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Bim-Based 3d Modeling of Computer Lab in an Institution and IoT-Driven Internal Comfort Investigation- a Real-Time Case Study

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Abstract: *Institutional buildings are vital to society, offering education, administration, and public services. BIM for design, construction, and IoT for monitoring, and improving internal comfort are helping architects and engineers optimize functionality and occupant comfort. BIM and IoT devices are used to combine 3D modeling of an academic building and analyze interior comfort in this project. The first step of the project entails creating a realistic 3D model of a laboratory of an institutional building, highlighting the value of BIM in capturing physical geometry and crucial data. The BIM model supports efficient and collaborative design and construction decision-making, improving stakeholder coordination. The second part of the project employs IoT devices to monitor and optimize interior comfort in the modeled institutional setting. Real-time environmental data are collected by strategically positioned IoT sensors including temperature, and occupancy. This data is processed using powerful algorithms and machine learning to determine building thermal comfort, indoor air quality, and energy efficiency. By using BIM for exact modeling and data integration, architects and engineers can make better building performance and sustainability choices. This research suggests a more comprehensive and data-driven approach to institutional building design and operation. BIM and IoT will enable AEC professionals to design buildings that satisfy functional requirements, emphasize occupant well-being and comfort, promote sustainability and efficiency.*

Keywords :- *BIM, Real-time monitoring, Predictive maintenance, Building projects.*

1. INTRODUCTION

Building Information Modeling (BIM) technology is a big change in the way design, engineering, and construction (AEC) are done. The way buildings and facilities are planned, built, and handled has changed a lot because of this digital method. BIM isn't just a piece of software or a way to model in 3D; it's a whole process that brings together information from many different angles. This helps people work together, makes it easier to make decisions, and improves the whole lifecycle of a built asset. The power of BIM lies in its ability to model and view projects in a 3D world. This allows stakeholders to predict problems, improve plans, and make choices based on data before building starts. BIM adds the fourth and fifth dimensions, which are time (4D) and cost (5D), to 3D models. Project managers can plan building schedules and budgets more correctly by using time-based scheduling and cost estimates. A unified technical platform may facilitate the administration of all building information, from architectural design through post-occupancy maintenance. This notion underpins Building Information Modeling (BIM) technology. There is increasing interest in using this technology in the AEC business. A parametric BIM model is connected with visual presentation but is also a rich source of information [1].

The first advantage of BIM is the automated generation of a 3D model from 2D lines and element characteristics inside the program. BIM is more than just visuals since each architectural piece is an object with unique information and identity. While in its early stages of research and deployment, BIM is a promising technology for integrating teams on a project. Interoperability, a key need for BIM, is essential for integrating collaborators in projects [2]. Many in the construction sector utilize it to increase the speed and quality of documentation [3]. However, building information is still often stored in separate models.

To create and manage a BIM model, users must understand data identification, organization, classification, and reuse, determining which additional phases to develop or coordinate. The application of this notion requires several participants from various AEC business areas [4]. The professional architecture and engineering community quickly adopts new technology to streamline design and save time and money [5], while the academic community takes a more deliberate approach to incorporate new technology and offer new courses [6]. Civil Engineering education will increasingly need students and professionals to be proficient in BIM technologies because of cost and schedule constraints.

Building Information Modeling (BIM) [7] is mostly used in the design phase (54.88%) and pre-construction phase (51.90%) of various projects. Building Information Modeling (BIM) is used to a lower degree throughout the building phase, as shown by 34.67% of the participants reporting frequent usage, while 52% reporting occasional utilization. A mere 26.92% of individuals often use Building Information Modeling (BIM) for preliminary feasibility assessments. The statistical data pertaining to the operation and administration of the building indicates that its utilization rate is rather low, occurring a restricted number of times (8.82% of the time). The low use throughout the operation and management stages might also be attributed to the recent adoption of Building Information Modeling (BIM) or other Facilities Management software, such as Archibus.

2. LITERATURE REVIEW

Over 180 publications, including books, academic or applied papers, relevant standards, and online sources, were analyzed. Of these, 95 were journal articles, 63 were conference papers, and the remaining 26 were other publications, such as books or papers in applied journals. As can be seen, more than eighty percent of the articles that were evaluated include clear references to BIM ('BIM' in the abstract or key phrases). The remaining publications are relevant despite the fact that some of them either (8) do not mention BIM in their keywords or abstract, despite the fact that it is addressed in the publication, or (9) regard 3D building models that are not explicitly BIM, partly due to an unclear definition, for example models that lack semantic information or parametric representation of components (such as surface, BREP, CSG, or CAD models), or (10) deal with related topics, such as cloud computing or semantic web services. In addition, it is obvious from that the majority of BIM articles were published after 2008, with a significant increase in publication activity in the most recent years. Modeling involves creating BIM objects with geometric and non-geometric properties and connections to represent architectural components. If BIM is modeled from previously acquired building information, the deployment technology and LoD affect data quality. To evaluate various methodologies and their modeling capacity, produced models could be tested e.g. with regard to modeling correctness, LoD, or CMM6 [11], [12]. We have no common BIM evaluation technique to compare model characteristics. Interactive “as-built” BIM modeling is time-consuming and error-prone [13] e.g. using Autodesk Revit and Navisworks, Bentley Architecture, Graphisoft ArchiCAD, Tekla, or Nemetschek All plan. Table 8 of the journal analyzes reverse engineering, data acquisition, processing, and BIM modeling software. BIM is used to models structure using previously acquired building information, the deployment technology and LoD affect data quality. To evaluate various methodologies and their modeling capacity, produced models could be tested e.g. with regard to modeling correctness, LoD, or CMM6 [11], [12]. We have no common BIM evaluation technique to compare model characteristics. Interactive “as-built” BIM modeling is time-consuming and error-prone [13] e.g. using Autodesk Revit and Navisworks, Bentley Architecture, Graphisoft ArchiCAD, Tekla, or Nemetschek All plan. It analyzes reverse engineering, data acquisition, processing, and BIM modeling software.

3. IDENTIFICATION OF REAL-TIME PROBLEM

The computer lab of an Institutional building in Madurai encountered a real-time issue characterized by elevated temperatures and resulting annoyance. To determine the temperature generated by the computers at different times, Internet of Things (IoT) device was used to facilitate the monitoring of temperature levels. The device contains an LM35 sensor for this purpose. The LM35 sensor was mostly used for precise temperature measurement. The device had a linear output voltage that exhibits a direct correlation with the temperature measured in Celsius. The measurement of ambient temperature in various settings, such as buildings and industrial operations, was a widely used practice in temperature monitoring systems. The LM35 sensor was used in climate control systems, namely in heating, ventilation, and air conditioning (HVAC) systems.

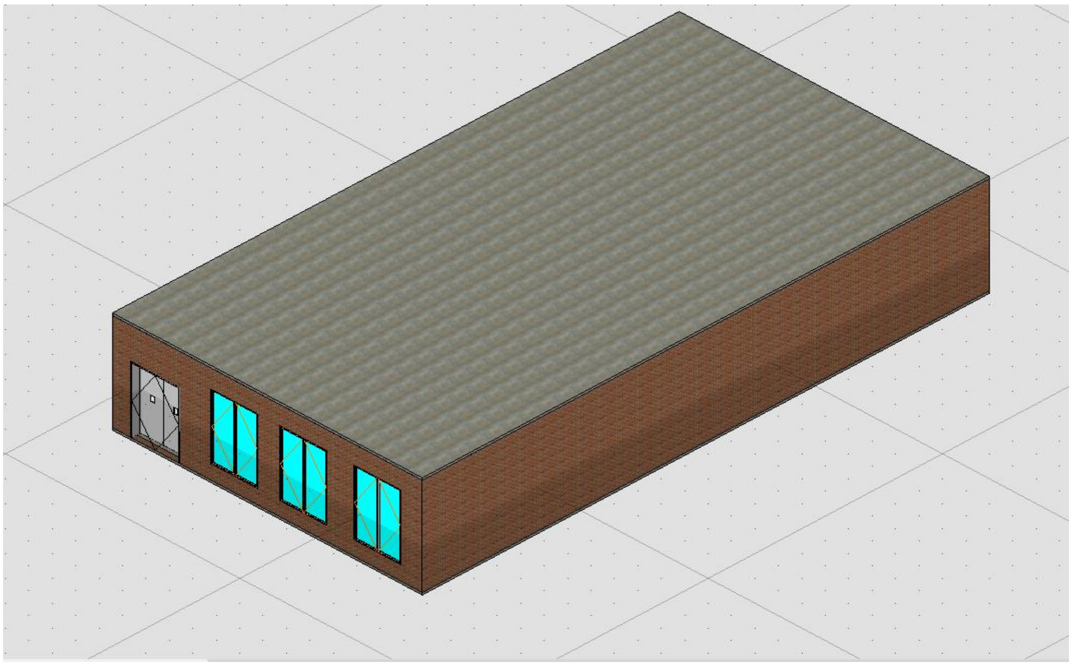

Fig.1. Modeling of Computer Lab in Open Building Designer

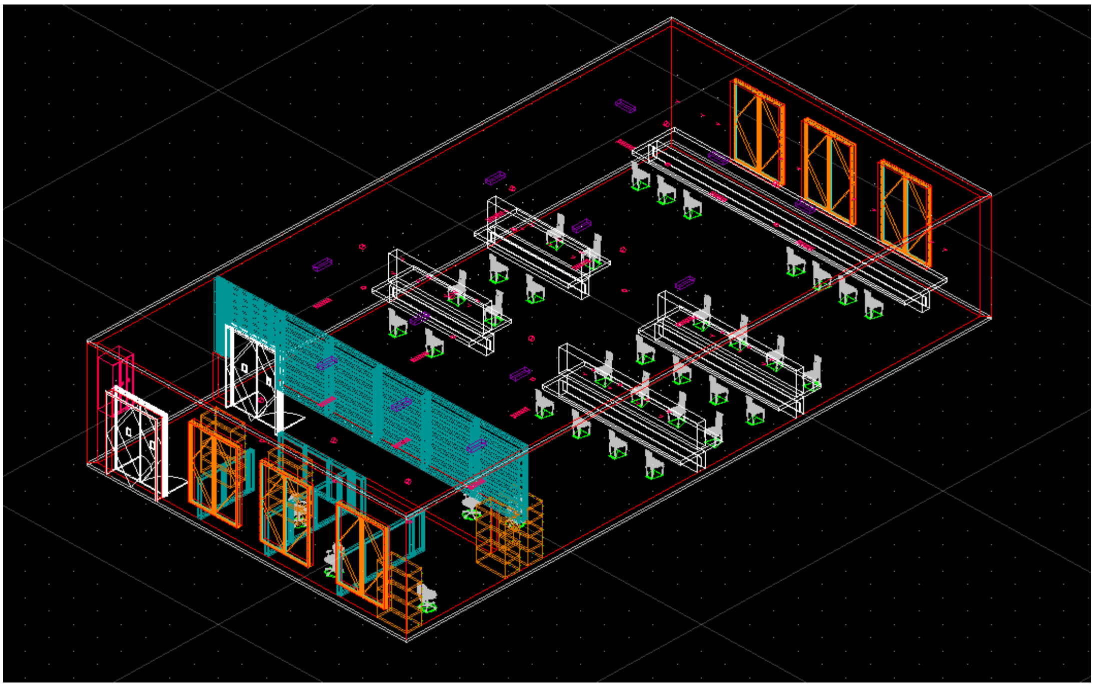

Fig .2. Wire Frame View of the Computer Lab

Figs 1 and 2 show the 3D modeling of the Real-time project in the Institution environment using Open Building Designer software.

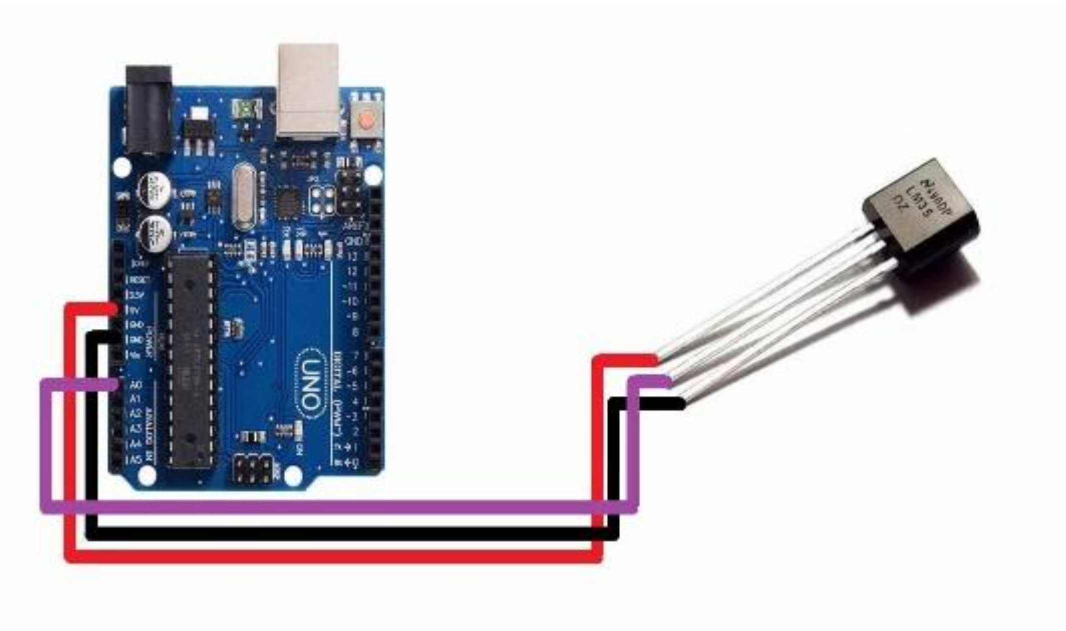

Fig. 3. Circuit Setup for LM35 sensor

The connection of the LM35 sensor to the Arduino UNO board is seen in Fig 3, along with the associated circuit.

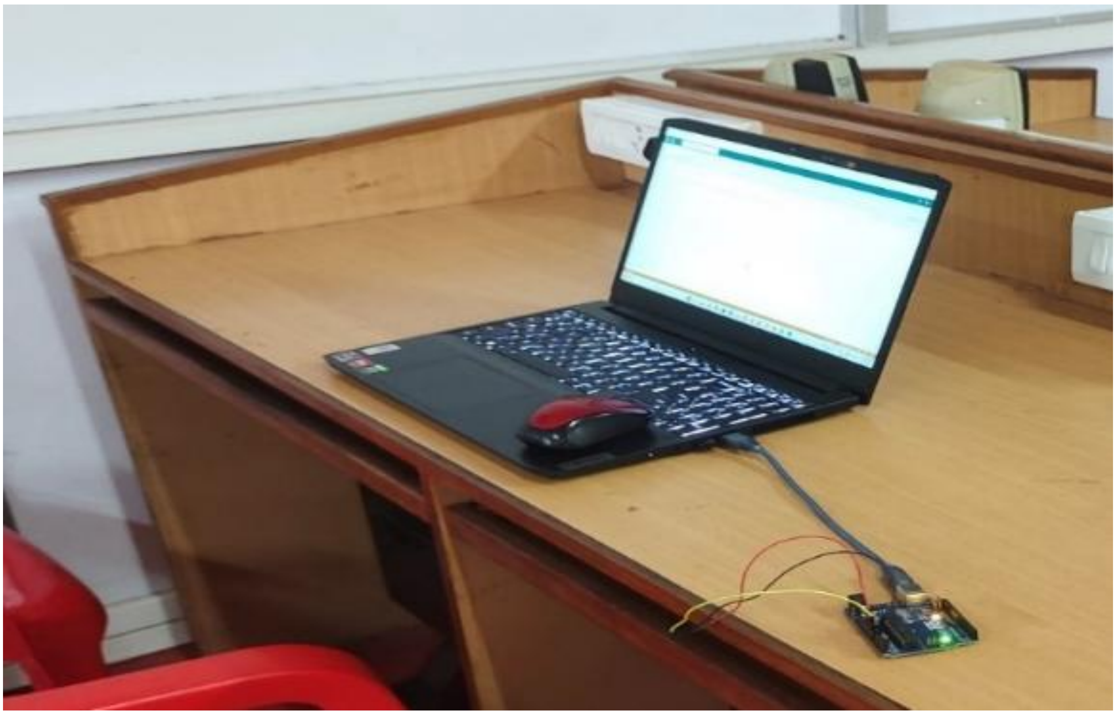

Fig.4. Temperature Sensor Reading (9:50 AM to 10:10 AM) North Side of the Room

Fig 5 Temperature Sensor Reading (10:20 AM to 10:40 AM) South Side of the Room

Figs 4, 5, and 6 depicts the positioning of the LM 35 temperature sensor inside several locations within the computer laboratory. These placements were chosen to observe the fluctuations in temperature over consistent time periods while ensuring that **fans and other computers were not in operation.**

Fig.6. Temperature Sensor Reading (10:20 AM to 10:40 AM) South Side of the Room

Fig.7 depicts the graphical representation plotted using the temperature reading taken from the computer lab using the IoT device. The readings show the variation in the temperature at different places and gives the average value of 32 degrees Celsius. This means that without any operation of the computer or other electrical appliances, the temperature was found to be too high in the computer lab which would affect human health and make the building less sustainable.

The Laboratory consists of 38 Computers, 4 Ceiling Fans, 4 Exhaust Fans, 4 Wall Mounted Fans, and 2 Table Fans.

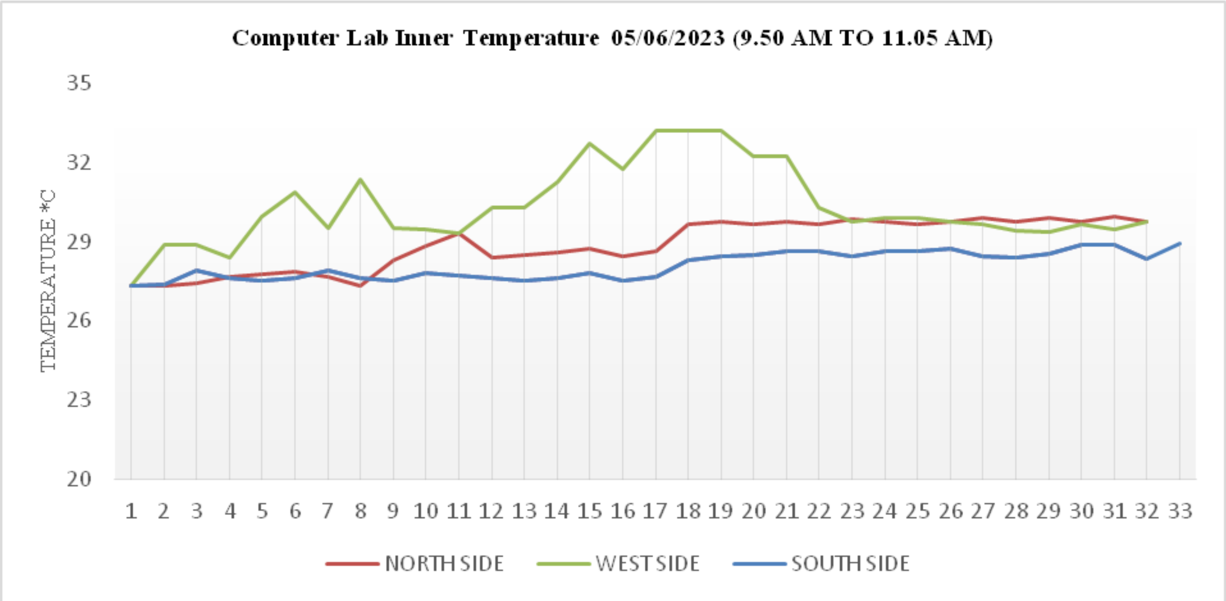

Fig.7. Graphical Representation of Temperature Taken Using IoT Device Without Operation of Computer and Other Appliances

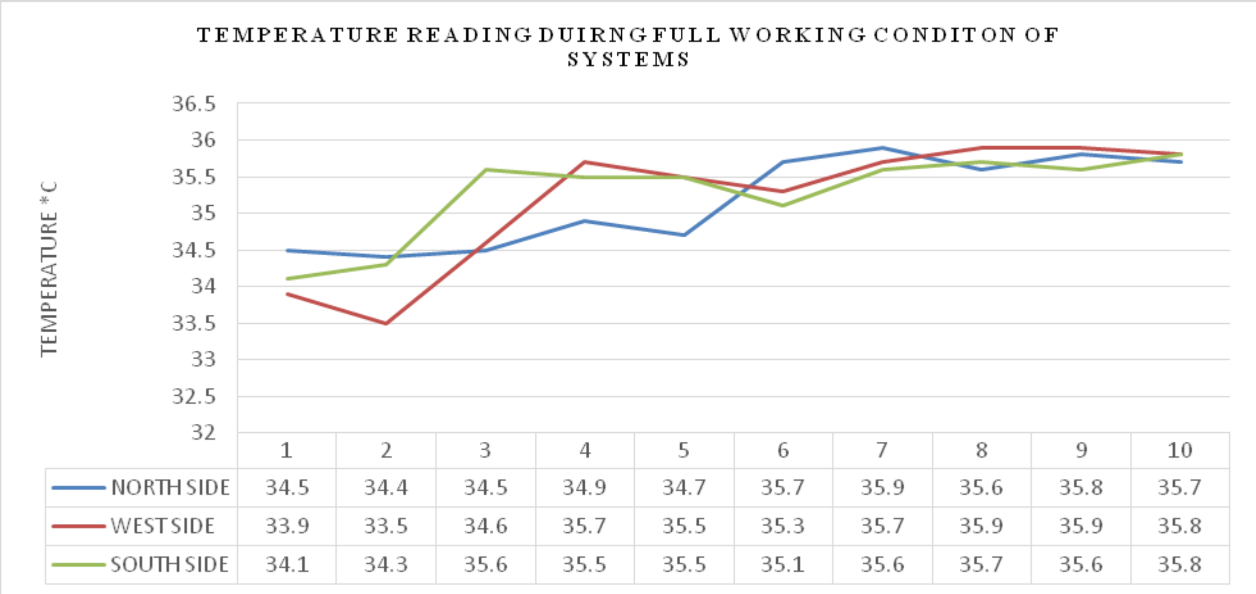

Fig.8. Graphical Representation of Temperature Taken Using IoT Device With Operation of Computer and Other Appliances

Fig.8 depicts the recorded temperature readings of the computer laboratory when all equipment was operational and the space was filled by occupants. The data shown in the graph indicates that elevated temperatures were seen during periods of human occupancy, as well as during periods of increased activity inside the computer lab. The temperature range fluctuates between **34 and 36 degrees Celsius**. This temperature is very high and not suitable for the human condition and the building sustainability will also be affected. The Optimum thermal comfort condition for buildings are mentioned in the National Building Code of India 2005: Part 8, Section 1.[17] is shown in the Table 1. As per the provision it can be seen that the temperature prevailing in the computer lab is found to be not suitable for livable condition. Building performance simulation tools are often used by design experts in order to forecast energy consumption in comparison to a reference scenario, as a means of ensuring compliance with building regulations. Nevertheless, the estimation of energy conservation in comparison to the standard building may vary as a result of inconsistencies between building regulations and the actual behavior of occupants. Hence, the results given in this research study prompt legitimate demands for revising the existing occupant-related factors in order to address these discrepancies

Season	For air-conditioned buildings			For non-air-conditioned buildings		
	Air Temp(°C)	RH(%)	Air velocity (m/s)	Air Temp(°C)	RH(%)	Air velocity(m/s)
Winter	21-24	50	Nil	18-22	50	nil
Summer	23-26	50	0.15-0.18	25-30	50	nil

Table 1 Optimum Room Temperature as per NBC 2005: Par

4. CONCLUSION

The computer lab of an institutional building in Madurai served as the setting for a real-time case study that was carried out there. The structure was modeled using the software known as BIM (Open Building Designer), and Internet of Things devices were used to study whether or not the circumstances were pleasant. Even though artificial ventilation was installed, it is clear from the results of the experiments that the laboratory did not provide conditions that were conducive for a pleasant working environment. Therefore, it is advised that air conditioning with a capacity of 1.5 tons be installed in order to improve the living conditions, particularly while the laboratory is operating at full capacity.

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