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INDUSTRIALIZED TIMBER CONSTRUCTION – CONSTRUCTION MANAGEMENT ASPECTS AND INFLUENCES IN MODULAR TIMBER BUILDING SYSTEMS

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Advancements of recently developed timber products and their application within the prefabrication process in construction industry demand more standardisation and unification of construction management processes. Within the timber industry the prefabrication of modular building units with an optimised prefabrication grade experienced an ascending development over the last decade. Today's methodology is based on a formal concept of realized projects that provides the methods of the production whereas the basic components behind do not change. Especially modern timber construction is mostly suitable for prefabrication, caused by the material specific properties, possibilities in prefabrication and quick assembly time under dry construction circumstances. According to an expert survey undertaken within a research project, the integration of a consistent data workflow in the production process allows a significant shortened construction period and cost reduction. Following these expert interviews timber construction systems with a high percentage of prefabrication are considered to be less expensive than on-site building methods. High productivity combined with excellent quality in short installation periods delivers arguments for best practice examples in construction management of modular timber building systems.

Keywords: Prefabrication grade, Cost reduction, Potentials, Turn-key system, Standardization, Cross laminated timber.

1 INTRODUCTION

Modern timber construction systems are different to the traditional work of carpenters known over the last centuries. This is mainly caused by technical developments in the recent decade as well as the size, complexity and application was extended significantly. Therefore these building systems require further analysis to ensure confidence and settlement within the building market. Although cross laminated timber (CLT) experienced great success it was hardly examined up to now regarding economic aspects and construction management in general. The presented expert survey gives an insight into the current situation of modern timber building systems with a high variety in the grade of prefabrication (Staib 2008). Highly prefabricated 2D- timber elements and 3D-timber modules have a substantial impact on the performance for large scale timber construction systems and its reliability in future in order to originate a leading appropriate building system.

2 PRINCIPLES OF INDUSTRIALIZED CONSTRUCTION

An industrialized building system is the transfer of various industrialized functions from the stationary industry into the decentralized systems of the construction industry. However the word prefabrication is used generally for building in series, building in systems that include production and construction with 2D-elements and 2D- or 3D-modules. Industrialized construction encompasses a production of building elements in an industry setup that is not subject to changes in weather (Girmscheid 2010).

Building in systems often implements the typical building systems of the 1960's with its unification in repetitive multi-storey concrete buildings in middle Europe. To achieve an economical advantage at that time building components were standardized and produced at a high quantity. In contrast the introduction of the principles of lean production the leading production systems were changed completely (Piller 2006).

2.1 Modular Timber Building Systems

The industrialized timber building section, which differentiates significantly from the traditional carpentries through the implementation of automated production and prefabrication methods has been developed constantly by introducing technical developments on the material level as well as computer based manufacturing process over the last decades (Lennartsson 2009).

The types and systems of the industrialized timber construction division range from simple and unready products to semi-finished building elements and turn-key modules. The variety on the market is high and complex as many producers are selling their own systems especially developed for their needs and markets. However the current state of the art in middle Europe in modular timber buildings with a turn-key prefabrication grade up to 95 % does show the possibilities within this building material and potential for a wide range of use. Especially in the case of buildings with a repetitive room arrangement such as hotels, student accommodation and nursing homes with completely prefabricated room-modules done in timber are indicating the high quality in the building sector in middle Europe nowadays.

2.2 Expert Survey on Industrialized Timber Construction

Accurate data and reflections on industrialized building systems with its advantages, constraints and challenges in future are not well investigated especially when it comes to timber construction methods and systems. To generate considerable data an expert survey was conducted from November 2014 to February 2015 (Hintersteininger 2015). Within these experts of various disciplines were interviewed such as architecture and engineering, builders and SME's, public and private investors as well as experts from R&D. The results from this survey where then compared to existing and comparable investigations on these topics to verify the accuracy of the expert statements.

3 PREFABRICATION IN TIMBER CONSTRUCTION

The characteristic of timber as building material dominate the processability and offers therefore a wide range within the prefabrication applications. Partial or entire prefabrication is not clearly defined into depth and often misused for various types of

preassembled elements. Especially during the planning phase a systematic and consequent coordination is required to develop modules with a clear joining technology. Basic grids form the fundamental set out not only for building physics and structural line up but also for the production process and transportation constraints (Staib 2008).

3.1 Significance of Prefabrication in Timber Construction

Compared to international research also the survey undertaken shows that prefabricated building systems offer a constant growth within the upcoming years. Especially in the field of multi-storey residential and commercial buildings as well as intra-urban and inner-city developments industrialized building systems implement great advantages and a prosperous future is illustrated.

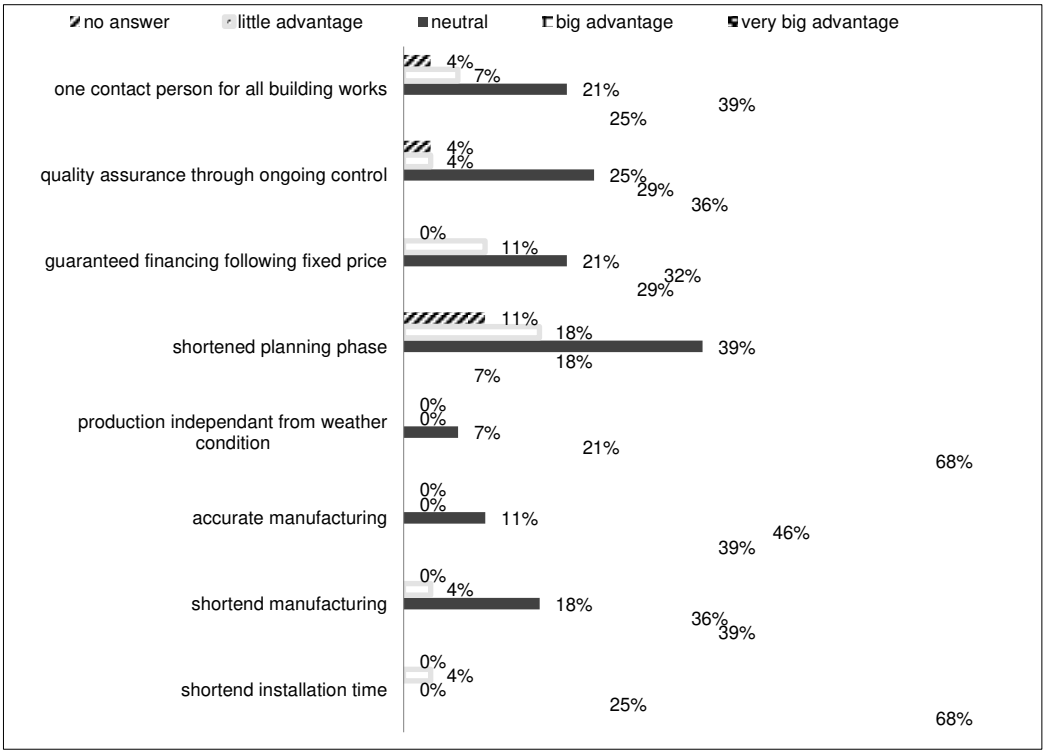

Figure 1. Expert survey advantages of industrialized compared to traditional systems (Hintersteininger 2015).

However the reasons for using industrialized building systems are not related on the material used are diverse. Figure 1 originated through the expert survey shows that especially the quality reasons, lower general building costs on site as well as an easier production under dry and constant conditions do include the greatest advantages for using prefabricated building systems. Accurate production methods as well as fast manufacturing and short installation time on site form the main benefit in implementing more industrialized building systems in the construction industry.

3.2 Criteria Grade of Finishing Works

The grade of prefabrication does offer a wide range of interpretation. However there is a big lack of understanding even in specific literature on the economic results generated by the grade of finishing work throughout the prefabrication. Meanwhile the expert survey features a constant increase of the market especially in the case of timber building systems with a deeper prefabrication over the next years (Schnittich 2012). This includes systems using 3D-modules with a high degree of prefabrication as well as 2D-elements with finished surfaces internally as well as externally.

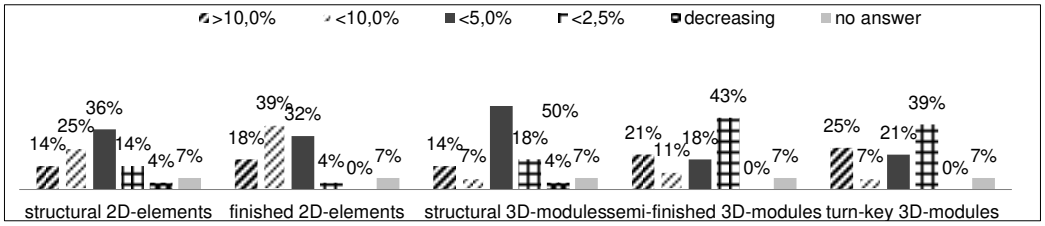

Figure 2. Expert survey market development of industrialized timber building systems depending on the grade of finishing works (Hintersteininger 2015).

4 CONSTRUCTION MANAGEMENT ASPECTS

Within the big variety of products and manufacturing process general construction management aspects such as modularity, turn-key building systems, comparable cost calculation schemes, adequate integral planning tools as well as the ongoing discussion on the topic of interfaces on trades have the advantage to allow the development of timber from a simple product level to a system level within the construction industry.

4.1 Modularity in Timber Construction

Building systems are always generated by a set up and combination of 2D-elements and 3D-modules. Various impact factors have the opportunity to develop traditional building components into industrialized building systems without losing the advantages and significance of the individual tasks but generating a bigger benefit by an intelligent combination of the planning and production factors (Rinas 2011).

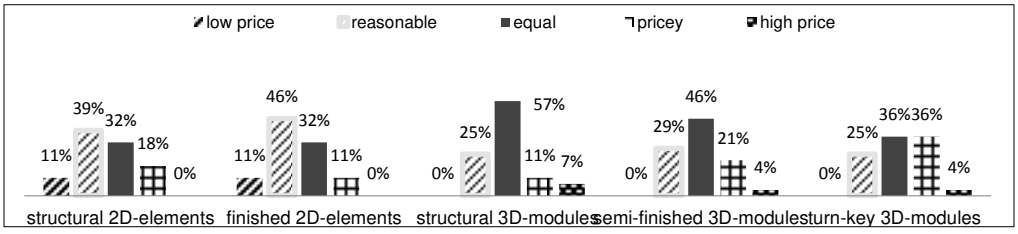

Figure 3. Expert survey cost comparison of traditional to industrialized building systems Hintersteininger 2015).

This can be spotted in the expert survey by identifying the cost influence and chance using a higher grade of prefabrication within the finishing works. So the expert

opinion offers a fast benefit when using prefabricated 2D-elements and 3D-modules; however finalized turn-key 3D-modules are still indicated with higher costs but with a very large opportunity in the coming years.

4.2 Planning in Modular Timber Building Systems

When it comes to the discussion of planning systems, level of detail and simple questions of who is responsible for developing which detail and drawing, not only the timber industry has the discussion on responsibilities. However as various timber products have been developed recently, a lack of knowledge does appear not only when it comes to construction but especially during the planning stage. Therefore a majority of current timber buildings are designed by specialized often in-house timber industry planners as the general planning community with a standard education and training on conventional building systems cannot comply the level of detail required for an appropriate timber solution. This offers the chance for the planning industry to develop new and simple integral planning systems on one hand with a big market development in the future. But on the other hand a large variety of new materials, construction systems, details in connection and building physics and new timber building systems contain the risk of failure by incorporating too much variability for simple planning tasks. More complexity in 3D-systems has an exorbitant higher risk when used. Therefore the implementation of integral planning systems such as building information modeling (BIM) is needed for the entire timber construction industry in future (Girmscheid *et al.* 2010).

4.3 Interfaces – Materials – Building Systems

The increase in complexity in the construction industry has a major impact also on the timber building systems. Especially the fact that recently developed building materials and products have a low level of trial and error and impound a big risk when implemented in today's building systems. The number of interfaces increased over the last decades exorbitant as numerous trades and business urge into the construction market. The level of detail is much higher than 10 years ago where many details could be solved on site when the question of how a new systems should be include in conventional building solution didn't even exist. Nowadays complex CAD-CAM combined systems do offer the chance to reduce the risk of failing by too many interfaces. Just-in-time deliveries of products and systems which need to be implemented in standard structural elements do offer a big chance especially cost wise and the majority of costs nowadays are generated by building services engineering instead of structural components (Koppelhuber *et al.* 2015).

5 POTENTIALS AND TENDENCY

The high potential of timber construction building systems can clearly be spotted in the short period of installation required on site in comparison to conventional building systems. Especially prefabricated 2D-elements and 3D-modules deliver arguments for the wider use of timber as the main structural material even though the cost impacts are not commonly used as arguments as they are hardly quantifiable and ratable.

5.1 Potentials of Prefabrication

Although timber construction has a high potential for pioneering tasks especially when implementing turnkey strategies transforming the advantages into an integral building systems (Rinas 2011), the successful way over the last years of this building material can be extended further as also the expert survey covers these facts. Effort is required not only in the technical and material sector but also in the building economic domains.

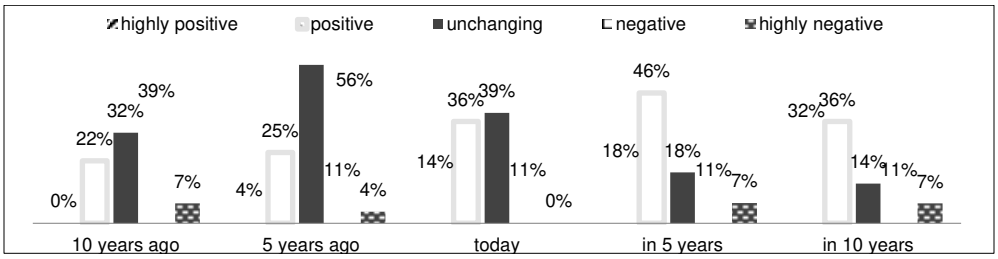

Figure 4. Expert survey potential of modular timber building systems (Hintersteininger 2015).

Particularly for achieving a higher planning reliability and better quality assurance a standardization of building components as well as system components in general are required and the planning and management process needs to be more professionalized.

In addition the rising demand makes the development of a comprehensive prefabricated timber construction system, as well as neutral cost studies of the effects of an industrialized construction and adaptation of building regulations mandatory. It can create another step towards industrialization in the building industry by implementing turn-key concepts to create meaningful construction management tools to allow ecological friendly material to become a widely used standardized building system.

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