INTEGRATION OF BUILDING INFORMATION MODELING FOR HVAC DESIGN AND OPERATION

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Abstract: As we look at the industry of Air Conditioning, especially in the building sector from design stage to operation & maintenance a huge amount of man power is required at various stages like System Design, load estimation, coordination, costing, scheduling, energy simulation and operation & maintenance of facilities & services. These different stages have different expertise involved in carrying out these activities. In addition to this lot of problems arises due to lack of coordination.
Using information model (BIM) from the beginning of a project helps engineers and designers make better decisions earlier in the process. Thus BIM provides a complete solution from designing to operation & maintenance. BIM is not just a software but it is a collaboration of different software's, its consist of 2D, 3D, 4D, 5D, 6D and 7D in a single module with which all the activities with respect to the project completion can be made easy. These simulation results could help the project team to know the energy consumption details by which one can alter the project to achieve energy conservation and maintenance and operation of Air condition system as well.

Keywords: Air conditioning, BIM, DesignBuilder, Archibus, Coordination.

Introduction: Architects, Civil Engineers, MEP Services Engineers, project management and contractors are the professional people who have to work on board together to complete a project. All these professionals have to coordinate with each other at various stages of the project right from the conceptual stage to the operation and maintenance stage to streamline the progress of the construction with respect to its status, time, cost and quality. This will practically have lot of complications in terms of expectations with the design, cost and many such parameters. No matter how simple a construction project is but from the pre-planning on through to completion there is always a lag in the organizing and comprehending the design data. To encounter these issues BIM is used and analyzed to see if these problems are handled and dealt with.

BIM is a multi-dimensional process which can give us information along with the visuals of 3D,4D,5D,6D and 7D in a common data environment on the model. Project managers of different disciplines will be using specialized software tools to create the required design and information for building, all these files containing the detailed information including all its unique characteristics are stored within the same project for making things easy to work. To analyze the design and showcase the information on these multi-dimensional aspects, a model has been generated with the ideal conditions for showing all the necessary dimensions that are possible by the tool from its conceptual stage to O & M stage.

A duplex villa with 4 BHK having a built-up area of 2800 sft. is modeled with Air cooled type air-conditioning system considering the Hyderabad climatic conditions. The design which was made in

CAD is been imported in Revit and the different dimensions are identified with respect to the HVAC design.

I. 2. Dimension (Building Data): BIM being a single point of reference for information and operational activities having multiple dimensions in which the second dimension of the tool in this project gives us the provision for making Heat load estimations, duct sizing, pipe sizing, duct & pipe design. Heat load calculations can be carried out readily if the building envelope properties are given such as walls, floor, ceiling, slab, type of building typology, location of the building, activity in the building, lighting load, equipment load, no. of people, etc., has to be specified. It automatically takes dry bulb temperature, wet bulb temperature, humidity, etc., by specifying the location of the building and these are basically ASHRAE standards.

Fig 1 shows the BIM model of the designed building to calculate Heating and cooling loads. Fig 2 shows the results calculated for the BIM Model with the given specifications of the building design.

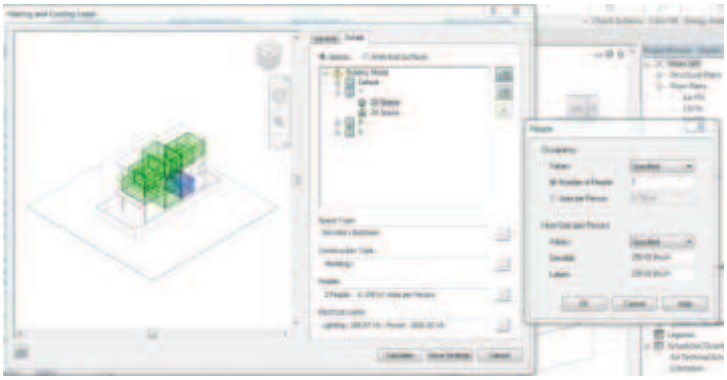


Figure 1: Heating and Cooling Load

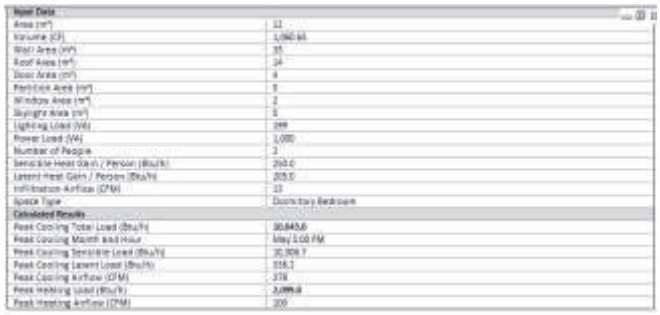


Figure 2: Inputs for the Model and Results of Heating and Cooling Loads

Known with the required heating and cooling loads, the desired ducting is designed. normally the duct design is a quit a hectic job to do with the sizing of the duct at different areas to deliver desired conditioning but BIM gives us the duct sizing according to the calculated CFM and FPM just by entering the value of flow velocity as shown in fig 3. It also automatically calculates frictional losses in the duct by taking pipe bends and material friction factor etc. and varying velocity in the branches gives the size of branch duct.

Figure 3: Duct Sizing

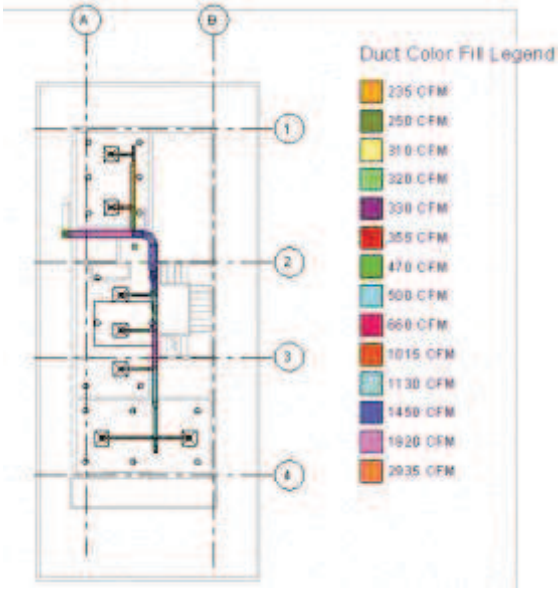


Figure 4. Duct size color coding

II. 3. Dimension: (Shared information Model): In 3D model it gives complete visuals of the entire building. Here all the engineering components of the buildings along with its structural and architectural ones can be view in 360 degrees in different spectrum of the view frames such as wire frame, fine, rendered etc.. The modeled building can be visualized by a walkthrough which will give us a tour of the entire building in and out. The significance of the tool lies in its most importance feature of detecting the clashes in the building with respect to the services and the building components and also between the services. The model is imported to the Navis works which is another plug-in for Revit which will perform the clash detection giving us a visual detection of the clashes and also it can generate report. This clash detection can be done for whole building at once and it can also be done for desired areas of the building.

Fig 5 shows the complete HVAC design for the building which simplifies the visual understanding of the Ducting network and its essential components.

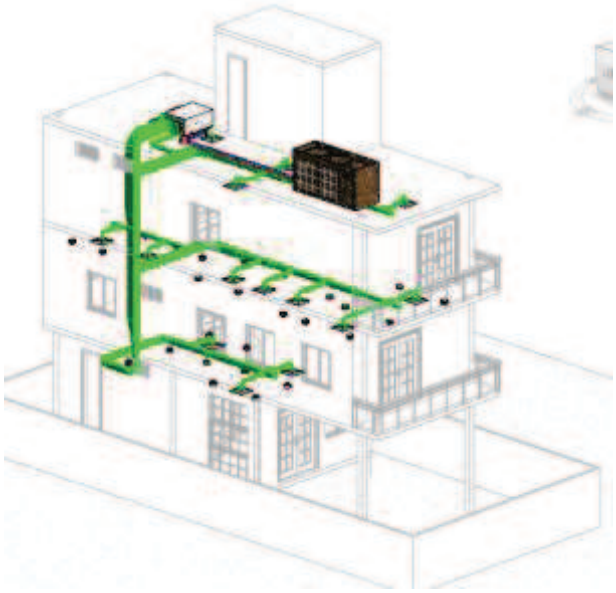


Figure 5: HVAC Design

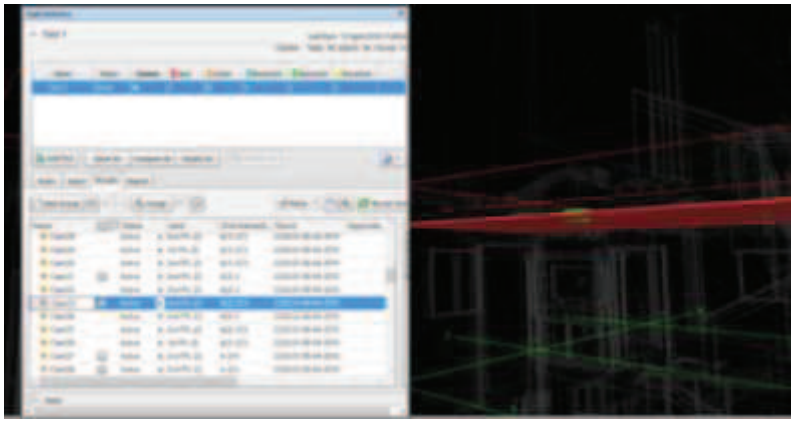


Figure 6: Clash Detection Test Run

The design of the project has flaws with respect to the coordination which is intentional to show the clash detection test which is shown in fig 6.

III. 4Dimension (Construction Sequence): Time estimation and scheduling is an another dimension which can be given by the tool with the help of Microsoft project. This tool by Microsoft project gives us the time estimation for the installation of AC service as 61days for the project from designing to testing and commissioning when the tool is fed with the activities of the work to be done. It will calculate the non working days by itself based on the calendar days. This report can be pluged-in in Navis work and the scheduling of the work to be carried can be prepared. Fig 7 shows the time consumption by the various activities to be done and on the right hand side of the picture, planning and scheduling as per the time consumption is shown.

Figure 7: Time Framing and Scheduling Results

IV. 5Dimension (Cost Estimation): The modeled project had a pretty much information with it to carry on with the execution but the most essential but one is the budgeting. To estimate the budget for the project the cost estimations has to be given to the chosen material and products.

<Pipe Schedule>

A	B	C	D	E
Cost	Diameter	Family and Type	Length	Item Cost
0.1000	2"	Pipe Types: Return	115	11
0.1000	2"	Pipe Types: Return	559	56
0.1000	2"	Pipe Types: Return	5576	558
0.1000	2"	Pipe Types: Supply	267	27
0.1000	2"	Pipe Types: Supply	864	86
0.1000	2"	Pipe Types: Supply	5423	542
				1280

Figure 8: Cost for Piping Schedule

This will generate the cost estimation for the desired systems in the building as followed given for the piping and ducting.

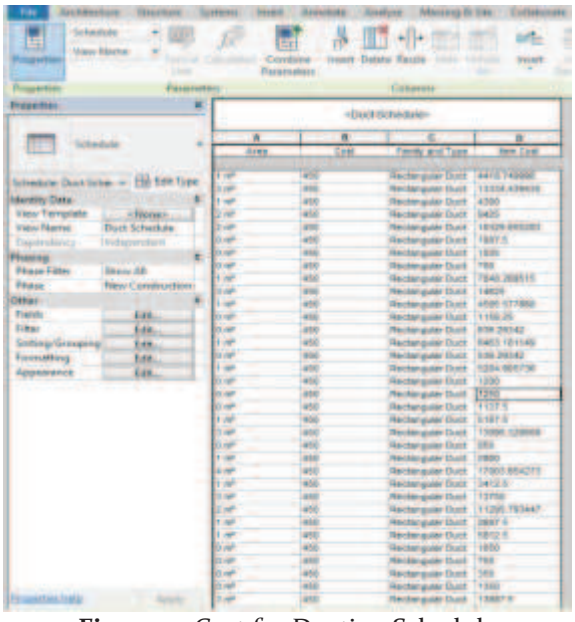


Figure 9: Cost for Ducting Schedule

V. 6 Dimension (Building Performance): The sixth dimension intends to present the data on thermal performance of the building. In any conventional air-conditioned building, the air-conditioning system generally consumes the maximum power therefore by taking a little care to minimize energy consumption, will result in substantial savings in the long run.

The main objective of this building energy simulation is to predict the monthly and annual energy consumption of Heating, Ventilation and Air-Conditioning (HVAC) system with respective to the thermal comfort and indoor air quality.

The choice and design of HVAC system is defined here with required calculations and performed simulations for selected HVAC systems, with12 hours as operational time in everyday for 365 days.
The simulation is performed using a tool namely Design Builder for the whole building energy simulation. Following are the inputs given to the tool to check the case example resulting energy consumption pattern with respect to the building characteristics.

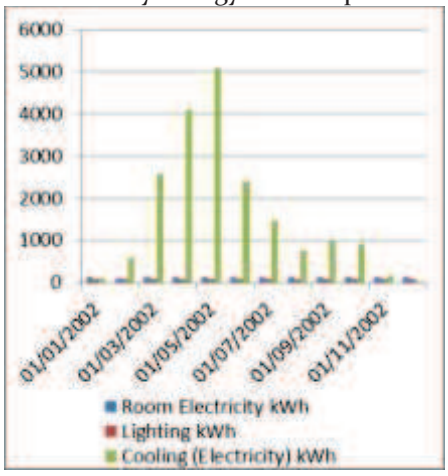
Table 1: a, b, c: Simulated Input Data Parameters

Envelope Characteristics			
	U-Factor with Film [W/m2-K]		
Base wall	2.1		
Base roof	3.9		
Floor	0.25		
	Glass U W/m2-K	Glass SHGC	Glass VT
Window	1.96	0.69	0.74

Internal Loads	**Value**
Occupant Density (m2/person)	0.022
LPD (W/m2)	5
Equipment load (W/m2)	3.58
Infiltration (ac/h)	0.55

Ventilation	
Fresh air (l/s-person)	10
Mech vent / area (l/s-m2)	10

Table 2: Monthly Energy Consumption Pattern



VI. 7Dimension (Operation& Maintenance): Another significant dimension of BIM in this paper mainly addresses how Building Information modeling can play a significant role in maintenance of HVAC system of the building using ARCHIBUS & Autodesk technology.

In ARCHIBUS-Revit integration one can easily maintain and retrieve information about HVAC System along with all electrical components, including electrical panels, circuits, lighting, receptacles, control systems and more. ARCHIBUS easily create the detailed electronic inventory of the HVAC systems of the facility using pre-defined component standards with key information such as Model number, power requirements, heat load and vendor information. Check for circuit and panel loads and component counts, reporting calculations by building, floor and room from the built-in reporting system. Overloaded circuits and other potential problems can be prevented during the operation level.

The first step in data transmission is to establish a communication link between the two applications, Revit and ARCHIBUS. The link connects the Revit model to a pre-existing project (building and floors) in the database. As a prerequisite, this background information, which includes the building asset, location, and its organizational attributes, should already exist before a link is attempted. After the link is made, this data is cataloged and synchronized between Revit and ARCHIBUS.

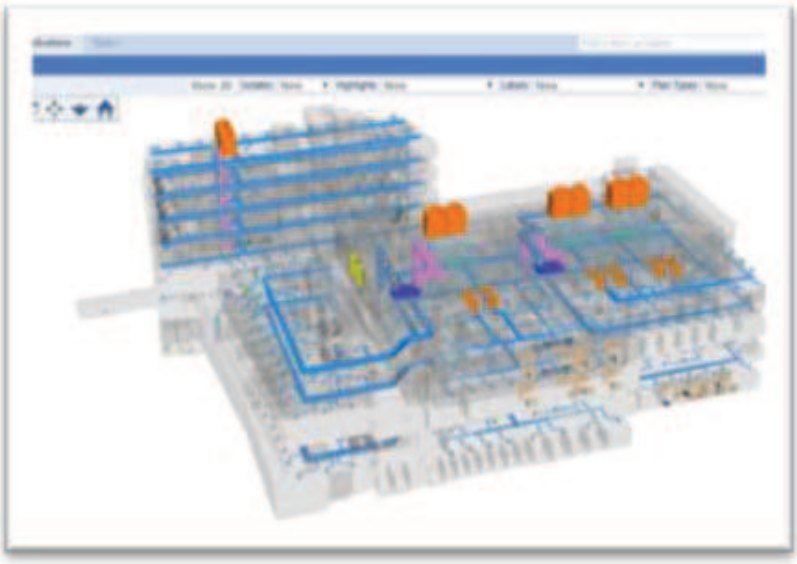


Figure 10: Building Floors with HVAC and Piping in ARCHIBUS Web Central

Mapping HVAC Equipment Parameters: Revit models are often populated with a wide range of equipment from a variety of categories like mechanical, electrical and many more. Every individual equipment asset arrives with a significant amount of parametric data already built in its system. Smart Client extension for Revit is designed to map and capture this data through a synchronization process where Revit parameters are mapped to ARCHIBUS tables and fields. This process is done by a BIM specialist ahead of time and in a planned manner in order to capture only FM appropriate data and to ensure the system proper use.

Figure 11: ARCHIBUS HVAC equipment table

In order to synchronize the asset with the ARCHIBUS database, catalog the HVAC equipment from Revit to ARCHIBUS database.The Extension for Revit also support Web Central functionalities by creating a series of graphics files (Flash and SVG) that are used throughout the applications including mobile. To produce the graphics file user must publish the floor plans by level. Once published users can view and interact with floor plans and equipment without opening Revit. However, ARCHIBUS is not a drafting application, so cannot make architectural changes to the plan. If changes are required, they must be done in Revit and republished for the changes to be reflected in ARCHIBUS.

Conclusion: Communication is made so easy by the mobile phone which has changed the phase of technology, similarlyTransformation is what we can see in the project production while using the BIM. Building Information Modeling (BIM) is a per-project collaborative process that provides a framework for stakeholders' interaction with the purpose of streamlining administration, improving design, setting data-transfer guidelines, responsibilities and overall, increasing quality while reducing the cost of a project's production. Following are the benefits that can be seen out of BIM:

- Improved visualization of the project, communication of design intent.
- Improved multidisciplinary collaboration and Reduction in reworks.
- Integrating BIM 4D simulation model brings benefit to participants in terms of planning optimization. Builders and manufacturers can optimize their construction activities and team coordination.
- Integrating BIM with 5D Simulation models enables development of efficient, cost-effective and sustainable construction.
- Integrating BIM with 6D simulation model helps to project team in predicting whole building energy consumption pattern to enhance the building performance.
- Integrating BIM with 7D simulation model optimizes the asset management from the design to demolition phase.

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