Feasibility Analysis on Energy Saving in Existing Building

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Abstract—**This research focuses primarily on modelling of an existing building using Revit architecture and importing the model in energy analysis software Green Building studio, applying the energy efficient parameters for light and thermal energy in order to obtain the optimum energy saving and minimise the loss of energy in the building. In this context, subject building refers to the existing building which is individual residential home located in Tambaram, Chennai. The results of the study are demonstrated using potential energy savings chart which is an output from energy analysis software Autodesk Green Building Studio. The most sensitive building features for energy use are the wall insulation, Plug Loads, and Infiltration. Lighting efficiency is improved significantly due to the inclusion of skylights in Hall, living room and dining area. For avoiding excess radiation of thermal energy, Low E glasses with 0.25 Solar Heat Gain Coefficient and Visible Light transmittance of 0.4 is used in the glazing of windows and skylights. The final results of study from Green Building Studio is the potential energy savings chart which shows 10% savings /Loss potential in light and thermal energy, thus showing a substantial reduce in loss of light and thermal energy which is due to inclusion of energy efficient parameters.**

Index Terms—Revit architecture, Green Building studio, Solar heat gain coefficient, Visible light transmittance, Potential energy savings chart.

IV. INTRODUCTION

Retrofitting an existing building can oftentimes be more cost-effective than building a new facility. Since buildings consume a significant amount of energy, particularly for heating and cooling, and because existing buildings comprise the largest segment of the built environment, it is important to initiate energy conservation retrofits to reduce energy consumption and the cost of heating, cooling, and lighting buildings.

II. BUILDING INFORMATION MODELLING

Building information modelling (BIM) is a new way of approaching the design and documentation of building projects. BIM Models and manages not just graphics, but also information that allows the automatic generation of drawings and reports, design analysis, schedule simulation, facilities management, and more ultimately enabling the building team to make better-informed decisions.

A. Revit architecture

The energy analytical model feature in Revit building design software provides tools for fast, flexible creation of models for energy simulation. Autodesk Revit Architecture software provides architects the tools to easily capture and analyse design concepts, and more accurately maintain coordinated and reliable design data through documentation and construction.

Energy analytical models are created to suit different design stage needs, workflows and precision preferences. A model to be created directly from architectural building elements and room/space elements, or manually using conceptual massing.

B. Green building studio

Green Building studio is an online software to perform energy analysis of buildings. The analytical building model is imported from Revit architecture. The original Green Building Studio web-based service was first introduced in 2004 and by 2007 its analysis results had met American Society of Heating, Refrigerating and Air- Conditioning (ASHRAE Standard 140) and were certified by the U.S. Department of Energy. The link between the Revit platform and the Green Building Studio web service, now an Autodesk product, has been streamlined through a plug-in that enables registered users to access the service directly from their Revit design environment. Various project default settings enables to set spaces, zones, surfaces, Heat Ventilation and Air Conditioning (HVAC) and zones. The nearest weather station appropriate to the location of the building is automatically selected by the software. The advantages of analysis is to improve analysis quality to find potential opportunities for energy savings. It presents analysis results in a highly visual format for easy comparison and interpretation.

III. DETAILS OF THE EXISITNG BUILDING

The existing building is located in Tambaram, Chennai. The plot area is 2531 sq. ft. The building type is single family residential building constructed ten years ago. The plan of the building, windows and doors orientation are studied.

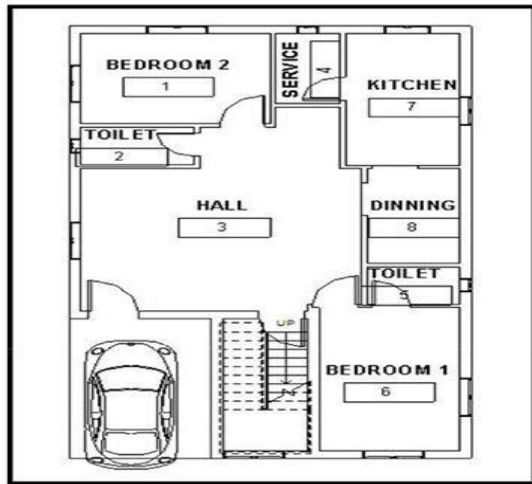The building location comes under Hot and humid zone according to SP 41.

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Fig. 1. Plan of the existing building in Tambaram

Fig 2 View of the existing building in Tambaram

III. MODELLING OF THE EXISTING BUILDING IN REVIT ARCHITECTURE

Revit is 4D BIM capable with tools to plan and track various stages in the building's lifecycle, from concept to construction and later demolition. The Revit work environment allows users to manipulate whole buildings or assemblies (in the project environment) or individual 3D shapes (in the family editor environment). Modeling tools can be used with pre-made solid objects or imported geometric models.
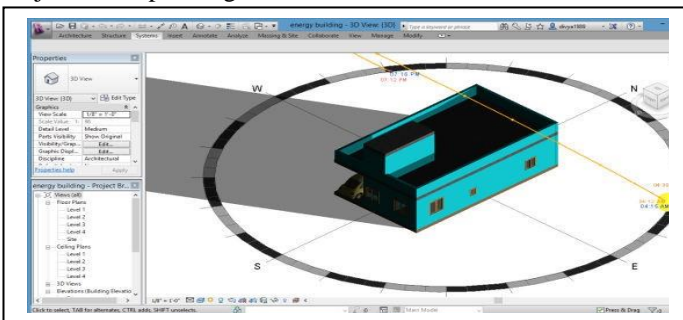

Fig.3. Modelling of existing building in Revit architecture

The existing building in Tambaram is modelled in Revit architecture in order to create a digital representation of the building and to serve as a input to perform energy analysis in Green building studio.

Although the native Revit BIM data provides considerable "intelligence" relative to more basic CAD data, which consist of dumb shapes and lines, it does not contain the volumetric/zonal data required by building performance analysis tools such as Green Building studio.

IV. TRANSITION FROM ARCHITECTURAL TO ANALYTICAL MODEL

This data must be super imposed on top of the native Revit architectural model. It is usually referred to as the "Analytical Model" because it is the model on which subsequent analysis is based. The diagram below shows the data objects involved in the transition process from Revit to Green Building studio.
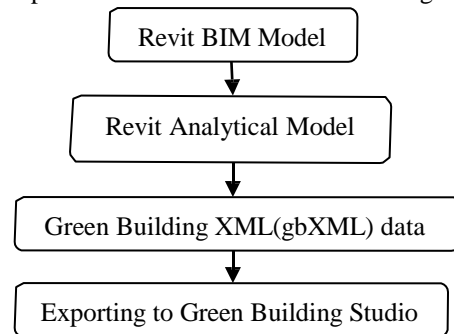

Fig. 4. Data diagram for the Revit to Green building studio transition

V. ENERGY ANALYIS IN GREEN BUILDING STUDIO

The Autodesk Green Building Studio web-based service allows users to perform fast, whole building energy, water, and carbon emission analyses of a Revit-based building design. These analyses can be performed by architects directly over the Internet from within their own design environment. This streamlines the entire analysis process and allows architects to get immediate feedback on their design alternatives making green design more efficient and cost effective.

The output also summarizes the water usage and costs and electricity and fuel costs, calculates an ENERGY STAR score, estimates photovoltaic and wind energy potential, calculates points towards LEED day lighting credit, and estimates natural ventilation potential.

A. Energy analysis of the existing building with existing parameters

Firstly, the Revit model of the existing building is analyzed in Autodesk Green Building Studio as such with the existing details at the time of construction. Fig 6 shows the Potential energy savings chart which is obtained as output from the analysis with 90% losses. There is significant loss in wall insulation, infiltration, roof insulation and plug load efficiency.
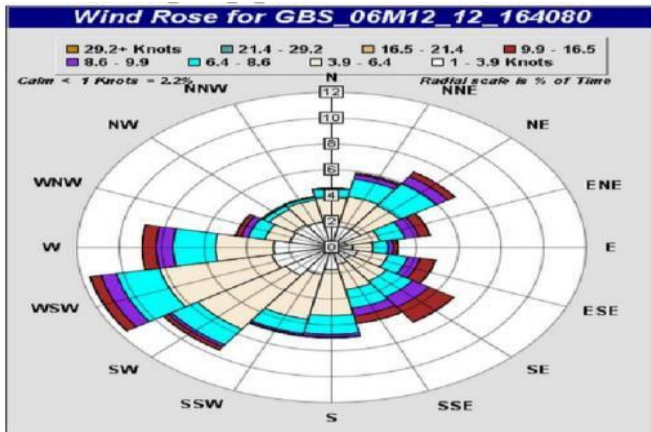
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Fig 5 Wind rose data for the existing building in GBS
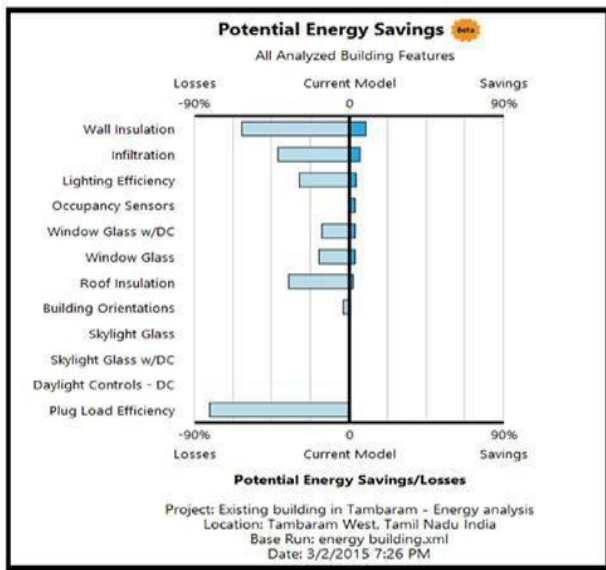
Fig 6 Potential energy savings - base run of existing building analysis

B. Parameters for improving energy efficiency

This research work mainly focuses on heat and light efficiency improvement in the existing building. In order to achieve this insulation and skylight parameters are calculated.

C. Insulation details

R-value expresses the resistance to heat transfer. The U-value is the rate of heat transfer per unit area per degree of temperature difference, and is the inverse of the R-value. That is, $U=1/R$ and $R=1/U$.

If different cross-sections through a building assembly such as a wall, roof, or floor have different R values, the effective R-value for that surface must be calculated by first calculating the U value of each different cross-section.

D. Inclusion of skylights

Skylights are designed to bring in natural light, but they also can allow in heat and cold. Skylights that are too large can cause a significant increase in heat during summer months and cold during winter months. Either way, the result is decreased energy efficiency, because more power is required to heat or cool the room. Measuring for the right size skylight will prevent energy efficiency problems.

To keep skylights energy efficient for the homeowner, the industry standard says that a skylight should be approximately 5 percent of the floor size of a room where there are many windows and 15 percent of the floor size of a room where there are few windows. Fig 7 shows the skylight area which is included in hall, kitchen and dining area
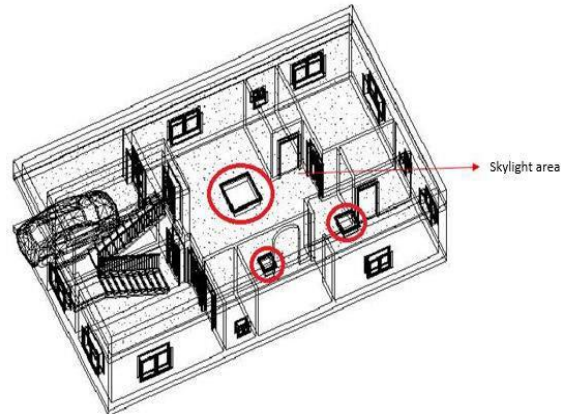

Fig. 7. Skylight area inclusion in subject building

TABLE I
SKYLIGHT CALCULATION – MULTIPLICATION FACTOR

Number of windows	Factor of Multiplication
Plenty numbers	Plenty numbers
0.05	0.05
Few numbers and dark	Few numbers and dark

Skylight Area = Area of the room X factor of multiplication
Using the above formula, skylight area is calculated

for hall, kitchen and dining area. It allows the daylight to pass in but not the heat. Windows if covered by curtains during summer may make the room dark. At that time skylight enables natural day lighting to the building thus eliminating the use of artificial light during day time

E. Parameters in green building studio

When performing energy simulation using Green Building Studio, building type of the model need to be defined. In order to generate an energy model for simulation, Green Building Studio uses a default value based on building type and project location if a parameter has not been defined in your model.

F. Outdoor air infiltration

The Outdoor Air value defaults to 15 cfm/person. This value can be edited from the edit menu using Outdoor Air per Person; Outdoor Air per Area; or Air Changes per Hour.

Additional input defaults used in the energy analysis, but not exposed in the Revit or Vasari Energy Settings, are based upon ASHRAE Standards. These defaults can be edited using the Green Building Studio Project Template, Project Default, and Design Alternative features.

These defaults are primarily based upon the ASHRAE 90.1, ASHRAE 90.2, ASHRAE 62.1 and CBECS data, and vary with building type, location, size, and number of floors. For energy settings where ASHRAE baselines do not exist, regional code baselines, or building survey findings are applied as a reasonable starting point for new construction projects.

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G. Design alternatives

The Design Alternative feature allows to modify the base assumptions about your model and then run a simulation that estimates the impact of the modifications on energy efficiency. This feature helps to make significant design decisions quickly. The Design Alternative feature is accessed from My Project tab Run List tab page. `The top portion of the table has standard links to the Run List. The bottom portion of the page has tabs corresponding to the values in the run.

H. Iterative process

The energy analysis in Green Building studio involves iterative process in order to obtain the optimum output in potential energy savings chart. The software comprises of many default options in the Projects default tab for the spaces , zones and opening which differs by material type, thickness and resistance value for insulation. Various options are iteratively analysed and comparatively optimum result has been taken into account.
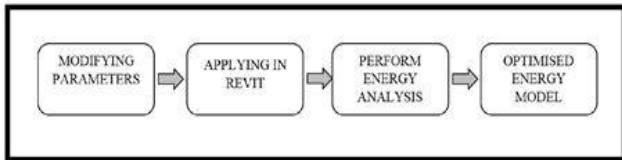

Fig 8 Flowchart representing the iterative analysis process

The first initial analysis had 90 % loss in energy and the following figure shows the analysis made after inclusion of energy efficient parameters with 70% loss in energy. Many trials are run and finally concluded with the minimum loss of 10%. It has been demonstrated that losses reduced substantially from 90% to 10% thus contributed significant savings in energy.

VI. SIGNIFICANCE OF POTENTIAL ENERGY SAVINGS CHART

The Potential Energy Savings chart is a tool to focus their limited time on only the features of a building's design, construction, and systems that can save the most energy. Fig 9 shows the potential savings chart with savings/losses potential 70%. The loss is influenced mainly by plug load efficiency. The chart serves as an alternative option by the use of varied material for insulation and glazings.
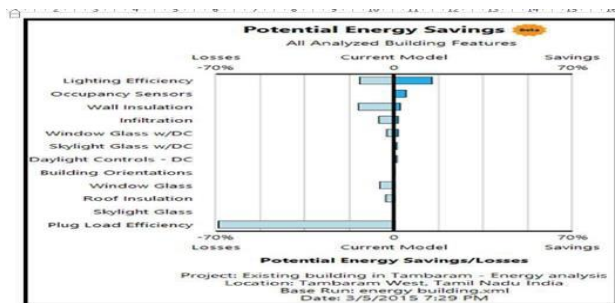

Fig. 9. Alternative trial - Potential energy savings chart

VII. VARIOUS PARAMETERS USED TO IMPROVE ENERGY EFFICIENCY IN GREEN BUILDING STUDIO

Solar Heat gain coefficient (SHGC) is defined as that fraction of incident solar radiation that actually enters a building through the entire window assembly as heat gain. The SHGC is expressed as a dimensionless number from 0 to 1. A high coefficient signifies high. In the energy analysis SHGC value is 0.25

Visible Light Transmission (VLT) indicates the percentage of visible light that is transmitted through the window. Visible transmission is relatively high for clear glass (about 81% for a single pane) but can be reduced by adding a tint to the body of the glazing, or by applying a colored or reflective film or coating to the surface. In this research VLT is taken as 0.4 based on the default options from Green building studio

Low emissivity (low e or low thermal emissivity) refers to a surface condition that emits low levels of radiant thermal (heat) energy. In this project Low E glazing is adopted. Underfloor air distribution systems shall incorporate variable air volume (VAV) units designed to distribute the supply air from under the floor using variable volume boxes or variable volume dampers running out from underfloor, ducted, main trunk lines. The maximum zone size of an underfloor air distribution system shall not exceed 2,360 l/s (5,000 CFM). The domestic hot water system with improved energy efficiency and Package VAV with Underfloor air distribution systems are selected from the drop down list in Green Building Studio.

VIII. RESULTS AND DISCUSSIONS

Energy analysis is most valuable when used early and often enough in a project to take advantage of opportunities to make choices that will reduce a building's energy use. Architecture and engineering teams need to work together to plan and prioritize energy efficiency measures. Potential energy savings chart (Refer fig.no 10) is meant to make energy efficiency process easier and can be generated easily from energy analysis software Autodesk Green Building Studio
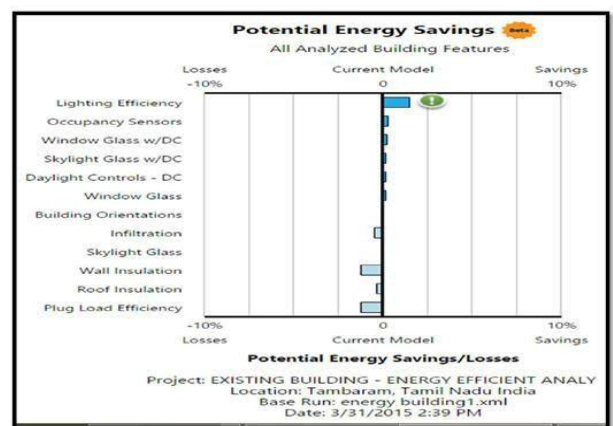

Fig 10 Potential energy savings chart – Optimum model

Wall insulation and Plug load efficiency are important building features affecting energy use (more sensitive). Infiltration and roof insulation are less important to energy use (less sensitive)

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Lighting efficiency, occupancy sensors, window glass, skylight glass, daylight controls have higher potential for energy savings and infiltration, wall insulation, roof insulation and plug loads have higher potential for energy losses

IX. CONCLUSION

The most sensitive building features for energy use are the wall insulation, Plug Loads, and Infiltration. Given the alternatives tested, wall insulation and plug load efficiency has the potential to impact energy use by about 10%. Other parameters that are important, with about a 2.5 - 5% potential impact to energy use, are Roof Insulation, and infiltration.

There is a significant savings in energy in lighting efficiency with the inclusion of skylight. Changes in infiltration and plug loads make a big difference to energy use. If the building is sealed poorly, infiltration could cause over 30% worse energy performance than the model submitted. Daylight controls are bundled with skylight and window glass to determine if it gives more benefit from daylight controls if different glass is used. Lighting efficiency is improved significantly due to the inclusion of skylights in Hall, living room and dining area. For avoiding excess radiation of thermal energy, Low E glasses with 0.25 Solar Heat Gain Coefficient and Visible Light transmittance of 0.4 is used in the glazing of windows and skylights. Attic ceiling with wooden frame insulation in floor and ceiling has proved to be worth and thus insulation losses in roof and ceiling is substantially reduced. Light and thermal energy comfort is improved in the building

X. SCOPE FOR FURTHER RESEARCH

Feasibility of minimizing the loss of light and thermal energy is studied with the software Green building studio. Similarly factors to contribute increase in savings part in the Potential energy savings chart need to be studied.

New construction building energy analysis in the design stage can be studied to implement changes in the structural aspects Comparative analysis with usage of different default material types provided in Green Building studio can be studied involving the market cost thus aiming at economic feasibility of implementation in improving the energy efficiency in the building.

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