Industrial bridge building- An effective bridge construction process through an integrated design and construction process

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ABSTRACT

This PhD-project aims to develop and industrialise bridge building, in order to achieve a more efficient and sustainable bridge construction process. The advancements of several key areas - materials science and technology, design and analysis methods, production techniques and information and communication technology - have resulted in a vast potential to rationalise the process and renew the designer's role. Initially, the project will define effective bridge construction criteria's by means of interviews and case-studies. The work should result in an integrated design and production process. This project is a collaborative project, involving: Swedish Transport Administration, WSP and Chalmers.

Keywords: Industrial bridge construction, sustainable, efficient process, structural design

1. BACKGROUND

An effective building industry creates possibilities for an increased value for society, i.e. the same or higher quality to a lower price or a higher quality from the same costs as today. Furthermore, an effective building industry should of course not only consider costs; solutions should also be chosen from the view of a sustainable society. The solutions can range from process to details, but the leading character should relate to productivity and innovation. The productivity in the building industry is lagging behind other industries. This is evidenced by increasing costs and lead time (time for planning and execution of a building project). A market driven innovation is lacking because of deficient incentives, insufficient competiveness and because demands of quality and function are not clearly formulated. The main client in Sweden is the Swedish Transport Administration, which thereby has a unique position that influences the productivity and innovation capacity of the building industry.

Poor productivity and innovation capacity of the building industry leads to misused investments in new bridges. The investments are mainly misused due to non-integrated design and production processes and long lead-time for both planning and execution of projects. In addition to less value for invested money, the ineffectiveness causes disturbance for stakeholders in society.

Productiveness and innovations are clearly related and will never reach a final state. Instead a continuous development of the processes, methods and products of the building market is needed. A development that should incorporate the advancements of other areas such as: materials science and technology, design and analysis methods, production techniques, as well as the rapid development in information and communication technology.

If an effective and sustainable bridge building process was clearly defined, a design process that combines aspects of structural resistance and production can be developed and integrated into the building process. This new design process should include the above mentioned advancements and consider already established innovations.

2. PURPOSE AND AIM

The purpose of this project is to develop and make bridge building more effective where the general requirements not only define an effective and sustainable building process, but also includes an innovative design process that combines aspects from structural and production points of views.

The overall aim is to make the bridge building process more effective by integration of the structural design process and the bridge production process. This will be achieved by fulfilment of the following objectives:

- Derive criteria’s that defines an effective and sustainable bridge building process.
- Study the system of communication in the building process where the use of Building Information Modelling (BIM) is especially interesting.
- Study and develop the structural design process to promote technical innovations and information modelling.
- Disseminate the results continuously in order to get feedback from researchers and industry and to generate impact on the Swedish Transport Administration and industry.

3. STATE OF THE ART OF SWEDISH RESEARCH ON EFFECTIVE BRIDGE CONSTRUCTION

In the last decade or two, industrial production has shifted its focus from being generally connected with mass production towards increased customer value through adopting the philosophies of Lean production. Mass production is a concept that never been suited to bridges and this shift in focus has therefore enabled a large amount of industrial concepts to be adopted for industrial bridge construction.

Frequently mentioned techniques and methods that characterize industrial construction are standardisation, modularisation, prefabrication or off-site fabrication, as well as on-site fabrication, pre-assembly, mechanisation, automation and the use of different building systems. Many of these techniques and methods, if not all, can be applied in bridge construction. And of course, the goals to generate products at low cost, to produce higher quality products at the same cost and to reduce the overall construction time while maintaining the quality and environmental requirements are applicable also to industrial bridge construction.

It also can be seen in Swedish literature that the perception of the term industrialized building can vary between different authors. Not seldom, industrialization is mentioned as the solution to the lack of productivity in the construction industry, but still it may not be clear to the industry what the terms of industrialization and industrialized construction actually represents.

Some research argues that industrial development is reached mainly through modernising of traditional construction methods (industrialization) while other argues that it is reached by developing new methods or materials from scratch (industrial construction approach). Of course, there are also those who mean that it is more a question of the distinction between pre-fabrication and construction on-site and its degree of industrialisation, and states that there is no difference between the two mentioned approaches.

There can also be found agreement within the industry. One is that there are a lot of different actors, components and parties involved and that industrial construction clearly are multi-disciplinary. In such a multi-disciplinary environment, information- and communication technology (ICT) plays a key-role to generate the possibility to work efficiently within and in between all the involved disciplines.

Based on the TFV-concept presented by Koskela (2000), which is one comprehensive theory for the construction industry, Harryson (2002) presented three cornerstones of industrial bridge construction which was identified as process development, productivity development and product development, the three P's. Serving as the natural link and generating a continuous circle of development between the three P's is ICT. The rapid progress of development and increased knowledge about the use and strategies about how to implement the use of ICT/BIM into industrial construction, this might be the single most important factor for developing new and successful industrial concepts.

Resent research at Luleå University of Technology presents two strategies that normally are undertaken to minimize the complexity of construction, which are standardization of products and standardization of processes, Larson et al (2013). It is also stated that it have been proved difficult to achieve standardization in both due to the lack of utilising the experiences and innovative ideas from contractors in early stages of design. Some core elements to support standardization and increase the industrialization of infrastructure construction is identified in the article, and also some barriers and its actors which has the power to eliminate them. Many of the core elements which are identified are related to long term actions, such as processes, rather than short term actions, such as projects. Here, integration between design and production is

identified as one of the five largest core elements. Notably, and very interestingly, three out of the five largest perceived barriers is considered to be able to be eliminated by the client's role.

4. SCIENTIFIC APPROACH

To meet the specified objectives, the scientific approach will include: literature review of several related research areas; qualitative studies, such as observing projects of best practice; quantitative studies, such as studying the processes of today; and using case studies for deriving research questions and develop show cases.

5. EXPECTED OUTCOME

The project should result in an innovative bridge building process that:

- decrease the time used for planning and production,
- includes information and communication technologies,
- facilitates a continuous improvement of productiveness, product development and innovation,
- creates incitement for an industrial driven productiveness, product development and innovation,
- and creates incitement for the industry to develop standards and modular thinking of products.

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