Status determination and risk assessment of measures in historic buildings

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Abstract – Today there is a need for energy-efficiency measures in historic buildings. Clarifying both opportunities and risks for energy-efficiency measures in historic buildings is a challenging task. To ensure that such measures will provide the planned result without damage to the building or poor indoor climate, a skilled holistic approach is required. To be able to propose accurate measures requires a thorough understanding of the individual cultural heritage, the existing building’s function and how the measures will affect the building. This requires a multidisciplinary knowledge, for example building antiquarian, building biological and building physical expertise. In this paper, a method for status determination of existing buildings, and a method for risk assessment of energy saving measures, are presented.

Keywords – historic buildings, energy efficiency, moisture safety, status determination.

1. INTRODUCTION

1.1 BACKGROUND

There is currently a major focus on how use and maintenance on one side, and climate and climate change on the other, influence service life of materials in historic buildings. [5,6]. Less known is the problem how other changes significantly can influence the building physics performance and any consequential damage due to this [7,13]. Most of Scandinavia’s historic buildings have during various times undergone changes in design and usage. Older structures have been renovated with new construction solutions and materials. Changed requirements for indoor climate and energy use has led to use of new heating and ventilation systems. The results of these changes have not always been satisfactory, and sometimes resulted in different building damages or non-acceptable indoor climate [8,16]. These mistakes have sometimes led to extensive costs in damage remediation. In addition, in many cases, important historic values are lost during the restoration work.

Building a new energy efficient house requires considerable expertise in a number of areas. To implement energy-saving measures in existing buildings often requires even more. Changes into thicker insulation, intermittent heating, new types of building materials and reduced or modified ventilation, affect the thermal and hygroscopic properties of the building. These changes increase the risk for moisture and mould damage [15,11]. Unfortunately, it is usually the case
that the sensitivity and the risk of for example moisture damage have increased because of these measures. A number of structures, which we know is critical to moisture, will become even more sensitive, and new parts of the building, which previously functioned well, will be in the risk zone. We have many examples of this in buildings with crawl space basements or cold attics that were remedied after the energy crisis in the 1970’s. When additional insulation is used in the building envelope of poorly insulated buildings, the temperature in the crawl space, attic and parts of the outer wall will be lower than before during the cold period. For example, if warm moist air can be transported from the heated space in the building up of the attic, it cools down and the relative humidity increases. Also, during cold clear winter nights, the inside of the outer roof will sometimes be so cold that the outside air, through ventilation from outside, may condense on the inside of the attic. The inside of the roof becomes damaged, as will the attic floor because of the condensation that forms on the inside of the outer roof, dripping down and causing moisture and mould damage [18]. Basement walls were up to 1994-95 thermally insulated on the inside, normally in combination with a windbreaker against the foundation wall and a damp barrier on the warm side of the insulation. Such construction is a high-risk construction with respect to moisture problems, and in old buildings, where there might be some intrusion of water through the wall, the risk of both mould fungi and decay fungi is extremely high [4]. If we look at the crawl space, it is another time of the year that becomes dangerous regarding moisture. In winter, the crawlspace cools down. When spring and summer arrive, warm and humid outdoor air gets into the crawlspace through ventilation openings. The crawl space is still cold and when hot humid outdoor air enters the crawl space, it cools down and the relative humidity of the air increases. When humid air comes into contact with sufficiently cold surfaces, condensation and free water occurs. This increases both the risk of moisture and mould damage [19] and decay problems [13]. Use of modern building materials, such as gypsum boards and fibreboards instead of traditional wooden materials, also increases the risk of mould damage due to poor mould resistance capacity in modern materials [18,17].

A number of measures to reduce the risk of moisture damage are found in modern constructions. These should however also be adapted to use in historic buildings. Often change in heating system is made, for example from a local system to district heating. A chimney that previously was hot and warmed up the cold attic gets cold. The negative pressure created through the "chimney effect", and contributed to the ventilation, is gone. The result can be a building, which is indeed energy efficient but has a very high risk of moisture and mould, poor ventilation and therefore a bad environment for both the building and humans. A critical side effect in access to moisture problems is also often elevated radon values in these poorly ventilated buildings, especially in basements and the ground floor. Change of windows and more efficient air-tightening reduce the natural ventilation in old buildings. In concrete buildings this can be critical and change from a ventilation rate about 0.5 to less than 0.15 air change/hour, which has been documented after replacement of windows [16].
A methodology to handle renovation and energy update of historic buildings is requested by many actors in the process of updating historic buildings without causing damage and undesirable effect. A method that takes into account various important aspects would reduce the risk of this kind of negative effects during renovation.

1.2 AIM
The goal is to develop a method and to produce different types of tools that are necessary to ensure proper status determination and risk assessment of energy update targets in historical buildings. The method should take into account the various aspects that are believed to affect the results of renovation/energy updates of historic buildings.

1.3 LIMITATIONS
Effects due to actions in connection with the accessibility and fire safety has not been fully taken into account so far. These parts will be developed within the framework of the project.

2. METHOD
Performing a risk assessment of existing and future problems and damage is complicated. No complete method, dealing with this, is used today. To make an accurate risk assessment requires knowledge of a number of factors.

The work to develop a methodology for status determination and risk assessment of energy conservation in historic buildings involves different experts working together. In our case it is limited to building physicists, building biologists and building conservators but also fire safety and accessibility will be considered within the project. Also other relevant disciplines can easily be supplemented if needed.

The goal has been to develop a method that can be used in the same way for the different disciplines, reflecting the different aspects but in the end create a result of consensus for the proposed actions. Different existing working methods and methodologies have been looked at and parts of them have been adopted and put together under a development in time. Through frequent meetings and discussions, with a goal to understand more of each other’s specific areas and way of thinking, the method has grown and been developed.

Different versions of the method have been tested in real case scenarios during the process and the experience of the practical use of the method has caused changes and corrections to make the method better and easier to understand and use. Examples, where the method has been used, have earlier been published and can be found in [1] and [2].

At present, the method is ready to be tested by other actors, consultants as well as national boards and agencies, to get their feedback and make the necessary adjustments in order to find a working method for future renovations and energy updates of historic buildings.
3. RESULT

3.1 SUMMARY OF THE DEVELOPED METHOD

The work has resulted in a method to address the building physical, biological, and antiquarian aspects, as well as fire safety and accessibility of a building at present and after certain measures.

Each of the disciplines has been treated in a similar way, which makes it possible to handle them all within the same system. The systematics in the method is inspired from the ByggaF-method [14], which is developed to assess the moisture safety in buildings throughout the whole building process.

The Building physics part deals with energy efficiency, moisture safety, ventilation and indoor climate, but also building technology. A number of checklists are developed to cover and assess the different building physical aspects. Example of a checklist is found in Appendix 1.

The Building biological part deals primarily with the presence of different kinds of mould and wood-decaying fungi and insects. However, absence of expected damage is also of special interest. Examples of checklists have been designed to facilitate the possibility to assess the degree of attack and how dangerous it is, but also the reason behind and the way to minimize the future effects [10].

It is important to distinguish between old, inactive and ongoing active attacks of various organisms. One must also be able to assess the occurring organisms and the current building physics that cause the suitable conditions for bio-deterioration. In addition, it is important to distinguish between species that can easily be developed further by even low humidity values, and those that die out if it is not very wet. This knowledge and understanding is in fact the foundation in order to be able to assess the consequences of various energy efficiency measures in the building in question.

The building conservator (conservation consultant) deals with building technology, traditional building materials and heritage values. The care of the historically valuable buildings is governed by certain general principles, special requirements and legislation, based on each building's individual cultural and technical characteristics. Some general guidelines are: preserving the character, using minimally invasive procedures, preventing damage, using traditional materials and traditional techniques. This does not necessarily exclude modern technology as long as it preserves both the character and the life of the house.

The method is divided in different modules:

1. The building (building envelope)
2. The interior (lose and solid)
3. Building services installations
4. Climate (outdoor, indoor)
5. Current laws and regulations (informative part)

The information is built up by the different experts from “bottom to top”. All details are dealt with and successively put together in bigger and bigger units and
modules that are either approved or not. In Figure 1 a schematic picture of the process is showed.

When the status determination is made, it is much easier to see what has to be done and what is the most urgent to take care of. Different measures, and how they may influence other parts in the system, have to be assessed. A kind of risk assessment has to be made, at this stage we use different mould models.

All together the result of the method gives an overview of the present status of the building and also the possibilities for different measures. It forms a more holistic base for decision makers to be able to decide what to do and at what risk.

Figure 1. The “bottom to top” process. All details are successively put together in bigger and bigger units. The objective is to give an, easy to understand, overview as a base for decision makers.

The method can also be used the other way around, “top to bottom”, see Figure 2. If a module is not approved, it is possible to step down in the hierarchy and in detail find the reason why a special part has failed to pass. The reason could be found in any of the main three different parts; building physical, building biological or building antiquarian aspects.

One challenge in the Building Antiquarian aspects is to find levels and adequate information and guidelines within the method in order to identify and preserve cultural and historical values. As a user of the method, one must also be aware of, and accept, that conservation aspects will not always lead to optimal improvements and vice versa. Another challenge was to make the whole method user-friendly.

For historic buildings and those of traditional construction, an appropriate balance needs to be achieved between building conservation and measures to
improve energy efficiency if lasting damage is to be avoided both to the building’s character and significance and its fabric. [9].

An understanding of what constitutes the special interest or significance of a historic building requires experience. Very often technical, philosophical and aesthetic conflicts will need to be resolved and on occasion highly creative solutions to problems will be necessary. In such circumstances there is no substitute for the knowledge, skill and judgment of qualified and experienced professional advisors, such as architects or surveyors experienced in historic buildings. Such experts have both the technical ability and wide working knowledge of historic buildings, essential to properly informed maintenance and adaptation. Their advice can thus prevent damage and unnecessary expense and heartache [10].

3.2 PRACTICAL WORK USING THE METHOD

The typical procedure for carrying out a status determination and risk assessment of actions in a historic building, is divided into the following working parts:

3.2.1 Preparations

This part clarifies which laws and regulations apply to the particular object. Drawing documents are provided as well as any documentation of previous actions. If possible, interviews are conducted with persons who know the history of the objects.

Figure 2. The overview of the status of the building is shown with coloured boxes. For more detailed information it is possible to get more and more information about the background to different problems or damage.
3.2.2 In situ inspection
In this part, different experts work parallel to each other and collect information important for their specific expertise. Photo documentation and checklists are used to ensure that all parts and aspects of the object is considered and checked. Necessary measurements are made and samples are taken. Larger measurements or samples are suggested. The checklists are made in a way that makes it possible to get necessary help, partly through concrete proposals, but also through examples from already completed status determinations.

3.2.3 Status determination
The different experts discuss and explain their results to each other. A joint document is created that describes the status of the object. This document is the most important and most comprehensive in the method, and will provide the basis for future assessment and decisions regarding any changes and renovations of the object.

3.2.4 Proposed actions
With a well-conducted status determination, it is easier to assess which actions must be done and which are possible to be implemented. Sometimes immediate action is required to prevent further damage; sometimes it is an assessment where one must take into consideration the future desirable use of the object.

It is common for different experts to have different views/opinions about what kind of actions need be taken in an object. Everyone monitors their respective special areas. In order to find out which measures are best suited, measures in which all areas are taken into account, require the different experts to explain how they have thought and prioritized. The aim of this is that in consensus find out what measures are possible to take within the framework of the different scenarios of the object.

3.2.5 Documentation
All steps presented above are documented in a transparent way to give experts, as well as decision makers, as much information as desired.

4. DISCUSSION
In order to propose measures in an existing building, it is important to know the status of the building at present. One must get a clear picture of how the existing building works building physically today (and maybe even how it was intended to work from the beginning), considering heat-, air- and moisture transfer in materials and structures, and what influence various changes might have.

The condition of the materials and structures must be determined with respect to moisture exposure, mould, wood decaying fungi and wood-destroying insects. This is important both for the potential need for repair or replacement, and also for evaluation of the risk for a possible further development of the occurring damage, such as in cases with dry rot.
Due to the fact that damage, caused by bio-deterioration in old buildings, are the result of an accumulated damage development through the buildings’ service life, it is important to clarify when and why the damage has occurred, and what the yearly development has been [11]. Such knowledge of damage does often give a detailed understanding in both what the general risk for bio-deterioration in the actual building is, and the consequences of a possible further development.

Lack of expected attack also provides important information that must be considered and analysed.

5. CONCLUSION

Energy efficiency measures in old buildings are a challenging task. By using a multi-disciplinary approach, it is possible to interpret how the building has functioned so far and what consequences various changes in use and construction may have. This provides an opportunity to optimize measures regarding energy efficiency while maintaining cultural heritage values and reduce risk of occurrence of fungal and insect damage, and a poor indoor-air climate.

5. REFERENCES


Appendix 1 – Example of a checklist

<table>
<thead>
<tr>
<th>3.1 Outer wall</th>
<th>Building antiquarian aspects</th>
<th>Building Physics Aspects</th>
<th>Building Biological Aspects</th>
<th>Result All Aspects</th>
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