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Analysis of the severability of material layers of hybrid interior building components concerning repair and modernisation measures – Compilation of a practically oriented database for the sustainability assessment

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The author is responsible for the content.

1 Introduction

With the introduction of the German Sustainable Building Certificate, all environmental effects of a structure over all stages of life cycle are to be determined quantitatively with the help of an ecobalance in the future. This means that all maintenance measures and modernisation measures have to be considered in the building assessment.

More and more frequently, maintenace measures and repair measures become necessary due to the fact that requirements for modern buildings upgrade noticeably. Hence, there is a social interest in reduction of the environmental effects of such measures and in optimisation of the suitable processes. The enormous importance of the sustainability assessment of maintenance measures and modernisation measures is also documented by the admission of the criteria "maintainability of the construction" and "recycling-friendliness" to be evaluated in the German Sustainable Building Certification. Due to missing scientific investigations on this subject, an objective assessment by the certifier is not possible yet.

The purpose of this research project is to examine the environmental effect of maintenance measures and modernisation measures in office and residential buildings in terms of a reduction of the energy consumption and material consumption and to develop an assessment tool for the estimation of the severability of different materials concerning interior components (wall, floor). Such construction elements show the prevailing material inventory in case of a new building construction, as well as concerning maintenace measures and modernisation measures in the building stock and can therefore be considered to represent the standard task.

The consideration of the necessary energy and material consumption of maintenance, repair and modernisation shows that the severability of the used materials and therefore the recycling-appropriate deconstruction and the installation of materials in a resource-friendly way are an important criterion of the sustainability assessment. Besides, the most important influences are the type of connection between materials, the accesibility of materials to be separated, as well as the disassembling technology. The type of connection between the material layers determines in which amount technically still useful material layers must be exchanged too, because they cannot be separated from the primarily exchanged material layer

any more or only with considerable effort. In these cases, it is necessary to restore the base layer (e.g., plaster, screed) after removing the material or product to be exchanged (e.g., wallpaper, tile), before a new material can be applied. Through this, additional material flows are generated which have to be optimised in terms of sustainability. Within the scope of the research project recommendations are supposed to be derived which enable the designer to design dismantling-friendly and recycling-friendly buildings which can be evaluated well within the scope of sustainibility certification.

The energy and material consumption of maintenance and modernisation measures can be optimised by the results of the research project in terms of sustainability. The assessment methodology provided within the scope of the research project, allows for an objective estimation of the maintenance friendliness, the possibility of dismantling and the recycling friendliness within the scope of the certification procedure. Furthermore potentials of development can be indicated for the German construction industry in the field of interior fittings. The manufacturers of corresponding products receive hints about problems that can appear during the deconstruction and are thereby able to generate new competitive advantages by innovation.

Maintenance and modernisation are not limited to a certain part of the building industry. In the private or commercial building sector, maintenace and repair measures are conducted by application of comparable methods. For this reason, the results of the research project are transferable to all sectors of the building industry.

2 Procedure

The start of the research project is the assessment of the energy consumption and material consumption as a consequence of maintenance and repair over the life cycle of a building. For this purpose, the energy and material consumption is examined starting from the component requiring renovation over the deconstruction to the production of the ready base layer for the new coating. The ecobalance of the production of the single layers and coating is not considered because the production is not included in the system frame of maintenance, repair and modernisation although considerable differences can be expected. Within the scope of the experimental series, 28 representative wall constructions and 16 representative floor constructions as well as the corresponding repair methods are defined. The suitable wall and floor systems are established as a component test and the coatings will be removed under controlled conditions. The occurring energy and material consumption is documented. For the ecological assessment of the determined material streams the available material properties of the federal ecobalance data bank "Ökobau.dat" are used. Unsupported material data can be taken from other data bases (e.g. GABI, ecoinvent) or from environmental product declarations. The material streams are evaluated and analyzed with the help of the "Ökobau.dat". Based on the investigation results a methodology is developed with allows for an objective assessment of the possibility of dismantling and recycling-friendliness of

different wall and floor systems. In addition, the results make possible a quantification of the environmental effects originating during modernisation measures which can fill the information gaps in existing lists of components. The procedure is displayed in Figure 1.

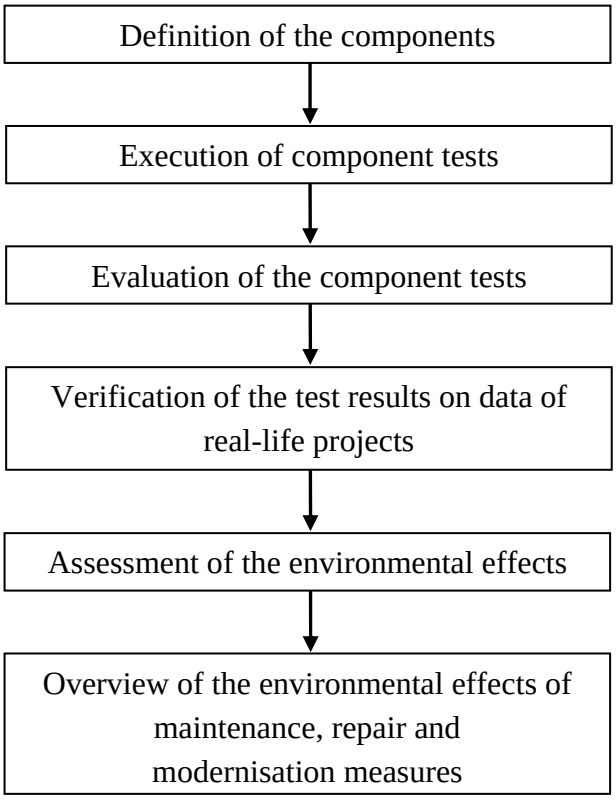

Figure 1: Procedure within the research project

3 Scope

The assessment of the environmental effect concerning maintenance, repair and modernisation measures aiming at a reduction of the energy consumption and material consumption is defined as frame of investigation. Thus, the energy and material consumption is examined starting from the component requiring renovation over the deconstruction to the production of the ready base layer for the new coating, see Figure 2.

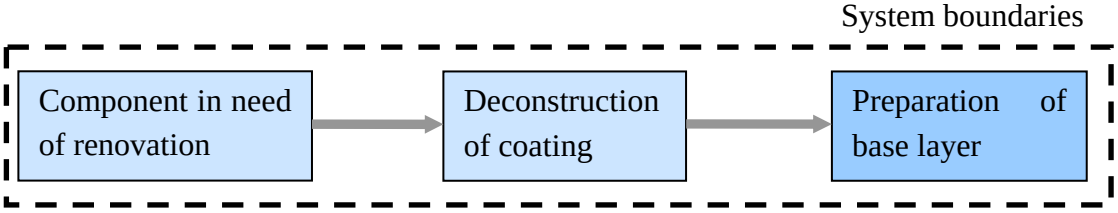

Figure 2: Representation of the system boundaries

The system boundary of the consideration includes the pure repair process of a wall coating or a floor covering which seems to require renovation. This process consists of the dismantling

of the layer to be exchanged and the necessary preparation of the base layer. A reflection of the whole life cycle of the coatings, in particular the production of the layers, is not necessary within the scope of this study. The base layer of the walls and floors which are the basis of the applied layers and coatings is not taken into account as well, as far as this is preserved within the scope of maintenance work.

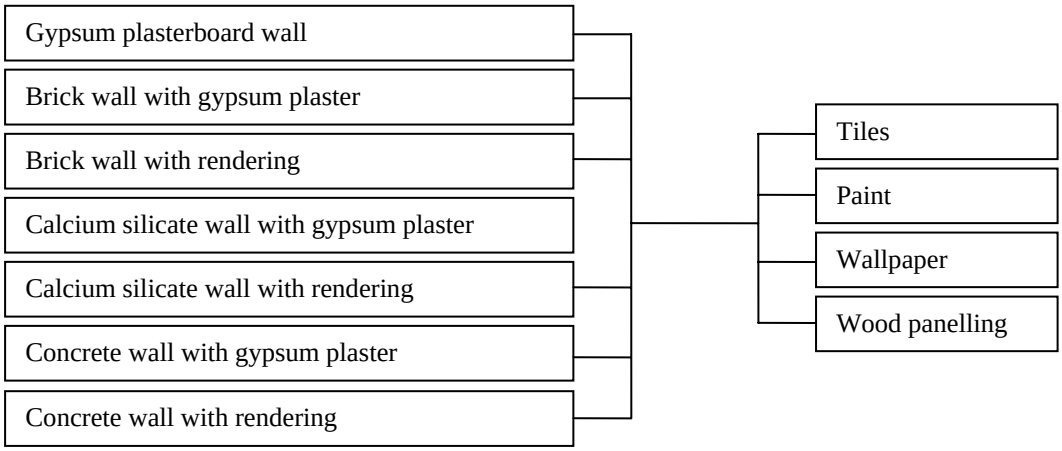

Figure 3: Wall constructions and wall cladding

As basic functional unity, „m² repaired component“ is taken for the study to enable comparability of the results of the balance of repair measures. To carry out realistic tests, the specimens are full-scale with the dimensions of the wall specimens of 2.0 m x 2.5 m (width x height) and floor specimens with the dimensions of 2.0 m x 2.0 m (width x length). These dimensions of the wall components are necessary to be able to simulate the labour over head as well as on floor level. Differentiated consequences on the quality of the severability and a practically oriented average value are to be expected due to the different positions with differently large effort and labour. Within the scope of the test series, the supporting structures and claddings shown in Figure 3 and Figure 4 were combined with each other.

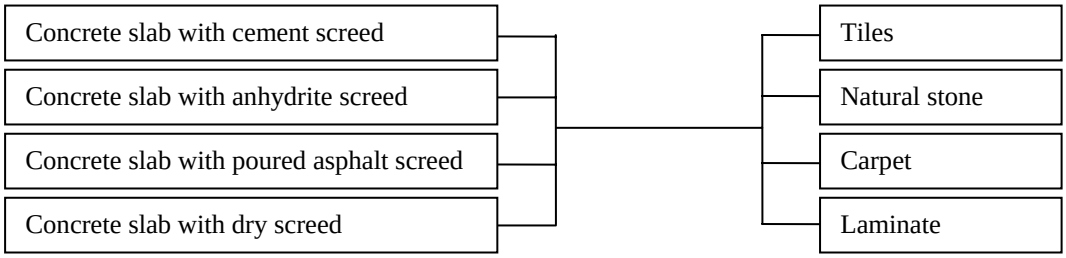

Figure 4: Floor construction and floor covering

Besides, the scientifically and code-fixed acknowledged criteria of the main criteria group „ecological quality“ of the "German Sustainable Building Certificate“ were used as investigation criteria:

- Primary energy non-renewable [mj]
- Primary energy renewable [mj]
- Abiotic consumption of resources [kg Sb-equivalents]
- Global warming potential [kg CO_2-equivalents]
- Ozone-depleting potential[kg R_{11}-equivalents]
- Acidification potential [kg SO_2-equivalents]
- Eutrophication potential [kg PO_4-equivalents]
- Photochemical oxidant potential [kg C_2H_4-equivalents]

Due to the limited acceptance among professionals and public and the only partially available data basis, the representation and interpretation of other criteria, as for example human toxicity, was not taken into account. The modelling of the single processes and partial products within the environmental assessment happens with the help of the "Ökobau.dat" of the Federal Institute for Research on Building, Urban Affairs and Spatial Development. The records available there are maintained regularly and guarantee a high data accuracy and data actuality.

4 Results and Recommendations

It is necessary for a very practically-oriented assessment of the repair and modernisation measures to face and compare all ascertained expenditures. Such an evaluation is carried out with the help of a methodology, rooted in the system of weighting factors from the DGNB-outlines for office and administrative buildings version 2009 [inc. DGNB (Ed.)]. These factors give a weighting of the single environmental effects. Within the scope of this work, the hourly expenditure of the staff is added in terms of cost shares.

Table 1 shows that the dismantling of tiles has considerably bigger consequences than the other wall coverings. It is pointed out to the fact that within the scope of the test series the cement plaster had to be removed completely after the dismantling of tiles. This involves significant consequences in all fields. The situation is similar to the necessary replacement of the plaster boards after removing tiles, but here the expenditure remains a little lower. Paint and wallpapers as wall coverings are quiet similar. They have very low environmental effects in comparison to tiles and wooden panelling. The dismantling of a wooden panelling can cause a negative consumption of resources by burning the panels and the substructure what consequently positively affects the eco-balance. Besides a carefully dismantled wooden panelling can be reused according to age and appearance what leads to a life-time extension

and with it to another positive influence on the eco-balance. The verification of the results in different real objects showed that the entire removing of the cement plaster is not absolutely necessary during the dismantling of tiles. At this point other investigations are mentioned which should be carried out possibly in close future.

Table 1: Assessment of repair and modernisation measures of wall covering

Base layer	New wall covering / Old wall covering	Tiles	Wallpaper	Paint	Wood panelling
Gypsum plasterboard wall	Tiles	medium	medium	medium	medium
	Wallpaper	very good	very good	very good	very good
	Paint	very good	very good	very good	very good
	Wood panelling	very good	very good	very good	very good
Brick wall with rendering	Tiles	very poor	very poor	very poor	very poor
	Wallpaper	very good	very good	very good	very good
	Paint	very good	very good	very good	very good
	Wood panelling	very good	very good	very good	very good
Brick wall with gypsum plaster	Tiles	very good	good	good	very good
	Wallpaper	very good	very good	very good	very good
	Paint	very good	very good	very good	very good
	Wood panelling	very good	very good	very good	very good
Calcium silicate wall with rendering	Tiles	very poor	very poor	very poor	very poor
	Wallpaper	very good	very good	very good	very good
	Paint	very good	very good	very good	very good
	Wood panelling	very good	very good	very good	very good
Calcium silicate wall with gypsum plaster	Tiles	very good	good	good	very good
	Wallpaper	very good	very good	very good	very good
	Paint	very good	very good	very good	very good
	Wood panelling	very good	very good	very good	very good
Concrete wall with rendering	Tiles	poor	very poor	very poor	poor
	Wallpaper	very good	very good	very good	very good
	Paint	very good	very good	very good	very good
	Wood panelling	very good	very good	very good	very good
Concrete wall with gypsum plaster	Tiles	very good	very good	very good	very good
	Wallpaper	very good	very good	very good	very good
	Paint	very good	very good	very good	very good
	Wood panelling	very good	very good	very good	very good

The used floor coverings were glued over the full surface with the respective subsoil and had to be removed almost entirely with an electric stripper tool. Nowadays laminate and carpets are rarely glued over the full surface, however, repair and modernisation measures likely face such stuck layers. In comparison to the wall layers, the assessment of the floor coverings show a little more differentiated picture (see table 2), in which the respective complete exchange of the dry screed after the dismantling of tiles, laminate and natural stone has great impact on the result.

Table 2: Assessment of repair and modernisation measures in floor covering

Base layer	New floor covering / Old floor covering	Tiles	Laminate	Carpet	Natural stone
Cement screed	Tiles	medium	medium	medium	medium
	Laminate (totally glued)	medium	medium	medium	medium
	Carpet (totally glued)	very good	very good	very good	very good
	Natural stone	good	good	good	good
Anhydrite screed	Tiles	medium	medium	medium	medium
	Laminate (totally glued)	good	good	good	good
	Carpet (totally glued)	very good	very good	very good	very good
	Natural stone	good	good	good	good
Poured asphalt screed	Tiles	medium	medium	medium	medium
	Laminate (totally glued)	good	good	good	good
	Carpet (totally glued)	good	good	good	good
	Natural stone	good	good	good	good
Dry screed	Tiles	poor	medium	medium	poor
	Laminate (totally glued)	poor	medium	medium	poor
	Carpet (totally glued)	very good	very good	very good	very good
	Natural stone	poor	medium	medium	poor

The investigations first carried out in this work to the severability of different material layers of composite components show clearly that the present approach which is assuming an entire strip-off of single layers from all wall coverings or floor coverings does not correspond to the state-of-the-art. This work lays a first cornerstone for all glued compounds or wet-on-wet compounds which always need a more precise consideration.

The results of the research project provide an assessment method which helps to decide whether a wall or floor construction can be repaired and modernised sustainably by reduction of energy and material consumption on objective basis. The methodology can already be applied in design and planning of a building and contribute to reduce the environmental effects over the whole service life. The results provide valuable information about the assessment of dismantling processes in the sustainibility-certification to the certifier. In addition, the environmental effect of repair and modernisation measures is added to the existing ecological component lists. All this forms a contribution to the reduction of the cost for certification.

It has to be noted that within the scope of the research project only single products on common wall constructions or floor constructions could be examined, so that, indeed, a very practically oriented, but still not generally accepted result for all product groups could be gained. Further comparative tests of single coverings should be carried out in the future, especially by manufacturers.

Besides, it is required to closely examine the ageing behaviour and the progress of the bond strength of single layers. Currently, no results about the delamination of "older" layers are available. The assumption that single layers do not furtherly bond with the layers underneath

after drying is the basis of the current research project. A increase or decrease of the bond strength due to aging had to be excluded.