TECHNICAL UNIVERSITY OF DENMARK
MSc Civil Engineering / Architectural Engineering

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Advanced Building Information Modeling (BIM)
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Assignment 3

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1. Introduction

It is more expensive to repair something poorly done in engineering rather than doing it properly in the first place. It is also a case for challenging construction projects since by the nature of the industry almost all the productions are unique in their own right, even though designs are applied multiple times and they need to comply with the same rules. Promising warranty for a predetermined time is also seen in the construction industry. Under the light of all these, coming up with certain quality standard is essential for contractors. Quality comes with trade offs such as cost, time and constructability.

Constructability or buildability refer to applicability of the project as a blueprint form to the construction site. The production quality of the sites are restrained by the capacity and experience of the construction teams. Attention given to the work is also a factor for buildability. A work can be realized more coarsely but quickly and cost effectively or more meticulously but costly and slowly. Inevitably, meticulous works return better quality hence effecting the actual structural strength and integrity of the building. Other side of the medallion is the fact that construction is a commercial activity by profit driven establishments which need to deliver the projects at desired quality but as fast as possible and as cost effective as possible which doesn't go hand in hand with the upmost quality.

Design process in construction contains tons of regulations and norms just like many other sectors which can harm people when they don't produce their products with certain seriousness. Variation in the quality of the end product is a very well-known phenomenon in construction industry. The sector includes safety coefficients dictated by regulations in various forms in the designs, whether increasing the loads or decreasing the strength of the element in calculations. The reason for this approach is the quality loss when the blueprint becomes a solid three-dimensional building in the site. Overdesign during the calculations is a norm to achieve planned strengths in reality because of the losses in the sites.

Construction includes many stages and many parties who are responsible for delivery of these stages. All the steps require different specializations; hence they can't be performed by the same team at the same efficiency. Because of that, general contractors must maintain working with multiple subcontractors and teams. All site workers bring their own buildability and quality trade off. The proposed BIM tool aims to identify a group of bids which satisfies quality requirements of the project but still constructable by choosing one bid for every production stage.

2. Use Case Analysis

2.1.Goal

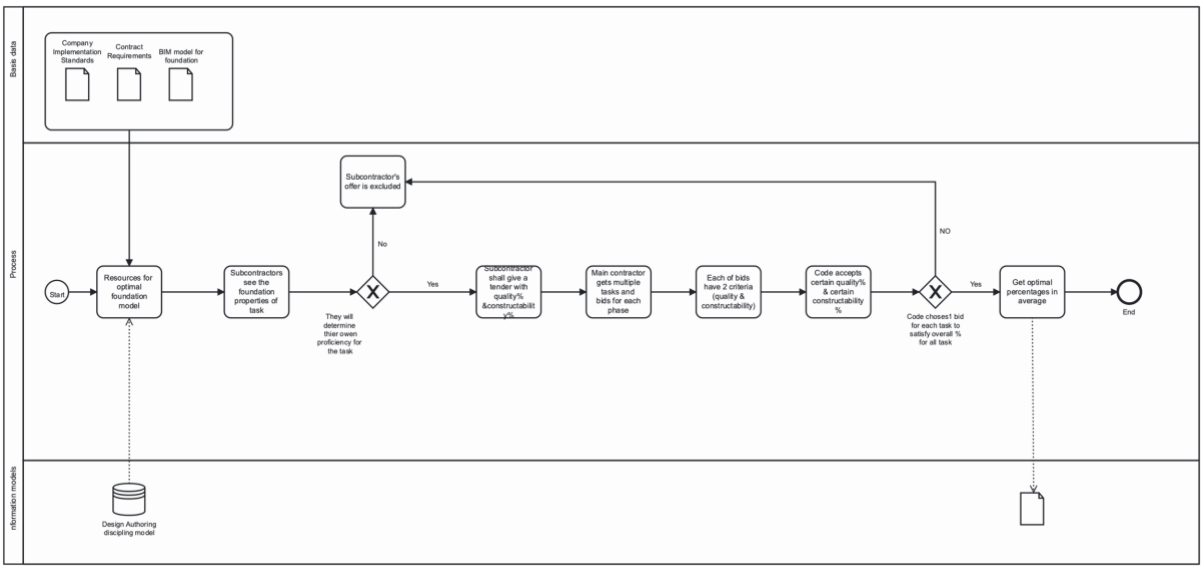
Goal of the tool is to determine optimal combination among the bids given by construction teams for the tasks during foundation construction in respect to constructability and quality which effects strength and structural integrity of the building, inevitably.

2.2. BIM Use

The tool benefits from size, dimension and placement information of the foundation that can be found in the BIM model for its purpose. Depending on the method of choice of the general contractor, either the construction teams under the umbrella of general contractor or the subcontractors who are tasked with certain steps of the foundation construction can gather information about the workload on their shoulders by seeing the size and amount of the materials needed for the foundation in the model. They can prepare their own reports to present to their superiors. In this case, they are required to inform the project about constructability and quality of their bids for the element in question. They can see the structure standing above the foundation, they can determine their needs, they can asses their capabilities and provide information based on demanded information from them.

3. Tool Design

3.1.Process (BPMN)



3.2. Description of Process

Process is about receiving information about multiple stages of foundation construction from the parties who will be responsible of construction works on the field and choosing optimal combination regarding their constructability and quality values for the task. BIM model is useful for subcontractors since it provides insight about the size of the tasks and the proposed tool will determine optimum solution regarding their response.

First of all, the stages of constructing the element in question must be determined in order to understand the workforce needed. BIM is a practical tool since it allows seeing multiple elements, their size, location and amount at the same time. The later tasks can determine the elements that need to be constructed prior. For the case of foundation, the

construction divided into 9 steps which require different teams with different equipment or specialization.

Retention walls which can be built by multiple different ways if needed; excavation, which requires heavy machinery and operators; drainage, which needs pumps and tankers when the groundwater is an issue in the site; leveling, which is done by total stations and geotechnics teams; preparation of subbase, which is realized by concreting teams and concrete with low strength; rebars, which need special equipment for bending, welding and experienced workers; formworks, which is done by a different team usually since it requires calculations for the weight of the concrete; concreting and curing, which is the responsibility of concreting teams or subcontractors and last but not least isolation, which requires different experts are 9 identified steps for foundation construction.

All steps require different expert teams, all expert teams can provide different quality with different constructability levels. After the construction is divided into steps, the construction teams can see the work needed via BIM model. Subcontractors or construction teams can analyze the model and decide on their own proficiency about the subject. When subcontractors come up with a plan to realize their task, they can give an offer to main contractor with two different percentages; one for their quality of the work and one for the constructability of their work.

Multiple constructions teams or subcontractors propose their bids for the tasks of their expertise. The main contractor ends up with multiple bids for multiple assignments. The proposed BIM tool helps the main contractors to choose one winning bid for every task according to quality and constructability requirements. While the offered quality or constructability of winning bid for one task may be below the main contractor's needs, the code would choose other winners in other tasks to reach healthy and optimal average percentages in the end when one winner bid for each task is selected.

As a result, a main contractor can reach out to a solution which would provide desired quality and constructability with the selected teams in charge, using a tool based on BIM.

4. Information Exchange

The tool enforces information exchange with different parties since the success depends on the efficient use of BIM. The information about the dimensions and elements of the foundation can be found in the IFC file. If they exist, number of the piles can be learned from the IFC file. There are several types of foundations, single footing and continuous footing are some of them. Their case requires number and the location of the footings as well and these data can be found in the IFC file, if the building was designed in such way. These data, which are available in the IFC model, must be taken by subcontractors or construction teams responsible for one or multiple tasks in foundation construction.

In the sequential step, the task groups should study the data and provide a bid for the tool. The bid should include two parameters in percentages. A percentage for quality and a

percentage for constructability. Constructability percentage denotes the dedication and ability of the bidding task group to the task, it is a result of the complexity of the project, experience, speed and willingness to reduce the fineness of the team. They would give themselves a constructability rating. Quality percentage is the other side. It mostly depends on the same parameters, while they both may benefit from same qualities such as the expertise of the team, quality requires the opposite approach in general. This creates the tradeoff between two given percentages and creates space for optimization via the proposed BIM tool.

The norms and regulations are also needed to be externally included in the tool because the tool has to determine a group of bids by one bid for each task while it pays regard to m thresholds. The standards dictated by regulations should be presented as a percentage of quality and the ambition of the general contractor must be given as constructability percentage.

In this case, it is assumed that the subcontractors have deep knowledge of the BIM and the tool, they are capable of assessing their abilities accurately and they can complete the task as they promised. The tool exists because of the uncertainty of the production quality in the sites and if the subcontractors' values don't match with reality, the purpose doesn't materialize.

5. Potential Improvement

5.1.Business Value

The proposed tool for optimizing tradeoff between buildability and quality comes with huge benefits in terms of businesses. First of all, sharing information with subcontractors and leaving assessment of their own capabilities create time and cost savings for the main contractor's engineering and management teams. It introduces information technologies to the parties involved in construction other than engineering and management teams of the general contractor, thus increases knowledge and expertise of the area, industry-wide. It increases information sharing because of the subcontractors' access to BIM file.

It increases accuracy of the main contractor's estimations for delivery and given promises by main contractor to the client. It allows main contractor to decide a certain way and lean to a certain direction if it is desired since the main contractor can see the capabilities of the teams under its management.

5.2.Societal Value

The buildings are for use of common people. The society would benefit from better and more accurate construction practices. As it was mentioned before in the introduction, it is more expensive to repair poor products than producing high quality products in the first place. This tool would provide more accurate evaluation of the quality of the production since it shrinks assessment to smaller levels, thus increases accuracy of assessment. Better evaluation results in better chance to achieve desired quality, hence decreases maintenance and repair works afterwards, when the building is in use. Repair works are disturbing and messy mostly.

Another value to the society is spared funds. The tool allows contractors to achieve desired quality and save more profit for themselves. It creates savings by knowledge not by cutting down. Competition in the market may reduce construction costs for the client since the construction companies may opt for same profit levels as previous but more competitive price to convince the client. This situation returns as fund savings. Savings of public funds may return as more investment to social policies or better public services if the client is a state agency. If the construction company works with a private partner, then the monetary savings can infuse to the economy in a different channel and enhance general circulation.