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TRANSFORMATION OF RECLAIMED MATERIALS FROM BARN BUILDINGS – DESIGN OF A NEW TIMBER BUILDING FRAME

Terje Planke[1], Kristine Nore[2], Victoria Rygh Nordhagen[3], André Bockelie[4], Dimitrios Kraniotis[5]

ABSTRACT: Norsk Folkemuseum, the Norwegian Museum of Cultural History, plans to build a centre for traditional wood crafts and building customs, *TradLab TRE*. TradLab will be built as a modern and traditional building with the reuse of the materials of old barns. A desire to use these materials for the load-bearing system and in the new buildings demands careful dismantling of the barn building. The Norwegian Museum of Cultural History requires the design and execution of special solutions by the design team and executors. The goal is to integrate as much old timber as possible in the new building and to add new timber where it is needed. The project also wants to reuse cladding and find more ways to use the material in the new buildings, such as in the floor surface or climate walls. By using the craftmanship skills to integrate the traditional knowledge into the design of the building, the overall goal is to investigate the actual efficiency of tradition.

KEYWORDS: Reuse of timber, Problems of legality, barn, digital mapping, demonstration project, standardisation.

1 INTRODUCTION

TradLab will increase interest in and strengthen the practice of traditional crafts inside and outside the museum. Through exploration and training, the museum will attract both established expert environments at (international) level and new, broad target groups in the museum's catchment area [1]. TradLab will be the preferred place to cultivate the sustainability of tradition.
In the sub-project TradLab TRE, the focus will be on continuing and disseminating knowledge about material quality and wood crafts related to handicrafts, building customs and building protection. The primary goal is to erect a new building at *Østlandstunet* in the centre of the openair museum, which is well adapted to conduct training in manual wood crafts and building customs. The reuse of (reclaimed materials of) barns is a mission of the SirkLåve project within the bigger SirkTRE-project [2]. In a resource-efficient circular economy perspective, the ideal practice of reuse is to keep the structure of building in the existing location. The next level, when the barn's use life is ended, is the reuse of the area, preferably with the materials from the old barn. This was the main execution of new barns during the raise of the "unit-barn" which led to almost 10 000 barns raised between 1820 and 1920 in Norway. In this period, the reclaimed wood from earlier logged barn buildings was used to build the new, larger structure, leading to more built area. However, the functionality of these barns has been reduced because of the introduction of threshers and tractors in general.

2 METHOD

Norsk Folkemuseum was able to receive materials from old barns which did not serve society anymore and would be demolished, see Fig. 1 and 2. The goal is to use as much as possible of the materials for the load-bearing system and climate wall in the new buildings. This demands a sufficiently careful, and efficient dismantling of the barn building. The museum also wants to reuse cladding and find more ways to use the material in the new buildings.

Figure 1. The first old barn from Sande.

2.1 EXISTING BUILDING – OLD BARNS

The project started with documenting an old wooden barn located in Vestfold, Norway, see Fig.1. This old construction has been housing multiple functions throughout the last hundred years and has gone through several structural changes in that time. The barn is supported by a wooden structure consisting roughly of

[1] Terje Planke, NTNU Norwegian University of Science and Technology, Norway & Norsk Folkemuseum, ORCID 0000-0001-9561-5419
[2] Kristine Nore, NTNU Norwegian University of Science and Technology, Norway Omtre AS, Norway, kristine.nore@omtre.no ORCID 0000-0003-0008-9853
[3] Victoria Rygh Nordhagen, Omtre AS, Norway, victoria@omtre.no
[4] André Bockelie, Resirqel AS, andre@resirqel.no
[5] Dimitris Kraniotis, Oslo Metropolitan University (OsloMet), Oslo, Norway, dimkra@oslomet.no

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155 × 155 mm timber (columns, beams, truss). There is a simple truss design supporting the roof. As for many traditional buildings, it is the total building system, with the dependency between different building parts that gives the full load capacity of the barn structure. The building represents a tradition of great strength with a minimum of wooden structure. In addition, only a small amount of iron parts was used, which supports easy reuse. The existing building has been documented through traditional means and by a full scan.

The chosen building for reuse was suddenly not available, due to external causes. The museum chose to look for other possible objects and was offered the spare parts from the large barn from the Nedre Sem farm in Asker that was to be taken down. This project is a "FutureBuilt" project where they are reusing much of the old construction [3], see Fig. 2.

Figure 2. The second old barn from Nedre Sem in Asker.

2.2 BUILDINGS IN TRADLAB

The new construction project consists mainly of two buildings, see Fig. 3. TradLab TRE is placed in a building environment consisting of many old wooden buildings. The two buildings are placed next to each other. The first building is given a traditional construction based on reuse of the 155 × 155 mm^2 beams, see Fig. 4.

Figure 3. Traditional structure to be built for a new purpose. Drawing by Olav Vidvei.

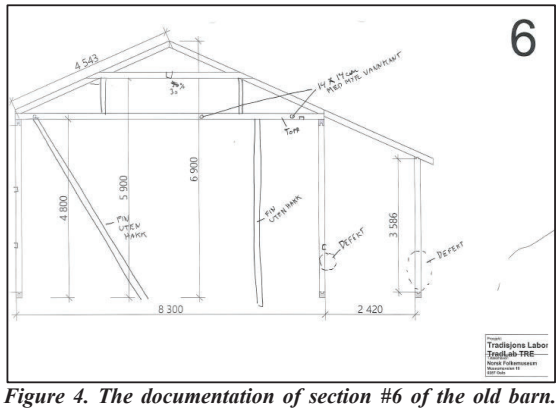

Figure 4. The documentation of section #6 of the old barn. Drawing by Magnus Wammen and Olav Vidvei, Norsk Folkemuseum.

Traditional building

This building will house a workshop for researching and teaching traditional wood techniques. It also includes public areas for exhibitions of woodworking technologies. The museum wants the building to express craftsmanship and display traditional ways of making wooden constructions. At the same time, it must fulfil modern demands required by a new building, as a workplace for traditional craftsmen.

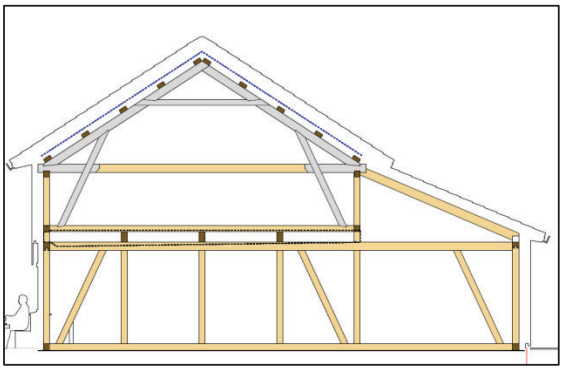

Figure 5. Traditional structure to be built for a new purpose. Drawing by Olav Vidvei, Norsk Folkemuseum.

The open building

The other building will be a two-storey building for outdoor work and outdoor exhibitions about "Norwegian Wood". This building also functions as a means for general availability to the main building by connecting the first floor to the terrain. This building construction is named "grindbygg", which could be translated with timber framing with "post and beam", see Fig. 5. This open structure is extremely material-efficient, made from local wood, with a minimal effort for manufacturing the logs into beams.

2.3 CONCEPTS CONSIDERED

Two main concepts have been considered in the startup of the project: *reuse in the same way* and *reuse in a new way.* The objective was regardless to find the best use of the

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existing barn, thereby ending up in between the two ideal types.

Reuse in the same way

This method of reuse is about taking down the existing building and use the reclaimed timber in nearly or the same way it stood before, see Fig. 6. This has been used extensively in Norway with wooden/timber buildings traditionally. The museum has moved and reused many buildings "as is". The museum has recorded that many of the log buildings and the "post and beam" buildings have been moved, also before the museum collected them. The challenge in doing it now lies in new demands and regulations. The fact that it will have a different use (a public building and a two-storey building) also entails challenges.

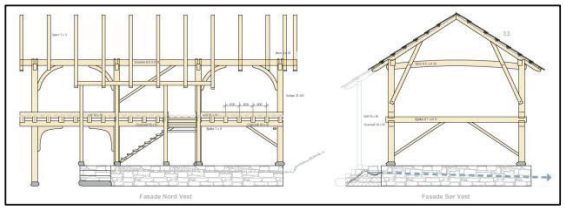

Figure 6. The grindbygg, as an open building without insulation nor wall-cladding.

Reuse in a new way

Reuse in a new way is at the other end of the scale of reuse. This method is about finding new ways of using the reclaimed old building parts in new buildings. This can be as simple as using a beam as a column. Finding new uses for what has been load bearing constructions in the climate wall, interior, non-load bearing constructions (internal walls e.g., or combine elements to form a load-bearing element. The need for design must follow Eurocode 5 [4].

Combination new and old

This envelops finding new ways to use old building elements and adding parts of new structures where necessary. Using old wood for a cordwood masonry wall or stack wall will ensure a near to 100% use of the old timber frame elements.

2.4 SCANNING AND MODELLING OF THE OLD BARN

One important step is the diagnosis, which means collecting data and information for careful dismantling and design choices [5]. The scanning of the barn in Vestfold was done with a Leica BLK360 imaging laser scanner, resulting in dome pictures. The point cloud (Fig. 7) was used as reference to create a BIM model. The point cloud of the barn contains of 480 820 205 points from 22 scans linked together. The scans have all been done on about the same level 1,3 meter above the ground. The overall error of the point cloud was 3mm and have an average overlap of 58%. The model is based on the point cloud where the framework is modelled with an accuracy of ±2,5mm. Information about position, damage, load impact and variation in dimension are included in the BIM model.

The barn was also measured manually, taking out the relevant dimensions of reusable elements.

Figure 7. Sitemap of the scans.

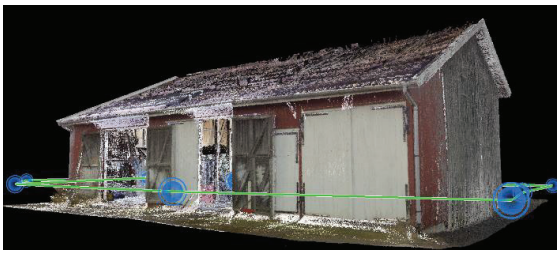

Figure 8. 3D representation of point cloud.

3 RESULTS

In this project we ended up using the principles and dimensions of the old barns and reshaping it for our new purposes. The design of the new building was thereby closely related to the dimensions and quality of the old, reusable parts. The old posts (155×155 mm) and beams are sorted out for reuse as posts and ground sills. The quality of each post must be assessed. This is done when dismantling the old barn, and further in the process of pre-cut all the parts before shaping the joints.

The craftspeople who will do the joinery and raise the building, are certified for controlling and sorting constructive timbers into classes like C20, C30 by visual means [6], and are now establishing a procedure to certify constructive timber for C40 for traditional constructions.

The main challenge in the design process is to make the building according to tradition, while supporting the building technical requirements in the Norwegian

building regulations TEK17 [7], since the project is moving besides or outside the pre-accepted solutions within the standard. The goal is to use as little constructive timber as possible to reduce the footprint.
The solution chosen in this project, for reusing as much as possible of the original timber is to use the old parts in the vertical standing and horizontal elements with little forces, for the parts with most tension. To maximize the reuse, all the shorter fragments of the posts is to be used as *kubb*, or bricks in between the posts. This way, all parts longer than the thickness of the construction, will be used as the inner part of the outer climate structure.

3.1 MAPPING OF DAMAGES

Figure 9 is also a screenshot from a dome picture showing damage, drying cracks, and cut-outs. The dome pictures make it easier to identify the quality of the timber. Figure 10 shows the same area but as a point cloud from about the same spot.

Figure 9. Screenshot from a dome picture of the barn showing damage.

Figure 10. Screenshot from the point cloud of the barn showing damage.

Fig. 11 and 12 display a screenshot of TruSlicer in Cyclone REGISTER 360 BLK edition of the point cloud from above showing point around columns, walls, and some items. In the TruSlicer mode it is possible to slide through the point cloud and find damage and measure them like in Figure 13.

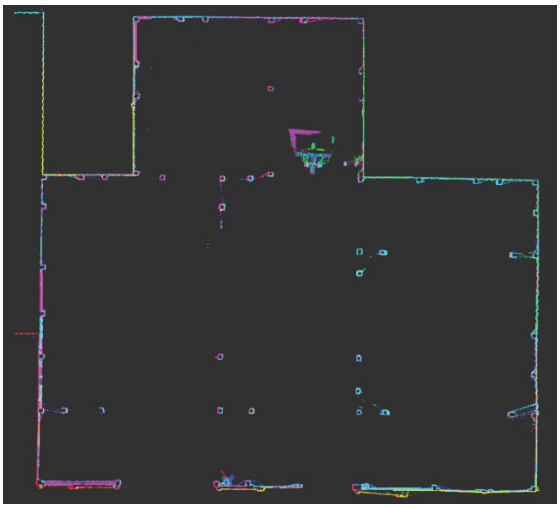

Figure 11. Screenshot of floor plan view of the barn.

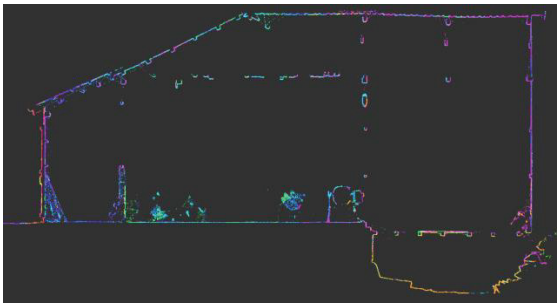

Figure 12. Screenshot of a section of the point cloud.

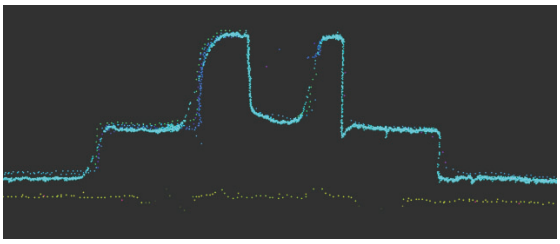

Figure 13. Damage shown in TruSlicer.

3.2 Natural materials - beneficial for ventilation

When it is not painted, the wood has a great hygroscopic quality to support a wanted indoor climate. The wooden bricks will be mortared with local clay. Wood and clay are hygroscopic. The beneficial effect is called hygrothermal mass, a moisture buffer effect which increase human comfort and reduce the need of energy for comfort reasons, and thus energy needs of the building. Hence, the properties of clay and wood fit well with passive

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ventilation. The effect of these choices will be studied after the building is raised. A minimum and natural source of ventilation will be chosen in the first period, when starting the use of the building.

4 DISCUSSION AND CONCLUDING REMARKS

Reduce – the need for a new building?
This project already had a good decision for the barn mapped in Sande. When the farmer saw the value of his old building, he decided not to replace it with a new building. From a circular economy perspective, not building and prolonging the service time of the construction can be the best option. However, an additional critical question must be raised [8]. Is the service time extension beneficial, healthy, and safe for the user and/or society?

Reuse of material - in the same way
How much of an existing construction is fit for reuse in the same way? Since it was not possible to copy the shape of the old building, it was impossible to reuse the parts just as they were. In Norway, existing standards for testing or assessing the load bearing capabilities are available. By visual assessment of the class or quality, the loadbearing parts are sorted out. This documentation enables further use.
Architectural challenges exist. The architecture is closely designed based on the dimensions of the old parts. The architect is basing the structure on dialogue with the craftspeople and the solutions are further discussed with the engineers to have sufficient capacity.
Which jointing techniques are preferred? Old notches in the reused materials are placed in the places with least stress and static problems. The joints are "bladed" with 1/3 and 2/3 felling and wooden pegs, to ensure easier disassembly and reuse in the future.

Reuse in a new way
The new use of the timber structure is different from the use in the old barns. During the design, three questions arose which are related to the diagnosis methods, and the domains of architecture and building physics:

1. How much of the existing construction is fit for reuse in a new way?
2. How can we adapt and match the architectural needs, structural demands, and material properties of reclaimed wood?
3. Do traditional timber structures (when using old building parts in walls, or using traditional techniques) used in new constructions provide satisfactory building physical properties?

For the TradLab TRE project, it turned out that the main delivery of structural reclaimed timber will come from Sem Gård in Asker. The TradLab will need more timber parts, preferably reclaimed wood of constructions that do not serve society anymore.

Combination new and old
By using the craftmanship skills to integrate the traditional knowledge into the design of the building, the overall goal was to investigate the actual efficiency of tradition. The prospected way of using old beams combined with new ones and in addition using the small parts for *kubb* led to a very high degree of reuse. The building system is also linked to a former technique. A desire for the future is that the TradLab TRE will inspire future generations to use old building techniques, customised for the future needs. Cooperation with traditional craftsmen in circular construction projects brings in inherited properties and intangible cultural heritage that can create multiple value for society. Mapping of the basis is the way to learn old structural techniques and to provide a material bank for planning the next use of this valuable resource. The potential use of reclaimed wood is emerging in the construction sector and should be explored more in future practice and research.

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