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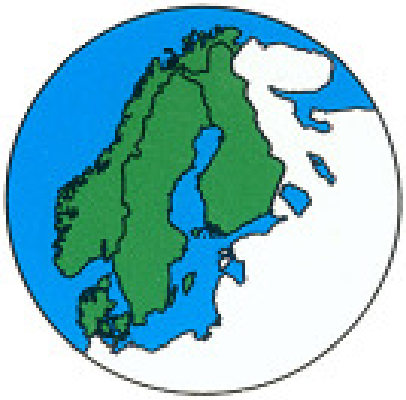

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Architects', and Building Engineers', and Stakeholders' Perceptions to Wood in Construction – Results from a Qualitative study

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Abstract

The study presents information about Swedish engineers' and architects' main considerations in material selection. It describes the material selection process, including perceptions of wood compared to other materials, the influences of main stakeholders, and how wood construction relates to professional roles and career prospects. Issues related to knowledge about wood as a material, the position wood construction has in the Swedish education and recent developments in wood-based construction techniques are also highlighted. Finally, we present the needs architects and engineers have of wood suppliers. Our results are translated in a number of improvements to increase wood as a construction material in large-scale construction.

Keywords: wood-frame building, attitudes, stakeholders

Introduction

In Sweden, wood frame construction techniques dominate single-family housing, whereas concrete is the most common material for multi-story housing (Bengtson 2003). In January 1995, restrictions for building multi-story wood-frame houses in Sweden were replaced by criteria for functional performance. Consequently, the wood industry expected a promising new market in the construction sector (Nord 2005). A governmental investigation (Anon. 2004) concluded an increased use of wood in construction is desirable for the industry and environmental reasons. Wood has good environmental credentials with regard to energy savings and carbon sequestration (Upton et al. 2008, Gustavsson et al. 2006). And, new alternatives for construction would increase competition in the building sector and lower prices. Therefore, a programme for promoting wood-frame is currently underway. Wood-frame construction is also promoted at the European level. However, the expansion of wood frame

building has not become a natural method for multi-story construction in Sweden or in Europe (Nord 2005).

Current construction technical requirements focus on function and safety. Construction must also comply with local building regulations, which address zoning, maintaining historic and cultural traditions, and environmental requirements. Yet, to an increasing degree, building practices are formed by European directives and committee work on wooden constructions. Stricter norms on energy saving capacity of buildings have recently been introduced in Sweden.

Much R&D work on wood frame building has been focussed on technical issues. Since wood frame building is essentially a cultural change, topics referring to attitudes, traditions, culture and the professional roles merit further studies.

Architects and structural engineers are two key groups that together affect material selection in construction. Knowledge about the perceptions, beliefs, influence and knowledge that these professions have towards wood in construction would provide valuable input for the wood industry. Such input could form the basis for improved offerings as well as gaining the confidence of key advocates in the material selection process.

The purpose of this study was to assess Swedish building engineers' and architects' perceptions on wood in construction. We also examine their role in relation to the different stakeholders in the decision process. The study is limited to multi-story residential buildings and larger projects such as schools, institutional buildings, and commercial buildings.

Previous studies on perceptions on wood frame

Recently, a number of researchers have studied the implementation process of new wood-frame approaches in the Swedish building sector. Bengtson (2003) explained concrete's dominance as a combination of different contextual factors and industrial networks. Bergström (2004) and Sardén (2005) studied pilot projects that introduced timber structures on project level. Their results confirmed the importance of integration and information sharing between the actors in the value chain and reasonable balance between customer focus and efficiency. Nord (2005) inferred that large Swedish sawmilling companies can be grouped into different waves of suppliers and partners for industrialized wood-frame building in Sweden.

In the USA, Kozak and Cohen (1999) claimed that the wood industry lack the resources and competence to market wood as a building material to architects and engineers. O'Connor et al. (2004) identified barriers among North American architects and structural engineers for an increased use of wood in non-residential construction: fire codes, costs, design difficulty, and poor training among designers and trade people. Similar results were acquired in an Australian study (Bayne and Taylor

2006). The authors explained the low degree of adoption by designers/specifies of timber structures in non-residential buildings by fire performance concerns and an overall lack of designer confidence, lack of knowledge in timber design, and lack of marketing by the wood industry.

Research approach

The Theory of Planned Behaviour (Ajzen 1991) was used as a conceptual framework for our enquiry about wood framed construction. Our applied interpretation raises three main considerations which influence professional's intentions to either suggest or support wood-frame in building projects. Firstly, *Attitudes about the perceptions of* wood, particularly whether they regard wood as a reliable, appropriate, high performance building material. Secondly, *Subjective Norms*: a professional's anticipation of the normative reactions of others, particularly whether experience of wood frame building entails professional respect or is likely to lead to the commission of new projects. *Control beliefs*, which cover perceived factors that facilitate or hamper the proposal to have wood in the construction, i.e. knowledge about wood construction, or perceived problems implementing wood in the industrial network.

Since perceptions and beliefs were theoretically important, and the work had an explorative character, a standard qualitative analysis was chosen (Silverman 2001, Miles and Huberman 1994). Respondents were purposively selected to constitute a diversity regarding gender, role in the decision process, and wood building experience. In total 23 people were interviewed. The interviews were conducted, mainly face-to-face in 2007, and transcribed. These were analysed using a coding procedure (Miles and Huberman 1994), where researchers separately coded the same text and then discussed the various coding outcomes to reach a negotiated consensus on coding principles.

Results

Factors influencing material selection

Respondents considered an important factor that influenced material selection in multi story buildings and larger constructions was dominating ***standard practices*** in construction. That is, the most applied and practiced building methods for constructing a particular type of house. Respondents in the largest companies were also particularly constrained by ***corporate policies*** that advocated 'platforms' and prescribed materials. A related factor was the ***availability of good examples*** showing that a material and building technology works. Architects frequently use such examples for inspiration and models in their planning. Structural engineers preferred to use existing building examples, since it verified a construction method

worked in practice. "*It is never good to be number one – it is better to be number two when it comes to applying something new (high rise wood frame)"* (engineer).

Another consideration that mostly architects raised was that the new building should harmonize with its ***built and natural environment.*** This also included ***local building traditions,*** which tended to support the use of wood in rural areas and in Northern Sweden."*In rural settings, wood is the natural choice in the Nordic countries – This is our cultural background"* (architect). ***Aesthetic*** aspects also referred mainly to visible surfaces.

Most respondents considered that the regulatory changes in 1994/95 meant that ***codes, regulations and authority decisions*** were of minor importance in material selection. Nonetheless, the influence of these factors on building norms, and local historic considerations in urban areas could still influence material selection outcomes. Similarly, the impact of ***physical requirements of the frame*** on material selection depended on the function, building details and ground conditions.

Respondents also assumed that ***energy efficiency*** and ***environmenta***l arguments would increasingly exert an influence on material selection.

Economic and cost considerations were stated as an important factor. However, the issues weighted in such calculations differed from project to project. Key costs parameters ranged from construction costs, maintenance costs, life cycle costs, construction time, risk considerations etc. However, a frequent phrasing was, *"The budget must be respected"*

Wood's relative merits in construction

Fire properties were still frequently mentioned as obstacles for wood in construction by many respondents. Others pointed out that massive wood structures have an advantage since these have a predictable reaction to fire (pyrolysis), where total collapse is less likely than for steel.

Sound transmission properties were a serious technical obstacle to wood, since concrete required less space to solve sound transmission problems.

Form stability and movements were also stated as drawback for wood. Form stability was often associated with ***moisture content*** issues, which can also lead to mould, and unhealthy dwellings. However, some respondents claimed that moisture issues could easily be handled with the building techniques. Other respondents perceived a ***higher risk*** when building in wood, and consequently higher costs. Wood was also seen as more difficult to pre-calculate.

Woods' variability and biological origin lead to some respondents considering it as ***insecure supply***. Engineers in the construction industry complained about fluctuating prices and had a feeling that producers gave priority to export markets, at the expense of long term business relations in

Sweden. Further, the ***fragmented wood industry*** was reported to constitute an obstacle for sufficient ***support*** of architects, engineers and builders.

According to our respondents, woods' ***light weight*** saves energy in and money in the construction phase. They also stated wood is more appropriate for industrialised building methods because larger building components can be prepared in the factory, in dry conditions, and then transported to the building site. Some building engineers said woods' strength to weight ratio was an additional argument in favour of wood. However, it was also acknowledged that wood was not as suitable for large ***span lengths*** as concrete. *"Wood is not appropriate for very large industrial buildings. But glulam is very suitable for large warehouses and hall"* (engineer). Wood as a building material was also characterized as ***flexible,*** enabling design opportunities and changes during and after the building process.

In visible applications wood is often claimed to have an ***aesthetic*** advantage because of its natural, warm and human appearance. It also is said to create a ***pleasant indoor climate*** and ***atmosphere***. However, visible wood requires ***maintenance*** so the surface retains its appearance.

Views on ***cost advantages*** varied. Several respondents affirmed that wood can be cost-competitive, because of its light weight and opportunities for industrialised building methods. However, one entrepreneur/contractor stated that on-site construction of wood can become prohibitively expensive due to the man hours involved. Lack of experience in using wood gave rise to feelings of insecurity, which are calculated to add costs to a project.

Wood was also considered to have ***environmental and climate advantages*** since it assimilates and stores carbon, has good insulating properties and requires less energy for transport and construction. Large builders were reported to have an environmental policy, although few could describe its main content or whether it would influence the material selection. *"They do not prescribe specific materials – rather, they pose environmental criteria on the materials that are being used"* (engineer).

The decision process

The actor in the process with the largest control over the material selection was the ***commissioner*** of the process. "*The developer must prefer wood – otherwise it won't be wood" (architect).* Local housing firms were reported as tending to prefer concrete since they perceived concrete as longer lasting, with little maintenance requirements. However, low costs and fast assembly of wooden constructions may lead to some developers adopting the view that wood out competes concrete in some cases.

In Sweden, ***builders*** can be segmented according to whether they work in large corporations with operations throughout the country, SME:s which are often regionally based, or micro enterprises. Several respondents

viewed the large builders as very influential actors in the concrete tradition." *The developer and the builder – it's mainly their decision (architect).*" Nonetheless, respondents informed that a few smaller builders had more favourable approaches to new technology, with some even specialising in wood construction. Builders can also play two roles in construction: acting as a commissioner, including selecting a parcel for construction of apartments, also acting as a constructor to build the properties; and, finally, acting as an entrepreneur and selling the properties to a housing cooperative. ***Architects*** were curious about wood and the use of wood as a structural element, however they had a limited authority." Swedish architects have a weak influence compared to other countries (architect)." Their possibility it influence increases with experience and reputation. And, there was also an opportunity to support wood-frame in smaller projects outside the largest cities.

The ***structural engineer*** normally took responsibility for the structural aspects of the project." *Architects can influence the visible parts – the engineer influences the frame" (engineer).* Several respondents perceived this category mainly favoured concrete, often indirectly influencing decisions by displaying unease about the possible use of wood.

As implementing bodies of zoning and local building regulations, ***local authorities*** have an impact mainly on façade materials. One local municipal commissioner had received instructions to always include one wood frame alternative when evaluating all new housing projects.

Respondents working in the construction sector frequently complained that ***wood material suppliers*** were rather anonymous and passive in their marketing of wood products. People in the building sector wanted more product and systems innovation, support and active, personnel marketing. Wood suppliers' current marketing efforts did not match those of other material providers.

End-users can rent apartments, which is more common in Sweden than many other countries. End-users can also be cooperative owners of a house, where ownership is jointly held by all dwellers and shares are allocated to individual owners on the basis of apartment standard and size. End-user preferences were not expected to tend towards any specific structural material. Some interviewees even claimed that dwellers often were unaware of the structural material. Developers/builders of new cooperatives assumed that sound isolation preferences currently exclude wood structures on multi-storey buildings.

The process was dependent on the ***type of project*** and its ***contracting forms***. Large housing projects were often managed by a large builder, and main decisions implied by the policies of the enterprise. Smaller projects however could provide more power to the individual architect. The project could also be pre-specified by the developer (including material choice) or it

could be open both for wood or concrete. The process could also be structured openly, with project development taking place when the parties moved in a stepwise fashion.

Views on the most recent developments in wood construction

Based on our interview material, the most recent developments affecting wood building can be classified as institutional, organisational, industry and technical. The most pivotal ***institutional change*** was the removed restrictions on multi-story wood wood frame in 1994. Several respondents claimed that the new regulatory situation had not had a fundamental impact on wood frame's share of construction. Respondents also mentioned increased focus on energy savings. Local instructions to seriously consider wood frame building were other developments of this type mentioned by the interviewees. Research programmes to improve and adapt wood properties and technologies were also mentioned.

Organizational changes included a network oriented towards educating and inspiring professional architects about wood architecture. Currently a wider promotion campaign is co-financed by the wood industry and the government. It features seminars, courses and demonstration projects.

An ***industrial change*** is the emergence of new actors adopting wood construction, who use with industrial methods. These can be wood industries advancing in the value chain, or contracting SME:s.

A number of ***technical and systems innovations*** have occurred. These involved sound insulation of wood materials, panel products, fire resistant materials, improved lumber quality, glulam, and engineered wood. In some cases, however, we were told that innovation projects had been inhibited prior or after market launch. Several persons described ***industrialized wood building methods*** as promising for several reasons: dry pre-fabrication increased quality, speed of on-site assembly, requiring less personnel on site.

Main actors driving the positive development towards innovative products and materials were innovative wood industries, mid-sized builders, and research institutes, whereas the four largest firms were considered to have chosen a inactive position.

Professional role

Both architects and engineers thought it was interesting and challenging to work with wood. But it was more complicated and difficult because of woods' variability and moisture sensitivity. Some respondents considered these properties as essentially as wood's negative aspects, whereas others just saw them as an issue that could be solved with the right education and experience. Architects normally did not favour one material – it all

depended on the vision and purpose of the project. However, as one responded said, some architects can be more focused on the material and what it can express. Architects and some engineers stated that the most salient attribute was woods' visual possibilities and some regretted that wood facades are often prohibited in large buildings.

Professional experience in wood frame building were not reported to improve possibilities to win new engagements.*"Wood experience doesn't improve my career" (architect).* What meant most for architects' prestige was winning competitions. The attitude among the most famous architects also mattered. *"When the "big names' engage in wood architecture – then it becomes interesting" (architect).* An annual wood architecture prize was for therefore highly valued. For engineers, professional reputation is often associated with experience of larger projects. One architect was dissatisfied by the modern wooden architecture of multi-story buildings.

Knowledge

Both professions considered their education had little content associated with wood construction. Furthermore, both architects and engineers though that architecture schools focused too much on design and very little on construction and physics.*"Students in Austria and Switzerland learn more about wood construction" (architect).* Structural engineers recalled wood construction was only taught in association with introductory smaller projects (detached house or carport), while concrete was seen as the only option in larger constructions. *"Concrete dominated during the later years in education" (engineer).*

It was also asserted that general knowledge of wood construction is weak throughout the building sector. One engineer also added that there is now much new wood construction know-how, although older experience-based knowledge necessary. *"We have forgotten much about wood construction during the concrete-era" (engineer).* While architects were claimed to lack general construction knowledge, engineers with thorough know-how in wood were scarce, thus creating a bottleneck for wood in construction. *"Architects often make mistakes in the small design details (engineer)" "It is disconcerting to hear an engineer say: Maybe it can be done in wood, but I don't know how" (architect)*

Although the increased importance of environmental performance was frequently emphasized, some respondents said it was warranted to request more data about environmental properties of different materials.

Frequently used information sources were on-the-job training, colleagues, professional journals and publications, internet, handbooks, software, courses and seminars, information from suppliers (more frequent from non-wood suppliers, though).

Future prospects and desired improvements from suppliers

Depending on cost, most respondents foresee a growth of wood frame building, driven by increasing environmental requirements. However, the main prerequisite for success was that wood frame could present even clearer cost savings than today compared to concrete. ”*The future of wood-building – it's all about the economy” (architect).*

However, this will also depend on whether wood-frame can improve in a number of areas:

- Wood frame must clearly demonstrate that it makes sound business sense compared with concrete and steel.
- Information flows from the construction industry to the wood sector and back needs to be open and function smoothly.
- Improved wood construction approaches should be provided via hassle free building systems.*”Supply systems that fit together – demonstrate intelligent solutions that permit flexible solutions and appropriate span-lengths” (architect).*
- Wood-frame should emphasize aesthetic and visual aspects, making more of its components visible and as a part of the architectural expression.
- Finally, wood-frame suppliers could provide more information about woods' environmental advantages.

Conclusion

Our results can be translated in a number of improvements to increase wood in large-scale construction:

1. Identify the most important criteria for the material selection
2. Identify the market segments where wood is competitive
3. Create strategies to
    a. Enhance the scope of the wood curriculum in university education
    b. Choose appropriate ways (information material, personal contacts, courses) to reach practicing engineers and architects with appropriate information
    c. Tackle the common widespread misconceptions about wood
4. Make wood fashionable, attractive, and challenging for both professions
5. Above all: Address the desired improvements from architects and engineers for
    a. Systems solutions
    b. Support
    c. Information
6. Present objective environmental performance measures on wood

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