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Challenges for the integration of sustainable material use into dwelling design and construction

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Abstract: The environmental impact of building materials is gaining significance. However, architects face a number of challenges when trying to integrate sustainable material use in the design process. In this paper, the main challenges are listed based on lessons learned from the Flemish design and construction practice. A combination of research outcomes is used: 1) results from a large-scale survey on the architects' knowledge of environmental impact assessment (EIA), 2) semi-structured interviews with architects on the material selection process whilst designing and 3) semi-structured interviews on criteria for architect-friendliness of EIA tools. A survey with clients and interviews with contractors are used to include their point of view. Generally, it seems that architects have already come a long way on energy performance, but there is still much work on implementing sustainable material use in building design. Since there are no targets for the environmental impact of buildings (yet), there is a lack of awareness, knowledge and information on sustainable material use. Most architects have developed a pattern of habits for material choices, which does not include sustainability as a selection criterion. These identified challenges need to be overcome to achieve more sustainable material use in design and construction practice.

Keywords: Sustainable material use, architectural design process, design challenges, material choices

Introduction

Up to now, the focus of sustainable building has mainly been on energy performance. Due to the strict EU energy performance targets, the operational energy use of buildings has already significantly improved over the last years and the relative share of the environmental impact caused by building materials has increased (Hollberg and Ruth, 2016, Passer et al, 2012). Therefore, the responsible use of resources and raw materials in building construction is gaining importance.

In Europe, initiatives such as the "Roadmap to Resource Efficient Europe" (European Commission, 2011) and the "Closing the loop" action plan on circular economy (European Commission, 2015) were launched over the last years, in which a Life Cycle Assessment (LCA) based environmental impact assessment (EIA) of building materials and construction is promoted. Hence, sustainability has to gain importance in the material selection process to further improve the buildings' overall environmental performance.

In order to be effective, the integration of sustainable material use should become an inherent part of the design and construction process. In Flanders (Belgium), architects, clients and contractors are identified as the three main actors in the decision making process (Meex et al, 2016). However, these actors currently face a number of challenges when trying to implement sustainable material use in design and construction practice.

Methods

This paper combines research outcomes from different empirical research steps that explore the role of the architect, client and contractor in the Flemish design and construction sector. The focus is on dwelling construction, which implies that mostly individual clients, small-scale contractors and architecture offices are questioned. For the perspective of the architect, three different series of research data are used: 1) results from a large-scale survey (N=364, 2014) on the architects' knowledge of EIA principles and tools, 2) semi-structured interviews (N=9, 2015) on the material selection process whilst designing and 3) semi-structured interviews (N=5, 2014) on criteria for architect-friendliness of EIA tools. For the clients, a survey (N=138, 2016) was conducted at a construction fair in Brussels (Batibouw). For the perspective of the contractor, findings from a series of structured interviews and a brief questionnaire (N=9, 2015), conducted in Flanders, are used (Claes and Smetsers, 2016).

Results and discussion

The barriers found in this research are categorized into three main categories: 1) lack of awareness, 2) lack of knowledge on sustainable material use and assessment tools and 3) lack of legal requirements. The findings are discussed in more detail here below.

Lack of awareness

Firstly, it is found that there is a lack of awareness regarding the environmental impact of buildings and the role of (sustainable) building materials. The large-scale survey showed that most architects (67%) are concerned with sustainability in their design practice (Figure 1 (left)), but that this concern is mainly related to energy efficiency measures such as insulation and compactness. This is confirmed by the interviews: most architects associated sustainable building with sufficient insulation, passive solar gains, compactness,... and less with material choices or other additional efforts to reduce the environmental impact of building design. Similarly, in the interviews with contractors, sustainability was found to be related mostly to the good practices of energy-related measures (e.g. airtight construction, no thermal bridges,...).

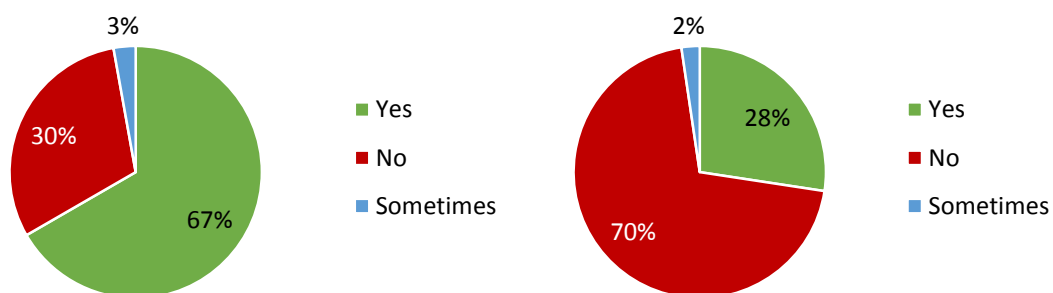


Figure 1. "Concerned with sustainability in design practice?" (left, N = 354) and "Additional efforts to reduce the environmental impact of building design, besides energy efficiency measures?" (right, N=343)

In the survey with architects, it was questioned whether respondents make additional efforts, besides energy efficiency measures, to reduce the environmental impact of building design (Figure 1, right). Only 28% of the respondents already tries to reduce the environmental impact of their designs. Of the 70% that does not (yet) deliver additional efforts, 44% indicates that they would be willing to do so, 7% would not be willing to do so

and for 49% it depends on the circumstances. Most frequently mentioned reasons for not making additional efforts relate to the additional work load, costs and time. Some architects who are willing to make additional efforts think it will become necessary in the future. However, they also indicate that they have too little knowledge on environmental impact and fear the additional costs. Respondents who indicated that it depends on the circumstances, also mostly mention the additional costs, the interest of the clients, the rate of return for the office and the additional work load and time investment. Similar barriers for moving towards more sustainable design and construction practices in general were also found in e.g. Häkkinen and Belloni (2011) and Pitt et al (2009).

Architects' drivers for material choices are mainly cost (79%), clients' wishes (75%), previous experience (73%), personal knowledge (68%) and aesthetics (68%); other and more sustainability related drivers (such as sustainable production process or recycled content of the materials) are less prominent (<30%). On the other hand, for clients' material selection, the look of the material and durability/low maintenance are the most important drivers (Figure 2). Factors such as technical quality and cost are also quite important, but the ecological footprint of the material is found to be the least important driver for material choices among clients. In general, the awareness of all actors in the design and construction process on the importance of sustainable material use seems limited and sustainability related aspects are the least decisive drivers for material choices in design and construction yet.

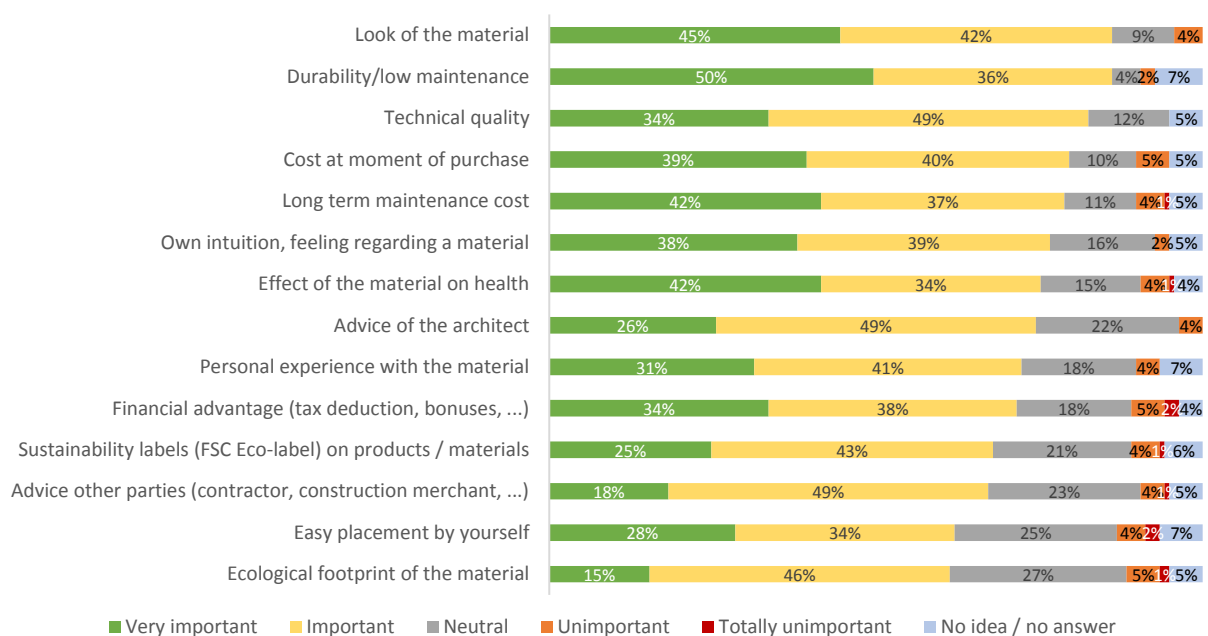


Figure 2. Clients' drivers for material choices and their importance (N=137)

Lack of knowledge on sustainable material use and assessment tools

Throughout the research, it became clear that the interpretation of sustainable building and sustainable material use is rather subjective and mainly depends on personal beliefs of architects and contractors. When architects in the large-scale survey were asked what they associated with sustainable material use (Figure 3), the most frequent response was related to the materials' durability (71%), followed by the recyclability (54%) and the low environmental impact during e.g. the production process (53%). Among contractors,

durability was also most frequently selected, together with a material certificate/label (89%). However, it should be noted that the contractors also considered a general quality label (i.e. Belgian BENOR label) as a sustainability label. End-of-life recyclability (56%) was also associated with sustainable material use by contractors. For clients, the fact that a material requires little maintenance (85%) and/or is durable (79%) was found to be (very) important in order to be considered as sustainable, followed by its impact on health (63%). These results indicate that sustainable material use has a subjective interpretation and is still related more to a material's durability than to other ecological aspects.

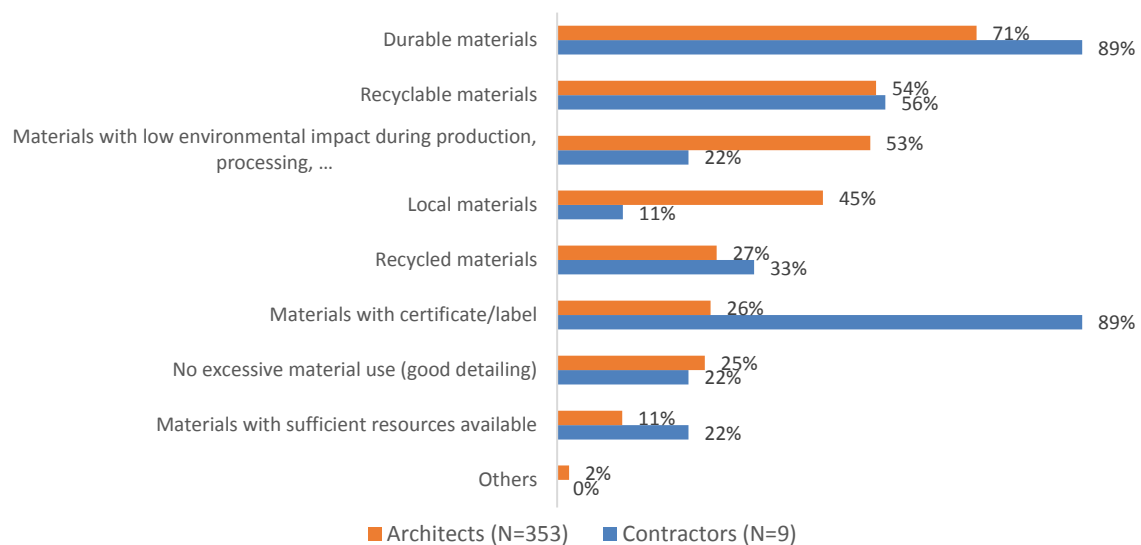


Figure 3. Interpretations of sustainable material use by architects (N=353) and contractors (N=9)

This subjective interpretation is linked to the lack of (general) knowledge on sustainable material use. LCA is widely recognized as a scientific method to evaluate the environmental impact of materials and products. Although several LCA-based environmental impact assessment tools have already been developed, it was found in the large-scale survey that architects have little knowledge on EIA methods and tools. For instance, only 42% has heard of the LCA method and only 15% heard of an Environmental Product Declaration (EPD). Also among the contractors, the knowledge of LCA and EPD was found to be quite limited: only 33% has heard of LCA and 11% of EPD.

The familiarity of the architects with LCA-based databases and EIA tools was also quite limited (Figure 4). Global sustainability assessment tools (e.g. BREEAM) were quite well-known and used to some extent. Considering LCA-based databases and EIA tools, only the Dutch NIBE classification (NIBE, 2016) was quite well-known and used to a certain extent by the architects. The NIBE classification was also mentioned by a small number of architects and contractors in the semi-structured interviews as one of the few aids that they are familiar with when integrating sustainable material use. However, the reliability of this classification system was often questioned by the respondents, as classifications changed over time (probably due to changes in the impact assessment methodology). Similar results were found in a survey by Olinzock et al (2015): they uncovered that the expertise level of building practitioners on LCA is often limited and that LCA-based software tools are currently rarely used beyond research purposes. Also by Means and Guggemos (2015 pp. 802), similar findings were done: "LCA tools and databases generally require a completely separate activity, data input and expertise; they are not integrated into routinely used architecture, engineering and construction (AEC) tools, methods or best practices".



Figure 4. Architects' familiarity with LCA-based databases and EIA methods and tools (N=330)

In addition, it was uncovered that both architects and contractors consider it hard to find reliable, objective information regarding the environmental impact of construction materials and products. Since architects and contractors have a large responsibility in the quality of the design and construction of a dwelling, they are not eager to deviate from their usual choices of mainstream or conventional products. These conventional products have already proven their value over the years, whereas newer, more alternative products often still lack these references and proof of quality or (added) value over a longer period and therefore present a greater risk. Some contractors (and some architects) also declare to mistrust environmental product information due to assumed lobbying practices from the material producers, which could influence the objectivity and reliability of the environmental product information. In addition, contractors often think that the integration of sustainable material use is more a responsibility of architects and material producers.

Nevertheless, the majority of architects (54%) indicates that they would use a tool to assess the environmental impact on a voluntary basis. 40% of the architects would not do this and 6% was in doubt and answered sometimes (Figure 5). Most mentioned reasons for not using such a tool are related to the additional work load and time investment, lack of knowledge, lack of interest of client and the lack of legal requirements. Additionally, some architects do not think this fits within their work package.

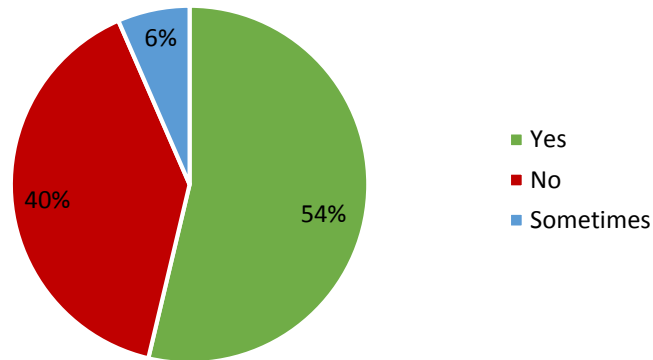


Figure 5. "Would you use a tool for the environmental impact assessment on a voluntary basis?" (N = 337)

This unwillingness to use an environmental impact assessment tool on a voluntary basis, in combination with the low familiarity with the existing LCA-based environmental impact assessment tools and limited knowledge on EIA, could indicate that there is a need for a user-friendly tool, oriented to architects, which enables them to perform such an environmental impact assessment of their design solutions.

Lack of legal requirements

At this moment, in absence of legal requirements or targets for the environmental impact, most architects (and contractors) miss a valuable argument to convince clients. According to the interviewed architects and contractors, regulations and/or policy incentives are needed to introduce a shift towards more sustainable selection motives for materials. This would encourage the uptake of sustainable material use: "The sustainable evolution will happen but it has to be imposed by the government, because for clients only cost matters". Especially cost was found to be an important barrier for clients to choose sustainable materials, at least according to the architects and contractors. For instance, one architect states that "it depends on the client, if he says that he has a budget to insulate his roof with flax or a bio-ecological material then it is possible [...]". And a contractor claims that "I always choose the most sustainable material, but when this is three times as expensive, than the client will never pay this. The client is willing to pay a little bit more when a product is sustainable".

Although the "willingness to pay more for sustainable materials" is seriously doubted by architects and contractors in the interviews, the survey among clients shows that the majority (84%) is willing to pay more for more sustainable materials (Figure 6): 21% is willing to pay 1-5% more, 43% is willing to pay 6-10% more and 20% of the clients is even prepared to pay more than 10% more than for conventional materials. However, when the additional cost approaches 25% or more the willingness significantly decreases.

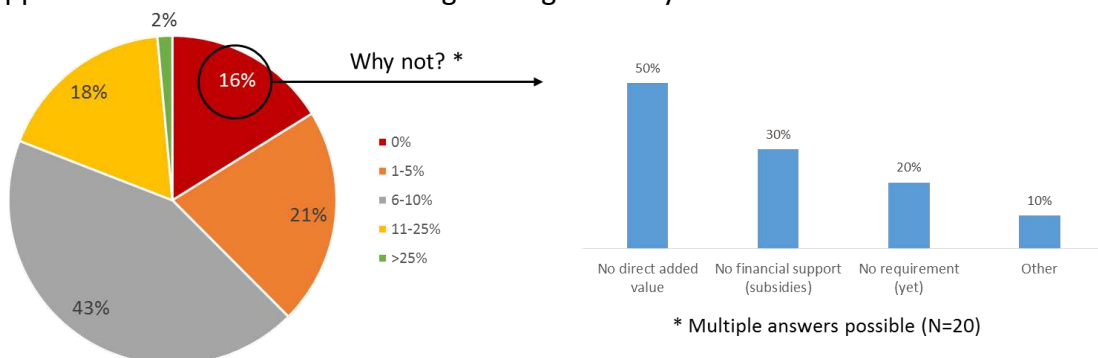


Figure 6. "How much are clients willing to pay more for a more sustainable material (N=136)? If 0%, why?"

This willingness to pay more for sustainable building materials is similar to tendencies found in marketing research regarding other green consumer products (e.g. Miremedi et al, 2012). The limited share of clients who are not willing to pay more (16%) mainly do not see the added value (50%) and/or lack financial support (30%) or legal requirements (20%). Further research is needed to determine how much clients are willing to pay more in case of real material choices.

Nevertheless, according to Pitt et al (2009), architects have an educating role towards the client, who is a principal stakeholder in determining the sustainability level of a construction project. Similar to sustainable building in general, there is still room for improvement on the knowledge level and communication of information regarding sustainable material use in the design and construction practice. Imposing requirements could support and/or accelerate this process.

However, implementing legal requirements for the environmental impact of buildings would influence the design practice. Therefore, the architects (in the large-scale survey) were asked to specify their attitude towards a future obligation to assess the environmental impact of building design in two situations: 1) without a mandatory benchmark to comply with and 2) with a mandatory benchmark. In case no mandatory benchmark is imposed (Figure 7, left), most respondents have a neutral attitude, which is also slightly skewed towards the reluctant side. In case a mandatory benchmark is imposed (Figure 7, right), the architect's attitude clearly shifts more to the reluctant side. Most commonly given explanations on the reluctant side are the additional cost, extra work load and the overregulation limiting the architectural freedom. Nevertheless, these respondents also mention that an obligation without mandatory benchmark would have little to no effect. Architects on the enthusiastic side almost all state that it is about time to take environmental impacts into account. According to these respondents, an assessment obligation without mandatory benchmark would have a sensitizing effect and it would be a valuable argument towards clients. However, in case a mandatory benchmark is imposed, even these architects fear the additional cost and work load.

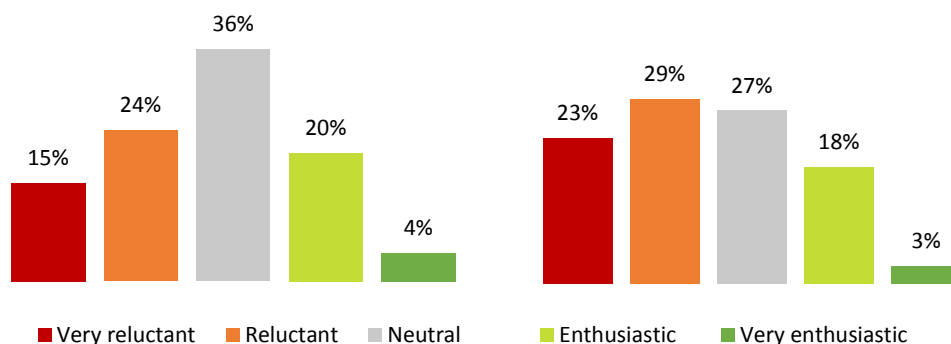


Figure 7. The attitude of the architects towards a future obligation to assess the environmental impact without (left, N=338) and with (right, N=328) mandatory benchmark

Conclusions

This paper discusses the challenges for the design and construction sector when moving towards more sustainable material use. In general, it can be concluded that most architects, clients and contractors lack awareness and knowledge on sustainable material use and environmental impact assessment. Currently, sustainable building is still mainly associated with achieving good energy-efficiency performances by means of passive design solutions,

insulation, etc. It is found that the majority of architects and contractors do not really make additional efforts to integrate sustainable material use in their design and construction practices yet: the application of conventional materials is part of standard practice and a pattern of habits. In addition, architects and contractors declare that, without regulation or obligation, they often lack a valuable argument towards the client. Financial incentives and subsidies could stimulate the uptake of sustainable material use, according to clients. Nowadays, clients simply wish to meet the requirements and are mainly concerned with the cost and timing of a design project, which makes it hard for architects to gain experience with and knowledge on sustainable material use in the context of a design project. However, implementing such regulations would also influence the design and construction practice and architects mostly fear the additional costs, extra work load and a limitation of their architectural freedom. These findings also indicate the need for the availability of a user-friendly environmental impact assessment tool. In conclusion, to move towards more sustainable material use in practice, the general awareness regarding the importance of sustainable material use and the knowledge level and availability of usable tools will have to increase and legal requirements on sustainable material use will have to be implemented.

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