holds?

This new ability of communities to deal flexibly with their heritage has meant that often the main objective is not conservation as it once was. For instance, preserving and expanding the social and community functions of a heritage place is at times placed ahead of preserving the character and setting of the place. As you may see in the image, the character and setting of Mecca has been seriously eroded over the last decade to accommodate the expectations of a new wave of more demanding and very rich Hajji pilgrims, and with obvious monetary benefits to some.

The acceptance of a multiplicity of political and economic values has thrust the heritage community into the political arena, a skill that we have not been trained to deal with. Heritage is becoming a complex issue with many possible divergent objectives, as well as a political tool with multiple uses.

With heritage increasingly linked to sustainable development goals and poverty reduction, its economic values have tended to coalesce with the social and political ones into an indivisible unit that often places the authenticity and integrity of our heritage resources at considerable risk. At meetings between the Advisory Bodies and the States Parties of the World Heritage Convention while I was President of ICOMOS, we heard a loud demand from many of the African States for more flexibility and assistance on the part of ICOMOS and IUCN in accepting major mining initiatives in World Heritage parks in order to show our commitment to sustainable development. It seems that amid the confusing evolution that heritage is undergoing, some have concluded that they can have their cake and eat it, too.

Perhaps an even more serious threat - and definitely more widespread than mining - is the increasing belief in tourism as the great panacea for all the economic tribulations of local communities and national governments. Using once again the case of the World Heritage Convention, we have seen how over the last years there has been a frantic rush for inscriptions in the List at any cost. We know from official statements issued by nominating States parties that their motivation is not always to achieve better conservation of these properties, but to move them to the top of the food chain in the tourism markets.

The material erosion of heritage properties along with the cultural dislocations in local communities often brought by enhanced tourism must continue to be a major concern. But equally important is documenting how the masses of tourists, often from cruise ships, bring about changes and mutations in the local culture, the cultural identity and the intangible attributes of cultural heritage. The list of heritage places being overrun by tourism is long, and includes iconic sites such Venice, Florence, Prague, Havana, Machu Picchu, the Athenian Acropolis and Angkor.

Another effect of tourism are the many manifestations of reconstructions under the guise of anastylosis and but that are really driven to enhance the tourist attractions of heritage places, especially, but not limited to archaeological sites.

The precision and accessibility of 3-d scanning technology has abetted such reconstructive activities, as was the case in the Parthenon, where the accuracy of the new documentation allowed for the identification of the exact position of the column drums that had been scattered in the sites for centuries, Thus, we now have a complete peripheral colonnade in the Parthenon.

We have been referring indirectly to the third and perhaps the most subtle of the changes inherent in the new heritage paradigm, which is the emergence of intangible concepts as repositories or vessels of the values that render a place as heritage. As explained earlier, the modern view of heritage as captured in the Venice Charter, was originally shaped by the assumption that most values and the significance of a place rested on its physical or material attributes. This Eurocentric curatorial approach was fully endorsed by the original World Heritage Operational Guidelines, which from 1978 and continuously until 2005, dictated that that authenticity and significance of cultural properties resided exclusively on four physical attributes of design, materials, workmanship and setting.

It was the Nara Conference on Authenticity and its resulting Document that in 1994 ushered in a whole new universe of possibilities that legitimized alternatives to the Eurocentric Curatorial approach to heritage conservation that had prevailed until then. We need to remember and honor Knut Larsen, the President of the ICOOMOS Wood Committee at the time, who was a major influence behind the Nara Conference. Through his work in his native Norway and also in Japan, Larsen understood that the need to replace wooden elements as they deteriorate as well as the ancient Japanese traditions on how to replace them had no negative effect on authenticity.

The global impact of Nara in bringing about the emergence of the new heritage paradigm cannot be exaggerated. Nara shattered once and for all the long-held Eurocentric insistence that there were universally accepted cultural principles for heritage identification, documentation and treatments.

Nara demonstrated that the significance and authenticity of a heritage place must go beyond the strictly material focus on its form, materials, craftsmanship and setting to include a much broader set of vessels of values, such as the historic social function or the sacredness of a place, which, unlike physical form, are intangible in nature, and whose documentation requires non-traditional methodologies or methodologies that are different from those used to record physical reality.

The most convincing example of the need for a new paradigm was the conservation of the Ise Shrines presented by Japan. Every 20 years for over 1,000 years, the wooden shrines are ritually dismantled, and a new facsimile is built next to it, beginning with building reproductions of the tools used in and saved from the previous reconstruction. This ritualistic reconstruction consists of a complex liturgy that itself is part of the heritage value, and which includes using wood from forests that themselves require conservation and management. As you can see, this is very distant from the European concept of materials conservation.

What is ironic is that while the Nara Document was meant to legitimize non-European concepts of heritage, it became evident that those very same principles could be and are being applied to the traditional heritage of Europe. Thus, the transfer of heritage theory has become a two-way exchange between east and west and between north and south

Following the path opened by Nara, the 1999 ICOMOS Charter for the Conservation of the Vernacular Heritage continued to enlarge the elements the embody a heterogeneous set of values that range from static materials to intangible dynamic concepts. This Charter states that the Vernacular embraces not only the physical form, design and fabric of buildings, structures and spaces, but more important perhaps, the transmission of knowledge about the ways in which they are built, maintained, used and replaced, as well as the traditions and intangible associations rituals that may be attached to them. The implication here is also that the evolution of using traditional versus modern materials is a communal decision of the stakeholders that has to be accepted a valid preservation.

When dealing with tangible and intangible containers of value, the overlap and disconnect between the disciplines that deal with intangible and tangible heritage demand a degree of coordination that often does not exist. In fact, some heritage places have no tangible vessels of value; their only physicality is their geographic specificity. This is particularly obvious when rituals and festivals that not only are inextricably associated with a specific historic location, but whose continuing existence depends outright their on a specific location. Again, as a result of the Nara Document, protecting the traditional material authenticity of a place must now be accompanied by the protection of the visual and the functional authenticities in order to ensure their holistic and sustainable preservation.

The fourth characteristic of the new paradigm is a shift from the assumption that cultural heritage is static to a belief that there are dynamic sites whose very essence relies on the inevitability to be in constantly change. The overwhelming change in conservation in the last 50 years is that where once we tried to prevent change, we now find ourselves managing change, and the challenge is how to understand what changes are desirable and how to document change with precision and accuracy.

We can pinpoint the moment when we went for preventing change to managing change. It was in 1981, when the ICOMOS Florence Charter on Historic gardens drew our attention to a brave new world inhabited by dynamic and evolving heritage sites. When preserving gardens we no longer were focused on immutable static materials of construction, but with living organisms that begin, undergrow seasonal growth and die. Unlike in buildings, the elements to be preserved in historic gardens are the species and not the specimens, as well as the layout, spirit and the intent of the garden design, its setting and the focus of its view cones.

When we deal with sites in constant flux, none are more dynamic than historic towns and cultural landscapes: By their very nature they are the epitome of dynamic heritage.

Being the result of an ongoing interrelation between humans and their natural setting, cultural landscapes are in constant flux as they adapt to the full complexity of evolving social, emotional, transportation, production, technological, political, and spiritual needs. Because they are palimpsests that simultaneously illustrate multiple layers of history, they are fragile and vulnerable, and their conservation and documentation are complex.

Historic cities are a concentrated form of cultural landscapes. As centers for the continuing close interaction of diverse populations, they must constantly adapt to new demands and new trends without losing their character and meaning. The latest confirmation of the emergence of ecological heritage paradigm shift are the UNESCO Recommendations for the Historical Urban Landscape and the ICOMOS 2011 Valletta Principles for the Safeguarding and Management of Historic Cities, Towns and Urban Areas, which jointly offer a new concept of the historic city that embraces the four characteristic changes: community participation, acceptance of a broader range of values, recognition that significance resides in both tangible and intangible elements, and that urban heritage is a dynamic resource whose constant change needs management and safeguarding.

How then, is all this a challenge?

For one thing, if we look back at the curatorial approach to material conservation, it is evident that it became deeply embedded in institutions, practice, legislation and training, and that in fact, it still is. The material aspects of a historic building, an urban district or an archaeological site have protection against demolition, disfigurement or any physical threat that will negatively impact its significance. In comparison, there is no protection for the equally important intangible vessels of value that are characteristic of the new heritage paradigm, such as function, use, communal memory and cultural identity.

How do you preserve and protect heritage places such as Chinatown in San Francisco where the buildings and other tangible aspects have no special merit, but where it is the specific uses given by the Chinese community and their presence that make the place significant?

To begin to wrap up my topic, which is basically about Evolving Heritage and Evolving Practices, I would like to share with you how in ICOMOS we are now involved in a major global discussion about how our practice should evolve regarding reconstruction, a perpetual taboo in Eurocentric heritage conservation.

Keeping in mind all that I have said about the acceptance of new sets of heritage values that are economic in nature, and the role of stakeholder communities in decision-making processes, we have detected in many archaeological sites a growing tendency towards what once would have been considered excessive reconstruction, all under the guise of anastylosis.

In Epidaurus, new stones have been re-integrated into building portions that for centuries had ceased to exist. One assumes that the reason is to provide greater visual attraction to tourism in an increasingly competitive market.

A different example would be the recent restoration campaign at the Parthenon, which relied on new analytical techniques to determine with some exactitude the position of the fragments that since the 1687 explosion of the Venetian bomb had been strewn over the Acropolis. When I last visited I was surprised – shocked? – to find that the columns that had been destroyed by the bomb were now fully re-assembled, and the peripheral colonnade had been completed.

The rise in heritage destruction resulting from natural and human-induced catastrophes, especially armed conflict have also led to what appears to be a tacit acceptance of the growing tide of reconstructions under circumstances that have not been clearly laid out. The best example of this is perhaps the reconstruction of the Bridge at Mostar intentionally blown up during the Balkan Wars. UNESCO later justified its reconstruction as a symbol of the ethnic unity that the Balkan war had sought to destroy, and Pressured ICOMOS to recommend it for inscription in the World Heritage List..

We faced similar challenges regarding the reconstruction of the Bamiyan Buddhas, and of course, in light of the destructive binge brought about by ISIS in places like Palmyra, have added to the urgency of figuring out when and where reconstructions are acceptable. After a number of high-level discussions, a decision was taken not to rebuild.

It is clear that the issue of reconstruction has risen to become a major topic in guiding our evolving understanding and protection of the authenticity in heritage. In Dubai, where the entire historic center of Khor Dubai was demolished in the 1960s and has now just been accurately reconstructed as an anchor to an increasingly diluted cultural identity, I challenged ICOMOS to develop criteria that would help assess when reconstruction is acceptable. To jump start the debate, I have offered six areas of discussion around which criteria could be developed:

- WHY? Reason for the demolition or loss of the original
- WHO? Source of intentional demolition or loss of the original
- HOW MUCH? Partial or total destruction; respect for extant parts; manner of replacing missing portions.
- WHEN? How long ago? Is there a statute of limitations
- PURPOSE? Justification for reconstruction. Tourism? Cultural identity? Recapturing lost functions?
- VALIDITY: is the reconstruction accepted as heritage by stakeholder community?

I leave you with these thoughts and urge you to get involved in all these issues.

The concept of minimal intervention in the conservation of wooden heritage

Mikel LANDA and Alazne OCHANDIANO

Landa-Ochandiano Arquitectos, Av. Madariaga 1. Of. 204. E-48014 Bilbao, Bizkaia, Spain, +34656715541, www.lo-arquitectos.com

Abstract The article reviews the concept of “minimal intervention” in the conservation processes of cultural heritage assets built mainly with wood, from various angles, focusing the examples mainly on World Heritage sites. Without attempting to carry out an exhaustive review of the concept, different approaches are provided with the intention of detaching it, as far as possible, from the traditional field of material conservation. Thus, for example, the concept of minimal intervention is associated with the intangible part of the structures, or temporary or evolutionary heritage sites.

Keywords: Authenticity, minimal intervention, intangible, evolutionary, fragile.

The concept of Minimum Intervention

In 1999 the first Principles of the ICOMOS International Wood Committee were approved. During 2016, a thorough review[1] of the same was carried out, a process in which experts from nine countries participated, to finally approve the final document at the ICOMOS General Assembly in Delhi, in December 2017. This revision aimed to broaden the scope of the principles, from an almost purely material and structure-centered approach, to all wood heritage, including both the material and intangible parts.

And yet, despite this profound update, the body of the original document remains. The 1999 Principles, in article 6, say “*Intervening as little as possible in the fabric of historical wooden structures constitutes an ideal”, a concept that continues to exist in the second document, this time in article 12, “Interventions must follow the criterion of minimal intervention…*”.

From the foregoing we deduce the importance of the concept of "minimal intervention", and, nevertheless, this article will avoid falling into the temptation of formulating a definition for this concept. Instead, it will seek to show some of the application possibilities, trying to open up this field, beyond the purely material.

Despite having resigned, from the outset, to define "minimal intervention" as a single concept, with a single formulation, we do not renounce asking the question, what does minimal intervention consist of? And given that to answer the question there are as many possibilities as there are people

[1] “*the primary aim of conservation and preservation is to maintain the authenticity of the historic fabric*.” ICOMOS IIWC (2017) *Principles for the conservation of wooden built heritage*. IIWC. Art. 12.

who face its practical application, with variations for each case of heritage conservation, we will proceed modestly, to show some examples that will serve as subject matter for the debate.

Structural authenticity, material authenticity

It seems clear that the processes of conservation of cultural heritage are dependent on a diversity of factors, one of the main ones being the cultural context[2]. In the same way, these processes will depend, among other factors, on the material or materials with which they are built or on their state of conservation.

We will begin, therefore, by applying the concept of minimal intervention to material conservation, since the authenticity of the good is sometimes linked to said material conservation, that is, to maintaining or retaining the largest amount of existing material of the good in question. It is the case of Tampone that in the introduction to his work "*Il restauro delle strutture di legno*"[3], he defines not only the material authenticity, but also the structural authenticity, *"... that minimizes the alteration of the structural, material and rigging authenticity of monuments and their supporting structures…"* Both Tampone's publications and his interventions in the wooden heritage, especially in linear structures, are focused on maximizing material conservation, avoiding, if possible, altering the materiality of said structures in the least. To do this, he introduces, if necessary, elements built with other materials, mainly steel, the objective of which is to supply the part of the resistance that the wooden structure has lost and that, given his engineering training, he was capable of exquisitely designing. This approach, subordinates any other consideration regarding the intervention in the structures built with wood, to the material conservation, and associates the concept of minimal intervention with the ability to retain the greatest amount of material, introducing elements, generally of other material, that help the wooden structure perform its function.

---

[2] "…"… The respect due to all cultures requires that heritage assets must be judged and taken into consideration within the cultural contexts to which they belong.". ICOMOS (1994). Nara Document on Authenticity.. Nara. ICOMOS. Art. 11.

[3] "*Poiché da anni perseguo una constante ricerca su una sorta di restauro alternativo che riduca al mínimo l'alterazione dell'autenticità strutturale, materica e d'apparecchio dei monumenti e delle loro strutture portanti, anche in quest'opera mi sono ispirato ai principi conseguenti esponendo sempre criticamente tecnologie e tecniche ed indicando con franchezza la natura e l'entità dei compromessi che ciascuna di esse inevitabilmente comporta*". Tampone (1996), *Il restauro delle strutture di legno*. Milano. Hoepli. Introduzione.

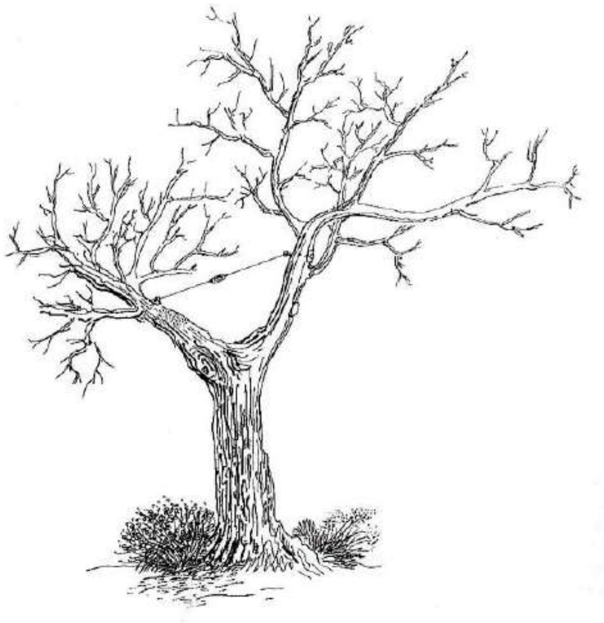


Image 1. Consolidation of a monumental tree. Tampone, (1996). Il restauro delle strutture di legno. Milano. Hoepli. P. 368. The image is a simile of the concept of intervention in a damaged wooden structure, based on the material conservation advocated by Tampone. The introduction of an external element, in this case metallic, is designed to withstand the forces that the tree can no longer support.

Just as there are authors who focus conservative intervention to retain the maximum amount of existing material[4], the Principles of the international committee on wood of ICOMOS, draw a broader picture, defining as the main objective of conservation the maintenance of authenticity and historical integrity of cultural heritage[5].

Therefore, understanding the conservation of cultural heritage from an integral perspective, means taking into account not only the material part of the building, but also the intangible. In the case of a wooden structure, the material part is made up of the wooden elements, posts, beams, joists, or others, which, placed one next to the other and joined in various ways, form the resistant set. The intangible part of this structure is diverse, but in this article, we will refer only to the structural function.

Preservation of the resistant function

The resistant function of a wooden structure is an intrinsic part of it and is important to understanding its authenticity. Therefore, from a vision of the conservation of a wooden structure in a more complete way, we could expand the principle of minimum intervention, to say that it is

[4] "*The major objective of current preservation theory and practice is to retain as much as possible of the existing materials of the historic building*" Larsen, K.E.; Marstein, N. (2000) *Conservation of Historic Timber Structures. An ecological approach*. Bath. Butterworth-Heinemann. p. 14.

[5] *""The primary objective of preservation and conservation is to maintain the historical authenticity and integrity of the cultural heritage.""*. ICOMOS. IIWC (1999). *Principles that should govern the conservation of historic wooden structures*. México. IIWC. Art. 4.

important that the process of conservation of a wooden structure includes all the necessary efforts, directed both to preserve the maximum possible amount of the original material, as well as its resistant function[6].

Often times, the conservative intervention must be carried out in an asset whose structure has suffered damage or decrease in the specific resistant capacity, in some of its elements or, more generally, in important parts of the ensemble. The damaged element may have suffered a loss of material, such as a rot fungus attack, or a split, which does not entail loss of material. In both cases, the resistance capacity of the element has suffered a reduction. To return to the element enough resistant capacity to fulfill the original resistant function, it will need to be repaired.

Repair could be defined as the set of actions[7] necessary to recover the structural efficiency of an element or structure. In the event that the pathology consists of a deformation that endangers stability, the repair could be defined as those actions aimed at recovering a safe geometry of the structure, with a minimal alteration of the current shape.

Since wooden structures are mainly isostatic, due to the way in which they have traditionally been joined with assemblies, any intervention can focus on repairing only those elements that have pathologies, without intervening in the joints, so that the structure continues to work as the same way. Traditionally, any carpenter, regardless of their cultural context, has used similar methods for repair, consisting of preparing the wood to be repaired by making an assembly, and placing a loan of wood that joins the first. This technique called grafting, greffe[8], incalmo[9] or Stiel[10], achieves, thanks to the elimination of a minimum part of wood, usually damaged, the partial or complete recovery[11] of the resistant capacity of a structural element.

Due to the isostatic behaviour of wooden structures, it can be said that, if you have the ability to repair a single wooden element, whatever its pathology, you may have the ability to repair the entire structure, whatever its damage.

---

[6] Yeomans, D. (2007) *Appropriate technologies for conservation.* Journal of Architectural Conservation. Donhead Publishing. Dorset. p. 15.

[7] "*repair is a painstaking intervention in the historic fabric, aiming at replacing only decayed parts and otherwise leaving the structure and the materials intact*". Larsen, K. E. (1994). *Architectural Preservation in Japan*. Trondheim: Tapir publishers.

[8] *The same word, graft, is used by some authors in French, greffe*. Abraham, B., Brindel-Beth, S., Florentin, G-H., Maisonneuve, P. (1993). *Le bâti pan de bois*. Paris: Électricité de France. p. 94.

[9] *The same word, graft, is used by some authors in Italian, incalmo*. Laner, F. (2011). *Il restauro delle strutture di legno*. Palermo. Grafill. pp. 57-73.

[10] *Stiel, del alemán, significa tija o pecíolo*. Mönck, W., Erler, K. (2004*). Schäden an Holz-konstruktionen. Das standardwerk für Sanierung+Denkmalpflege. 4. Auflage*. Berlin. Verlag Bauwesen. p. 237.

[11] Landa, M., (1997). *Behavior of glued joints for the repair of wooden structural elements that work in flexion*. Doctoral Thesis. Higher Technical School of Architecture, University of Navarra.

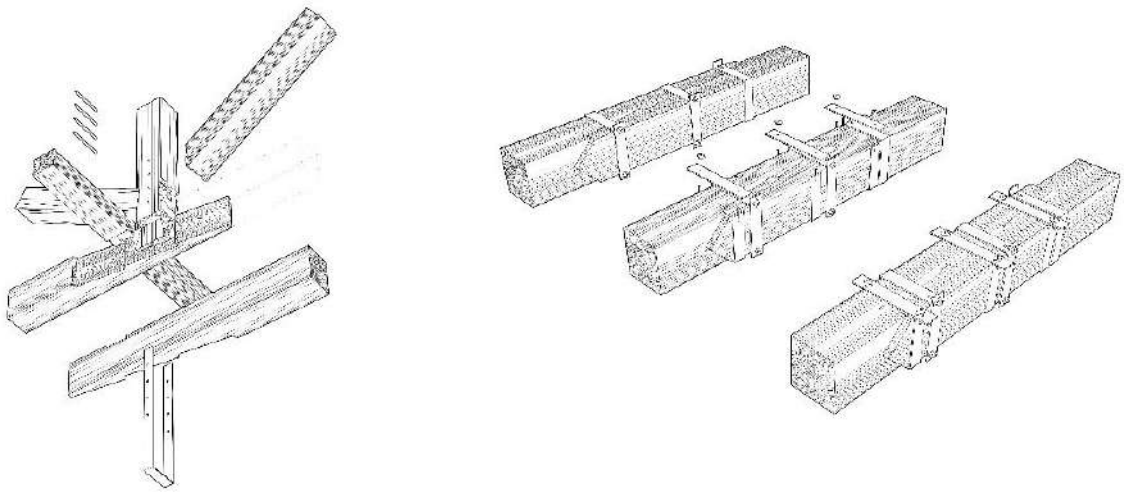


Image 2. Left: Double beam junction of Jupiter in the center of a truss tie at l'Arsenale in Venice. Right: Same joint, used by Claudio Menichelli in the repair of several braces. The logic of its use is that the tensile stress is constant along the tie of the truss.

Adaptation of the concept of minimal intervention to conservation needs

Next, we will show four examples of intervention in a well-built mainly with wood, in which the concept of minimal intervention has had to be adapted to the needs of the object. The first three examples correspond to works carried out by the authors of the article. The fourth is Kizhi Pogost's restoration.

Preliminary actions

The Mendieta shipyards in Lekeitio were built in 1917 and were in operation until the 90s of the last century and showed generalized and multidirectional deformations that endangered the stability and survival of the building and its subsequent conservative intervention. In this previous phase, the objective was for the building to stand upright at the moment when it could be intervened.

Image 3. Left: Interior view of the main nave of the Mendieta shipyards. The fragility of the structure and its deformations can be seen. Right: The stabilizers already placed in the building, respect all the main, secondary and minor elements of it.

Once the diagnosis had been made, it was found that despite the fact that the stability of the ensemble was compromised, the quality of the pillars was sufficient to bear forces, so a stabilizer was devised, which, supported by said pillars, and using them as part of the stabilizer itself, horizontal wooden bars and diagonal stainless steel bars were introduced. While waiting for the intervention project, no action was taken on any element of the building.

Preliminary studies

The Getty Conservation Institute commissioned us to learn about the viability of preserving the wood of the Ica cathedral structure, which, covered with quincha, comprises all the pillars, vaults and domes, and which had suffered significant damage in several vaults and in the main dome, in the 2007 and 2011 earthquakes. The cathedral of Ica is one of the typological buildings selected by the GCI to be studied in order to then design earthquake-resistant techniques to reinforce similar buildings without damaging the original material and design of the building.

The work was very short and required intensive work in situ, studying the different aspects of construction and wood, and the existing pathologies. In its conclusions, it determined the reasons why the main dome had fallen and the failure that had occurred in the supports of the lunette beams.

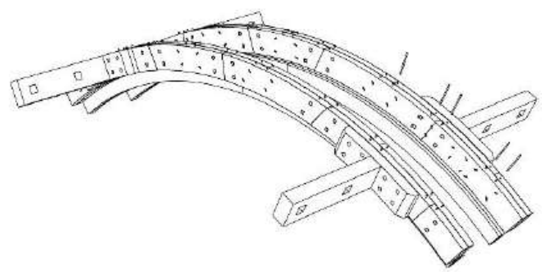


Image 4. Left: Interior view of the main nave of the cathedral in Ica, Peru. The damage caused by two earthquakes, the one in 2007 and the other in 2011, can be seen. Right: Construction drawing of two transverse arches, with the meeting of the lunette beams and the reinforcing pins of the cracked arches.

The concept of minimal intervention in this case is associated with the fact that a greater investment in the study of the building facilitates a conservative intervention of a lesser magnitude, to achieve the same ends. Specifically, the recommendations of the report indicated, among other things, the possibility of preserving almost all the wood of the roofs, advised how a small modification in the support of the lunette beams would be enough to have them repaired, the possibility to recover the arches, by carrying out a small repair, and placing them in their original place again, and finally recommended the use of a more durable species of wood for the reconstruction of the main dome and the small lateral domes.

In situ intervention

During the restoration process of the Cathedral of Santiago, several pathologies were detected in the baldachin, built with chestnut wood in the mid-17th century. One of these pathologies consisted of a loss of section of two beams that, together with an unfinished structural design, had resulted in the loss of the support of several joists from which the decorated ceiling hangs.

A solution based on replacing the damaged beams with new ones was unfeasible, as well as unnecessary, so a solution was designed consisting of making a series of combined grafts, which would allow the gradual reconstruction of the two beams from inside the baldachin, in order to have the beams completed, repaired, and structurally functional. The final This beam is formed in one half, by the original beam, and the rest by wood provided for the occasion, joined in the appropriate way to allow the beam to recover its original resistance capacity.

The wood used in the repair comes from another building in Santiago de Compostela, the Bonaval convent, and is also made of chestnut, with a similar age, that is, three and a half centuries. The concept of minimal intervention, in this case, is based both on avoiding any disassembly, carrying out the repair in situ, and on the use of wood with the greatest technical and historical compatibility.


Image 5. Left: Santiago the Apostle, kindly, points out with his stick the point where the solivos had lost their support. The seat of the coffered ceiling is obvious to the naked eye. Right: Inside, the support of the solivo on the left is, seen from above, the same as the one indicated by the apostle. The planks between solivos are the troughs that, in the image on the left, are carved and covered with gold leaf. The repair had to be carried out with grafts, to avoid disassembly. Both the repaired and supplied wood is chestnut, of similar origin and age: approximately 350 years.

Disassembly intervention

It is not uncommon to find the assertion that it is only the Japanese who have the habit of periodically dismantling wooden buildings for their preservation, and that this fact is based on a cultural question. The previous sentence contains several inaccuracies. There are many cultural contexts in which disassembly is used as a tool for the conservation of wooden heritage, with greater or lesser frequency, among them, Norway[12], Russia[13], Mexico[14] and Spain[15].

Can it be called minimal intervention, that consisting of dismantling the building completely? This is the case with the restoration of Kizhi Pogost, begun in 2011 and completed in 2019. After several previous restoration processes, of lesser magnitude, and due to serious structural problems, the building was lowered with a metallic structure in 1982. Subsequently, and for the current restoration, the shoring was modified, to allow the upper part of the building to be supported, while annually a strip of it was dismantled, to carry out the necessary repairs in the workshop. The process, recently completed, has involved repairing the damaged logs, replacing the unrecoverable ones, and keeping all the others in their original position. It has also been an important source of knowledge, both in the documentation and intervention processes, including traditional techniques for building construction with wood and repair techniques for wooden structural elements made with wood.

1

Image 6. Left: Exterior view of the building and the area to be intervened in 2016. The corresponding strip of logs has been dismantled to proceed with the repair of the damaged elements and the replacement of the irrecoverable ones. Right: The same strip, reassembled in the workshop, to check the adjustments, before being disassembled again and finally reassembled on site, before the arrival of winter.

[12] During the Stavkiche conservation program, led by Riksantikvaren, and led by Sjur Mehlum, the criterion of completely dismantling the building was used in the case of the Borgund bell tower, while the main building of the Borgund tower was not dismantled. Borgund Church, nor any of the other 27 Stavkirche.

[13] Restoration led by the architect Vladimir Rakhmanov, the engineer Iosiph Rasha, and the carpenter Alexey Chusov.

[14] La Petatera, in Villa de Álvarez, Colima state, Mexico, is a bullring that is dismantled and reassembled annually using the same material, kept for the rest of the year by 71 families. It is not properly a conservative intervention, but conservation by use.

[15] Medieval tower of Jaureguía in Donamaría, Navarre, was restores by architect Maite Apezteguía. The two upper levels, fully built in Wood, were completely disassembled during the process of intervention that took place in 2001.

Partial conclusions

From the above, it seems to be deduced that the concept of minimal intervention is not limited to a specific recipe applicable in all cases, but varies depending on the building, its constructive conditions, its pathologies, its conservation needs, and the phase in question. The minimum intervention criterion, and its application to a specific intervention will be conditioned by the cultural context, but also by the fact that it is a construction made with wood. The latter produces a certain homogenizing effect between cultures.

Photographs: 3-1, 3-2, 5-1, 5-2, 6-1, 6-2, 7-1, 7-2 Author: Mikel Landa. Copyright: Landa-Ochandiano arquitectos. 4-1, Author: Mikel Landa. Copyright: Landa-Ochandiano arquitectos, for the Getty Conservation Institute.

Drawings: 1-1. Author: G. Tampone, 2-1, 2-2. Author: Landa-Ochandiano arquitectos 4-2. Author: Landa-Ochandiano arquitectos. 4-1 for the Getty Conservation Institute.

RESEARCH RELATED TO THE EFFICIENCY OF REPAIR METHODS FOR HISTORIC WOODEN STRUCTURES

Jorge M. BRANCO
ISISE, University of Minho, Guimarães, jbranco@civil.uminho.pt

Abstract
In many countries, traditional buildings comprise timber roof and floor structures. Most of these structures are degraded from different causes and need to be repaired or strengthened to ensure current and/or to fulfil the requirements of a new use of the building. Current knowledge assumes the need to preserve and to protect existing timber structural systems as a cultural value, with important advantages to the overall behavior of the building. This growing sensibility towards the preservation and maintenance of heritage buildings has led researchers to study different repair and strengthening solutions. This lecture aims to present a state-of-the-art review mainly on repair solutions for timber roof and floor structures, focusing on the most promising techniques taken into account the level of intrusion and reversibility. "Dry" interventions, based on timber or timber based elements will be highlighted.

Key words: Repair, Strengthening, Timber elements and joints

Introduction

Nowadays, the increased sensitivity towards the conservation of cultural heritage leads to the adoption of restoration techniques which guarantee as much as possible the preservation of the building authenticity and integrity, the conservation of the materials, the construction technology, the original structural system, the minimal interventions, their reversibility and compatibility with the existing parts of the buildings (Venice (1964); Krakow (2000); ISCARSAH (1999); UNI 11138:2004). Current knowledge assumes the need to preserve and to protect as much as possible of the authentic material (e.g. minimization of re-placements of timbers) using either simple techniques or more precise and sophisticated ones. Moreover, the original and authentic structural systems, must be protected and preserved too, even if they will not be visible after the restoration works, as a cultural value with important advantages for the overall behavior of the building especially in seismic areas.

In many cases, all over the world, traditional buildings involve timber structures at least as timber floors and roof systems. Damage in these structures can have different sources:

- ✓ natural defects of wood;

- ✓ biological degradation;
- ✓ fire;
- ✓ environmental and atmospheric agents in particular, transient moisture content;
- ✓ original design, execution, maintenance or intervention errors;
- ✓ excessive loading.

Before any intervention, the first step is the assessment of the existing timber structure according to the materials, the elements, the joints (strength and stiff-ness) and its overall behavior. Proper assessment of the material (risk of decay or insect attack) with appropriate techniques is obviously of major importance and therefore the study of recent state-of-the-art concerning the diagnostic procedures, is highly recommended (Kasal and Tannert (2011); Cruz et al. (2015)). Techniques are in profusion. They pro-vide huge support for the structural understanding of the whole load bearing sys-tem, however their use and choice must be discussed among all scientists involved in the assessment process to ensure the right agreement between the aim and the diagnostic or intervention techniques that will be used. This assessment may lead to the replacement of a portion or the whole member. On the other hand, in the case that the member or joint is kept in service and reinforcement is needed, an accurate assessment of the state of conservation of the structural elements (timber or metal ones) is crucial too.

Many retrofitting techniques have been developed and several of them have been reported in relevant manuals, books and scientific papers. However, while some applications were largely used and taught, others have been slowly left aside, with the risk of forgetting them and losing an important and valuable part of our heritage concerning the construction technology. For instance, the retrofit-ting of historical timber elements with prestressed systems has been performed several times in the past, but still there are many uncertainties and difficulties that discourage new applications and limit their development. For new constructions or for restoration projects, the post-tensioning with steel elements has been proposed since the beginning of the 19th century (Gasparini and Porto, 2003) as a specific way of applying the prestresses. Some inspiring cases, realized on historical timber trusses by Italian conservators, have already shown the potential of this strengthening method, as the roof structure of the theatre of Sarteano (Tampone, 1996), or the one of Savona (Paolini et al., 1989). Regarding existing timber single elements several studies on post-tensioning methods have looked for the optimal layout to improve the load-bearing capacity of these timber elements. Different configurations are still under analysis and the application are very broad from the strengthening of simple short-span beams (Song et al. (2007); Gesualdo et al. (2014)), to the retrofitting of wooden bridges (Al-hayek, 2014). Old timber floors as timber roofs suffer mainly from decay problems at their support areas (timber parts of the beams embedded in the external walls) and from excessive in-plane bending deflections since they are usually one-span beams designed to bear moderate loads, compared to current uses or a new use with heavy load requirements. The structural refurbishment of tradition-al/historic timber floors can be achieved, in order to increase the bending stiff-ness and strength of the main elements, by using steel or FRP plates or bars or by using and activating as structural members other elements, such as a concrete slab, timber planks or timber wood-based panels (plywood). The structural behavior of the resulting timber composite structure is governed by the strength and stiffness of the mechanical fasteners that connect the existing timber beams to the new elements. Another important aspect to be keenly considered is the timber floor diaphragm effect, which may affect the structural performance of a traditional masonry building subjected to lateral seismic loads: the common con-figuration of existing timber floors or ceilings with a crossly arranged single layer of wooden planks or the use of plywood panels consist a common solution for an in plane shear strengthening, in order to ensure a redistribution of lateral seismic loads and an efficient connection of the load bearing walls improving the seismic performance of the whole building (box-behavior) (Bertolini et al. (2007); Tsakanika (2005); Tsakanika (2007); Tsakanika et al. (2010)). It must be highlighted that this paper will focus mainly on reinforcement methods of traditional roof and floor structures and not on intervention techniques used for replacing timber elements that suffer from biological attack.

Timber joints

In the past, joints were not designed to transfer loads through shear, with metal fasteners such as nails, screws or bolts. Their ability to carry the loads was achieved through friction and mainly the direct contact of special cuttings and notches formed usually at the end of the connected members. The few metal fasteners that were used in parallel with carpentry joints, were ensuring the good fitting and contact of the members at the area of the connection (see Fig. 8). These types of joints are called carpentry joints. The last years, various new reinforcement techniques such as the use of screws (including self-tapping-screws), metal elements (plates, strips, stirrups), glued composites (glass or carbon fibres, weft knitted textiles) and glued-in rods and bars, or even full injection with fluid adhesives among others have been proposed.

Whatever the joint is, in order to ensure the transmission of the loads from one member to the other and the required strength and stiffness, it is important to keep all the surfaces of the joints in close contact. In the case of reverse loads, uplift, poor construction (Figure 1(c)), or high shrinkage of the wood elements, joints may develop gaps between connected elements, reducing the contact areas. One traditional reinforcement technique consists in placing a wooden wedge or a piece of timber to ensure perfect contact between the tenon and the mortise or the timber elements (Figure 1). This wooden wedge should be made of hardwood (for strength and stiffness) and its moisture content (MC) should be as close as possible to that of the reinforced wooden elements in order to avoid any shrinkage of the wedge.

Pinned tenon joints also have a very low bearing capacity in tension since only the wooden pin acts. If it is possible (eg. replacement of the member), a traditional technique can be used which consists in fashioning the new joint with a dovetail tenon increasing the strength in tension. If the element remains in place and in service, a binding metal strip may be used as reinforcement in tension. In order to avoid cracks, the strip can be screwed or bolted under the supporting beam and the spacing, the distances from the end and the edges of the connected timbers must be respected.

Figure 1. (a) Tenon and mortise joint: additional wooden wedge used to ensure a tight contact between the tenon and the mortise, (b) additional wooden piece to ensure the contact of the timber elements (c) Proposal for the reinforcement of a poorly constructed heel joint. Addition of a new wedge and screws.

The strengthening of existing notched joints, the most common connection in traditional roofing systems, mainly aims to avoid shear failure in the front portion of the notch. Most of the time, an end beam repair is required too because of decay and a wooden prosthesis must be used to replace the degraded material. As mentioned before, in past times, binding strips, stirrups, nails and bolts were used to ensure the contact of the connected timber members and to avoid their dismantling under reverse loads in severe wind or seismic events. The intervention concerning the metal elements that were used in the original construction of the joints, or, added later, usually included the substitution of the old type metal connectors (gypsy nails, binding strips, etc.) by new ones (screws, bolts, new type strips etc.) and either the treatment of the original metal or the use of a new one.

The strengthening techniques used nowadays try to reproduce the old techniques even when using new metal plates, strips and fasteners like screws and self-tapping screws. These kinds of interventions can affect the stiffness of the joint, and they should be checked too and designed accordingly.

Strengthened joints with metal devices were tested by Branco et al. (2009) under monotonic and cyclic loading. The purpose was to uncover any advantages and drawbacks in the behaviour of the joint and of the strengthening as well as to look at different types of strengthening. The four types of strengthened joints tested are modern implementations of traditional techniques. All the tests conducted have concluded that all the strengthening techniques are efficient and the metal devices carry a part of the loads too, improving the load-carrying capacity of the joint. However, the improvement in terms of strength and stiffness may varies substantially for different technics. The least efficient regarding both maximum force and stiffness is the solution with the external tension ties.

In dovetail-lap joints loaded in tension, the splitting of timber is a common failure mode. The traditional reinforcement of those joints consists in adding fasteners (bolts, nails, screws, etc.) restoring the shear mechanism provided by the pin. The design of this strengthening technique is based on the calculation of the shear resistance of the new fasteners. This intervention affects the stiffness of the joint (displacement of the center of rotation). Binding strips or steel wire may also be used.

The easiest way to reinforce a scarf joint in tension or realize a prosthesis connecting the new member with the sound old part can be achieved by adding metal fasteners (screws or bolts). On the contrary, the compression forces must be transferred by the contact areas of the timber elements. The addition of metal fasteners must secure the contact of these timbers. For the same reason, in previous historic periods, wooden pegs were used. In case of high loads, lateral metal, timber or wood-based plates can be added to improve the load-bearing capacity of the joint and to increase the stiffness. Both types of reinforcements are used in restoration works. In both cases the distances between the fasteners and between the fasteners and the ends or edges of the timbers must be followed according to relevant rules usually found in modern standards. Otherwise failures may occur.

Under bending, the rule of thumb that the weak point is the risk of premature splitting of wood is encountered here too (joints cut with right angles are less suitable due to the concentration of stresses at the corner of the cuttings). Self-tapping screws can also be used to strengthen splitting at the area of a scarf joint. From this point of view, scarf joints are better than halved-scarf joints. Under tension only, reinforcement screws can be driven only in the overlapping area. This reinforcement can be checked using Johansen's equations assuming that the tensile load is completely carried by the screws.

In the case of the Trait-de-Jupiter joint it is common to add metal connectors passing through the joint depth to reinforce the joint. It is important to be mentioned that the reinforcement method depends on the loading condition of the joint and the type of stresses that need to be transferred to the connected members (tension, compression, shear, or/and bending).

Conclusion

When working on old timber structures, the fact that the structure has survived for decades or centuries without failure it may be sufficient proof of its load bearing capacity if the use is not changed and it has to be taken into account if any or what kind of intervention is needed. On the other hand, this maybe not be sufficient proof for the future when new use and new imposed loads are introduced. If the decay of timber elements is too large, then local replacement of the decayed part is clearly the only solution. If repairs are necessary, specific reliable on-site assessment techniques are required to determine the appropriate level of intervention needed. This point remains very important to evaluate the replacement, repair and strengthening solutions along with the cultural significance of each case, the know-how and the associated project costs. Evaluation of the durability of the intervention works carried out with new innovative techniques is necessary too. Reinforcement may help to achieve several aims, for example, increasing the load bearing capacity (strength and stiffness) when is needed, or increasing the ductility of timber members or timber structures.

For joints, reinforcements help to reduce gaps in order the mechanisms of transmitting the loads to work properly, overcome timber weaknesses by increasing the shear strength and the tensile strength perpendicular to the grain, also helping to reduce the propagation of cracks. It is important to be pointed out that the interventions in joints (repairs or reinforcements) must not change their stiffness and consequently the overall original behavior of the original structural system.

For timber beams, reinforcements help to restore the load bearing capacity that has been lost because of the material decay at the support area, to increase the moment of resistance (and so limit the deflection too) or to increase the in-plane stiffness for lateral loads.

The study of reinforcement techniques is not yet included in European standards as Eurocode 5 but only, for specific aspects, in the National Annexes of some countries. Investigations on that promising topic have helped to figure out how to overcome timber weaknesses and have resulted in the proposal of design models and reinforcement methods. Some of the most important and applicable outcomes will probably be integrated in the revision of Eurocode 5 to help engineers to restore timber floors or timber roofs. But since existing structures and mainly historic structures are not covered by the new standards suitable for mainly new built structures, it is urgent and of great importance relevant European Standards to be developed too. These Standards have to provide the necessary tools for structural engineers, members of a multi-disciplinary team that have to work together in a restoration project, to evaluate the existing condition of a historic timber structure and moreover to select the proper interventions using innovative and/or simple techniques that will save the authenticity of our architectural heritage, including the authenticity of the “invisible” in many cases load bearing system.

References

Al-hayek, H. W. H., 2014. Flexural behaviour of post-tensioned timber beams, Winnipeg: University of Manitoba.

Bertolini C., Touliatos P., Miltiadou N., Delinikolas N., Crivellaro A., Marzi T., Tsakanika E., Pignatelli O., G. Biglione G., 2007. The timber roof of Hagia Paraskevi Basilica in Halkida, Greece: Multi-disciplinary methodological approach for the understanding of the structural behaviour. Analysis and diagnosis. *Proceedings of XVI International Conference and Symposium of the IIWC From Material to Structure*, Florence. (http://www.icomos.org/iiwc/2007.htm).

Branco, J.M., Cruz, P.J.S., Piazza, M. (2009). Experimental analysis of laterally loaded nailed timber-to-concrete connections. *Construction and Building Materials*. 23 (1), 400-410.

Cruz, H., Yeomans, D., Tsakanika, E., Macchioni, N., Jorissen, A., Touza, M., Mannucci, M., Lourenço, P.B. (2015). Guidelines for the on-site assessment of historic timber structures. *International Journal of Architectural Heritage: Conservation, Analysis, and Restoration*. Volume 9, Issue 3, 2015.

Gasparini D. A., da Porto F., 2003. Prestressing of 19th century wood and iron truss bridges in the U.S.. *Proceedings of the First International Congress on Construction History*, Madrid: S. Huerta ed., pp. 978-986.

Gesualdo, F. A., Rezende, R. B. & Cunha, T. A., 2014. Numerical and experimental evaluation of a double inverted trussed. *Construction and Building Materials*, Volume 50, pp. 736-743.

ISCARSAH: Principles for the analysis, conservation and structural restoration of architectural heritage (2003), IIWC ICOMOS Committee: Principles for the preservation of Historic Timber Structures (1999).

Kasal B., Tannert T. 2011. In Situ Assessment of Structural Timber. *RILEM State-of-the-Art Reports*, Vol. 7, 129 p.

Krakow Charter, International Conference on Conservation Krakow 2000, Krakow, 2000.

Paolini L., Messina C., Marradi A. M., 1989. Il restauro della copertura del teatro Chiabrera a Savona, in “Legno e restauro”, a cura di G. Tampone, Firenze: Messaggerie toscane.

Song, J.-K., Kim, S.-Y., Yang, K.-H. & Han, S.-A., 2007. Flexural behavior of post-tensioned glued-laminated timber with wire rope. Seoul, s.n.

Tampone G., 1996. Il restauro delle strutture di legno, Milano: Hoepli, pp. 321.

Tsakanika E., 2005. Methodology concerning the restoration of Historical Buildings. Case Studies: The Turkish Mansion and the Hagi Mehmet Aga Mosque in Rhodes. *Proceedings of International Conference of the IIWC Conservation of Historic Wooden Structures*, Florence 2005, Volume 2., 194-203.

Tsakanika E., 2007. Byzantine and Post-Byzantine Historical Timber Roofs in Greece. Typical failures, misunderstanding of their structural behaviour, restoration proposals. *Proceedings of XVI International Conference and Symposium of the IIWC From Material to Structure,* Florence (http://www.icomos.org/iiwc/2007.htm).

Tsakanika – Theohari E., Mouzakis H., 2010. A post-Byzantine mansion in Athens. The restoration project of the timber structural elements. *Proceedings of 11th World Conference on Timber Engineering*, (WCTE 2010). Riva del Garda, Trentino, Italy, vol. 2, 1380-1389.

UNI 11138:2004. Cultural Heritage – Wooden artefacts - Criteria for the preliminary evaluation, the design and the execution of works. *UNI Ente Nazionale Italiano di Unificazione*, Milano (Italy), 2004.

Venice Charter, Second International Congress of Architects and Technicians of Historical Monuments, Venice, May 25-31, 1964.

Timber Frame Conservation: Keeping the Traditional Craft Alive

Jack A. Sobon

Architect/Builder, Windsor, Massachusetts, USA

Abstract While it is certainly important to conserve the building as an artifact, it is equally important to keep the practical knowledge of the particular craft alive. By employing trades people that work with raw materials, tools, and techniques as evidenced by the old work, we further our understanding of the craft that produced the artifact. The trade or craft is then preserved along with the artifact.

Approaching the Work

When we approach the repairs to a timber framed building, there are the obvious considerations of minimizing disturbance to the original fabric, maintaining the structural integrity of the building with the repairs, and of course keeping as much original work as practical. However, if we are preserving the artifact, shouldn't we also be preserving the craft that created it? In my opinion, preservation of the craft is equally important, if not more important.

There is a tendency in repairing timber framed buildings to use the latest, high technology fixes such as adhesives, epoxy resin fillers, steel fastenings, and the like. They are after all, what is being marketed to those architecture and engineering professionals involved in the repairs of those buildings. We all know how important advertising and promotion are in dictating outcomes. If there is no vested interest, there is no promotion. No industry is promoting a simple carpentered solution using locally obtained wood. Thus, highly engineered products, shipped thousands of miles is what we are offered. I can't deny that there are times when those products may be the best approach to meeting the above mentioned criteria, in some cases they may the only approach. (Figure 1) They don't however, further our understanding of the carpentry craft that created these wooden structures originally. Use of these new products creates a new class of technicians, chemists, and mechanics that become involved in the repair work rather than carpenters. The high tech solutions should only be the last resort, after the carpenter or craftsman has exhausted all the usual, time tested possibilities within his scope. After all, timber framed buildings have been traditionally repaired primarily by carpenters for a thousand years or more. If a carpenter couldn't make it work with wood alone, a local blacksmith would be brought in to fashion some ironwork.

Figure 1. Modern high-tech materials may have their place in repairs to timber framed buildings, but only after all other traditional carpenter's techniques have been considered. The decayed eave end of this early nineteenth century roof truss required some custom fabricated steel reinforcing to make the wooden repairs structurally sound.

The Design Professionals

To resurrect, and preserve the carpentry craft as well as the actual building, there first needs to be a better understanding of traditional carpentry by the professionals: the architects, engineers, and building officials. All those professionals involved in preservation of timber framed buildings should have as a minimum, a basic introduction to the history of the craft and its development across both time and space, and guided tours of their local timber framed buildings representing various periods. Learning the nomenclature of the various components and different framing systems is essential for communicating with others involved in the work. There should be in addition, practical "hands-on" courses on the use of traditional hand tools, on working with new, freshly felled timber of different species, with layout and cutting of wooden joinery, shaping of pins, and erecting the frame using traditional methods. (Figure 2) Lastly, they should execute some of the common, traditional repairs using wooden joinery secured with wooden pins. As seems to be typical today however, these professionals rarely have any practical "hands-on" experience. This needs to change. In the United States, continuing classroom or on-line education is required of architects, engineers, and building professionals periodically in order to renew their licenses. Courses of this type could easily be certified towards that continuing education. Armed with this basic knowledge, they are better able to understand an old timber framed structure, how and when it was originally built, how it was modified, added to, what types of timber were used, how they were converted from the log, and most importantly, how best to specify the repairs. They will also be on a more even footing communicating with the craftsmen that will carry out the actual work and gain their respect.

Figure 2. “Hands-on” courses should be required for all professionals involved with repairing old timber framed buildings as well as constructing new ones. Here at Jamtli Museum, Sweden, students with a variety of professions and trades are learning the timber framing craft. The long plate timber is being raised using an efficient and safe traditional technique called “parbuckling”.

The Craftsmen

The craftsmen (I don’t intend to be gender specific here) should also have a basic introduction to the history of the craft and its development across both time and space, and guided tours of local timber framed buildings of various periods, also learning the nomenclature of traditional building components. The “hands-on” courses in timber building with new material and repairing old, are even more essential to the craftsmen for they are the ones to be carrying out the actual repair work. And, as nothing impacts the quality of traditional timber joinery more, a thorough course on sharpening of edge tools is critical.

If a carpenter has constructed new timber framed buildings using traditional methods and tools of the particular period, he is in a good position to work on a historic building of that period. He will recognize the layout marks, level marks, the numbering of components, etc. on the old work, thus understanding the particular layout methodology that was used. This will be to his advantage for the laying out of the repairs and new components. He will recognize the earliest phases of construction and how the building was modified, repaired, or shored up throughout its life. He will identify important artifacts and remnants of materials that give clues as to how it was constructed and used. The species of wood, where in the tree it comes from, and its proportion of sapwood and heartwood will be identified. How it was converted from the log, ie. hewed, sawed, or riven will be evident to him. This will be used to guide the selection of the replacement materials and matching the replacement section to the existing one. He will be able to examine tool marks on the old surfaces and readily understand how the original tools were positioned and wielded to produce those particular marks. A competent craftsman will likely build up a collection of historic tools or modern reproductions of them that he can use to create new replacement sections, modifying the tools' cutting edges as necessary to match the marks on the original work. While he is free to use modern tools to perform some roughing out tasks, the tools that leave the finish marks should be the traditional ones.

Figure 3. Rather than blindly following an architect's specifications, a well-trained craftsman can better interpret the structure, its needs, and the approach to repairing it. He can bring this knowledge to the architect's attention and improve the project's overall outcome. This craftsman is fashioning a scarf joint on an existing sill timber, a traditional carpentry repair.

Since the carpenter will likely spend far more time in the historic structure than all the other professionals combined, he could be a valuable asset to those professionals, guiding them, offering advice, and helping with specifications on the actual work. While many architects and engineers are reluctant to accept advice from any workmen, I feel they would likely listen attentively when they realized the extent of a particular craftsman's knowledge. Over time, their attitude would begin to change, developing a greater respect for the craftsman. I have noticed that when I am working as an architect on old buildings with craftsmen educated as mentioned above, they will bring to my attention interesting construction anomalies, deficiencies in the structure, or other items I might have missed. I am thankful to have them involved and respect their opinions. They are a pleasure to work with and can be better counted on to do a proper job. (Figure 3) The competent craftsman will also be of great value to the preservation of the building itself. A fully knowledgeable craftsman will produce far better and more lasting work than one who is just a workman blindly following an architect's specifications.

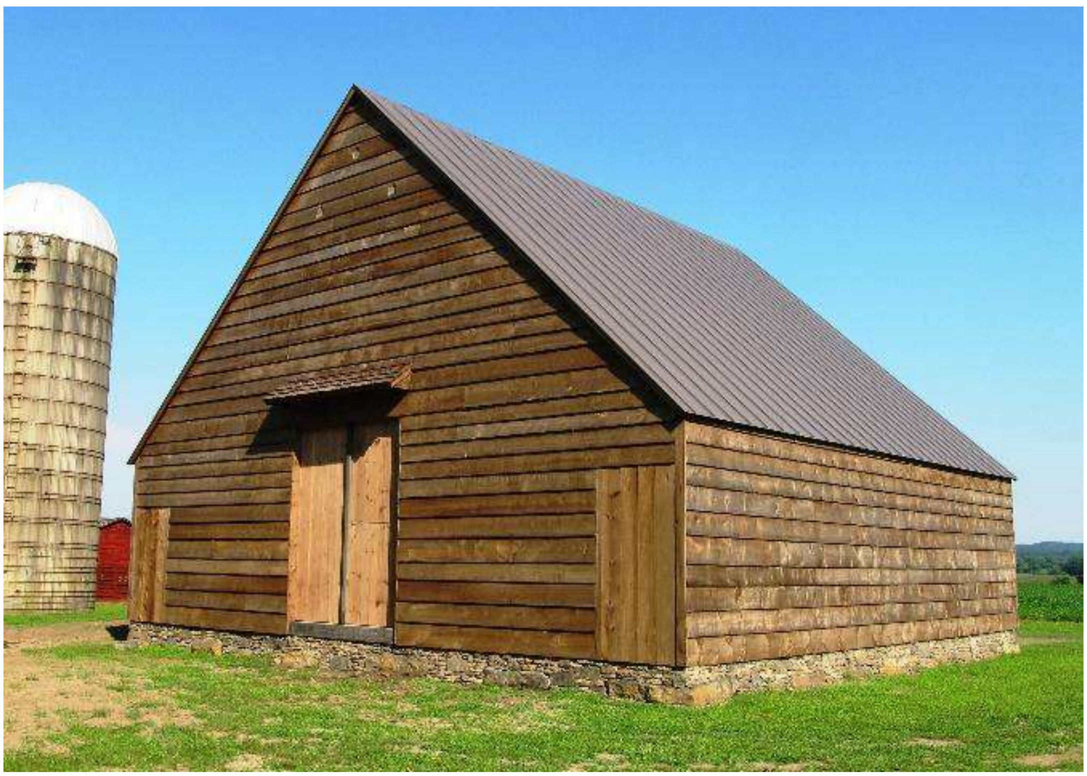


Figure 4. This New York State Dutch barn is a reconstruction of the original 18th century barn that graced this historic farm property. Many of the original barn's timbers survive re-framed in an adjacent mid 19th century barn and were documented for the re-construction.

Figure 5. Virtually all of the timber, siding, and flooring for this barn was harvested out of the farm's woodlot, matching species as much as practical. Traditional scribing methods and hand tools were used to fashion the joinery.

The dichotomy that has existed with design professionals on one side and the craftsmen on the other does not produce the best results. Having design professionals produce copious drawings and specifications to enable bidding by multiple contractors creates a "race to the bottom" effect. The least competent contractor will often get the work! However, this dichotomy has begun to be blurred over the last few decades. Many structures are being built today by design-build firms where all work from the client meeting to the finished building is done in-house. This is somewhat similar to the ancient approach where there was a Master Builder who was as good at geometry, design, and ornament as he was at selecting stone in a quarry, picking out timber in the forest, or showing a workman how to properly use a tool. It is a good model to return to. Pick the design professional team and the contractor simultaneously, then amongst them, work out the specifications and negotiate the cost.

New Traditional Work

Because of his skills and understanding in working with historic construction, it is likely that a significant portion of a craftsman's work will be creating entirely new, but traditional structures using period tools and techniques. It is almost inevitable that his curiosity and understanding of the old will prompt him to delve into this new work. I received my initial hands-on training dealing with stinging insects, hay dust, and animal excrement while repairing centuries old timber framed barns. It wasn't long before I was dreaming of working on freshly cut, new timber. After working by hand in new wood, using only traditional hand tools, I soon found that I was gaining extra insight into understanding the old work that I saw. By working with both old and new buildings, the two approaches complement each other.

There is a growing market for such new "historic" structures to stand along with other truly historic ones both in the private sector and in the public (museums). (Figure 4, 5) While these new structures aren't historic, they serve as examples of how the historic ones might have appeared when they were new, in their pure, original form. The built environment will improve overall when there are more traditional, vernacular structures in a given area, even if some are newly built. As old ones are lost, the newer ones keep up the vernacular appearance of the area. Working in both preservation and reproduction of historic work should be encouraged and perhaps even required, as it will keep the craftsman in his best form.

Preserving the Craft

The above recommendations will better preserve the buildings and at the same time, *keep the craft alive*. The artifact (the building), with time will eventually wear or degrade to a point where the layout markings, the individual tool marks, or the conversion methods are no longer discernable. It will just be some rough, fuzzy old wood thing without much story to tell. Maybe the last original section of a building, the only part that hasn't been replaced, now needs replacement. While the new work replaces the old, at least the original form of the building is preserved. Or, perhaps a building is lost completely to fire, flood, or some other natural disaster. The artifact is gone completely! If the craft that created it is preserved, the building can be reconstructed. The trees are once again felled and hewn to size, the carpenters then frame them up with mortises and tenons, and the building's framework is raised up again. The knowledge is still there, as are the professionals and craftsmen skilled in doing the work. The craft has been preserved and will hopefully outlast any one building.

CONSERVATION WORKS OF THE KIZHI POGOST

Margarita KISTERNAYA

Kizhi open-air museum. Kirova sq., 10, Petrozavodsk, 185610, Russia,
kisternaya@kizhi.karelia.ru

Abstract The Kizhi Pogost of Our Savior – the World Heritage Site (C544) is one of the most famous wooden architectural ensembles in the world. This is an illustration of a carpenter pushing a technique to its furthest limits. During its 300 year long history the Kizhi Pogost structures has been periodically repaired and maintained. Paper presents the history of the architectural ensemble and focused on the restoration of the Church of the Transfiguration (XVIII c) – the summer church of the Kizhi Pogost. It last for nearly 20 years and was completed in 2019.

Key words carpentry, conservation, wooden churches

Introduction

Russian north has preserved best examples of historic timber structures, which are an integral part of the history and the global cultural heritage. The Kizhi Pogost of Our Savior is located on a small island of Kizhi in the Onega lake in Northwest Russia close to the Finnish border. Carpentry traditions arrived in this region in the 14^{th} century from Novgorod the Great - the biggest economic and cultural center of Northern Russia at that time. The newcomers were attracted by routes to Northern seas to trade with European countries. They brought new constructive technologies and forms, more progressive soil cultivation, crafts, high spiritual culture and a new, Orthodox, religion. The *Pogost* churches on the Island of Kizhi were first mentioned in Moscow census books of the 16th century. The Russian word “pogost” has several meanings. The first meaning is “an administrative centre of the area”. In the 16th century the Kizhi *Pogost* united 130 villages situated on the peninsula and the surrounding islands. Parishioners came here not only to pray, but also to participate in the meetings of peasants’ community, to pay taxes and to celebrate holidays. The next meaning is “a place, surrounded by a wall, comprised of 3 structures: a summer church, a winter church and a bell- tower. And the last and the most recent meaning of the word is “cemetery”.

According to the historic documents the previous Kizhi Ensemble was struck by lightning and burnt down in the end of the 17th century. The current architectural ensemble of the Kizhi *Pogost* had been formed during two and a half centuries. The winter church – the Church of the Intercession (Fig. 1) was built after the fire in 1695 and reconstructed in 1764. It represents a traditional type of northern churches built in the form of a ship. The summer church – the 22-domed Church of the Transfiguration (Fig. 1) shook the people of the area with its magnificence and beauty in 1714. The erection of the Bell Tower in 1864 completed the Kizhi Architectural

Ensemble. The Bell Tower was built instead of old dilapidated one. The final element of the Kizhi Architectural ensemble is the 495-long Enclosure. Unfortunately the original wooden enclosure has not been preserved. The replica was made by an architect Alexander Opolovnikov in 1959.

Figure 1. The Kizhi Pogost. The Church of the Transfiguration (1714), bell tower (1864), the Church of the Intercession (1694-1764) in the enclosure (mid-XX cc.).

Nowadays the Kizhi Pogost of Our Savior is the only preserved architectural ensemble with multi-domed churches. In 1990 it was included into the List of the World Heritage of UNESCO. In 1993 Kizhi Churches were listed as the most valuable objects of the Cultural Heritage of the Russian Federation. The Kizhi *Pogost* is mentioned not only as a unique architectural ensemble, but also as the site of one of the most difficult restoration of wooden monuments. The restoration of the summer church of the ensemble, the Church of the Transfiguration lasted almost two decades, and preparation for it took almost half a century.

The Church of the Transfiguration (1714)

The structure is 37 m (123 feet) high and it incorporates three octahedrons set one on top another with transitional quadrangles (Fig. 2). Four annexes face the cardinal points. The church was built on a loose rock foundation. The walls were aired and dried from beneath. It has a well thought system of drains which protects the structure from water and, therefore from biological deterioration.

The church is crowned with 22 domes. They differ in size. It gives the impression of upward movement. The 600-ton church doesn't seem massive and heavy. The domes are covered with aspen shingles. The church is a bright example of engineering wisdom and practicality. It was built of pine logs – most durable material in our region. Moreover special pine trees growing on pour sands and rocks were selected. The carpenters used only axes because when the tree was cut with an axe the resin didn't go out, so the timber was longer lasting.

The Church is an illustration of a carpenter pushing a technique to its furthest limits. The key to its interpretation as an architectural masterpiece is not because of its sheer size, its magnificent form, the complex details of its construction, or the fact that it was built using only axes and adzes and without metal nails, though these issues are formidable. The Church of the Transfiguration is quite simply a masterpiece of log engineering. The building forms and structure are superbly integrated. This is why this structure attracts the people's attention for nearly three centuries.

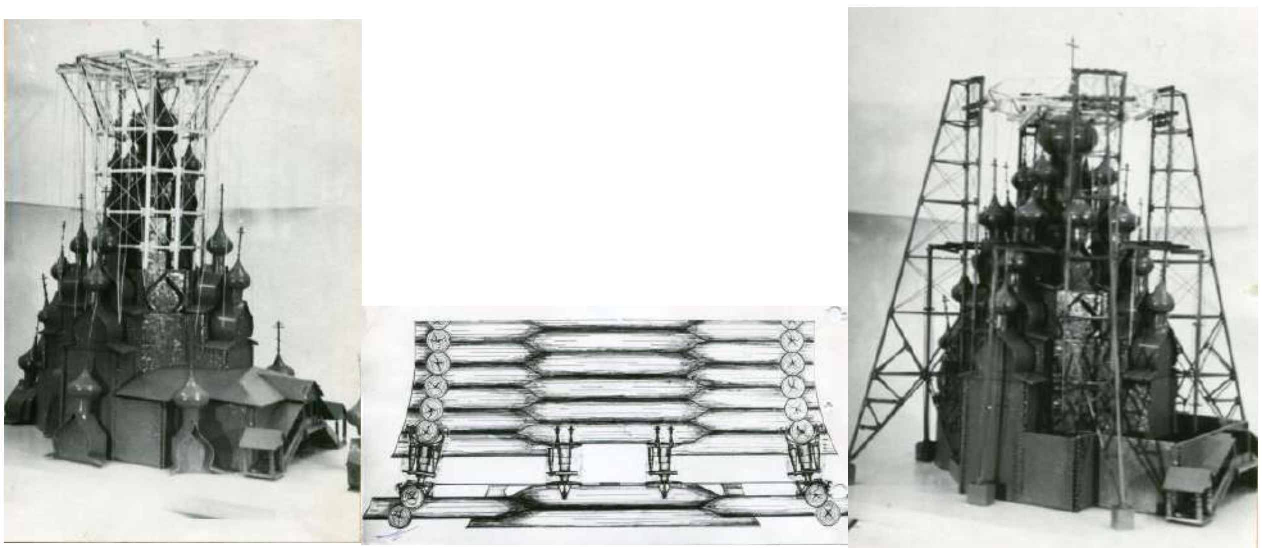


Figure 2. Proposals for the restoration of the Church, made in 1880's

Problems with the structural stability arose immediately after the construction of the church. The huge structure was put on a loose-rock foundation. Due to the movement of soils, the building began to roll. Several attempts had been made to stabilize the building in the XVIII- XIX cc.

During the first 100 years, the walls of the Church of the Transfiguration were not covered with protective siding boards. These were installed in 1818 and at the end of the XIX c. walls were painted white and the domes were painted blue. From the 1930's to the 1950's the Church was closed and was not used for services. Between 1957 and 1959, the weatherboards were removed and aspen shingles were reinstalled on the domes. This restoration did not solved engineering problems of the structure and deformations continue.

Conservation of the Church of the Transfiguration 1960-1999

Numerous attempts to find the decision for the church conservation were made (Kozlov et.al., 1997, Vakchrameeva, 1999). Leading architectural institutions from Moscow and St. Petersburg were involved in the process of conservation of the church.

The complexity of the tasks assigned to them was determined by the need to find a solution that would preserve the architectural and artistic appearance of the structure, the interior of the temple and at the same time strengthen the structure and eliminate the building's deformation. It was at this stage that the first systematic instrumental studies of the structure deformations began.

All researchers who studied the Church of the Transfiguration were unanimous in that the deformations that arose as far back as the 18th century appeared due to the fact that the structure, set on an insufficiently strong and rigid foundation, sagged unevenly, since its central the part is more loaded than adjoining annexes (Gusev, 1999). In 2005, it was found that the soils on the north, east, and south sides of the temple differ in their composition and properties, which cannot but affect the stability of the structures (Simagin). Undoubtedly, the destruction of logs by wood-destroying fungi and insects also had an effect on the occurrence of wall deformations. At that time the researches estimated, that 30-40% of logs in different parts of the church should be replaced.

Figure 3. Metal scaffoldings in the interior of the church

Different approaches were proposed for the structure restoration at that time (Fig. 3). None of them have been approved.

In 1980, the condition of the church was declared in emergency. The vertical deviation was 0,8 m. During 1981-1983 a steel framework was installed inside the building to support and reinforce the structure (Fig. 4). At this time the iconostasis and "sky" ceiling were removed from the interior of the Church and placed in the depositary.

Since that time different approaches had been widely discussed for the conservation of the structure. Special; non-destructive technique for evaluation of the wood quality was developed. The international competition was announced. Conservators from all over the world were involved in discussion. It was recognized that the ways and means to preserve the authenticity of the cultural heritage depend on the traditions and culture of the region.

Conservation of the Church of the Transfiguration 2000-2019

In 2000 the overall restoration concept for the Church of Transfiguration which would address the impact of continuing deterioration of the building on the authenticity and integrity of the site was worked out. It was proposed to divide the structure into 7 restoration tiers and using the existing steel supporting structure lift up the upper 6 restoration tiers, then dismantle the lower one and built a new foundation .according to the modern building code.

The restoration project aimed at regaining structural strength, dismantling the steel supporting structure inside and re-establishment of the interior started only in 2008/ A long period from 200 to 2008 was needed for preparing the lifting equipment, logs and other facilities for the restoration.

Figure 4. The Church is under the reconstruction

One of the challenges was the searching for timber for the restoration. The Church was built of Scots pine (*Pinus sylvestris* L.) logs with density from 400 to 600 m3, average tree ring width from 0.08 to 0.20 cm, late wood content from 22 to 30%, resin content from 5 to 10%. All logs have 200-300 annual rings. The task was to find a 200-300 year old tree with a certain (sometimes quite big) diameter and length. One should remember however that due to intensive forest management the structure of forests and the quality of timber have changed greatly. Nevertheless. old-growing pine trees had been found (Kisternaya, Kozlov, 2006).

The current restoration included large-scale element-by-element reassembly of the walls with repair of damaged logs, elimination of walls deformation, and reinforcement of weakened load-bearing structures and joints.

In 2009 the technological lifting system was installed in the church. In 2010 the porch and the refectory were dismantled and the lifting of the restoration tiers was successfully done. Next year the lower restoration tier was dismantled and the new foundation was built. The disassembled logs were restored at the specially constructed restoration workshop at the northern part of the island of Kizhi. The proposed conservation technology included the assembling of the restored tier, a detailed examination, repair of the damaged elements with the priority of preserving the authentic material (or making precise copies), test-assembling of the restored tier, preliminary tests, complying with remarks, and the submission to the acceptance commission.

The reconstruction of the church foundation was completed in 2013. Its visible part is the imitation of the original stonework of lime mortar. The most laborious work was matching the upper part of the foundation with the assembled portion the wooden underfloor part of the church. In April 2013, the central part of the 6th restoration tier was presented to UNESCO and Russia experts.

The upper part of the 6th restoration tier was restored by June 2013. The most diffcult problem of the preliminary assembly was a considerable deformation of log walls in vertical level, particularly in the joints of four annexes with the main building. Difference in height between originally horizontal logs was up to 0.4 meters within 5 meters of length.

These deformations appeared in first 50 years of the church life. A huge weight of the central part caused its sinkage due to lack of a rigid stone foundation, and with that, the annexes preserved their initial static position. Even with those serious deformations, the church didn't crash thanks to a flexibility of wooden structures. The attempts to press out the central part back to the upper position with hoisting jacks as well as the other methods were not successful. The church remained in this position almost 250 years. The deformations were concealed of view by making the second layer of floors in a straight horizontal way and by remaking doorways and window openings.

Next year the disassembly of four domes on church annexes was done prior to the disassembly of church log walls. The specificity of church building set a new challenge of changing the disassembly direction from 'bottom to top' to the opposite one, i.e. first the disassembly of domes and, after that, of log walls.

After the domes had been disassembled, so were the log walls, carefully, in the course of three months and by the means of lifting equipment. Totally, 1,5 restoration tiers were disassembled, about 460 logs and other elements. There were no serious difficulties during the work; however, the increased height of work area caused certain changes in work procedures. Another traditional problem was the presence of two contractors on the working sites simultaneously, i.e. the mounters, who were disassembling the log walls, and the carpenters, who were assembling the restored log walls at the same time. According to the safety rules, the simultaneous work above each other was excluded, and that caused delays. However, both of the contractors managed to keep a good pace of work and to set correct disassembly-assembly procedures that did not cause any serious stoppage of work.

Unlike 2012, when the log walls were assembled right from the ground level, the carpenters faced the same problem as the mounters had before, i.e. the increase of height of work area. In the regular course of work, the decision was made to set the external scaffolds only if extremely needed. The reason is that they are too labour and resource demanding. Actually, it was never needed because the internal metal support and the scaffolding of the refectory were used to the utmost.

The external scaffolds were used at the assembling of domes. Until that moment, the carpenters prefer operating from the internal scaffolds and free outside space. This is a kind of a traditional technology because the carpenters in the old times used to work exactly inside when assembling the church, and used the outside space just for lifting up the logs. The conservation of the church for winter period proceeded after the disassembly of logs and the assembly of the sixth restoration tier.

So, log by log, restoration tier by restoration tier in the 5th restoration tier was assembled in 2014, 4th – in 2015 and in spring 2019 we saw the Church of the Transfiguration in its beauty. As it looked like in 1714.

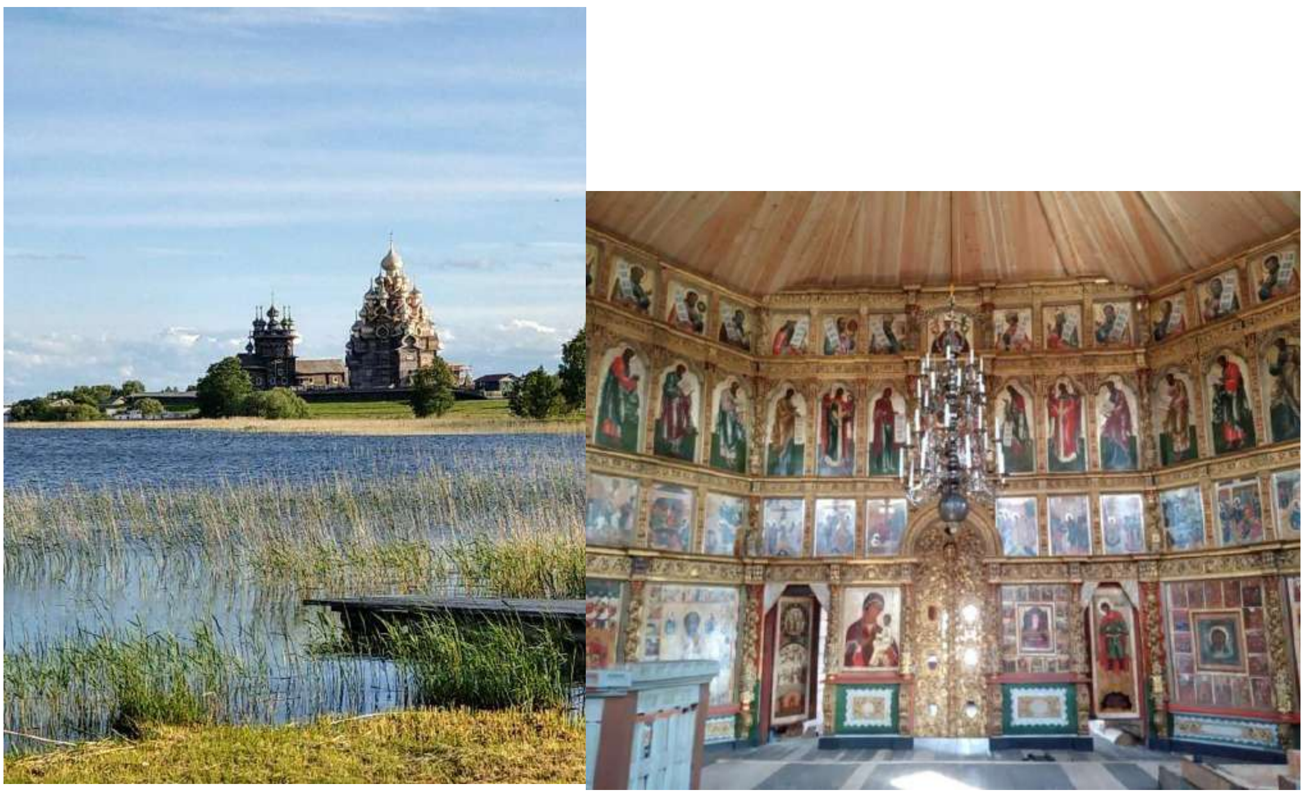


Figure 5. The Church after the restoration.

To our opinion the lifting technology has two advantages. First, the church preserves its silhouette during a long-term restoration, and, second, the portion of restored material is limited until the next summer stage of work. The first above-mentioned point is quite clear, but the second one requires some clarifications. The navigation on Onego Lake and, consequently, the delivery of materials and people lasts only 5 months a year. It is difficult to run a large-scale production in this hard-to- reach area without building a serious infrastructure, which is a really a problem on Kizhi Island. The limited amount of work material enables to keep the anthropogenic and other kinds of loads on the island eco-system within reasonable limits.

At the final stage the steel frame was dismantled and the reconstruction of the interior has started. Reconstruction of the interior was an important part of the restoration. The preserved iconostasis of the Church of the Transfiguration was installed in the second half of the XVIII c. It was 7 m high and 24 m long. Icons (101) were installed in the wooden gilded frame. The church also had a ‘heaven” ceiling.

The wooden frames for the iconostasys is made of different wood species: linden, alder, aspen and pine. The baguette of beveled windows is made of oak. The iconistasis was repaired for the last time in 1901. In 1980 when preparing the church for the engineering reinforcement, the iconostasis and the ‘heaven” ceiling were dismantled and before that the gilded layer was sealed with adhesives resistant to RH&T fluctuations. By the mid-1990’s the state of the gilded layer worsened. Cracks and ground stratification appeared. Some fragments of the carved wooden frame were lost.

The stage-by-stage restoration of the iconostasis started in 2009. It was aimed at conservation of the gilded coat and painted layer and restoration of the wooden base and carvings. The leading conservators from Moscow and St. Petersburg took part in the process which lasted for nearly 10 years. In September 2019 the installation of the gilded wooden frame of the iconostasis has started. In August 2020 at the Feast of the Transfiguration the Church will be opened for visitors and parishioners.

Bibliography

Kozlov V. A., Kisternaya M, V., Krutov, V. I. Estimate of Condition of the Timbers in the Church of The Transfiguration on Kizhi Island. Proceedings of Workshop and Conference on Board M/S Andropov, Sept. 1997, Virginia Tech, Blacksburg, Virginia,USA, P. 28

Vachrameeva T.I. Preobrazhenskaya tserkov’ Kizhskogo pogosta: obzor meroprijatij po ee sohraneniju (1993-1998) // Actualnye problemy issledovanija I spasenija unikalnyh pamjatnikov derevjannogo zodchestva Rossii/ Doklady mezhdynarodnogo sympoziuma. SPb. 1999. P. 95-98

Gusev B. P. Unikalnyi pamjatnik derebjannogo zodchestva na ostrove Kizhi (Sostojanie, problemy, perspektivy) // Stroitelstvo I nauchno-technicheskij progress. 1987. №9. P. 20-44

Kisternaya M., Kozlov V. Russian wooden architectural heritage: century-old traditions to use forest products // Cultural heritage and sustainable forest management: the role of traditional knowledge. – Florence, 2006. - V. 2. - P. 465-469.

THE JAPANESE APPROACH TO WOODEN HERITAGE CONSERVATION

Masahiko TOMODA

Tokyo National Research Institute for Cultural Properties, 13-43 Ueno Koen, Taito-ku, Tokyo, Japan +813-3823-2150 tomoda@tobunken.go.jp

Abstract The repair of wooden heritage buildings in Japan has been developing, on the basis of traditional repair techniques, in its own way by reflecting the modern concept of heritage conservation, given environmental conditions, anti-seismic performance and other different requirements. Despite of some issues to be discussed, it has advantages worth to be shared with other countries in the cultural region of wooden architecture, including minute investigations, publication of detailed reports, and efforts to ensure transmission of skills and technologies.

Key Words Japan, periodic repair, disassembly, original technique

Wooden buildings in Japan and the basic idea for their repair

About ninety percent of the over five thousand buildings nationally designated as Important Cultural Properties including National Treasures are wooden buildings. Almost all of "non-wooden" buildings were constructed after the Meiji period from the middle of 19th century, which means that Japanese architecture until then was basically built in wood. Masonry construction using bricks or stones was scarcely applied in Japan, which makes its architectural history unique and different from most of European and continental Asian countries like China and India.

Needless to say, repair work of wooden buildings has been performed continually even before introduction of the modern concept of heritage conservation. Different from substantial and durable masonry structures, wooden buildings made up mainly of vegetal materials are always threatened by deteriorating factors such as rotting and insect damage, and this is still more so in Japan because of its humid environment with large rainfall. That is why advanced construction techniques from China and the Korean Peninsula spread rapidly being combined with indigenous techniques. By adding further technical invention to adapt to the climate and to withstand frequent earthquakes, Japanese architecture continued to evolve on its own. Nevertheless, it was definitely impossible for wooden buildings to survive for hundreds of years without receiving periodic repair works. Historic records mention such repair works, together with remaining traces on the building itself of various works such as partial repair to renew the bottom section of pillars, reroofing of the roof, insertion of eave-supporting posts, etc. Although largely dependent on the building's design, material quality and environmental settings, it is generally said that the preferable frequencies of repair works are:

every 20 to 40 years for reroofing with partial repair of wooden elements, and every 150 years for full-scale repair in which the structural frame is partly or fully disassembled, repaired and reassembled. Since obtaining quality materials and processing them always requires substantial labor and cost, during a repair work as much members as possible ought to be reused by combining them with new material or diverting them to other parts of the building where the required level of strength and soundness is more modest. Therefore, even after repeating repairs many times, a large proportion of the original material has been still preserved until today.

Image 1. Horyu-ji Temple built in 7th century

Establishment of conservation methodology for wooden buildings as cultural heritage

The Japanese conservation technique of wooden building is on the extension line of the traditional maintenance repair followed from ancient times, and even today such conservation work of historic wooden building is carried out by skilled craftsmen including carpenters holding a knowhow of wooden construction technique inherited from the early-modern period. On the other hand, since the late 19th century when the government initiated with the state budget the conservation projects of ancient buildings in shrines and temples recognizing them as cultural heritage, it formed a management system for this kind of project nominating experts with such academic knowledge as art history, architectural history and structural engineering to supervise the project. At this stage, an argument started to discuss how the conservation of cultural heritage building should be. The first point at issue was a treatment of elements modified in the later periods of the building's history.

Image 2. Priests' quarters of Gango-ji Temple with roof tiles from early 8th century

Image 3. An example of partial disassembly

In the early process of trial and error, conservation policy was largely dependent on the person in charge and varied from a project to another. The general conservation project of Horyu-ji Temple started in 1934, in which detailed scientific surveys of architectural members revealed the past state of the building together with the disappeared construction techniques from different periods, had a great impact on the future direction of the heritage building conservation. The Guideline for the Maintenance Repair of the National Treasure Buildings enacted in 1940 set the fundamental concepts for conservation as follows; 1) The main focus should be put on the repair of the deteriorated and damaged parts, keeping the existing structure, design and methodology, by using the old members as much as possible. 2) Alteration of the current state is only permitted in the case, where it is inevitable for the preservation of the structure itself or particular necessity of the restoration exists to preserve the original structure, design and/or methodology. The characteristic methodology continuing up to now for the conservation of heritage building in Japan was basically established in this period, such as thorough scientific investigation during the full-scale conservation and publication of the detailed report including the survey results.

Image 4. A repaired pillar

The practice of wooden heritage building conservation

The following introduces the general process of a wooden building conservation work that is currently carried out for Nationally Designated Important Cultural Properties in Japan. The conservation work can be divided into two categories. The maintenance repair consists of such works as reroofing, repainting of mud walls or colorings, and partial repair of the structural frame. The full-scale repair involves partial or overall disassembling of the structure. For receiving a subsidy from the government for a full-scale repair, it is required to appoint a conservation expert with sufficient experience and prescribed training to be permanently stationed at the site for supervising the work, and to publish after the work completion a conservation project report.

When a building is recognized to be in need of repair, a survey is carried out, within the realms of possibility, on its damage condition and the cause of deterioration. Based on the results, basic area and methodology of the conservation are examined to establish the overall conservation plan on which the necessary budgeting is performed. As for the full-scale repair involving disassembly work, an execution design for the first phase until completion of the disassembly is prepared to begin with, and then after completion of the disassembly an execution design for the second half phase that is repair and reassembly process is established reflecting the investigation results.

Image 5. A traditional method of replacing weathered part of a timber

Since a wooden building after removing roofing materials is very vulnerable against the wind and rain, and also for securing safety during the work, the disassembly work is usually undertaken inside a temporary roof covering the whole of the object building.

Image 6. A repaired member

In Japanese wooden buildings, vegetal roofing materials such as cypress bark shingles and thatch, wall materials such as mud, plaster and substrate bamboos, and painting materials on the timber surfaces are generally regarded as consumables. They are usually renewed during the repair work unless there is any specific technique or design worth to be preserved. Some exceptions to this are mud walls as important design elements of the space inside a tea house, and colored surfaces inside the building without much environmental effect from the outside.

Image 7. Soshidou Hall of Hokekyo-ji Temple before restoration

After removing roof, wall and other fixtures, only the wooden structural frame remains. The process of the disassembly work follows the reverse order to that of the construction. Every single piece of the members is marked with an identification tag and its current position and details recorded. Then, starting from roof foundation, roof structure, eaves structure, beams, floor structure and pillars with their connecting members are disassembled. Finally, only pillar base stones remain. As the most vulnerable parts of a wooden building are around roof edges and bottom of pillars, the area of disassembly is sometimes limited only up to the eave level and then the deformed structural frame is adjusted, or the whole structural frame is raised to repair the bottom parts by using jacks.

Image 8. The same building after restoration to the original design

Uneven settlement of the foundation is often related to the deterioration of a building. When foundation improvement is needed, pillar base stones are also removed once to adjust their level. Archaeological excavation survey is often conducted on this occasion to investigate the underground remains, which provides clues to learn about the transformation history of the building.

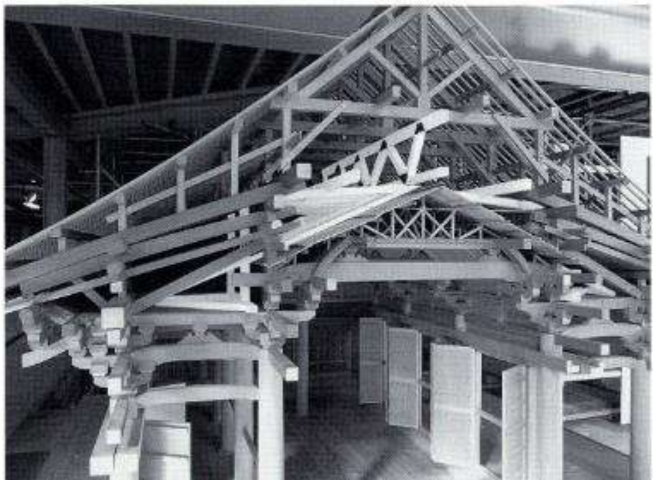


Image 9. Main Hall of Toshodai-ji Temple. A model showing the reinforcing design.

During and after the process of disassembling, each member is investigated for remaining traces and other details, one by one, and its capability to be reused as well as the appropriate methodology for repairing its damaged section is examined. Even in cases where initially only partial disassembly was planned, the repair plan will sometimes be changed to total disassembly if further deterioration of the materials than estimated is recognized as the disassembly process goes on. Nevertheless, unnecessary disassembly must be avoided, keeping the area of disassembly to the minimum.

Image 10. Main Hall of Joko-ji Temple

Based on the comprehensive analysis of the survey results on the composing members' specifications, traces and that from the excavation, together with the collected historic documents, an intensive study is carried out to clarify how the building has been transforming from the moment of construction to date and which member corresponds to each period of the history. Recently, such scientific investigation methods as dendrochronology and radiocarbon dating have become widely used.

In preparation for drafting the design of the re-assembly, necessity and other policy on the alteration of the current state are considered. Criteria for determination are; 1) Conservation or improvement of the heritage value, 2) structural stability and safety, 3) compatibility with the future utilization policy, and others. In particular, it is always the biggest point of controversy if the floor plan and structural design should be kept as it is or returned back to that of any specific time in the past. A logic for justifying the restoration is that a heritage building should represent to the maximum "the heritage value to be preserved" such as representativeness, rarity or uniqueness in the historic period, building typology or region, to which the building is belonging. On the other hand, the position placing importance to the history and the accumulation of time rebuts that such alteration is nothing but to hinder opportunity forever to obtain information from the real material evidences. There is also an opinion saying that, regardless of the target period, it is hardly possible to have one hundred percent of evidence, for which the restoration containing even a little of conjecture or quotation from other sources becomes a fabrication of the history.

"Repair work could upgrade the heritage value" might be a peculiar idea to Japan. Since the proportion of the remaining original material always decreases, without doubt, we cannot deny the fact that the material authenticity also decreases. This suggests that the backgrounds of this idea are prioritization of design and technical authenticity, as well as the confidence that recovery of the structurally sound condition is an indispensable factor to secure the persistency of the value.

For repairing the damaged or deteriorated members, traditional carpentry techniques such as *tsugiki* (spliced joint) and *hagiki* (spliced fill) are used trying to preserve as much old material as possible. Instead of the removed degraded part, a new timber of same species and quality is combined like a puzzle. When the whole single piece of the member needs to be replaced to satisfy the structural strength requirements, the new material is cut into the same shape, dimension and finishing as the old one, but its traces from different period, that are not necessary for assembling, are not reproduced. The newly supplemented member is marked with a brand describing the repair year, but its visible part is stained into antique look to make the repaired part inconspicuous at a glance. The old timbers which were not reused are disposed of, except the ones holding particular value as historical evidences. This is another target for frequent criticism. Because it is quite usual during the repair work that discovery of an old member that was converted to other portion by the previous repair provides significant information. Disposal of the old materials means to take away such an opportunity from the future repairs including a possibility of investigation by using any currently unknown technology.

The percentage of replaced material differs from one project to another, as it is largely dependent on the difference in quality of the original materials, location of the building and other environmental factors. In reality, as vulnerable parts of the building are limited, it hardly happens that the majority of the main structural members such as pillars and beams are replaced. Even so, further development of reinforcing techniques is needed to enable the old members to be reused in the portion that requires substantial structural strength.

Anti-seismic measures

As described above, architectural conservation in Japan has two major features; prioritization of the succession of values regarding techniques and structural systems, and recovery of structural soundness being the precondition. For the latter, it is probably related to the fact that Japan is located in one of the areas of highest seismic risk in the world. A large number of heritage buildings collapsed or suffered severe damage by the Hanshin-Awaji Great Earthquake in 1995. After then, anti-seismic measures became an important subject even in the repair of heritage buildings.

Image 11. Collection of cypress bark for roofing

The target level of anti-seismic performance for heritage buildings is set independently in accordance with the usage and other conditions of the subject building. For evaluating the structural characteristics and strength of the traditional architecture as much as possible, structural analysis is conducted based on the various data, obtained through laboratory or on-site tests when necessary. It is decided to introduce a structural reinforcement if the original structure is assessed to be insufficient to achieve the required level of safety. One of the alternative methods of improvement is weight reduction of the roof. For example, removing the foundation soil layer beneath the roof tiles and changing it to a combination of crosspieces and metal wires can reduce substantially the roof weight.

It is preferable to make structural reinforcements in concealed areas such as above ceilings and in a traditional manner using timbers. Only if the required strength cannot be achieved this way, modern materials like steel are used even in an exposed manner at visible parts occasionally. This is because of the basic principle to make reinforcement in an additional and removable manner without altering the structural frames constituting the original building. However, due to this principle, there are such cases that bold reinforcing steel pillars stand inside of a traditional *tatami* room, which looks rather uncomfortable in view of keeping value of the original space design. Though exceptionally, even base isolation devices were installed in some heritage buildings.

Image 12. Reroofing work with cypress bark

Succession of repair techniques

In Japan wooden construction is still common, but there is a variety of special techniques only used for the repair of wooden heritage buildings. For maintaining and succeeding such knowledge and experiences to the future generations, it is necessary to constantly implement a certain number of repair projects, in which a new generation of experts and craftsmen is cultivated. The Agency for Cultural Affairs promotes as the subsidized projects training of experts in designing and supervision of heritage building conservation, as well as craftsmen of different fields of work such as carpentry, roofing and plastering. It also determines various techniques concerning the heritage building repair as the selected preservation techniques to upgrade the techniques and foster their successors.

Securing the material supply is also an indispensable condition for the sustainability of heritage building conservation. Therefore, the Agency provides subsidies also to the projects concerning a stable supply of timbers, thatch and other vegetal materials, training of skilled workers to produce materials, promotion of public awareness, and management of the recognized production areas.

Bibliography

The Japanese Association for Conservation of Architectural Monuments. 2019. *Revisiting the approach to the conservation work of architectural heritage buildings: Concept and Actuality of Wooden Buildings.* Tokyo, Japan: Yamakawa Shuppansha. **ISBN**: 978-4-634-52026-4. *Bunkazai kenzobutsu no hozon syuuri wo kangaeru: Mokuzou kenchiku no rinen to arikata*

Knut Einar Larsen. 1994. Architectural Preservation in Japan. ICOMOS Interbational Wood Committee. **ISBN**: 82-519-1432-9.

Shigeatsu Shimizu. 2013. *Formation history of the concept for architectural preservation*. Tokyo, Japan: Chuo Koron Bijutsu Shuppan. ISBN: 978-4-8055-0697-4. *Kenchiku hozon gainen no seiseishi*

Methodology in assessment and conservation of wooden built heritage

Ainara IROZ-ZALBA

Gipuzkoako Foru Aldundia-Diputación Foral de Gipuzkoa, Urdaneta kalea 9, Donostia-Gipuzkoa
646569622, airoz@gipuzkoa.eus

Abstract The Historical and Artistic Heritage Section of the Provincial Council of Gipuzkoa is responsible for the conservation of heritage in the province, as well as its dissemination. Among our competences, one of our greatest challenges is the protection of the farmhouses, an emblematic part of the Basque rural heritage. Although until recently they were considered simple rural buildings, this perception is changing, and especially due to their impressive wooden structures, they are beginning to be valued as an important part of our heritage.

Key words farmhouse, Basque Country, wood, cider/lever press, vernacular heritage

Introduction

The Statute of Autonomy of the Basque Country grants the Autonomous Community of the Basque Country exclusive competence in matters of historical, artistic, archaeological and scientific heritage (article 10.19 Organic Law 3/1979, of 18 December 1979).

The Basque Country, with the approval of the Basque Cultural Heritage Law in 1990, Law 7/1990 on Basque Cultural Heritage, was one of the pioneers in the creation of a legal system that guaranteed the defense, enrichment, dissemination and promotion of its cultural heritage. But the time passed since the approval of this first law made it necessary to draft a new law that would incorporate the evolution that cultural heritage has experience in recent years. Thus, on 9 May 2019, the new Law 6/2019 on Basque Cultural Heritage was approved.

This law, unlike the previous one, establishes general criteria for interventions in protected assets, and in relation to wood, emphasis is placed on valuing not only the building envelope but also the interior structures. Along the same lines, the last Decree for the protection of a historic center approved in 2019 (Decree 68/2019, of 16 April, by which the Old Part of Donostia-San Sebastian is qualified as a Monumental Site), refers to the maintenance of generic materials, both for carpentry and for structures, where, in addition to generic material, its typology must be maintained.

With regard to the competences, The Law 27/1983 on Historical Territories and the Basque Cultural Heritage Law establish the competences that, in the field of heritage, correspond to each of Basque public administration. The competence of the Provincial Councils is the conservation and restoration of cultural heritage. Therefore, the Historical and Artistic Heritage Section of the Gipuzkoan Provincial Council, is responsible for authorising and inspecting interventions on listed cultural heritage, as well as promoting economic measures for the conservation and restoration of listed and protected heritage in the province of Gipuzkoa.

Gipuzkoa, even being a small province, has a rich and varied historical, artistic, industrial and ethnographic heritage. Among them, one of the most singular elements of our heritage are Basque farmhouses, *baserriak* in Basque. And this is especially due to their impressive wooden structures, which are the core of the farmhouse. The farmhouses are considered to be a symbol of Basque culture and traditions, that are closely linked to the past, preserving them over the centuries. In this respect, the charter of vernacular architecture points out the importance of the vernacular heritage as an expression of cultural diversity, as well as its fragility to face changes.

"The built vernacular heritage is important; it is the fundamental expression of the culture of a community, of its relationship with its territory and, at the same time, the expression of the world's cultural diversity"
"Due to the homogenisation of culture and of global socio-economic transformation, vernacular structures all around the world are extremely vulnerable, facing serious problems of obsolescence, internal equilibrium and integration"
(Charter on the Built Vernacular Heritage. Ratified by the ICOMOS 12th General Assembly, in Mexico, October 1999)

An approach to the farmhouses
The farmhouses, big solid rural buildings, are a characteristic part of our landscape. They represent a type of architectural model with a special identity. With a rectangular plan, clay tile gable roof and with hardly any windows, the interior is a dark place. They are usually isolated (fig.1), or in some cases, forming small groups of houses (fig.2). They are very large buildings, usually divided into two floors, with a great variety of facades: stone facades, with wooden frameworks, with wooden boards, mixed facades of wood and stone, with a porch...

Figure 1. Eitzeta farmhouse

Figure 2. A group of farmhouses in Idiazabal

The farmhouse, as a economic and social entity, is considered to be the special basic nucleus of family production in the agricultural or livestock sector. But nowadays the use of most of the farmhouses is for housing, although in some cases they still maintain the agricultural use, assigning a space for the animals in the ground floor. Due to social and economic changes this use is disappearing, losing a way of life traditionally associated with farmhouses.

Traditionally the ground floor was mainly for animals. With an average of 300 m2 per floor, the space set aside for family life was very reduced[16]. Due to their large size they could accommodate in a single building all the functions that a rural building used to need: stable, barn, warehouse, workplace, and dwelling[17].

The concept of the Basque farmhouse is also closely related to nature and mythology. In some farmhouses there are Christian symbols, but underlying this has remained an equally strong spiritual tie to the Pagan roots. Safety was achieved by placing symbols and objects in the house which acted as protective good luck charms[18]. Some of these symbols are still placed on the houses, such as the Christian crosses or the thistle flowers on the doors (fig.3).


Figure 3. Eitzeta farmhouse


Figure 4. Zelaa farmhouse

Until recently the oldest farmhouses were considered to be from the 16th century, but the latest dendrochronological datings are confirming the idea that Gipuzkoan farmhouses began to be built at least in the 15th century[19].

The older farmhouses, although apparently they are simple rural architecture, without great ornaments, inside they keep their greatest treasure, an impressive wooden structure. This timber frame structure is composed of great size one-piece posts from the floor to the roof, and a system of horizontal and diagonal beams and braces (fig.4). This wooden skeleton is usually covered with a double-slope roof of purlins and one-piece rafters, running from the ridge to the eaves (fig.5). The joints between the wooden elements of the structure are normally mortise and tenon joints, some of

[16] (Santana, 1993)
[17] (Santana, 2001)
[18] (Santana, 1993)
[19] (Susperregi et alii, 2017)

which are secured with wooden pegs. The use of braces and the so-called “swallow joints” (lateral joints with curved silhouttes) are also common in the older famhouses (fig.6). Another characteristic are timber walling with cladding partitions and facades made with wedge-shaped boards joined by a vertical tongue-and-groove joint.

Figure 5. One piece rafters and the cladding (Bengoetxea txiki).

Figure 6. “swallow joint”

But there is a special feature that distinguishes the original Gipuzkoan farmhouses, the integration of a cider press, a type of lever press, *dolarea* in Basque, inside the building.

Producing cider was the main function of the farmhouse, and the huge machine that formed the press was part of the structure of the building. This was its main use, and therefore, the structural organization of the farmhouse was conditioned by the integration of this machinery. Instead of dwellings, farmhouses were considered to be large cider making machines.The cider press, a lever press, was located on the first floor of the farmhouse, on the central axis, and consisted of the beam, screw, nut, stone, trough and joists. The main element was a large beam that acted as a lever. To star the machinery, the vertical screw was moved, and the main beam, with a support point, made pressure in an area where the apples had been previously placed. The platform on which the pressure was made, called *masera*, had to resist a great load, so it was reinforced with huge parallel beams, called *sobigaño*. To avoid lateral movement the main beam was placed between two pairs of posts, called *bernia* (fig.7). This type of building stopped being built in the middle of the 17th century and today there is none that is preserved in its entirety, except for the Igartubeiti farmhouse in Ezkio-Itsaso, now a museum, which was restored and its press reconstructed[20].

As the centuries went by, the characteristics of the original farmhouses were modified. Among other modifications, the posts were cut, becoming storey post (each post arrange in each storey), the

[20] (Santana, 2003)

beams became shorter and required the use of bolsters, and the rafters went from being a single piece to shorter pieces supported between purlins.

Assessment and conservation of wooden built heritage

In accordance with the competences of the Provincial Council, both in the case of authorisations and funding, the first task of the Heritage Section consists of a visit to the building in order to assess its heritage values and the state of conservation.

Figure 7. Cider press-lever press (Igartubeitia) Figure 8. A pair of post“bernia” (Ernataitz)

Focusing on wooden elements, different typologies, types of wood, joints, sections, carpenter´s marks… are aspects that indicate the heritage value of these structures, and give us the basis to establish guidelines for future actions. In these first visits we find all kinds of cases, different uses, states of conservation, farmhouses whose structure has already collapsed, farmhouses that are still used for agricultural purposes, or are abandoned… aspects that often make an initial analysis difficult.

Regarding typology, today we can still find farmhouses with remains of the wooden presses from the 15-16th century, especially the two pairs of posts, with their side holes, or the large beams that reinforced the pressing area. These fixed parts of the press have been preserved because they are an inseparable part of the structure: The two pairs of *bernia*, the *masera,* the *sobigaño*… are elements that have been maintained in some farmhouses in spite of the modifications suffered over the time (fig.8).

> *“Nowadays many families live in old 16th century farmhouses, unaware that their house, before being a farm or a simple dwelling, was designed by their ancestors as a real cider house”* [21].

[21] (Santana, 2005)

The interventions in the farmhouses, depending on their state of conservation, range from minimum maintenance works, reinforcements, restoration or rehabilitation works, to works with greater impact such as those that require the dismantling and reassembly of complete structures.

The most common intervention, and one of the most important to prevent water from entering the building, and to preserve the wooden structure, is the renovation of the roof. The roof, usually quite simple, is formed by a planking nailed to the rafters, and on this the Arabic tile. The intervention in the roof can be minor, where the rafters are preserved and only the planking and tiles are replaced (fig.9), or with some changes where only rafters in poor conditions are replaced. In many cases, the intervention is used to add a waterproofing sheet, or even insulation, depending on the use the floor under the roof is going to have. A complete renovation of the roof involves replacing all the rafters with sawn wood, or lately also with laminated wood (fig.10).

Throughout history, farmhouses have been adapted to different uses, with the consequent modifications in the buildings. The structures, formed by a network of posts, beams, tie beams, braces, were usually extended, the directions of the slabs were modified, and elements such as tie beams and braces normally disappeared over time, giving rise to stability problems. The lack of foundation also contributed to this. Therefore, a common intervention has been, and still is, to replace the bases of the wooden post with a padstone. The wooden bases were usually deteriorated by water from the ground and by the urine of the animals in the stable.

In some cases, specific parts of the structure that are deteriorated are replaced. And in order to avoid total replacement of structural elements, grafts on beams and posts (fig.11), or metal reinforcements, are also common. Exceptionally, as a last option, and especially whenever stability is compromised, a farmhouse has been dismantled and reassembled (fig.12).

Figure 9. Rafters are preserved (Zelaa)

Figure 10. Complete renovation of roof (Loidi Azpi)

The social and economic changes, in addition to modifying the origin of daily sustenance, are causing radical changes in the building itself as a dwelling, a place to live. With the disappearance of certain economic activities centred on the farmhouse, many of its spaces have also lost their functions, which is causing an important transformation and disappearance of the spaces, structures, etc., in order to adapt them to current needs. For example, until recently, the upper floors in the farmhouses were used as storage spaces, and these spaces were well ventilated (fig.13). In addition, the roof was not insulated, and this situation has helped to keep the wooden structures in good condition. However, now, with the change of use and the new conditions of habitability, the facades are closed, the carpentries are changed, the roofs are insulated and heating is installed, creating airtight spaces, and therefore changing the conditions that the wooden structures had until now.

Figure 11. Grafts (Garaikoetxea)

Figure 12. Reassembling (Garaikoetxea)

The social and economic changes, the special characteristics of the farmhouses (the situation of isolation, their conditions of habitability,...) as well as the high maintenance/restoration works costs and the loss of skills and knowledge of traditional construction technology has led to the loss of a large number of these buildings.

Igartubeiti Farmhouse Museum

In the early 1990s, the Gipuzkoa Provincial Council aware of the problem that rural architecture suffered, with its poor protection, and therefore disappearance, established a rural heritage restoration programme.

Figure 13. Ventilated space under the roof   Figure 14. Igartubeiti before restoration

At that time the Igartubeiti farmhouse was in danger of being demolished, so the Council bought it in 1993 to restore it and promote its dissemination. The building had been in use until it was sold, and until then it had undergone modifications, extensions, partial demolitions... It was especially important the expansion and modification of the building in the 17th century, where it underwent an important transformation process. This extension consisted of a new lateral bay on each side, and a new front bay with a new main facade (fig.14). Igartubeiti is not an exceptional element in terms of its typology, as it is believed that thousands of these farmhouses existed. Its uniqueness lies in the fact that it has been preserved without many modifications since the 17th century, having preserve most of its original wooden structure and facade[22]. When the Council acquired the building, it was in a state of ruin, but the main wooden structure, of excellent quality, was generally in good condition, although it was very differently altered depending on its location[23].

Figure 15. Igartubeiti Museum   Figure16. Igartubeiti Museum-cider press

[22] (Santana, 2003)
[23] (Ayerza, 2003)

The building had a serious collapse problem, so after considering different choices, finally it was decided to dismantle the structure and reassemble it. The criteria applied was to conserve as much as the original wood as possible, so inserts were grafted on to partly damaged pieces and only those which had suffered major damage were replaced entirely. The restoration works, and the dismantling and reassembling of the farmhouse, have made it possible to interpret the construction methods, and to know new details about these large wooden structures, the mounting systems and the joints of the different elements[24]. These investigations established the 16th century as the date of its construction: *"the present building did not begin its construction until the middle of the 16th century, approximately around 1540"*[25]. The dendrochronological analysis has not been done yet, although it is the intention of the Council to carry it out during this year.

In this sense, it is important to highlight the importance of the restoration, and the reproduction of a lever press, of a 16th century farmhouse. Igartubeiti not only shows us how these machines worked, but also gives us information about the way of life at that time and the importance of cider making. Moreover, taking into account that there are still farmhouses with remains of these presses, Igartubeitia allows us to compare them and understand these remains.

Dissemination was the final objective of the project, so the farmhouse became a museum (fig.15). To enhance the value of the museum, original furniture from the 16th century, belonging to the collection of the Council, was placed. And as a novelty, to verify the effectiveness of this impressive machinery, it was decided to put it to work. In this way, the Igartubeiti farmhouse is today one of the most interesting farmhouses in the Basque Country, and for one week a year the public can enjoy the exceptional experience of seeing the farmhouse producing cider as Basque farmers used to do in the 16th century (fig.16).

Conclusion

Throughout history, farmhouses have been transformed to adapt to new times and new circumstances. The fact that they are renewed, adapted, used, responding to a functionality, and their ability to continue is what has made their survival possible.

It is a challenge for the Heritage Section of the Council to establish a balance between the use and the intervention. The challenge of intervening in a building to adapt it to current uses and needs, while maintaining its heritage values, and in the case of the farmhouses especially with regard to their wooden structures, of great heritage value. It is essential to find a balance between the transformation required by society and the conservation of heritage, so that the farmhouses remain as the living entities that they have always been.

[24] (Izagirre, 2003)
[25] (Santana, 2003)

References

Alberto Santana. 1993. *Baserria. Colección Bertan 4*. Donostia-San Sebastián. Gipuzkoako Foru Aldundia, Kultura eta Turismo Departamentua. 108 p. ISBN 84-7907-119-2

Alberto Santana, Juan Angel Larrañaga, Jose Luis Loinaz, Alberto Zulueta. 2001. *Euskal Herriko Baserriaren Arkitektura. Baserriak-La arquitectura del caserío de Euskal Herria.* Caseríos. Servicio Central de Publicaciones del Gobierno Vasco. Vitoria-Gasteiz. 541 p. ISBN 84-457-1699-9

Josué Susperregi, Ibon Telleria, Mertxe Urteaga, Esther Jansma. 2017. *The Basque farmhouses of Zelaa and Maiz Goena: New dendrochronology-based findings about the evolution of the built heritage in the northern Iberian Peninsula.* Journal of Archaeological Science: Report 11 (2017) 695-708

Alberto Santana, Manu Izagirre, Iñaki Sagarzazu, María José Torrecilla, Ramón Ayerza, Miriam Cano, Giorgio Studer, Josu Tellabide. 2003. *Igartubeiti Gipuzkoako Baserri bat. Ikerketa, zaharberrikuntza, zabalkundea=Un Caserío Guipuzcoano: investigación, restauración, difusión*. GFA, Kultura, Euskara, Gazteria eta Kirol Departamentua. Donostia-San Sebastián. 288 p. ISBN 84-7907-407-8

Alberto Santana. 2005. *Las casas de la sidra*. Aunia 12: 105-112

All the images belong to the photographic archive of the Heritage Section of the Provincial Council of Gipuzkoa

INTERLACED CARPENTRY A HYPOTHESIS ABOUT ITS ORIGIN

Enrique Nuere
Real Academia de las Bellas Artes de San Fernando
enrique.nuere@upm.es

Abstract The conducting of a thesis on interlaced carpentry in Toledo, has led me to carry out an in-depth analysis on the development of the eight-star of said carpentry, which together with the research on the carpentry technique of the moment, throughout almost four Decades of intervening in various restorations of this type of carpentry, has led me to the conviction that they could have been carpenters of the Visigoth-Toledo tradition to whom we owe the origin of our spectacular lattice framework.

Key words. Eight star, latticework, interlaced carpentry Triangles, Toledo

Introduction

My experience in restoration and rehabilitation has been developed mainly in two very specific fields: interlaced carpentry and the rehabilitation of buildings with wooden structures. The second seems easy to understand, the first is perhaps not so simple; what is interlaced carpentry? The best thing, to have an approximation of what we are facing, is to see at least one example, (fig. 1) and it is evident that the images are more eloquent than trying to describe with such singular words the works of our historical carpentry. When it comes to intervening, a kind of drawn x-ray will help us more, trying to explain how such a roof was built. (Fig. 2) In order to make this drawing without being able to see its back, and to get the imagined interpretation correct, it was necessary to carry out an important previous investigation on this type of carpentry, a work for which, when I faced it, there was insufficient study on the same, and the few existing ones, assumed that it was an art imported from the Islamic world.

My experience in its restoration denied that principle, and I was not the only one who proposed it. As an example, the respectable opinion of Torres Balbás, who textually writes: ¨*Both the founders of the Almoravid-nomadic empire of the Sahara-and the Almohad-rude highlanders of the High-lacked artistic tradition capable of modifying or supplanting the existing one. The political union favored the diffusion of the Andalusian civilization through the regions of the southern shore of the Strait of Gibraltar. What we improperly call Almoravid, the same as the Almohad, are imported Andalusian arts in Barbary, a consequence of the kingdoms of Taifa, with oriental contributions*¨ Initially, I myself did not doubt the so-called Islamic origin which is so widespread, to the point that I searched by all possible means for its history. The geometric decoration seemed like a contribution from Seljuk Turkey, where there were even some examples of this type of work carried out on wood, but never on carpentry structures for making roofs. And when I exceptionally found some, they were always resolved according to the traditional Roman technique, based on the triangulated knife, ignoring the pair systems.

This question, purely technical, was what encouraged me to continue investigating the origin of our interlaced carpentry, thus raising enormous doubts, given the scarce documentation on the subject, conditioned by its undisputed Islamic origin. As for the technical aspect, there was another interesting fact, which initially I did not know how to give the importance it had: it was the use of some sets of triangles for the layout of their lattices, which also served to build any deck framework without using any blueprint. These triangles confirmed the technical relationship of our traditional carpentry, with the Anglo-Saxon, which is being used to this day. And the most surprising thing is that those North European triangles were not only designed to find out the dimension of the components of a framework, but they also care about establishing the correct angles to compose any type of regular polygon. Although it surprised me then, today I understand the enormous interest that Dr. Christian Ewert showed me when he asked me for an article about the use of those bevels, of which he had never heard of, despite being an expert and having the knowledge of all Islamic art made in our neighbor Morocco.

Most studies on interlaced carpentry were made when there was hardly any interest in any other works than Andalusian ones, especially those of the Alhambra and the Reales Alcázares from Seville, and although some other similar works carried out by Castilla were known, their authorship was assigned systematically to Mudejar carpenters. In the search for something similar in the Islamic world I found nothing in their territories. After investigating this heritage, which is so little known, another of the questions that inclined me to look for a Castilian origin of this art, was the scarcity of Islamic buildings with such roofs, especially in relation to the enormous quantity existing in Christian buildings. While the Islamists can hardly be counted on the fingers of the hand, the Christians are by the hundreds. I also started another type of investigation, forgetting the established common places, based on what was written by authors accustomed to handling Islamic documentation, and in this field several French North Africans, such as Elie Lambert, Lucien Golvain, Henri Terrasse, etc., were interesting, who were especially interested in what happened in western Islam, highly dependent on what was happening in our peninsula. For example, Lambert mentions the need that the invaders had to inherit the construction techniques of the countries they occupied, and in his text, he repeatedly mentions the important tradition, Roman and Visigothic, that inspires the main monuments that were made then, including in the time of the Umayyads, it influenced even more than possible from the Byzantine or Damascene east. Another French author, Georges Marçais picks up, mentioning a text from Terrasse, that after the Almorávides unification of Morocco, the conquered Spain will seduce them to the point of bringing Andalusian culture to the Maghreb.

Lacking a solid documentary base, the only possibility to get to know our carpentry to the maximum was in its direct study, logically limited to what exists, trying to understand the role of those remains that, detached from their original sets, have been preserved, something only possible by analyzing the carpentry structures in their restoration process, which explained how their elements were joined, what role each played, etc. and I soon realized that most of the framework in which I intervened had been prefabricated, logically fragmenting them into sets that could be manageable with the means available at the time. At some point I understood that the lace was not only decorative, it had a more important function: to guarantee the precision of the measurements of the partial sets of each framework, since when performed by different teams, it was essential to guarantee the final assembly of all the components without problems. Not all the woodworking I faced was interlaced, but the concept of modulation and repetition was always present. Fortunately, my encounter with historical carpentry, until then totally unknown to me, was in a peculiar intervention, in which I had to face fragments and fragments of roofs, not only of everything that was preserved in the Alhambra, but others brought from some other museum, or stored in Granada convents, putting in my hands some material that even in years of intense search I could not have collected. When the trace was of lace, no matter how deteriorated the existing pieces were, the relation of some fragments with others was evident. After the Granada experience, the lace allowed me to relate some pieces with others with absolute security, which happened in the choir of Santa Maria de Arévalo, whose composition was the closest thing to solving a simple puzzle, thanks to the enormous help of its interlaced wheels, whose joints in our carpentry, were only made in one way. All this made me understand that, in most of the frameworks in which I intervened, prefabrication was present, forming sets that could always be handled by a few people, with the means then available.

Many interventions have confirmed my first intuitions, especially that a technique, apparently so complex, could only be carried out based on some simple rules, otherwise this art could not be maintained for five centuries, and even carried to Latin America, passing through the Canary Islands, and of course Morocco, but in Castilla, where the guilds exercised serious control over the work of their members, it was the only place where it continued to be done correctly until this practice was abandoned. On the other hand, as my talks and publications were published, a large number of artisans spontaneously emerged, who, handling the simple historical rules, today are able to carry out these works as well as our carpenters did in past centuries. Recently, by directing his doctoral thesis to the architect Elena Franco, and focusing again on the Toledo framework, I have consolidated my idea that Toledo could be the place where this type of carpentry began, and not by Muslims, but by carpenters of Ingrained Visigothic tradition, a fact that also supports the Etymologies of San Isidoro, in which the main person responsible for the building was the carpenter, as it would continue to be in the countries of northern Europe, where the overabundance of wood favoured this role of the carpenter in the building.

What most encourages me to believe in this Toledo origin of the interlaced carpentry, is precisely the first chosen ornamentation, which although it may seem related to Islamic geometry, does not have to be. It is the simple eight-pointed star, with its interwoven lines, already present in Roman mosaics, it even appears on the pavement of the Palatine Chapel in Aachen, built by Charlemagne. Could it have been a new and important symbol of Christianity? On the other hand, in what we have left of the early Celts, we see their taste for ornamentation based on capriciously interwoven ribbons, in drawings more or less subject to certain geometric rules, themes also frequent in Nordic civilizations, so the taste for geometric lines did not need influences from the east for its incorporation into carpentry.

It is also very interesting to verify that the traces of the eight-pointed stars, with which the Toledo roofs were decorated, are very easy to carry out with the use of the aforementioned triangles (fig. 3). Analyzing the transformation that the eight-point star of Toledo underwent, the possible evolution of the lace to become a wheel is understood, which would give rise to the appearance of a new aesthetic, which played with combinations of wheels with different number of arms. The so-called interlaced wheels in Toledo were very late and few. How the evolution from the stars that appear in the first framework to the most complex interlaced wheel paths took place, is something that we will hardly come to know, but what is evident is that in the oldest known framework, and especially the ones in Toledo, only the eight-pointed star appears interlaced in a couple of different ways. (Fig. 4) In its first evolution, after lengthening its arms it converts into another with the same number of points but of 45 degrees, which gives rise to a short series of new designs.

It is surprising that in the wide repertoire of Seljuk designs collected by Gerd Schneider, there are eighty-seven designs based on the eight and its derivatives, and although one of the Toledan seems to include such a design, in Toledo, the need to adapt it to the resistant link of a structural set of equidistant woods makes it different. At some point, it is possible that the Castilian carpenters were inspired by the plaster craftsmen, whose traces lacked structural commitment. The transition from the simple star to the interlaced wheel is simple, just lengthen its sides and then surround it with a regular polygon, with the same number of sides as the star has points. When the arms reach the said polygon, they bend, and extend again until they meet the parallel side, forming a cross that, due to its shape, receives the name of aspilla. Whatever the time of the appearance of the interlaced wheel in the carpentry works may be, the Castilian one is based on an inexcusable requirement, the position of the aspilla with respect to the center of the wheel can only be one, ruled by the use of the triangle gauge, which is the third in the game necessary to design the entire latticework. Each interlaced wheel is drawn with three triangles. (Fig. 5) whose generation is based on rules, graphically unforgettable. To form a wheel it is enough to follow a sequence which is understood better drawn than described in words. (Fig. 6). Other rules, also elementary, allowed drawing the dependent wheels. Maintaining this layout discipline, non-existent in the Islamic world, allowed carpenters to prefabricate their reinforcements, given that using this method, and respecting the separation of wood based on its thickness, control of the work was complete. If the design of the lace does not lose continuity in the meeting of the different gables, it is because the carpenter had adequate knowledge of geometry, essential to control these designs. Despite the necessary geometric rigor, the Castilian carpenters knew how to falsify orthodoxy when it was convenient for them.

At some point the lace became pure ornamentation, forgetting its possible integration into the structural elements of the roof, but so that the design could have continuity in the different panels, the carpenter, after using the lace triangles, also used the initials, which allowed him to obtain, from the designed gable, the armature triangle with which he would obtain the measurements of all the pieces that compose it. We have a good example to explain this process on the roof of the Alcoba del Trono in the Salón de Comares, in the Alhambra in Granada. Its artist first designed the gable with the chosen decoration, and from its shape he obtained the albañacar triangle, which provided it with the framework, whose hypotenuse would allow him to size the necessary pairs to support it, and its angles would allow cutting the crest, the temple and the chin of said pairs. (Fig. 7) Perhaps when the interlaced wheels became widespread, the carpenter would have thought of simplifying his work. But even these designs were made with the carpentry triangles, which means without a doubt that the Toledo, probably Visigoth, carpentry tradition was still alive, basing all its carpentry craft on the handling of this type of templates.

Our carpentry distinguishes its designs from the rest of the Islamic ones, being always dependent on the use of the triangles. In the Islamists there is freedom of design, the size of a wheel is not conditioned by any specific rule, while in Castilian it is compulsory. This is best understood with an example of three lacing designs, all made with tapes of the same width, and spaced the same distance from each other, however the size of the three sets is different. Any of them could have been made by a Moroccan carpenter, but only one of them would have been made by a Castilian carpenter. (Fig. 8) Would anyone be able to recognize which is Spanish? The design shown starts from an eight-arm wheel, which unravels to one of sixteen, and so that it always comes out with the same measurements, the starting wheel must have specific dimensions, which are established without a doubt with the use of the triangle gauge.

But although the theme of the development of the star is important to follow the evolution of the first framework, it is not the only detail that makes us think of a Visigoth-Toledo origin. One could also think that it could be in Córdoba where the first interlaced carpentry appeared, in fact the mimbars of the Moroccan Qarawiyin and Kutubiya mosques were the work of Cordovan artisans in the 12th century, but if so, the technique of the first framework manufactured there, being similar to the Nordic, they should have learned it from Toledo of Visigothic heritage, which for reasons of work would have ended up in Córdoba. Already from the time of the Almoravids, the work of the Cordovan carpenters, Gómez-Moreno, was appreciated in Morocco, when referring to several mimbars built for the Moroccans, he literally states *"We have, therefore, here an admirable revelation of the artistic strength of Cordoba in the 12th century, which was unknown to us, justifying the fact that Yúsuf ben Texufín procured Córdoba architects for his buildings in Fez".* And after reading this text by D. Manuel, how could he affirm that we owe our carpentry to the Almohades?

We will probably never know when the first eight-loop framework was made, but the existence of the throat and ergot ensemble that was introduced into our woodwork, changing the European tradition, (Fig. 9) Explained only to allow prefabrication. Could it be this need for transportation that forced the shape of the pair and knuckle assembly to change, or the fact that at some point they decided to prefabricate the collars which allowed the Moroccan roofs to be partially prefabricated? I think we will never know the answers, but the reality is that in these covers, as can be seen in detailed photos, the assembly between pairs and knuckles is precisely that of throat and ergot, (Fig. 10) similar to that of most of Toledo's roofs, an assembly that would continue to be used systematically until interlaced carpentry was abandoned in the mid-18th century.

CONCLUSION

It is evident that all the arguments used have a logic that is hardly debatable, but not conclusive, so it will be necessary to continue this investigation until we find answers, which at least do not admit doubts about the origin of our carpentry. Since as I don't have them yet, my research ends for the moment at this point, but I'm absolutely convinced that our carpentry was not a direct inheritance from the Islamic world, whose culture is true that it could have influenced the results achieved, but it was only possible thanks to a carpenter heritage from the Northern Europe, conscientiously developed by initially Visigoth carpenters, later from Toledo, later from Cordoba and finally from Castilian carpenters, but never Mudejar.

ANCIENT FOREST AND WOODEN HERITAGE IN GALICIA (SPAIN).
THE “AIR BEAMS” FROM SWEET CHESTNUT POLLARDS

Manuel C. TOUZA VÁZQUEZ

Galician Forest Industry Agency (XERA-CIS Madera).
Parque Tecnológico de Galicia. San Cibrao das Viñas, Ourense E-32901, Spain.
manuel.cesareo.touza.vazquez@xunta.gal

Abstract The ancient timber structures are a result of the historical and social circumstances of the times in which they were built. These circumstances, often unknown, make part of the inherited historical heritage. This article briefly reviews the facts that led to the rise and decline of a very common constructive typology in Galicia (Spain), between the 17th and 19th centuries, the "air beams" of brown chestnuts.

Key words: Sweet chestnut, Galicia (Spain), pollard, air beams, wooden heritage.

After the discovery of America, throughout the sixteenth century, Spain consolidates an extensive empire that requires an important naval fleet. To achieve this goal, it was necessary to ensure the supply of large volumes of oak with the form required for shipbuilding.

The royal privileges granted to the Mesta to facilitate the increasing transit of sheep herds had already caused deforestation problems in Castilla and it becomes strategic for the Crown to defend the oak forests that persist in northern Spain. These forests were under pressure due to the increase in the population and the subsequent demand for pastures, agricultural land, charcoal for the ironworks, bark for tanneries, firewood for domestic use, construction timber, etc.

Thus, throughout the sixteenth century, several ordinances were created by the Crown aiming to guarantee the availability of oaks with the appropriate shape for shipbuilding. In this regard, as reference example, some of the forestry ordinances approved in Galicia (northwest of Spain) are summarized as follows:

- In 1503 it is detailed the bark that the shoemakers can extract from an oak so as not to damage the tree. The oak bark was the main source of tannins to tan the skins.

- In 1550 it is forbidden to cut oaks and chestnut trees to the ground with a penalty of two years of exile.

- In 1551 it is authorized to kill the goats that were surprised by "stopping" the trees.

- In 1573 it is forbidden to export oak barrels.

- In 1598 are detailed the penalties for anyone who was surprised by removing the bark or cutting an oak to the ground without leaving a standard and fork branches *(”dejar horca y pendón”).*

After cutting an oak to the ground, it was generated a regrowth of many straight growing stems, which could be pruned again every 12-15 years or so. This practice was of great importance for the local economy since contributed to produce charcoal, poles, building frameworks, etc., and at the same time it could be used to feed the livestock. The trees resulting from this type of management (coppicing) were named “*jarales*” in Spanish (Cantero et al., 2013).

On the contrary, pollarded oaks were originated by cutting the trees at a height of about 2.5 to 3 m above the ground to prevent the access of cattle. Subsequently, in the oaks oriented for shipbuilding, one good branch should be left almost perpendicular to the trunk (“*horca*”) and another forming an obtuse angle (“*pendón*”).

On the contrary, pollarded oaks were originated by cutting the trees at a height of about 2.5 to 3 m above the ground to prevent the access of cattle.

In Galicia, as in other regions, the imposed ordinances were aimed to protect the oaks by preventing them from being cut to the ground (brave oaks) and promote the guided pollards to produce wood for shipbuilding as well as other possible uses such as timber products, firewood, charcoal, or food for the livestock. Nonetheless, in many cases, these new ordinances caused conflicts with the rural populations as it was perceived as a competition with their local needs.

While the priority use of oak was oriented towards shipbuilding, in Galicia, the “*soutos*” of pollard sweet chestnuts (*Castanea sativa*) should acquire a great prominence during the sixteenth and seventeenth centuries, providing numerous advantages over the forests of “brave” chestnut trees (not pollarded).

In Galicia, sweet chestnuts had been pollarded for centuries, allowing to combine a harvest of chestnut fruits, an essential food in the peasant diet; with the feeding of livestock; obtaining also wood for multiple uses as beams, pavements, exterior and internal walls of houses, basketry, tool handles, fencing, post for vines, etc.

In this mixed system of forest management, the chestnuts were cut at 2-3 m high from the ground and the production is done at the expense of the new branches formed on the crown. These branches can be ordered to allow a staged production of wood and cut periodically, every 20 to 30 years, when they may reach lengths between 7 and 10 m (Vieitez et al., 1997).

Image 1. Aspect of an old Galician "souto" of pollard sweet chestnuts.

In his book, "El Castaño en España" (Elorrieta y Artaza, 1949), the author refers to this treatment in the following terms *"However, in Galicia, it brings together so many advantages, which favor in such a degree its rural economy, which perfectly explain that this form of cultivation persists from immemorial time... In cattle regions, it allows the entry of livestock from the day after its exploitation, thus reconciling grazing with the conservation of woodland, in such conditions that it is possible to obtain timber and wood products in abundance, together with a substantial fruits that serves as food for both the rural population and the numerous pigs that are raised in Lugo".*

Thus, the sweet chestnut and, particularly, the "air beams" from the chestnut pollards will become an identity sign of the Galician houses. The data on dimensions and typologies included below are indicative and are based on visits made by the author to different buildings erected between the 17th and 20th centuries. The most common length pattern is the Castilian "*vara*" (≈ 0.84 m) subdivided into three "*pies"* (≈ 28 cm) or four "*palmos"* (≈ 21 cm).

The main beams of structural floors are usually "*cuartas*" of one "*palmo* " by one "*palmo*" (≈ 21 x 21 cm) or "*tercia y cuarta*" (≈ 21 x 28 cm). These dimensions allow to save spans often between 4.2 m (5 "*varas*") and up to 7.1 m (8.5 "*varas*"). The most common distance between the axis of the beams is ten "*palmos*" (≈ 2.1 m)

Image 2. Galician house with “air beams” from pollard chestnuts. The beams, joist (“pontones”), pavement and the timber frame walls are all made from sweet chestnut wood.

The secondary structure of joists (“*pontones*”) usually has a square or slightly rectangular section. The most usual width is half a “*palmo*” and the distance between the joists is usually a “pie” or a “pie” and a half. Sometimes, shorter units could be employed resulting in other measurements. For example, the beams of 24 x 24 cm (one “pie” by one “pie”) corresponding to the 72 cm “*vara*”.

The design of the constructive solutions also adapts to the particularities of Galician forests, through two-order structural floors that reduce the number of main beams in exchange for greater use of secondary joists. On the contrary, in other regions of Spain, the most common floor slabs are formed by pine beams with sections of “*cuarta y sesma*” (≈ 14 x 21 cm) and arranged to “*calle y cuerda*” (with a distance between beams of two times its width).

Throughout the 17th century, after major fires have occurred in several cities, the use of stone walls in urban areas extends in Galicia, gradually replacing the traditional wooden houses.with timber facades or wooden frame walls (Soraluce, 1998). In Santiago de Compostela, for example, most party walls are made of masonry with an average width between 50 and 80 cm. Between these walls are the slabs formed by wooden beams that save spans often between 4 and 7 m (Ramos et al., 2002).

Several contracts signed throughout the sixteenth century, usually linked to religious buildings, provide us with a proper understanding of the knowledge of that time (Taín, M. 1998).

Often, the contracts did not include the dimensions of the beams and joists since these data should be well known by the carpenters employing simple rules of thumb to determine the size of the beams according to the spans to be saved. On the contrary, the distance between the beams (most of the times 10 "palmos" between beam axes) and the distance between joists (usually one "pie" or, on special occasions, one "palmo") are usually mentioned.

The ratio between the span and the edge of the beam are similar to those used nowadays. So, an "air beam" with 21 cm in its minor end ("*cuarta en punta*") that saves a span of 5 "*varas*" (4.2 m), has a ratio between span and edge of 20. A similar ratio (19.5) is found when a "*tercia*" beam (28 x 28 cm) saves a span of 6.5 "*varas*" (≈ 5.5 m). In the most unfavorable cases, a ratio of 25 can be achieved, saving spans of 8.5 "*varas*" (7.1 m) with beams that have a "pie" (28 cm) in its minor end. Nevertheless, due to the irregularities of the "air beams" the section use to be larger in the central section of the beam.

The construction deadlines should induce to use green beams which, apparently, was not a big inconvenience in the case of the sweet chestnut. In the case of oak, the situation should be different as several contracts insist on using chestnut beams instead of oak because their tendency to twist.

It is mentioned, sometimes, the moisture level that must have the flooring (chestnut boards) to avoid the appearance of checks on the flooring. In these cases, controls are established based on the fact that, if after a while, a given coin enters between the boards of the flooring, it will be the carpenter's responsibility to replace them at his own risk.

Sometimes, when it is necessary to save large spans or the project has a special aesthetic importance, the contract expressly requested that the beams were made of "brave" chestnut (not from pollard trees). These beams will become increasingly scarce, to become, probably, a symbol of the status of the client that, often, will try to let them visible.

At the same time, during the seventeenth century, war conflicts occur almost continuously. In Galicia stands out the impact of the restoration war (1640 - 1668) that will end with the independence of Portugal. In this regard, several documents mention problems due to wood shortages. Also, in landscape engravings of those times, large spaces without trees begin to be seen.

With the arrival of the Bourbon Dynasty, the Royal Navy was reorganized (1726) in three Maritime Departments where the arsenals of Ferrol, Cádiz and Cartagena will be built.

The vanguard of the naval engineering of the 18th century is the ship of the line, a warship whose construction required an extraordinary technology as well as important resources. As reference, the oak required to build a seventy-gun ship of the line has been estimated at 10,800 m^3 of standing timber (Aranda y Antón, G. 1999), to which we had to add many other elements as the conifer masts which depend upon the availability of trees with exceptional dimensions and quality.

The arsenal of Ferrol (Galicia), will become the main Spanish shipyard in the Iberian Peninsula being capable of building twelve ships of the line in only three years. During the second half of the

18th century, ships built in Ferrol with more than 50 guns required more than 600,000 m^3 of standing oak wood.

An immediate effect of shipbuilding was the expansion of tree-felling to a wider area around the arsenal. Historical documents reflect the shortage of wood available in Galicia that makes necessary to look for timber beyond the region. The oak for the arsenal will come mostly from Asturias (Spain) while conifers for masts and rods will be mostly imported from the Baltic countries.

To improve the supply of wood, Forests Ordinances (1748), allowed the Crown to regulate the forests located in areas next to the coast or navigable rivers. In Galicia, 729 forests were subjected to the jurisdiction of the Spanish Navy, being primarily oriented to the production of oak for shipbuilding.

At the same time, complaints about wood shortages for housing in Galicia were also common throughout the 18th century. Several documents refer to the use of chestnut from Asturias and Scots pine (*Pinus sylvestris*), commonly referred to as "Riga pine" to highlight the quality of the wood shipped from Riga (Latvia) or also "Flandes pine" since the Dutch were specialized in their trade. Both names are still used in Spain to refer to Scots pine.

At the end of the 16th century, Galician population was estimated between 750,000 and 800,000 inhabitants. In 1787, it reached 1,400,000 inhabitants (Spain had almost 10,500,000). Ferrol, with 25,000 inhabitants, was the most crowded city in Galicia and the province of La Coruña, where the arsenal was located, the most populous in Spain.

While the Galician population increased significantly, during the second half of the 18th century, very probably, the availability of brave chestnuts was greatly reduced. In 1790, the "*Hospital de Invalidos*" (also known as "*Cuartel de San Fernando*") was completed in Lugo. This building is a neoclassical style construction where 132 beams and 2,340 brave chestnut joist with high quality were used and whose supply caused many difficulties and delays. The arrangement of the floor structure follows the constructive practice seen above, with beams "*tercias y cuartas*" (≈ 21 x 28 cm) to save spans of 6.5 "*varas*" (5.46 m), and distance of 10 palms between the axis of the beams.

At the end of 18th century, the harvesting system of the chestnut pollards also begins to show symptoms of exhaustion since the role of the chestnuts in a peasant diet dominated for centuries by rye and wheat will be relegated by the implantation of corn and, well into the nineteenth century, the potato.

However, it will be the appearance of diseases such as chestnut ink (*Phytophthora cinnamomi*) and blight (*Cryphonectria parasitica*) that will cause a decisive blow to the Galician "*soutos*".

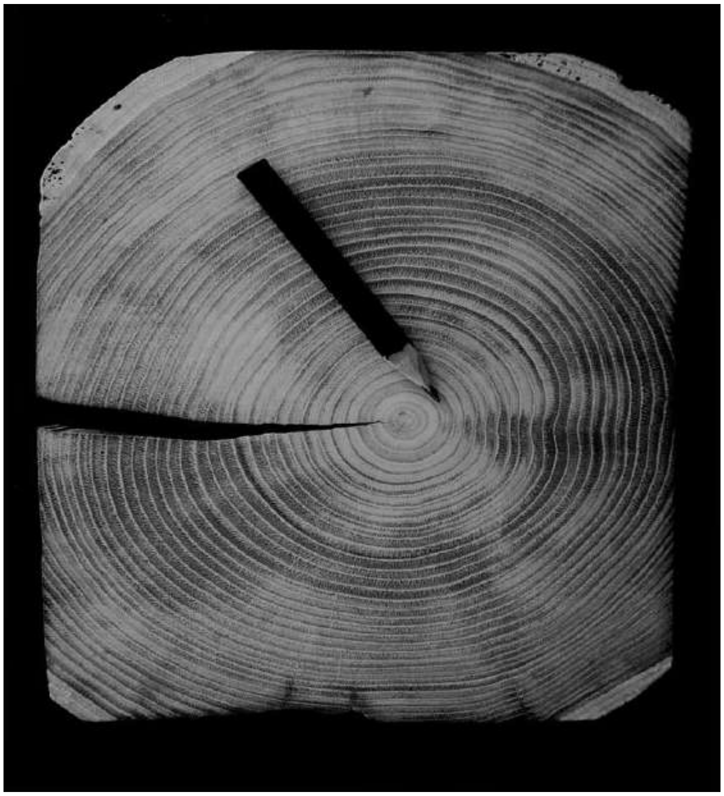


Image 3. “Tercia y cuarta” beam”(≈ 21 x 28 cm) from a brave chestnut (not pollarded). Note the wanes where the sapwood has been removed.

In the middle of the 18th century, the “*Catastro de Ensenada*” a large-scale census conducted by the Crown allows to deduce that chestnut forests had already diminished significantly in the Galician coast. This could indicate that the chestnut's regression in Galicia had already begun as a result of the ink disease along with the action of many owners, who, fearing that their trees could get sick, would not hesitate to cut them down to sell the valuable timber (Molina, 1984).

The nineteenth century begins with the defeat of the French and Spanish Navies against the British Navy in the battle of Trafalgar (1805), which will mean, in practice, the end of the era of the ships of the line.

Subsequently, the seizure and sale of properties caused by the Spanish governments to dispose of income to amortize the titles of public debt, will turn the 19th century into the most damaging in the history of Spanish forests. Although exact figures are not available, it is considered that the different confiscations and, mainly those of Mendizabal (1836-37) and Madoz (1854-56), involved the sale of about 5 million hectares of forests, more than half of the total inventoried in 1859.

In a time of scarcity and difficulties, it is easy to imagine the rapid disappearance of the oaks subject to the jurisdiction of the Spanish navy in Galicia, once their role as suppliers of timber for shipbuilding no longer made sense.

With the rapid spread of diseases, it also disappears the traditional use of chestnut pollards. In Galicia, considering only the ink disease, more than 80% of the chestnut trees may have died towards the middle of the 20th century (Vieitez et al., 1997).

As the nineteenth century progresses, a decline in the quality of the last air beams can be perceived (greater presence of knots, irregular sections, less straightness), probably due to the scarcity and absence of forest management. At the same time, the carpenters' ability to build houses with lower quality beams can also be appreciated.

During the second half of the nineteenth century, as in other parts of Europe, lumber shortages were solved by importing large volumes of beams, mainly longleaf pine coming from the virgin forests situated in the Southeastern United States.

This timber, of extraordinary quality, became the main building material between the 1880s and until the 1930s. The availability of beams of large length also induced a great change in the architecture of the time. Even today it is possible to perceive, in many streets of Galicia, the effects of the arrival of this species (Touza et al., 2013).

However, the huge demand for this kind of wood meant that by the 1930s, most of the United States virgin forests had already disappeared and the timber was progressively replaced by new construction materials.

Seen from a historical perspective, the use of chestnut pollards was a very intelligent way to reconcile many different uses and, at the same time, to provide a construction material in reduced rotations and in a sustainable way, anticipating the development of forest plantations and the circular economy concept.

The air beams still remain in numerous dwelling in Galicia, the last witnesses of a history worth preserving.

Bibliography

Aranda y Antón, G. 1999. *La Carpintería y la industria naval en el siglo XVIII*. Madrid, Madrid, Instituto de Historia y Cultura Naval. 123 pp. ISSN:84-0212-467-X

Cantero, A.; Passola, G.; Aragón, A.; de Francisco, M.; Mugarza, V.; Riaño, P. 2013. Apuntes sobre trasmochos. Guía de buenas prácticas para el trasmocheo. Diputación Foral de Gipuzkoa. 90 pp.

Elorrieta y Artaza, J. 1949. El Castaño en España. Ed. IFIE. Ministerio de Agricultura. Madrid. 311 pp.

Molina, F. 1984. Cuarenta años de investigación sobre el castaño en el Departamento Foresta de Lourizán. Congreso internacional sobre o castiñeiro. Lourizán (Pontevedra). pp. 23-38

Ramos, J.; Panero, A.; Camiruaga, I.; Tomé, P.; Fernández, R. 2002. La arquitectura histórica y los criterios de la rehabilitación. 2002. Consorcio de Santiago. 137 pp. DL: C-2237/02.

Soraluce, J.R. 1998. Aspectos de la construcción urbana en la Galicia del siglo XVI. Boletín Académico. Escola Técnica Superior de Arquitectura da Coruña, 1998, 23: 32-37. ISSN 0213-3474.

Taín, M. 1998. Domingo de Andrade, maestro de obras de la Catedral de Santiago: (1639-1712). 2 Vol. Ediciós do Castro Sada, A Coruña ISBN: 84-7492-899-0.

Touza, M.C.; Soilán, A.; Lorenzo, D. 2013. Evaluation of the Load-Carrying Capacity in Bending of Large Cross Section “Pitch Pine” Beams in Standing Structures. Advanced Materials Research, Vol. 778, pp. 410-417.

Viéitez, E.; Vieitez, M.L., Vieitez, F.J. 1996. El Castaño. Caixa Ourense, Edilesa. 337 pp. ISBN: 8480121343.

The Stave Church Program and the relationship between theory and practical work

Sjur Mehlum

Head of Section, Multiconsult

Abstract Stave Churches were once common throughout Northern Europe. Today only 28 Stave Churches remain in the whole country. They are Norway's most important contribution to world architecture and among the oldest preserved wooden buildings in the world. They are unique in a European context and represent our foremost contribution to international construction history. One of the churches, Urnes, is listed on the UNESCO's World Heritage List.

Due to the poor condition of the Stave Churches the Directorate for Cultural Heritage initiated and ran a repair programme from 2001 to 2015. The aim of the Stave Church Programme was to repair all the churches. In the Program, the Directorate has placed great emphasis on the importance of handicraft and material quality. The approach to the repair-work has been to use the same techniques and the same quality of materials as originally used. The Stave Churches have with their old age shown that the materials and techniques used have a long living age, and the repair and maintenance focused upon using the same kind of techniques and the same quality of materials in order to give the Stave Churches further hundreds of years of living age.

In the Stave Church Programme, the craftsmen have played a central role in all phases of repair. The central role of the craftsman is new in the management and maintenance of the Stave Churches. While previously the craftsmen were told what to do, they were now part of the team - conducting the necessary investigations and appraisals. They have been responsible for the detailed condition assessment reports, including detailed damage analysis. In many cases, the craftsmen have also been directly involved in choosing the materials for the work which is to be done. They have been in the forests selecting appropriate trees and have been responsible for the timber production process; including the felling of the trees and the preparation process. In this way, the selection of appropriate wood for the work to be undertaken was secured. The reasoning behind the choice and preparation of material was justified by the craftsmen by looking at the very structures they were working on.

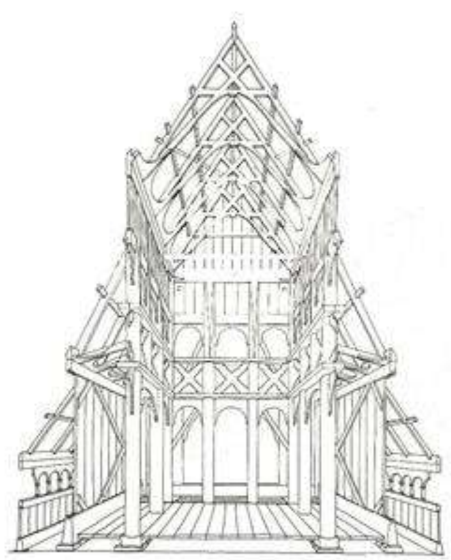
In close cooperation with the Directorate for Cultural Heritage, the craftsmen developed the plans for the actual repair work to be undertaken. Often the plans were quite general in character as the scale of work was hard to judge before actually starting the work. For example, a plan for repairing a roof could include directions for changing all damaged shingles, but it didn't define the condition a roof shingle should be in to justify replacement. It was also not possible to know the exact number of shingles which would need to be replaced before the building site was established and the scaffolding erected. Therefore, detailed decisions had to be made thru discussions between the administration and the craftsmen.

Traditionally studies of the stave churches have been an arena for academicians such as architects and art historians. The stave church research has until recently been done solely of people from such background. For the cultural heritage management in Norway to be developed, and for all the parties involved to learn from what they do, it is vital that the craftsmen who master the traditional crafts, maintain their position in the work being done. In this way, the cooperation between the administration and the craftsmen can contribute to furthering our knowledge in the future.

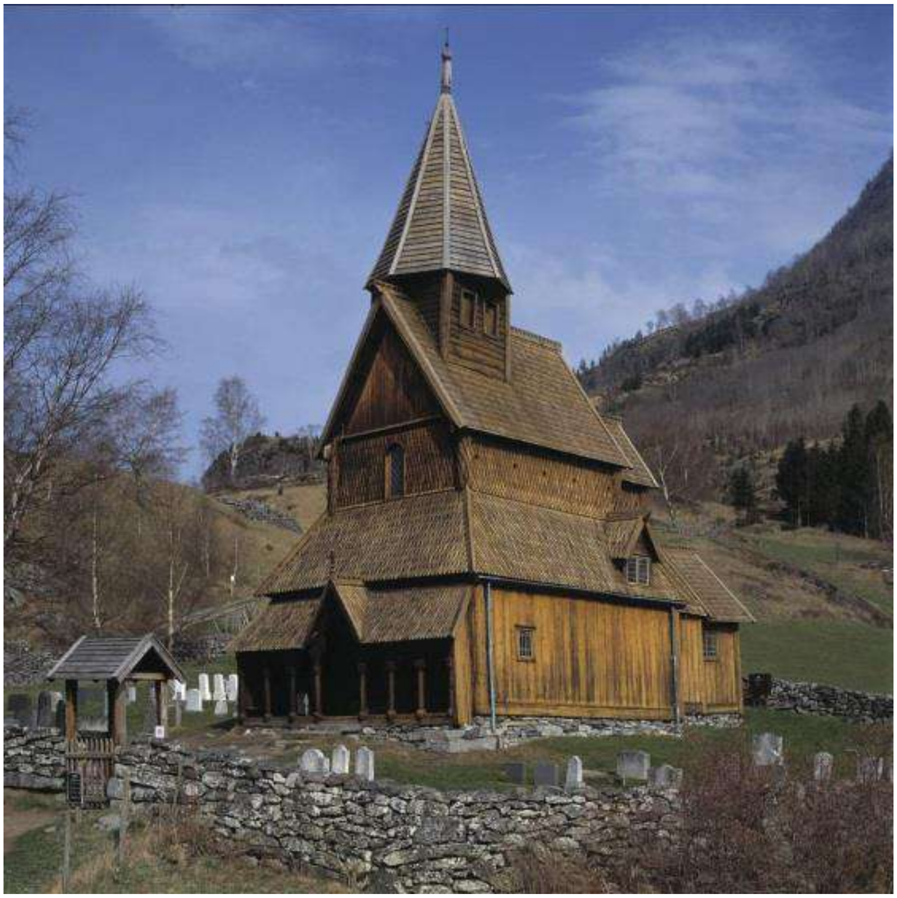
Introduction

In 2001, the Directorate for Cultural Heritage in Norway initiated a programme to repair all the Stave Churches in the country. This project will be completed by the end of this year.

A Stave Church is a medieval wooden Christian church building once common in North-Western Europe. The name is derived from the building's structure of posts and lintels, a type of timber framing where the load-bearing posts are called "stav" in Norwegian. (figure 1)



Stave Churches were once common throughout Northern Europe. In Norway alone, it is thought that there were about 1500. Today only 28 Stave Churches remain in the whole country. They are Norway's most important contribution to world architecture and among the oldest preserved wooden buildings in the world. They are unique in a European context and represent our foremost contribution to international construction history. One of the churches, Urnes, is listed on the World Heritage List.



The Stave Churches are not only valuable as buildings. They also form valuable elements in the cultural landscape, and contribute to illustrating where the major traffic arteries have been routed, and how the landscape has previously been used. It is therefore vital that the area surrounding the churches are not diminished or changed.

The Stave Church Programme

Due the poor condition of the Stave Churches the Directorate for Cultural Heritage, initiated the repair programme in 2001. The aim of the Stave Church Programme, which will be completed by the end of this year, is to repair all the churches. In the following paper, I will concentrate on the actual work that was done by using two illustrating examples, but first I will describe the central position the actual craft, along with the skilled craftsmen, have in a project run by The Directorate for Cultural Heritage.

Craft and Craftsmen

In order to illuminate the importance of handicraft and the craftsmen and their role in the work with cultural wooden heritage in general, I will use the *Medieval Project* of The Directorate for Cultural Heritage as an example. The Medieval Project was initiated in 1991 and completed in 1999. The project was motivated by the aim of repairing to an acceptable standard, all wooden profane or non-religious buildings dated prior to 1537. At the time the project was completed, a total of 230 wooden buildings had been repaired to the point of being saved for the foreseeable future. One of the conditions of the project was that the buildings should be maintained and restored using the same techniques and quality of materials with which they originally had been built.

The main challenge was that a lot of the knowledge about the old techniques had been lost. From the time of the middle ages up to industrialization, there had been an almost unbroken chain of building techniques and choice of building materials. The knowledge had been transferred from father to son and from master to apprentice for generations. Learning by doing had been the pedagogical technique for generations and is often referred to as action-borne knowledge.

The work maintaining the buildings from the Middle Ages made it necessary to re-activate this knowledge. The result was that the project to maintain and rehabilitate buildings from medieval times, turned out to be much more than just a maintenance program. Instead, it developed into a crafts program where the skills and knowledge of the craftsmen were in focus. In connection with the project, several seminars and courses were held with topics such as tools, working and building techniques, constructions, choice of materials and preparation of raw materials. All the topics were of great importance in order to be able to do the practical work.

At the gatherings, those still practicing the traditions were used as instructors, together with experienced and also young and inexperienced craftsmen. In that way the knowledge was passed from one generation to another.

In addition, the craftsmen got the role of being building researchers. The most important source of knowledge about the medieval building traditions are the structures themselves. There are few other sources than the actual buildings. Evidence regarding the use of tools and the signs of use were copied in such a way that the old techniques could be perfected. The quality of the original material was studied and similar quality materials was selected in the case where material replacement was necessary. The craftsmen had an important role to play in the documentation of the maintenance work. Working operations, building parts, use of materials and types of materials were described and photo documented.

To carry out the Stave Church Programme, it was necessary to further develop the knowledge about what was already known regarding the usage of traditional handicrafts, and “new” knowledge concerning the use of different traditional materials was re-discovered.

The Stave Church Program

In the Stave Church Programme, the craftsmen have played a central role in all phases of repair. They have been responsible for the detailed condition assessment reports, including detailed damage analysis. In many cases, the craftsmen have also been directly involved in choosing the materials for the work which is to be done. They have been in the forests selecting appropriate trees and have been responsible for the whole timber production process; including the felling of the trees, the timber seasoning and the preparation process. In this way, the selection of appropriate wood for the work to be undertaken was secured. The reasoning behind the choice and preparation of material was justified by the craftsmen by looking at the very structures they were working on.

In close cooperation with the Directorate for Cultural Heritage, the craftsmen developed the plans for the actual repair work which was to be undertaken. Often the plans were quite general in character as the scale of work was hard to judge before actually starting the work. For example, a plan for repairing a roof could include directions for changing all damaged shingles, but it didn't state the condition a roof shingle should be in to justify replacement. It was also not possible to know the exact number of shingles which would need to be replaced before the building site was established and the scaffolding erected.

In the following I will give to examples of the work undertaken as part of the Stave Church Programme.

Borgund Stave Church

Borgund is stylistically dated to around 1180 and is amongst the best preserved of all the Stave Churches. The roof shingles on Borgund form, along with the external gallery, dragonheads and carved ridge turret, the very identity of the church. It is remarkable that the elaborately carved, original ridge turret is still in place. It is not possible to date with any certainty the age of the roof shingles, but it is probable that some of them are original.

The roof shingles were of different sizes and their condition varied considerably. Most of the shingles were made using an axe. Only in smaller areas, newer shingles had been made using a saw; a production method which first became usual around the second half of the 19^{th} century.

To make the necessary repairs to the roof, it became clear that several thousand roof shingles would have to be replaced. But as the shingled roof played such an important part in the visual identity of the church, it would look very different if all the shingles were to be changed at the same time. It would be extremely difficult, if not impossible, to recreate the same visual expression that hundreds of years of weathering combined with smaller repairs had achieved. It was therefore decided to do some test-areas of repairs, a procedure which demanded great skill of the craftsmen involved.

Another big decision was whether the shingles should be made using an axe or a saw. The sawn shingles are much more precise in their shape than the axed ones, and roof surfaces with sawn shingles have a stricter and straighter expression. As much of the existing roof had been made using axed shingles, it was decided that the new ones should be produced the same way.

During the work on the test areas, different methods of working were tried. In this early stage of the work, the project manager was often on site to discuss the different solutions. Through close dialogue with the craftsmen, a preferred method was chosen where they could reproduce new shingles while at the same time secure the usable existing ones. In this type of work it is important to find the right balance between conserving and renewing as it is vital to have a weatherproof roof, also over time. Conservation principles can't be too rigid where roof shingles are concerned; the shingles are placed directly on the underlying wooden sheathing without any additional materials and if water gets in rot can quickly occur.

After having completed several smaller test areas, the Directorate for Cultural Heritage concluded that the method where individual axed shingles were replaced was suitable for the whole church. But before the work could start in earnest, the right wood had to be found.

The awareness of the importance of choosing the right material was not really apparent before the 1990's. The best preserved shingles on the church are made of slow growth, dense pine. Analysis of the shingles shows an extreme density which is hard to find in Norwegian forests today and the craftsmen working for the Stave Church Programme had a real challenge on their hands trying to locate suitable wood. The shaping of the shingles with an axe demands good wood which should be both dense and straight in growth, something not possible to find in the near vicinity. The search had to be extended and eventually enough material was collected so the work producing the shingles could begin.

Part of the preparatory work on the church was also to determine what kind of scaffolding should be used. It was decided that a large frame should be erected around the entire church clad with tarpaulin. This scaffolding had two functions; it gave the craftsmen good working conditions while at the same time providing tourists and visitors to the church the opportunity to see the work being done. (figure 5)

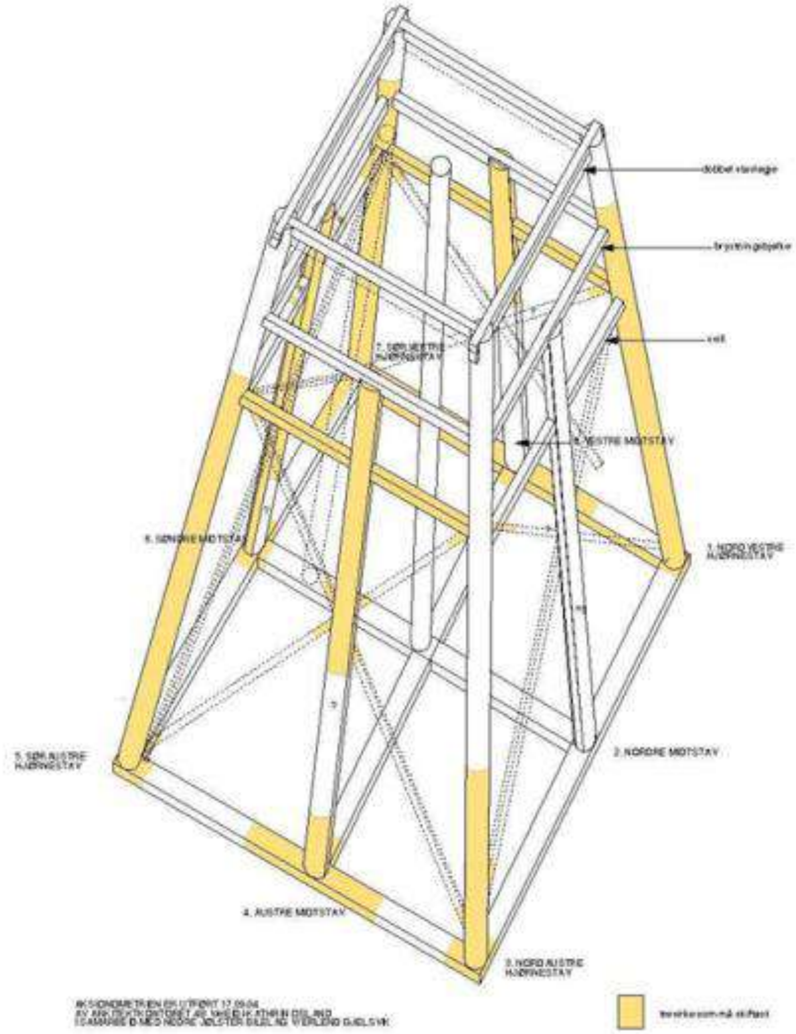
When the work changing the shingles was started, the craftsmen used the test areas as a reference to the work they were doing, regarding both which shingles were to be kept and how the new ones should be adjusted. The test areas had also given a good indication as to how many shingles would have to be changed. This proved to be an efficient and effective way of continuing the work as most of the major decisions had been made during this earlier phase. After many months of work, the shingles were treated with wood tar. In total, about 8000 shingles were replaced.

The Belfry at Borgund

The belfry at Borgund, also included in the Stave Church Programme, is the only one of its kind left from the medieval period. It has a stave construction very similar to the type found in the Stave Churches and is an important element in the cultural landscape surrounding the church.

Significant parts of the belfry are medieval but it has undergone changes and additions in the 17th, 19th, and 20th centuries. Condition assessments determined that the belfry was in critical shape. It was only the part above the bell room which was in relatively good condition, while the other parts had significant damage. The “staves”, or poles, had such a high degree of rot that several were completely hollow. The ground beams and joints were also full of rot.

The damage was so great that deterioration would accelerate if nothing was done quickly. Figure 8 shows the damaged parts, marked with yellow.



Several options were discussed; strengthening the existing construction by adding a wood or steel load-bearing frame inside the original was one option, thereby propping up the damaged belfry. Because of the extent of the damage, this option would be very dominating and it was unclear how one could attach the old belfry on to the new frame. It would also be necessary to make certain changes to the original belfry so as to be sure no further moisture would enter the already severely damaged wood. In short, this option would have brought about a radical change to the belfry.

Another solution which would have guaranteed a complete preservation of the belfry was to move it under cover at a museum and build a copy on site. The belfry as an object would in this case be preserved but as a museum piece. One of the main reasons why this option was not chosen was that it directly opposes one of the main principles of Norway's cultural heritage legislation: that a cultural heritage object should be preserved in situ wherever possible. If the belfry was to be moved, the cultural landscape at Borgund would be diminished, even with a replacement copy.

The option which was chosen was to repair the belfry and to remove the rotten material. The work would be extensive so it was decided that the whole belfry would be taken down. The top section was hoisted down first, followed by the stave construction which was dismantled piece by piece and transported to a workshop where the work was done. An advantage with the dismantling was that every single piece could now be thoroughly examined by the craftsmen who made detailed reports on joins and tool marks.

These studies formed the foundation in the work involving the remaking of building parts. Large amounts of original material had to be replaced, and it wasn't until all the pieces were examined that the extent of the damage became apparent. In the same way as the work on the churches, great emphasis was placed on locating replacement material of similar quality to the original wood. The craftsmen also used the same type of tools as far as possible.

Not just the visible elements were exact copies of the originals, but also all the hidden elements were recreated down to the smallest detail. For the belfry, it was of great importance that several of the load bearing elements were changed so the stave construction retained its load bearing function.

Conclusion

In the Stave Church Programme, the Directorate of Cultural Heritage has placed great emphasis on the importance of handicraft and material quality. The central role of the craftsman is also something new in the management and maintenance of the Stave Churches. While previously the craftsmen were told what to do, they were now part of the team - conducting the necessary investigations and appraisals. They gave important advice and their assessments played an important part in the discussions where principles were discussed. For the cultural heritage management in Norway to be developed, and for all the parties involved to learn from what they do, it is vital that the craftsmen who master the traditional crafts, maintain their position in the work being done. In this way the cooperation between the administration and the craftsmen can contribute to furthering our knowledge in the future.

ISBN 978-0-6485799-2-2