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ZERO WASTE IN RENOVATION

Peter A. Erkelens

Abstract

The huge amounts of waste produced during building and renovation is a serious environmental problem, which is worsening as building activities are increasing over the years. This paper investigates in a case study possibilities for reducing waste production in renovation activities. It is found that a different approach of the planning phase results in more materials being left in situ or being re-used and a change in floor plans leads to more re-use of materials, less waste and less need for new materials. The achievable reduction of environmental impact is calculated with Life Cycle Analysis (LCA) calculations. The environmental impact of this renovation project could be lowered by 5-10%, which is promising for other ones. More precise data on impact of waste reduction will be obtained if LCA are improved.

Keywords: environment, housing, renovation, waste, reduction

INTRODUCTION

A report published as far back as 1988 Zorgen voor Morgen (Take care for Tomorrow, RIVM, 1988) revealed an alarming picture of the environment in the Netherlands. It indicated grim consequences for agriculture, traffic, industry and households. The following year, in response to this report, the Dutch government launched the National Environmental Policy Plan, which is still in force today (MVROM, 1989). This plan presents three basic concepts for an environmental policy that supports the idea for sustainable building and construction:

- Integrated life cycle management of materials
- Energy reduction through higher efficiency, use of renewable raw materials, and reduction of energy consumption
- Quality improvement of products and processes; minimisation of the use of resources; and, where necessary, the use of renewable resources.

If sustainable building and construction is to be achieved, one of the main aspects requiring corrective measures is the reduction of building and construction waste. Ten per cent of the materials used in building and construction end up as waste. But waste does not end there: it actually increases several fold during the lifetime of a building due to maintenance, renovation and, finally demolition. Also in other parts of the world this building and construction waste is a matter of concern. Smith (1998) noted that in the USA 20% of the total materials were wasted. Typical construction generated 20-35 kg of solid waste per m2 of floor space. Vingerling (1994) reported that the total amount of building and construction waste in the Netherlands per annum could be used to build 30,000 houses. In 1997 the reported amount of building and construction waste was 16.1 million tons (RIVM/LAE, 1999) and 23 million tons in 2001. Although 90% of this waste is re-used in one form or another, the environment would certainly be better off if waste levels were reduced in the first place.

One of the solutions can be found in dematerialization (KIBERT, 2001), which leads to the use of less materials and consequently to less waste. Other ideas are deconstructable buildings, components which can be easily decoupled from the building and are comprised of products that are themselves designed for recycling. Löflad (2002) investigated the possibility of using global recyclable materials. He distingu-
ished 3 categories of materials: global recycling material (straw etc.), conditional global recycling material (bricks) and not global recycling material (plastics). If well designed he found that 90% of a house can be built of global recycling material. For new construction the proposals from both references may be useful, yet for renovation of existing buildings, this is just a partial solution, as we have to deal with a partial replacement of existing materials.

Housing alone contributes to 3.1 million tons, or 20% of the waste, and half of this comes from renovation activities. In the near future, the number of houses to be renovated will exceed new houses. This means that unless special measures are taken, waste created by renovation will increase even further. Currently, qualitative and quantitative data on waste is available only at the national level for both renovation and new construction. Moreover, detailed data per housing project is limited and very little data is available for renovation. Here it is worth drawing attention to three studies. Stroband (1991) monitored a building project of 57 new houses and managed to achieve a reduction by 41% of waste, compared with a reference project. Although the research was restricted to new buildings, the result demonstrates the feasibility of reducing waste. Nunen (2001) investigated the re-use of concrete floor and wall elements from a demolished apartment building. This was a feasible option and the environmental impact reduction compared to new was 35%. A similar approach is documented by Vries (2001) on a building project in Maasluis. An apartment building was topped off and the lowest two storeys were converted into detached housing. Although the reported cost reduction was 10%, the environmental impact reduction was lower than expected because of the need for additional stabilizers. A different, still ongoing research, under the framework of IFD-research is the re-use of foundations of demolished apartment buildings (HENDRIKS, 2002a).

Apart from the approaches, referred to above, waste reduction should already be considered during the planning and design phase of renovations. Recently, the Eindhoven University of Technology has initiated a research program about waste reduction in building renovation. This research concerns: (i) the inventory of building material aspects such as environmental impact, (ii) the development of options for re-use, (iii) improved demolition techniques and (iv) environmental impact calculations and (v) a discussion of the re-use market opportunities and threats. The research results will be used for the development of a tool to prepare renovation proposals. This paper addresses two of the research questions: (a) what is the waste production in an actually executed renovation project and (b) is it possible to improve renovation alternatives by comparison of environmental impact results. To answer both these questions we will draw on the research carried out by MSc students in our department. Our discussion is limited to one case (Lievendaal).

REDUCING BUILDING WASTE IN LIEVENDAAL IN EINDHOVEN, A CASE STUDY

The research model
The basis for research is the following research model (Fig. 1). This model depicts the materials flows in a renovation project. At the right hand side are the out-coming materials. Materials in flow (A) are re-used for the same application in this renovation project or in some other projects. Those from flow (B) are re-used for a different application here or elsewhere. (C) will be recycled and flow (D) is discarded as waste. At the left hand (input) side are materials for re-use from flows (A) and (B). Flow (C) consists of recycled materials and flow (E) has new materials. In case of new, the preference is for renewable materials. The aim is a maximum reduction of the materials flows.

In this context the following definitions apply: Reusable materials are materials, which do not require any treatment apart from cleaning. Recyclable materials are materials that are used as raw material for the production of new materials.

Lievendaal
Since there is a considerable lack of data on materials waste, the research had to be done through case studies with extensive measurement at the project site. The first case study is a renovation project in Lievendaal a suburb of Eindhoven. This project consists of 248 houses (Figs. 2 and 3). These houses were built in 1949 and partly renovated in 1977. The family houses have two storeys and an accessible attic. There are three bedrooms: one of twelve and two
of seven m² respectively, a dining-sitting room combined with kitchen of 34 m², a bathroom and a toilet (see Figs. 4 and 5). The exterior walls are of masonry work and the interior has B2 concrete blocks. The floors consist of prefabricated concrete and there is a ceramic tiled roof on bituminised hardboard panels placed on concrete girders and rafters (Fig. 6). The actual renovation is planned for 2002 / 2003 under the supervision of a project architect.

**Measuring of demolition waste**

To collect the detailed data on waste production, three students carried out on-site measurements on one house; this was done over a period of three days. This house will function as a test house during the renovation. They monitored the out-coming materials, caused by demolition of parts of that house. The materials were counted and categorized by visual inspection on their re-use potential: re-use in this project, re-use elsewhere, use for a different application, or discard. In addition a check was done on the degree of treatment before the materials could be reused. There were four categories of treatment: no treatment, cleaning, light treatment and intensive treatment respectively.

**Renovation scenarios for Lievendaal**

In the second part of the research, six scenarios were developed for the renovation.

Table 1. depicts the lifetimes of the various building components, which are applicable for this project. As can be seen the lifetime variation is from 25 years to 50 and 75 years respectively.

The aim was to find out how the waste production of a renovation project could be reduced by an improved renovation design and by re-use of materials and what the environmental impact of this would be. The ECO-Quantum program calculated this impact. The reference scenario (1) assumed that the houses would be preserved by maintenance for another period of 25 years. Consequently the environmental impact was calculated for the planned renovation with new materials (scenario 2), then we looked into the re-use of out-coming materials, whereby scenario (3) assumed a maximum re-use and scenario (4) represented a more realistic percentage of re-use. In scenario (5) the original renovation plans were critically reviewed and altered, further limiting production of waste. In particular the changes in circulation space — location of the staircase and the corridor — resulted in an improved dwelling layout. This scenario assumed the maximum re-use of materials while scenario (6) assumed a realistic amount of re-use (ROND, 2002).
Figure 2. The renovation project

Figure 3. New roofing panels put in place

Figure 4. Existing floor plan groundfloor (ROND 2002)

Figure 5. Existing floor plan 1st floor (ROND 2002)
RESULTS

Analysis

The first part of the case study showed interesting results, and lists of out coming materials categorised for re-use. It was observed that the labourers demolished parts of the house at a high speed within three days. More materials would be left intact if demolition were done with carefully. But the labourers were not asked to do so. Demolition was done “oversized”, more than was indicated on the drawings, with an increased materials flow, both in and out. Some materials and installations removed from the house turned out to be outdated, so although these materials were still functioning well, they were not re-used in this project.

Environmental impact calculations in the second part of the case study gave the following results (Table 2). The figure for maintenance is set at 100 relative environmental impact points. In case of a maximum re-use the impact of the renovation by the project architect could be reduced from 152 to 129 points, and the revised plan gave a reduction from 152 to 122. A more realistic re-use percentage of materials lead to higher totals, 142 and 147 respectively.

Discussion

1. From the demolition study, we can observe that more re-usable materials would be available if labourers receive a list of materials that need to be removed with care, along with proper instructions on removal. However, this would require a different approach of the project and consequently, a different cost estimate. While this may increase the labour cost, the cost for discarding will be lowered. The re-use percentage of materials varies significantly. For example re-use of timber products and roofing metals can be 60-70%, and for tiles and staircases 30% (BOUWCARROUSEL, 2001).

2. The façade, internal walls, roofs and installations are responsible for the highest environmental impact. The proposed revisions of renovation plans give a lower impact because of simple measures like re-use (10% less impact of roofing and 50% of inner walls). A better layout and shorter mains, etc. could save materials. The results show that improvements are possible with even limited actions. An alternative roofing material with sheep wool insulation put into hollow panels of recycled aluminium turned out to have a 30% higher impact compared to a panel made of polystyrene covered with layers of chipboard (Opstalan in scenario 2). The higher impact is unrealistic, which is a shortcoming of the program, as this doesn’t contain the option of re-used aluminium. The program also lacked information on thick chipboard walls. By manipulating available data of a chipboard cupboard, we were still able to make calculations. These shortcomings were also reported by HENDRIKS (2002b).

3. Only net amounts of building materials were used in the impact calculation. In fact one should bring in gross amounts of materials, as there is also creation of waste due to sawing, cutting to size, etc. That also causes an environmental impact. When new materials are used, the additional amount of waste can be estimated. However, for the existing materials in the building, this estimate is not easy and should be studied in more detail.

4. If the project architect could use at an early stage, precise as-built drawings and lists with the used materials and their expected environmental impacts, he would be able to decide which materials should stay in place and which should be removed.
<table>
<thead>
<tr>
<th>1949</th>
<th>1977</th>
<th>2001</th>
<th>2026</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation, facades, floors, wall plates, purlins</td>
<td>Windows and frames, internal door/frames, ceiling plate</td>
<td>Windows and frames, internal door/frames, ceiling plate</td>
<td>Windows and frames, internal door/frames, ceiling plate</td>
</tr>
<tr>
<td>Windows and frames</td>
<td>Internal door/frames</td>
<td>Roofing-plates, tiles, rafters</td>
<td>Roofing plates, tiles, rafters</td>
</tr>
<tr>
<td>Internal door/frames</td>
<td>Ceiling plates</td>
<td>External finishing of dormer window</td>
<td>External finishing of dormer window</td>
</tr>
<tr>
<td>Ceiling plates</td>
<td>Roofing-plates, tiles, rafters</td>
<td>Roof gutters, rain-water pipes</td>
<td>Roof gutters, rain-water pipes</td>
</tr>
<tr>
<td>Roofing-plates, tiles, rafters</td>
<td>External finishing of dormer window</td>
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</tr>
<tr>
<td>Roof gutters, rain-water pipes</td>
<td>Internal walls, shower, toilet, kitchen, wall tiles, mains, installations</td>
<td>Internal walls, shower, toilet, kitchen, wall tiles, mains, installations</td>
<td>Internal walls, shower, toilet, kitchen, wall tiles, mains, installations</td>
</tr>
</tbody>
</table>

Table 1. *Lifetime of building parts*

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
<th>(Relative) environmental impact points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Maintenance</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Renovation by project architect to plan</td>
<td>152</td>
</tr>
<tr>
<td>3</td>
<td>Renovation by project architect maximum re-use</td>
<td>129</td>
</tr>
<tr>
<td>4</td>
<td>Renovation by project architect realistic re-use</td>
<td>142</td>
</tr>
<tr>
<td>5</td>
<td>Renovation revised maximum re-use</td>
<td>122</td>
</tr>
<tr>
<td>6</td>
<td>Renovation revised realistic re-use</td>
<td>147</td>
</tr>
</tbody>
</table>

Table 2. *Relative environmental impacts of six renovation scenarios, maintenance is set at 100, which is causing the lowest impact*
before he actually starts the design work for the renovation. The case study demonstrated the viability of this option. The housing project in this study can be considered representative for more of these housing estates. In order to obtain more data, also estates with different types of housing should be surveyed.

CONCLUSION

Conclusions can be drawn, for the case study as well as more in general.
1. Although just one case was investigated, the results are promising. More materials and components can be re-used if both demolition methods and labour instructions are adapted. Reduction of demolition to a minimum will not only result in less waste but also in less need for new materials.
2. The achieved reduction of the environmental impact is limited to 5-10 (152-147; 152-142) points only, which may give the impression that this exercise of re-use and reducing waste is just marginal.
3. The conclusion still holds that comparison of renovation scenarios through programs like Eco-Quantum is a feasible option.
4. The Eco Quantum program has too limited an option for calculations of environmental impact with waste reductions. This program needs an in-depth revision so as to include effects of waste reduction. Up to now this effect has been given a factor zero. A different option is to produce a better LCA program.
5. It turns out that the cost factor is important for decisions on re-use of materials. Changes in the macro economic system — changes in eco-taxation, for example — can push decisions more into the “right” (= environmentally sound) direction.

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