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Optimum Building Orientation Study for Central India by Simulation

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ABSTRACT

Orientation of building plays very important role in energy efficienncy of building. Proper orientaion of building depends on the location of building with respect to latitude and longitude. With orientation to design energy efficient building natural air flow is also important in naturally ventiilated building. Paper discussed the optimum orientation required for Nagpur city in central india. Result are valid for area nearby nagpur region. Simulation study was done on model having having generalise length to width ratio. Simulation result define the best orientation analgle of building as per the thermal load calculation.

Keywords: Orientation, Simulation, Nagpur, India, Solar Radiation.

I. INTRODUCTION

Building are largest energy consumption sector in the world. Design of energy efficient building is the need to reduce the CO2 emission in atmosphere. Proper orientation of building is one of the key factor in design of energy efficient building. Air conditioned building having maximum facia exposed to solar radiation consumes maximum load for cooling the rooms. With provision of sunshade and proper building material, energy consuption of building can be reduced. On different parts of india as per the latitude, longitude and altitude of location, solar radiation is different. Hence the study of orientation performed on other far region can not be used as guideline. With the help of simulation software, building can be model in computer and energy consumption for various orientation can be calculated.

In summer solar radiation is highest in month of may. To avoid over heating of wall orientation of building should be such that minimum area is exposed to radiation. When it is not possible to orient building in optimum angle, shading or proper room location should be defined in planning to avoid over heating of habitable area. Sanctioning authority should ask for proper orientation study of proposed sanctioned project if orientation options are possible.

2. LITRATURE REVIEW

Nedhal Ahmed M. Al-Tamimi, Sharifah Fairuz Syed Fadzil, "The Effects of Orientation, Ventilation, and Varied WWR on the Thermal Performance of Residential Rooms in the Tropics", paper discuss the importance of orientation in hot humid region of malaysia. An investigation was done on the effect of building orientation in view of varied area ratio of glazed window to wall , solar radiation absorptance of exterior wall and the effect of natural ventilation on the thermal performance for residential building in tropical region. Experimental investigation was done at Fajar Harapan building which is a postgraduate student residential building.

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Kamyar Tolou Behbood, Mohammad Taleghani and Shahin Heidari, "Energy Efficient Architectural Design Strategies in Hot Dry Area of Iran: Kashan", diiscuss the importance of orientation in Hot dry area of Iran. It is required to incorporate natural climatic strategies to face hot harsh weather condition. Design stategies are examined such as , selection of the area, orientation , building envelop, building form and distance between buildings.

National Building code of India 2005, provide guidance related to solar intensity at various location in india. India is divided into 5 climatic zone as per the previous climate study. Code provides the climatic map of India. Total Solar radiation incident on various surface of building is summer and winter is provide in code. Code discuss the various climatic factors which influence the orientation of building.

3. RESEARCH OBJECTIVE AND METHODOLOGY

Research objective is to assess the impact of building orientation on building energy consumption. Nagpur was selected as location for study which is at center of india.

Methodology of the research is to model the room of size 4 × 10m in ecotech software. Following simulation parameters are consider for modelling in Autodesk Ecotech software.

Location	–Nagpur	
Latitude	–21.1^{o}	
Longitude	–79.1^{o}	
Altitude	–310 m (Elevation from MSL)	
Climate Zone	-Hot Dry	
Min. Comfort Temperature	–22^{0} C	
Max Comfort Temperature	–28^{0} C	
Lighting Level	-300 Lux (Depend on Room type)	
Weather File	-American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Inc., Atlanta, GA, USA. (www.ashrae.org) For India	
Room Size	– 6 × 12 m (L/B ratio = 2)	
Floor Height	–3m	
Internal Design Condition		
Clothing	-Trousers and Shirts	- 0.6 col
Humidity		- 60 %
Air Speed	- Pleasant Breeze	- 0.5 m/s
Light level		- 300 lux
Occupancy		
No. of People	- Five persons (normal home works ; 24 hours occupancy)	
Activity	- Sedentary	- 70 W
Internal Gains		
Sensible Gains		- 5 W/m2
Latent Gains		- 2 W/m2

Infiltration Rate

Air Infiltration - well sealed	- 0.5
Wind sensitivity- Reasonably protected	- 0..25
Outside heat transfer coefficient:	22.7 W/m2-K

Wall Material–Red brick wall palstered on both face

Thickness	= 230 mm
U-values (U: W/m²K)	= 2.101
specific admittance (Y: W/m²K)	= 4.38
solar absorption (Abs: 0-1)	= 0.418
Thermal lag (Lag: hrs)	= 4 hr

Roofing–RCC Slab with integral plaster at top

Thickness	= 125 mm
U-values (U: W/m²K)	= 2.97
specific admittance (Y: W/m²K)	= 2.3
solar absorption (Abs: 0-1)	= 0.9
thermal lag (Lag: hrs)	= 7 hr

Simulation months –Complete Year

Simulation Time – 10:00 to 17:00 hr

Zone: Dwelling

Total Surface Area: 252.000 m2

Floor Area: 72.000 m2

Volume: 216.002 m3

Surface Area/Volume = 3.5

Analysis was done for heating and cooling load calculation. In Central India region it is found that peoples are not using heater for comfort, hence calculation can be done for cooling comfort. In Ecotech simulation software Solar Access analysis was performed. Direction of building was set from North (0^0), East (90^0), South (180^0) and West (270^0) with increment of 15^0 each.

4. RESULT AND DISCUSSION

4.1. Modeling

For the plan of size 6m × 12m, as per the parameters defined above, heating and cooling loads are calculated for angle 0, 15, 30, 45, 60, 75, 90, 105, 120, 135 Degree orientation. While orientation software rotate the North direction by the orientation angle, keeping the building at same loacation. Basic building is planned in such that on east and west side exposure (Width) surface is less. East side surface area of building is less then North side surface.

Following is the results of Simulation of monthly load of 0 and 90 degree

Following table shows the heating and cooling load for change in orientation. For every orientation angle simulation process was run and total load is calculated.

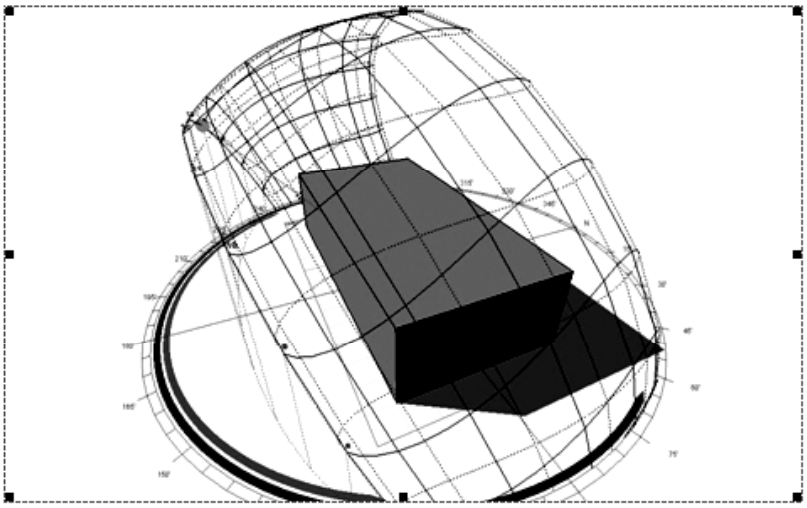

Figure 1: Annular Sun path for 0 Degree Orientation

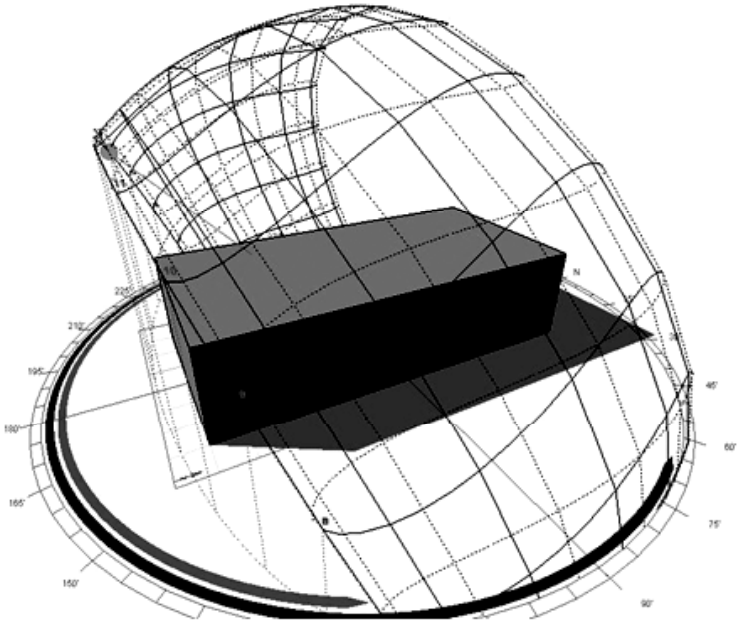

Figure 2: Annular Sun path for 90 Degree Orientation

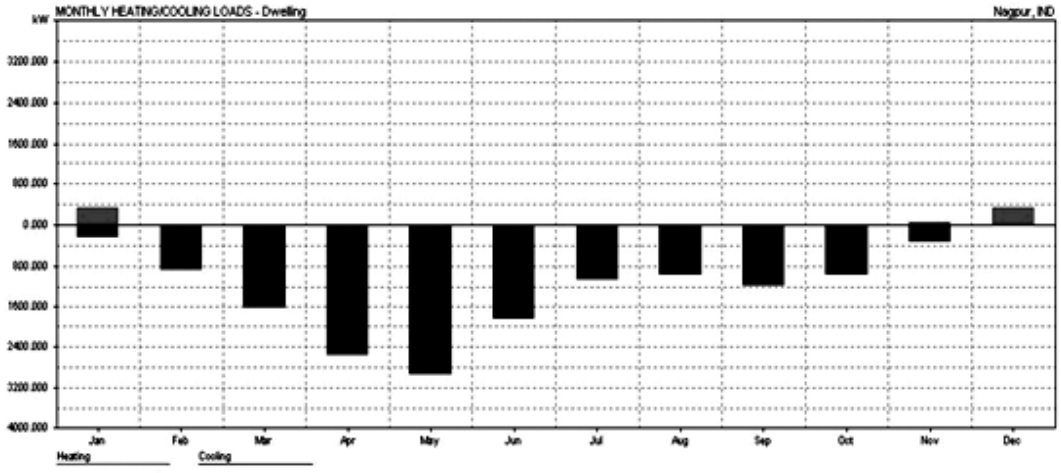

Figure 3: Monthly Heating/ Cooling Load for 0 Degree Orientation

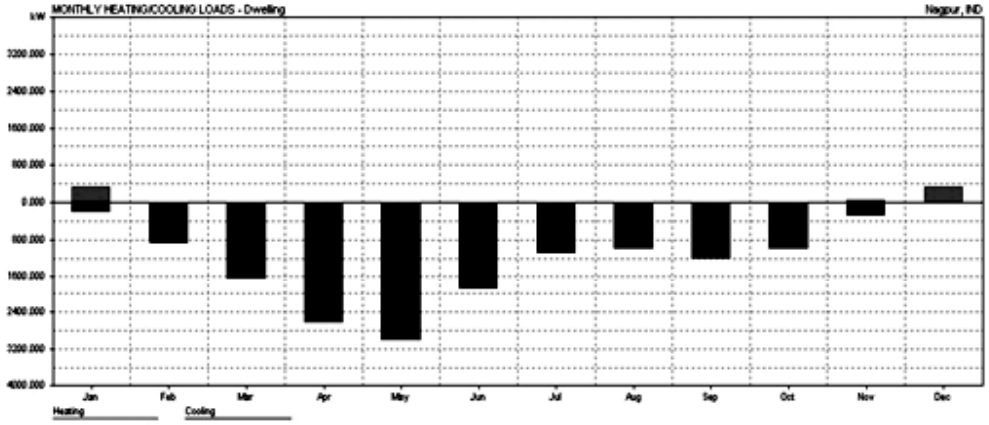

Figure 4: Monthly Heating/ Cooling Load for 90 Degree Orientation

TABLE 1
Average Cooling and Heating Load

Orientation Degree	*Heating Load (kWh)*	*Cooling Load (kWh)*	*Total Load (kWh)*
0	683.24	14643.15	15326.39
15	680.44	14736.82	15417.25
30	682.46	14831.51	15513.97
45	684.30	14916.99	15601.29
60	684.29	14934.84	15619.14
75	685.34	14934.11	15619.45
90	688.15	14904.44	15592.59
105	690.63	14876.47	15567.09
120	694.58	14840.48	15535.06
135	694.60	14757.76	15452.36
150	689.38	14696.38	15385.76
165	684.34	14635.16	15319.50
180	683.24	14643.15	15326.39

As per the load calulation graphs are prepared for heating load and orientation angle.

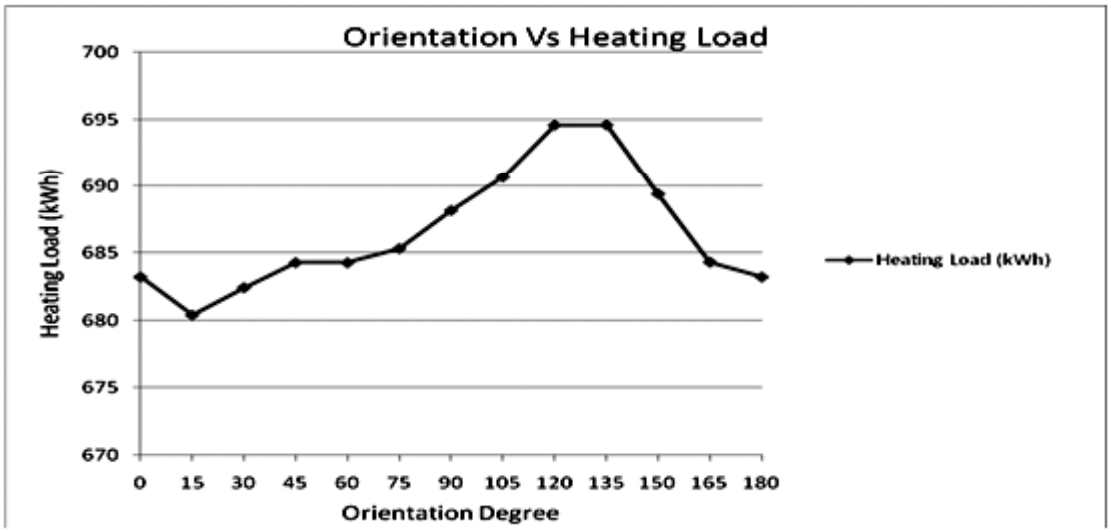

Figure 5: Heating load in kW/m2 for various orientation angles

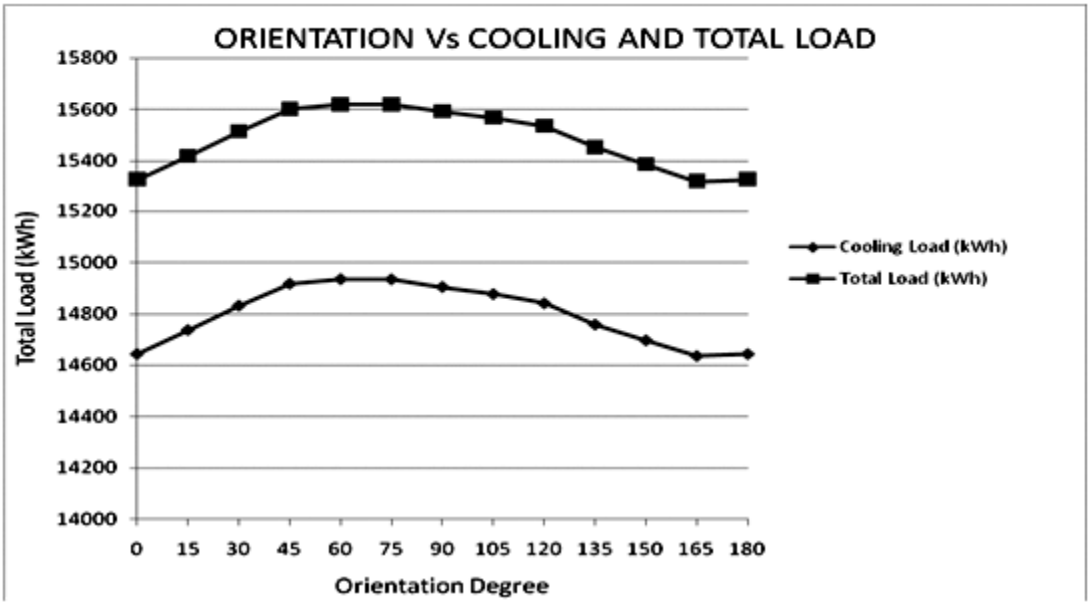

Figure 6: Cooling and Total load in kW/m2 for various orientation angles.

5. CONCLUSION

As per the annual Cooling and total load calulation graphs, cooling load was maximum when orientation angle is 60 degree. Maximum cooling load is 14934.84 kWh . Minimum Cooling load is 14643.15 kWh which is at 0 degree orientation. South and north facing walls are easier to shade than east and west walls. Hence optimum orientation should be at zero degree orientation. An east-west orientation (i.e. longer axis along the east-west), should be preferred for central India location.

6. LIMITATION AND FURTHER RESEARCH

Study was conducted on single story building with roof exposed to sun and length to width ratio 2. Same study can be done on various proportion of length to width ratio. Location of building will affect the solar radiation intensity, hence study can be done for various location in india.

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