THE ECONOMY OF SPEED IN CONSTRUCTION PROJECTS

1. WHY HURRY?

1.1 Growing urban needs

The world around us is evolving rapidly. Every day there are around 90,000 people more [1]. Each day more people move into cities and by 2050 around 66% percent of us will live in urban areas [2]. As a result, cities are growing at an increasing rate. The urban land area is estimated to triple from 2000 to 2030 [3]. As new buildings are being constructed, the needs for improving the sustainability of the existing building stock increase.

How the world´s largest and fastest growing cities are being built is critical to human wellbeing, economic growth and climate. It has been estimated that the next 15 years will be crucial in this development, as the global economy will experience a deep structural transformation from a fossil-based to a renewable economy [4]. Also, investments in infrastructure are expected to double within this period [5]. Because of the fast speed of global development, time is of the essence in meeting the needs of our rapidly urbanising planet in a sustainable manner. We need novel solutions for meeting these needs in the construction sector.

Improving efficacy in the use of resources is at the core of both economic growth and sustainable development. In the following article, we will take a look at how materials, capital, human labour and knowledge can be utilised in a sustainable way for building a better future.

1.2 A lean approach to construction

In most industries, lean manufacturing has become a path to meeting the changing needs of our societies in an agile manner. In the building sector, “lean construction” can be understood as improving the construction process with minimum costs, while simultaneously maximising the value by considering the needs of the clients [6]. Such an improvement is based on collaboration between the stakeholders of the project to a greater extent than contractually required.

The lean approach may cover design, production, supply and assembly phases of the construction project. The reports on the benefits of lean construction are convincing: In a study of companies that have applied lean construction methods, 84% report higher quality in construction, 80% experienced better customer satisfaction, 77% benefited from greater productivity, 77% from improved safety and 58% experienced reduced project schedules [7]. Thus, a body of evidence suggests that lean construction holds potential for meeting global needs that the construction sector faces. It also seems to be a path to building faster without unproductive delays.

1.3 Reasons for delays

Building construction projects play an important role in the economic and social development of our societies. Despite this, construction projects are often finished late and, in addition, they generate lots of waste [8], cause significant amounts of greenhouse gas emissions [9] and often lead to claims [10]. These decrease the productivity of the construction sector. Thus, there are several good rationales for improving the performance of construction.

Several reasons may delay construction projects. Weather, poor activity planning or coordination, inappropriate work methodology, lack of supervision, problems in material supply, equipment failures,

design changes, poor performance of sub-contractors, cash flow problems, permit problems or unexpected archaeological or wartime findings in the ground are among the typical causes for delays [11] [12]. Weather-related delays in particular are causing great and often unexpected problems to building construction. These delays are expected to increase in the future, as extreme weather events are becoming more frequent due to the changing climate [13]. The most common causes for delays depend on the building type and building area. However, weather, insufficient design documents, inadequate coordination and financial problems are very frequent [11] [12].

It has been known for a long time that if delays are compared to budget over-runs, the former play a much greater role in the profitability of the construction project. A commercial construction project that over-runs its budget by 50% but is finished in time, earns only 4% less than the one that keeps both schedule and budget. On the contrary, if a construction project stays in budget but exceeds its schedule by half a year, its earnings may drop as much as 33% [14]. Furthermore, of various criteria for defining whether a construction project has been successful or not, time performance has been identified to be the most important, leaving behind also cost and quality performance [15]. These findings suggest that genuine advantages can be found in a fast building process.

2. ADDING PACE AT THE BUILDING SITE

2.1 Essentials for building fast

In order to keep the pace of construction at the desired level, certain pre-requisites have to be met. The essential ingredients of success include standardised building methods, prefabricated building elements and optimised construction design management.

Prefabrication itself is an old method, but its current renaissance can be traced to the rise of Building Information Modelling (BIM), green building trends and quality concerns in construction. The advantages of prefabrication are clear, as concluded in a study [16] by McGraw Hill in which hundreds of design and construction professionals were interviewed. They reported that 66% of projects that used prefabricated products had shorter schedules, 65% had decreased budgets and 77% reported less waste on the construction site. In addition, when the construction work takes place in controlled indoor conditions at the prefabrication site, there is less risk of accidents and consequent delays at the building site. This follows the principle of substituting a potentially dangerous work phase at the construction site [17]. For example, assembling prefabricated roof elements can replace the potentially more dangerous process of having to build a roof from beams, panels and bitumen at height on an unfinished building.

In order to make the building process smooth, prefabricated elements need to be delivered just in time. Modularity and standardised details improve the assembly process. The features of Kerto prefabricated roof and floor panels are designed for these requirements.

2.2 Final roof instead of an assembly tent

In the eternal battle against the weather, one of the most important construction phases is to get the roof and weather protection done quickly, in order to enable the next stages of construction to take place without weather-related risks. Today, there are three main alternatives for achieving this: utilisation of prefabricated volumetric units, building under a tent or applying fast construction methods. Volumetric units are suitable for modular construction, in which spans and spaces remain small. Tents are used for a number of construction projects, especially for multi-storey wooden buildings. They provide good weather protection, but are an additional cost.

Fast construction systems, such as Kerto roof panels, are based on the concept of erecting the roof from prefabricated modular roof elements very rapidly. Kerto roof panels include the final roofing and thermal insulation. This way, they may provide the building site beneath far better weather protection than tents, especially when it comes to enduring wind and snow loads. This is not slower than erecting a temporary shelter, as up to 1000 m^2 of Kerto roof panels can be assembled within a single working day.

For example, Kerto roof elements used at the logistics centre of DB Schenker, Finland could provide a roof over the entire building in just 15 days [18], which is the same time that erecting a temporary tent would have required [19]. Using prefabricated roof panels ensured that the rest of the work could be completed in a protected environment and without additional costs for temporary protection. A similar example of rapid building can be found from the headquarters of the Diesel-Benelux Company in Amsterdam. An extremely tight building schedule of only 9 months resulted in choosing Kerto roof panels under which the rest of the construction work could be finished on time.

3. ENHANCING THE SPEED AND QUALITY OF DESIGN

3.1 The importance of the concept and design phase

The early operative stages of the project are those in which most of the quality and value of the project can be ensured or lost. One of the paths towards better value and quality is to apply modular design, standardisation and prefabrication in construction projects [5], as these both time and costs.

Fast design is a two-edged sword. On the other hand, the design agency may benefit from shorter design times as more projects can be handled per designer per year. On the other hand, hurry leads too often to design mistakes, which are a significant cause of delays at the prefabrication lines and building sites. Thus, when accelerating the speed of design, one must pay careful attention to quality as well.

The design process has typically been considered to be the “Achilles’ heel” of industrial wood construction. This is often due to the fact that most buildings are designed from concrete or steel and thus the design expertise for wooden buildings does not accumulate to similar levels. This can be seen in the concerns of some structural designers who comment that designing wooden multi-storey buildings would require up to 50% more work than the design of a conventional, standardised sandwich-panel concrete building [20, p. 40]. Furthermore, the amount of details in wooden multi-storey buildings is perceived to be higher than in comparable concrete buildings [20, p. 150]. To overcome these issues, tighter collaboration between different designers and use of building information models (BIM) has been proposed. The role of the leading architect is often seen to be the most crucial for ensuring a successful outcome.

Design itself is not fundamentally difficult. What seems to cause the problems is an insufficient flow of information between the client, constructor, authorities and various design agencies that collaborate on the same project. One way to decrease these problems is to utilise “prefabrication” in design as well. Instead of developing the designs from scratch each time, certain predesigned components can be utilised. These speed up the process and may eliminate mistakes.

3.2 Tools and data for fast design

To enhance the design process, design tools and objects for BIM design are essential. In order to get the most out of Metsä Wood´s modular building products, designers are provided with tools that help and improve the design process. Many of Metsä Wood´s engineered wood products and wooden elements are available as BIM objects, which make the design easy. In addition to these basics, a suite of comprehensive software has been developed for supporting the structural design.

Finnwood software helps architects or engineers to calculate the structural dimensions of floor joists, roof beams and columns made from Metsä Wood´s glulam, engineered wood products or LVL. Compatible with Eurocode 5, the software produces a clear documentation of the structural calculations required for the wooden parts of the building project.

Finnframe software is built on supporting the design of engineered wooden joists. The application follows both European and British standards. Once the structural concept of the building has been decided, floorplans can be converted into exact structural and assembly drawings with Finnframe. In addition, a concise bill of quantities is compiled. For improving resource efficiency, the software also optimises cuts of the joists so that losses are minimal.

Several calculator tools are also available for Metsä Wood´s wood products. These applications enable the designer or constructor to specify the required amounts of materials for e.g. decking, flooring and cladding. Such pragmatic tools enable developing both prefabrication mills and building sites towards “zero waste” goals.

In addition to software, product specifications and documentation are also needed for keeping the design process going without delays. Metsä Wood´s Environmental Product Declarations give fundamental information about the environmental performance of Kerto LVL products. Such data make it possible to meet the documentation demands of green public procurement in advanced markets.

4. FASTER BUILDING PROJECTS LEAD TO FASTER REVENUE

4.1 Increasing the profitability of construction project

Compared to manufacturing industries, the construction sector is still suffering from poor profitability. The average revenues of manufacturing companies have risen steadily from 1990s, whereas the productivity of construction companies has stayed flat or even declined. McKinsey reports [5] that the productivity gap between these two industries is currently already 1.7-fold. However, as construction companies are typically operating with thin profit margins, even relatively small reductions in costs can cause significant positive impacts. A cure for this can be found in raising the degree of prefabrication. Saving money and time are, according to McGraw Hill report [16], the main drivers for increasing the future use of prefabrication and modularisation.

Every building project usually begins with the selection of the site. As a result of the rapid urbanisation rate of most countries, land prices have been steadily rising in most growth centres where construction is active. When a plot of land is purchased, the period from making the investment until a building can be taken into its designed can be seen as a journey through “the valley of death”. The shorter the journey, the quicker the return on investment will become. Depending on investment rates, different degrees of prefabrication may pay off, even if their prices would be higher than those of building on site.

4.2 Adding competence and social revenue through lean methods

The performance of a construction project can also be measured through its social impacts. Prefabricated elements may help in this quest as well. Examples of increased social revenue include less loading on the neighbourhood and healthier companies.

Fast building with prefabricated wooden elements leads to shorter construction times and less annoyance for the neighbourhood. The former is perhaps self-evident, but the latter benefit should not be overlooked either. As our cities grow both larger and denser, the loadings of a single construction project will increase. There will be more of the city zone to cross for the logistics and more people working and living next to the

building site. In addition, social acceptance in the building permission process can become one of the strengths of light-weight and modular wood construction.

The healthy economic status of companies is another social benefit. This is highly important in the construction sector, where companies have shorter average lifespans than in other industrial sectors. Healthy and productive companies may generate tax income and thus play an important role in the economic well-being of the societies.

Wooden modular building products can play a part in this development. For example, in Sweden the lean approach to managing prefabricated house factories was found to hold a potential for boosting their productivity from 10.3% to staggering 230% [21]. In this case, facility layout and stock management were of key importance. Experience from Metsä Wood´s client Kannustalo, an industrial house manufacturer in Finland, shows that the just-in-time deliveries of Kerto LVL products and their high dimensional accuracy have cut down the need for storing building products on construction sites [22]. This has indeed brought direct savings and helped to improve the profitability of the company.

5. THE ECONOMY OF SPEED

Taken together, both scientific and practical findings suggest that avoiding delays may significantly improve the profitability of building construction projects. Furthermore, faster building may reduce loading on the neighbourhood and shorten payback times of investments.

Perhaps the greatest potential for improving building times and quality simultaneously lies in smart shortcuts in a construction process. Such include, for instance, replacing the weather protection tent with a permanent roof. This benefit is especially suitable for projects that are large in scale and where the collaboration of several construction teams is desired and where short construction times are aimed at. Similar shortcuts can be found in the use of advanced design tools that are built on the modularisation and prefabrication of building elements. These key aspects seem to reduce design times and risks for design mistakes at the same time.

Wooden modular building elements that are accompanied by strong design documentation and tools offer a promising range of solutions for building better buildings with better profitability. With faster revenue, shorter building time and easier design, we may meet the rapidly growing needs of urban construction and sustainability demands at the same time. As discussed in the beginning, the next 15 years will be crucial for setting the mankind into a sustainable path towards future. This requires building solutions that are not only environmentally friendly, but also bring added value in the fields of economic and social sustainability. Highly engineered wood products, such as LVL-based modular elements, can provide a short cut to a better built environment of the future.

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