

## **BIM and Conditional Query Estimation**

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### **Abstract**

This paper discusses about the development of user friendly interface to generate quantity estimates for the schedule of activities that facilitate the project schedule implementation from subcontractor's perspective. Today, Building Information Model (BIM) plays an important role to draw quantity estimates during the different phases of project life cycle. Many BIM solutions are available to extract quantities and material definitions out of a BIM into a cost estimating system. Implementation of these existing exclusive BIM solutions partially generate an automatic quantity estimates for the schedule of activities of the entire project. During the construction phase, these generated estimates need to be tailored by the subcontractor to execute the daily construction activities. This process is tedious and not user friendly. A user friendly tool that helps to generate the quantity report for the specific duration which is tractable for the subcontractor's needs during the construction process is required. This paper discusses the conceptual framework which facilitates to generate a customized quantity estimate report from BIM. This paper discusses the feasibility of generating a customized report from BIM based on project schedule. It also discusses the pilot study conducted to develop the interface to generate a customized quantity estimate report by using Autodesk's BIM software.

### **Keywords**

BIM, quantity estimate, conditional query, construction phase

### **1. Introduction**

During construction process, customized conditional quantities reports are required to implement the project schedule. These reports are prepared based on single or multiple conditions. Traditionally, two dimensional (2D) drawings are most widely used for creation of these reports. Reports generated through 2D drawings are prone to more human errors. In addition to errors, report generation is also cumbersome and time consuming process. Some of the problems associated by traditional quantity estimation means can be reduced by using Building Information Model (BIM). BIM reduces the drawing errors, estimation processing time and human errors (Autodesk, 2007; Khemlani, 2006; McCuen 2009; Tiwari et al., 2009). Considering the advantages, BIM is widely used to draw quantity estimates during the different phases of project life cycle. Many software solutions are available to extract quantities from BIM. Implementation of these existing exclusive BIM software solutions is useful for generation of whole project quantities estimate report. However, the quantities extracted from BIM by these software solutions are independent of project schedule. During construction phase the quantity estimate reports are to be

extracted based on the project schedule. Currently, the quantity estimate prepared from BIM by using these software are not derived using the project schedule. The generated quantity estimates from BIM and project schedule exists as an independent entities. These estimates need to be customized to cater the needs of the project schedule. This customization is a time consuming and cumbersome process. This process of generating a customized report from BIM using project schedule can be automated by providing an interface between BIM and project schedule. This paper discusses the feasibility of generating a customized report from BIM based on project schedule. It also discusses the pilot study conducted to develop the interface by using Autodesk's BIM software.

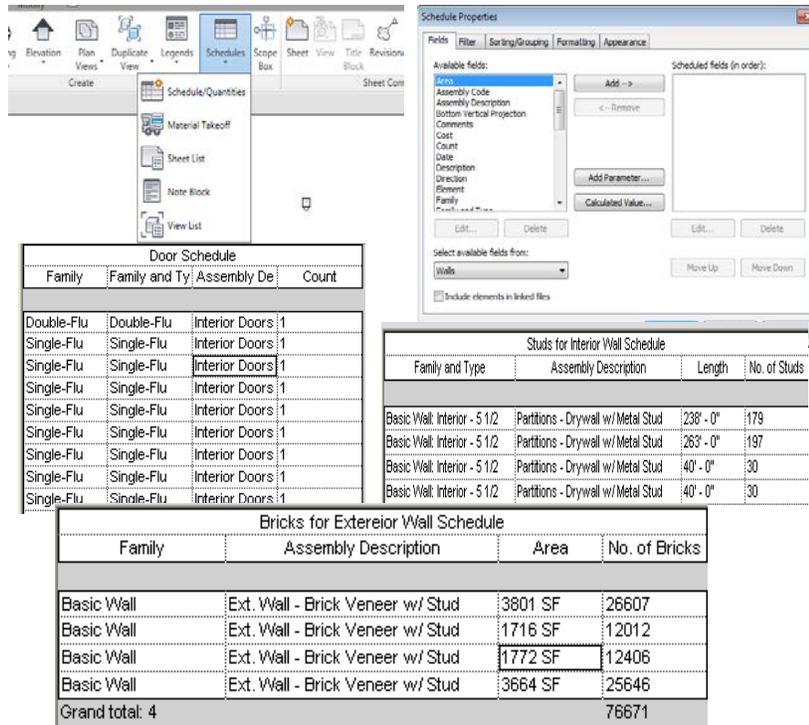
## **2. Conditional Query Estimation**

The quantity estimates at different stages of the lifecycle are generated by executing conditional queries. Based on the number of conditions used to retrieve the information the query can be classified as single or multiple conditional query. Quantity estimate report generated based on a one single condition is referred as single conditional query. For example: Generating a quantity estimate report of a particular component in a project is considered as single conditional query. Quantity estimate report generated based on a more than one condition is referred as multiple conditional query. For example: Generating a quantity estimate report of a particular component installed during a particular period of time is considered as a multiple conditional query. Revit is one of the Autodesk's BIM software which is widely used for BIM applications. In Revit, estimates based on conditional queries can be achieved partially through the inbuilt features such as "Schedules/Quantities" or "Material Quantity Takeoff" and through its filters as shown in Figure 1. Since there is no linkage between project schedule with these inbuilt features, the quantity estimates generated through these features are independent of the project schedule. These features cannot be able to generate estimates of the multiple components in a single report. The framework that facilitates generation of customized quantity estimate from BIM is shown in Figure 2. This framework will be useful to generate multiple components quantity estimate based on project schedule. The components of the framework include BIM database, Software Application, Quantity Estimate Report, and Elements highlighted in BIM. Software Application interacts with the BIM database through the BIM Application Program Interface (API). Based on the conditional query parameters Software Application retrieves the information from BIM Database. The retrieved query results are available in a pdf and excel file format. In addition to the report, thorough BIM API the corresponding elements are also highlighted in the BIM.

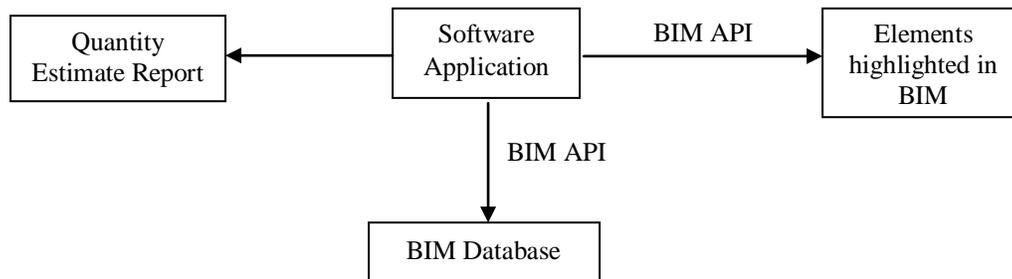
## **3. Pilot Study**

A pilot study is conducted by using the framework to demonstrate the feasibility of customized report generation from BIM. A fire station of 16,883 square feet floor area is considered for the study. A BIM for this project is developed using Revit Architecture 2010 and Revit Structure 2010 software. Architectural components such as walls, windows, doors, flooring, and roof shingles and the structural components such as wall footing, spread footing, columns, beams, joists are included in the BIM. The software application was developed using the Visual C#.Net programming language. The steps involved in the development process include:

1. Creating and populating parameters in Revit,
2. Developing BIM database,
3. Automating information flow by developing the software application.



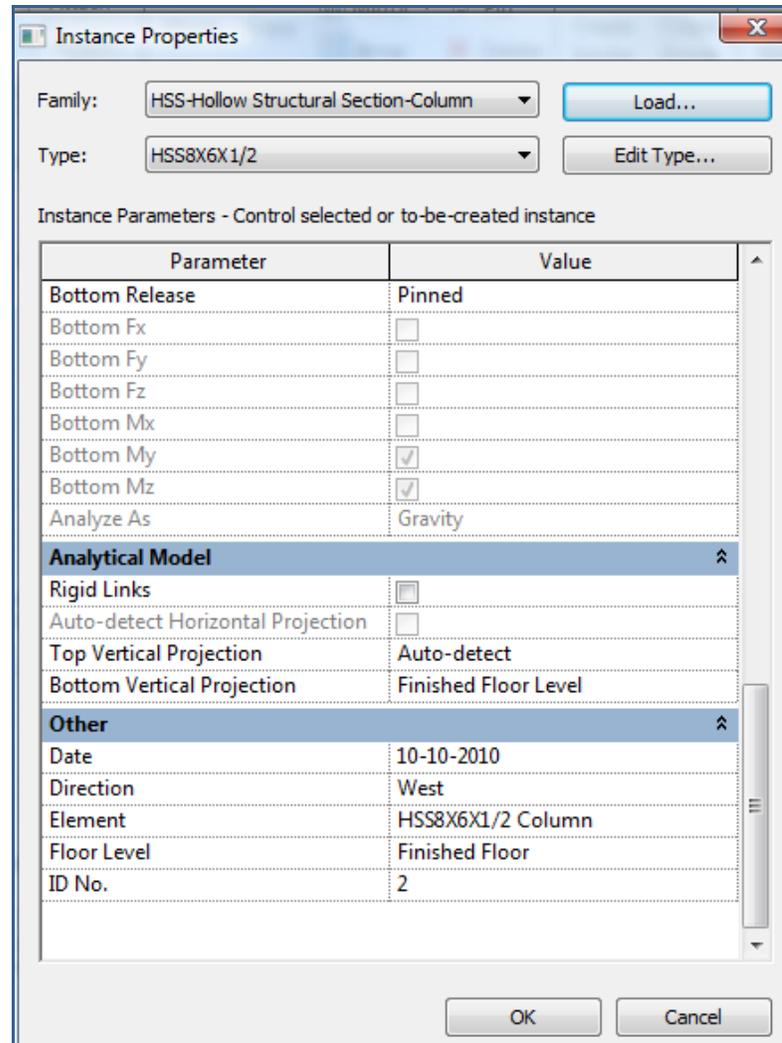
**Figure 1: Sample quantity estimates created by using inbuilt features in Revit**



**Figure 2: Conceptual framework of generating customized quantity report from BIM**

### 3.1 Creating and Populating Parameters

In Revit, each element is associated with predefined parameters and these are categorized into type and instance parameters. The type parameters control properties of elements of that type while the instance parameters control the instances properties. The type and instance parameters are further categorized into different groups. The data format stored in each parameter is of type: text, integer, number, length, area, volume, angle, URL, material, and yes/no (Meadati and Javier, 2010). The parameters such as From Date and To Date of activities, Element type, Floor Level, Direction of the element and the customized Identification Number assigned in clock-wise direction are defined as type parameters to the different components of the BIM. The inputs for the parameters are given manually. The parameters of the component populated with respective information are shown in Figure 3.



**Figure 3: Populated Parameters of the Component in Revit**

### 3.2 Developing BIM Database

The BIM database was developed in MS Access 2007. This was accomplished by exporting the Revit Architecture model to MS Access 2007 through Open Database Connectivity (ODBC) feature available in Revit (Goedert and Meadati, 20008). ODBC exports the BIM and creates database tables for model types and instances. Some model type and instances tables are shown in Figure 4.

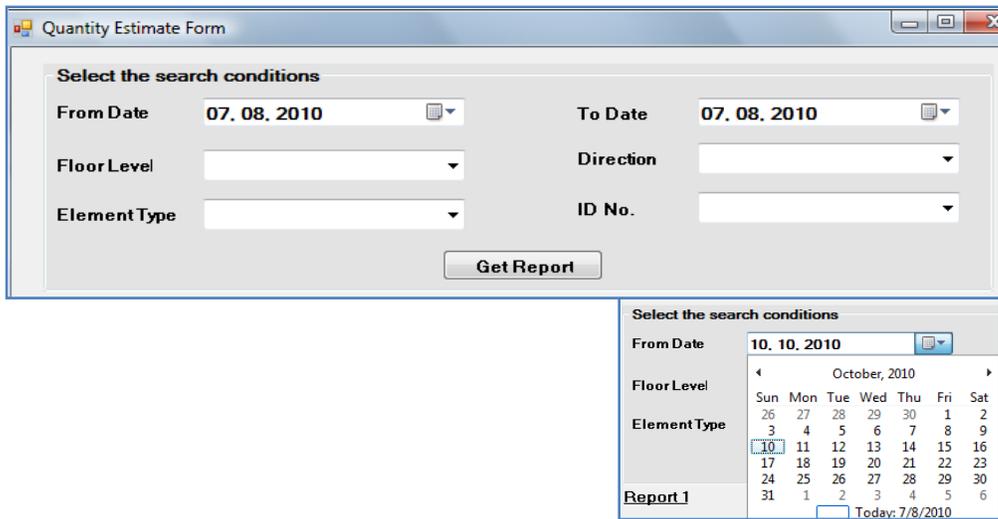


**Figure 4: BIM database tables in MS Access**

### 3.3 Automating Information Flow for Report Generation

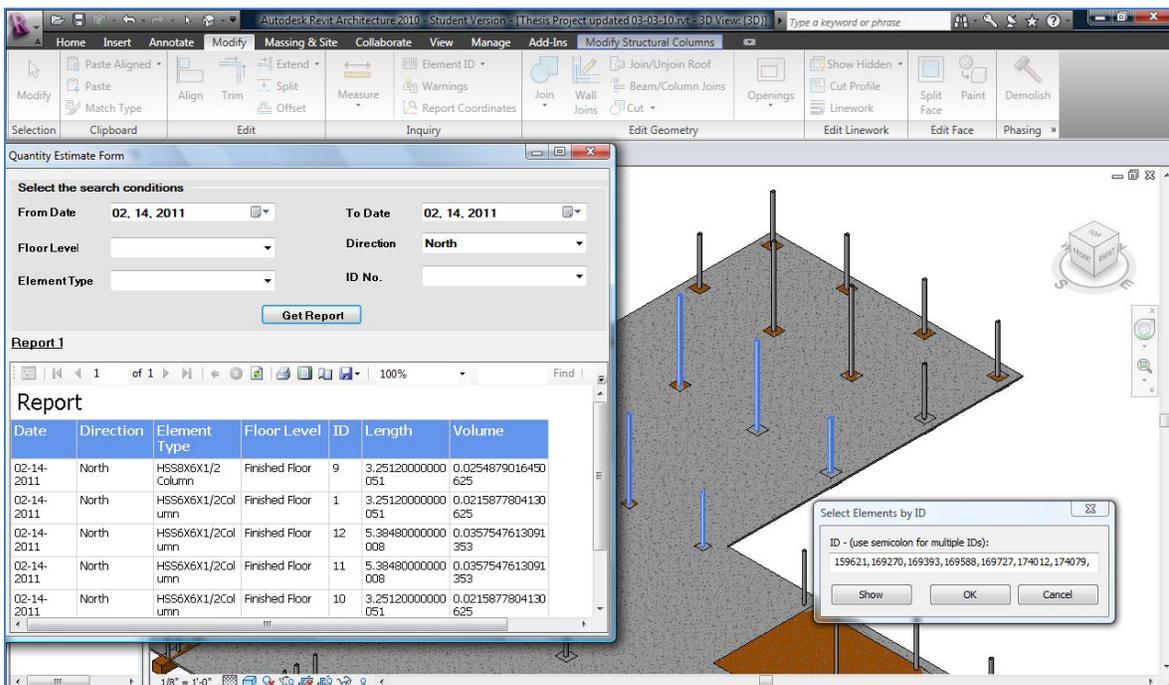
A user friendly interface is created to retrieve the required data for developing quantity estimate from the BIM. The interface screen as shown in the Figure 5 displays the user input options. The interface form was then made available in the Revit software as an external command under Add-Ins tab.

The input data includes From Date, To Date, Floor Level, Direction, Element Type and Identification Number (ID No.). From Date and To Date tabs are provided with the date picker control available in the menu bar. This facilitates the user to pick desired date from the calendar. Floor Level tab and Direction tab are provided with the combo box control available in the menu bar. Floor Level tab allows selecting the required floor from the drop down menu. Direction tab consists of the pre-defined orientations such as North, South, East, West, North-East, North-West, South-East and South-West to facilitate end user to get the quantity estimates for one particular direction of the building. Element Type tab and ID No. tab are also provided with the combo box control available in the menu bar. Element Type tab provides all the elements available in the project in a drop down menu. ID No. tab displays the list of identification numbers available in the project in a drop down menu.



**Figure 5: User interface screen**

All the input controls in the user interface are designed as mutually independent entities. This provides the user different options to retrieve the quantity estimates. This can be accomplished by providing the input data in the required tabs and clicking the Get Report button. When Get Report button is clicked, the user inputs serve as query parameters to retrieve the information from BIM. The results of the sample query generated for the components installed in a particular period of time based on the selected direction by using the interface are shown in Figure 6. The query result has two components. One component includes quantity estimates in the tabular format. The generated quantity estimate report is available in pdf and the excel file formats. The report can be printed directly from the user interface form. The second component of the report includes highlighting the elements in BIM.



**Figure 6: Sample query results**

## 6. Conclusion

Implementation of existing exclusive BIM solutions can partially generate an automatic quantity estimates for the schedule of activities of the entire project. These generated estimates need to be tailored by subcontractor to execute the daily construction activities. This process is tedious and not user friendly. The objective of the study is to develop an user friendly tool to extract the quantity estimates which are tractable as per the subcontractor's requirements. This facilitates to procure and monitor the required materials as per the construction schedule. A user interface was developed to generate the customized quantity reports. This interface allows the user to retrieve the quantity estimates as per the customized requirements in a printable report format. Additionally, the resultant elements of the query can also be displayed visually by highlighting them in BIM. The methodology developed to generate quantity estimates from BIM for the schedule of activities that facilitate project schedule implementation serves as the stepping stone to continue the future research.

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