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Swedish architects view of engineered wood products in buildings

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ABSTRACT

From a climate perspective, it could be advantageous to increase the use of wood products in buildings, but the use of sawn timber and engineered wood products (EWPs) in multi-storey buildings above two floors are a relatively new business (in Sweden since 1995) and there is a risk that wood as construction material is met with low awareness and high uncertainty by the construction sector. The purpose of this study was twofold: 1) to learn Swedish architects' views of using EWPs in buildings, and 2) to identify parameters that positively influence the likelihood that EWPs will be selected to a greater extent and the relative importance of those parameters.

A survey was sent out to Swedish architects and 67 answers were received. The result indicates that architects in Sweden have a positive attitude towards EWPs in general and that the majority think that they will probably increase their use of these materials. Low impact on the environment, aesthetic appeal, and fast construction were the most common reasons stated for selecting EWPs. The Swedish architects have in general a moderate impact on the selection of materials, and the most common reason for not selecting EWPs was that other decision makers involved in the building projects prefer other materials. A lack of knowledge and information as well as uncertainties regarding the quality over time were other common reasons for not selecting EWPs.

It was found that architects who had participated in building projects where EWPs had been chosen due to their low environmental impact and/or aesthetic appearance were more likely to state that they will increase their use of EWPs. The results also show that influence on material selection, knowledge of EWPs, experience of the use of EWPs, and the architect's own attitude to the use of EWPs affect the likelihood of an increased use.

1. Introduction

The construction and real estate sector is responsible for about 30% of the Swedish society's energy use and year 2014, 70% of the greenhouse gas emissions from this sector originated from new builds and rebuilds (Boverket, 2016). It has been shown that increasing the share of sawn timber and other wood-based products such as cross-laminated timber (CLT) and cellulose fibre insulation in buildings, and thereby reducing the share of non-biobased materials such as concrete and mineral wool, reduces the impact of the building on the climate (Asdrubali et al., 2017; Guo et al., 2017; Hurtado et al., 2016; Peñaloza et al., 2016; Rajagopalan and Kelley, 2017; Schiavoni et al., 2016; Teh et al., 2017; Thiger et al., 2017). Using wood products from sustainably managed forests for long life-cycle construction products could also be a better option for the environment with regard to climate impact than leaving the forest intact (Ramage et al., 2017). Another advantage of using timber in construction is that there are several options for cascade use of timber waste which can further prolong the service life of the wooden raw material and thereby its carbon sequestration (Arm et al., 2016; Fraanje, 1995; Sommerhuber et al., 2015; Thonemann and Schumann, 2017).

Only recently, in a historical perspective of human use, has wood been developed to form a range of products that are increasingly functional, based on a combination of performance

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and sustainability requirements, i.e. engineered wood products (EWPs) (Sandberg, 2016). This has been possible because new industrial processes have been developed for the modification of wood, and because residues and lower grade trees are being increasingly used for more versatile and consistent products with dimensions considerably larger than that of the tree. The result is a vast array of EWPs used in contemporary architectural design. There are EWPs suitable for e.g. floors, walls and roof elements, beams, columns, insulation, cladding, decking, and also a number of engineered panel products that can be used to add bracing and shear strength to timber constructions (Ramage et al., 2017).

The introduction of new products in the construction sector is generally met with low awareness and high uncertainty (Malaval, 1998; Robichaud et al., 2009). Several studies have contributed to the understanding of the market for timber as a structural material in multi-storey buildings by studying e.g. actors' awareness and perceptions, hindrances and drivers for adoption, and innovation diffusion (Bysheim and Nyrud, 2009; Hemström et al., 2011; Hurmekoski et al., 2015; Lindgren and Emmitt, 2017; Mahapatra et al., 2012; Mallo and Espinoza, 2015; O'Connor et al., 2004; Riala and Ilola, 2014; Roos et al., 2010; Robichaud et al., 2009; Thiger et al., 2017; Tykkä et al., 2010). Some researchers have focused on a specific EWP (Mallo and Espinoza, 2015). Less focus has been placed on the use of EWPs other than for structural purposes. Nevertheless, some studies have been made of e.g. consumer acceptance of wood-plastic composites (Osburg et al., 2016) and professional adopters perceptions of thermally modified wood (Gamache et al., 2017), together with some more general studies of experts' perspectives of the use of wood-based products in green buildings (Wang et al., 2013) and success factors and barriers for the innovation diffusion of new wood-based materials (Roos et al., 2014).

The majority of these studies are descriptive and only Bysheim and Nyrud (2009) and Hemström et al. (2011) focus on the relative importance of factors believed to influence the material selection, and only Mallo and Espinoza (2015), Osburg et al. (2016), and Gamache et al., 2017) focus explicitly on EWPs.

The aim of the present work was to obtain a broad picture of the views of Swedish architects regarding the use of EWPs in building construction and to identify factors that positively contribute to the probability that EWPs will be selected to a greater extent in the future. To do so, the following research questions are addressed:

1. What are the views of Swedish architects regarding EWPs in buildings?
2. Which parameters influence the probability that EWPs will be increasingly used in buildings by Swedish architects?
3. What is the relative importance of the identified influential parameters?

2. Literature review and theoretical framework

2.1. Material specification in the construction industry

The selection of materials is an important aspect of architectural design and it also determines the quality of the built environment. There are constraints of time, finance, and expertise in nearly all projects, and this influences the selection of materials and the parameters to be prioritized. Earlier studies indicate that most of the professionals who specify products have a preference for products with which they are familiar, especially in projects where time is highly prioritized, and the same products are often specified within an architectural office and among colleagues (Emmitt and Yeomans, 2008).

A key determinant for the choice of building material and construction technology tends to be the construction cost (Tykkä et al., 2010). A more recent study indicates that this is changing and that the construction sector is moving towards a focus on total life cycle costs (Riala and Ilola, 2014). An important barrier for the selection of wood products is thus the perception that wood products involve higher costs due to a more frequent maintenance and/or shorter life cycles. Riala and Ilola (2014) also conclude that there is an unwillingness to pay extra to reduce the environmental burden of construction even though the environmental awareness has increased among the stakeholders. For architects, it may be somewhat different, since they do not have easy access to the price of different products as do contractors (Emmitt and Yeomans, 2008). Thus, architects are not in general as price-focused as other stakeholders. A selection criterion of great importance for architects is instead the aesthetics of the product.

2.2. Factors influencing human behaviour

A theoretical framework to describe the probability of certain behaviour among individuals was introduced by Ajzen (1985) and is called the theory of planned behaviour (TPB). In TPB, perceived behaviour control is one of two main parameters and depends both on internal factors such as past experience, knowledge and skills, and on external factors such as the presence of time and opportunities. In construction, previous experience - in terms of amount and whether it has been positive or negative - has been proved to affect product choice to a great extent (Bysheim and Nyrud, 2009; Emmitt and Yeomans, 2008; Mallo and Espinoza, 2015). Knowledge and education regarding timber construction in Sweden has earlier been identified as being inadequate (Roos et al., 2010).

The second main parameter in TPB is intention, which depends on the individual's attitude towards the behaviour and on subjective norms. In construction, subjective norms have been shown to have little influence on material selection, whereas an individual's attitude has an influence but to a lesser extent than perceived behaviour control (Bysheim and Nyrud, 2009). In general, Swedish architects have been found to have a positive attitude to timber frames in multi-storey buildings mainly due to their environmental performance, but their attitudes towards concrete and steel are even more positive (Hemström et al., 2011). Other perceived positive aspects with timber in construction are e.g. that it is a strong and light material, have a natural and warm appearance, is energy-efficient (Roos et al., 2010), and have shorter construction time (Mahapatra et al., 2012). Perceived negative aspects are sound transmissions, decay, and poor shape stability and movement connected to changes in moisture content (Roos et al., 2010). A mixed view has been seen regarding fire-related properties and costs.

2.3. Innovation diffusion in the construction industry

A concept that is in some respects related to TPB is innovation diffusion. An innovation can be defined as *"… an idea, practice, or object that is perceived as new by an individual or other unit of adoption."* (Rogers, 2003, p.12) and diffusion as *"… the process in which an innovation is communicated through certain channels over time among the members of a social system."* (Rogers, 2003, p.5). Since some of the EWPs may be new to the architects, the theory of innovation diffusion can help to yield an understanding of architects' views on the use of EWPs and of factors that may influence the likelihood for an increasing use, and thus complement the TPB that not specifically describe behaviour related to innovations.

According to the theory, the rate of adoption depends on how individuals perceive the innovation with regard to relative advantage, compatibility, trial ability, observability and complexity