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Timber Reuse in Mediaeval Churches of Finland

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Abstract

Reusing construction materials is as old as construction itself. The most prevalent historical examples of reuse, especially *spolia*, consist of buildings made of hard and durable materials, such as stone and bricks. We examined circular wood use, including reuse, remanufacturing and recycling, on large-scale mediaeval construction sites, specifically in Finland's mediaeval stone churches. In the Nordic countries, especially Denmark and Sweden, the reused pieces from older churches were intentionally positioned in niches, doorways, and window sills.

In this study, we reflect on two standing examples of the mediaeval reuse of sacral timber from Finland: St. Mary's Church in Pohja and St. Henry's Church in Pyhtää. Our study aimed to highlight the practical starting points and motivations for reclaiming timber and the possible intentional positioning of sacred wood in ecclesiastical buildings. The analysed Finnish cases could currently be considered examples of a local 'circular material economy', with opportunities for recycling and reuse. Our research shows that ritualistic or artistic expressions did not motivate the Finnish reuse cases. Instead, the reuse helped reduce the time- and labour-intensive work of the local mediaeval community, given the modest available energy surplus for large-scale construction projects.

Keywords

church – Finland – Middle Ages – reuse – roof structure – timber

1 Introduction

The reuse of building materials has been widely studied in the history of architecture and construction. Since the 1970s, and especially for the last 10 years, the reuse, circular material economy, and the modern interpretations of *spolia* have become prominent in contemporary architectural and construction research (e.g., Kalakoski & Huuhka 2018). The accelerating depletion of resources and problems caused by extractivist architecture have also resulted in growing interest in the historical patterns and skills of the reuse of building materials. However, the modern intentions of circular wood use, including reuse and recycling, differ considerably from the mindsets and processes that existed hundreds or even thousands of years ago.

In this study, we approach the mediaeval reuse of timber in sacral buildings through two case studies from late mediaeval Finland, more precisely through the stone churches of Pohja and Pyhtää. We reflect on these case studies

through a literature review of timber reuse in mediaeval stone churches along the Baltic Sea. A review of an early-15th-century Italian pastoral manual on sacral timber reuse illuminates the topic from a different perspective. The main research question is why and how the timber was reclaimed during the construction of the roof trusses of the churches of Pohja and Pyhtää. This study also expands on the question by exploring possible motives and mediaeval mindsets regarding circular wood use and waste management in the context of mediaeval sacral construction sites.

The main aspect of state-of-the-art reuse of building materials is the reuse of masonry architecture. Bricks and stone, which are durable, have received greater scholarly attention from architectural historians than ephemeral timber. Nevertheless, the roofing of sacral buildings involves a wealth of timber reuse, which is a conventional and commonplace phenomenon in mediaeval buildings. The significance of this study is that it reveals the processes of timber reclamation and waste management for large-scale construction projects. The study also reveals decision-making and mistakes that occurred during the construction process, which have particular relevance for Finland, which has no written historical records of mediaeval construction sites. Even in Northern Europe, which did not suffer from large-scale deforestation during the Late Middle Ages, timber was reused in most churches. This offers a new perspective on material availability in local mediaeval communities and its cultural value.

Terms, such as reuse, recycling, and remanufacturing are used in this study. In this context, reclaiming is an umbrella term. Remanufacturing refers to how a product made for a certain purpose is reworked in order to be reused. Reuse means that a product is used again for an adapted purpose or for its original function. Recycling refers to giving a new purpose to waste materials, mostly lower quality products, as in this study.

The article is structured as follows. First, we focus on a mediaeval manuscript that explains the conventional ways of reusing timber from ecclesiastical buildings in 15th century Italy. Second, we examine the patterns and examples of timber reuse in churches in Denmark, Sweden, Finland, and Northeastern Germany. Then, we explore the two Finnish cases, the churches of Pyhtää and Pohja. Finally, we summarise and conclude the study with remarks on reclaimed timber and waste management in mediaeval roof structures.

2 Reuse — Anachronism or Mediaeval Mindset?

The reclaiming of the timber of churches merits consideration in the pastoral literature, as demonstrated in the following quotation from *Supplementum*

Summae Pisanellae, published by Franciscan friar Nicolaus de Ausmo in 1444 and printed in several incunabula editions in the late 15th century:

> Timber dedicated to a church should not be harnessed for purposes other than benefitting another church, to be burned, or (to be used) for the profit of brothers in monasteries. It must not be granted to laypeople's works, on which, says the Gloss, that said timber should be placed in honest places, namely in a chapter house or dormitory or similar, but not in a kitchen or as the support for a vine plant or similar entity.[1]

Nicolaus de Ausmo's work is a perfect example of the mediaeval mindset of reuse. As the title suggests, it is based on an earlier work, the popular 14th-century confessors' manual by the Dominican friar Bartholomeus de Sancto Concordio (d. 1347), whose text Nicolaus republished with his own commentary (Michaud-Quantin 1962: pp. 60–64). The discussion about the timber of a church comes from Nicolaus, and his concern is its special status: once a church was consecrated, holiness started to reside in its building materials. Such an attitude toward holy matter was both theologically controversial and universally accepted in the Middle Ages (Bynum 2011: pp. 154–158).

Confessors' manuals and other guides for priests are normative sources, and it is often impossible to determine the extent to which these norms were followed. With this caveat, these manuals are a valuable source of mediaeval worldviews, as they addressed issues that the clergy responsible for pastoral care might encounter in their work. From the 1220s, pastoral manuals increasingly took the form of practical literature, often written by and for the members of the mendicant orders (Klepper 2022: p. 29). While the several-hundred-page works by Bartholomeus de Sancto Concordio and Nicolaus de Ausmo were probably more suited to the learned settings of mendicant convents than for the practical use of parish priests, they were mediaeval bestsellers. At least one copy of the *Summa* of Bartholomeus was available in mediaeval Sweden, attested by fragments in reused parchment from 16th-century account books.[2]

1 'Ligna ecclesie dedicata non debent ad aliud opus iungi nisi ad aliam ecclesiam vel igni compurenda sunt; vel ad profectum monasteriorum fratribus. In laicorum opera non debent admitti, vbi dicit. Glo(ssa) quod dicta ligna possunt poni in locis honestis, scilicet in capitulo vel dormitorio vel simili sed non in coquina vel vineis pastinandis et huiusmodi.' Nicolaus de Ausmo, *Supplementum Summae Pisanellae*, Venetiis: cura ac dilige(n)tia Bartholomei de Alexa(n)dria, Andree de Asula (et) Maphei de Salo socio(rum), 1481, keyword *Consecratio quinto*.

2 F.m.VIb.4 (Summa de casibus conscientiae), Finnish National Library, *Fragmenta membranea*, available online at http://urn.fi/URN:NBN:fi-fd2011-fra108 (accessed 2 September 2024).

The excerpt from Nicolaus de Ausmo's manual demonstrates that timber from mediaeval churches was commonly reused, that there was both secular and ecclesiastic demand for such timber, and that educated clergymen were anxious over the possibly profane reuse of consecrated building materials. Such an attitude is in stark contrast to later examples of mediaeval churches sold for use in barns and farmhouses (see Section 3.1).

3 Timber Reuse Along the Baltic Sea in Mediaeval Stone Churches

The construction of churches in the Baltic Sea Region dates back to at least the 11th and 12th centuries, before the firm establishment of Christianity (Hiekkanen 2007: p. 16; Hilling 2022: p. 13). The first churches in Northern Europe were built using timber. There are many types and subtypes of timber churches, such as stave churches in Sweden and Denmark (Hilling 2022: pp. 20, 120), timber-frame churches in Northeastern Germany (Schöfbeck 2014: p. 233) and log-frame construction in Finland, Sweden, Poland, and Latvia (Ahrens 2001a: p. 347).

Churches constructed from natural stone or bricks gradually replaced wooden churches in Sweden and the islands of Gotland and Åland from the 12th century onwards (Hilling 2022: p. 141). However, in Finland, then the eastern part of the Kingdom of Sweden, the transition in building materials started only at the beginning of the 15th century (Hiekkanen 2007: p. 25). Estonian churches witnessed a parallel development, as evidenced by a written request for permission to build a stone sacristy at a wooden monastery church in Pirita in 1417, followed by the continuation of stone church construction in almost every parish (Tuulse 1951: p. 177; Hiekkanen 1991: p. 18). However, in Finland, Gotland, Åland, and Sweden, the era of stone churches lasted only for a brief period and wooden construction resumed after the Reformation (Hilling 2022: p. 147). This transition probably left over 50 stone churches in Finland unfinished. Their incompleteness is expressed in missing vaults or other construction phases, or even in the abandonment of the entire construction (Hiekkanen 2003a: pp. 76–81; Mäkinen & Taskinen 2019: p. 24; Hiekkanen 2007: p. 27). Many original mediaeval roof structures of the stone churches along the Baltic shore collapsed or were gradually destroyed owing to fire, structural issues, abandonment, or wars, and were replaced by newer wooden or metal structures. However, surveys of the surviving original mediaeval timber structures in Sweden (including Gotland), Finland (including Åland), Northeastern Germany and Denmark highlight that not all elements originated from the same mediaeval era but show diverse traces of reuse (Fig. 1).

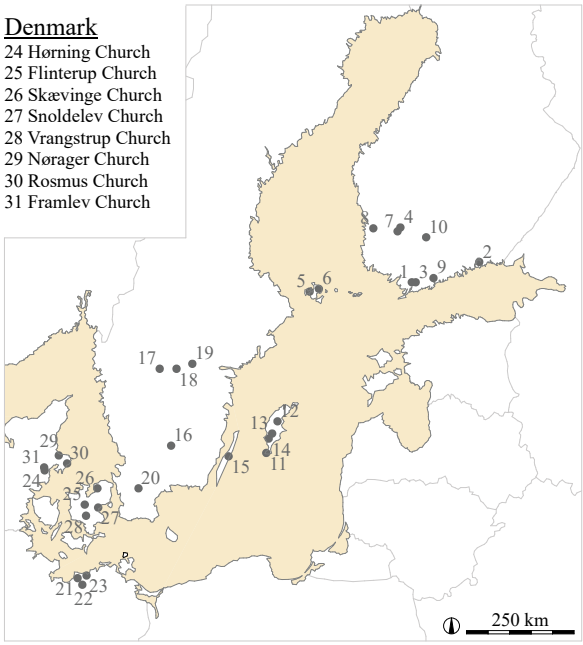

FIGURE 1 Location of the documented examples of timber reuse in the mediaeval stone churches along the Baltic Sea
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Examples of reused timbers that were integrated into church walls are frequently found in Denmark and Sweden. These cases include the reuse of 32 original 12th-century boards, of which 24 are decorated with Byzantine-style paintings, in two wall cabinets of the chancel in the 13th-century Sundre Stone Church on the island of Gotland, which has been part of Sweden since 1645. Based on excavations, these boards were likely taken from the ceiling of a previous stave church (Andrén 2011: p. 216; Lagerlöf 1999: pp. 60–62). In the Dalhem Stone Church, also located on the Swedish island of Gotland, there is a comparable case of the 13th century of painted boards of previous church buildings being reused in a wall niche (Lagerlöf 1999: p. 67). This exhibit is likely intended to commemorate older church buildings. Elna Møller and Olaf Olsen (1961: p. 36) described the reuse of timber in Denmark, assumed to originate from the demolished wooden predecessor churches, especially as fill material in the core of the stone walls of subsequent stone churches, such as Hørning Church. Such cases are also known on Gotland Island, such as Lojsta Church, where the beams of a former stave church were walled into a mediaeval stone tower (Lagerlöf & Stolt 1977: pp. 27–28).

The most visible cases of reuse in Denmark are, however, the planks of a stave church reused as doorway lintels, as found in the churches of Flinterup, Skævinge, Snoldelev, Vrangstrup (Møller and Olsen 1961: p. 36), Nørager, Rosmus (Vellev 1983: p. 60) or boards reused as a continuous window frame in the choir in Framlev Church (Møller & Olsen 1961: p. 15). The positioning of the parts on doorways and windows shows a similar ritualistic intention to display marked bricks and graffiti in mediaeval churches (Rümelin 2003; Hollis 2024). In Sproge Church on Gotland Island, 43 former boards were reused as floorboards and five former bearing-structure pieces and two tie beams of the former roof structure we integrated into the walls during the church construction. Those reused parts and their former functions were determined by the typical notches of the joints (Ahrens 2001b: p. 263). The reuse of former timber roof structures was also documented in the medieval Swedish Långlöt Church nave walls, where the roof element of a predecessor church dated around 1080 was walled in. Additionally, reused wood was found in the existing roof structure of the church, and traces revealed its repeated reuse (Boström 1973: pp. 113, 217).

Recent studies of reused timber found in the nave roof structure of the Swedish Ör Church enabled the reconstruction of the possible appearance of the early mediaeval predecessor church (Forssgren & Lorentsson 2022: pp. 41–46). Other examples of the reused structural roof members in Sweden are those of the tie beams of the Våmb Church or of the ridge purlins of Östergötland's Herrestad Church and Östergötland's Flistad Church, in which not only was the material, but also the former rafter spacing, notches, and dimensions were reused (Gullbrandsson 2023: pp. 83, 110). Further, in the former Danish mediaeval diocese of Scania, which has belonged since 1658 to the Swedish diocese of Lund, the reuse of roof structures was identified, such as in Norra Mellby Church (Melin & Ranta 2020: p. 115). Tie beams from the 1060s were reused in the chancel roof structure, and 12th- and 14th-century roof elements were reused in the nave roof structure. Additionally, parts of older log churches were identified in Swedish post-medieval churches, such as in Hakarp Church from 1694 (Gullbrandsson *et al.* 2015: pp. 25–28).

The reuse of the older structural roof timber in newer church roof structures during the Middle Ages has also been frequently documented in Mecklenburg-Western Pomerania in Northeastern Germany. In these cases, the visual appearance of the timber elements in the roof structures showed additional notches without any connections in atypical places. According to Schöfbeck (2014, pp. 185, 232–233, 296–297), efforts to increase the span of stone church naves during the 13th century resulted in structurally unresolved

FIGURE 2 Roof elements with notches reused as braces on the rafter feet in Karjaa Church © MIINA TOLONEN (2020). (B) Gable of Sastamala Church made of reused logs © MARKO HUTTUNEN (2018). (C) Walled-in scaffolding with the traces of previous use in Espoo Church © PANU SAVOLAINEN (2020). (D) Remanufactured and reused roof structure in Sastamala Church attic © LAURI SAARINEN (2018)

roof systems, which remained underdeveloped and lacked sufficient load-bearing capacity. For example, this led to the reuse of the elements of the roof structures in the town church of Neubukow. Further, many cases of the reuse of the roof structures of the previous wooden church, such as those of the church of Laase and the village church of Steffenshagen, are known.

The reuse of the mediaeval Finnish stone churches has also been reported — precisely, the reuse of the structural roof elements of the wooden predecessor churches. Two extensive cases of reuse in the structural roof timber of the churches of Pohja and Pyhtää will be discussed in the next section. Another case was found in the Church of St. Catherine in Karjaa (Fig. 2), of which longitudinal timbers were atypically used to reinforce the rafter foot by connecting all sole pieces together, as well as all ashlar posts. These timbers show the traces of the previous use, such as notches with used drill holes. In the case of Karjaa Church, whether these reused woods were surplus material from the same construction process or they originated from an older wooden predecessor church could not be determined (Aakala 2020: p. 2).

In the Church of St. Mary in Sastamala (formerly Karkku), built during the period 1497 and 1505, the west gable was built of logs instead of typical masonry (Fig. 2). On closer inspection, one can see that some of the logs show fragments of paintings and even of a consecration cross. This reveals that the logs belonged to a previous wooden church (Palmroth 1963: pp. 46–47;

Pettersson 1986: p. 62). Dendrochronological dating showed that most logs were felled in the mid-15th century, but some were felled from the turn of the 14th and 15th centuries. One log dates back to the mid-14th century. This shows that part of the timber has been reused more than once. Some logs could have served in two generations of wooden churches or some other wooden buildings (Zetterberg 1998: pp. 137–139, 142–143; Hiekkanen 2007: p. 256). Another example of the timber reuse in the Church of St. Maria in Sastamala is the reuse of mediaeval roof truss members by rearranging them in 19th century roof structures that replaced the original roof (Fig. 2). Fragments of the roof were still preserved in the attic.

The cases of the painted reused timber in Finland are rare. Besides the Sastamala Church, St. Michael Church in Pernaja is another case, where a board that was probably part of the wooden ceiling dismantled in the 1450s (Savolainen *et al.* 2020: p. 27), now serves as roof decking. Unfortunately, when the board was brought into the attic cannot be said with certainty. Ritualistic placement could be ruled out based on the random location of the board.

The integration of timbers into the walls was also common during the construction of Finnish stone churches. Restoration works on the up-to-2-metres-thick fieldstone church walls of the Church of St. Catherine of Alexandria in Hammarland, St. John the Baptist Church in Sund, St. Olaf's Church in Tyrvää and St. Olaf's Church in Ulvila revealed that the layer of the inner wall filling not only contains gravel, sand, and lime mortar but also wood (Hiekkanen 2003b: pp. 35–36). It remains unclear whether the timbers are older and reused, but the possibility cannot be ruled out. In several churches, such as Espoo Cathedral and the Church of St. John in Hauho, reused timber was built into the gables, which probably served as scaffolding (Fig. 2). In the following two chapters, the two cases of timber reuse and waste management in the mediaeval Finnish churches of Pohja and Pyhtää are discussed in more detail.

3.1 *St. Mary's Church in Pohja*

According to four dendrochronological samples from the original roof structures, St. Mary's Church in Pohja is a graystone church built in the late 1470s (Zetterberg 2002: p. 7). The church features one of approximately 15 surviving examples of original Finnish Gothic trusses, characterised by rafter feet and the absence of a tie beam (Savolainen *et al.* 2023: p. 71). The structure consists of 24 roof trusses connected by longitudinal beams (Fig. 3).

The roof structures were erected from timber felled in 1476–7. The structure follows the principle of a Gothic roof truss, which was typically used in 15th and early-16th century Finnish stone churches. Recently, scholars analysed the structure as part of the research project 'Historic Timber Structures and

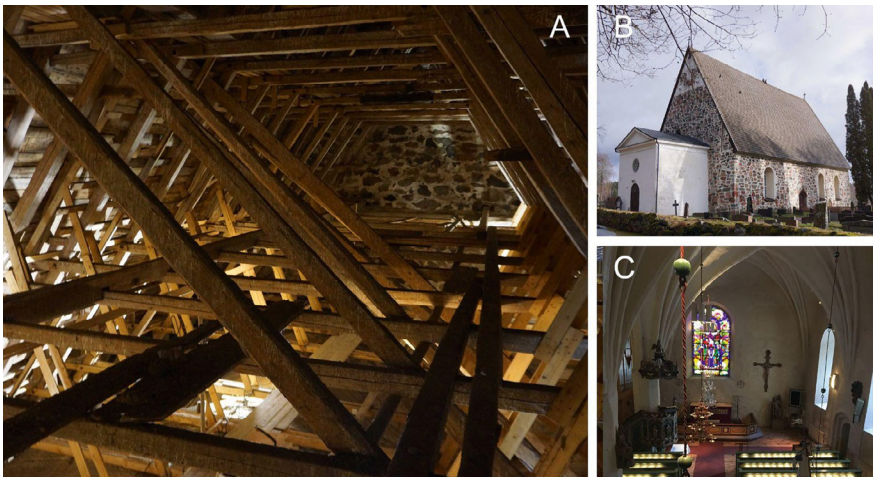

FIGURE 3 (A) Nave of Pohja Church © MIINA TOLONEN (2020). (B) An exterior view of the church © MIINA TOLONEN (2020). (C) An interior view of the church © MIA PURANEN (2020)

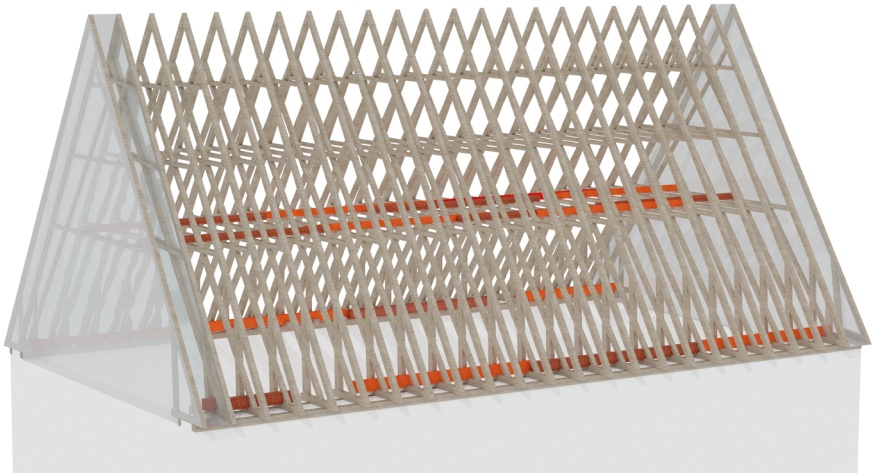

FIGURE 4 Nave of Pohja Church, a view from west gable to east gable. (Red) Reused elements. (Timber) Structural elements produced in the 1470s © FRANZISKA DALHEIMER (2024)

Architectural Innovations in Late Medieval Northern Europe'. In the fieldwork conducted in 2020 and 2022, 18 reused structural members were discovered in these structures. All reused parts were positioned longitudinally and used to tie the roof trusses together (Fig. 4).

A closer examination of the reused parts revealed a hewing technique that differed completely from that of the roof structure members of the 1470s,

FIGURE 5 The reused timber in the nave roof structure of Pohja Church. (A) The joint of a wall log of the 14th century wooden church. The piece was reused as an anchor beam on the collar beams of the 1470s' structure © PANU SAVOLAINEN (2020). (B) The joint of a wall log of the 14th century wooden church. The piece was reused as an anchor beam on the wall plates © PANU SAVOLAINEN (2020). (C) A tie beam from the 14th century wooden church, reused as an anchor beam © PANU SAVOLAINEN (2020)

which were finally revealed as wall logs and roof tie beams of a wooden church, presumably the predecessor of the stone church of the 1470s. Of the 18 parts, four were tie beams and the other 14 were wall logs. All tie beams and most of the log walls contained carvings and numbering; crosses were also carved in the tie beams, which indicates a possible location on the roof of the choir of a wooden church. The meticulously hewn surfaces on all sides of the logs also indicate that the surfaces were likely finished to remain visible and serve as part of the architectural expression of the wooden church. Many of the log walls contained joints or the remains of joints (Fig. 5), which indicates that the building had a gable wall of approximately 7.6 metres.

Unfortunately, only one of the reused parts featured an outer surface, which makes the dendrochronological dating of the pieces of the wooden church uncertain. Zetterberg (2002, pp. 10–12) has already dated the only reused part containing surface; however, it was not understood that the part came from a wooden predecessor of the 15th-century stone church. This piece was felled during the winter of 1369–1370. In 2023, ten reused parts were dated, with the last tree rings from 1222–1350 and with 62–259 rings. This enabled tentative estimations that the reused parts could be from a wooden church built at the latest in the middle or latter half of the 14th century, perhaps in 1370, as one piece with yearly precision may indicate (Wallenius 2020: p. 3; Aakala 2023: pp. 2–3).

First, the case of Pohja Church shows how reused parts may unveil the remains of the completely vanished layers of built heritage, such as the mediaeval wooden churches of Finland. Second, it raises questions about the

reasons for and intentions behind reuse. Was the reuse motivated only by practical needs, or did the builders intend to leave a trace or memory of the older church in the new one? Or else, was the reuse motivated by the need to move the sacral wood to a new sacral context?

The positioning of the reused parts in the roof structure of Pohja Church is systematic and repetitive. On each side of the structure, four members (all wall logs) were placed longitudinally on the sole pieces. On the lower collar beams, also on both sides of the structure, five members as anchor pieces were placed, six of them wall logs, and four tie beams of the previous wooden church (Fig. 4). The composition is symmetrical, and all the anchor pieces of the entire structure are the reused parts of the wooden church. The overall assemblage appears to be well planned. However, the placement of the parts into a dark attic, out of sight, suggests no intention to display the remnants of the earlier church or churches to users and visitors of the church.

From post-medieval sources, we know that after the Lutheran reformation, the logs and stones of dismantled churches were reused, for example, in domestic buildings such as farmhouses and barns (Hiekkanen 2007: pp. 149, 278, 489). At least during the Lutheran reformation, the timber of sacral origin was treated like a construction material with a secular origin. Most parts of the wooden church of Pohja probably ended up elsewhere for secular use, as only approximately 5 percent of the timber of the church was placed in the roof structures. The wooden church appeared to be in use, or was at least extant, until the walls of the stone church were ready. It was likely dismantled at the same time the roof was being constructed.

The reused mediaeval wooden church of Pohja, besides being an interesting case of the mediaeval reuse of sacral buildings, reveals how the vanished wooden heritage may be discovered in hidden contexts, such as church attics. Although the parts do not enable a complete reconstruction of the building, they provide valuable insight into features, such as the hewing techniques of mediaeval wooden churches of Finland.

3.2 *St. Henry's Church in Pyhtää*

The roof type of the mediaeval stone church of St. Henry's Church in Pyhtää is a typical Gothic roof truss without a tie beam, similar to Pohja Church. On top of the 27.8-metre-long and 16.5-metre-wide nave wall of the hall church (Hiekkanen 2007: p. 465), 22 nave roof trusses stand, of which are two embedded within the east and west gable walls (Fig. 6). The wooden material used was felled between 1461 and 1462 (Zetterberg 1991: pp. 2–3), which was in the Finnish Late Middle Ages and a period marked by intensified stone church construction. The overall picture of the building material is uncleaved, axe-hewn,

FIGURE 6 (A) Nave of Pyhtää Church © PAULIINA SAARINEN (2022). (B, C) The exterior and interior view © FRANZISKA DALHEIMER (2022)

and square-shaped timber. Few pieces had one or more waney edges, which, in some cases, still contained bark. These factors indicate that the material originated from forests with large trees.

The most interesting feature of the Pyhtää Church are the traces of an extensive change during the construction process of the roof structure. Fieldwork conducted in 2022 and 2023 revealed dozens of clearly reused and remanufactured structural members in different locations and over 100 other possible cases of reuse. In this case, the reused material comes not from a wooden predecessor church but from the same construction phase of the stone church.

The remanufactured and reused pieces indicated that the alteration of the plans was related to changes in the roof pitch and height during the implementation of the construction project. All trusses for a lower roof had already been produced when, for reasons unknown, a decision was made to increase the height of the roof by approximately one metre. (Fig. 7). Because Pyhtää Church follows the same series of building plans as the churches built decades earlier in Sipoo, Pernaja, Porvoo, Vehkalahti, and Helsinki Parish, it seems plausible that such alterations were intended to individualise the church by giving it a comparably taller structure (Hiekkanen 1994: p. 218; Savolainen *et al.* 2020: p. 21). Although Pyhtää Church's floor plan is not larger than those of the other churches, there appears to have been a clear intention to construct walls as high as those of the roughly 10-years-older Helsinki Parish Church, which featured an even higher and steeper roof. The exact motives, especially whether this was done to gain higher prestige than other churches or to receive more

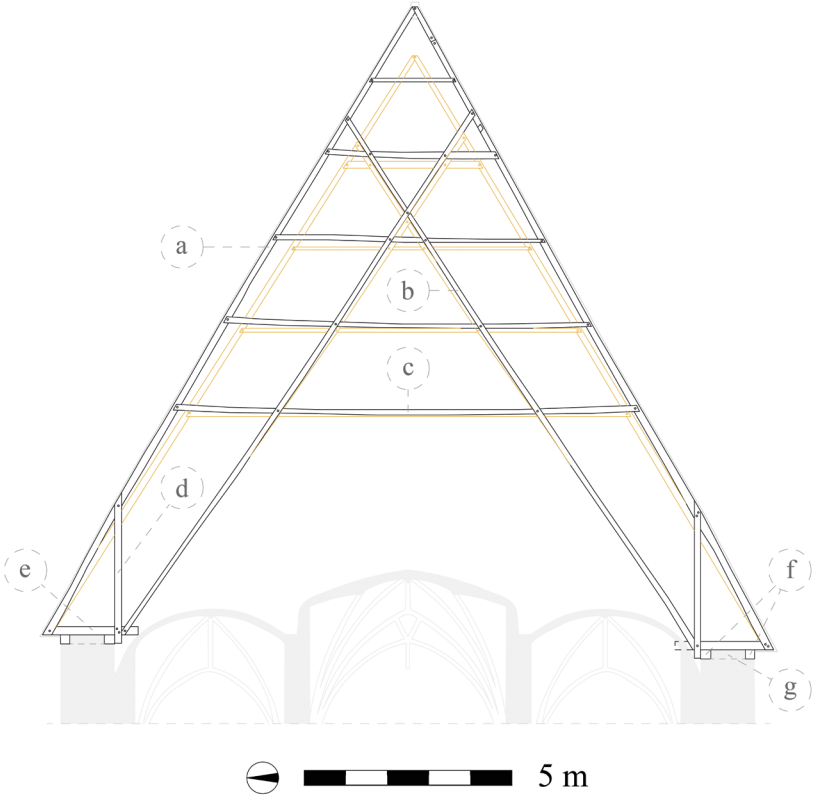

FIGURE 7 Nave roof truss scheme of Pyhtää Church. (Yellow) The possible original design with approximately 57° roof pitch. (Black) The built structure with approximately 60° roof pitch. (a) Rafter, (b) scissor beam, (c) collar beam, (d) ashlar post, (e) sole piece, (f) wall plates, (g) tie

divine blessings and protection against disasters, remain uncertain. However, neither the size of the floor plan nor the total height of Pyhtää Church come close to the large size of Porvoo Church.

It can be clearly identified that thirty structural timber members in Pyhtää Church's nave were reused and were not original compared to the rest of the structure, with an assumption of up to 156 additional not clearly identifiable reused structural elements. At first sight, the traces of the reuse were visible in 21 ashlar posts, two sole pieces, one collar beam, and in total eight wind braces on both the north and south sides of the nave. In 12 of the 44 rafters, a roughly 1-metre-long extension towards the top was found. They never appear in the same truss but are distributed in an offset manner.

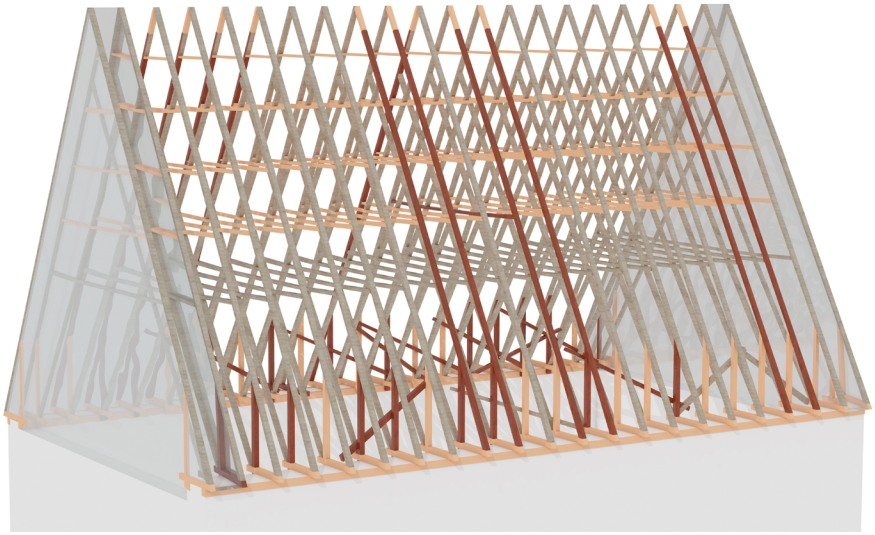

FIGURE 8 Nave of Pyhtää Church, a view from west gable to east gable. (Red) Reused elements with notches. (Orange) Reused structural elements that are assumed. (Timber) Structural elements newly produced in the 1460s

The reused timber can be identified through the randomly-placed notches without any relation to the current roof structure. Figure 8 shows that their location and sequence follow no obvious pattern, as the reused elements in 45% of all ashlar posts, 8% of all sole pieces, 66% of all wind braces, and 1% of all collar beams are equally divided between the north and south sides and between the east and west sides. However, there seemed to be more reused elements towards the west gable on the north side and towards the east gable on the south side. The absence of any chronology in the reused elements indicates that the decision on reuse did not happen midway through the construction, but was pre-planned before the assembly and construction. Thus, the reason for the reuse was not because of a supernumerary of the prefabricated roof elements.

However, the reused timber shows no difference in profile dimensions or hewing techniques or the signs of weathering compared to the general appearance of the timber in the attic. Only one timber reused as a wind brace on the north side was not rectangular but still had two waney edges without bark. Additionally, all the reused timber lacked the traces of nail holes, where the roof decking, shingles, or ladder rungs would have been fixed. This rules out the likelihood that they have ever been used as structural elements, such as

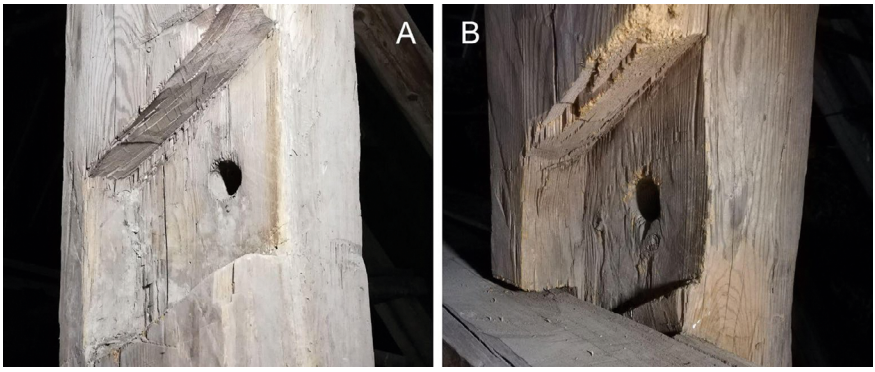

FIGURE 9 Ashlar posts manufactured from reused timber on the south side of the nave of Pyhtää Church. (A) The notch has an unused drill hole © FRANZISKA DALHEIMER (2023). (B) The notch has a used drill hole © FRANZISKA DALHEIMER (2023)

rafters or scissors. The reused timber also did not differ among the wood species. One of the reused elements found as a wind brace was microscopically identified as Norway spruce (*Picea abies*) (Zetterberg 1991: pp. 2–3), and two ashlar posts as Scots pine (*Pinus sylvestris*), which corresponds with the overall image of approximately 86% pine and 14% spruce in Pyhtää's nave structure based on 34 identified samples (Dalheimer & Aakala, 2024: p. 48).

Another uncharacteristic detail is the difference in the drilling holes in the notches of the reused elements (Fig. 9). The drilling holes indicate that the elements were assembled while the holes were drilled. However, the majority of drill holes appear to be unused; in some cases, they are not completely drilled through and show no traces of joining with wooden dowels. This indicates that the trusses were never completely assembled and placed.

The angles and joint types found in the reused timber indicated that they were originally manufactured as rafters. Typical joint types for rafters of discontinuous lap joints (Fig. 10A1 and A2) for scissor and collar beam joints, and simple lap joints for rafter foot connections (Fig. 10B1 and B2) can be found. The 1-m rafter extensions caused a change in the roof pitch from 57° to 60° (Fig. 7). However, this apparently had little influence on the joint angles because comparable angles were found in the notches of the reused timbers and rafters of the implemented construction. They vary from 55° to 60° at the rafter and collar beam joints, and from 62° to 68° at the rafters and scissor beam joints.

It appears that 12 of these rafters were reused as a whole with an additional extension, and 32 rafters were produced according to the new height. However,

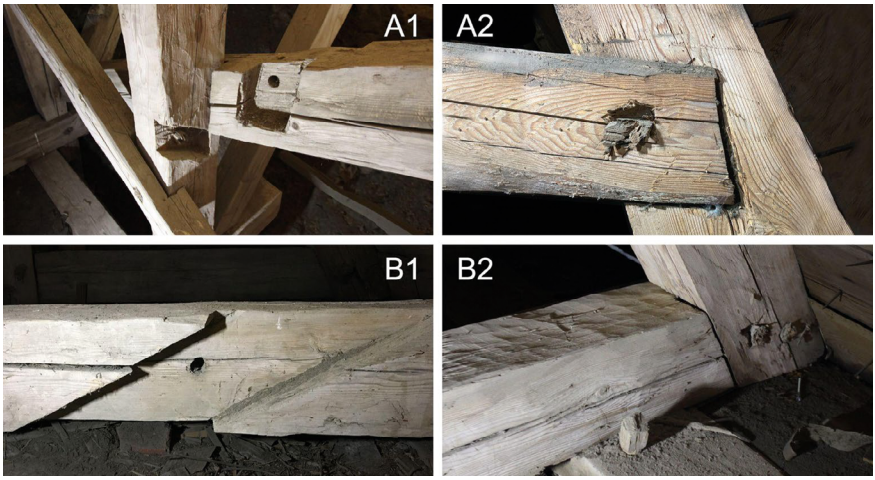

FIGURE 10 Notches and joints in the nave roof structure of Pyhtää Church. (A1) An discontinuous lap joint in an ashlar post and a wind brace © PANU SAVOLAINEN (2022). (A2) A discontinuous lap joint connecting a rafter and a collar beam © MARKO HUTTUNEN (2022). (B1) Simple lap joint notch in a sole piece © MIA PURANEN (2022). (B2) Simple lap joint connecting sole piece and rafter © PANU SAVOLAINEN (2022)

because the reused rafters already had notches for scissor beams, collar beams, and ashlar posts, their connections were reused and not replaced with additional notches. It is likely that the collar beams were pre-produced with the rafter connection either in the same manufacturing process or during construction, which aligns with the overall image of the used and unused drill holes on the reused timbers (Fig. 9).

Conversely, the collar beams were likely pre-produced without the notches of the scissor beams. Therefore, all of them could have been reused by shortening, whereas all the lower-collar beams were produced again. All the scissor beams and ashlar posts were too short for the new design. It is not clear whether the scissor beams were produced again or were produced longer from the start to adjust their position into the trusses later on, which varied from several centimetres to several decimetres from one another. The latter seems more plausible because of the lack of other signs of scissor-beam reuse. However, the 32 replaced rafters in the old design were remanufactured and reused as other structural elements. The lower quality material was reused as wind braces and the better quality and higher in diameter, presumably as rafter extensions, and as all new ashlar posts, even though only 21 of them had visible signs of reuse, such as notches.

FIGURE 11 Dowel profiles in Pyhtää Church with a different wood grain pattern
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Dowels belong to the original structure and can provide information on the management of the smaller waste parts of timber, leading to possible recycling. Figure 11 shows the profile of dowels in the nave roof structure of Pyhtää Church, microscopically identified as both pine and spruce (Dalheimer & Aakala, 2024: p. 48). The grain pattern indicated that both tree branches and scrap wood from sapwood were used for the dowels. Approximately 750 dowels with a length of around 30 cm and a diameter that corresponds to a bore size of 3.8 cm were needed for the whole nave roof structure of Pyhtää Church. They were likely composed of waste from manufacturing processes.

After around 560 years, the mediaeval approach of 'waste management' regarding the wooden leftover parts or scrap wood from the production and construction phases cannot be completely understood. Rather than leaving wooden waste to decompose, reclaiming the material as firewood is more likely because of its recovery potential in domestic ovens and sauna stoves. However, the larger leftover timber was probably recycled into lower products such as shingles, roof decking, or dowels. Whether the current roof decking of Pyhtää Church originates from the Late Middle Ages is not certain. The 44 original ashlar posts, which are too short for new design, provide larger and already square-shaped materials to be recycled as pine roof decking, pine, or spruce shingles. It remains unknown whether these ashlar posts were sold as building materials for other construction projects.

The meticulous analysis of the reused and remanufactured parts of Pyhtää Church reveals in detail a previously unknown, but complex, and labour intense phase of the construction of the roof structure. The intentions for the change remain unclear, but the alteration may be related to the competition between parishes to build higher churches, since the alteration cannot be explained by any structural matter.

4 Conclusions: Understanding Mediaeval Reuse

This study aims to understand the reclaimed timber in mediaeval stone churches based on their intentions and historical context. The mediaeval Finnish stone churches St. Mary's Church in Pohja and St. Henry's Church in Pyhtää served as case studies. Their analysis, in combination with a broader picture of mediaeval reuse along the Baltic Sea and a mediaeval pastoral manual on timber reuse has enabled a reconstruction of historical circular wood use practices. The local timber reuse shows regional differences in terms of intention and implementation.

Pohja Church is an example of the structural timber reuse of a previous wooden church. Four tie beams of a roof structure and fourteen wall logs from a 14th-century wooden church were placed on the roof structures of a stone church built in the 1470s. The displacement of the parts is symmetrical and logical, as the pieces serve structurally important functions, but the assemblage does not indicate any intentions of *spolia* for religious displacement. However, the reuse could have followed the idea of relocating sacral timber to a new sacral building. As the 15th-century pastoral manual quoted in the first section of this article demonstrates, timber from a consecrated church was not supposed to be reused for profane purposes. While the church builders in mediaeval Finland probably had not read Nicolaus de Ausmo's reflections, the conviction that holiness resided in the consecrated matter was universal in late mediaeval Europe, whether among the clergy or the laity. Later, in the Lutheran era, timber taken from churches was sold at auctions, as shown by written testimonies in the 18th and 19th centuries.

Similarly, rather practical and economical intentions were also seen at Pyhtää Church from the 1460s. After all the structural roof timber was already pre-produced, the design of the roof structure was changed to individualise the church roof, and it was decided to reuse most of the parts, likely because of convenience regarding workload and time expenditure. The reason for this reuse may not be the scarcity of wooden materials. Even if many structural elements could be reused or remanufactured at other positions in the roof scheme, the change in design might have extended the work schedule, possibly for months or even years, depending on the availability of green or at least semi-air-dried materials for 32 new rafters and 20 lowest collar beams.

The two Finnish cases examined in this article do not witness the spiritual and religious intentions behind the reuse — the display of decoration as *spolia*, or the intentional symbolic positioning of the reused timber. They indicate a technical and economical approach and cannot be considered as *spolia*. They

commonly have no ornamentation or paintings and are hidden from the public eye behind brick vaults.

In Finland, where written historical documents are scarce, the study of the reused timber opens a window into decisions taken and mistakes made during large-scale mediaeval construction projects. These reconstructions are important, especially in the Finnish context, where almost no documentary evidence exists regarding the construction of mediaeval churches. It also offers insight into the possible time and energy surplus, material availability, and cultural value of local mediaeval farming communities. Owing to the rather practical approach towards reuse in the Finnish Late Middle Ages, many older timbers of previous constructions or even wooden predecessor churches have been preserved to this day. The fact that they were given a new life and use hundreds of years ago enabled us to study the older construction types of roof trusses and crafting techniques which would otherwise have been lost.

The unveiled reuse, remanufacturing, and recycling of timber shows a behaviour which would nowadays be considered part of the 'circular economy', with opportunities to recycle instead of a recovery- and waste-centred context. However, modern ideologies of reuse, the circular economy, and even recycling differ considerably from mindsets and intentions that existed hundreds or even thousands of years ago. However, according to modern definitions, the late mediaeval constructions of Pohja and Pyhtää's roof structures are the epitome of sustainability and illustrate, unknowingly, a mentality focused on circular material economy. Alongside practical and economic aspects in the mediaeval reuse of timber from earlier churches, mediaeval builders along the Baltic Sea had different views on how to deal with building materials that, through a bishop's words of consecration, had changed into something more than mere wood and stone.

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