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Building Information Modelling in Sustainability Analysis

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ABSTRACT

The construction industries are by far one of those industries whose project works takes much more time i.e., months and years in comparison to other industries. There may also be delays and problems due to the enhancement to the working process and inclusion of new techniques in the construction industries which sometimes lowers the pace of the project work. Hence, there is an utmost need to bring innovations such as sustainability to the construction industries. Therefore, a lots of construction companies have attempted to use different kinds of software for the development of sustainable design. One of those software is Building Information Modelling (BIM). In this case study , the main motive is to find out application of BIM in sustainability using the BIM software Autodesk Revit i.e., rendering , estimation , etc.

Key Words : **BIM (Building Information Modelling) , Sustainability , Autodesk Revit**

1. INTRODUCTION

Infrastructure is the fundamental part of a nation. As the population and urbanization are increasing at a rapid rate, more importance must be given to infrastructure development in the country. Sustainable infrastructure has shown its worth in current industries as an option which is more efficient, productive and more environmentally friendly. It has more advantage because if we replace old urban infrastructure with new or modern and sustainable systems that for sure will make cities more inhabitable and comprehensive. The term "sustainability" can be described as a way of enhancing the quality of life by allowing people to live in a healthy environment and to improve social, economic and environmental conditions for the present and future generations. Sustainable buildings help in balancing all social, economic & environmental factors in one go. Moreover, the improvement of factor like sustainability is drawing the attention of construction industry which is a globally emerging sector because of its advantages of providing vast and a highly active industry in both developed and developing countries. There is a large need to find out how infrastructures are planned, delivered and managed as urbanization, digitalization and climate changes are impacting the world at very big level. So, we can say that if we keep developing more sustainable infrastructure that will definitely help in reducing cost of the buildings as well as will provide high value during design for more development. Construction companies have tried to use different types of software's for the sustainable development of the infrastructures, BIM (Building Information Modelling) is one of them. So, we can focus on implementing BIM in the sustainability analyses of any construction project. In present study the sustainability analysis is to be performed by using BIM software i.e., Autodesk Revit. In this analysis a no. of aspects such as orientation (east, west, north, south), location of project, sun-path, etc. are needed to be considered.

2. BIM AND SUSTAINABLE CONSTRUCTION

Building Information Modelling is the process of creating a digital model of a building or infrastructure facility. BIM is a developing software for the sustainable design; however, it lacks somewhere in the construction stage of the project. In the different stages of the work, the construction companies go through BIM to insert, extract, update and modify information's in order to support the respective responsibilities. The fundamental idea behind BIM is to create and share the right information at the right time throughout the design, construction and operation of a building or facility, in order to improve efficiency and decision making. If we use BIM, it helps to process data in faster and safer way as well as provides less wasteful construction work. BIM

also provides another way to the users by enabling much more integrated design as well as a feasible construction process. BIM results in better quality buildings which are more cost effective. BIM in the design stage can help in performing complex building activities & their analysis to ensure sustainable design. BIM helps in understanding the behaviour of a construction project or any building before it is actually constructed. By this we can rectify the errors which we are getting in the plan or the layout of the building. So, it gives number of solutions and advantages, if implemented in sustainability analyses of any construction project. According to Costanza and Patten , sustainability focuses to achieve present needs with taking care of the needs of future generations. The concept of sustainability depends upon three pillars, i.e., social, economic & environmental. It is also known as profit, planet & people respectively. Sustainability can be carried out to save our environment, to reduce building cost, to increase efficiency of the project and to add durability to the construction project. Sustainability can also provide healthy environment to the people, hence its importance to be applied or to be implemented in the construction industries is more required.

3. AUTODESK REVIT

For architects, structural engineers, MEP engineers, designers, and contractors, Autodesk Revit is a software for building information modelling. Simply , Autodesk Revit is the software / platform which is provided by Autodesk to fulfil the purpose of designing and it also make possible to build concepts, make drawings and schedules which are very much required in Building Information Modelling. Revit helps in designing exterior , interior , area , etc. There are three types of components which are model attributes, datum components and view-specific elements. In Revit , the elements are also called as “families”. Revit consists of various types of families such as ; columns , floors , walls , windows and doors , etc. which makes work a little bit easier. Users are allowed to create, delete and modify these families at their will. This BIM tool helps users to design building layout and all of its parts in 3D by analysing and interpreting the model by using 2D elements and it also obtains various details from the archive of the building model such as ; elevations , sections , etc. Different views i.e., 2D , 3D , each and every drawing sheet & schedules are available in Revit as a depiction of information from same model of virtual build of same project. Revit collects various information regarding the building project on which we are working and for the same it uses the building plan & uses the information through the project representations.

4. LITERATURE REVIEW

Building Information Modelling (BIM) by Shrikant Bhuskade observed the case study demonstrating that BIM is replacing conventional scheduling and expense estimating approaches with a more efficient and automated system. Centred on the feedback on BIM and the case report, the research points out that , the quantity taken offs can be established as the Building Information Model is being designed to provide cost estimates on a project , BIM-based 4D scheduling helps to illustrate the building elements and prioritize progress so that better construction planning occurs in effect and BIM provides reduction in time and costs and yields higher performing building products and services. Research on Building Information Model (BIM) Technology by Tianqi Yang and Lihue Liao gives a rundown of a whole aspect to the technology involved in the Building Information Modelling. This research paper gets under way with a scientific definition of the BIM whereby they define the inner function of BIM in narrow and broad sense. BIM based sustainability analyses for a construction project by Ahmed Khan & Dr. Anil N Ghadge aimed to perform the sustainability analyses of hotel building with the help of BIM (Building Information Modelling). The research aim is to show through BIM the various aspects such as; building sun path, location, orientation, thermal properties of materials, ventilation and daylighting analysis. Building information modelling (BIM) for sustainable building design by Kam-din Wong and Qing Fan aimed to introduce BIM enabled sustainable design and to explore how BIM can potentially facilitate and benefit sustainable design. The research aim is to discuss BIM 's approaches to sustainable building design, examine the advantages and drawbacks to implementing BIM to promote sustainable design, and include guidance for how to adapt BIM to sustainable design.

5. RESULT AND DISCUSSION

5.1 Rendering using Autodesk Revit

Rendering is the process in which photorealistic image of the model is created. Revit is such a software which is very useful in creating different elevations and then its rendered image with easiness. To get better look and a realistic look to the building model or to create a visual look , we perform rendering. There are various types of renderings which are used , some of them are :- Revit cloud-rendering and 3D max rendering. While performing the rendering , the most important factors which are to be kept in mind are quality and speed of the process.

Figure 1 - Model with Rendering

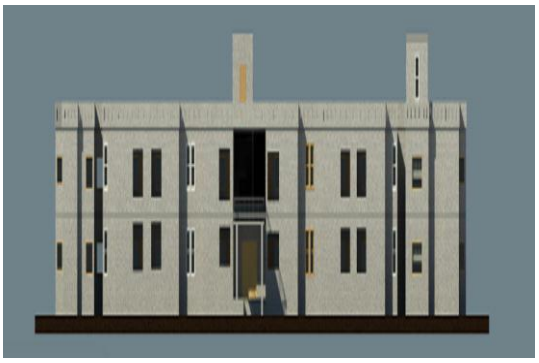

Figure 2 - Front Elevation

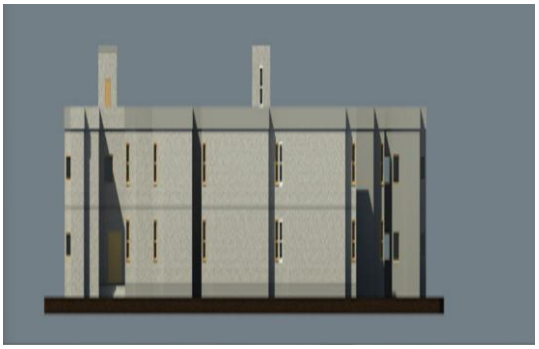

Figure 3 - Rear Elevation

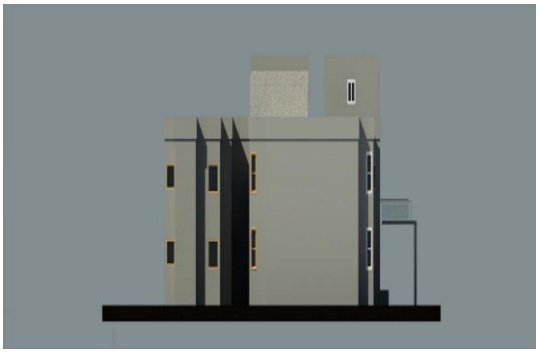

Figure 4 - Side Elevation – 1

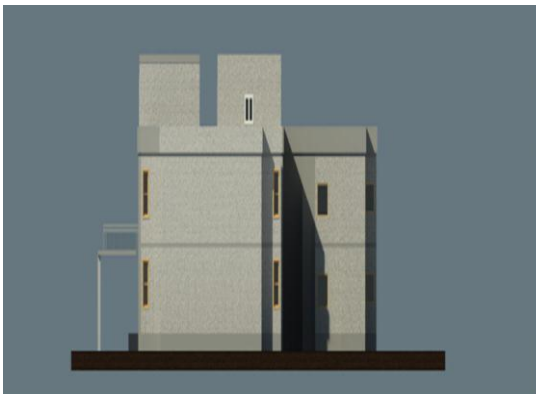

Figure 5 - Side Elevation - 2

5.2 Various Analysis Done Using Autodesk Revit

5.2.1 Energy Analysis

Energy analysis can be done by preparing a model using Revit. To perform the energy analysis, firstly we need to generate an energy model by using the model geometry to understand that what are the changes occurring with the design and what impact does it make to the energy performances.

System zones can be created using Autodesk Revit which is basically a graphic element which is used to show areas of the project / building and it is also served by an analytical space or system . These analytical systems are added in a 3D geometry to all the enclosed volumes which are available. Each of the analytical space is assigned to a specific system zone which is either available inside or it will be touching the boundary of the energy model. System zones can also be created by including the sun path into it. Sun path tells that, in which direction sun shadows moves at the building project side. When sun path is turned on , the software shows the sun path through the building.

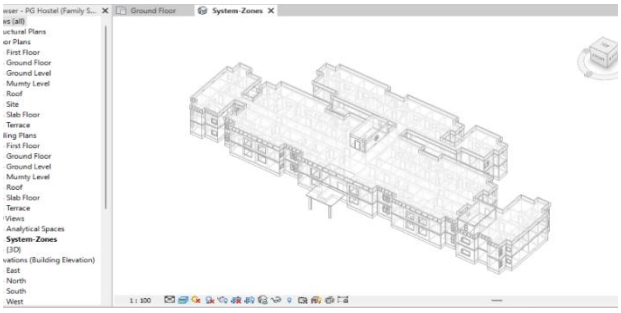

Figure 6 - System Zones

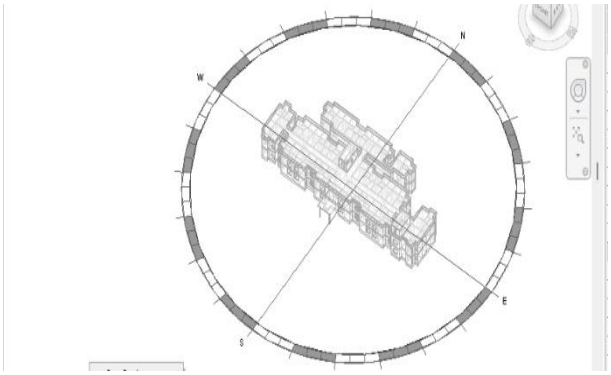

Figure 7 - System Zone When Sun Path Is Turned On

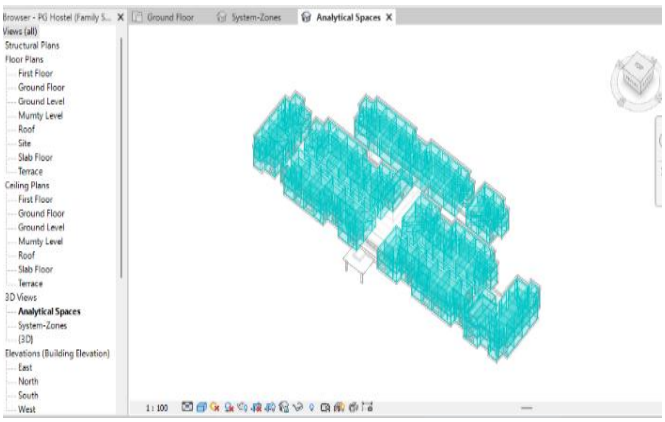

Figure 8 - Analytical Spaces

5.2.2 Sun Path Analysis

Sun path analysis is a very useful process to determine appropriate locations for the installation of various families such as; solar panels, electricity generation, and other various types of solar related equipment's which are to be installed inside the building complex to use the solar energy in maximum possible ways.

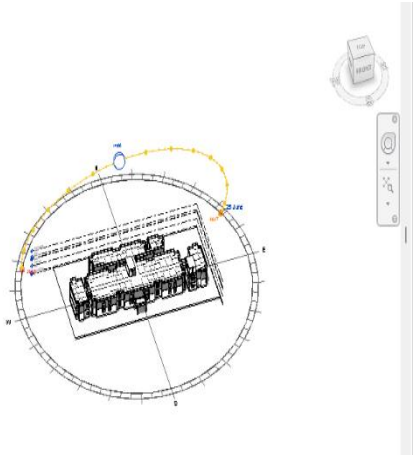

Figure 9 - Sun path along with the shadows as visible

5.2.3 Shadow Analysis

Shadow analysis can be done also to reduce energy uses and cost which just need a little investment in the systems. It can be very useful in reducing the summer heat absorption , in reducing electricity bills , etc.

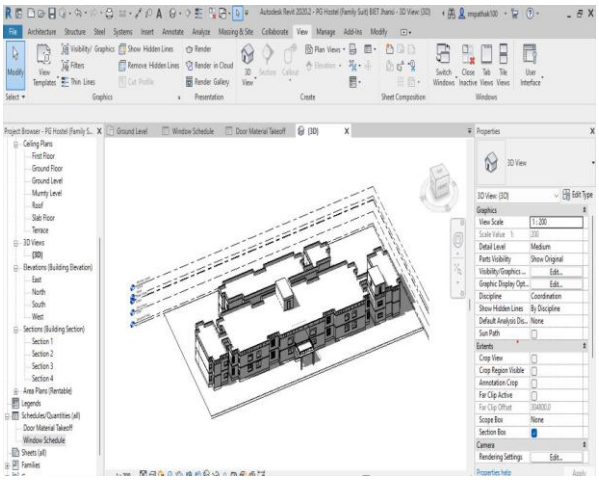

Figure 10 - Shadow Analysis

5.2.4 Heat And Cooling Analysis

With the help of Revit, we can easily generate heating and cooling design temperatures. If we need to assess the building's energy requirements and to assess the space and zone needs , then review of heating and cooling loads is essential. We need to keep control over the heating and cooling loads because these loads are specifically associated to fuel and electricity consumption. We know that if thermal heat gets accumulated within the building, then it starts causing more and more heat and due to this the daily maximum temperature starts decreasing. So, we need to focus on the parameters which help in performing the heating and cooling analysis. Heating and cooling analysis is performed using BIM for designing a better sustainable building which gets heated and cooled naturally in a very efficient manner. In Revit, we go to location and weather section and then through weather to check the heating and colling temperatures.

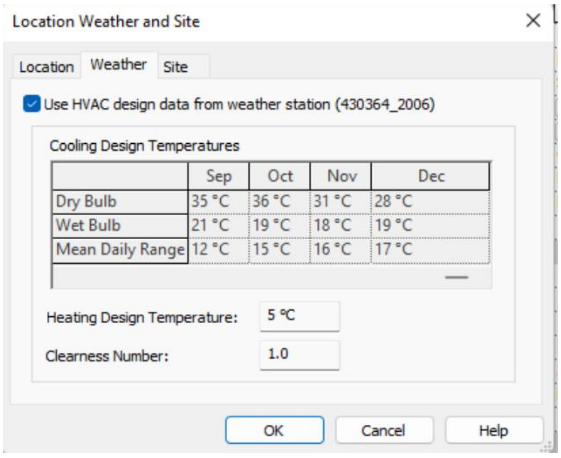

Figure 11 - Cooling and Heating Design Temperatures

5.2.5 Scheduling And Material Take-offs

Scheduling with material take-off is the process of finding out the estimate of cost and the material which is required in the project and also to give an idea of family, material name, material cost , area and volume of the material such as door , window, etc. This is a very important aspect while finding out an estimate during the construction work.

<Door Material Takeoff>

A	B	C	D	E	F	G
Family and Type	Height	Width	Material: Name	Material: Area	Material: Cost	Total Cost
Double - Flush: 92	2040	1220	Wood - Pine	16 m^2	2500.00	40550.87
Double - Flush: 92	2040	1220	Wood - Pine	16 m^2	2500.00	40550.87
Double - Flush: 920: 2						
M_Single-Flush: 09	2134	915	Door - Panel	4 m^2	1666.67	7027.04
M_Single-Flush: 09	2134	915	Door - Frame	2 m^2	1777.37	3844.34
M_Single-Flush: 09	2134	915	Door - Panel	4 m^2	1666.67	7027.04
M_Single-Flush: 09	2134	915	Door - Frame	2 m^2	1777.37	3844.34
M_Single-Flush: 09	2134	915	Door - Panel	4 m^2	1666.67	7027.04
M_Single-Flush: 09	2134	915	Door - Frame	2 m^2	1777.37	3844.34
M_Single-Flush: 0915 x 2134mm: 6						
M_Single-Flush: D	2100	1000	Door - Panel	5 m^2	1666.67	7527.02
M_Single-Flush: D	2100	1000	Door - Frame	2 m^2	1777.37	3856.55
M_Single-Flush: D	2100	1000	Door - Panel	5 m^2	1666.67	7527.02
M_Single-Flush: D	2100	1000	Door - Frame	2 m^2	1777.37	3856.55
M_Single-Flush: D	2100	1000	Door - Panel	5 m^2	1666.67	7527.02
M_Single-Flush: D	2100	1000	Door - Frame	2 m^2	1777.37	3856.55
M_Single-Flush: D	2100	1000	Door - Panel	5 m^2	1666.67	7527.02
M_Single-Flush: D	2100	1000	Door - Frame	2 m^2	1777.37	3856.55
M_Single-Flush: D	2100	1000	Door - Panel	5 m^2	1666.67	7527.02
M_Single-Flush: D	2100	1000	Door - Frame	2 m^2	1777.37	3856.55
M_Single-Flush: D	2100	1000	Door - Panel	5 m^2	1666.67	7527.02
M_Single-Flush: D	2100	1000	Door - Frame	2 m^2	1777.37	3856.55
M_Single-Flush: D	2100	1000	Door - Panel	5 m^2	1666.67	7527.02
M_Single-Flush: D	2100	1000	Door - Frame	2 m^2	1777.37	3856.55
M_Single-Flush: D	2100	1000	Door - Panel	5 m^2	1666.67	7527.02
M_Single-Flush: D	2100	1000	Door - Frame	2 m^2	1777.37	3856.55

Figure 12 - Door Material Take-off

<Wall Material Takeoff>

A	B	C	D	E
Family	Material: Name	Material: Volume	Material: Cost	Total cost
Basic Wall	Default Wall	1.96 m^3	3000.00	5884.43
Basic Wall	Default Wall	1.54 m^3	3000.00	4611.48
Basic Wall	Default Wall	1.22 m^3	3000.00	3658.93
Basic Wall	Default Wall	1.69 m^3	3000.00	5084.65
Basic Wall	Default Wall	2.07 m^3	3000.00	6218.27
Basic Wall	Default Wall	1.38 m^3	3000.00	4135.86
Basic Wall	Default Wall	1.76 m^3	3000.00	5267.02
Basic Wall	Default Wall	2.80 m^3	3000.00	8411.33
Basic Wall	Default Wall	1.38 m^3	3000.00	4135.86
Basic Wall	Default Wall	1.81 m^3	3000.00	5438.66
Basic Wall	Default Wall	1.30 m^3	3000.00	3897.85
Basic Wall	Default Wall	1.22 m^3	3000.00	3658.93
Basic Wall	Default Wall	1.25 m^3	3000.00	3758.82
Basic Wall	Default Wall	1.61 m^3	3000.00	4818.28
Basic Wall	Default Wall	2.54 m^3	3000.00	7633.49
Basic Wall	Default Wall	1.69 m^3	3000.00	5065.43
Basic Wall	Default Wall	8.26 m^3	3000.00	24793.03
Basic Wall	Default Wall	2.77 m^3	3000.00	8302.74
Basic Wall	Default Wall	1.92 m^3	3000.00	5766.99
Basic Wall	Default Wall	2.33 m^3	3000.00	6998.64
Basic Wall	Default Wall	1.53 m^3	3000.00	4589.81
Basic Wall	Default Wall	2.78 m^3	3000.00	8333.76
Basic Wall	Default Wall	1.61 m^3	3000.00	4818.28
Basic Wall	Default Wall	0.89 m^3	3000.00	2679.36
Basic Wall	Default Wall	1.76 m^3	3000.00	5293.90
Basic Wall	Default Wall	2.31 m^3	3000.00	6920.27

Figure 13 - Wall Material Take-off

If , we simply talk about scheduling , it is used to create the data of materials used as well as the quantity in which it has been used and to found what is the actual cost of all these materials. Schedules such as window schedule can be found out using Revit.

<Window Schedule>

A	B	C	D	E	F
Family and Type	Type Mark	Width	Height	Sill Height	Count
M_Fixed: KW3	28	985	1050	1050	1
M_Fixed: KW3	28	985	1050	1050	1
M_Fixed: KW3	28	985	1050	1050	1
M_Fixed: KW3	28	985	1050	1050	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W5	30	1500	1200	900	1
M_Fixed: W5	30	1500	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: KW3	28	985	1050	1050	1
M_Fixed: W6	27	1800	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: KW3	28	985	1050	1050	1
M_Fixed: KW3	28	985	1050	1050	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1
M_Fixed: W4	29	1200	1200	900	1

Figure 14 - Window Schedule

6 CONCLUSION

BIM is an impactful concept in the field of AEC industries , as it has influence on the society and environmental factors . Due to the implementation of BIM in sustainable construction and also for sustainability analysis , BIM will play a vital role in the development of construction industries and will speed up the pace of work during project. BIM based sustainability analyses also helps in increasing the performance rate of the project. With the help of BIM , we are also able to save the resources , time and cost as well. Using the BIM technique , we can create 3D models , find out the material take-offs to provide cost estimations on any construction project. Hence , BIM helps to achieve the design intent during the construction of building facility and also in comparison to the new techniques BIM is more efficient in reducing cost and time during the project.

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