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**Remarkable historic timber roofs. Knowledge and conservation practice.  
PART 1 - Construction history and survey of historic timber roofs**

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**Cover illustration:** Lattice roof trusses in the nave of Jät church, Småland, Sweden, 1225–1226 by Robin Gullbrandsson. © Robin Gullbrandsson (2022)

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**Remarkable historic timber roofs. Knowledge and conservation practice**

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## Abstract

The remarkable clusters of preserved high medieval church roofs in Scandinavia have been known since the early 20th century, but surveys aimed at mapping and documenting these structures began around 2000. The author reviews the State of Scandinavian research and presents recent and ongoing survey projects in Swedish dioceses. These cross-disciplinary projects have enhanced the value of historic timber structures as archaeological source material. A reading of craft techniques and tool marks provides insight into the work of the medieval carpenters. The presented example shows how a structured survey followed by moderate cleaning shaped a basis for maintenance and restoration in compliance with international principles.

## Keywords

Medieval roofs, Medieval church buildings, Medieval carpentry, Survey methods.

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## 1. INTRODUCTION

This article deals with research on medieval roof constructions of churches in the Scandinavian countries (Denmark, Norway, and Sweden) (Fig. 1). The scarce economies of Scandinavian parishes after the 16th century Lutheran Reformation have often been mentioned as an explanation for the high authenticity of their medieval churches. This is not all true since many churches were modernized in the 17th and 18th centuries, not to speak of the large-scale demolitions of the 19th. However, a remarkable number of medieval churches still retain their original roof structures, several from the High Middle Ages, when the first stone churches got erected in this northern outskirt of Christian Europe. Clusters of preserved 12th century roof structures, such as the ones in western Sweden, are rare in Europe. Since these roofs are part of a European tradition of trussed tiebeam roofs, they are interesting material for comparison with structures in other countries [1].

This text aims to summarise the State of Scandinavian research. The focus, though, will be put on the last eleven years of structured surveys in the current Swedish dioceses (thus incorporating formerly Danish and Norwegian provinces), their methods, and outcome, also concerning the question of maintenance and conservation. The author has participated in several of these projects and recently published a report on the State of Swedish research in relation to European literature [2]. This is the basis for the present review.

## 2. HISTORY OF RESEARCH IN SCANDINAVIA

The interest in medieval carpentry was evoked among European architects in the wake of the 19th century Gothic revival with names such as Eugène Viollet-le-Duc in France and the Brandon brothers in Britain. Soon the ar-

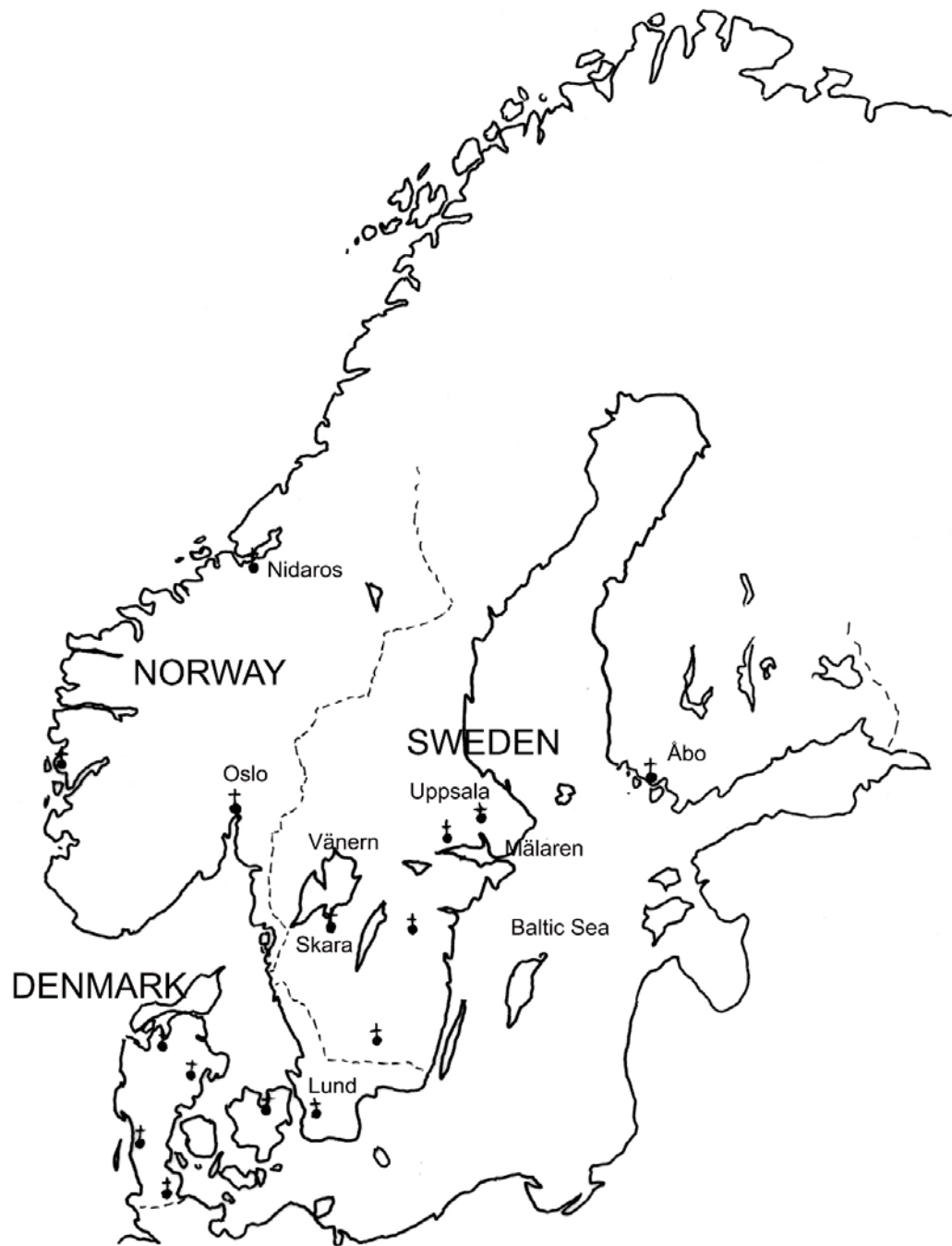


Fig. 1. Map showing Scandinavia, including Finland with the medieval state borders and the diocesan towns. (Map by the Author).

chitects got joined by scholars from the new discipline of art history. Nevertheless, before the birth of modern buildings' archaeology in the mid-20th century, very few regarded the timber structures covering the monuments as worthy of any deeper study. First, in the 1980s and 90s buildings' archaeologists raised the importance of studying the roof structures to fully interpret the buildings. Since then, the historic roofs have received a steadily increasing interest. In large, the history of research in Scandinavia follows this European pattern.

## 2.1. ART HISTORICAL BEGINNINGS – C. 1900-1970

The open roof structures – that is, open to the interior and without tiebeams – of Norwegian stave churches were the first Scandinavian church roofs to get studied in the mid-19th century and attained interest even outside Scandinavia. The likewise open roof of the large church in Værnes, Trøndelag, was long considered the sole surviving medieval roof among the Norwegian stone churches and was used to reconstruct lost roofs in some

monuments. This fits the image of an interest connected to contemporary architectural trends and the quest to discover and partly reconstruct a national heritage in several countries. The question of the open roof as an integrated part of the original church interior was debated among Danish archaeologists of the late 19th century, who started to investigate and interpret small-scale Romanesque parish churches. This reflects a general shift in focus from the significant monuments to a broader field of study around 1900, which went hand in hand with the emergence of national “art histories” and a centralized organization of heritage care in the Scandinavian countries. A result of this was the ambitious national survey projects of historical church buildings, still ongoing in Denmark and Norway but in the case of Sweden, very far from finished and, since c. 2000, put to a halt [3, 4]. In the Swedish publications, the roofs are often treated very briefly and from a pure art historical perspective, naturally since the project was “an art historical inventory” and one of the means of creating a Swedish art history.

In the early years of the 20th century, some Swedish art historians and archaeologists made minor studies of a handful of well-preserved 12th century tiebeam roofs, newly discovered, which due to their decorate features, were interpreted as once visible parts of the church interior. The later head of the National Board of Antiquities, Sigurd Curman, regarded these roofs as the meeting between surviving prehistoric Scandinavian carpentry traditions and the European novelty of masonry building [5]. The awareness of high medieval roofs and their inherent values led to strengthened protection. However, the slow rate of surveys in “Churches of Sweden” left the majority of medieval church attics unexplored and many medieval church roofs have, up until today, been the object of interventions not paying regard to the historical values.

The Norwegian stave churches and their structures have been studied by mainly Norwegian researchers throughout the 20th century [6], but roofs of other medieval churches in Scandinavia have to a much lesser degree, found its ways into publications. Two architects, though, put effort into approaching and trying to read these structures, the swede Erik Lundberg and the dane Elna Møller, whose studies were made possible by the

large-scale church surveys. Møller, with a background as a trained carpenter, found that medieval church roof structures were more common in Danish churches than formerly assumed. She could be regarded as one of the key persons in shaping the Danish church archaeology and developed survey methods for roof structures with “truss cards” inside the project “Churches of Denmark” (ongoing since 1933 at the National Museum) and made a typology for “Romanesque” and “Gothic” truss types, (the former with tiebeam), long referred to in Danish research. Møller was also the first to pay respect to tool marks [7, 18, 19]. The focus of Lundberg was structure and shape, marked by a diffusionist art historical perspective, putting the constructions in a European context and questioning their “national” character. He claimed the importance of influences from Carolingian Europe and played down any pure Scandinavian character in the Swedish High Medieval roofs [8].

## 2.2. THE ARCHAEOLOGICAL PERSPECTIVE – C. 1970-2000

The development of buildings’ archaeology and the advent of dendrochronology in the 1970s and 1980s got a foothold also in Scandinavia, giving birth to new methods and raising new questions in the research on medieval churches, often revising earlier stylistic datings. In the 1980s, Nordic researchers on medieval churches started a group focusing on roof structures, which presented their view on the state of research in a seminar on church archaeology held in Viborg in 1993, which showed the need for intensified documentation. Mainly motivated by the increasing archaeological excavations of cultural layers in medieval towns, but also as a part of “Churches of Sweden” and its sub-project “Medieval timber churches”, dendrochronological samplings started to be taken and reference curves being built. In Denmark, dendrochronology got incorporated in the surveys of “Churches of Denmark”. An interest in questions of building techniques and building organization manifested itself in the 1980s, marking a shift from the macro-perspective of earlier art historians to a micro-perspective examining the building materials, their tool traces, and the local preconditions. Parallel to this, village and settlement archaeolo-



gy evolved, and several aristocratic and royal manor sites from the Viking Age got excavated, giving a backdrop to understand the transition of Scandinavian countries into Christian kingdoms.

Architect Peter Sjömar's thesis from 1988 on medieval timber buildings emphasized the study of the crafts in historic timber structures [9]. In two subsequent articles, Sjömar called out for structured surveys of preserved medieval roofs in Sweden [10, 11]. Together with his Norwegian colleague Ola Storsletten he made the first in-depth documentation of Swedish church roofs and sketched an outline for a national project on behalf of the National Board of Antiquities, but it never got started. In Norway, such a project came about through the work of Storsletten, published in his 2002 thesis, which showed the presence of several original roofs in Norwegian stone churches that also got dated [12]. Both Sjömar and Storsletten stressed the importance of a solid Scandinavian carpentry tradition and the local resources for the character of the roofs studied. In both Norway and Sweden, institutions for the education in, and research on, traditional crafts got established (Norwegian Craft Institute and The Craft Laboratory at the University of Gothenburg), paving the way for a new reading of historical constructions, the craft's perspective.

### 2.3. CROSS-DISCIPLINARY NETWORKING – AFTER 2000

Even though the research on medieval churches in Scandinavia remained a small world with a limited amount of researchers, the research proceeded very much along parallel lines, the art historical, the archaeological, and the architectural/technical, connected to different universities and seldom traversing the disciplinary limits. Triggers for a widened networking concerning research on historic roofs were the European programs “Wooden culture” and “Roofs of Europe” in the first decade of the 21st century, making practitioners and researchers in crafts meet with art historians, archaeologists, and architects in enhancing the timber structures as a valuable cultural heritage. This cross-disciplinary approach took physical shape in the Norwegian projects aiming at properly maintaining the stave churches around 2000

[13]. The reconstruction of the burnt 14th century timber church of Södra Råda in Sweden acted as a catalyst for “practice-led” craft research connected to medieval churches, providing a full-scale archaeological experiment finished in 2021 [14]. This project renewed the interest in making reality of a national survey. Architect Kristina Linscott put on behalf of the Church of Sweden forth a report on the state of research in 2007, including a database of known structures and a typology [15]. A structural investigation into medieval roofs as load-carrying structures was made by engineer Carl Thelin in his thesis 2006 [16].

In Denmark, the well-preserved church roofs of southern Jutland have been thoroughly documented and dated. They have been interpreted and published by medieval archaeologist and art historian Per Kristian Madsen, The National Museum, in 2007 [17, 18]. He points at the remnants of a highly developed domestic carpentry tradition open to new ideas from abroad. In an article on the Arrild church roof, he also combines historical and archaeological sources to put the construction in a socio-political context [19]. Inger Laigaard, in 2018 evaluated and dated the tools and techniques encountered in danish church roofs [20]. It should also be mentioned that extensive research on Viking Age carpentry finds in Denmark and Norway has been done in relation to settlement archaeology and the finds of Viking ships. This provides a domestic context to some of the techniques found in Scandinavia's high medieval church roofs.



Fig. 2. Survey of trusses in the chancel of Knätte, Västergötland, Sweden. (Photo by the Author).



### 3. RECENT AND ONGOING SURVEYS IN SWEDEN

The altered relations between the Swedish State and the Church of Sweden in 2000 led to a mutual agreement on the future preservation of the churches as cultural heritage, while the other Scandinavian countries have maintained their state churches. The Swedish dioceses became crucial in administering the new state funding and creating an up-to-date knowledge base for managing the church buildings and their complex historical values. In 2010 the author headed a small pilot project aiming to map the extent and character of medieval church roofs in a part of the province Småland, Linköping diocese [21]. Seven dioceses have run similar survey projects in the following ten years, some still ongoing [21–28]. The primary objective was to grasp and evaluate what remains of medieval timber constructions in attics and bell towers; in short, a rapid inventory becoming a prerequisite for correct maintenance and a starting point for further research (Fig. 2).

#### 3.1. METHOD

Although the composition of the survey projects has varied somewhat from diocese to diocese, since they were all individually run, they share common points of departure and aims. Central has been the collaborative work of conservators, archaeologists, dendrochronologists, and, not least, craft researchers and traditional carpenters with experience from the Södra Råda project. Whereas the preserved structures are the primary source material, complementary dates have been searched for in the archives (although these mainly concern early modern times).

The projects have been run as hermeneutical processes with stages zooming in from a macro- to a micro-perspective. Limited archive studies were used to sort out churches that could have preserved structures and would be the object of survey. This meant spending half a day in each church to map if any timber structures were preserved, if so, their extent and general character, using a standardized checklist resulting in a protocol, sketch drawings, and photos. Questions were formulated based

on the results of the survey, and a selection of objects was chosen for continued in-depth field and archive study, forming the following case studies.

The investigations in selected structures focused on identifying original parts and later alterations, their relation to the masonry, traces of use, and the understanding of the system, tools, and techniques applied by the original carpenters. For the latter part, reading and interpreting the tool marks and other traces of the production and erection processes was vital. The astoundingly well-preserved surfaces of many timbers in Scandinavian church attics give good possibilities for what has been labeled as “traceology” or “forensic perspective”. The experiences of craft researchers and carpenters in recreating these traces with replicas of historic tools were necessary to fully understand and value these “fingerprints” of the medieval craftspeople, which earlier often had been passed by. Such traces contain information vital to understanding the craft.

Analyzing these roofs in detail resulted in hypotheses that were tested by dendrochronological samplings in selected promising timbers. Exact dating is, nonetheless, tricky in the high medieval structures since the carpenters seldom left any vaney edge or sapwood. Thus, the sample timbers must be sought out and examined carefully to determine the presence of vaney edge or sapwood, top or bottom, and the number of year rings. The most common species used in medieval Norway and Sweden were pine, to a lesser extent oak, and spruce, whereas oak was all present in the churches of medieval Denmark. Pine and oak have good reference curves while spruce poses a much greater challenge. Much of the dendrochronological analyses have been made at the Department of Geology, University of Lund, the central archive for Swedish samples. The extensive comparison material from different regions also allows for suggesting provenance. The samples also give information on the growth circumstances for the actual timber, giving an image of how the forests once looked and were used. Such questions have been highlighted in the diocese projects, and dendrochronological methods have been further developed in a project run by the Craft Laboratory and the University of Lund [29].

### 3.2. A SHORT SUMMARY OF RESULTS FOR SWEDEN

The diocese projects have enlarged and deepened the knowledge of medieval roof structures and timbered bell towers in contemporary Sweden. The amount of known structures has doubled since the report of 2007, from 268 churches to well over 500, and still much remains to be surveyed. Circa 160 constructions, to a large extent preserved in situ, can be regarded as pre-dating 1250, a unique European corpus. The dendrochronologically dated structures have also doubled from circa 100 to more than 200. To summarise the material is consequently not possible in this article. Now the work is to process this extensive empirical material scientifically and put it into context, regionally and in relation to Europe. The author is treating

the West Swedish material in an ongoing PhD-project; another PhD-project concerning the material from the Danish period in the diocese of Lund in southern Sweden is run by carpenter and archaeologist Karl-Magnus Melin. A minor part of the earliest dated west Swedish roofs were the objects of a dissertation by Kristina Linscott in 2017, focusing on the relation between the inner space and the roof and its possible perception [30]. The regular contacts with colleagues in other countries through the network of “Arbeitskreis Dachwerke” and the “Construction History Society” seminars have given valuable input for the research on roofs in current Sweden. Summarizing articles on Swedish and Danish material will be included in the upcoming publication “Dachwerke vor 1230”, headed by the “Arbeitskreis”.

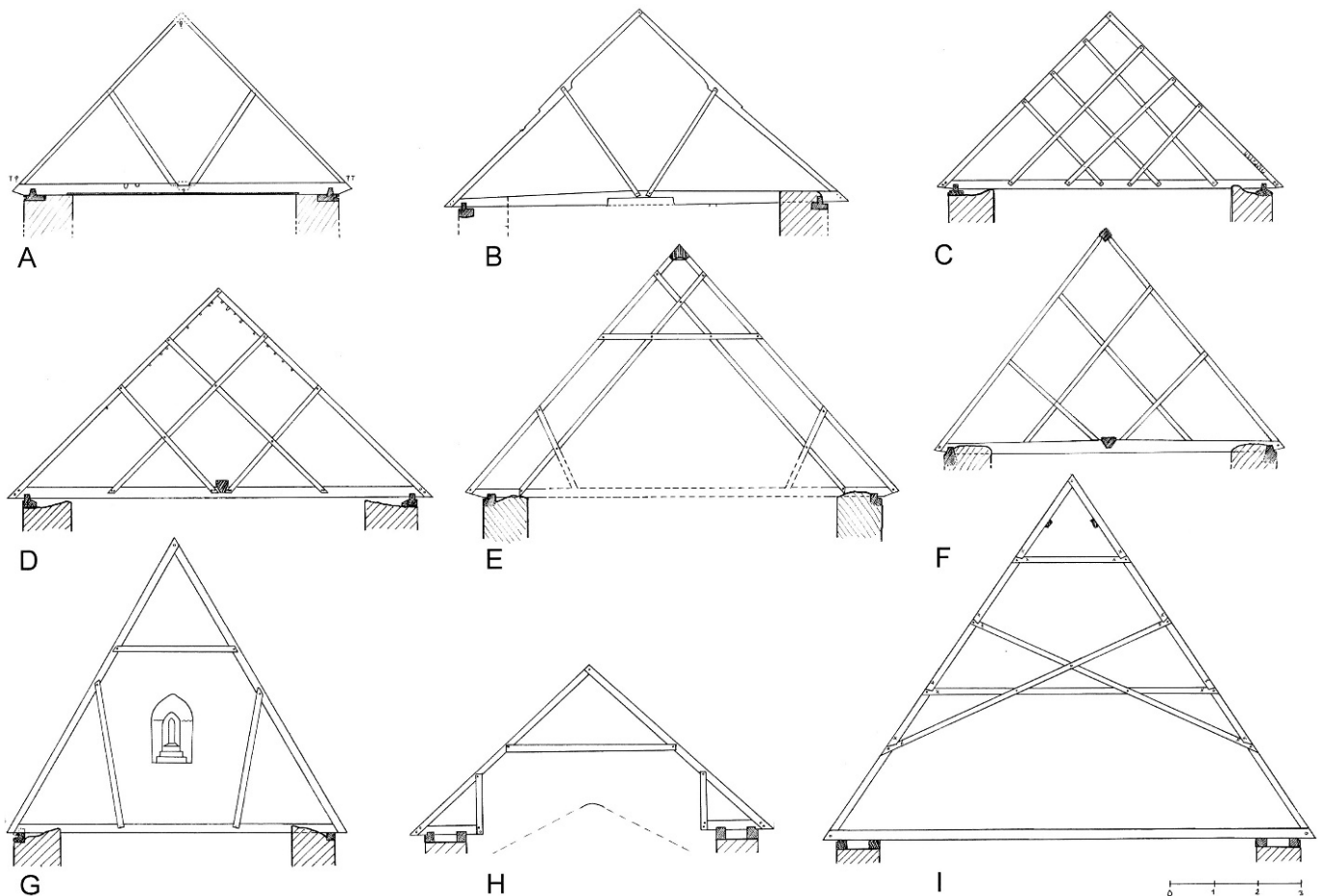
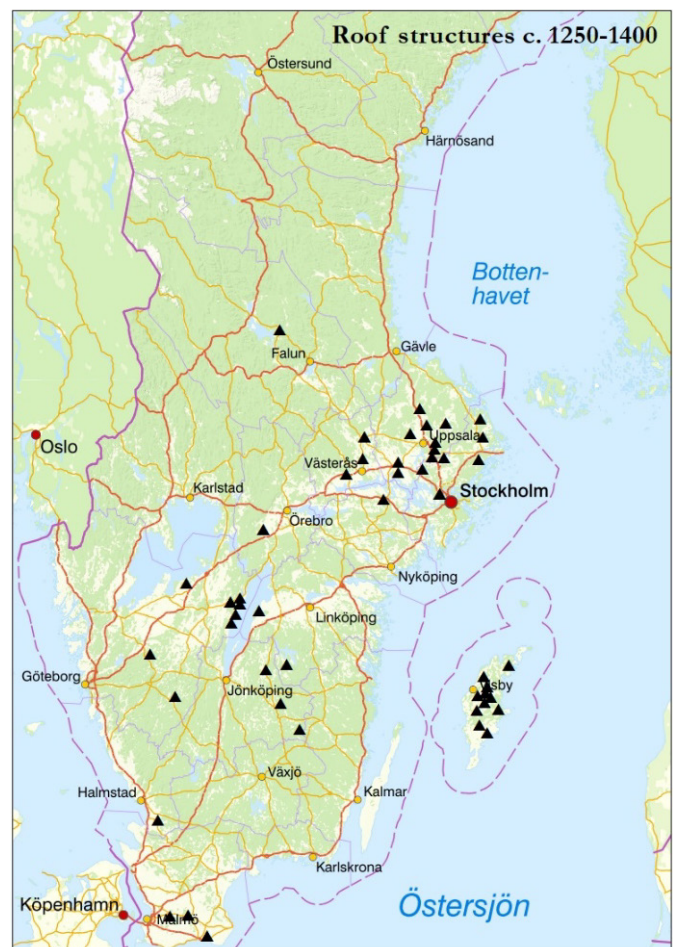
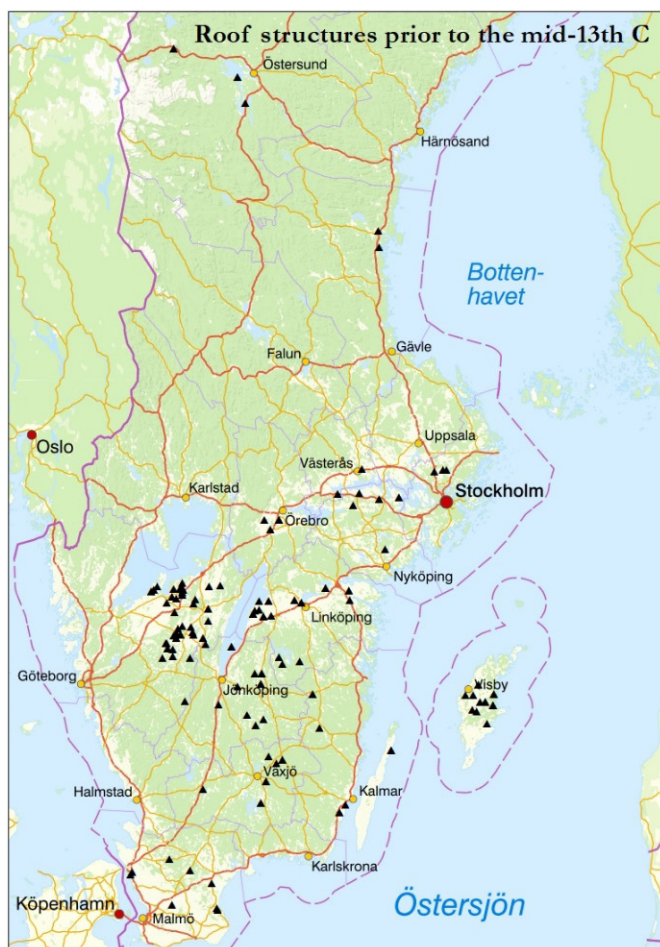


Fig. 3. Examples of church roofs in West Sweden from 1100-1400. A. Truss with canted struts inserted in mortises without dowel, the 1120s (d), Vässterplana church, nave roof. B. Truss with canted struts and lap joints, 1135-1137 (d), Forshem church, nave. C. “Lattice” truss with crossing struts, together with the D variant, the most common type from the 12th and 13th centuries, 1138-1149 (d), Marum church, nave. D. “Lattice” truss with a steering beam on the tiebeams, undated, Sveneby church, nave. E. Truss of the South Norwegian Østland type, here with a steering beam on the ridge, 1205-1207 (d), Ljungsarp church, nave. F. Truss with rafters inserted into a ridge purlin, 1200-1204 (d), Valtorp church, nave. G. Steep pitched truss with canted struts and collar beam, probably late 13th or early 14th century, Knätte, chancel. H. Truss adapted for vault with ashlar and sole pieces, standing on double wallplates, 1269 (d), Forshem, chancel. I. Truss with scissor beams and dovetail lap joints with carpenter marks, 1378/79 (d), Mölltorp hall church. (Drawings by the Author).

I will here try to sketch some more general conclusions apart from the simple mentioning of numbers, names, types, and dates. The Middle Ages is a long period, and carpentry shows some radical changes from the oldest remains of the late 11th century to the structures before the Lutheran reformation shortly before the mid-16th century. Nevertheless, these changes occur in different regions at different times and paces (Figs. 3 and 5).

The oldest dated remains belong to the second half of the 11th century but are only preserved as reused timbers in younger constructions. Still, these few traces of tiebeams, wall plates, and steering beams found in early stone churches in Scania (until 1658 part of Denmark) and remnants of stave churches in Östergötland and on Gotland testify to the use of tiebeam trusses. To determine when and where this new way of roof construction got introduced in Scandinavia is difficult due to the scarcity of remains, but it seems that domestic carpenters

were at work already in the early examples and had a high level of skill. Up until the mid-14th century, most structures show the same set of tools and techniques, most characteristic the hewing with knife grinded felling axe in the direction of the wood fibers, shaping a fish-bone pattern (Fig. 7). The oldest preserved trusses date from the first half of the 12th century and are found in Scania, Väster- and Östergötland, Södermanland and Gotland, early centers of Christianity and worldly power. These trusses with high tiebeams and slender rafters supported by canted struts, all nicely square hewn, are closely related to the oldest preserved examples in Western Germany. In total, 21 structures could be regarded as preserved. Dominating the corpus of high medieval roof structures are the tiebeam trusses with a lattice of crossing struts, which seems to have developed into a normative type from the mid-12th century, enduring for more than a century in newbuilt stone churches but also timbered ones. In total, some 90 are known, of which



Figs. 4 and 5. Distribution of preserved church roofs from the period 1100-1250 respectively 1250-1400 in current Sweden, stand 2020. (Maps by the Author).



69 can be regarded as preserved structures, mainly in Västergötland, but also in other provinces (Fig. 6). 12 roofs are rare hybrids between the trussed roofs and the older post-and-purlin roofs, featuring rafters inserted into a ridge purlin. A characteristic feature of 12th and 13th century church roof trusses in medieval Sweden is their tight and, in effect, over-dimensioned spacing around one ell (Fig. 7c, 10). In contrast, the spacing in the rest of Scandinavia and northwestern Europe has a standard measure of the double (only the earliest dated structures up until the 1120s show a more European spacing). Decorative elements on tiebeams and steering plates, as well as plastered surfaces between the tiebeams and traces of fixation for small bells, imply that the roof structures originally were visible from below, to become hidden by flat wooden ceilings first in the 13th and 14th centuries and subsequently resulting in less refinement in the following roofs. Also, the use of seasoned timbers, evident in the still very accurate and tight joineries, marks a difference against continental roofs. The dendrochronological samplings indicate the use of local timber resources during most of the Middle Ages [31].

The carpentry innovations brought forward by Gothic architecture on the continent reached the Scandinavian regions very unevenly. The first dated applications of a hierarchical roof structure adapted for vaults (with primary tiebeam trusses and secondary ones with ashlar and sole piece) are on the island of Gotland from the early 13th century. In Västergötland it is stated first from c. 1270 and in very few examples since few Gothic refurbishments were made. Instead, the regions around lake Mälaren and the north thereof advanced as centers for large-scale church projects, including the insertion of wooden trefoil and barrel vaults, which are known from 28 churches, though none of these vaults today is preserved in situ. From the mid-and late 14th century, the few dated structures might reflect a decline in building activities in the wake of the Late Medieval Agrarian Crisis and the Black Death. Whereas some parts of medieval Sweden retained the Romanesque roof solutions, the carpentry in general adopted the techniques of continental truss and timber frame building such as working on templates, use of carpenter marks, increased spacing, bracing with scissor beams,

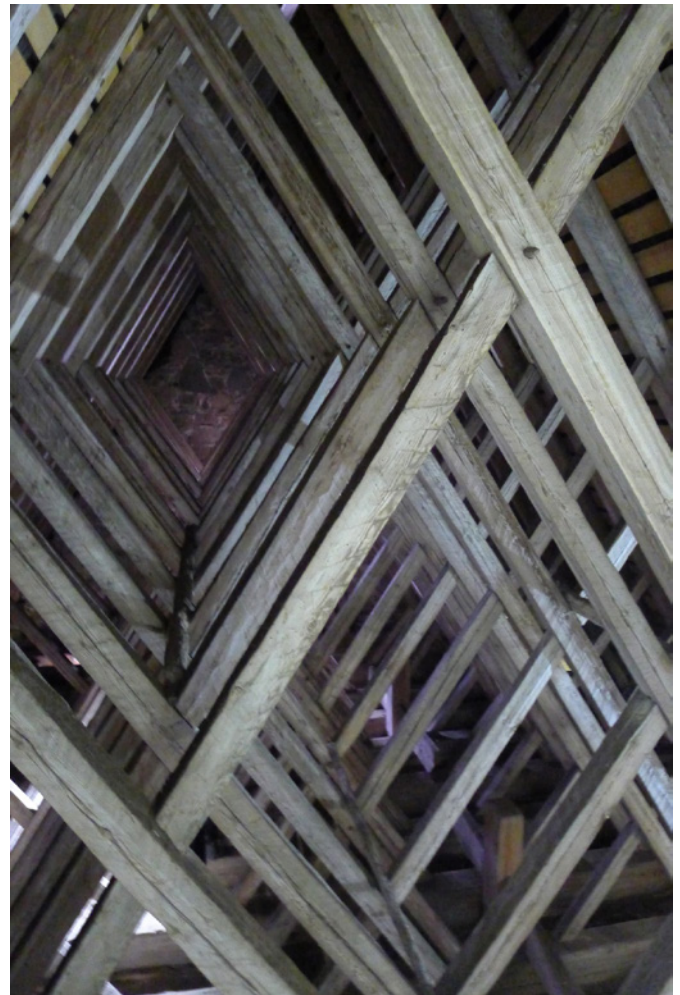


Fig. 6. Lattice roof trusses in the nave of Jät church, Småland, Sweden, 1225-1226 (d). Note the hewing marks going along the fibers ("sprätthuggning") and the sharp edges without vane. (Photo by the Author).

hewing mainly with the broad axe across the fibers and the use of more developed lap joints or doveled tenon and a mortise (Fig. 8).

The Late Medieval roof structures are closely related to the continental ones, even though the old-fashioned tiebeam roof held on, especially in Western Sweden due to the lower rate of vaultings. Most preserved 15th and 16th century roofs are found in the regions around Mälaren and in the North. Medieval Sweden has few examples of Gothic double-framed roofs. The earliest known example was erected on the bridgettine convent church of Vadstena in 1418, followed by the roofs some large city churches, maybe under the influence of German merchants and craftsmen.

Ten Romanesque masonry towers still preserve their original roof structures, but these remain to be studied closer and dated. A handful of timber-framed campani-



Fig. 7. Different 12th century surface treatments. A. Slender rafters in Jäla church, Västergötland, 1124-1142 d, of cleaved pine and oak, hewn with a felling axe in the direction of the fibers, the Scandinavian technique of "sprätthuggning". B. Tiebeams and ornate steering plate in the nave of Hagebyhöga church, Östergötland, 1119/20 d; the surfaces worked with a plane, and the edges enhanced with a profile plane; note the traces of a later inserted ceiling on the bottom of the beam. C. Tiebeams in the nave of Mularp church, Västergötland, 12th century, the beams are full timbers hewn to a conical shape in the technique of "sprätthuggning", the sides finally flattened with a broad axe working cross the fibers, leaving a stroke of "sprätthuggning" along the edges. Note the flush and tight strut lap joint and the embedding of the beams in the masonry, originally plastered. (Photos by the Author).

les have also survived, belonging to the High and Late Middle Ages, related to preserved ones on the Danish islands.

### 3.3. STATUS IN THE OTHER NORDIC COUNTRIES

In Denmark, there are few known remains of roofs older than 1200, though traces have been found in some 50 churches in Zealand [32]. Twenty-three medieval roofs on southern Jutland have been more closely investigated and dated from the 13th century until the 16th, most interpreted as younger than the church itself [17, 18]. Inside the project "Churches of Denmark", documentation of medieval churches is ongoing in eastern Jutland and on Funen, including studies and dendrochronolog-

ical sampling of roof structures [3]. The overall picture is similar to the former Danish provinces of Scania and Halland, where Late Medieval structures dominate, and High Medieval remains are few compared to medieval Norway and Sweden. The Danish roofs have been structured into four types by Møller: the Roager type with tiebeam, canted struts, and often a collar beam, the Arrild type where two or four of the struts cross each other; the Scissor braced type with or without tie or collar beam, the Collar beam type with small ashlar pieces and sometimes sole pieces. The preserved tiebeam types have mainly datings from the 13th and 14th centuries, the ones adapted for vaults are mainly dated from c. 1400 onwards. Some types have been applied throughout the Middle Ages, showing lasting carpentry



traditions. The roofs of medieval Denmark have many similarities with roofs in Northern Germany from the

same time and also share features such as pit-sawn quarter timbers in rafters and bracing.

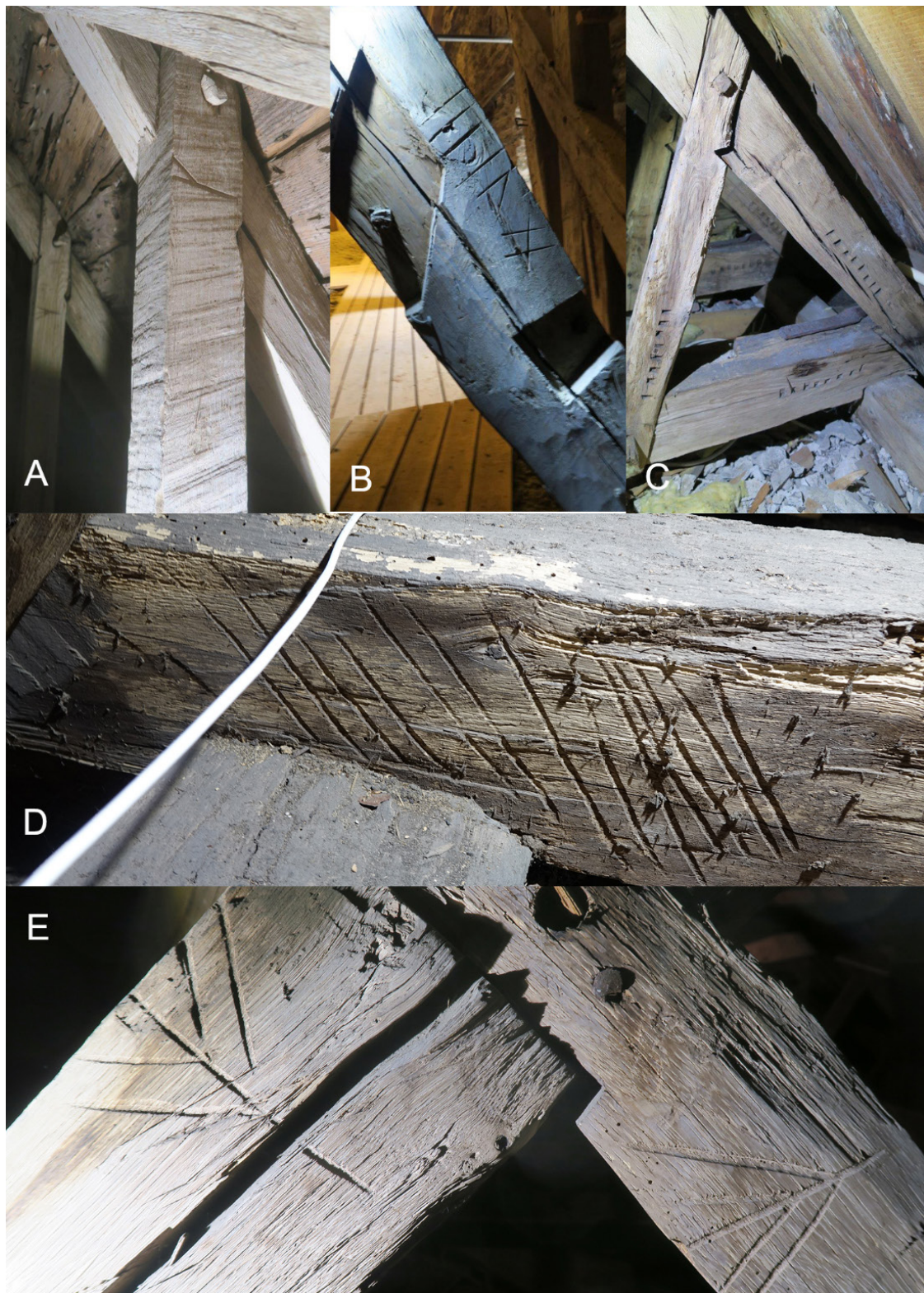


Fig. 8. Examples of high and late medieval carpenter marks in Sweden. A. Symbolic runic mark made with race knife on ashlar piece, pit-sawn quarter timber, in the chancel of Ysby church, Halland, 1275-1287 d. B. Cut Roman marks on reused broadaxed beam from the original double-framed roof of the convent church in Vadstena, Östergötland, from the 15th century. C. Square cut marks ("Macken") on oak rafter foot in Torslanda church, Bohuslän, 1470-1472 d. D. Race knife lines on tiebeam in the hallchurch of Sällstorp, Halland, 1460s d. E. Race knife marks on the double-framed nave roof of Veinge church, Halland, 1517 d. (Photos by the Author).





Fig. 9. Carpenter Mattias Hallgren hewing a new wall plate of oak to the church of Gökhem, Västergötland, Sweden, in 2019 using the same tools and techniques that could be read on the original. The church in the background still has 20th century roof tiles. (Photo by the Author).

Since the research of Storsletten, the complete corpus of high medieval church roofs in Norway is today known, comprising 53 preserved structures from circa 1100-1350, of which 28 are found in stave churches (with a span of datings from the mid-12th century up until the first half of the 14th). Storsletten has created a typology consisting of six types, of which three are solely connected to the open structures of the stave churches. The advanced internal bracing of the trusses is highly characteristic, such as the doubled rafters of the Østlandtype, also found in a few Swedish examples, and the elaborate fan-shaped lattice bracing of the open trusses of the Trøndelag type, which, as the stave church roofs, applies trusses without tiebeams long before the innovations of Gothic carpentry reached Scandinavia. These imposing roofs have also been found in the current Swedish provinces of Jämtland and Hälsingland, showing strong influence from neighboring Trøndelag and the Norwegian archdiocese of Nidaros. The craft techniques and tools used in the Norwegian roofs are more or less identical to

those found in most of the high medieval Swedish material, stating the existence of an overarching Scandinavian carpentry tradition.

In 2020 a Finnish survey project started, conducting cross-disciplinary in-depth field studies of the 20 known late medieval church roofs preserved. Since Finland, from the 12th until the early 19th century, was part of the Swedish kingdom, several comparisons can be made. Of high medieval structures, only some reused fragments seem to remain, mainly due to the relatively late start in constructing the still-standing stone churches.

#### 3.4. SURVEYS AS A PRECONDITION FOR MAINTENANCE AND CONSERVATION

People can properly maintain and preserve only what they know. The surveys have been motivated by the need for better knowledge to preserve this significant part of the oldest surviving Scandinavian carpentry in situ. The lack of knowledge is evident in several attics and con-





Fig. 10. Restoring severely damaged tiebeams (1140/41 d) in the nave roof of Gökhem church, 2019. Carpenter Bengt Bygdén making a recess for a lap joint. Note the hewing of the tiebeams, made according to the technique used on the scarfed piece. The log was cut square with a felling axe working in the direction of the wood fibers; finally, the somewhat protruding sides got flattened with a broad axe working across the fibers, a treatment connected to the original visibility of the beams in the church interior. (Photo by the Author).

structions, which had not been recognized as historical structures with their own values. Even recently, values have been lost forever or damaged due to random alterations, exchanges, and technical installations. Creating awareness among local trustees, decision-makers, and entrepreneurs is a great task, the surveys are the necessary starting point.

A few high medieval timber structures have recently been the object of well-planned restorations and conservations. A good example is the works concerning the unique 1140s nave roof of Gökhem church, Västergötland, 2017-2021 (Figs. 9 and 10). Before a planned renewal of the 20th century roof covering of tiles, a study was made of the structure in the attic, which partly was covered in birds nests and waste material, making an evaluation of damages difficult. An archaeological cleaning of the attic was

made by the author and craft researcher Mattias Hallgren, followed by a buildings archaeological investigation and thorough inventory of damages, the latter showing severe inner damages of fungi in several tiebeams, aggravated by their embedment in the masonry [33].

Such a cleaning and detailed investigation could be considered a third stage following the surveys and case studies. This shaped the basis for a restoration plan in which engineer Carl Thelin also ensured the level of necessary structural function. The aim was to minimize the interventions to preserve the maximum of the original substance, but also to respect the original working methods, materials, and techniques, and not least, to maintain the authentic visual impression of the attic, whose trusses were once visible parts of the church interior. This meant that each truss was treated as a unique case with regard

to the degree of damage and information on the original surfaces. Luckily the roof is typically over-dimensioned in its spacing of the trusses, meaning that it would be enough if only every second truss were fully functioning. Thus a lot of work and original substance could be spared. The worst damaged tiebeams had to be scarfed with new material of corresponding quality, hewn in the same techniques and with the same type of axes as the original, a process which in itself meant a deepened knowledge of the original techniques [34] (Fig. 11). In other cases the damaged tiebeams with intact surfaces underwent surgical reparations getting new form shaped infills. The tiebeams cut for vaults in the late 15th century were reconnected with iron anchors, preventing further deformation. The destroyed southern wall plate was reconstructed in oak (Fig. 10). The archaeological building investigation showed that the present embedding of the tiebeams in masonry was not original; thus, it was decided not to reconstruct it on the fungus-infected southern side, leaving the tiebeams free. 20th century random additions could be removed. To lessen the weight put on the trusses, the decision was made to change the roof covering from tiles to lighter shingles, which could be historically stated both through the archives and through findings in the cleaning. Throughout the process, public demonstrations of the project were made as well as a temporary exhibition, which met with great interest from locals, tourists and visiting experts. In upcoming years the aim is to make part of the roof accessible for smaller groups and create a minor exhibition. Thus the surveys shape a foundation for better-planned maintenance and restorations in line with the principles stated in the Mexico charter of 1999 and letting the timber structures speak for themselves.

#### 4. CONCLUSION

Since the turn of the Millenium, significant efforts have been made in all Scandinavian countries to better understand the extent and character of preserved medieval carpentry in the churches. This has highlighted the roof structures as unjustly neglected sources of knowledge concerning crafts and building in the Middle Ages. The cooperation between scientists and craftsmen has given

new insights and readings of the well-preserved material, valuable for both the research and the challenges of preservation and conservation.

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