Heat Balance through Building Envelope

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HEAT BALANCE THROUGH BUILDING ENVELOPE

ABSTRACT:

The study of this research tends to see how the building envelope functions in hot and humid Building envelope is the most significant parameters as it is only expression that get affected due to the climate or weather change and can be altered and this research tends to see how the building envelope functions in hot and humid conditions.

There are various parameters that may affect the building envelope such as the materials used, any special construction technique or the source of ventilation, Floors (Below-Grade Systems), Walls (Wall Systems), Roofs (Roofing Systems), Fenestration (Glazing Systems), Shading Elements.

Addressing concern of this study is the major problem of energy consumption that negatively impacts economy and the environment. Thus, the interconnectivity of modern design with the building envelope is the most suitable way of promoting the building design.

In the cases considered the building envelope has been analysed in the three building cases all of them belonging to the hot and humid climate zones. The parameters associated with these building envelope have been discussed and talked upon in the study.

The results or the conclusion has been such that the materials used in the building envelope have been listed along with their properties regarding the heat transfer that how efficiently the heat is being released from the buildings.

The analysis done can be shown using the graphs depicting the amount of heat balance done through the materials for the building envelope. The parameters associated in building envelope would be discussed and the results for these factors affecting the heat balance is to be shown through the values and the graphs.

Keywords: Environmental sustainability, building envelope, heat balance, Parametric, materials

INTRODUCTION:

Due to the constant change in the field of technology and advancement in the field of building design, it is really important that we consider the building envelope and its parameters. This is because it is the only expression of a building that may get affected due to weather and climate change. Through the data information it has been observed that the building is involved in most of the energy consumption and also the factors leading to the environment degrading. A suitable blend of passive and active technologies creates a building envelope that separates the indoor environment from the outside environment while also creating a comfortable indoor environment. The study has been done for the different buildings. A construction material's thermal characteristics are generally ascertained by calculating the thermal conductivity of its constituent parts, which directly relates to a material's capacity to efficiently transfer heat. High thermal conductivity materials will facilitate heat transmission and permit heat to go through them quickly. A building envelope should ideally consist mostly of materials with extremely low thermal conductivity values and include additional materials that serve solely as thermal insulators to further stop heat transfer from a structure's inside to its exterior. Building designers are admonished to choose

the ideal mix of materials to naturally control heat circulation without the use of pricey mechanical heating and cooling systems. Depending on how well it performs, a building

envelope is frequently categorized as "tight" or "loose." A more uncontrolled air transfer is made possible by loose building envelopes, which can enhance indoor air quality and eliminate the need for additional mechanical ventilation. Although a loose building envelope may create a cool atmosphere, they also have a tendency to make a structure draughtier and less able to keep the inside temperature consistent. Due to the additional energy required by mechanical systems, an increase in airflow is directly correlated with an increase in the release of damaging greenhouse gases. When it comes to heating and cooling a structure, a draughty building envelope can cause a significant increase in a homeowner's energy costs. A tighter design will be used in a more energy-efficient enclosure, allowing for more control over the temperature, humidity, indoor air quality, and energy usage. The significance of choosing thermally beneficial materials, such as insulation, caulking, adhesive tape, and sealants, is highlighted by a tight building envelope design. It's difficult to go wrong with additional sealing materials because they entirely prevent uncontrolled airflow and heat loss while reducing the likelihood of water intrusion, which can result in mildew or mold due to the presence of additional moisture.

CONCERN/PROBLEM:

Due to the increasing energy consumption in the building, it’s most important to look upon the modern design strategies or technologies to design the building effectively and sustainable. The other factor is the building envelope which can be altered according to the climate of that location and the properties affecting the building envelope and the design.

There are many factors that can be looked upon to the building envelope such as the daylighting, HVAC or maybe insulation but this research talks about the analyses of heat balance through the building envelope on the basis of materials, glazing or maybe the wall insulation according to their properties.

LITERATURE STUDIES:

1)MUSEO SOUMAYA, MEXICO

- The building is located in Mexico City which is a region of hot and humid climate.
- The building is a museum typology that has a height of 46 m and is a seven ring structure.

Figure 1- View of Museo Soumaya, Mexico

- The form of the building is trapezoidal form with exterior aluminum cladding.
- The structure consists of a framework of steel and concrete as the base materials.
- Due to the changing building appearance from exterior, the visitors get different views depending upon the weather and time period.
- Special blinds were used under the skylight to break up the sun rays so that the work of arts are not exposed to harmful UV radiation.
- Only source of ventilation is the rooftop oculus opening through which there is flow of air and heat. Rather than this there is no window opening in the whole structure.
- No source of artificial lighting being used in the building structure, the sculptures and the exhibits are lit up by the natural light

ANALYSIS OF THE BUILDING ENVELOPE:

So the structure has been built by the steel and concrete framework with aluminum as the exterior cladding material. Steel has a property to lower the temperature that enables to lower the temperature of the building by the insulating property of steel.

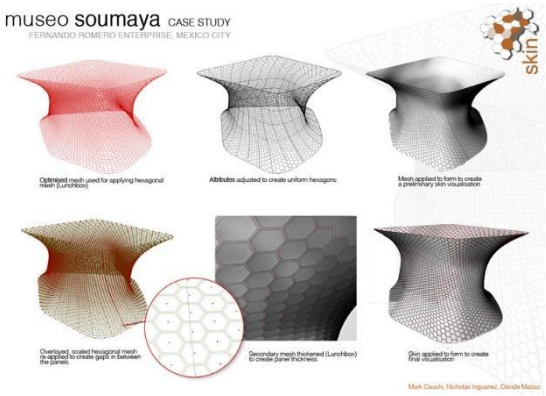

Figure 2-Step by step development stage for building envelope of museo soumaya

The exterior aluminum cladding act as a reflective material for the building envelope. Aluminum has a property that it reflects 80-95% of the heat into the atmosphere making it an energy efficient material to use for the building envelope. Thus only 5-10 % of the heat is entering into the building.

GALAXY SOHO, BEIJING, CHINA

- The building typology is a commercial building which is an 18 story building.
- There are different zones that are divided within the building.

Figure 3- View of Galaxy Soho, Beijing, China

- 4 domed shaped structure used for form of the building with bridges in between for the connectivity showing the flowing nature.
- The building is designed such that the upper floor projection act as a shading projection for the lower floor.
- The Galaxy SOHO's lower three levels are home to public spaces for shopping and leisure. Clusters of creative enterprises have workspaces available in the levels directly above. Bars, restaurants, and cafés with views of one of the city's best avenues are located at the top of the structure. Through intimate interiors that are always connected to the city, these various roles are interlinked, making Galaxy SOHO a significant urban landmark for Beijing.

ANALYSIS OF BUILDING ENVELOPE:

For the exterior the material is aluminum cladding which is energy efficient. The ring structure being formed for the floor plate and thus forming the whole domed structure. For the floor plate insulated glass units have been used to reduce the heat and solar heat gain entering into the building. Cooled roofing system being used in the building to control the microclimate. Also the structure has a large sized oculus at the rooftop for the easy flow of heat outside the building maintaining the temperature of the building inside.

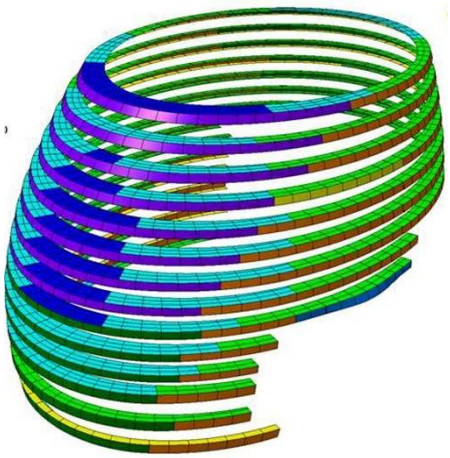

Figure 4-Energy efficiency shown in building envelope of Galaxy Soho

Figure 5-Spaces and the functions according to building form in Galaxy Soho

SHIRDI SAI TEMPLE KOPUR:

- This study is a blend of parametric and vernacular architecture such that it has a parametric form in its design implementation and at the same time allows the environmental aspects such as the daylight, shadow etc

Architecture and research firm rat [LAB] Studio and Shilpa Architects have designed a new temple in Koppur that reinterprets India's vernacular through parametric design. Called the Shirdi Sai Baba Temple, the project is located on the outskirts of Chennai on an 11acre site at the epicenter of a 338-

acre masterplan.

Figure 6-Top view of Shirdi Sai Temple, Koppur, Chennai

- The design features an 11sided polygon (hendecagon), articulated as a three-dimensional polyhedron.
- Balancing sacred geometry with engineering logic, the new temple was created through an algorithmic process using spatial and structural constraints as its parameters.
- The hendecagon evolved into three- dimensional spaces while evaluating

  environmental aspects such as daylight, solar heat gain, and shadows.

- Inside, the flooring pattern in the main hall is a mathematical looping system using 11 vertices of the hendecagon that fold to form interstitial spaces within the geometry.
- A recursive division of curves creates a focal point at the ground level where the pattern curves and guides the visitors for prayers and offerings.

- A pure white space from inside is lit by sunlight diffusing from the oculus on top.
- Overhead, the team explains that the double fold origami structure created a rigid structure with fluid columns that blend into the interior space while allowing a long-span shell-like structure.

Figure-7-Elevational Building form of Shirdi Sai temple

Figure 8-Interior form with punctured surfaces of Shirdi Sa Temple

ANALYSIS OF SHIRDI SAI TEMPLE:

The building has the punctured surfaces that have been designed for the ventilation purposes at the intersection points. The exterior material is aluminum and there are curvilinear columns that area there to support the structure. The structure is a double fold origami structure and the surfaces or the punctures created are also helping to reduce the direct heat glare that is entering into the building. The oculus at the top of the structure helps for the movement of heat flow releasing the hot air outside of the building. Since the structure is not a very big

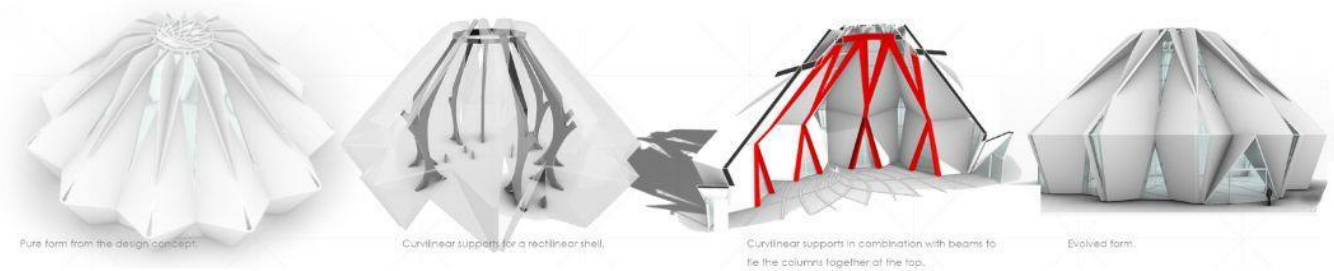

Figure 9-Step by step development of form and geometry of Shirdi Sai Temple

span structure and also considering the geometry, the heat would enter into the building and is being released from the roof oculus at the top of the structure.

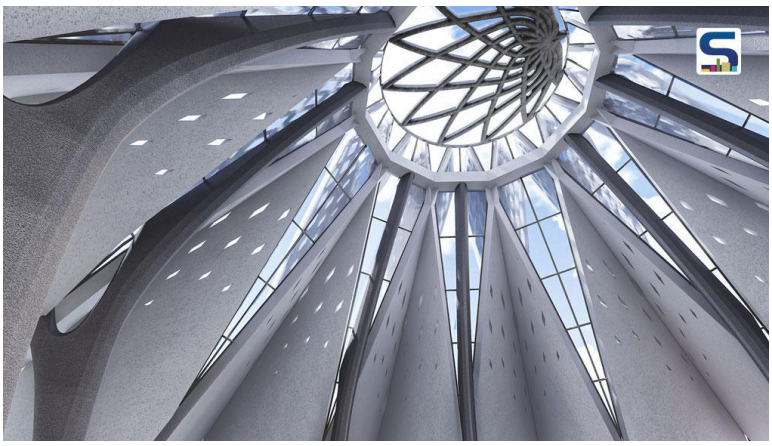

Figure 10- View of roof oculus for daylighting and punctured surfaces in Shirdi Sai Temple

RESULTS/INFERENCES:

The exterior surfaces of walls and roofs are impacted by solar radiation in the summer. The amount of radiation that is absorbed raises the surface's temperature over that of the surrounding atmosphere. The location and surrounds of a structure are important factors in controlling its temperature and lighting. For instance, hills, trees, and landscaping can offer shade and reduce wind.

Buildings should be designed with south-facing windows for milder climes. enhances passive solar heating, which allows more sun (and subsequently heat energy) to enter the structure while using less electricity. Heat loss can be reduced by 25–50% with tight building design, which includes energy-efficient windows, well-sealed doors, and additional thermal insulation of walls, basement slabs, and foundation. (2) Artificial lighting requirements can be decreased by strategically placing windows, skylights, and using architectural features that reflect light into a building. One study found that using more natural and task lighting increased productivity in classrooms and offices.

The following results/inferences have been done by the simulation of the building design.

The data achieved has been on the basis of the building location, and the materials of the building envelope such as the walls, glazing type, roof and the base ground.

The data has been derived for the hot and humid climate zones areas according to the literature study and is according to the typical summer week design period.

RESULT 1 ANALYSIS (MUSEO SOUMAYA):

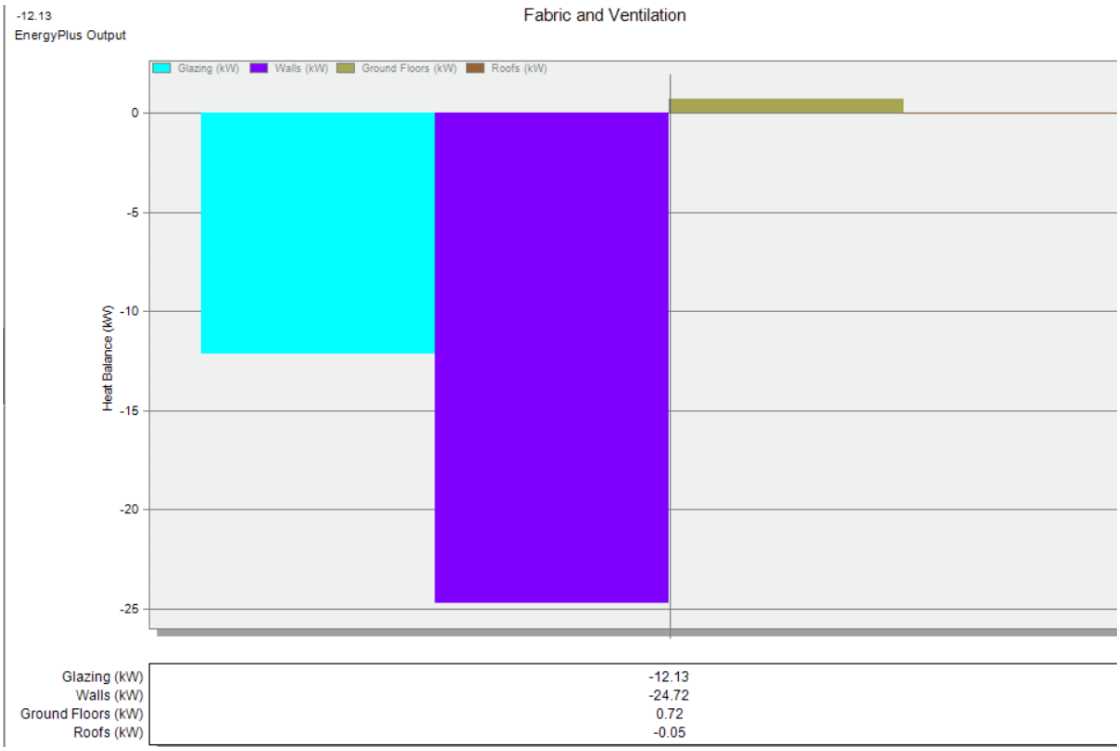

Figure 11-Heat Balance simulation result for Museo Soumaya, Mexico

The first case is a case of a museum typology building in which the museum is a steel and concrete framework with exterior aluminum cladding. So in the following case the parameters have been set according to the above structure conditions.

As a result, as discussed above in this case there is no window opening or a source of ventilation rather than just an oculus at the top of the structure resulting in the little less negative impact of the heat balance.

*Positive heat balance **happens when there is a reduction in amount of heat getting lost but, the production of heat remains same**. Negative heat balance happens **when there is an increase in amount of heat getting lost but, the production of heat remains same.**

This means that the roof would have less impact on the heat balance of the structure. On the other hand, if we consider the case of framework or the wall of the structure it is a steel framed structure resulting in a very high amount of negative heat balance hence more effective in maintaining the temperature of the building and also dissipating the heat more quickly.

Talking about the floor finish, the ground is a concrete floor which is uninsulated normal concrete band resulting in the positive heat balance hence the concrete is not suitable for the heat flow impacting the building envelope.

RESULT 2 ANALYSIS (GALAXY SOHO):

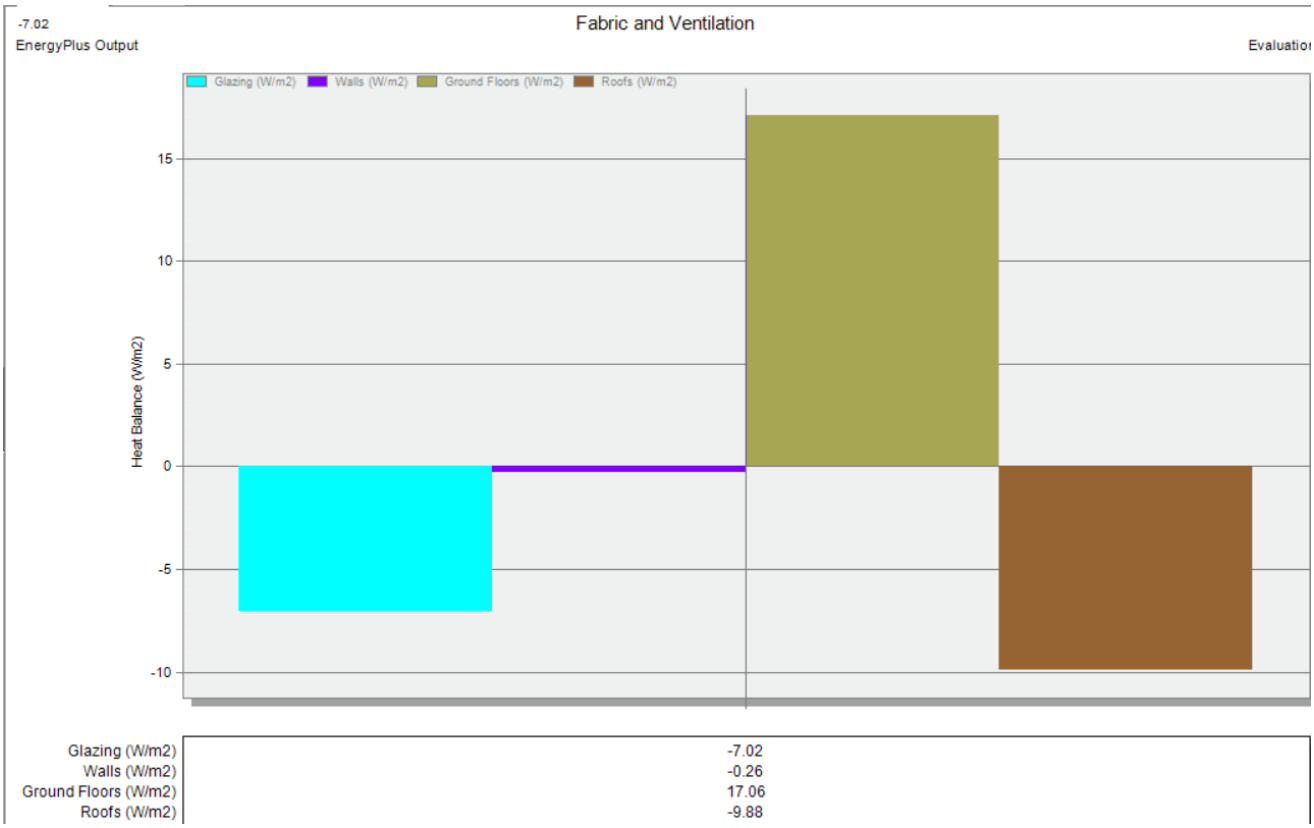

Figure 12-Heat Balance simulation result for Galaxy Soho, Beijing, China

The second case is an office and a commercial typology building design. In this case the structure has the curtain wall as the strips of band running which is the double glazed glass resulting in the negative heat balance hence faster dissipation of heat.

The other factor was the floor that has been of uninsulated concrete band in this structure along with the basement floors as well in this building resulting in an extensive amount of positive heat balance hence creating a problem for the building and increasing the amount of energy consumption hence restricting the easy flow of heat.

The walls are mainly the semi exposed lightweight structures and thus the impact is less as compared to any other type but it is resulting in the negative heat balance which is better for the building envelope.

The last factor is the roof which has an enhanced cooling system and also a large oculus at the top resulting in an excellent heat balance for the structure thus the value for the roof is the highest in this scenario.

RESULT 3 ANALYSIS:

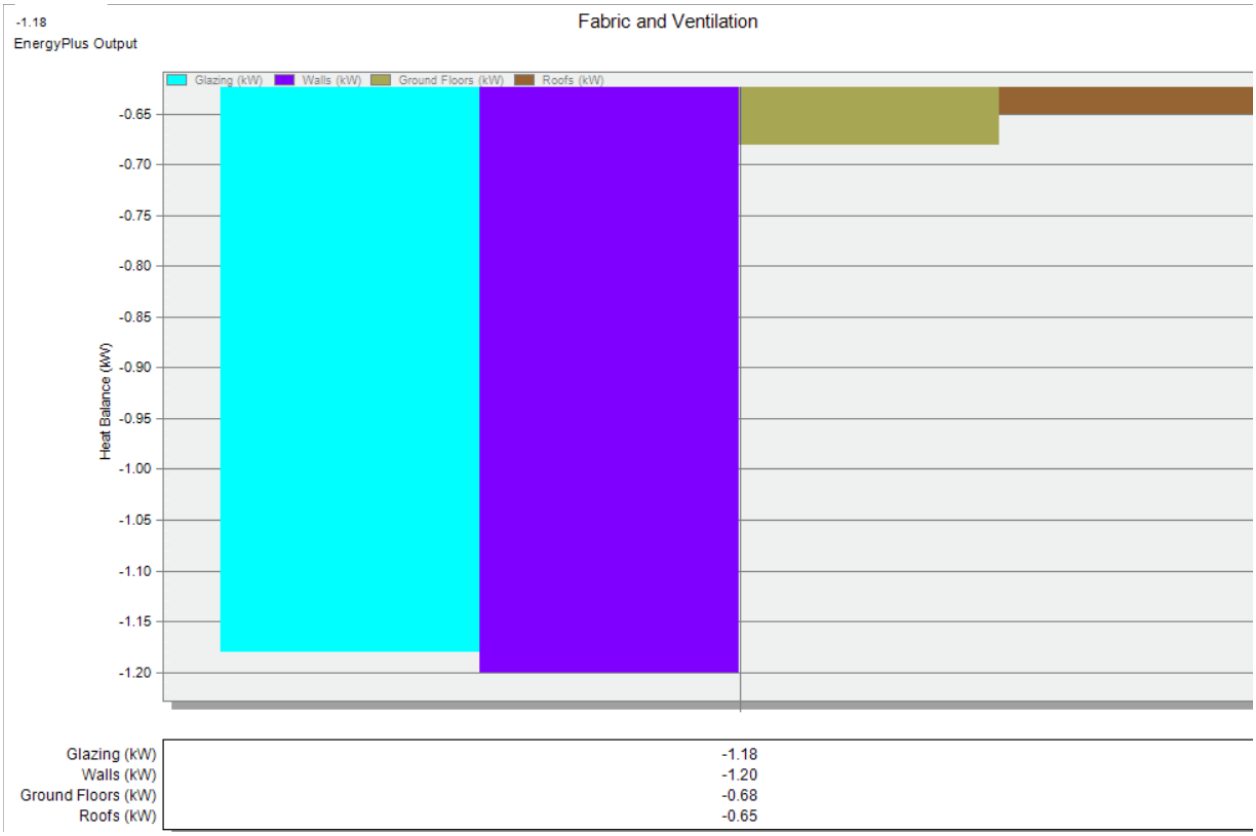

Figure 13-Heat Balance simulation result for Shirdi Sai Temple,Koppur,Chennai

The third case is a temple typology structure which is a blend of vernacular and parametric architecture. In this the structure has been developed by whole mathematical and geometrical design.

In this the glazing's are the exterior panels of glass with less amount of glazing rather than a larger amount of glazing as in the above cases hence the heat balance value according to the glazing is somewhat less as compared to the above cases.

In this the structure has a roof oculus which has a negative impact in terms of heat balance and resulting in adequate amount of heat balance through the roof.

The walls for the structure are also somewhat intermediate in terms of the properties and hence an adequate value for heat balance has been obtained.

CONCLUSION:

In addition to assisting in compliance with the Energy Conservation Building Envelope a well-designed building envelope can also lead to initial cost reductions by utilizing daylighting and other factors. The envelope shields the interior of the structure and its occupants from weather and other outside factors.

From the above results and inferences, it has been observed that the building envelope has been depended on the different parameters. These parameters differ from one another on the basis of the building form and the structure of the building. From these parameters the

amount of heat balance we observed in the different building structures and the data was collected according to the values of walls, glazing, roofing and also the floor. The research has been done for the hot and humid climate zones keeping in mind the temperature in summers and thus how the structure is maintaining that temperature. The analysis showcased the different properties of the material in terms of the heat control in all the three cases along with the diagram. It also represented the materials standards and the graphical number data according to which we can configure the heat control through that material in the building envelope.

According to the three case results and the inferences it was observed that the glazing of the envelope should be insulated glass glazing or the double glazed glass that provide a better insulation and helps to control the direct heat gain into the building. Glazing's are necessary so as to provide the ventilation in the building design or the structure otherwise the heat flow of the structure may not be uniform or that much quick that it is able to release the heat outside the building maintaining the inside temperature.

The roofing should be such that the size of the roof oculus or the opening should be proportionate to the building size such that the hot air is released from the building through that passage. Also in some cases as it was observed that special construction techniques were being used so as to control the micro climate.

The walls used as the framework structure or the external frame must be that of insulated materials such as aluminum and steel both of them having its own advantage. According to the data it was seen that aluminum reflects 80%of heat whereas steel because of its insulating property helps to control or lower the building structure. Both the above materials have been extensively used in the building structures for the exterior as they are energy efficient leading to less energy consumption. In the above cases it is seen that steel is better in terms of heat balance hence will be better as a material in terms of values.

Last but not the least the floor is again an important parameter of the building envelope.In the above cases it was observed that the floor should be an insulated floor rather than uninsulated floors without any specifications. This was the case in most of the discussed building hence resulting in the positive heat balance that is it would have stuck the heat within the floor itself rather than dissipating the heat or releasing it.

Therefore, the above results have been derived after the analysis of the building according to their respective conditions concluding the impact of these factors i.e the wall, roof and the glazing on the fabric of the building envelope in terms of heat balance and which are the best outcomes for the hot and humid climatic conditions.

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