Improving Thermal Performance of a Residential Building, Related to Its Orientations - A Case Study

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Abstract. Urban planners and stakeholders require knowledge about the effectiveness of city-scale climate adaptation measures in order to develop climate resilient cities and to push forward the political process for the implementation of climate adaptation strategies. This study examines the impact of modifications in orientation of buildings with respect to heat load. Heat load calculation is a mathematical process to determine the best capacity, application and style of HVAC system. The purpose is to ensure energy efficiency while also maximizing comfort inside the building. This study of load calculation is essential for a building because it helps to pick the best orientation and focuses to find an orientation that will reduce energy due to direct solar radiation. One of the factors affecting this assessment is the latitude of the location. The heat gain is effective through walls and fenestration. Improper management through ineffective orientation of the building's natural heat gain leads to excessive consumption of energy in the form of CL. The total heat gain for the above factors is calculated with the equations and assumptions as per ASHRAE code. After the calculation of heat load for different orientations, the best suited orientation of the building is found. By altering the building to suitable orientation, the dependence on electrical equipment can be minimized and thereby helps in energy conservation.

1. Introduction
Buildings consume more than half of the total energy generated in building. Energy efficiency is a high priority in many countries. Nowadays, energy conservation is of high importance. Efficient use of energy is important as the power generation using fossil fuels has adverse environmental effects. Conserving energy is the best way to ensure a secure and sustainable energy supply and to reduce global warming. Energy efficiency and the sustainability of buildings play a vital role in the construction industry. Energy efficiency measures reduce the amount of energy consumed by maintaining or improving the quality of service provided in the building. The importance of energy efficiency in building sector is especially significant in developing countries owing to rapid new construction with opportunities to employ efficient materials and best practices. [3]

2. Methodology
The methodology for carrying out the thermal auditing process in an exciting building in order to determine the thermal comfort temperature in that particular building is summarized below
3. Method of calculations of Heat load
The CLTD/CLF/SCL method uses predetermined set of data to expedite and simplify the process of cooling/heating load approximation. The data is divided into many different sections based on many different variables. These variables include, building material of the envelope, thicknesses of the building materials, day of the year, time of day, orientation of the surface (e.g. wall or roof, 90 degrees or 180), and wall face orientation (cardinal directions, i.e. N, NW, S, SE, etc.), to name a few. In order to determine which set of CLTD/CLF/SCL data to look at, all the requisite variables must be defined.

The respective tables of data were generally developed by using the more complex transfer function method to determine the various cooling loads for different types of heating. The results gained by doing so are then normalized for each type of heat gain used for the tables, CLTD, CLF, and SF.

3.1 Case study
The following building with plinth area75’03” was chosen for calculating the total solar heat gain and show the variation of it with respect to the orientation of the building. It is located in Trichy district. It has an aspect ratio of 1.4 which is suitable for showing significant changes in the solar heat gain calculated.
**Table 1.** Heat load through walls in different months about different orientations

| Month    | Heat load at 9am | Heat load at 3pm |
|----------|------------------|------------------|
|          | 0°   | 90°  | 180° | 270° | 0°   | 90°  | 180° | 270° |
| March    | 858.76 | 848.702 | 856.411 | 866.473 | 2090.007 | 1993.43 | 2115.643 | 2021.055 |
| June     | 833.739 | 729.05 | 830.97 | 706.261 | 858.764 | 848.702 | 856.411 | 866.473 |
| September| 2090.00 | 1993.43 | 2115.64 | 2021.05 | 2064.98 | 1873.77 | 2090.20 | 1860.84 |
| December | 470.558 | 848.702 | 856.411 | 866.473 | 1701.801 | 1993.43 | 1727.72 | 2010.148 |

Note: All Heat Loads are in Watts, Area in m²

**Table 2.** Heat load through fenestrations in different months about different orientations

| Month    | Heat load at 9am | Heat load at 3pm |
|----------|------------------|------------------|
|          | 0°   | 90°  | 180° | 270° | 0°   | 90°  | 180° | 270° |
| March    | 1803.46 | 1558.09 | 1301.14 | 1558.094 | 1515.03 | 1742.14 | 1913.70 | 1742.14 |
| June     | 1575.54 | 1275.81 | 1126.75 | 1275.812 | 1286.13 | 1388.67 | 1642.32 | 1388.67 |
| September| 1734.85 | 1501.23 | 1258.19 | 1501.233 | 1465.76 | 1681.00 | 1844.06 | 1681.00 |
| December | 1676.21 | 1582.29 | 1285.35 | 1582.292 | 1537.27 | 1841.81 | 1847.48 | 1841.81 |

Note: All Heat Loads are in Watts, Area in m²
4. Results and Discussion

4.1 Solar Heat Gain
After obtaining the necessary heat gain results for the orientations of 0, 90, 180, 270 degrees for all equinoxes and solstices for the year 2016 and also for two different times in a day for the building as a whole, the average of the solar heat gain for each orientation is found. The table below shows the solar heat gain for different orientations and for different times during each day. Based on the above calculations, the graph is plotted between the Orientation and heat gain.
Table 3. Average heat load of various orientation (in watts)

| Orientation | 9am     | 3pm     | Avg      |
|-------------|---------|---------|----------|
| 0           | 9812.41 | 13751.51| 11781.96 |
| 90          | 9153.795| 14468.9 | 11811.35 |
| 180         | 7983.734| 15296.79| 11640.26 |
| 270         | 9212.204| 14566.73| 11889.47 |

Figure 5. Max heat load with respect to orientation.

5. Recommendations
The admission of solar radiation into an interior space may cause problems such as indoor temperature, thermal and visual discomfort to the occupants, damage to sensitive objects and furnishings. Thus, it is of vital importance that the total heat load on the building must be controlled so as to increase the comfort conditions inside the building. The following recommendations can be taken into consideration to reduce the total solar heat gain on the particular building that we have chosen.

6. Orientation
From the obtained results, it be inferred that by orienting the building to 180°, min heat load can be achieved on the building compared to the other orientations. The average for this particular orientation turns out to be 11640.26 W which is the minimum of the orientations. In the present orientation of the building, the sunlight enters the bedroom in the afternoon and living room in the morning. Thus, if the building is constructed with the recommended orientation, the bedroom may receive sunlight during morning and reduce the heat load on air conditioners if used in bedroom.

7. Conclusion
This Case study provides an idea for implementing thermal auditing procedures for any type of building. In all respects, it involves in analyzing the thermal efficiency of the building. Equations used are well assessed before being adapted in the analysis of the building. This represents the detailed reference for performing an auditing process. Recommendations have been stated based on the thermal whereabouts of the building. This application acts as the initial step towards a larger research and also study in the existing building to save energy and to reduce the consumption of energy. This auditing procedure is procedure generic to all types of buildings. This thermal auditing provides recommendations about the provision of air conditioners in the building, it’s capacity, with numbers, if the building is equipped with air conditioning system. If the building is not provided with air
conditioning system, then they can achieve the determined thermal comfort temperature using some passive cooling techniques. Therefore, this project presents a required thermal analysis that allows the detection of all the parameters which affect the thermal efficiency. Once all the characteristics of the building are known, the engineer or air conditioning technician would be provided with all the necessary details to model the insulation system adequately may be practically implemented in the residential, institutional and commercial buildings where the cooling loads are necessary. If all the above suggestions are applied in practical, the occupants can enjoy the thermal comfort for the entire year during their stay.

References
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