Extending Service Life Of Buildings And Building Components Through Re-Use

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Summary: From an environmental point of view, the extension of the service life of a building is only useful under the condition that the environmental load generated by the maintenance and renovation activities, and the use during the remaining lifetime of resources like water and energy, is less than the load generated by demolition, sustainable new construction and use.

Resource conservation in this context means a very important minimisation of the use of resources, making use of renewable resources and of the ideas of biotecture for example. The combination with the re-use of buildings parts, components and materials (bcm's) is important in this respect. These themes are further elaborated in this paper.

LCA-based assessment methods have to show the optimum selection of design approaches.

The paper concludes that there still are significant problems to be overcome when applying these assessment methods, as a result of a lack of technical data and missing links in the methods themselves.

Keywords: Renovation, re-use, sustainability, waste reduction

1 INTRODUCTION

Building and construction is one of the engines of the economy, considering their contribution to the Gross Domestic Product, Gross Fixed Capital Formation, and employment. The general expectation is that there will be economic growth in the future too. Due to the strong relation between building activities and economic development, there is an increased need for more and bigger housing, and utility buildings (Erkelens, 1991, p. 25).

As building has a significant impact on the environment it is justified to look at means to reduce this impact and to seek for sustainability. The second-best option, after not building at all, is to introduce the concept of extreme sustainability within building, which is far beyond the current building practice.

A building is in fact a structure that protects the users against all sorts of external influences and provides a comfortable space for all human activities. Like man, a building has a life period, which starts during the construction, continues during its use, its maintenance phase(s) and rehabilitation phase(s) and ends with its demolition. For all these phases (except the latter one) resources are needed.

A utopian approach for sustainable building would be to develop building products and buildings that do not produce waste, cost energy, require transport etc. and are cheap. Although this will not be elaborated on further, the idea is very interesting.

Resource conservation means that in the whole life span of the building, the use of resources (building materials, energy, etc.) should be such that the environmental impact is as low as possible and / or, better still, zero. Ideally, the combination of resources should have zero impact on the environment or even improve that environment, including its best quality and health. So far this is not yet feasible. A more realistic approach can be sketched as follows:

- Minimisation of the use of resources, and where necessary
- Use of renewable resources applying the ideas of biotecture, as well as
- The extension of service life through re-use and recycling (at all levels from whole buildings down to materials).

Environmental impact assessments are needed to check for the best combination of options, as it is not always the solution with the minimum use of resources that results in the minimum environmental impact. The following sections elaborate on these themes in more detail and discuss the constraints to be faced.

2 MINIMISATION OF THE USE OF RESOURCES

Minimisation of the use of resources also implies minimisation of the use of so-called endless resources because they too need energy for transport, exploration, exploitation and manufacturing.

This minimisation can primarily be achieved through reduction of the demand in various ways.

In essence, the reduction (of the amount) of building and construction waste causes reduced demand. The Dutch Foundation for Building Research (SBR 1998, pp. 5,6) reports a reduction of 41% in waste production in a housing project through good management.

Moreover, through the design of compact buildings, the amount of resources (i.e. building materials) can be minimised. This may not be the optimum solution given the local circumstances. Another approach is dematerialization. This means the reduction of quantities of materials needed to serve economic functions. To achieve sustainability von Weiszäcker *et al.* (1997) suggests that the materials input per service unit must be reduced by a factor of 10! This is an interesting thought for building too, but it requires extensive research. A parallel approach may be the development of smart building technology: fewer materials with better performance.

3 USE OF RENEWABLE RESOURCES, BIOTECTURE

It is often said that use should be made of renewable resources like wood, flax, hemp for building materials, components and services (like water and forms of energy). These resources have a short regeneration time: the resources can be grown and harvested. However, they have a limited capacity for renewal and can thus be subject to overexploitation. So, there is also a need to cascade these renewable resources. Cascading means the sequential exploitation of the remaining full potential of a resource during its use.

As renewable resources are not always environmentally friendly (e.g. the need for fertilizer to make materials grow), LCA's need to be made for them as well. At times this may lead to the conclusion that another (non-renewable) resource is a better option.

Another suggestion is to utilize grown structures and living plants, and space enclosed by trees. This so-called biotecture (Fraanje, C3-4.2) can be applied in the design of buildings. This has important resource-saving potentials and can contribute to a more natural regulation of the internal condition.

4 EXTENSION OF SERVICE LIFE

The extension of the service life of buildings and building components, products and materials is the third approach to be reviewed here.

4.1 Building

The ability to extend the service life of a building or parts of it depends on different factors.

Schulte (1997, p. 37) distinguishes three groups of aspects that are decisive for any decision on the future of an existing building:

1. Societal aspects: socio-economic, historical, juridical, financial and ideal aspects;
2. Urban aspects: historical, morphological, spatial / functional and use aspects
3. Building technological aspects: infrastructural, structural, manufacturing and building physical aspects.

An important question is whether society allows for the extension of service life: is it still the "fashion" to have such a building. Does it fit into the contemporary vision / policy.

Another point can be that the building, although old, contributes significantly to the 'value' of a location; an artistic value making it worth extending its service life, or a building with a historical value.

More complicated is a building that functions according to the original set-up, but does not fit into the functional / technical comfort requirements as formulated in the contemporary building regulations.

In this case it depends on the remaining qualities of the building whether the service life of either the building as a whole will be extended or only parts thereof, or whether the service life of just the structural framework of the building will be extended while the rest is being replaced or renovated, see 'Fig. 1'.

Fig. 1 A fully stripped building for re-use

4.2 Building parts, components and materials (bcm's)

The service life of building parts (façade, roof, etc.) components (windows, panels) and materials (glass, timber, tiles) also depend on the above mentioned aspects. Through renovation and rehabilitation activities bcm's will be sometimes replaced, repaired or left untouched, removed or demolished, partly or as a whole.

The service life of bcm's can also be extended through reuse in another project (e.g. the Carrousel experiment in The Hague whereby cleaned and repaired bcm's are stored for future reuse in renovation projects with a limited remaining life span), although this is more complex. The option of another location seldom is used for the main structure of a building.

From the point of view of the optimum use of resources, the best option would be if the service life of bcm's could be extended in this same building. In addition, we can consider recycling, although this option has a minor preference. Ultimately, discarding should be prevented.

4.3 Design requirements

Whether the service life of a building, a building part, a component or a material can be extended, also depends on the following:

1. The design proposals through which different quantities of bcm's have to be removed.
2. The initial design phase in which the future reuse of bcm's is already taken into account.
3. The quality of the bcm's that indicates whether they are reusable in this (or another) project. (This depends on the quality of the used materials, details, craftsmanship, maintenance, way of use and the method of demolition or demounting).

4.4 Environmental requirements

The consequences of the various options for the extension of service life have to be checked with the LCA programs, which take into account the use of materials resources, energy, waste and emissions. This results in an ordering of the design proposals along increasing total environmental impact. Usually, in daily practice, the economic costs of the proposals are decisive for the final selection. The initial costs in particular are focused on. A form of subsidy could stimulate a more environmentally friendly choice.

5 RESEARCH

Apart from saving resources by reusing a building, it is very useful during renovation to look into the reduction of the waste production. If renovation projects could be developed with a minimum waste output, this could contribute significantly to sustainable construction (Erkelens, 2000, C3-2.7). This involves anticipative thinking about the intended demolition: Can it be kept to a minimum, can the materials and components be taken off without damage and can they be re-used in the same project preferably for the same purpose? Or, if that is not the case, can they be re-used in other projects?

For new construction this means anticipating future re-use, through the application of other than (e.g. gluing) jointing techniques, design for deconstruction, and the use of (industrial) flexible and demountable components. Furthermore, the development of special demolition methods is of importance. As a start, the Technische Universiteit Eindhoven has developed a model to investigate the flows of all the building parts, components and materials (bcm's) in a renovation project, see 'Fig. 2'.

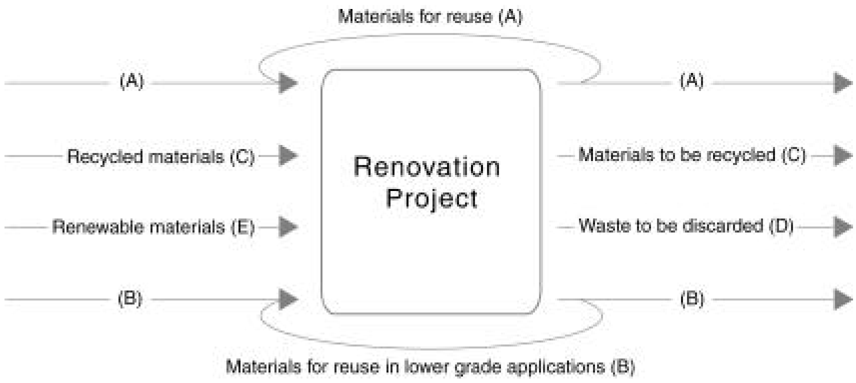

Fig. 2. Minimum waste research model

The model shows bcm's on the output side. Those of flow (A) are re-used for the same application after some repairs. Those of (B) can be re-used for lower grade applications. Those of (C) can be recycled and those of (D) can be discarded as waste. On the input side we see bcm's of the type of flows (A) and (B), and flow (C) consisting of recycled bcm's and flow (E) with new but renewable bcm's.

While researching a building project one first needs to establish the 'remaining' potentials of the existing bcm's in terms of quantity, quality, remaining life span, ease of dismounting etc. Furthermore, the potential reuse has to be sorted out and its level determined (primary reuse, secondary reuse, recycling or discarding).

The various options for part renovations will have different environmental impacts. The variation can be in floor plans, materials (re-)use etc. The various designs for a total renovation plan gives an order of increasing environmental impact. This guides us to find the best design proposal with a reduced environmental impact. Alternatively we can tune a preferred design in such a way that the impact is reduced.

6 CASE STUDY

A complex of 248 houses in the suburb Lievendaal of Eindhoven (the Netherlands), was used as a case study. These houses were built in 1949 and partly renovated in 1977. The coming renovation is planned for 2002. The total estimated lifetime is up to 2026. Kevin de Rond and Dieter van Riel (MSc. thesists) made a number of calculations based on three scenarios: (1) A continued use without changes, maintenance only; (2) a renovation in 2002; and (3) demolition and new construction in 2002 lasting up to 2026. The following 'Table 1' indicates the changes in the building parts over time. Some parts can be used continuously while some others have to be replaced.

Table 1. Lifetime of various building parts

1949	1977	2001	2026
Foundation, facades, floors, wall plates, purlins			
Windows and -frames Internal door/frames Ceiling plates	Windows and -frames Internal door/frames Ceiling plates		
Roofing-plates, tiles, rafters External finishing of dormer window Roof gutters, rain-water pipes		Roofing plates, tiles, rafters External finishing of dormer window Roof gutters, rain-water pipes	
Internal walls Shower, toilet, kitchen, wall tiles Mains, installations	Internal walls Shower, toilet, kitchen, wall tiles Mains, installations	Internal walls Shower, toilet, kitchen, wall tiles Mains, installations	

Based on detailed LCA calculations with Simapro and Ecoquantum, estimates were made of the total impact for the scenarios. Both Simapro and Ecoquantum are dutch LCA computer programs which are interrelated. As these LCA calculations are not yet totally optimised, the students had to sometimes estimate the input. Calculations were made for energy, waste, emissions and use of resources.

On the condition that the maintenance scenario is set to 100, the environmental impact scores of the scenarios are as follows: 157 negative points for scenario 2 and 274 negative points for scenario 3. The main relative environmental impacts in scenario 2 compared to scenario 1 are the roof and the installations.

The follow-up of the project will consist of an improved renovation design for scenario 2, which reduces the score by 26 points, compared to the original renovation in scenario 2. This research project is on-going and during the conference in Brisbane some more of the results will be presented.

7 MISSING LINKS / CONCLUSIONS

The case study showed a number of specific problems that a worth reporting.

The reality shows specific problems because of missing or incomplete as-built information and a lack of proper calculation tools.

7.1 Environmental gaps

Calculation programs are not yet completely satisfactory. For proper information one depends on the industries for building materials and components**.** For example, it is difficult to obtain calculations for old constructions and materials. Furthermore, it is difficult to establish which life span has to be applied when making comparisons for existing buildings, reused components or new materials. Besides that, it has proved problematic for LCA's to add up environmental aspects such as energy, waste, raw materials and emissions.

7.2 Technical gaps

Up until now designers have lacked complete insight into options for design variations. It makes a great difference if, for example, a wall is placed in a plan or moved just 10 cm more to one side.

Moreover, there are no simple and clean methods for demolishing or demounting. This would make options for reuse in the same project much more easy to come by.

7.3 Economic gaps

Naturally, economics are seldom good for the environment as a number of hidden costs are not calculated or taken into account. Through incentives like subsidies for reuse, levies for discarding and a premium for the return of good bcm's, the most economic solution may be different from the traditional ones.

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