Risk Analyses Reduce Maintenance

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ABSTRACT: In the Netherlands the principles of Sustainable Building are being applied to a considerable extent. This has led to a large number of sustainable houses with varying success. Although a sustainable house has got a good comfort and a low energy use, defects are detected, which could have been prevented. Recently, the Dutch media have frequently reported about these defects, such as the damaged wooden supporting structure of the balconies (EVA-Lanxmeer project, Culemborg) or rotten wood at window frames (Morrapark project, Drachten). These kinds of defects are not only found in sustainable houses but also in every other building method, but the chances of defects are smaller because well-known materials and systems are being used. Not only defects can be found at the window frames, but also at the installations and brickwork. These reports harm the image of Sustainable Building. After all, a house is only sustainable if it functions well in time. The principles of Sustainable Building are being applied with varying success. The cause of this varying success is that there is no direct relationship between the design and the degree of maintenance during the life span (risk of maintenance). One of the solutions for this problem is to form a relationship between the design and the risk of maintenance, in order to provide qualitative and quantitative insight into the maintenance consequences of design choices.

Conference Topic: 5 Materials, building techniques and sustainability
Keywords: Sustainable Building, RISK analyses, Design model, Risk Factors, Maintenance, Design.

1. INTRODUCTION

In 2002 and 2003 a dozen Sustainable projects have been visited [1,2]. Residents have been interviewed and a check has been made for available literature on these projects. During this research the main topics were maintenance and complaints made by the residents. The first results were:
- In general the residents are satisfied with their sustainable houses;
- There are doubts regarding the maintenance;
- Avoidable defects were found.

The fact that the residents are very pleased with their homes is a compliment to the initiator, architect and contractor [3]. For the success of Sustainable Building a positive perception is needed and the other two must be reduced to an absolute minimum. The lacks and complaints are in particular related to the façade, the indoor climate and the installations.

The following aspects and construction parts have been analysed:

Building Envelope:
- Façade
- Window frames
- Roof
- Integrated installations

Indoor climate:
- Noise nuisance
- Temperature

Installations:
- Noise
- Complex operation
- Disturbance
- Liability to maintenance
- Incompetent installation

1.1 Building Envelope

The façade is the face of the house and gives the first impression of the house. Occurring defects at the façade can easily be observed visually and varying from algal growth on the brickwork till leakages. The wooden frame is the building part where advanced maintenance is frequently necessary [4]. An incorrect combination of design, detail, wood and painting is generally cause for accelerated degradation. This degradation is often found with Sustainable Houses. An example is the façade of a sustainable project in Delfgauw. This façade has a backward slope. The window frame in the façade was meant to be used vertically, so advanced degradation and leakages proved unavoidable in this design. An incorrect type of wood in combination with the design and the painting type can accelerate this degradation process. To prevent any further degradation a choice has been made to seal all the seams/joints.
Another example is a project in Stavoren. In this project it also concerns the window frames where advanced maintenance is necessary. The window frames, projected in front of the façade, have recently been repaired and provided with an extra protection layer. What matters here is the same as in Delfgauw: an incorrect combination of design, detail, wood and painting. A permanent solution for this problem would be to cover the windowsill with renovation profiles.

A permanent good performance of the building envelope depends on the right choices in the design phase. To reduce maintenance it is essential to quantify the aspects of degradation in this phase.

1.2 Indoor climate
The indoor climate of a house corresponds closely to the installations and the design. Causes of complaints and defects are mostly due to installation choices or body or façade design. A number of clear complaints has come forward with respect to climate and noise in some houses.

In one of the visited projects a complaint was: "when my daughter turns on her television set upstairs, I can hear it loud and clear downstairs". This complaint can immediately be related to the building method (timber frame) and its insufficient insulation. Therefore every sound could be heard everywhere in the house.

Another often heard problem is overheating during the summer season, caused by the big windows in the south façade, sometimes in combination with a lack of ventilation. In a few cases the windows couldn’t open for ventilation and cooling. In other cases the design of the building didn’t allow the mounting of sunscreens.

Here too applies that making the correct design choices can prevent overheating and noise complaints.

1.3 Installations
Problems with the installations manifest themselves on three aspects: incompetent installation, maintenance sensitivity and complex operation. Generally spoken: "the more complex the installation is, the more chance of defects". This can have both direct and indirect effects on the comfort and energy use of the house.

Installations have a direct influence on the use of the house; sometimes this influence is so strong that the residents are forced to change their normal habits.

An example: "the use of Combined Heat and Power Generation (CHPG), made the use of gas superfluous. The cooking is done electrically. Because of mistakes during installation the CHPG is frequently out of order. For this reason the residents built a backup system themselves: they cook and heat with butane, which can lead to very dangerous situations.

Sometimes mistakes are being made with the supply of drinking- and gray water: recent
examples can be found in IJburg and Leidsche Rijn. Wrong connections between the drinking water circuit and the gray water circuit caused a very dangerous situation to the public health. Therefore the application of gray water systems is currently prohibited in The Netherlands.

Sustainable Building is a rather new building method compared to the traditional one, and often new and innovative systems are being applied. These new and innovative systems haven’t proved themselves and are not yet fully developed. And like all new systems not much is known about their behaviour in practice, concerning functioning, performance and maintenance. The efficiency is unknown or could be disappointing, or systems could easily fail unnoticed just because their proper functioning is unknown by the user. The efficiency of sustainable systems like Heat Pumps, Solar Domestic Hot Water Systems or photovoltaic Systems is very promising [5]. However the design and application concerning management and maintenance can be improved.

2. THE CONSEQUENCES

An undesirable consequence of above-mentioned problems and defects is that the intended sustainable goals will not be reached. The environmental load will be increased instead of decreased, which, of course, wasn’t the first intention of the design. By repairing or adjusting the defects at an earlier stage, more materials will be used than would have been from a sustainable point of view. And sometimes not always the most sustainable materials are being applied.

For most of the residents the defects have direct consequences for their comfort, satisfaction and finances.

3. THE CAUSE

The most important cause of possible defects is that there is no direct relationship between the design and the possible risks for the degree of maintenance in time. This could be a tricky problem, because knowledge concerning new materials, systems and combinations, as applied at Sustainable Housing, is not yet sufficiently available or has been insufficiently embedded in the building practice. This problem is not only found in Sustainable Housing, but also in traditionally built houses. But in the latter case the chance of defects is smaller because well-known materials and systems are being used.

The factor time plays an important role in the quality of the house. More time is needed in the design- and building phase because a different building method, new materials and new systems are being used. Ignoring these factors can lead to problems in building and planning.

4. RISK ANALYSIS

The solution is to make the maintenance consequences of a design transparent, both qualitatively and quantitatively. Possible maintenance risks in a design can then consciously be avoided or taken. The question is how these risks can be made transparent. There is sufficient knowledge about the current building practice, but it is very divided. TNO Building and Construction Research has made an inventory of the maintenance risks for the building envelope, indoor climate and installations. With these data and knowledge a Risk Analyses Model has been developed. Because of the complexity of this model, at this moment only the risk analysis of wooden window frames has been finished. The other parts are still under construction.

4.1 Risk Analysis For Wooden Window Frames

In general the wood species is the main topic when there is a discussion about wooden window frames. Nevertheless there are other important factors: sustainability, durability and maintenance, and furthermore:
- how the façade has been built and where the window frame has been placed
- what the window details are, what the working details and what the built-in working details.

Within these two areas there are several factors (33), that influence the life span of the window frame. To indicate which factors are more important than other factors in this model, 3 or 5 different appraisals have been used.

- 5: there is a clear relation with the influence of the life span
- 3: it can influence the life span in association with other factors
- 1: there is a limited relation to the life span.

Some factors related to the façade:
- Outer reveal of the window frame
- Eave
- Layout of the window frame
- Slope of the façade
- Orientation of the façade (north or south)
- .....

Figure 4: Integral design
Some factors related to the window frame:
- Wood species
- Quality of the wood (knots/cracks)
- Preservation
- Finger joints
- Laminated wood

After each of the preliminary, definitive and building phases, a form with the 33 factors must be filled out. After calculating, the outcome can be analysed and the design in each phase can be adapted. Performed during service life of the building it can be used to form a plan for periodic maintenance.

<table>
<thead>
<tr>
<th>Form 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project name</td>
</tr>
<tr>
<td><strong>Design</strong></td>
</tr>
<tr>
<td>01. Outer reveal</td>
</tr>
<tr>
<td>02. Eave</td>
</tr>
<tr>
<td>03. Layout of the window frame</td>
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<tr>
<td>04. Slope of the façade</td>
</tr>
</tbody>
</table>

Figure 5: Input sheet

<table>
<thead>
<tr>
<th>Risks in the design phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>04. Slope of the façade</td>
</tr>
<tr>
<td>02. Reveal</td>
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<tr>
<td>03. Layout of the window frame</td>
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</tbody>
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Figure 6: Output sheet

**CONCLUSION**

The principles of Sustainable Building are being applied with varying success. The cause of this varying success is that there is no direct relationship between the design and the degree of maintenance during the life span. One of the goals of this model is that the sustainability of a building intended by its designer will be achieved!

**REFERENCES**

[1] www.dubo-centrum.nl