Resource Efficient Wall Systems

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- Problem Definition & Research Question

In a world where sustainability is becoming an essential concern in any sector, it seems a necessity that architectural engineering engages on the same path by focusing its research on more sustainability in buildings. If humans keep going on with building traditional architecture, the waste produced by construction and demolition will not be manageable anymore and will keep affecting the environment. The waste generation and raw material consumption could be significantly reduced if buildings were designed, not as an end stage, but with a long-term perspective. The building sector doesn't only contribute to waste but also to CO_2 emissions and to ozone layer depletion and thus to climate change. These impacts can be reduced with an improved management of the building stock and a sustainable design of new constructions. It is why the aim of this project is the search for an innovative design for outer walls within the overall goal to reduce resource consumption on a life cycle. This research being conducted by four students native of four different European countries (Belgium, Hungary, Poland and Switzerland), its background has been narrowed down to Europe and to these geographic areas, with a specific focus on the sustainable refurbishment and transformation of an existing student housing complex in Brussels, the capital of Belgium.

- Methodology

First, the current context of resources use in the European building sector is analysed, with a particular focus on external walls systems for residential function. This consists in the understanding of resource efficiency and its assessment as well as the EU policies related to energy efficiency and resource efficiency in the building sector. It is from main importance to highlight and compare how they are implemented on national level. An insight is than given on common wall constructions for residential buildings but also new constructive solutions implementing for "design for change" are considered. When considering the case-study conditions, where the primary existing structure is sufficient to bear walls, the design of non-load bearing external walls seemed more relevant. The research has thus been conducted on non-bearing walls. No less than 29 variants of wall systems have been designed and assessed, from which four – selected for their low environmental impact – have been even further developed. The design's innovation is here not based on high-tech solution but on the careful selection of materials. Materials are the heart of any system and building materials generate environmental effects at various life stages. "Decision-makers, I.e. architects, engineering agencies, contractors, proprietors, project developers and government bodies, often lack the environmental information that is required for objective and transparent creation, selection or support of eco-friendly materials solution. In addition, some manufacturers and distributors are unaware of the potential environmental impact that building materials have during their life cycle" (OVAM, 2013). Ones get easily lost in the long list of labels. Indeed, the labelling of products is not harmonized and often unclear. This work aims to highlight the environmental impact of building materials during their life cycle, in a contextualized design and to assess it considering quantitative but also qualitative indicators. A database of eco-friendly materials has been recorded using the Swiss LCI database EcoInvent. Local, eco-friendly materials convenient for the design of non-load bearing walls have been

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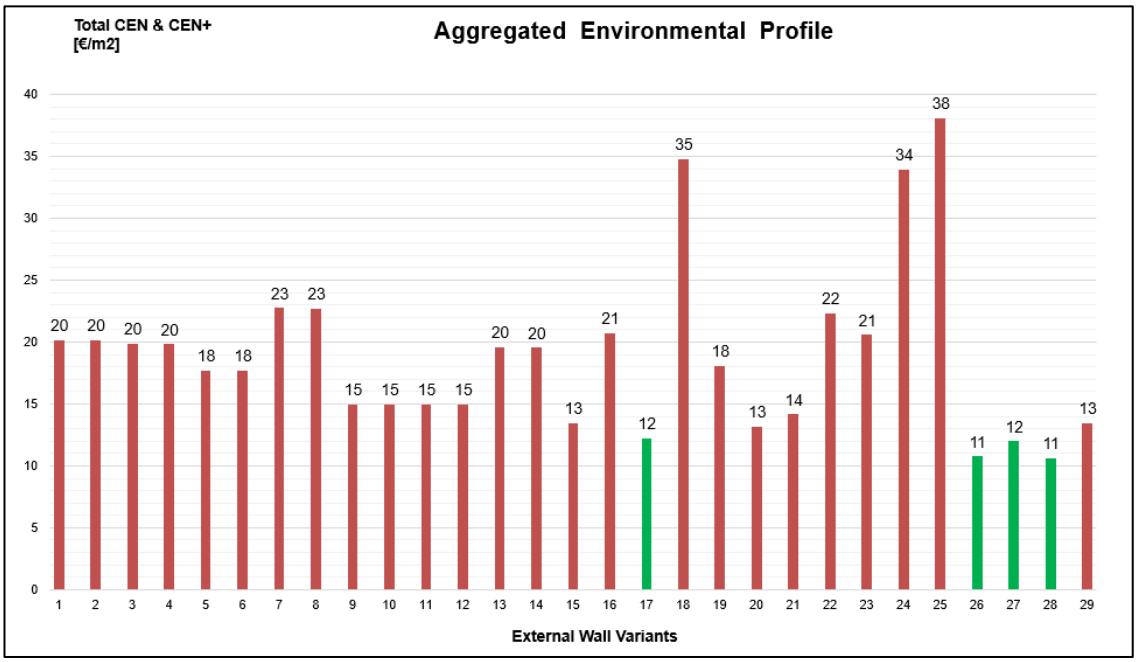
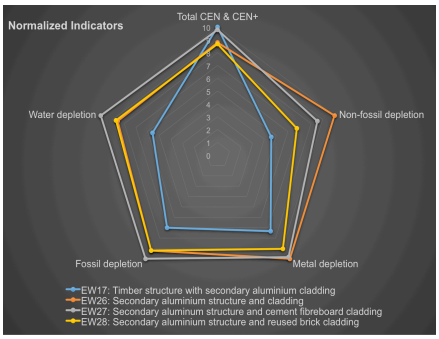
implemented. Attention is paid not only on the wall composition but also its constructive system, which consists in the materials connection and assembly. The assessment includes a complete life cycle analysis (LCA) performed with the MMG tool developed by OVAM. This determination method is based on the CEN and CEN+ indicators, giving a global picture of environmental impact with, here, a focus on the resource depletion. To this assessment, technical and economical parameters as well as qualitative indicators related to transformability are taken into account with the final aim to find an optimal balance between resource efficiency, architectural quality and sustainability (environmental, economic and social). Finally, a reflexion is done on an architectural level challenging the walls implementation in the case study. Future actions would include a development of guidelines helping decisions makers to choose the right wall system.

- Results

From the 29 designed and assessed walls, the four (in green) with the lowest environmental impact have been fine-tuned and further analysed. Each of them has the same inside finish (acrylic paint on gypsum layer supported by a wooden substructure) and the same insulation layer (cellulose flakes between the wall main structure and an extra layer of woodfibre board). Only the structure and the cladding vary.



No.	Wall System	Environmental Cost (€/m^2)
17	Timber structure with secondary aluminium cladding	12
26	Secondary aluminium structure and cladding	11
27	Secondary aluminium structure and cement fibreboard cladding	12
28	Secondary aluminium structure and reused brick cladding	11
	Average score of the 29 assessed wall systems	19



Considering, four depletion indicators (non-fossil, metal, fossil and water depletion), wall no.17 (in blue) is the most resource efficient, even if it has the highest global environmental impact of the "Top 4". Nevertheless, these results have to be put into perspective since, to fine-tune the assessment, the depletion indicators should be multiplied by a damage factor considering the amount of available resources and the global impact of the building sector compared to other industrial sectors. Considering the fact that sustainability should be affordable, not staying theoretical and reach the market, the cost (€/m^2) of "Top 4" was taken into account as an economic indicator. In the "Top 4", the cheapest wall is also the one with the lowest environmental impact; proving affordable sustainability. But it is too simplistic to link directly the market cost with the environmental cost since wall no.27 is cheaper but a little "less green" than no.26. Nevertheless, all designed walls are affordable and the difference of price between them remains reasonable.

- Conclusion

Sustainability is definitively not a synonym of boring and monotonous architecture. This research proves that it is possible to have a large panel of different sustainable aesthetics. The same process could be performed to test other claddings and structures or to improve internal finishes. It also becomes evident that construction materials have a major influence on the environmental impact of the building components. No doubt that the MMG tool could result in a user-friendly tool (like guidelines or a software) that could be used to choose the right constructive system. Finally "sustainability", should be carefully defined and assessed. As we have seen, resource efficiency doesn't mean sustainability since the designed wall with the highest environmental impact is the most resource efficient.

- Recommendations

As we can see, reusing or recycling[6] of material reduces dramatically the wall's environmental impact. It doesn't mean that companies should stop to produce construction elements but they should think of the materials end-of-life (EOL). Association of producers with companies taking care of the EOL based on C2C principles could be in a win-win situation on an environmental and economical level. One of the main challenges of recycling and reusing is to maintain a high quality of the processed materials. In Belgium, Websites like Opalis - a guide for building material reuse listing retailers, materials and advices – help Belgian to find professionals of the recycling/reusing sector to ensure the quality of the product. It is also to notice that unbaked bricks have a lower environmental impact than baked ones, but improvement is still need to meet waterproofness. Further research could be conducted to combine brick aesthetic, unbaked brick sustainability and impervious cladding. Moreover, MMG indicators do not include mineral resources, which are actually not taken into account in any impact assessment method. It is believed that availability and scarcity of mineral resources should be prioritized and that their exploitation should be considered to complete a LCA. Finally, design guidelines for a sustainable choice and use of building materials should be fine-tuned to offer a transparent and user-friendly LCA tool. Qualitative criteria related to transformability should also been taken into account (such as reversibility, simplicity, rapidity, durability, compatibility, reusability, smart layering, prefabrication, expandability, alterable functional subdivision, etc). The final aim is to reach an optimal balance between resource efficiency, contextualized architectural quality and environmental-economic-social sustainability.

[6] Recycled brick has not been assessed because it was not available in the database.