

Building Information Modeling in Building Management using 3D Techniques

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ABSTRACT- Building Information Modeling (BIM) has revolutionized the way the building industry operates. BIM is an innovative approach to building management that uses 3D modeling techniques to create digital representations of buildings and their components. This technology has become an indispensable tool for architects, engineers, contractors, and building managers to streamline the design, construction, and maintenance of buildings.

In this paper discusses the use of BIM in building management and the role of 3D modeling techniques in enhancing the accuracy and efficiency of building operations. BIM provides a comprehensive view of the building, including its systems and components, which helps in identifying potential issues and mitigating risks. The 3D modeling techniques provide a realistic representation of the building, which makes it easier for building managers to understand and communicate with stakeholders.

This paper highlights the benefits of using BIM in building management, including improved collaboration, enhanced communication, and reduced costs. BIM enables building managers to track and manage building data, including maintenance schedules, energy consumption, and occupancy levels. This data can be used to optimize building performance, reduce energy costs, and improve occupant comfort.

Finally, the paper identifies some of the challenges associated with the adoption of BIM in building management, including the need for specialized skills, the high cost of software and hardware, and the resistance to change within the industry. The paper concludes by emphasizing the need for continued investment in BIM and 3D modeling techniques to support sustainable and efficient building management practices.

KEYWORDS- BIM, 3D Techniques, CAD, CFD.

I. INTRODUCTION

A. Building Information Modeling

The increasing complexity of construction work requires the use of new methods and modern equipment that make conventional planning processes more efficient and also increase projects' transparency. With BIM technology, an accurate virtual model of a building is digitally constructed. When completed, the computer-generated

model contains precise geometry and relevant data needed to support the construction, fabrication, and procurement activities needed to realize the building. BIM also accommodates many of the functions needed to model the lifecycle of a building, providing the basis for new construction capabilities and changes in the roles and relationships among a project team. BIM therefore facilitates an integrated design and construction process that should result in better quality buildings at lower cost and reduced project duration.

“Building information modeling (BIM) is a term used to describe a collaborative work approach. Based on digital models, it can be used to compile and manage a consistent repository of a building's information and data that is relevant for its entire lifecycle. This information can also be shared between all parties using transparent communication, or it can be forwarded for further processing.” [2]

B. Applications OF Building Information Modeling

A building information model can be used for the following purposes:

- Visualization: 3D renderings can be easily generated in house with little additional effort.
- Fabrication/shop drawings: It is easy to generate shop drawings for various building systems. For example, the sheet metal ductwork shop drawings can be quickly produced once the model is complete.
- Code reviews: Fire departments and other officials may use these models for their review of building projects.
- Cost estimating: BIM software has built-in cost estimating features. Material quantities are automatically extracted and updated when any changes are made in the model
- Construction sequencing: A building information model can be effectively used to coordinate material ordering, fabrication, and delivery schedules for all building components.
- Conflict, interference, and collision detection: Because building information models are created to scale in 3D space, all major systems can be instantly and automatically checked for interferences. For example, this process can verify that piping does not intersect with steel beams, ducts, or walls.
- Forensic analysis: A building information model can be easily adapted to graphically illustrate

potential failures, leaks, evacuation plans, and so forth.

- Facilities management: Facilities management departments can use it for renovations, space planning, and maintenance operations.

II. LITERATURE REVIEW

Stober, et al. [3] presented an example of the BIM for designing parametric objects was to create a rich information model. Through the BIM 3D application, the main contractor participants can discuss the reasonably site plan according to construction condition and optimize the allocation space of facilities, equipment, and material store area. This process is helpful to construction management get suitable site layout and selects a feasible construction plan.

Jianhua, et al. [4] presented an example of highway project are integrated on the unified BIM platform for collaborative management to achieve intercommunicate information, exchange isolated situation information, improve the parameter management. The BIM is no longer as a simple reference file and create a project resource. The construction participants use this platform to integrate collaborative design between the various professional information

Mirzaei, et al. [5] presented that BIM dynamic clash detection was developed to identify conflicts which extremely impacted on project performance. This approach can shorten the construction time, reduce hidden cost and improve the construction site work efficiency. Finally, BIM technology can find these potential design problems optimize design quality.

Koseoglu, [6] thought that BIM are developed in order to increase productivity, efficiency and quality in construction by implementing various procedures, such as clash detection. By using BIM technology, the designers can easily check the conflict in the design stage under the virtual three-dimensional environment. This technology can greatly improve the comprehensive design ability for different special participants. It eliminates the construction collision risk and reduce delay cost through the construction coordination by BIM platform.

Cheung, et al. [7] applied the integration of BIM and Wireless Sensor Network (WSN) into a unique system which enables monitor the construction site visually under safety status. By using BIM corresponding accident analysis and simulation software, it simulates the disaster process before the accident emerged. This tool can analyze the reason of the accident and support first-aid plan. It provides important information for rescue workers when the accident appeared in the construction site. This method can reduce percentage of construction site accident and reduce the accident cost as possibly. It is helpful for participants to increase safety awareness in the construction activities also.

Li and Chen, [8] presented an example that BIM technology reduces the quality damages which caused by the clash issues from various special work. Through the BIM technology application, the various steel components installation accuracy are ensured in the construction site condition.

Iyakoregha, et al. [9] developed new competencies that enable construction project hand over effectively. Through

the BIM 6D application, a large amount of construction information contained into BIM platform. The BIM 6D combine with operation and maintenance information for the building management system. In addition, the BIM combined with RFID facilities label chip is helpful for operator to get relevant data & information in the building clearly and quickly.

Jones et al. [10] report in “The Business Value of BIM for Infrastructure 2017” a graph that measures the growth of BIM deployment (for projects using BIM) for infrastructure projects. This report shows that the percentage of engineers and contractors working with BIM in the UK tripled between 2015 and 2019, respectively from 21% to 69%.

Sanchez, Kraatz, Hampson, & Loganathan [11] indicate that the use of BIM at the early stages of infrastructure design would:

- Influence productivity gains;
- Allow for a comprehensive cost-benefit analysis leading to significant operating cost savings;
- Coordinate street and highway lighting planning concerning other energy and environmental aspects;
- Enable the measurement of key indicators, including long-term impact factors that could be transferred throughout the project life cycle; and
- Enable design documents to be integrated with sustainability objectives throughout their life cycle.

Yilmaz, Akcamete, & Demirors [12] proposed a BIM model for assessing the BIM maturity of building/infrastructure projects. However, it is more suitable for BIM maturity assessment of design practice, as four of its eleven measurement criteria – data volume, graphical information, 3D quality and information accuracy – are more closely related to design.

III. PROBLEM STATEMENT AND OBJECTIVE

A. Problem Statement

Building information modeling (BIM) is one of the most promising recent developments in the architecture, engineering, and construction (AEC) industry. With BIM technology, an accurate virtual model of a building is digitally constructed. This model, known as a building information model, can be used for planning, design, construction, and operation of the facility. It helps architects, engineers, and constructors visualize what is to be built in a simulated environment to identify any potential design, construction, or operational issues. BIM represents a new paradigm within AEC, one that encourages integration of the roles of all stakeholders on a project.

B. Objective

The objective of current research is to demonstrate the application of 3D BIM tool in design of G+2 building. The design modifications are made on existing design which are intended to reduce carbon emission and would serve the purpose of Green Energy Building design. The detailed objectives are:

- CAD modeling of G+2 building using Revit Architecture software. The material takeoff table (or BIM table) is generated for this design.

- Reducing construction cost by incorporating curtain wall(or walls) in existing design of G+2 building and generating material takeoff table (or BIM table) for the same. This is design 2.
- To reduce carbon emission (green building design), the inclined solar chimney is incorporated in existing design and generating material takeoff table (or BIM table) for the same. This is design 3.
- To reduce carbon emission (green building design), the wind catcher is incorporated in existing design

and generating material takeoff table (or BIM table) for the same. This is design 4.

- Comparative analyses on the construction cost for all the 3 designs i.e. design 1, design 2, design 3 and design 4.

IV. METHODOLOGY

A. Methodology Flow Chart

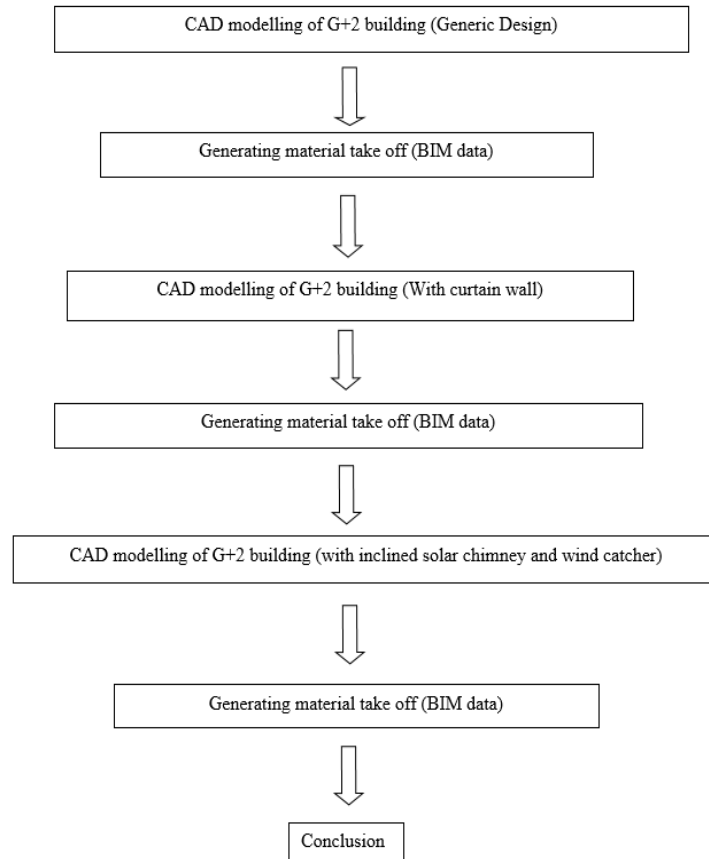


Figure 1: Flow chart of our methodology

B. Methodology Steps

The 1st set of analysis is conducted in single floor structure having 1 room. The dimensions of computational domain are 1m length and 1m width. The opening of .35m is located on right side of the structure and similarly opening of .35m is on top of air outlet. The computational domain is exposed in figure 1 below.

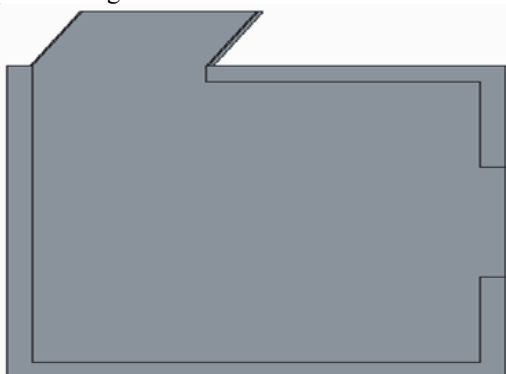


Figure 2: Automatic domain of chimney

The steps in 3D CAD modeling of G+2 structures involves generation of following elements.

Step 1: Create the Project Model File

Create a new project with a suitable template as a base. Refer to your BIM Lead/ BIM Manager to gain access to a standard template for your organization or select one of the default Autodesk templates as prompted

Step 2: Assign your Project Information

The following Information should be a minimum requirement for all projects to contain.

Step 3: Create your Grids

All Projects should have a Grid system in place, regardless of scale of design complexity

- **Copy Grids** into intervals those are required. Note how the Value of the grids automatically populates in sequence.
- Once you have your grids set out in one direction, repeat the process in the perpendicular direction

Step 4: Create Levels

To Create Levels in Revit, the Process is much the same as it was for setting out the Grids. To place levels in Revit do the following:

Step 5: Assign your Project Base Point

Once you understand your project particulars with a little more definition and you can identify a fixed point in the project (existing element that will remain unchanged) or something that is likely to be fixed from the early project development (eg. a grid intersection) it is time to set up the project base point location.

Step 6: Generating elements of model

The Revit Arch model comprises of following elements are:

- **Walls**
Use a Wall tool to create a non-bearing wall or a structural wall in the building model.
- **Doors**
Use the Doors tool to place a door in a wall. Select a door type from the Type Selector.
- **Windows**
Use the Windows tool to place windows in a wall or skylights in a roof. Select a window type from the Type Selector.
- **Components**
Components are used to model building elements that are usually delivered and installed on site, such as furniture and plumbing fixtures.
- **Architectural Columns**
Use architectural columns to model column box-outs around structural columns and for decorative applications.
- **Roofs**
Create a roof from a building footprint or an extrusion.
- **Ceilings**
Use the Ceiling tool to create a ceiling at a specified distance above its level. To place a ceiling, click within walls that form a closed loop, or sketch its boundaries.

- **Floors**
Use the Floor tool to create level, sloped, or multi-layer floors.
- **Curtain Elements**
Use curtain element tools to create building facades. You can use curtain walls, curtain grids, mullions, and curtain systems to create the desired look.
- **Railings**
Create railings that are free-standing or attached to hosts such as floors, ramps, or stairs.
- **Ramps**
Create ramps in a plan or 3D view by sketching the run of the ramp or by sketching boundary lines and riser lines.
- **Stairs**
Create a stair by assembling components for common runs, landings, and supports.
- **Model Text**
Use model text to create signs or lettering on a building or wall.
- **Model Lines**
Use model lines to create 3D lines that are part of the design.
- **Rooms**
Create rooms in a plan view with the Room tool, or add them to a schedule to be placed in the model later.
- **Openings**
Use an Opening tool to cut openings in walls, floors, ceilings, roofs, structural beams, braces, and structural columns.

V. RESULT AND DISCUSSION

A. Inclined Solar Chimney with single floor

The investigation has been approved out with ANSYS CFX software for tending solar funnel without any geothermal design mechanism and with geothermal mechanism. This section describes the results obtained from CFD analysis for inclined solar chimney with single floor

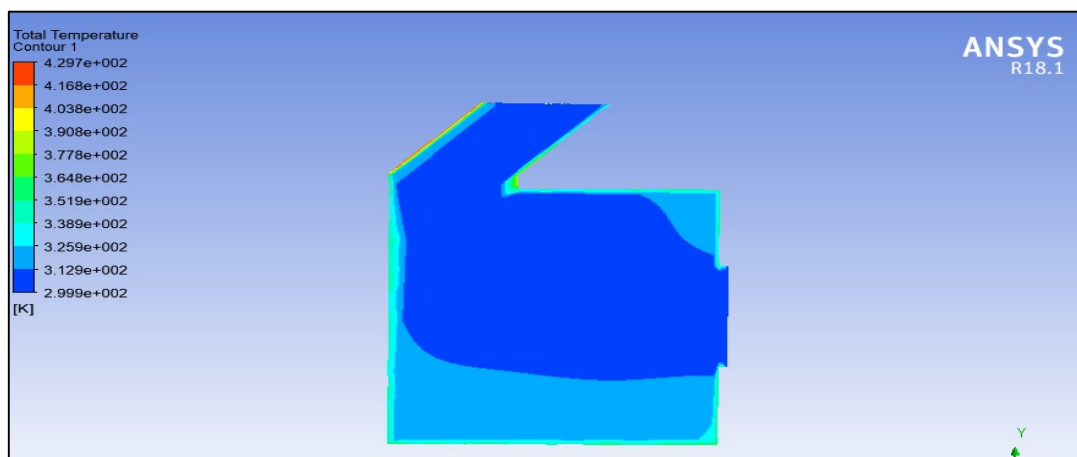


Figure 3: Temperature plot for inclined solar chimney without perforated plate

The temperature conspiracy obtained after CFD examination is exposed in figure 2 upstairs. The

conspiracy shows advanced temperature at locality of crystal and close absorber bowl.

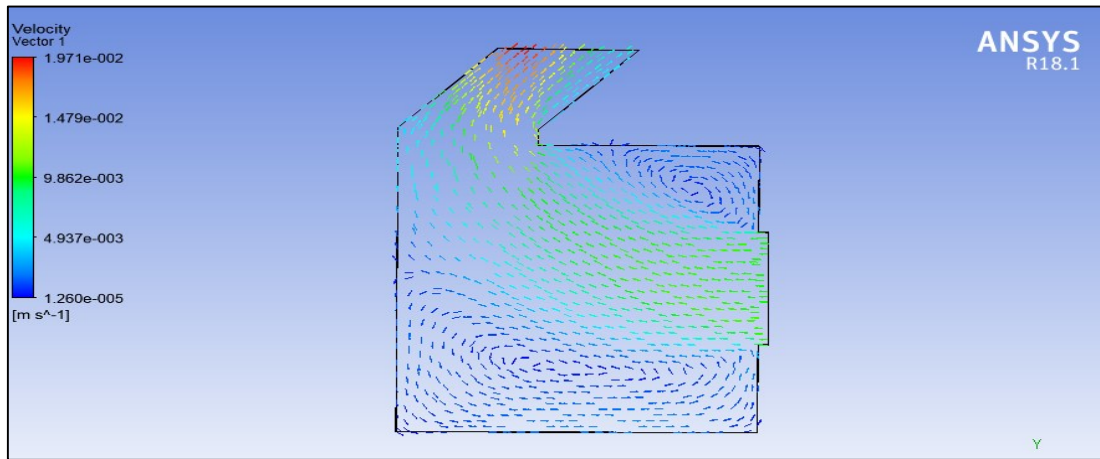


Figure 4: Velocity vector

The velocity course plot is exposed in above figure 3. The plot displays vortex group at two regions.

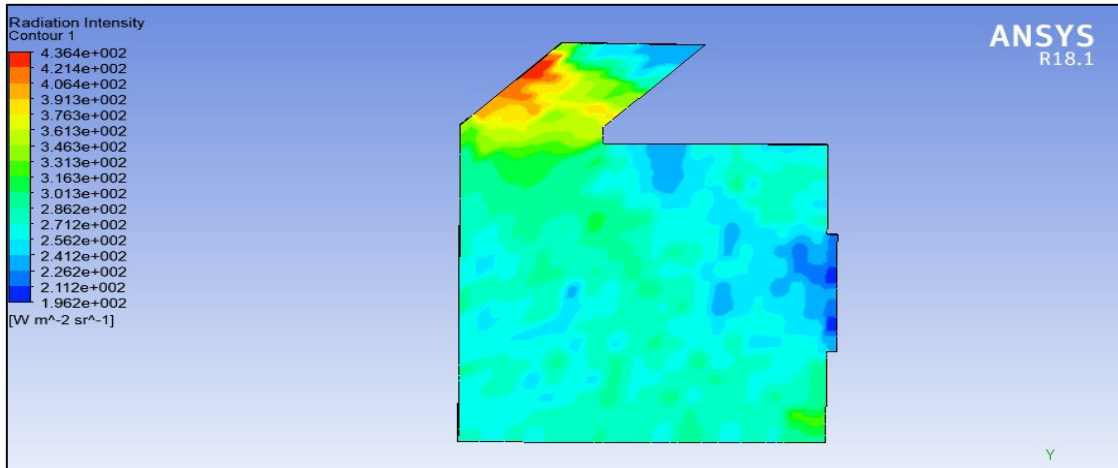


Figure 5: Radiation intensity

The radiation strength plot is exposed in above figure 4. The plot displays higher strength of magnitude which is 436.4 W/m² on the areas near the event glass superficial and on lowest right angle due to trail of event radiation. The regions anywhere air movement vectors are conventional (without swirl) consumes lower temperature

likened to regions anywhere air flow courses are commotion is generated.

The pressure plot is revealed in figure 7 lower. The pressure scheme shows suction (negative pressure) on regions between glass (on which sunrays are incident) and absorber plate.

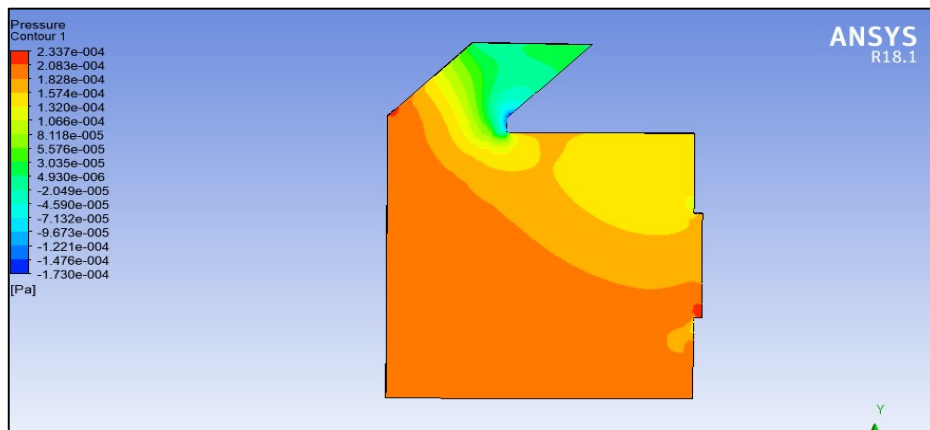


Figure 6: Pressure contour

The negative pressure is shown by light blue and dark blue colored regions as shown in figure 5 above. The other regions of the room at bottom and near the opening show positive pressure. The negative pressure on the top between glass and absorber plate and positive pressure on other locations results in air movement from positive weight region to negative weight region

B. G+1 building and curtain roof

After applying CFD technique in single room, the analysis is conducted on 3D model of G+1 computational domain. The pressure distribution plot is generated for the computational domain as shown in figure 6.

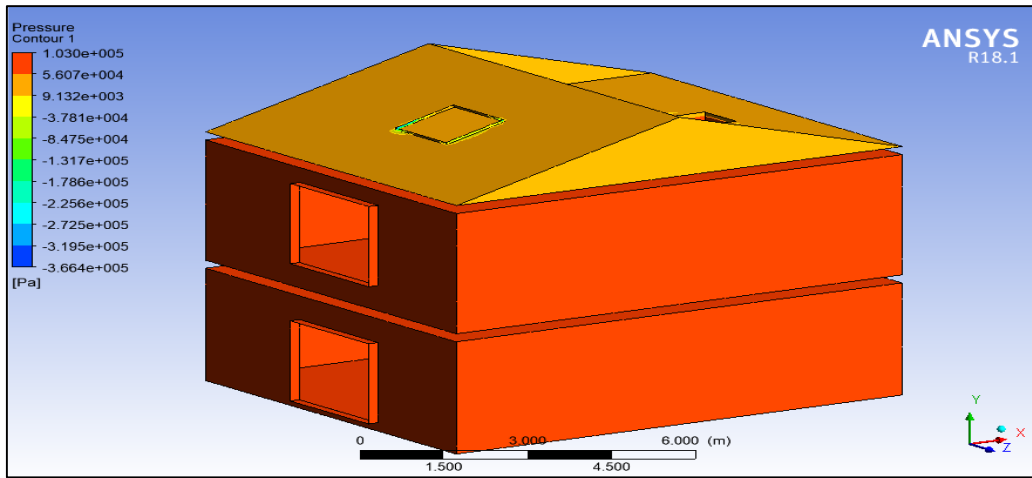


Figure 7: Pressure contour for G+1 building with curtain roof

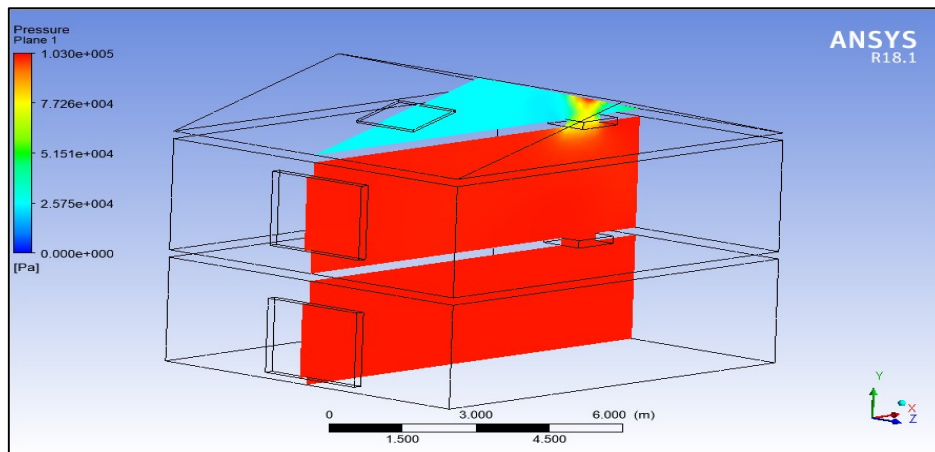


Figure 8: Pressure contour across mid-section plane

The pressure distribution across mid-section plane is shown in figure 67 above. The pressure on ground floor room and 1st floor room is high as represented in red

colored region. The pressure at this region is 1atm and pressure on the topmost zone i.e., zone with curtain roof has lower pressure as shown in light blue colored region.

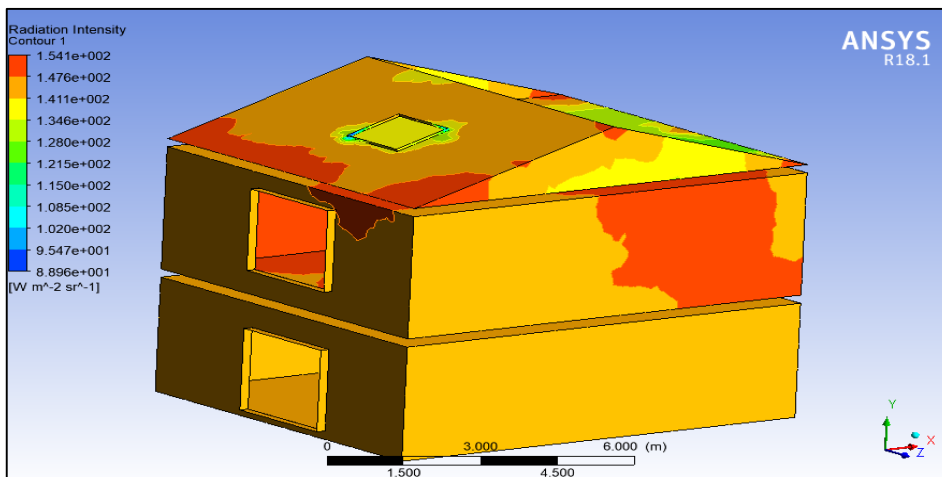


Figure 9: Radiation intensity plot for G+1 building with curtain roof

The pressure in this region reaches below atmospheric value (negative) which creates low pressure zone. The air of low-pressure region exits from the opening and the air from high pressure region on G+1 room space and ground floor space enter this region. The radiation intensity plot is generated for the entire building as shown in figure 8 above. The radiation intensity is maximum on the upper deck and is lower on lower deck. The maximum incident solar radiation on the upper deck is $154.1 \text{ W/m}^2 \text{ sr}^1$.

The results of this experiment may also have larger ramifications for green building techniques and sustainable building design. Maintaining interior air quality, thermal comfort, and occupant wellbeing all depend on proper ventilation. Buildings may be made that are not just energy-efficient but also conducive to a pleasant and healthy interior atmosphere by using CAD modelling and CFD analysis tools to optimise ventilation systems. The inclusion of BIM elements in this project serves as another evidence of how important digital technologies are becoming to the building sector. BIM enables improved stakeholder collaboration and communication, resulting in simpler and more effective building processes. By facilitating improved decision-making, lowering construction mistakes and waste, and maximising efficiency, virtual representations of building structures created by CAD modelling and BIM detailing may help promote more environmentally friendly building practises. Additionally, the comparison study based on material takeoff offers insightful information about the financial effects of various designs. In accordance with the principles of sustainable building practises, this information may be utilised to optimise material utilisation, decrease waste, and cut construction costs. Buildings may be made more sustainably and economically by taking the life cycle costs of the materials and design decisions into account.

VI. CONCLUSION AND FUTURE SCOPE

The ventilation project's goals have been effectively met thanks to a variety of CAD modelling and CFD analysis methodologies. The first goal included modelling a single room's structure using CAD software and doing a CFD study to figure out how much air is moving and at what temperature. In order to provide optimal ventilation and thermal comfort, it is essential to understand the air flow patterns and temperature distribution throughout the space. The second goal was to create BIM details and model a G+1 building construction without a curtain roof using CAD. This process assisted in developing a digital version of the structure that could be utilised for simulations and further research. The final goal entailed creating BIM details and CAD modelling of the same G+1 building structure with a curtain roof. This made it possible to compare the effects of the two designs on ventilation and thermal performance. The G+1 building with a curtain roof was the subject of a CFD study for the fourth goal in order to evaluate its temperature distribution, air flow rate, and radiation intensity.

A. Future Scope

In order to evaluate temperature distribution, air flow rate, and radiation intensity in a G+1 building with a curtain roof, CFD analysis was used. This analysis has shown

numerous new prospective areas for further study and development. The analysis's conclusions suggest that the following areas need further research and development:

- **Advanced Curtain Roof Design Optimisation**

The CFD research could have shown regions in which the curtain roof design might be improved for performance. To optimise temperature distribution, air flow rate, and radiation intensity inside the building, more study may concentrate on advanced curtain roof design optimisation approaches. For example, alternative curtain materials, configurations, and control algorithms might be investigated. To verify the efficacy of various curtain roof design alternatives, more CFD calculations and testing may be necessary.

- **Integration of Smart Technologies**

The performance of the curtain roof and overall building ventilation strategy may be improved with the use of smart technologies including sensors, actuators, and automation systems. Future studies could look towards integrating these smart technologies to optimise the curtain roof's performance based on real-time data like temperature, humidity, and occupancy both inside and outside. This would make it possible to dynamically and adaptively manage the curtain roof, resulting in ventilation techniques that are more effective and sustainable.

- **Evaluation of Energy Performance**

Information on the energy performance of the structure with the curtain roof may have been obtained from the CFD study. Future studies might concentrate on assessing the building's energy efficiency using various curtain roof layouts and operating approaches. This might include doing life cycle evaluations to comprehend the building's long-term sustainability as well as energy simulations and analysis to evaluate the energy savings and environmental benefits linked with the curtain roof.

- **Comfort and health of the occupants**

The CFD research may have looked at how the curtain roof affects the temperature and airflow within buildings, which may affect occupant comfort and health. The link between curtain roof design and occupant comfort, including thermal comfort, indoor air quality, and daylighting, might be further studied in future studies. In order to gather information on occupant comfort and health factors and analyse the results to guide design choices for increased occupant well-being, surveys, questionnaires, and field studies may be conducted.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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