Service Life of a Building in Environmental Assessment of Buildings

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ABSTRACT

The aim of this study is to analyse how the service life of a building should be taken into account in the environmental assessment of buildings. Over the past decade, various building environmental assessment tools have been developed for different needs and purposes. Many of these tools require an estimation of the building’s lifetime. However, the service life of a building has not been emphasised within the tools. Therefore, the research results of the service life of a building need to be combined closely with the development process of the building environmental assessment tools.

KEYWORDS

Service life, Environmental assessment, Building

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1 INTRODUCTION

The field of environmental assessment tools, developed for the building sectors, has become a popular research area over the past decade [e.g. Haapio & Viitaniemi 2008a; Peuportier & Putzeys 2005; Todd et al. 2001]. Numerous tools have been developed by various institutes and for different purposes. A variety of different tools exist for building products and components, whole buildings, and whole building frameworks. [e.g. Edwards & Bennett 2003; IEA Annex 31 2001]

In addition, the building environmental assessment tools cover different phases of the building’s life cycle and take different environmental issues into account [Haapio & Viitaniemi 2008a]. Building environmental assessment tools are not all commensurable. Consequently, the comparison of the results calculated with different tools is difficult, if not impossible. [Haapio & Viitaniemi 2007] The building environmental assessment tools often require an estimation of a building’s lifetime. However, the service life of a building has not been emphasised within the tools [Haapio & Viitaniemi 2008a]. And yet, a building may comprise over hundreds of different materials and products, all with different service lives [Kohler & Moffatt 2003].

1.1 Standardisation

The International Organization for Standardization (ISO) and the European Committee for Standardization (CEN) have been active in defining standardised requirements for the environmental assessment of buildings [see Haapio & Viitaniemi 2007]. ISO Technical Committee (TC) 59 Building construction and its Subcommittee (SC) 17 Sustainability in building construction have prepared standardised requirements for the environmental assessment of buildings. The standardised requirements concerning service life planning are also prepared by the same Technical Committee (TC 59), but by a different Subcommittee (SC 14 Design life). The principles for the service life planning of buildings are published in ISO 15686 series Building and constructed assets – Service life planning and it consists of the following parts:


1.2 Aim of The Study

The aim of this study is to analyse how the service life of a building should be taken into account in the environmental assessment of buildings. Over the past decade, various building environmental assessment tools have been developed for different needs and purposes. Many of these tools require an estimation of the building’s lifetime. However, the service life of a building has not been emphasised within the tools.
1.3 Content of The Study

In the first section, the research area, the standards are briefly introduced, the aim of the study is stated, and the content of this study is listed. The second section focuses on forecasting service life. The third section focuses on service life planning in the environmental assessment of buildings, and how it should be taken into account. In the fourth section, the future of service life planning and the environmental assessment of buildings is speculated.

2 FORECASTING SERVICE LIFE

The length of the service life is not precisely known in advance. Due to this, the objective becomes to make ‘an appropriately reliable forecast of the service life using available data’. The forecasting of the service life of a building (or a component) is to assure whether it can be expected to exceed the required design life with adequate reliability. [ISO 2000] Standard ISO 15686-1 gives the following definitions regarding forecasting service life [ISO 2000]:

- **Service life** is ‘a period of time after installation during which a building or its parts meets or exceeds the performance requirements’
- **Reference service life** is ‘service life that a building or parts of a building would expect (or is predicted to have) in a certain set (reference set) of in-use condition’
- **Predicted service life** is ‘service life predicted from recorded performance over time’
- **Estimated service life** is ‘service life that a building or parts of a building would be expected to have in a set of specific in-use conditions, calculated by adjusting the reference in-use conditions in terms of materials, design, environment, use and maintenance’

Forecast service life is based on either predicted service life or estimated service life. The service life prediction procedure is described in ISO 15686-1 clause 8, and detailed in ISO 15686-2. ISO 15686-1 clause 9 provides a method, a factor method, for estimating service life. [ISO 2000, ISO 2001] According to Davies and Wyatt [2004], ideally service life should be predicted according to ISO 15686-1 clause 8, and ISO 15686-2. Where the ideal cannot be achieved, estimations using the factor method, described in ISO 15686-1 clause 9, might be required. A clear distinction between predicted and estimated service life should be made when forecasting service life. [ISO 2000]

2.1 Predicted Service Life

In the predictions of service lives, the evidence from previous use, the knowledge of service lives of similar components, the tests of degradation in specific conditions, and combinations of these, are utilised. In an ideal prediction, service life is expressed as a function of the in-use condition (environmental condition under normal use). There are two methods of testing degradation; long-term exposures and short-term exposure, and normally they are used in combination [ISO 2000, 2001]. Ideally, a service life prediction based on exposure tests provides the reference service life for a factored estimation. [ISO 2000]

2.2 Estimated Service Life

The purpose of the factor approach, according to Davies and Wyatt [2004], is to provide a rough-and-ready means of estimating service life. As stated in ISO 15686-1 [ISO 2000], ‘the factor method does not provide an assurance of a service life: it merely gives an empirical estimate based on what information is available’. The factor method is based on a reference service life and a series of modifying factors. [ISO 2000] These factors are:

- Factor A: Quality of components
Factor B: Design level
Factor C: Work execution level
Factor D: Indoor environment
Factor E: Outdoor environment
Factor F: In-use conditions
Factor G: Maintenance level

The estimated service life of a component can be expressed as a formula, where the reliability of the reference service life figure is critical:

\[ \text{ESLC} = \text{RSLC} \times \text{factor A} \times \text{factor B} \times \text{factor C} \times \text{factor D} \times \text{factor E} \times \text{factor F} \times \text{factor G} \]

where ESLC is the estimated service life of a component and RSLC is the reference service life of a component [ISO 2000].

3 CONSIDERING SERVICE LIFE PLANNING IN ENVIRONMENTAL ASSESSMENT OF BUILDINGS

Numerous tools have been developed for the building sector to help decision making and improve the environmental performance of buildings and building stocks. The variety of the tools is wide; LCA based tools, rating systems, technical guidelines, assessment frameworks, checklists and certificates. [e.g. Boonstra & Pettersen 2003; IEA Annex 31 2001] Many of these building environmental assessment tools require an estimation of the building’s lifetime. The service life of a building, however, has not been emphasised within the tools. Rather, the service life is taken as given without further analysis [Haapio & Viitaniemi 2008a]. And yet, a single building may comprise over 60 basic materials and circa 2000 separate products, all with different service lives and unique production / repair/ disposal processes. [Kohler & Moffatt 2003]

3.1 Environmental issues within service life planning

Service life planning can be performed for several reasons. The economical and the technical aspects, including safety related issues, are quite obvious reasons. The economical viewpoint has been pointed out quite strongly in ISO 15686-1; General parts: ‘Service life planning is a design process which seeks to ensure, as far as possible, that the service life of a building will equal or exceed its design life, while taking into account (and preferably optimizing) the life cycle costs of the building.’ [ISO 2000]

The environmental viewpoint has been taken into consideration in the standards ISO 15686-6 Procedures for considering environmental impacts. The standard defines how to assess relative environmental impacts of design options, and furthermore, it identifies the interface between environmental life cycle analysis and service life planning. [ISO 2004] However, the standard does not take a position on the balance between environmental and other aspects. It is suggested in ISO 15686-6 that the environmental assessment of design option should be done parallel with the technical and economical assessments. According to the standard, the environmental assessment allows the design team to include environmental aspects into decision making. [ISO 2004] However, the standard does not make it mandatory to include the environmental aspect into service life planning.

The field of building environmental assessment tools is vast, as mentioned earlier. These tools are specifically for the environmental assessment of buildings. Different tools use different criteria and different indicators to correspond to these criteria in the assessments. Furthermore, the tools take different phases of the building’s life cycle into account. [Haapio & Viitaniemi 2007, 2008a] If the tool does not include all the phases of the life cycle, it is difficult to consider the effect of the service life on the results. On the other hand, life cycle assessment (LCA) is highlighted as a technique for assessing environmental aspects and potential impacts of a product in ISO 15686-6 [ISO 2004].
3.2 Maintenance of A Building

During the building’s service life, the building needs to be maintained, and some components need to be replaced. The service lives of the components are different. The service life of inaccessible parts should be the same as the service life of a building, but the service life of accessible parts may be shorter [ISO 2000]. If the service life of accessible parts is shorter than the service life of the building, these parts need replacements. As an example, if the design life (intended service life) of a building is 150 years, the suggested design lives are [ISO 2000]:

- 150 years for inaccessible or structural components
- 100 years for components where replacement is expensive or difficult
- 40 years for major replaceable components
- 25 years for building services
- (easy-to-replace components may have design lives of 3 or 6 years)

Maintenance and replacements have environmental impacts. In proactive maintenance, the action is taken in advance – before the damage occurs. In reactive maintenance, the action is taken afterwards – after the damage has occurred. There is a possibility the remaining service life of the components is lost if the replacement is done proactively. If the replacement of the component is done reactively, the component may have damaged its surroundings. The maintenance of these damaged surroundings has economical and environmental consequences.

The time between the needed maintenances and replacements differs between different components, and also, the demands for the maintenances are different. In addition, the quality of the maintenance, i.e. the workmanship, influences the forthcoming maintenances and may reduce the remaining service life. Poor maintenance, or disregarded maintenance, may cause damage elsewhere, and thus influence the whole building. For example, as a consequence of missing out the oil change of a car, the engine of the car may seize up. The repair of the engine is far more expensive than the oil change would have been. Also, wide repair is always more challenging and exposed to further damages.

3.3 Obsolescence

Obsolescence is a condition of being antiquated, or out-of-date. What was modern ten years ago is probably old fashioned today. An obsolete item simply does not meet a condition of the current requirements or expectations. [ISO 2000; Lemer 1996] However, this does not indicate the item is broken or dysfunctional. In other words, the service life of the item is not necessarily over, even if the item is obsolete. Currently, the number of renovations caused by obsolescence is increasing, as the requirements and needs of tenants grow. These renovations have environmental impacts; if the component is replaced before its service life is finished, the remaining service life is wasted. [Haapio & Viitaniemi 2008b] It seems a waste, especially if the replaced building materials and components are not recycled. In a case like this, the environmental viewpoint is often forgotten.

The service life of a building is usually long – decades or even centuries. The service lives of the components vary from a few years up to the service life of the whole building [ISO 2000]. But during the building’s long service life, manufacturing processes and products are developed. This causes problems in the maintenance; matching old and new techniques and products does not always go smoothly. Often at least some applications or compromises have to be made. For example, in the older buildings in Finland, the pipes are laid in concrete. If the pipes need renovations, the traditional renovation of the pipes is possible, or the service life of the pipes can be extended by lining the inside of the pipes with a newish technique.

The development of the techniques, processes and products has been overemphasised, and the importance of the implementation of the techniques has been underestimated. The requirements of the occupants have increased tremendously in recent decades, and there is no end in sight. In addition to
these factors, the development of information technology and HPAC set requirements for buildings. It is challenging to adjust these requirements in a sustainable way. These issues need to be taken into consideration in the design process. The focus should be on the development of easily replaceable components since the needs and requirements of the tenants grow and change constantly. The accessibility to the components during the maintenance and the replacement should be considered already in the design phase, in order to minimise the possible damages to the surroundings.

3.4 Experimental Building

To develop the construction processes, the buildings and the maintenance of the buildings, new designs, new products and new techniques are used occasionally. New designs and developments can be tested and studied in experimental buildings. These experimental buildings are important, since sometimes the experience from real construction sites is essential for the development process. Karjalainen [2002], for example, studied multi-story timber apartment buildings as pioneers in the development of timber construction. However, from time to time experimental building is regarded as a financing method. In these projects, nothing is necessarily experimented. These projects detract the reputation of the idea of experimental building.

The knowledge gathered during and after these on-site experiments is not utilised as well as it could be. Most of the knowledge stays with the people working in that particular project – it is not shared with others. The same mistakes might be made more than once. The knowledge gathered from experimental building should be taken to the next level. In order to be able to analyse building processes, solutions and components more thoroughly, at least some of the experimental buildings should be demolished before the end of their service life. Demolition, however, seldom takes place, even though it would provide more intimate knowledge of environmental performance and service life, and their interaction. How building solutions and components perform as part of a building should be studied by analysing them from demountable or demolished buildings.

4 DISCUSSION

Currently, most of the building environmental assessment tools are used towards the end of the design process to evaluate the environmental results. However, the assessment tools are not used simultaneously with the design tools. The later the evaluation of the results in the design process is made, the fewer possibilities it has to influence the design itself. In addition, optimising one structural solution may not be the ideal solution for the building. [Haapio & Viitaniemi 2008b] If the assessment tools and design tools are integrated, the task would be facilitated. Lützkendorf and Lorenz [2006] are expecting it to happen in the future.

The surroundings and the other components affect the component and its service life. The width of the ventilating slot between the wooden cladding and the exterior wall structure, for example, affects the maintenance and the service life of the cladding. When the distance between the wooden cladding and the exterior wall structure is adequate (i.e. the width of the ventilating slot is maximised), the situation can be compared to a fence in the field. On the other hand, when the width of the ventilating slot is miniscule, the wooden cladding acts as part of the exterior wall structure. Another example is the remarkable difference in the condition of the old and new wooden buildings in the town of Porvoo, in Finland. The cladding of the new buildings had to be renovated a few years after the completion. The cladding of the old buildings is in much better condition, even though the buildings are decades old. A controlled thermal leakage through the exterior wall structures could be one of the explanations for the better condition of the old wooden houses. In the new buildings, the thermal leakage through the exterior wall structures is much lower, but the cladding needs renovations more often. Which alternative is better from the economical viewpoint, and which is better from the environmental viewpoint? Which alternative is the best considering health related issues? If the observation time changes from 50 to 100 years, how does it affect the choice?
The service lives of building components, their effect on a building and its service life should be analysed in-depth. Currently, the effect of the service life has not been analysed thoroughly in the environmental assessment of buildings. [Haapio & Viitaniemi 2008b] The building environmental assessment tools often take the service life as given – no further analysis is made. It is not fully recognised how the service lives of the components and a building affect the results of the environmental assessment. Different building environmental assessment tools take different phases of the building’s life cycle into account. If the tool does not include all the phases of the life cycle, it is difficult to consider the effect of the service life on the results. There is a need to properly include the service life into the environmental assessment of buildings. Only then, will the integration of the assessment and design tools (suggested by Lützkendorf & Lorenz 2006) maximise the benefits.

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REFERENCES


