

INDUSTRIAL DRIVEN STUDENT RESEARCH; A CASE STUDY ON THE POTENTIAL FOR INDUSTRIALISING CONSTRUCTION OF BRIDGES

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ABSTRACT

The paper is based on our master project (30 ECTS) which was completed during spring 2017. We concluded that there is a massive potential for industrialisation of bridge construction, e.g. through the knowledge that there are a low number of span widths that is often repeated in the Norwegian highway network. However, the focus of this paper is not the technical content of our project, but how we gained from an R&DI-cooperation between construction industry and the university. The scope of this cooperation was to investigate the practice and potential of industrialising bridge construction. The master project was an initial demonstration of the potential for mutual benefit from an agreement on R&DI, entered between a governmental construction client organisation and the University of Agder. The outcome of the study was beneficial for industry and construction client and successfully demonstrated potential in cooperation with the university.

Keywords: Industrialising and prefabrication, University-industry R&DI cooperation, Bridge construction

1 INTRODUCTION

Investments in the transport sector are rapidly increasing in Norway. According to the National Transport Plan (NTP) 2018-2029 (Meld. St. 33 (2016–2017)), more than 5.6 billion USD will be invested annually in roads in the period (2018-2029) [1]. Traditionally, there has been one building client in Norway responsible for all national and regional planning and building of roads; the National Public Road Administration (NPRA). However, one of the reforms in NTP was to establish a highway construction company, called Nye Veier AS (NV). The company is a limited liability company, owned by the government. NV will be responsible for planning, construction, operation and maintenance of 530 km of main road network [1]. NV has been given the societal mission to build national roads more efficient and effective. One way of doing this is to use more standardised solutions. Standardisation in bridge constructions is currently not being utilised much in the Norwegian road building industry compared to the rest of the construction industry and road construction abroad. One-of-a-kind design and on-site production dominate the industry. Therefore, standardisation of procedures, solutions, and products for road constructions is now a prioritised area, for NV to build more efficient road constructions.

University of Agder (UiA) has recently entered agreements with NV, covering responsibility for education and R&DI. As part of the R&DI cooperation, four industry-academy-reference groups have been established. The topic for one of these is “industrialising and prefabrication”. The potential of prefabrication to increase efficiency in construction of bridges is debatable. However, the potential for reducing socioeconomic costs during erection is obvious. Nevertheless, practice for using prefabricated bridges in Norway is scarce. Construction clients, designers, and construction companies alike are seeking to explain the scarce use and searching for possible benefits of prefabrication.

Our master thesis has its basis in the R&DI-cooperation between NV and the university. To demonstrate the potential for mutual benefit from the recently entered R&DI agreement, the topic “industrialising of bridge constructions” was chosen for a master project [2]. The main research question was: “How can standardisation promote industrialisation of bridge construction?” The strategy for answering this question comprised several steps, including mapping state of the art

through the national database for bridges (BRUTUS) and interviewing stakeholders from construction clients, designers and construction companies.

This paper aims to describe how the industry has facilitated an R&DI-cooperation with the university, with the objective to investigate the practice and potential of industrialising bridge construction.

2 METHODS

The working strategy of the cooperation between UiA and NV is to involve stakeholders from the industry and other actors, to facilitate innovation.

The method chapter is divided into two parts:

- 1) How the industry has facilitated an R&DI-cooperation with the university
- 2) The methods used in our master project for investigating the practice and potential of industrialising bridge construction.

Methods used in the project are shown in Figure 1.



Figure 1. Methods used in the master project

2.1 R&DI-cooperation between the university and Nye Veier

A working strategy in the R&DI-cooperation between NV and the university was to involve large parts of the construction industry, to facilitate innovation. Four months after entering the agreement, more than 150 representatives from the industry and various academic institutions, participated in start-up workshops. Students and Ph.D. fellows contributed in these activities. Based on this cooperation the innovation cooperation has been divided into four different focus areas (Figure 2): Industrialisation, environmental impact, implementation strategies and digitalisation.

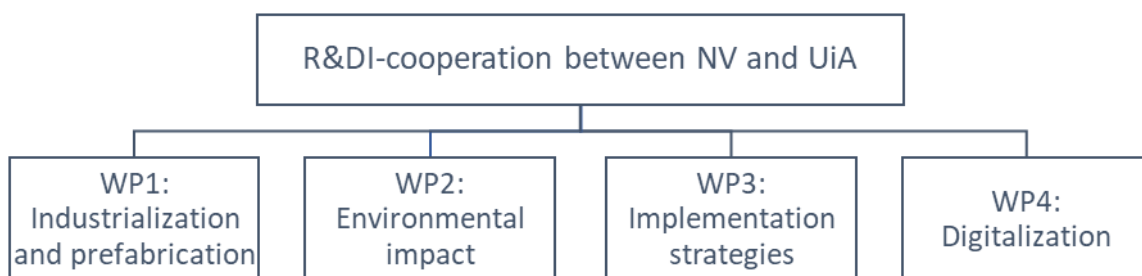


Figure 2. Focus areas of the R&DI-cooperation agreement between with the university and Nye Veier

This master project was part of “industrialisation and prefabrication”. The cooperation had large impact on the research question and design of the project. The thesis was relevant for two of the start-up workshops. For each of the focus areas, industry-academy-reference groups have been established. The industry-academy-reference groups consist of members from NV, UiA and competing companies from the construction industry, with an aim to increase and facilitate R&DI projects. As part of our master thesis, we were invited to join these meetings. A master thesis often has industrial supervisors from single companies; however, a panel of supervisors is not used frequently. Participants of the industrial panels and participants at the workshops were used as sources of information in the project.

2.2 Investigating the practice and potential of industrialising bridge construction

One method for acquiring knowledge to answer the research question was to collect data for the current bridges in Norway. This was done through a governmental database for bridges (BRUTUS). Two national roads (total 450 km) were chosen as representative for highways in Norway. During the analysis, approximately 700 bridges were analysed, considering length, construction year, longest span length and number of spans.

Another method for acquiring knowledge to answer the research question was to interview stakeholders from the construction industry. We questioned these industry specialists on what they thought the main obstacles towards more widespread use of standardised bridge constructions were. To gain this knowledge we organised in-depth interviews by a descriptive and exploratory survey, according to Jacobsen [3]. Ten representatives from the value chain in bridge construction were interviewed, including building-clients, contractors and consulting engineering companies. All interviews followed an interview guide with the same themes and questions. 8 out of ten interviews were done face-to-face, and two were done via Skype. All interviews were recorded and later transcribed.

After transcribing the interviews, the data was further analysed using the qualitative data analysis programme NVivo. The data was categorised for comparison and analysis, i.e. first-cycle-coding [3]. After organising the data consequently, it was easy to identify important findings within the different categories. The social sciences usually pursue a causal connection at this point in the investigation. Although this could have been an interesting investigation, this was not done in our project, as the main focus was to gather information from a wide range of sources.

Conclusively, a method for gaining knowledge was through a study travel, organised by The Norwegian Precast Concrete Association. This is an independent industry association for manufacturers of precast elements. The aim was to explore planning, production, construction and use of precast elements in Denmark and the Netherlands. The Norwegian participants were from different parts of the construction industry; building-clients, contractors and consulting engineering companies.

3 RESULTS AND DISCUSSION

3.1 Industrial R&DI-cooperation

The workshops were unique in the way that they gathered the entire supply chain from client to contractor. The reference group directed the workshop and challenged the industry to discuss possible solutions to problems identified by the reference group. In this way, consultants, contractors and suppliers could discuss new solutions and technologies with designers and clients. Also, these suppliers could inform clients and designers about challenges with solutions being used today. This way, actors in the value chain can learn from each other, possibly choosing more optimal solutions, rather than blindly ordering well-known products from previous projects.

By participating in these workshops, we got a clear view of the supply chain in road constructions and a broader perspective on the challenges in road construction. The workshop participants were also the pool from where we selected the respondents for our interviews.

We participated in the reference group for industrialisation and prefabrication (WP1). Our research question was a direct result of the discussion in these meetings, as we got a good insight into what the collective industry saw as challenges towards increased use of standardisation and prefabrication. Having dialogue with representatives from the whole value chain helped us get insights in the industry challenges, before conducting any further research. This close contact with the industry also helped shape our thesis more effectively than we would have been able to do on our own. Besides, the gap between the industry and academics was shortened, conclusively making our thesis highly relevant to the industry. One result from our work that has drawn massive interest is a figure illustrating the frequency of often repeated span lengths for bridges in the Norwegian highway network (Figure 3). The importance of this relevance has later been emphasised by several building clients and industrial companies requesting separate presentations of our work.

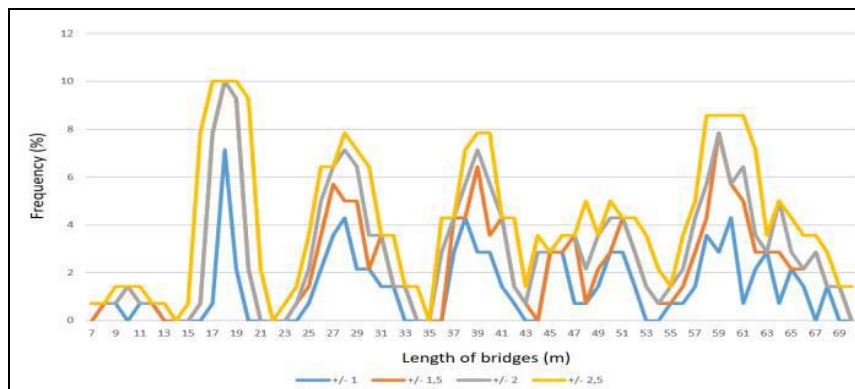


Figure 3. Frequency of often repeated span lengths for bridges in the Norwegian highway network [2]

The mentioned shaping of the thesis can also have a backside. As students, we look to the industry for answers. In such close cooperation, it may be difficult to challenge some of the “established truths” present in the industry. This may lead to reproduction of “old truths”, rather than innovation.

Responsible for conducting meetings and discussions between relevant participants, was a university employee, who was until recently architect and leader of the industrial cluster NODE and formerly leader of several industrial companies. Having more than 40 years of experience from working in and with the industry, the facilitator had no problem challenging established truths, and in this way helped shaping our thesis.

The R&DI-cooperation between NV, UiA and the industry aims to help NV in their societal goal of building more roads more effectively. Therefore, the focus of the workshops and reference groups is mainly solutions readily available and affordable, rather than technologically advanced and expensive. This excludes a lot of possible research directions for the thesis.

3.2 Interviews and study travel

The interviews were conducted as semi-structured interviews, where the respondents got to influence how much emphasis was put on each topic. Our job was mainly to ensure that all topics in our interview guide were covered during the one-hour long interview. This approach gave us a good insight as to what each of the respondents considered important. However, letting the respondents guide the interviews like this made it more challenging to compare answers from one respondent to the next. This was an acceptable trade-off, as the objective of the thesis was not to compare individuals or groups, but to gather as much information as possible from a wide range of sources.

A preferred method amongst engineers for gathering data is often through quantitative analysis where responses or measurements can be quantified and compared. Using a qualitative method in our thesis involved learning how to conduct qualitative investigations. This method was suggested by the reference group as a way of establishing state of the art knowledge from the industry. However, the reference group considered interviews as a relatively easy way to gather information. This is not the case when this information should be used for academic purposes, as it involves preparation and post-processing of the interview. The interview itself takes very little time compared to preparation and analysis, and this was not obvious to the reference group.

The thesis benefitted greatly from these interviews. The respondents had 225 years of experience all together, giving us a huge amount of relevant information during a short period. The experiences and opinions of the respondents would not have been possible to reveal from a literature study.

The study trip arranged by The Norwegian Precast Concrete Association attracted participants representing large parts of the value chain in road constructions in addition to us. The trip allowed for informal discussions between students and the industry representatives and gave us in-depth understanding on how the industry viewed industrialisation and prefabrication. Also, we got to observe solutions and principles applied in bridge construction in the Netherlands and Denmark first hand. We could, in turn, present these solutions to suppliers and clients upon our return to Norway.

The trip took place in the late stages of our thesis. This had some pros and cons. The benefit of participating in the trip late in the thesis was that we already had an understanding of some of the issues connected with prefabrication and industrialisation of bridges. In this way, we were able to engage in meaningful discussions with the other participants. However, much of what we learned

during the trip would have been interesting to discuss in our formal interviews and investigated further the adaptation of technology and principles to Norwegian conditions.

The fact that the trip was arranged by The Norwegian Precast Concrete Association indicates that the participants were somewhat biased towards the benefits of using precast elements in bridge construction. This needed to be taken into account when reviewing the trip as this could bias our thesis.

Being able to write our thesis in close cooperation with the industry, gave us a lot of benefits and opportunities. The threshold for getting help and guidance was low, and the thesis became highly relevant to the challenges the industry faces today. The close cooperation and communication also made the industry and its representatives more aware of the challenges and possible solutions presented in the thesis. Doing a master thesis in this fashion gave us a large network from where we obtained information, and the network can also be used for questions in the future. By showing our commitment to the industry through both the thesis itself and participation in reference groups, we were taken seriously when communicating with the industry. Quite a few of the industry representatives have later used our thesis in their discussions, and it has even united competing companies in finding good solutions to common industrial problems.

3.3 Outcome

When the results were presented to the industry-academy-reference group responsible for “industrialising and prefabrication”, it received massive interest and a professional dispute between the different industrial representatives. The national construction client organisation for railways, has requested (and received) a separate presentation, and are now searching cooperation with our university. In addition to the professional interests drawn to the research question, the thesis successfully demonstrated the potential for mutual benefits from cooperation on R&DI between university and industry. Less than a year after entering the agreement with NV, substantial results have been achieved for the engineering education. A 4 million USD research project has been established, including several Ph.D. projects, where one is succeeding our master thesis. The project is called MEERC (More Environmental friendly and Efficient Road Constructions) and is supported by the Research Council of Norway (NFR) [4].

This spring (2018) 34 bachelors and master students in civil engineering, industrial economy and renewable energy perform their thesis as part of the MEERC project. All projects have been forwarded by the industry, concerning relevant issues within road construction. All students within these projects are supervised by one or more of the members from the relevant industry-academy-reference group. Additionally, workshops are frequently held to facilitate more interaction and innovation. This is done by inviting all industry-academy-reference group members to cooperate with students on their projects. Already, one workshop has been held, where the students and 20 participants from the industry met and discussed the bachelor and master projects. The aim was to make the research questions for all projects as relevant as possible for industry and contribute to more efficient and environmentally friendly road constructions.

Hence, our cooperation successfully demonstrates the potential for pursuing diversity under the governmental quality assurance system, known to promote conformity in education.

4 CONCLUSIONS

Our master project demonstrates that:

- 1) There is a big potential for mutual benefits from cooperation on R&DI between the university and the construction industry.
- 2) Industrial involvement in a master project might be highly relevant and gaining for the constructional value chain.
- 3) Even our student assignment was considered so relevant, that it was made predecessor to a Ph.D. project in a 4 mill USD research project (MEERC).
- 4) The method of using plenars from the industry-academy-reference group to develop relevant projects and to use all industrial representatives as common supervisor pool, has been so successful that it has been reused in spring (2018). This year, this procedure includes 34 bachelor and master students.

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