FOLLOWING THE STANDARDS, FOLLOWING THE STRUCTURES – THE CASE OF LOUHISAARI CASTLE MID 17TH CENTURY ROOF STRUCTURES

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Figure 1: Timber roof structures of Louhisaari Castle. Photo: Panu Savolainen.

ABSTRACT

This article examines the assessment of Louhisaari Castle roof structures in southwestern Finland. We examine the practical implementation of an EU Standard [1] of the assessment of historical timber structures that was used in the research of the structures from 2017 to 2021, and also widely tested in university fieldwork courses organized in 2017 and 2021 [2].

Our article engages the assessment carried on and remarks on the fieldworks when the standard is used in practice. We conclude with critical remarks of the relevance of the standard in the fieldworks of the assessment of historical timber structures. Furthermore, we explore in brief the results of the assessment.

Our article examines the methods used in the study of the roof structure of Louhisaari Castle, the utilization of interdisciplinary university cooperation, and the experience we have gained in using the EU standard as a guideline for such research and cooperation. Finally, we briefly evaluate the project as a whole: what significance it has for the preservation and restoration of the roof structure and for the training of emerging professionals.

KEYWORDS: on-site assessment, timber roof structure, restoration, architectural conservation, training, 17th century, Finland

Figure 2: Louhisaari Castle (built 1654–1658).

INTRODUCTION AND BACKGROUND

Louhisaari Castle is one of the rare 17th century high nobility manors in Finland. The builder of the castle, Herman Fleming, was one of the most important political figures of the 17th century Sweden, who commissioned the building of the castle according to examples from Stockholm. Construction of the castle began in 1654 and the building was completed in 1658. [3] In the 17th century, Finland belonged to the Kingdom of Sweden.

The value of the building in Finland stems from its architectural exceptionality and historical importance, but also from its roof structure. The structure is exceptional of its constructional principles compared to trussed rafter roof that have been in use in large roof structures in Finland from the Middle Ages to the 20th century. Compared to the prevailing rafter structure the roof structure of Louhisaari Castle is remarkably rigid and the method and order of construction is rare in Finland. Besides Louhisaari Castle, only two other roof structures of the same principle are known to exist in Finland, both in churches in the surrounding area of Louhisaari.

Today, the roof structures of the castle, preserved in their original state over 360 years, form the one of the most valuable entirely preserved timber structures from the 17th century Sweden. The castle's original top of wall and wooden eave structure is probably the only or one of the only ones that have survived in its original state from the era in Sweden. The castle is a state-owned museum since 1961.

The roof structure has never been studied in detail before the work carried out by the current project running from 2017 by Livady Architects and university courses. The goal of the on-going study and courses is to find the optimal way to preserve the full authenticity and load-bearing function of the structure. [2] The only previous studies were dendrochronological datings from late 1990s, which were done to date the construction of the castle accurately.

A special course on architectural conservation *Traditional roof structures in Finland* was organized jointly by *Senate* Properties (The largest property and real estate owner of the state of Finland), the Finnish Heritage Agency and Aalto University (Helsinki) in 2017 and 2021. In 2017, the assignment of the course was restoration of the roof structure of the south-eastern annex of the castle and partially the roof of the main building. The course piloted the EU-standard [1], which was still in the draft stage at that time.

In the following years, the study of the castle's roof structure was mainly carried out by Livady Architects, until in 2021 a new course for structural engineering and architecture students was organized. This course engaged entirely the roof structure of the main building, and the task was a

comprehensive and extensive assessment of the structure in accordance with the final EU standard. The studies revealed relevant building archaeological information and new information about the structural resilience of the complex structure.

METHODOLOGY AND IMPLEMENTATION

Two international declarations and one EU standard were used to guide the research and restoration tasks of the course: *Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage* (ICOMOS 2003), *Principles for the Conservation of Wooden Built Heritage* (ICOMOS 2017) and *Historic Timber Structures - Guidelines for the On-Site Assessment* (EN 17121: 2019), which were tested to practice in both the research of Livady architects and the university courses.

The complex history of the structure requires studies and proposals in precise steps to gain understanding for individuation of the causes of damage and decay. The goal is to find correct choice of the restoring measures and to control the efficiency of the interventions. In order to cause minimal impact on the structure and preserve its heritage values it is necessary that the study repeats these steps in an iterative process. [4]

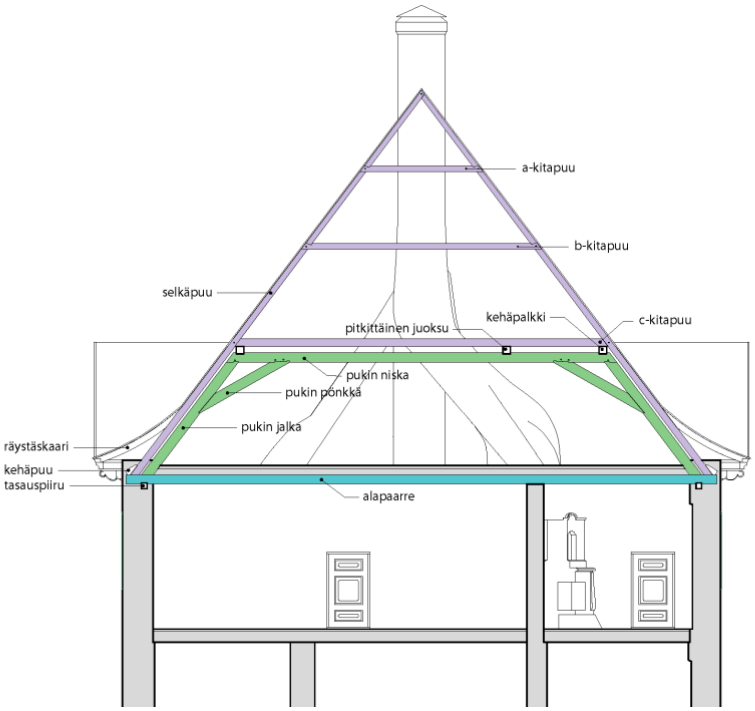

Figure 3: Cross-section of the roof structure. Livady Architects.

For research and monitoring of the roof structure, a coding system was created for the identification of structural member types. The system made it possible to identify each structural element and joint of the roof structure as well as the larger structure ensemble. In addition, Finnish names illustrating the structure or its function were developed for the gable roof structure and its structural member types.

The main purpose of the preliminary assessment is to determine whether the structure as such will be able to carry the loads and whether it will function properly in the future. The load-bearing capacity of structures is often difficult or impossible to calculate, so analyses are largely based on estimates. Understanding a structure and its loads requires an interdisciplinary approach and structural engineers must work in collaboration with architects, historians and conservation specialists. For this reason, the students of the course were chosen from different disciplines including mainly conservation architecture and structural engineering but also building archaeology.

In 2018–2019 the entire roof structure was modelled using the Rhinoceros 3D Cad program by Livady Architects. The model did not depict the current state of the roof structure, with its damage and deformation, but provided an ideal model for the roof structure as it was initially planned to be built. In addition to the original construction plan, historical information was added to the model as research progressed, for example on moisture damage affecting roof structures and observed changes during initial construction and later interventions.

In addition to the above-mentioned building information model, a photogrammetric model was used to document the current state of the roof structure, both outside and inside. The photogrammetric model is an excellent tool for observing the condition and structure of the roof and its overhead parts, as well as their changes. Besides these methods, also micro-drilling and surface radar were used to probe and monitor the actual state of the timber material and structures inside masonry structures.

In pedagogical terms, our central methodologies are Problem Based Learning (PBL) and Object Based Learning (OBL), which were used in the courses to implement the use of the standards in an authentic learning environment. In addition to the fieldworks the courses engaged historical roof structures and their restoration through literature, lectures, excursions, course publications and final exhibition at the site (2022).

At the beginning of the course, students prepared translation summaries of the EU Standard and the ICOMOS guidelines. Seminars and field research were organized during one week intensive period at Louhisaari Castle. Work on the assignments continued with seminars and culminated in an exhibition at Louhisaari in summer 2022.

The courses were attended by 20 graduate engineering and architecture students both in 2017 and 2021. The learning objectives of the course were that after the course, students will have basic skills in assessing and researching historic wooden structures, an understanding of the varying operating principles of traditional roof structures, restoration planning skills in accordance with internationally accepted principles and a preliminary ability to grasp a restoration project.

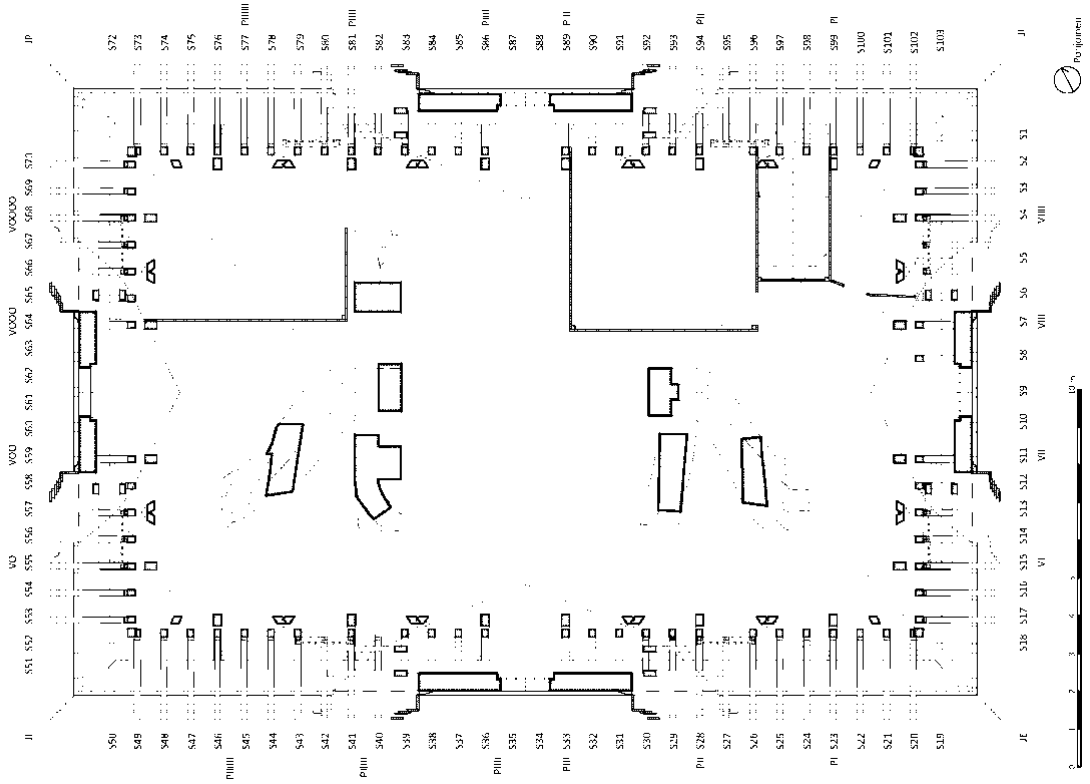

Figure 4: Floor plan of the attic, inscribed with the coding of the rafters and posts. Livady Architects.

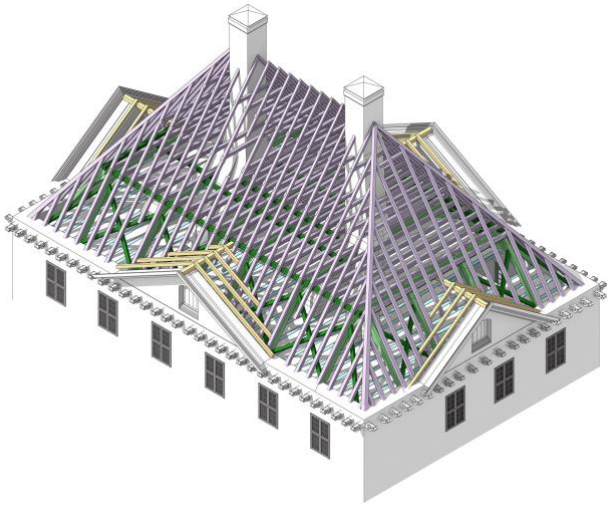

Figure 5: Axonometry of the roof structure. Livady Architects.
Figure 6: Wooden Corniche from the 1650s is preserved entirely. ´Photo: Finnish National Board of Antiquities.

RESULTS AND DISCUSSION

The results of the research are twofold. Firstly, our research unveiled how the EU standard can be implemented in practice by professionals, but also within groups of students performing their first conservational survey of a historical timber structure. Secondly, the research made both by Livady Architects and also the students revealed a lot of new information about the structure and its structural performance.

The practical results of the study, both by Livady Architects and the students, were the description of the history of the structure, the mapping and the mechanisms of damage, the modelling of the structural principles and the clarification of the causes of changes in the functioning of the structure. One of the results of the course was the comments sent to the Finnish representatives of the EU standards group about the functionality of the standard.

To understand the roof structure of Louhisaari castle, we compared it to other similar structures through field and archival studies. The most similar roof structure with Louhisaari Castle is the Skokloster castle in Uppsala County, Sweden, built between 1654 and 1668.

The only buildings in Finland known to have similar roof structures as Louhisaari castle are the Askainen church (1653) and the old church of Uusikaupunki (1629). In addition to the roof structures, what is also common to these three buildings is that designers and builders are known to have come from other parts of Europe. The building of Askainen Church was also financed by Herman Fleming, owner of Louhisaari Castle.

One of the historically most interesting observations was, achieved by combining the results of desk study and field work, that during the Great Northern War (1700–1721), the Russian forces looted, among other things, the iron tie beams of the eaves structure. This changed the principles of functioning of the structure.

The field study confirmed that the roof structure is original and has undergone little repair or modification. Furthermore, the field study found a feature of the structure that had previously gone unnoticed: the painted ceiling joists in the top floor are an integral part of the roof structure. Previously these parts, covered by exceptionally well-preserved paintings from the 1660s were conceived as an independent structure of the roof constructions. The conservation and preservation of the most valuable and well-preserved ceiling paintings in Nordic countries became therefore one of the key objectives also in the restoration of the roof structure.

In monitoring the student assignments, we identified several strong and useful aspects of the standard. These were firstly the processual nature of the standard, which enables learning step by step from basic tasks to more complex surveying and understanding the structural performance. The standard was also proved easily understandable and students were able to follow it with relatively short amount of time after reading it. The key weaknesses, however minor ones, we identified in the implementation of the standard by the students, were first of all the relatively structural and technical nature of the standard. It seems that more emphasis on the importance of desk survey and archival work, as well as familiarization with similar sites and structures, might be relevant prior to the fieldwork. We also observed, that the standard should give more detailed guidelines for the publication and accessibility (OA policies) of the results and reports. Furthermore, the standard relies very much on national legislations, which may cause problems with flexible international mobility of future professionals using it in different countries.

CONCLUSIONS

The research showed that the EN 17121:2019 works well in practice when applied to complex architectural conservation prtojects including also training and students. The different stages and the processual nature of the standard, proceeding from preliminary to more detailed observations and surveys, offer a precise but flexible framework in different situations in long-lasting projects. The standard also proved to be easily understandable and possible to adopt also by students doing their first heritage survey.

Furthermore, we conclude, that an in-depth understanding of the structure is crucial for limiting the invasive actions to minimum. The operation of traditional roof structures relies on the combined effect of different parts of the structure, the understanding of which requires a holistic approach. Instead of focusing on individual parts, the whole structure should be followed, and the standard also guides the research and surveys to this direction. Although weak and damaged structural parts and joints are found in the structure, their reduced capacity is compensated by intact and functional structural parts. The load distribution follows the stiffest path principle.

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