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Advanced Building Information Modeling (BIM)
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Assignment 3

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1. Introduction

There are multiple reasons for explaining existence of engineering branches, one of them is the ambition of creating more and another fundamental reason is realizing that ambition with limited resources. Both of the reasons, alongside others, become goals that needs to be satisfied in the end and they dictate knowledge, dedication and precision for upmost outcomes. The contradiction between the goals creates a unique playing field for educated experts who are named engineers. As it is required, precise information is crucial for engineers and BIM is an advanced tool which can provide that accurate data to civil engineers in no time.

Construction projects are challenging. By the nature of the industry, almost all of the productions are unique in their own right, even though designs are applied multiple times and they need to comply with the same rules. Production lines don't exist in construction industry. This situation means that the information needed for realization of a project by architects, civil engineers, accountants, managers, clients and other parties has to be prepared again and again in every project with their input. Coding, automatized solutions, software become important players in construction sector because of the required workload for a unique production. A Building Information Modeling tool gains value in this perspective, because a tool can generate desired outputs from certain inputs hence reduce the workload and consumed time.

Many different disciplines work on a construction project and give their distinct contributions. There are many aspects in every project. It is possible to see the same information from different aspects and benefit from the same thing. A BIM model provides this opportunity to separate teams. A BIM model can contain significant amount of information in a broad range. It is possible to gather information till structural design of the building. In the case of this assignment, the model in question provides information about numerous elements in a two-story building such as walls, doors, foundations, windows and other similar elements. The model contains data about their sizes, numbers and locations in the building, also it gives opportunity to identify other elements which are present in the building but not specified and determine their information. All these data can be used for multiple purposes.

The proposed BIM tool shows interest in the amount of structural materials in walls and foundations which are invisible. It is assumed that the building is a reinforced concrete example and it contains certain amount of steel in structural elements for desired structural properties. The BIM model shows the elements as a whole, a closed box can be given as an example to create an illustration in front of the eyes. While it is possible to roughly understand the size of the contents by simply looking at the box from the exterior, it is impossible to completely know what is stored in the box without opening it. The proposed BIM tool provides solution to this. The contents of the box are steel and concrete, the box is 100% full but their respective amounts are unknown. By rules, civil engineers have to calculate the ratio of area of steel rebars and area of concrete in a cross section. Cross sections are necessary applications for blueprints of the building since the field teams require them. The tool takes this ratio and finds the total amount and weight of the concrete and steel in every wall and foundation also calculates the new density and weight of the elements.

2. Use Case Analysis

2.1.Goal

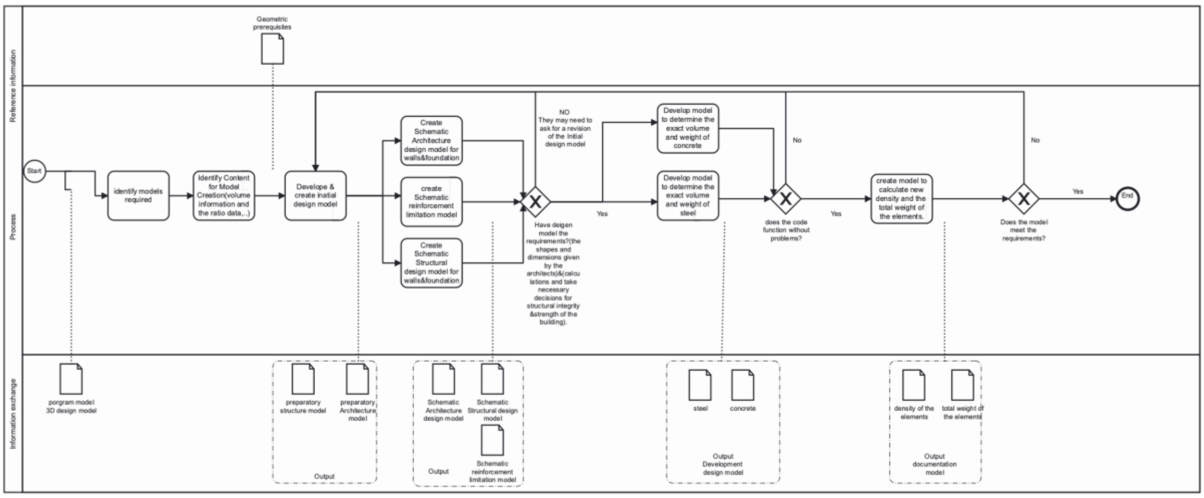
Goal of the tool is to determine the exact volume and weight of concrete and steel in every wall and foundation element, hence, calculate the new density and total weight of the elements which effects the accuracy of the structural calculations, inevitably.

2.2. BIM Use

The tool benefits from size, dimension and placement information of the walls and foundations that can be found in the BIM model for its purpose. The tool is placed in the expertise area of civil engineers. Architects provide an architectural design and civil engineers are responsible for making calculations for realization of the design. The design can be seen as a model in BIM but the additions of the engineers can't because they are embedded inside. Engineers take this architectural model from BIM tool and start their calculations with preliminary assumptions, then correct them with actual numbers in the end. The calculations provide a steel area concrete area ratio in a cross section which has to be generated in the engineering design phase. The BIM tool takes this ratio after preliminary calculations and generate exact weight and density values of all wall and foundation element by calculating exact steel and concrete volumes and weights in each element. In the end, it rapidly provides exact information to the engineers, managers, accountants and clients.

3. Tool Design

3.1.Process (BPMN)



3.2.Description of Process

The process is about receiving volume information from the architectural model and ratio information from civil engineer's design to generate weight and density information. The volume information already exists in the model and the ratio data, which is the input of the code, is something necessary to generate. It involves weight, volume, percentage and density calculations and automatizes the process for each of the wall and foundation elements.

First of all, architects start working and create a design according to client's demands and needs. They provide an architectural model to engineers. Civil engineering team is responsible of doing necessary calculations to be sure that the designed building stands against the loads and harmful effects and servers to the occupants for an expected lifespan without any concerns or problems. Engineers take the architectural model and fill inside of it with technical knowledge to make it physically existing.

Engineering team has a limited space to work with. Their designs can't exceed the shapes and dimensions given by the architects; they need to stay inside. Although, they may need to ask for a revision of the architectural design, if it isn't feasible. BIM comes into play in this area. Engineers see a three-dimensional architectural model and visually acknowledge the limitations of the building. They work on the structural part of the building and create their own structural model with load bearing elements.

Engineers do structural calculations and take necessary decisions for structural integrity and strength of the building. They design foundations, walls, columns, beams and slabs. They create reinforcement placement plans and give decisions on concrete class to carry the loads and moments they have determined prior to their design. Engineering work starts with load determination which requires a preliminary design since the building itself has a weight which has to be carried by the building along other dead or moving loads.

It is impossible to do a complete and accurate design in just one step. The weight in the end would be different than the weight in the beginning which was estimated for starting the structural design. Sizes may change if they don't meet the requirements and also, more importantly for the proposed BIM tools, weight of the element change because of their steel content and concrete amount and class. Both elements have their own unique unit weights and they are accounted for occupying certain volume in the elements. The entire volume of the element can't be considered as a single material. Two different materials with their own properties change the density and the weight of the element.

The proposed BIM tool particularly interests in foundations and walls. After working on the building, the engineering team provides a structural design. They identify structural elements. They contain some amount of concrete and some amount of steel. The tool calculates total volumes and weights in each wall and foundation element and finds new density from there. The code goes one step further and calculates combined weights of the elements as well.

The engineering team has to create blueprints and cross sections for site engineers and their construction teams. In these cross sections, reinforcement arrangement and the dimensions can be seen. Engineers calculate area of the reinforcement and the area of the concrete from these cross sections. It is a necessary calculation to understand compliance of the design since this ratio information is also used by regulations, there are maximum and minimum values. The ratio information is also required for other structural designs. The code benefits from this information. The code takes the ratio of their areas and multiplies automatically with the length of the elements. The code finds the total volume of the steel and concrete in each element as a beginning.

Secondly, the code proceeds from volume information to the weight information of all wall and foundation elements. Finding weight from volume involves a simple multiplication of volume and unit weight of the element in the equation. The code does the multiplications automatically for all the wall and foundation elements and finds the weights of concrete and steel in each element, in no time.

After calculation of the weights of the contents of the elements in question. The code adds them and finds total weight of each element. The code doesn't stop by finding the weight information of each element separately, it also adds them together and finds combined weight information of the walls and foundations. It gives the weight values of each element and their summation as outputs. This step provides the exact weight information which was unknown in the beginning of the design phase and which was necessary for structural design.

The outputs of the code don't stop by weight information. The code continues calculations to generate one more output for each element which is their new density values. Concrete and steel have different unit weights, which means that the same volume of concrete and steel weights different. The difference is enormous while the density of the concrete changes by the mix design, it is usually between 2,4g/cm^3 and 2,6g/cm^3, on the other hand, the unit weight of reinforcement steel is 7,8 g/cm^3. An imaginary density calculation of a wall with 2% steel ratio and 2,5g/cm^3 concrete unit weight would give a new 2,6g/cm^3 density for entire wall, approximately. The code does the density calculations for all wall and foundation elements and gives the exact density value for each element.

4. Information Exchange

The tool enforces information exchange with different parties since the success depends on the efficient use of BIM. The code needs structural model which identifies walls and foundations as separate elements, it doesn't identify them and their dimensions on its own. The information about the dimensions and the numbers of the foundations and the walls can be found in the IFC file that this tool is based on. The proposed BIM tool benefits from all of the mentioned information. The tool takes the dimensions information to generate volume data of the elements.

The sequential step requires inputs from engineers who have already had the information from the architectural model for their structural design. The inputs are concrete classes with steel area and concrete area ratio of the cross section of all wall and foundation elements. Separate inputs are required for separate elements because engineering team has independence to realize unique reinforcement designs and use different concrete classes in different elements.

The code calculates weight and unit weight values according to the dimensions information from the model and inputs from the user. It generates the outputs for each element separately as well as summum of the weights for two total weight values for the foundations and walls. The number information from the model is required for summum output.

5. Potential Improvement

5.1.Business Value

The proposed tool for finding exact volume, weight and unit weight values comes with huge benefits in terms of businesses. First of all, it massively accelerates the process of finding data which is necessary for structural design and saves huge amount of work. Reducing calculation workload on engineers means that they can spend more time on design process or more complicated challenges, thus improve the quality of their deliveries.

It introduces information which is initially reserved to engineers to the parties involved in construction other than them, thus increases information sharing and general intuition of other parties. It spreads expertise to the other parties who can see the data from the file and builds an idea of engineer's work and perspective in their minds. Hence creates a better understanding and allows better cooperation between different disciplines in the future for better outcomes with smoother design processes.

It also provides benefit to the parties who are responsible for cost estimations and field progress. They can easily find the information about weight and make estimations on their respective fields in advance. While their work accelerates, it becomes easier as well, since they gather the information from a three-dimensional visual model.

5.2.Societal Value

The buildings are for use of common people. The society would benefit from better and more accurate construction practices. This tool will help generation of more accurate computational results, hence improve quality of engineering and the quality of the building. Easing the work on the engineering team would allow them give more attention to the other areas for more comfort and better use.

Another value to the society is spared funds. The tool reduces work on engineers, while it is possible to replace the work with another topic and keep the total workload on the engineering team same, it is also possible to remove the load completely and improve efficiency. Improving efficiency creates monetary savings. 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 pricing to convince the client. This situation returns as 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.