Acta Sci. Pol.
Architectura 25 (2026), 34–53
aspa.sggw.edu.pl ISSN 1644-0633 (suspended) eISSN 2544-1760 DOI: 10.22630/ASPA.2026.25.3

ORIGINAL PAPER

Received: 13.02.2026
Accepted: 28.03.2026

VERNACULAR ARCHITECTURE OF NORWAY IN THE CONTEXT OF CONTEMPORARY SUSTAINABLE BUILDING PARADIGMS

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ABSTRACT

Developed in response to Norway's harsh climate and landscape, vernacular architecture exemplifies building traditions grounded in local resources, craftsmanship, and intergenerational environmental knowledge. This raises questions about the relevance and adaptive potential of traditional construction techniques and materials in contemporary sustainable design. This paper analyses selected examples of Norwegian vernacular architecture, focusing on locally sourced timber, passive design strategies, durability, and design features that enable repair, disassembly, and material reuse. These features are discussed in relation to contemporary criteria concerning energy performance and low-carbon construction. The analysis indicates substantial alignment between several vernacular practices and current sustainability frameworks, although present-day application requires critical reinterpretation to meet contemporary codes, performance targets, and safety requirements.

Keywords: vernacular architecture, Norwegian architecture, timber construction, traditional carpentry techniques, *stav* and *laft* constructions, sustainable construction

INTRODUCTION

Contemporary architecture faces growing challenges related to the climate crisis, increasing demand for natural resources, and the need to reduce greenhouse gas emissions in the construction sector. Construction is one of the most energy- and material-intensive sectors of the economy, which is why it plays a key role in achieving the sustainable development goals and the transition to a low-carbon economy. This is reflected both in international policies and in rapidly developing scientific research focusing on the adaptation of architecture to climate change, energy efficiency, and the sustainability of design solutions (Liu et al., 2022; Chen et al., 2024).

In this context, the importance of seeking solutions based on local resources, reducing energy consumption, and rational management of materials is growing (Liu et al., 2022; Chen et al., 2024). Vernacular architecture, which has developed over centuries in close connection with the climatic, geographical, and cultural conditions of a given region, is becoming an important point of reference for contemporary concepts of sustainable construction. Traditional forms of construction, shaped without the involvement of formally trained architects, are the result of empirical construction knowledge, adaptation to local environmental constraints, and the effective use of available resources (Stoica, 1979; Oliver, 1997).

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Contemporary research indicates that many principles characteristic of vernacular architecture are consistent with current sustainable design principles. This applies, among other aspects, to passive building design strategies, the use of renewable materials, reducing environmental footprints, and harmoniously integrating buildings into the cultural and natural landscape (Matar et al., 2023). The potential of integrating vernacular principles with modern design frameworks is increasingly being emphasised, allowing for the creation of solutions that meet contemporary functional and environmental requirements (Ayoobi et al., 2024). Analyses based on life-cycle assessment (LCA) confirm that traditional construction techniques can demonstrate favourable environmental parameters compared to selected contemporary solutions, depending on the assumptions and boundaries of the system (Andersen et al., 2022; Hegeir et al., 2022).

A particular example of vernacular architecture with high adaptive potential is the architecture of Norway, where wood has been the primary building material for centuries. Harsh climatic conditions, limited availability of other raw materials, and strong craft traditions have led to the development of unique construction systems and architectural forms characterised by durability, functionality, and material efficiency (Brekke et al., 2019). These solutions, found in both residential and religious buildings, are part of Norway's cultural heritage and serve as a reference point for contemporary projects that use wood on a new scale and with the help of engineering technologies (Abed et al., 2022; Andersen et al., 2022).

Despite the growing number of studies on timber construction, LCA environmental assessments, and green building practices, it is still relatively rare to combine specific principles of Norwegian vernacular architecture with standardised criteria for sustainable construction and their contemporary reinterpretation in comparable case studies. There is also insufficient description of which elements of traditional material and construction logic are transferable to contemporary building typologies and what technical and environmental compromises accompany this process (Andersen et al., 2022; Hegeir et al., 2022; Liu et al., 2022; Chen et al., 2024).

The hypothesis of this study is that Norwegian vernacular architecture, in particular the *stav* and *laft* systems, contains a set of design principles relating to material rationality, durability, maintainability, and resistance to climatic influences. These principles can be identified by analysing material and construction solutions and maintenance strategies, and then evaluated using a uniform set of comparative criteria, which allows us to identify elements that can be transferred to contemporary timber construction. The transfer primarily concerns construction and material logic and operational solutions, rather than copying historical architectural forms.

The aim of this article is to identify the principles of Norwegian vernacular architecture that are consistent with the criteria of contemporary sustainable construction and to evaluate them based on a uniform set of comparative criteria. Specific objectives include: (i) summarising the key features of *stav* and *laft* techniques in terms of materials and construction, (ii) developing comparative criteria relating to materiality, durability, passive strategies and potential environmental impacts throughout the LCA, (iii) comparison of selected case studies representing traditional and contemporary architecture, and (iv) identification of transferable elements and main implementation barriers related to technical requirements, safety, and design practice.

The study was based on a qualitative comparative analysis combining a literature review with deliberately selected case studies. The analysis covered historical forms of Norwegian vernacular architecture and selected examples of contemporary timber construction, focusing on material and construction principles, the durability of solutions, and their potential environmental implications throughout the life cycle of a building.

The selection of Gol stavkirke and Mjøstårnet stems from the need to compare the same fundamental principles of wooden construction logic and approach to durability in two extremely different design regimes: medieval vernacular craftsmanship and contemporary engineering and standardisation, which allows for the identification of continuity and the limits of transfer.

Although Norwegian vernacular architecture and contemporary timber construction have each been widely discussed in separate strands of literature, fewer studies systematically compare them through a shared analytical framework focused on material rationality, durability, passive climatic adaptation, maintenance logic, and potential life-cycle implications. This study contributes to current research by proposing a comparative set of criteria that makes it possible to identify which principles of vernacular Norwegian timber building remain transferable to contemporary sustainable construction, regardless of differences in scale, typology, and regulatory context (Andersen et al., 2022; Hegeir et al., 2022; Liu et al., 2022; Ayoobi et al., 2024). The novelty of the study lies not in comparing formal resemblance between buildings, but in comparing the continuity of construction logic and environmental strategies across distinct architectural regimes. For this reason, the analysis focuses on transferable principles rather than typological equivalence.

MATERIAL AND METHODS

Study methodology and objective

This study applies a qualitative comparative case study approach supported by a targeted literature review. The purpose of the analysis is not to compare functionally equivalent building types, but to examine whether selected principles characteristic of Norwegian vernacular timber architecture remain relevant within contemporary sustainable building paradigms.

Case study selection

Gol stavkirke and Mjøstårnet were selected as intentionally contrasting case studies. They represent two extreme yet analytically useful conditions of timber construction in Norway: medieval vernacular craftsmanship and contemporary engineered high-rise timber construction. The comparison does not aim to establish typological comparability between a religious building and a mixed-use high-rise. Instead, it uses contrast to identify the continuity, transformation, and limits of transfer of selected design principles related to timber use, structural logic, durability, maintenance, and environmental performance.

Comparative criteria and analysis procedure

The comparative criteria adopted in this study were derived from literature on vernacular sustainability, climate-responsive architecture, timber building performance, LCA, and the long-term durability and maintenance of wooden structures (Gjærder, n.d.; Andersen et al., 2022; Gürani, 2022; Hegeir et al., 2022; Ayoobi et al., 2024). These criteria were selected because they recur across both historical and contemporary discussions of sustainability in architecture and enable comparison beyond stylistic, formal, or functional differences (Liu et al., 2022; Matar et al., 2023; Ayoobi et al., 2024). The analysis focused on material sourcing and processing, structural logic, durability and moisture protection, maintenance and repairability, passive climatic response, embodied carbon and life-cycle implications, adaptability and reuse potential, as well as the relationship between buildings and locality, including the use of regional resource chains and local construction knowledge.

The analytical procedure was carried out in three consecutive stages: (i) identification of key material, structural, and environmental features of Norwegian vernacular architecture based on literature and historical evidence, with particular attention to the *stav* and *laft* systems; (ii) development of a shared comparative framework based on sustainability-related criteria applicable to both historical and contemporary case studies despite differences in function, scale, and technological context; and (iii) comparative assessment of the selected case studies, Gol stavkirke and Mjøstårnet, in order to identify transferable principles and to determine the main technical, environmental, and regulatory constraints affecting their application in contemporary timber construction.

LITERATURE REVIEW ON VERNACULAR ARCHITECTURE

The Latin adjective *vernaculus* refers to something native and local, directly related to a given area or country (Encyklopedia PWN, n.d.). Vernacular architecture is deeply rooted in tradition and has been shaped over centuries by local builders, who usually had no formal architectural training. For this reason, it is sometimes referred to as 'architecture without architects' (Kurzątkowski, 1985).

It was created anonymously, without a formal design, based on technical knowledge and aesthetic principles passed down from generation to generation (Oliver, 1997). Vernacular buildings were constructed primarily from locally available materials, regardless of their degree of processing, which means that this architecture is characterised by great diversity and cannot be easily categorised (Oliver, 1997). Its form and design solutions are strongly linked to local factors such as physiographic conditions, climate, and economic situation, which is why it takes on a different character in each country, and often even in each region (Stoica, 1979).

The perception of traditional architecture has changed over the years, but today it is an important source of inspiration for design because it combines material economy, clear spatial organisation, and simple forms created from basic materials with respect for the landscape and surroundings (Oliver, 2003). Vernacular architecture does not focus on decoration or following changing trends, but on the durability of solutions and understanding the properties of the material, its possibilities, and limitations (Oliver, 1997).

Nowadays, it is interpreted as an alternative to globalisation and standardisation in construction, as it promotes the use of local resources and the reduction of energy-intensive processes. Its aim is not to directly imitate historical forms, but to identify principles that are useful for contemporary environmental and economic needs (Encyklopedia PWN, n.d.; Oliver, 1997). The literature also emphasises the importance of passive strategies such as orientation, building geometry, solutions that promote natural lighting and ventilation, which contribute to reducing energy demand (Gürani, 2022). At the same time, vernacular architecture is not a static phenomenon, but is subject to transformation and reinterpretation, leading to the emergence of new variants that combine tradition with modern technologies and functional requirements, while preserving local identity.

OVERVIEW OF NORWEGIAN ARCHITECTURE THROUGH THE AGES

The beginnings of settlement and construction

The oldest known forms of buildings in what is now Norway were longhouses, which served as both dwellings and farm buildings. Together with smaller structures, they formed settlements, most often farms surrounded by fences (Ramqvist, 1983; Ødegaard et al., 2023; Sand-Eriksen, 2025). Early examples included both single-nave structures, where the roof rested directly on the walls, and double-nave structures, which in the Bronze Age evolved into three-nave buildings with two rows of columns supporting the roof load (Eriksen, 2019; Fransson, 2019; Christensen & Poulsen, 2025). These structures were built on a rectangular plan and were approximately 20–90 m long and 7–12 m wide (Fig. 1). In the late Iron Age, a gradual shortening of the structures was observed, which was associated with changes in the organisation of living and functional space (Ramqvist, 1983; Komber, 2002; Fransson, 2019; Sand-Eriksen, 2025).

The structural posts were arranged in pairs, forming load-bearing frames supporting the roof based on various purlin systems. The number of frames ranged from 2 to 19, with the most common arrangements comprising around 6 (Barnycz-Gupieniec, 1984; Fransson, 2019; Christensen & Poulsen, 2025). The placement of the supports was based on empirical construction knowledge, which resulted in irregular spacing between the columns and, at the same time, determined the functional division of the interior (Fransson, 2019; Johannsen, 2024).

The limited number of preserved walls from this period is linked to the use of perishable materials, such as raw wood and turf, which, combined with harsh climatic conditions, decomposed rapidly (Ramqvist, 1983; Fransson, 2019). However, archaeological analyses indicate that the walls could have been approximately 1 m thick and of comparable height (Fransson, 2019). During the Viking Age, structures with slightly curved walls appeared, whose curvature decreased towards the axis of the building, giving the structure a shape comparable to an inverted boat hull. This solution reduced material consumption and increased the stability of the walls, which, with a column inclination of approximately 80°, could reach up to 6 m (Komber, 2002; Eriksen, 2019).

Fig. 1. Reconstruction of a Viking-era longhouse. Lofotr Viking Museum

Source: photo by Zuzanna Hrab 2022.

The Middle Ages: *stav* and *laft* techniques

In the 11th and 12th centuries, significant changes took place in Norwegian wooden construction. Residential buildings began to move away from post systems in favour of the log construction technique. This involved laying horizontal logs with a diameter of approximately 0.20–0.30 m, joined at the corners with precise carpentry joints. This ensured the stability of the structure and effective load transfer. Until the turn of the 13th and 14th centuries, round logs were mainly used; later, more often hewn (Fig. 2). The buildings usually had a span of 5–7 m and were founded directly on the ground (Barnycz-Gupieniec, 1984; Trocka-Leszczyńska, 2001; Lehtonen et al., 2022).

Fig. 2. Carpentry joints in wall corners – round beams (left), hewn beams (right)

Source: photos by Zuzanna Hrab 2022, 2025.

The interiors of log houses were usually divided into a main room (*stove*), a vestibule (*forstove*), and a sleeping area (*kove*). In the 12th century, there are records of wooden floors on joists replacing the earthen floor (Fig. 3). The central element was the hearth (*are*), and smoke was vented through a roof opening (*ljore*). The roof was insulated with birch bark and thermally insulated with turf laid on peat; shingles, slate, and birch tiles were also used as roofing materials (Trocka-Leszczyńska, 2001; Crowley, 2023).

Fig. 3. Floor from the 12th century. Bryggens Museum collection

Source: photo by Zuzanna Hrab 2025.

At the same time, the stave technique was developing. The staves (*staver*) were not dug into the ground but were supported by foundation beams (*syllstokker*) placed on stones (Fig. 4). In the oldest churches, the staves were placed centrally, creating a nave layout, and later became an integral part of the external walls. The structural framework was filled with vertical boards (*tiler*). Stave churches are sometimes interpreted as the wooden equivalent of Gothic cathedrals, which is related to their verticality and complex structural logic (Brekke et al., 2019).

Fig. 4. Detail of the building's foundation (left); interior of a stave church (right)

Source: photos by Zuzanna Hrab 2022.

Both *stav* and *laft* constructions testify to advanced carpentry skills and knowledge of the properties of wood. Sculptural ornamentation played an important role in churches, including plant, zoomorphic, and figural motifs, as well as depictions of dragons (Fig. 5). Pine was the primary material, which was gradually replaced by spruce from the 16th century onwards; selected elements were made of hardwood, including elm, birch, and ash (Barnycz-Gupieniec, 1984; Brekke et al., 2019).

Fig. 5. Dragon motifs. Detail from stave church in Bergen Fantoft stavkirke

Source: photo by Zuzanna Hrab 2025.

The modern era and the 19th century

In the 16th century, with the development of Protestantism, changes took place in sacred architecture. Renaissance architecture placed greater emphasis on the geometrisation of the structure and the orderliness of the spatial composition, which favoured the spread of log construction and cogging techniques. In the 17th and 18th centuries, facades remained generally modest and made of unpainted wood, while greater changes concerned interiors and the gradual increase in the importance of detail. Around the 18th century, facade formwork, richer colours, carved portals, and more frequent use of windows became widespread with the popularisation of glass production (Fig. 6). Roofs were often covered with tiles imported from the Netherlands and Denmark, and in the 18th century, gable roofs inspired by Danish and German traditions gained popularity (Trocka-Leszczyńska, 2001). The end of the 18th century also brought octagonal churches that could be built using the *laft* technique and an increased interest in ornamentation, including acanthus motifs and rose painting (Fig. 7). There was also a noticeable trend towards marbling, i.e., painting surfaces to imitate marble (Espedal, 2017).

The 19th century brought significant legal changes resulting from numerous fires that led to the destruction of urban complexes. Regulations were introduced limiting the use of wood in larger buildings, allowing it mainly in small residential houses, and requiring larger structures to be built of stone. In practice, intermediate solutions became widespread, e.g., multi-storey houses, where the ground floor was made of stone or brick as an above-ground basement, and the residential floor was constructed of wood (Fig. 8). This type remains characteristic of the Norwegian architectural landscape to this day (Majka, 1972; Espedal, 2017; Champion, 2019).

Fig. 6. 18th-century buildings (left), detail of carved window frame (right)

Source: photos by Zuzanna Hrab 2025.

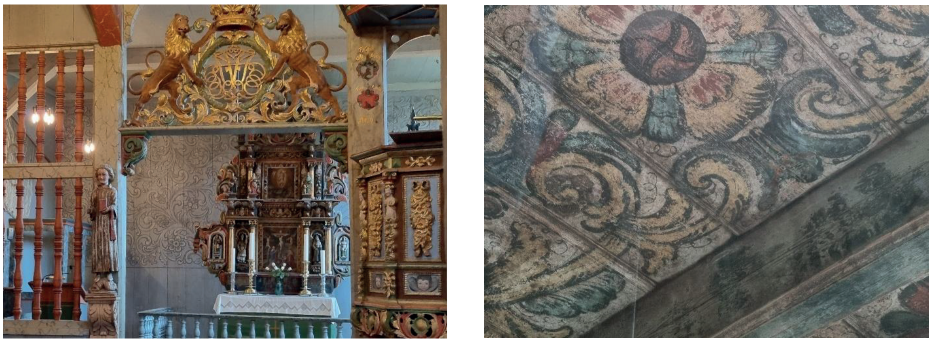

Fig. 7. Plant motifs: acanthus carving (left), rose painting (right)

Source: photos by Zuzanna Hrab 2022.

Fig. 8. An example of the interpretation of 19th-century law

Source: photo by Zuzanna Hrab 2025.

The 20th century

The 20th century was a turning point for Norwegian architecture, marked by the regaining of independence and the search for national identity. Initially, inspiration was drawn from native building traditions, especially medieval wooden architecture and rural buildings, emphasising the connection between architecture and the landscape, nature, and cultural heritage (Miller, 2016; Piórkowska, 2021). Functionalism and modernism then played an important role, quickly gaining acceptance thanks to technological developments, especially reinforced concrete (Fig. 9). Over time, modernism was criticised for its universality and unsuitability for harsh climatic conditions, prompting architects to take greater account of context and local materials such as wood and stone (Espedal, 2017; Piórkowska, 2021). Since the 1970s, Norwegian architecture has become more diverse, combining elements of modernism and postmodernism. The 1994 Winter Olympics in Lillehammer highlighted the role of wood as a symbol of identity and modern design possibilities, reinforcing a shift towards architecture rooted in tradition yet open to innovation (Espedal, 2017; Champion, 2019).

Fig. 9. Oslo Rådhus (1931–1950) as an example of functionalism/modernism (left), Kommunenes Hus (1957) as an example of modernism (right)

Source: photos by Zuzanna Hrab 2022.

Wood as the primary building material in Norway

Norwegian architecture has been significantly shaped by climatic and geographical conditions. Long periods of snow cover, low temperatures, and strong winds have forced the development of construction solutions characterised by high durability and resistance to environmental loads. Many wooden structures, including those built as early as the 12th century, have survived to the present day, and their common feature was the dominant construction material, i.e., wood, which was well suited to local conditions (Trocka-Leszczyńska, 2001; Brekke et al., 2019). Unlike many regions of Europe, wood remained the primary building material in Norway for centuries. This dominance of wood was due to its availability, relatively low cost, and ease of processing. These conditions were particularly important in the period preceding the discovery of oil deposits, when the economy was based mainly on local building resources (Trocka-Leszczyńska, 2001; Brekke et al., 2019).

The main structural species used in Norwegian vernacular architecture were primarily Norway spruce and Scots pine, while hardwoods such as birch, ash, and elm were used for selected elements where greater hardness or resistance was required (Barnycz-Gupieniec, 1984; Brekke et al., 2019; Gedde et al., 2025). However, the structural performance and longevity of timber depended strongly on protection against prolonged moisture exposure, fungal decay, and other forms of biological degradation. An important aspect of traditional timber construction was its natural ability to regulate indoor conditions. Thanks to the use of earthen materials as mortars, infills and plasters, buildings functioned like 'breathing organisms' – the structures retained heat while maintaining an appropriate level of humidity, and the water vapour permeability of the partitions was ensured by natural impregnates such as linseed oil or wood tar. These solutions were adapted to local climatic conditions and were the result of centuries of adaptation to the environment (Haupts & Steinkjer, 2023). In addition to material solutions, protection against adverse weather conditions was provided by structural solutions, such as raising wooden elements above ground level, using stone foundations, or protective roof eaves (Gjærder, n.d.; Trocka-Leszczyńska, 2001).

The preserved relics indicate a high level of carpentry skills, manifested, among other things, in structural connections that do not require nails or other metal fasteners. These skills were reflected both in the structural logic and in the ornamentation, which served aesthetic and symbolic functions (Komber, 2002; Eriksen, 2019). Another advantage of wood was its thermal insulation properties: compared to stone structures, wooden walls could be thinner while maintaining comparable thermal insulation, which was important in Norway's harsh climate (Barnycz-Gupieniec, 1984; Trocka-Leszczyńska, 2001).

Although wood is often perceived as a material susceptible to degradation, the number of preserved buildings proves its high durability when the right material is selected, the details are well designed, and proper maintenance is carried out. Norway, alongside Japan, is one of the countries with a large number of preserved wooden buildings dating back to before the 16th century, which represents both cultural value and a conservation challenge (Gjærder, n.d.; Majka, 1972).

Nowadays, wood is gaining additional significance in the context of reducing carbon footprints and searching for low-emission solutions. Research conducted in Norway indicates that replacing high-emission materials with wood products can contribute to reducing emissions in the construction sector. These trends are part of a tradition of rational use of local resources and linking architecture with the landscape (Champion, 2019; Lata, 2019; Abed et al., 2022; Andersen et al., 2022; Hegeir et al., 2022; Simonsen et al., 2023).

RESULTS

Continuity of the tradition of wooden construction

Norwegian architecture is characterised by a commitment to local materials and traditional construction methods, which have been adapted to changing social, technological, and environmental conditions. Although building technologies and structural knowledge have advanced significantly over time, the influence of earlier eras on contemporary architecture remains clearly visible. It is difficult to attribute it to a single style, as its identity is built primarily through the consistent use of wood and an understanding of its structural and aesthetic properties. Today's design solutions, though modern, still draw on the tradition that shaped the foundations of Norwegian architecture. Thanks to this historical experience, wood, a material that was once cheap, widely available, and thoroughly understood, has retained its unique position in Norwegian architecture and remains one of the most valued building materials to this day (Espedal, 2017).

To capture the continuity of traditional material use and construction principles while simultaneously evolving in scale, regulations, and technology in Norwegian construction, a traditional building (Gol stavkirke) was compared with an example of contemporary wooden architecture (Mjøstårnet).

Gol stavkirke

Gol stavkirke is one of the most representative examples of medieval wooden religious architecture in Norway (Fig. 10). Built at the end of the 12th century, it belongs to the so-called Valdres type, distinguished by free-standing structural masts and a relatively open interior. Compared to the more enclosed spaces found in Borgund or the monumental articulation of space in Urnes stavkirke, the interior of Gol stavkirke feels lighter and more transparent, emphasising the different relationship between the structure and the sacred space (Aune et al., 1983; Szilágyi & Sand-Eriksen, 2021).

Fig. 10. Gol Stavkirke: side-rear view (left) and front view (right)

Source: photos by Zuzanna Hrab 2022.

The structure is based on a mast-and-frame system characteristic of Norwegian stave churches. The main load-bearing posts are located at the intersection points of the lower foundations, while the four upper corner columns, referred to as 'hanging', rest on crossed wall caps. Only the corner masts are allowed to reach the floor level, while the others are shortened below the triforium zone. This solution necessitated the use of additional stiffening elements, such as St. Andrew's crosses and arched knees, often semicircular in shape, which served both a structural and decorative function (Aune et al., 1983; Fig. 11).

The craftsmanship of the carpentry is evident in the precisely crafted joints between elements and in the exposure of the framework as an integral part of the interior aesthetics. The literature emphasises analogies to the Viking shipbuilding tradition, suggesting that the framing systems and roofing solutions used have their origins in boat-building technology rather than in imitation of the stone vaults typical of Romanesque architecture in continental Europe (Tompsen, 2020).

The portals and exterior decoration are important elements. The preserved western portal and southern portal, reconstructed during the 19th-century restoration, are decorated with motifs of intertwined plants and fantastic creatures, including dragons. The ornaments, like the dragon heads on the roof slopes, refer to pre-Christian Nordic symbolism and served an apotropaic function. With Christianisation, these motifs were balanced with symbols of the new faith, as can be seen in the crosses placed on the tops of roofs and porches (Carli & Paniccia, 2011; Tompsen, 2020; Fig. 12).

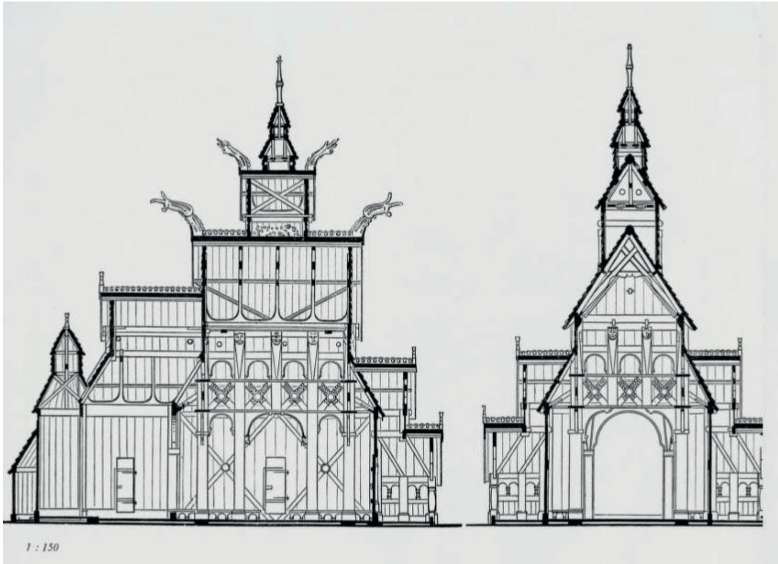

Fig. 11. Drawings of the Gol Stavkirke: side view (left) and front view (right)

Source: Bugge and Norberg-Schulz (1969).

Fig. 12. The combination of pre-Christian Nordic symbolism with symbols of the new faith-crosses

Source: photo by Zuzanna Hrab 2022.

The current appearance of the church is largely the result of reconstruction carried out after its relocation to Bygdøy in 1884. Prytz and Hansteen, based on the preserved fragments and analogies with other stave churches, sought to recreate the original form as faithfully as possible. Despite the interference, Gol stavkirke remains a clear example of Norwegian stave architecture and an important carrier of material heritage (Bakken, 2016; Szilágyi & Sand-Eriksen, 2021).

Mjøstårnet

Mjøstårnet is a recognisable example of contemporary Norwegian architecture combining the tradition of wooden construction with the idea of sustainable development. The 85-meter-high, 18-storey building was constructed in Brumunddal to demonstrate the possibility of erecting complex structures using local resources, construction expertise, and materials with a potentially lower environmental footprint (Abrahamsen, 2017; Liven & Abrahamsen, 2023).

An important element of the project is the use of engineered wood, including glulam and CLT, and a high degree of prefabrication. Approximately 4,000 m³ of wooden elements were used in the construction. These solutions help to reduce assembly time and material waste on the construction site, although their environmental assessment depends on production parameters, transport, biogenic carbon assumptions, and end-of-life scenarios (Andersen et al., 2022; Hegeir et al., 2022).

Tall wooden buildings require special control of performance parameters, including wind vibrations and acoustic comfort. Mjøstårnet uses a bracing system and hybrid solutions, including heavier 0.30 m thick concrete floors on the upper floors, which increase the mass and improve the dynamic behaviour of the structure (Fig. 13). The design refers to earlier Norwegian projects, such as Treet in Bergen, but differs in scale and prefabrication method (Abrahamsen, 2017; Erdoğan & Begeç, 2021; Liven & Abrahamsen, 2023; Arici, 2024).

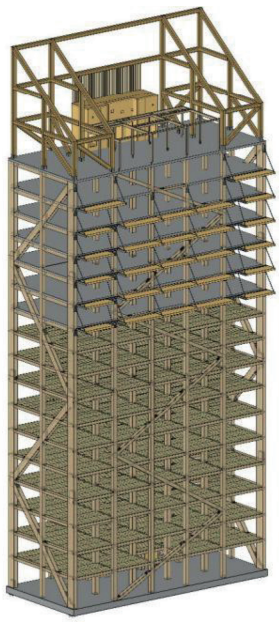

Fig. 13. Structural scheme of Mjøstårnet

Source: Liven and Abrahamsen (2023).

Summary of comparison of analysed objects

The comparison serves to identify transferable elements, not to assess the functional equivalence of the buildings. The results of the comparison (Table 1) present uniform evaluation criteria for both case studies and enable to organise conclusions regarding the possibility of transferring traditional solutions to modern ones.

Table 1. Comparison of traditional Norwegian architecture with contemporary architecture

Evaluation criteria	Traditional construction – the example of Gol Stavkirke	Contemporary construction – the example of Mjøstårnet
Material	Lightweight wood, sourced locally, handcrafted structural elements, no composite materials	Engineered wood: glulam, CLT, prefabricated wood elements, locally sourced
Durability	Centuries of durability thanks to the appropriate selection of wood, foundations laid on stone footings to prevent water seepage, details protecting against moisture, and regular maintenance	Designed durability based on standards, fire and moisture protection, and structural monitoring
Construction logic	Post-and-beam system, clear load-bearing structure, design based on carpentry experience and tradition, stabilisation of the structure using the weight of the roof	Hybrid load-bearing system, advanced engineering calculations, bracing with trusses and ceilings
Passive design strategies	Natural ventilation, thick wooden elements providing thermal insulation, protection from the weather through the shape of the roof and eaves	Use of material mass, aerodynamics of the structure, optimisation of dead weight, and energy-efficient building systems
Conservation/Maintenance	Regular manual maintenance, smoke curing and tarring, design allowing replacement of individual components only	Scheduled technical inspections, system maintenance, and use of modern material protection measures
Potential environmental impacts throughout the life cycle	Low carbon footprint, local materials, long service life, possibility of reusing wood	Low carbon footprint thanks to wood as a carbon storage, prefabrication, industrial production, higher energy consumption of processes, but high efficiency throughout the entire life cycle
Connection with the locality	Close ties to local tradition, materials, and craftsmanship	Utilisation of local resources and expertise, promotion of the regional timber industry

Source: own work.

DISCUSSION

Literature and design practice emphasise the potential of wood as a renewable material that promotes emission reduction compared to selected conventional solutions, although the results are sensitive to LCA assumptions, system boundaries, and maintenance and end-of-life scenarios (Andersen et al., 2022; Hegeir et al., 2022; Simonsen et al., 2023). In the Norwegian context, it is also important to embed the project in the regional value chain and identity of the place, which reinforces the dimension of locality as an element of sustainability understood more broadly than just the choice of material.

From the perspective of sustainable construction, it is crucial that Norwegian vernacular architecture developed as a direct response to climatic, raw-material and economic constraints, which in practice led to the minimisation of material consumption, the optimisation of structural solutions and the pursuit of longevity for buildings. In this sense, traditional building systems such as *stav* and *laft* may be interpreted as an early form of 'resource-based design', in which the availability of local materials, their efficient use and the ability of the structure to function in highly variable environmental conditions play a key role (Oliver, 1997; Brekke et al., 2019). This understanding of design logic is consistent with the principles of contemporary frameworks that integrate vernacular principles with sustainable design, emphasising the role of locality, adaptability and material rationality as fundamental criteria for architectural quality (Matar et al., 2023; Ayoobi et al., 2024).

Norwegian vernacular architecture may also be understood as a climate-responsive building model rather than only as a historical expression of local culture. Its contemporary relevance lies in the integration of material selection, structural form, roof geometry, moisture protection, and spatial organisation into a coherent response to severe climatic conditions. This interpretation is consistent with current research on vernacular sustainability and passive environmental design, which emphasises that the value of traditional architecture lies not in the direct repetition of historical forms, but in the identification and reinterpretation of adaptive strategies that reduce energy demand, improve environmental performance, and strengthen the relationship between buildings and place (Gürani, 2022; Matar et al., 2023; Ayoobi et al., 2024). According to a 2011 study, the building sector accounted for approximately 40% of final energy consumption in Norway. Consequently, plans were made starting in 2012 to implement regulations aimed at achieving nearly zero energy consumption. One example is the Norwegian white paper, which states that all new buildings constructed since 2015 should fall into the passive category (Woods & Korsnes, 2017).

An important conclusion drawn from the analysis of historical forms of Norwegian construction is the importance of structural 'simplicity with high efficiency'. In longhouses and later wooden structures, there is a consistent use of systems that enable clear load transfer, easy repair and replacement of elements, as well as adaptation of the structure to climatic conditions (Eriksen, 2019; Fransson, 2019). In the context of current discussions on embodied emissions and the environmental footprint of buildings, this approach highlights the importance of designing for durability, serviceability and potential functional adaptation (Andersen et al., 2022; Hegeir et al., 2022; Liu et al., 2022). The longevity of wooden structures in Norway, confirmed by the number of preserved buildings, proves that appropriate design solutions, protective details and a culture of maintenance can effectively compensate for the natural limitations of wood as a material susceptible to degradation (Gjærder, n.d.; Majka, 1972; Brekke et al., 2019). At the same time, research on the adaptation of cultural heritage in Nordic countries indicates that traditional construction solutions often demonstrate high resilience to climate change, provided they are properly managed and maintained (Granberg et al., 2022).

At the same time, it should be emphasised that wood and vernacular inspirations are not automatically synonymous with 'sustainability'. LCA results depend on system boundaries, assumptions about biogenic carbon, end-of-life scenarios (reuse, recycling, energy recovery) and local supply chain conditions (Andersen et al., 2022; Hegeir et al., 2022). In design practice, compromises related to fire safety, sensitivity to moisture and biological degradation, as well as the costs of maintaining details and protective coatings, which determine the durability and real environmental balance throughout the entire life cycle of a building, also remain crucial (Liu et al., 2022; Gaarder et al., 2024). For this reason, the transfer of vernacular principles requires not only formal reinterpretation but, above all, engineering refinement of details and exploitation strategies.

From an environmental assessment perspective, the apparent advantages of timber require careful interpretation within clearly defined LCA boundaries. The climate benefits of wood depend not only on the substitution of more emission-intensive materials but also on assumptions regarding biogenic carbon storage, service life, maintenance intensity, and end-of-life pathways. This is particularly important when comparing traditional low-processed timber systems with contemporary engineered timber construction. While vernacular buildings were generally based on local materials, low processing intensity, and long-term repair-based use, contemporary timber buildings often involve industrial manufacturing, adhesives, transport, hybrid structural elements, and additional technical layers required by current performance standards. As a result, the lower embodied carbon often associated with timber cannot be treated as universal but must be assessed in relation to the whole life cycle of the building and the durability of the adopted design solution (Abed et al., 2022; Andersen et al., 2022; Hegeir et al., 2022; Simonsen et al., 2023).

The history of Norwegian construction also shows that technological breakthroughs and social changes do not necessarily mean a break with tradition but can lead to its gradual transformation. An example of this is contemporary timber architecture, where advances in materials technology have enabled wood to be used on a new scale and in different types of buildings. At the beginning of the 21st century, as many as 74% of residential buildings in Norway were constructed of wood, and even in highly urbanised areas such as Oslo, more than half of the buildings were wooden (Gedde et al., 2025). This tradition continues to this day, and technological advancements and regulatory changes are fostering a resurgence in the importance of wood, enabling the construction of increasingly taller and more complex structures. Contemporary solutions also include advanced partition and facade systems, whose environmental assessment can incorporate scenarios of future climate conditions, expanding the classic LCA approach to include an adaptive dimension (Coelho et al., 2024).

It is worth noting that the choice of wood is not solely an aesthetic decision, but also has a significant environmental dimension, as replacing high-emission materials with wood products can lead to a reduction in greenhouse gas emissions in the construction sector, as confirmed by studies conducted in Norway (Simonsen et al., 2023). Norway aims to become a leader in this field. Since the 1990s, increasing the use of wood in construction has been a consistent policy goal, pursued through programmes that support technological development, industry growth, and collaboration among various stakeholders in the construction market (Sikkema et al., 2023; Skatvedt et al., 2025). At the same time, however, the literature on sustainable traditional environments indicates that an assessment of 'sustainability' should take into account not only the material but also the building's relationship with its settlement context, landscape, and the organisation of everyday life, which allows for a more complete interpretation of the significance of vernacular architecture as a design model (Liu et al., 2022; Matar et al., 2023; Chen et al., 2024).

Another important point of continuity between vernacular and contemporary timber construction concerns durability, maintenance, and the capacity for partial replacement of building elements. In Norwegian vernacular architecture, longevity was achieved not through technological complexity but through the combination of appropriate timber selection, protective detailing, structural clarity, and regular maintenance. In contemporary sustainable design, these same issues reappear in discussions on service life, resilience, adaptability, and life-cycle optimisation. What becomes transferable, therefore, is not the historical form itself, but a design logic based on repairability, moisture control, material awareness, and the expectation that buildings should remain functional and maintainable over long periods of use. In this sense, vernacular architecture offers a useful conceptual model for contemporary timber construction, especially where sustainability is understood as a balance between low embodied impacts, operational durability, and the long-term capacity of a building to remain in use under changing environmental conditions (Gjærder, n.d.; Brekke et al., 2019; Granberg et al., 2022; Liu et al., 2022; Ayoobi et al., 2024).

Considering the analyses presented, three key lessons can be drawn from the history of Norwegian vernacular architecture. Firstly, sustainable construction requires design based on local resources, which reduces the environmental costs of transport and promotes solutions adapted to climatic conditions (Stoica, 1979; Oliver, 1997). Secondly, an important element of sustainable construction is durability and the ability to maintain the building over a long period of time, which in practice means that structural details must be designed with material protection and easy maintenance in mind (Gjærder, n.d.; Brekke et al., 2019). Thirdly, traditional carpentry techniques demonstrate the importance of knowledge about materials, which can be reinterpreted in contemporary technologies without losing the basic principles of structural and aesthetic rationality (Trocka-Leszczyńska, 2001; Espedal, 2017).

At the same time, it should be emphasised that the transfer of vernacular solutions to contemporary design requires critical adaptation. Traditional architecture was created in different social, legal and functional conditions, which is why directly copying it is not a solution. The value lies rather in identifying universal design principles, such as locality, material efficiency, passive solutions and designing for longevity, which can be integrated with the requirements of contemporary technical and safety standards and user expectations (Ayoobi et al., 2024). In this sense, Norwegian vernacular architecture can be regarded as a source of design knowledge supporting the development of modern timber construction, combining tradition with technology to create low-carbon, adaptive and environmentally resilient solutions. At the same time, research indicates that the effective adaptation of such principles in contemporary projects requires overcoming regulatory and organisational barriers, which continue to pose a significant challenge in design practice (Nicu & Fatorić, 2023; Gaarder et al., 2024).

CONCLUSIONS

A comparative analysis of traditional Norwegian construction, using Gol stavkirke and the contemporary high-rise Mjøstårnet as examples, shows a noticeable continuity in the use of wood as the primary raw material, while techniques and design approaches have changed. Both structures were built using locally sourced materials, but they represent different eras, technologies and calculation methods – from the craftsmanship and empirical knowledge of medieval builders to the advanced engineering calculations and prefabrication technologies of the 21st century.

The analysis reveals that traditional buildings such as the Gol stavkirke achieved remarkable durability despite the absence of formally trained architects and engineers as we understand them today. This was due to deep material knowledge, highly skilled craftsmanship and maintenance practices that were passed down through the generations.

The results of the research indicate that the solutions used in vernacular architecture can be a significant inspiration for contemporary timber construction. Although much larger and more technologically complex, the modern Mjøstårnet still has much in common with traditional buildings. In this case, however, wood is the result of a conscious design decision based on environmental analysis and the desire to reduce the carbon footprint. Replacing high-emission materials such as concrete or steel with wood products can lead to a reduction in greenhouse gas emissions in the construction sector and support a renewable resource-based economy.

Furthermore, the analysis indicates that both Gol stavkirke and Mjøstårnet were built in close relation to the Norwegian landscape and climate. Historical buildings primarily served as shelters from harsh weather conditions, which is why their insulating properties and resistance to moisture, snow and wind were crucial. Contemporary projects, despite their different scale and function, also consider the local climate and landscape, and natural materials allow the buildings to blend harmoniously into their surroundings and age in harmony with the rhythms of nature.

However, it should be emphasised that the use of wood and inspiration from vernacular architecture alone do not automatically make a building 'sustainable'. Sustainability is determined by several factors that are considered at the planning stage: life cycle analysis of materials, energy efficiency, durability, reusability, and the method of sourcing raw materials.

In summary, Norwegian vernacular architecture can be a valuable source of inspiration for contemporary design practices. Its strength lies in its ability to adapt buildings to local climatic conditions, available resources and landscape, as well as in its structural logic that enables longevity and repairability. A comparison of Gol stavkirke and Mjøstårnet shows that, despite differences in technology and scale, the common denominator may be the responsible use of timber and the search for a balance between tradition and innovation in the face of contemporary environmental challenges.

Authors' contributions

Conceptualisation: Z.H. and M.D.V.; methodology: Z.H.; validation: M.D.V.; formal analysis: Z.H.; investigation: Z.H.; resources: Z.H.; data curation: Z.H.; writing – original draft preparation: Z.H.; writing – review and editing: M.D.V.; visualisation: Z.H.; supervision: M.D.V.

All authors have read and agreed to the published version of the manuscript.

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ARCHITEKTURA WERNAKULARNA NORWEGII A WSPÓŁCZESNE IDEE BUDOWNICTWA ZRÓWNOWAŻONEGO

STRESZCZENIE

Ukształtowana w ścisłej relacji z surowym klimatem i krajobrazem Norwegii architektura wernakularna stanowi przykład budownictwa opartego na lokalnych zasobach, rzemiośle oraz wielopokoleniowej wiedzy o środowisku przyrodniczym. Skłania to do refleksji nad aktualnością i potencjałem adaptacyjnym tradycyjnych rozwiązań konstrukcyjnych i materiałowych w świetle współczesnych standardów budownictwa zrównoważonego. Celami artykułu są analiza i porównanie wybranych przykładów tej architektury z zasadami projektowania zrównoważonego. Zestawiono takie cechy, jak: wykorzystanie lokalnego drewna, zastosowanie rozwiązań pasywnych oraz możliwość ponownego użycia elementów, z kryteriami efektywności energetycznej i niskoemisyjności. Wykazano, że wiele tradycyjnych praktyk pozostaje zbieżnych z dzisiejszymi strategiami projektowymi, choć wymagają one świadomej reinterpretacji w kontekście aktualnych norm technicznych.

Słowa kluczowe: architektura wernakularna, architektura norweska, budownictwo drewniane, tradycyjne techniki ciesielskie, *stav* i *laft*, budownictwo zrównoważone