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Effect of Building Orientation on Energy Consumption by using Building Information and Modelling

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ABSTRACT

The current effort aims to give a condensed energy analysis to evaluate the impact of building orientation on energy consumption. The solar heat gain and more frequently local conditions, including social lifestyle, determine how much energy is saved. In India, a multi-story, school building is used as a case study. Making a 3D model of the building is the initial stage in this investigation. The second phase entails using simulations to examine the energy situations for various orientations. The energy analysis is then carried out. In this study, 24 test scenarios are taken into consideration by rotating the building 15° each time, including the actual orientation, using the entire building as a unit for energy analysis. For performing energy analysis of the building energy simulation software's Green Building Studio and Autodesk Insight 360 are used. According to numerous studies, buildings are to blame for more than 40% of global carbon emissions. CO2 emissions are mostly caused by the consumption of energy for cooling, lighting, electrical equipment, and appliances in warm, humid regions like West Sumatra. Buildings with glass and glazing systems on their façade are becoming more commonplace these days. As a result, if the buildings are not appropriately orientated, they are susceptible to solar heat gains. This article examines the impact of building orientation on the quantity of energy consumed within buildings because it is one of the most significant elements impacting energy consumption. The paper presents a methodology to evaluate building form to in order to compare energy consumption of geometric variations and material considerations through two types of sensitivity analyses.

INTRODUCTION

Construction projects are becoming more complex and difficult to manage and as technology develops, more construction professionals are familiarizing themselves with BIM. This has led to a dramatic shift in attention towards the concept of BIM by the construction industry. BIM is currently the most common denomination for a new way of approaching the design, construction and maintenance of buildings. It is the creation and use of coordinated, consistent, computable.

BIM (building information modelling) has developed into a powerful solution that can improve many aspects of construction industry. Current research regarding the impact of orientation on a building's energy needs seldom tap into the potential of BIM. This study investigates the impact of orientation on energy consumption in small-scale construction and assesses how BIM can be used to facilitate this process. The methods adopted are three-fold. Firstly, a real-life building is modelled using Revit, one of the leading BIM tools. Secondly, through green building Extensible Markup Language, the model is exported to Green Building Studio, one of the leading energy simulation software. Thirdly, in the Green Building Studio, different building orientations are adopted, and their impacts of the whole building energy are investigated. Based on the analysis of the energy consumption corresponding to the different orientations, it emerged that a well-orientated building can save a considerable amount of energy throughout its life cycle.

Energy demand in buildings has increased by 7% in just 8 years. The 2019 emissions gap report recommends reversing the trend of consuming energy. By improving energy efficiency in buildings at a rate of 2 to 3 % each year by 2025[1]. Using sustainable materials, better waste management, and energy from renewable sources are the suitable ways that can help the buildings to be very different compared with conventional buildings [2]. In 2018, the building sector represented 28% of global carbon dioxide emission. The rate of electricity demand in buildings has increased five times faster and Co_2 emissions increase two- thirds from rapidly growing electricity use.

Building Information Modelling

Construction projects are becoming more complex and difficult to manage and as technology develops, more construction professionals are familiarizing themselves with BIM. This has led to a dramatic shift in attention towards the concept of BIM by the construction industry. BIM is currently the most common denomination for a new way of approaching the design, construction and maintenance of buildings. It is the creation and use of coordinated, consistent, computable information about a building project - information that is parametric and that can be used for design decision-making, production of high-quality construction documents, prediction of building performance, cost estimating and construction planning. BIM is a set of policies, processes and technologies integrated as a methodology to manage the essential building design and project data in a digital format throughout a building's life cycle. Froese argues that in the near future, BIM will be used to virtually construct an entire project through simulations before it is erected or constructed in reality. The fact that BIM can be used to model buildings and for analysis to be performed virtually before the buildings can be erected onsite isomer of the most important strengths of BIM. It is this aspect/feature that has been exploited in this study. BIM software packages are highly needed for the development/design of the virtual building models. The urgent need to incorporate BIM in managing construction information has led to a plethora of BIM software packages in the market.

BIM can be visualized in two areas, one area which deals with modelling while the other is related to analysis (energy simulations, quantity take-of, environmental impacts, etc.) and actions as well as data communications among the stakeholders. The multidimensional tool, BIM can be categorized into 3D-BIM for model making purpose, 4D-BIM for addition of time dimension for activity sequence simulation, 5D-BIM for cost element addition in estimation and costing purpose in the construction, 6D-BIM for achieving sustainability through thermal and global warming potential (GWP) simulations and 7D-BIM for fully developed wide range building performance management and for operation and management (O&M).

LITERATURE REVIEW

With an aim to reduce the energy consumption in buildings using BIM approach, there has been several studies and research to achieve the goal. Timothy L. Hemsath & Kaveh Alagheband Band Hosseini(2014) discussed that Building form does influence energy consumption. Designing low-energy architecture to minimize energy consumption requires thoughtful articulation of the shape and form of a building. The Architect's decision-making for more energy efficient building form is often based on rules of thumb. Historically, the rule of thumb regarding passive solar building design suggests that form and orientation matter to overall energy performance. The question of how much impact does form have varies between project to project, due to climate, location, and building size. However, evaluation of energy performance specifically relating to building form is difficult to quantify because of the large solution space, but nonetheless important to understand. The paper presents a methodology to evaluate building form to in order to compare energy consumption of geometric variations and material considerations through two types of sensitivity analyses. First, a review of related studies discussing energy and form are discussed, second the geometric methodology for vertical and horizontal proportion is described, and finally the linear screening local sensitivity index and a Morris global sensitivity results are reviewed. Findings compare geometric and material sensitivity, as well as the two different types of sensitivity analyses. Results indicate that both the vertical and horizontal geometric proportion is equally as sensitive as certain material aspects related to building energy use. Outcomes provide building designers clarity on the formal variations in the early design phase informing design decision-making.

Rania E. Ashmavy & Naveen Y. Azmy (2018) discussed that Nowadays, many countries suffer from severe shortage of energy resources and inability of saving it. It is necessary to develop an integrated strategy, to make buildings consume less energy and to integrate active and passive design techniques. Since the building orientation is one of the most important factors affecting the energy consumption, this paper addresses its effect on the amount of energy consumption within buildings. We employ the simulator "Energy-plus" to estimate the energy consumption, annually and during critical months in summer and winter. To obtain the best orientation for maximum energy saving, different orientations are tested. It is found that an airconditioned building that has a southern facade consumes less energy.

However, a western facade causes higher annual energy consumption by 26% over the southern facade. In the case of a two-facade building, the lowest energy consumption is obtained between the northern and southern orientations in Cairo, Egypt Subbarao Yarramsetty & M. Sayed Rohullah (2019) discussed that The present work targets to provide a simplified energy analysis to assess the influence of the orientation of the buildings. The energy savings mostly depends on the solar heat gain and more often local factors including social lifestyle. A multi-storied, multifamily residential house in Afghanistan is considered as case study. The frst step in this analysis is to develop a 3D model of the building. The second step is to study the energy scenarios for different orientations through simulations. Then the energy analysis is performed. In this study taking the whole building as a unit for energy analysis, 24 test scenarios are considered by changing the building orientation 15° rotation each time including the actual orientation. It is observed from the analysis of data collected that a saving of $1393 from the best orientation (+315° clockwise) to the worst orientation (+165° clockwise). The simulated electricity demand is validated by taking the original bills of the actual orientation and it is observed the values are 2.65% greater than the simulated values.

Soojung Kim & Puyan A. Zadeh (2016) discussed that in improving energy efficiency of buildings, windows play a significant role as they largely influence the energy load. Although there are many studies about the energy efficient window design, a rigorous study is missing which analyzes the mutual impact of windows' size, position, and orientation on the energy load. This study aims to address this gap through a case study on a single-family house. For this aim, 65 different design scenarios are created which vary by window size, position, and orientation. Building information models (BIMs) are created for each scenario via Autodesk Revit and are used for the calculation of the total energy load conducted by Autodesk Green Building Studio®. In the first analysis stage, window- to-wall ratio (WWR) and the windows' position are studied to assess their effect on the energy load. The preliminary results at this stage indicate that the total energy load increases when the WWR grows, and the windows' position has the biggest impact on the load when the WWR is 20. Using these results, in the next stage, the position of windows in different orientation is studied to assess how the energy load changes by windows' position in each orientation. The results show that the building requires the lowest load when the windows are located in the middle height in all orientations, and the east windows' positioning affects the total energy load the most.

Rini Mulyan & Wardi (2017) discussed that Many studies show that buildings are responsible for more than 40% of world carbon emissions. In warm and humid climates such as West Sumatra, CO2 emissions predominantly come from the use of energy to provide cooling, lighting, to power appliances and electrical equipment. Nowadays, the number of buildings that use glass and glazing system in their façade tends to increase. As a result, the buildings are prone to solar heat gains if not properly oriented.

This study aims to investigate energy use of a building in Padang City, West Sumatra, Indonesia with respect to different orientations by conducting building energy analyses. The outcomes showed that the optimized direction was when the building faces South-Southwest and the worst orientation was when the building faces East. It was estimated that the electricity use of the building was 64% for HVAC, 18% for lighting and 18% for miscellaneous equipment. The LCCA of the existing building was USD 872,995.29 for 30 years. However, this cost could be reduced by almost 2% if the building was oriented on the South-Southwest direction. The difference of the LCCA between the best and the worst building orientations, SSW and East, respectively, reached up to 4% Reza Fallahtafti (2015) discussed a case study to optimize building orientation in Tehran, as well as determining the impact of its shape, relative compactness (RC) and glazing percentage on its optimized orientation. A cubic module was used and a set of 8 of the same modules with 16 different formations were analyzed for their orientation (360°), the RC (four groups) and the amount of glazing percentage (25, 50 and 75 per cent). The results show that the optimized orientation of a building in Tehran strongly depends on its passive solar heat gain elements, their orientation, and their position in building; furthermore, glazing percentage amount, amongst the studied factors, plays the most important role in determining a building's orientation. The application of the findings of this study in Tehran city planning and technical details of buildings will lead to a great energy saving in construction sector. Furthermore, the deployment of the proposed design guidelines in construction has explicitly been proven to save a prodigious amount of energy.

Samah K. Alghoul & Hassan G. Rijabo(2017) discussed that the study has been conducted to investigate the influence of window to wall ratio (WWR) and window orientation (WO) on cooling, heating and total energy consumption. The study aims to provide architects with a simple correlation for proper design of facades for office buildings from an energy consumption point of view. The work includes a case study, in which an external wall of a small office space located in the city of Tripoli, Libya was analyzed. Walls with WWR between 0 and 0.9, and with orientation varied in steps of 45 degrees (i.e., facing all eight cardinal and intercardinal directions) were considered. Energy Plus software was used for energy simulation with "Open Studio plugin for SketchUp" as an interface. Results indicate that increasing WWR produces an increase in cooling energy consumption and a decrease in heating energy consumption. Cooling energy consumption is found to be substantially higher than heating energy consumption, however, when adding windows to southern walls, cooling consumption drastically increases, while heating energy consumption decreases to zero due to passive solar heating. In general, the effect of adding windows to facade results in an increase in annual total energy consumption by 6% to 181% for the cases explored in this study. Finally, a correlation representing the relation between total energy consumption, WWR and WO has been established in this paper.

Jie Zhang & Xuping Zhu (2022) discussed that the growing need for electricity has put Pakistan's burgeoning economy in peril. The notion of ''Construction 4.000 is considered in this study since it enables the greatest utilization of energy and architectural analysis. A case study and a method for building information modelling are used to analyze the concepts of green building. The case study building is represented as a parametric model using the Autodesk Revit platform with the original blueprints and data. Using Autodesk Insight 360, an energy analysis and comparison of optimization case study of the A-Block and Z-Block COMSATS Abbottabad, Pakistan is chosen. This study analyses an academic building's energy performance as a case study to reduce energy usage. By turning the building 360 degrees at 45-degree intervals and utilizing BIM to install energy-efficient construction materials, this study analyses the energy efficiency of an academic building. The average annual energy cost for blocks A and Z is decreased from 228 kWh/m2 to 160 kWh/m2 and 192 kWh/m2, respectively.

Mojtaba Valinejad Shoubi (2014) discussed that a sustainable building is constructed of materials that could decrease environmental impacts, such as energy usage, during the lifecycle of the building. Building Information Modeling (BIM) has been identified as an effective tool for building performance analysis virtually in the design stage. The main aims of this study were to assess various combinations of materials using BIM and identify alternative, sustainable solutions to reduce operational energy consumption. The amount of energy consumed by a double story bungalow house in Johor, Malaysia, and assessments of alternative material configurations to determine the best energy performance were evaluated by using Revit Architecture 2012 and Autodesk Ecotec Analysis software to show which of the materials helped in reducing the operational energy use of the building to the greatest extent throughout its annual life cycle. At the end, some alternative, sustainable designs in terms of energy savings have been suggested.

Problem Statement

The energy crisis needed to be addressed since it would have a profound impact on our daily lives at the turn of the century, with the collapse of the global economy and decreased global energy indices. Furthermore, because of the enormous technological advancements that have increased our energy consumption, we are becoming more and more dependent on conventional energy every day. It is well known that buildings account for close to 50% of both local and global energy usage.

The usage of separate glass facades in our environment and a growing reliance on mechanical methods rather than the best designs are the main causes of the high energy consumption in buildings. Due to separation from our environment, it was necessary to establish new rules for the formation of our lives and to rationalize the consumption of non-renewable energy. It should be a trend to find a strategy to take advantage of the natural energies that is abundant in the Arab world, such as solar energy and wind energy. Solar energy stands as the best choice for consumption in comparison to other forms of energy. However, the challenges facing this system are seen in the difficulty of covering the needs of big cities and supplying energy for longer periods of time. These challenges push us to seek energy- saving architectural designs that depend on its structure to improve the building design performance in manner that makes it an energy-saver. If integrating it with renewable energy structure, it will become a low energy consumption building. The research of methods that reduce energy consumption by regulating the building envelope has received a lot of attention.

DESIGN AND IMPLEMENTATION

Methodology

The research network is constructed by considering several techniques from the literature connected to BIM, energy consumption, and building orientation.

Stage 1

For each of the work's numerous domains, including the BIM domain, which covers the body of knowledge, context, framework, preliminary development, consensus building, and application cases, literature review research is undertaken. Factors and case studies of energy-efficient structures in the building energy sector. This study demonstrates how crucial the building's orientation is for energy calculations.

Stage 2

In the current paper, energy analysis/predictions of the building with integration/link with BIM are explored.

Stage 3

An existing residential building is used as a case study; the structure's details were gathered and recreated using BIM and AutoCAD 2D. Software and techniques for energy calculation were used on the chosen case study.

It is crucial to choose a well-known building with access rights and the necessary paperwork because doing so makes it simple to create simulation alternatives.

Model Generation, Energy Simulation and Energy Orientation

A private school building was utilized as a case study, and it is situated at ‘29.8138198852539,76.4246063232422’E in Kaithal district of Haryana, India. It is a three-story (basement, G+2) residential building with several classrooms on each floor. A typical floor design on the ground and first floors includes classrooms, a library, common restrooms with water closets, and stairs leading to the basement, first floor, and second and third floors. The fact that the chosen school building is one of my former schools made it simple to gather pertinent data to recreate the model in Revit. A series of analyses were conducted using various orientations, beginning with the building's true alignment, which is 30° anticlockwise from the north direction and is taken as 0°. In order to understand the impact of orientation on energy estimates, analysis refers to the use of BIM modelling software inconjunction with energy simulation tools (Insight

360, GB studio). The building's entrance or face is south (taken as Test 12's 180° orientation), and the north direction—taken as a 30° reference—provides information for Test 2's analysis. An increment of 15° in Test 3 Analysis' 45-degree analysis results in a total of 24 sets of analysis (23 + 1).

Real measurements of the building and its rooms are taken before the model is built in Revit. The lack of preservation by the owners of the building blueprints and site plans necessitated the use of actual measurements. Using the gbxml service, the model is created and sent to green building studio. The green building studio-Insight 360 and design builder are both add-ons to the most recent BIM tool (Revit). By importing and exporting, the interoperability problems when creating GBXML can be minimized. The floor plans and elevations are shown in Figure 3, and the 3D Revit generated model is shown in Figure 4. Once the building model has been created in Revit, it can be used with the Insight 360 plugin or exported as a gbXml file for a simulation run to GBS. The simulated energy outputs for the building's real direction are shown in Figure 5. The type of facility, building location, and utility information are all important project characteristics that must be provided in GBS.

Solar strategies for reduction of energy consumption
Design, orientation, the effectiveness of the building's outside envelope, and how the roof, windows, and outer walls are treated all affect passive solar tactics and procedures. This assists in regulating energy use and achieving thermal comfort.

The followings are the factors which affect energy consumption:

Orientation of the Building
The relationship between a building's elevations and its original geographic direction is known as the building orientation. The amount of solar radiation that actually strikes a building's façade as a whole must be taken into account during the design phase since it impacts the building's thermal load and regulates its thermal behavior and level of thermal comfort. Additionally, it influences the amount of ventilation passing through the building, which in turn influences the amount of energy used to meet the building's thermal and life requirements.

The Glass Thickness
One of the keys determining factors of apertures is glass since it allows light to enter the interior spaces. A fraction of the solar energy that strikes the glass' surface is reflected outside the space after entering the space and being partially absorbed by the glass substance. The amount of solar energy that is reflected depends on the angle of incidence; the amount of solar radiation that is absorbed will either be transferred via convection or conduction due to the material's characteristics.

The Wall Window Ratio
Windows are openings that symbolize the weak spots in a building's exterior where the building is vulnerable to the strongest radiation entering through the opening, allowing solar radiation to enter interior spaces. As a result, managing the windows effectively contributes to lowering the thermal loads within the building. According on the facade's orientation, the window ratio varies. Due to the sun's movement during the summer and winter, the thermal load on the building's façade fluctuates from one direction to another, necessitating the reduction of windows in some facade areas and their augmentation in others.

The Thermal Insulation
Heat movement from the outside to the inside and vice versa is lessened by thermal insulation. According to studies, between 60 and 70 percent of the heat removed by air conditioning in the summer is lost via walls and ceilings.

SIMULATION TOOLS DESCRIPTION

Autodesk Insight
The Autodesk AEC Generative Design Team's Insight product provides an efficient and comprehensive experience for enhancing a building's energy and environmental efficiency. With strong BIM connection, Insight enables you to track results throughout the building lifespan and visualize, interact with, specify, and document building performance data sooner in the design process than ever before.

Green Building Studio
To optimize energy efficiency and move closer to carbon neutrality early in the design phase, you may run building performance simulations using the adaptable cloud-based tool Autodesk® Green Building Studio. Web-based energy analysis tool Autodesk Green Building Studio may assist architects and designers with whole-building analyses, energy efficiency optimization, and efforts to achieve carbon neutrality earlier in the design process. It is possible to use Autodesk Green Building Studio as a stand- alone web service. Additionally, it fuels the overall building energy analysis tools in Autodesk Revit.

ANALYSIS OF TEST SCENARIOS

Test 1

This test is for the building's real orientation, which is facing south. The back face is facing north and is 30° anticlockwise to north when taken in the real-world test (also known as 0°). The front-facing bedrooms are in the southeast corner and the drawing room. Simulated electric energy consumption for the life cycle (LC) was 39,861 kWh and 119, 5832 kWh, respectively.

Test 2 (30 Degree)

The structure is oriented so that its face faces directly south, allowing sunshine to enter through both its side faces and openings. By choosing + 30° rotation, the building model is rotated by 30° clockwise when using the design alternative tab in GBS. The simulation yields annual electrical energy usage in LC of 39,760 kWh and in LC of 1,192,809 kWh, respectively. Test 4 (60 degrees)

All of the classrooms' east-facing windows let in sunlight till midday. The face of the structure receives sunshine throughout the noon hour. For this orientation of yearly and LC electricity, GBS produced results of 39,673 kWh and 1,190,190 kWh, respectively.

Test 6 (90 degrees)

The front and right side faces (classroom sidewalls and windows) of the building receive a considerable amount of solar radiation in the winter and little in the summer due to this orientation. The LC electric energy value is 1,186,531, and the annual simulated value is 39,551 kWh.

Test 10 (150 degrees)

All of the building's classrooms and the hallway are visible from both the back and the classroom face (right face), which are both exposed to sunlight. The building's orientation results in the lowest simulated electric energy consumption, which results in minimal power usage for both cooling and heating purposes. For both the yearly and LC, the simulated electricity values are 39,198 kWh and 1,175,948 kWh, respectively.

Test 14 (120 degrees)

The back face, right face and front face of this building are obstructing the availability of sunlight in winter and reducing summertime sun exposure. The estimated annual and life cycle electric energy is 39,263 kWh and 1,177,891 kWh, respectively.

Test 18 (270 degrees)

The stair side face and the back face receive plenty of sunlight. The estimated amounts for yearly and LC electric energy simulations are 39,632 kWh and 1,188,946 kWh, respectively.

Test 20 (300 Degrees)

For both yearly and LC, the estimated electric energy for this orientation of the structure is 39,790 kWh and 1,193,693 kWh, respectively. Only the building's front and back facades receive direct sunlight. The stair side face receives a lot of solar radiation, especially in the winter, but only one single bed is placed there to take advantage of it.

Test 22 (330 Degrees)

In the winter, the front and right-side faces (the stair face) receive a lot of sunshine. The estimated values for electric energy are 1,197,417 kWh throughout the course of a life cycle and 39,914 kWh annually. To determine the optimal orientation, which uses the least amount of energy, the real building orientation plus 23 test scenarios (24 Test scenarios) covered one full 360° rotation. This analysis simply took electricity into account. The yearly and life cycle electricity and fuel energy, as well as costs, are projected. The Indian rupee, abbreviated as (Rs), is used as currency. 1 Rs was converted to 0.012 USD for the cost estimations. Fig. 8 plots the annual electric energy estimates, and it is clear that the optimal orientations are between Tests 8 and 14, According to Fig. 8, the least estimated annual electricity usage at Test 10 orientation was 39,198 kWh, with a total difference from maximum to minimum of (39,948-39,198 kWh) being 750 kWh. Table 2 shows the estimated life cycle power usage, with a range of 1,175,948 kWh to 1,198,442 kWh and a difference of 22,494 kWh.

DISCUSSION

It is possible to produce the data needed to address the target technique by conducting a thorough analysis of the chosen case study over its orientation. The BIM-Revit model and GBS were utilized in this investigation to get energy simulations for various orientations. It is obvious that a significant factor in naturally producing a good amount of solar gain is the solar sun's route and the exposure of the building envelope to it. The analysis makes it abundantly evident that the building's orientation has a significant impact on energy usage. The relationship between them is influenced by the type of building, the envelopes, the lifestyle of the occupants, the resident's financial situation, the quantity of opening area, and the regional climate. The conduct and financial situation It is impossible to model or control the of the residents.

There are two techniques to forecast the outcomes: (1) focusing primarily on estimates for electric energy (see Table 2). (2) Combining estimates for fuel and electricity (see Table 1). Due to the wide variances in the residents' financial situation and way of life as well as the interruptions in the provision of power, there are two ways to project the results. From table 1:

The highest cost of $7146 at an orientation of + 165 (Test 11) from the base case contrasts with the lowest annual energy cost estimate of $7044, with a difference in cost of $102 for the life cycle estimates (30 years span). Similarly, the difference in electric energy costs from the best orientation ($95,934) to the worst orientation ($97,327) is contrasted with a difference in cost for the life cycle estimates (30 years span). On the other side, Test 21 is the best orientation and Test 11 is the worst when comparing total energy (including electric and gasoline). Figures 8 and 9 help to visualize this variation. People use firewood for heating purposes rather than gasoline or electricity, as seen in the buildings on the property.

From Table 2:
The greatest cost of $3765 at an orientation of + 345 (Test 23) from the base case, with a difference of $71 is highlighted by the lowest yearly electric energy cost estimate of $3694 at a rotation of orientation of + 150 (Test 10) from the real case (base case). The cost of electric energy varies from the best orientation ($110,833) to the worst orientation ($112,953) over the course of the life cycle estimates (30 years) and is compared to a difference in cost of $2120. The building's orientation is found to have a substantial impact from the electric energy study.

CONCLUSIONS

By using Green Building Studio
The research suggests that with the right orientation, a structure will get enough solar energy and natural light through its openings to brighten its interior. This will dramatically cut down on the utilization of traditional energy sources. The lifestyle of the occupants, building glazing, parts and components, direction, form, and size of the structure are only a few of the variables that affect energy requirements. Residents require little sun gain in the summer and a lot of solar interception in the winter. The energy of heating and cooling systems varies depending on the actual orientation and the motion of the solar path. This study avoids laborious human calculations that involve error in the estimation of energy consumption for various building orientations. The usage of potential BIM by energy estimation practitioners is uncommon. This could be brought on by a lack of knowledge, training, or local government regulations. As a result, there are no advantages to energy requirements estimation for various building orientations and components at the early design stage. In this study, several building orientations were taken into account in order to examine the energy needs while using a case study of a school located in Kaithal, Haryana, India. Autodesk Revit and the web-based building performance analysis tool, Autodesk Green Building Studio, were utilized for building modelling and energy simulation. The findings demonstrated that there is a significant discrepancy between the values of simulated and actual electric bills. When determining the estimate, the actual building conditions were taken into updated simulation results. For the whole building's life cycle, the results demonstrated a cost savings of $1393 from the best orientation + 315 (Test 21) to the poorest orientation + 165 (Test 11). The goal of the current study was to illustrate how building orientation affects energy demand and how its effects might be reduced by using the right solar shading equipment. The usage of GBS for performing alternative simulations is outlined in detail. For better analysis, it is advised to create a model in Revit with minute features. Other energy simulation methods will be used in a future investigation on other structures with various building envelopes.

By using Autodesk Insight 360
The research suggests that the best orientation is 0 to 45 degree and the worst orientation is +225 where the energy cost is maximum and the best WWR is 30%.

Future Scope of Work
The research done in this paper is done on the small-scale buildings and the cost variance is very small but if the same research will be done on large projects, then we can save a large amount of cost and energy. The work done in this research is only subjected to the effect of orientation on energy consumption but there are several more factors like WWR, Window shades, Window glass, Wall construction, Roof construction, Infiltration, Light efficiency, Daylight and efficiency control, Plug load efficiency, HVAC, Surface coverage, Payback limit, Size of windows and doors, Thickness of wall, Height of floor, Sun path etc. These are some aspects on which further research can be carried out to save more cost and energy. Therefore, more research should be conducted to determine how orientation affects the energy burden of larger buildings. Additionally, this study is restricted to a case study of a structure. The crucial orientation may alter if the location or solar angle changes. More research should be done in more places. Additionally,

in order to focus solely on the heating and cooling burden, visual comfort is omitted in this study. When designing for actual projects, aesthetic comfort should be taken into account. Lighting load is also not taken into account

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