Enhancing Thermal and Lighting Quality with Modeling Software

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Abstract*: Concrete is a major construction material which absorbs and emits heat from the Sun. To compensate this, more cooling load is required and window blinds. This draws more electricity which in turn depletes the natural resources on a greater scale. Our study is to balance between the lighting and cooling load by analyzing the effects of two different window to wall ratios through Designbuilder. A residential space in Chennai, Tamil Nadu, India is chosen for the study. All details (materials used, thermal transmittance of these materials, climatic condition including ambient temperature and number of summer days, orientation of structure and window to wall ratios, number of occupants, purpose of building etc.) regarding the structure and the temperature of the city is fed in and the analyses are run. The software gives us an idea on the thermal and lighting characteristics of the 3D model of the structure created in it. This can be viewed in both daily and monthly intervals. Also the analyses give us information on paramount parameters of conserving energy. We compare the results between the two window to wall ratios. With this we suggest ways which bring us far from exploiting fossil fuels thus conserving energy in the ways possible. The conclusion of this study is illustrated later section in this paper.

***Index Terms*: thermal comfort, lighting quality, window to wall ratio, thermal properties, heat gain.**

I. INTRODUCTION

Concrete has gained its importance over the years in the construction industry. The effect of global warming is predominant as the ambient temperature increases on a daily basis. The contributing factor to this temperature increase is the concrete material that absorbs and emits heat to the exterior. Thus, concrete structures play a major role in escalation of ambient temperature of a built up area. Air conditioning has always been the best option to maintain thermal comfort in closed spaces. Also to thermally insulate the building, window blinds are installed which calls for artificial lighting devices. Since these draw more of the natural resources (fossil fuels) such as electricity, it has become uneconomical and an environmental hazard in the present days. To reduce the depletion of natural resources and to increase thermal comfort in a building, different techniques were devised.

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For this, usage of eco-friendly materials have been the solution from ancient times, such as “green materials” that pollute the least and provide comfortable indoor temperature to the dwellers. Green buildings are those which use green materials and are designed to reduce the impact of construction materials and related activities on the surrounding environment. For this, it incorporates energy efficient designs which protect both the natural environment and human health. This ensures reduction in pollution, superfluous energy consumption, and resource degradation. The prime concern of this concept is “more comfort with less energy/ natural energy”. Organizations like LEED, IGBC, BREEAM etc. use various codal provisions to certify and rate buildings based on the amount of usage of renewable resources and conservation of energy. The main objective of this project is to identify behaviours of materials and improve thermal and lighting quality in an enclosed area..

II. THEORY

Energy conservation has grown to an extent that it plays a vital role in the construction field due to reduction in resources. Materials used also impact the heat gain in a building. On a simpler note, green building concept works towards sustainable development and conserving natural resources for the coming generations. The other aspect of this is the energy design executed in a structure. Energy design includes orientation of the structure, materials of building envelop, method of construction adopted, degree of inexhaustible resources used, day lighting, shading, window to wall ratio, and so on which enable the structure to be self-sustaining to the maximum extent possible. On the other hand, rammed earth, bamboo, recycled plastic, hempcrete, green concrete, mud plaster etc. are few ancient materials that prove to transmit less heat inside. Thermal comfort and lighting sufficiency are psychological opinions of every individual. This can be analyzed and concluded upon a common scale. Designbuilder serves this purpose for several indoor analysis of a given building. It is a 3D model simulator which simplifies thermal simulation with Energyplus. It measures and controls thermal, lighting, energy and carbon content. Based on the data obtained from the function of the enclosed area, number of occupants, location of the building, equipments used, etc. the model is simulated and respective results are obtained.

Further, changes could be incorporated and analyzed for both new and existing buildings.

III. METHODOLOGY

To analyse the ventilation available in a building, suitable data are brought together. Various factors affect a building thermally and are interlinked in their own ways. Lighting and thermal factors go hand in hand thus necessitating the following analysis. Ambient temperature, material of building forms, their thermal transmittance, the sun path, location of the site, climatic condition there, height of the enclosed area are few aspects to be considered in the analysis. 3D model of the structure is created in Design builder and respective materials are assigned to the components. Location details are fed in for a realistic analysis, specifying the peak months according to the season chosen. According to the climatic condition of the region, the season is picked. Depending on the orientation of the structure, sun paths are determined and in turn ambient temperatures are self-calculated. Number of occupants and the activity inside the structure are to be specified to evaluate the heat dissipated by each contributing factor. Appliances and equipment details serve the same purpose in the proposed area. Materials and the thermal properties of the wall and slabs are to be specified. Dimensions of windows (window to wall ratio), wall thickness, slab thickness etc. should be detailed. In our study, we have considered a residential structure with a ground floor and a floor above it, facing west. The site is situated in Chennai, Tamil Nadu, in the southern part of India. India is predominantly a tropical country and thus the season chosen summer.

For the above said site, summer months were calculated to be from April to end of August. The software was fed in with the number of occupants with a minimum of 4 and a maximum of 6. Normal burnt earth brick wall with one coat of 12mm cement mortar plaster on each side and concrete slabs of 150mm thickness were taken into account. Window to wall ratio (w/w) was 20% approximately on all sides of the structure. Against all these conditions, the analysis was run and the results were obtained.

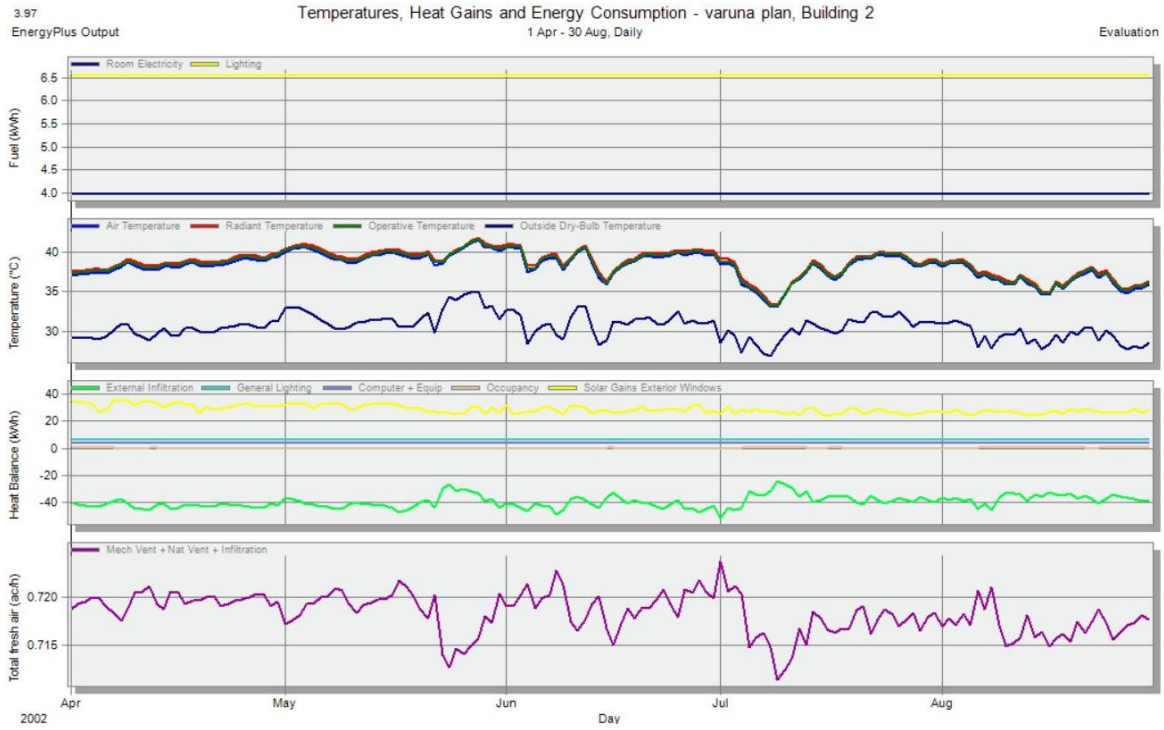

Fig No 1, Daily heat gain simulation for 20% w/w ratio

IV. RESULT

The graphs in Fig.1 show the variation of ambient temperature, heat balance and fresh air respectively. This variation was analysed on a daily interval throughout the summer months. The graph indicates its peak during the days of May and June and a gradual decrease after July. Fig.2 is the graph showing monthly variation of the factors considered in the above case. It is evident that the heat gained during all the 5 months of summer is nearly equal, i.e., despite varied temperatures every day, the net heat retained by the building forms is the same. The escalation of air, radiation and outside dry-bulb temperature is highest during May and reduces proportionally later on.

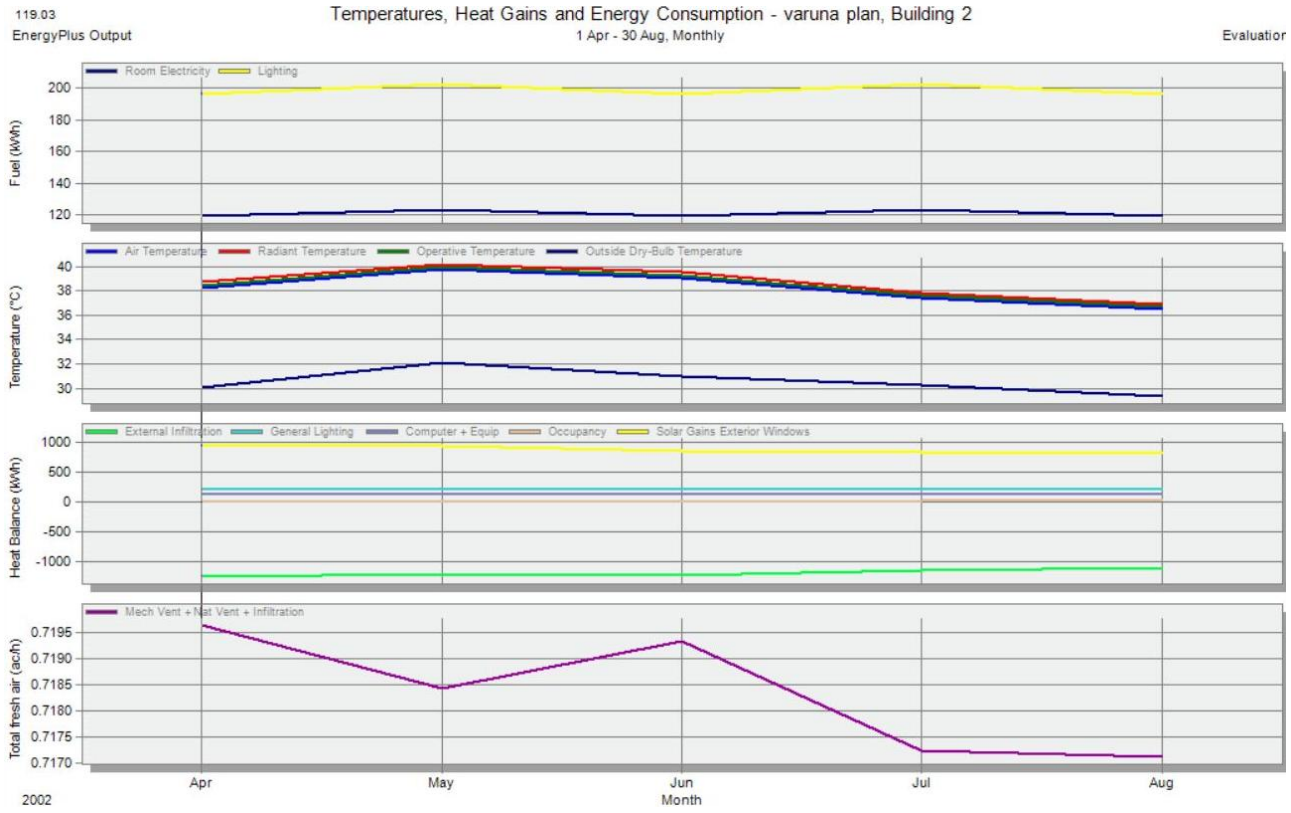

Fig no 2, Monthly heat gain simulation for 20% w/w ratio

As far as day lighting is concerned, the luminance lux gradually reduces upto approximately 1 meter away from the wall openings (Fig 3).

For the same given conditions, if the w/w ratio was increased to 40%, then there was an escalation in temperature in the closed space.

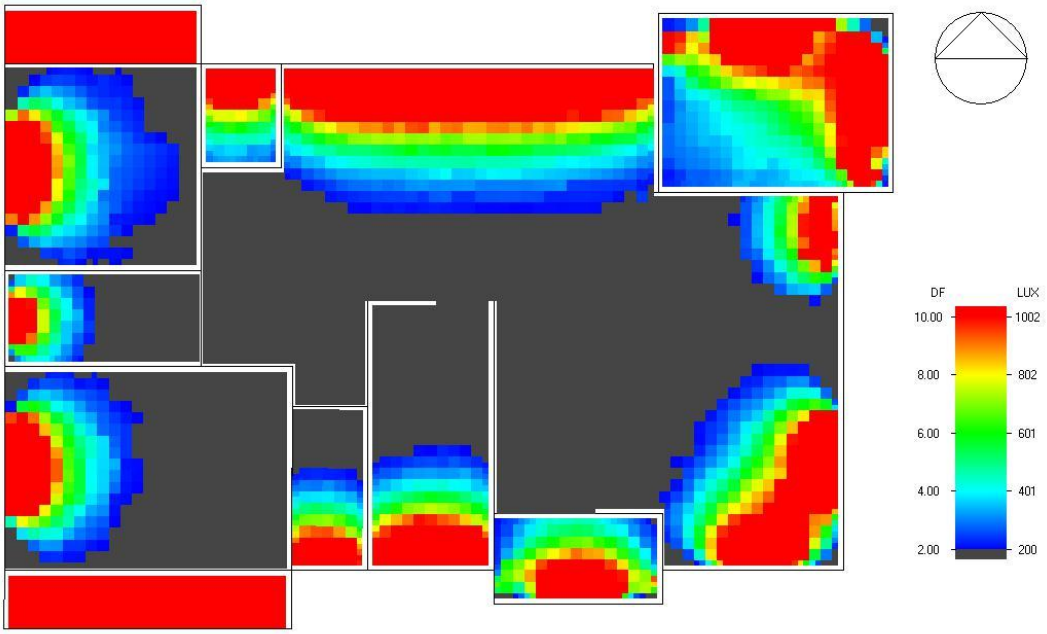

Fig 3. Daylight analysis for 20% w/w ratio

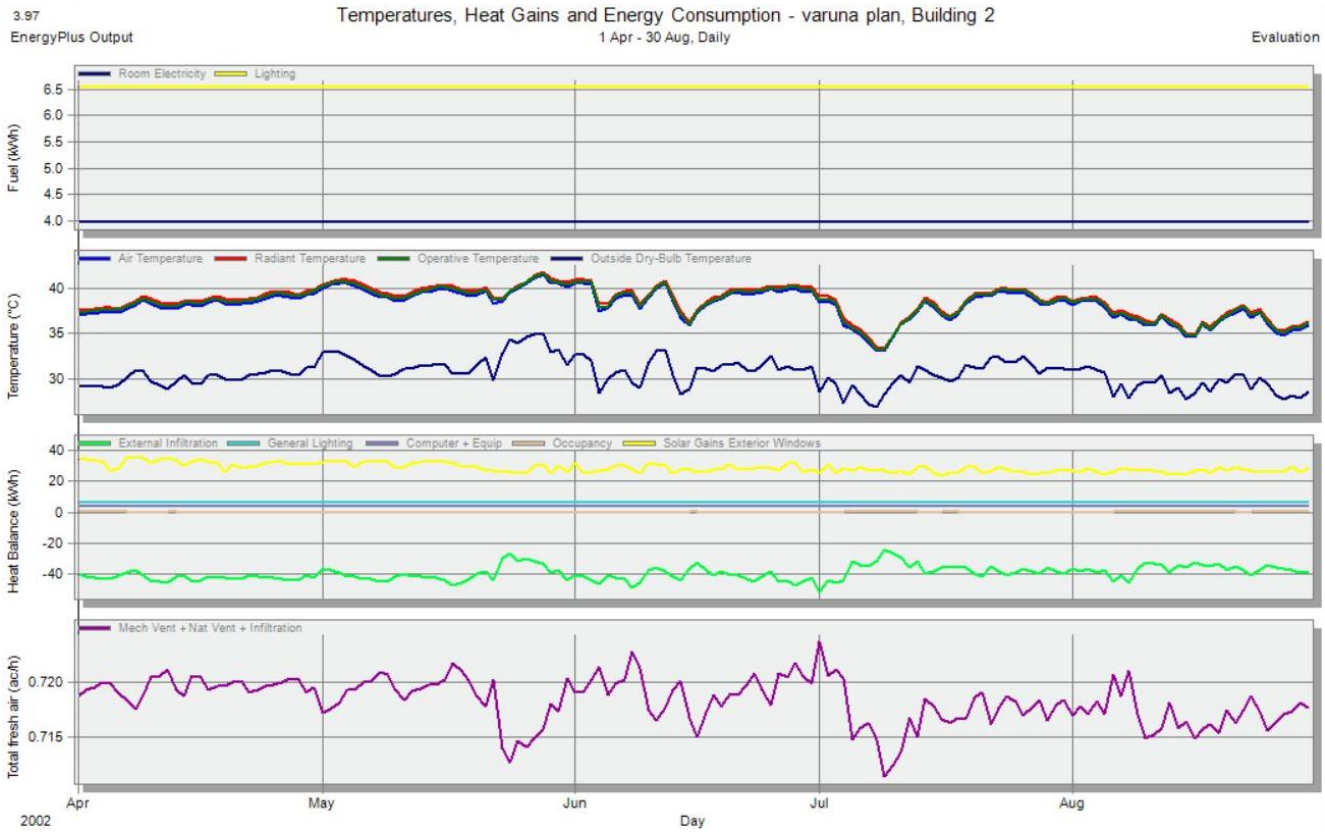

Fig.4. Daily heat gain simulation for 40% w/w ratio

Fig.4 provides the information that with 40% w/w ratio, solar gain from exterior walls can be reduced to some extent. But, this in turn reflects on the inside air temperature which shows an escalation in the some days of May, June and partly July. It has crossed 40ºC and in this case, the amount fresh air has improved.

Monthly variation for the same w/w ratio shows a similar trend as that of 20% (Fig.6). The difference lies in the peak temperature that is achieved during May and June. On the other hand, daylighting in such a condition has been enhanced (Fig.5) that the reach is beyond 1.5 meters from the exterior wall.

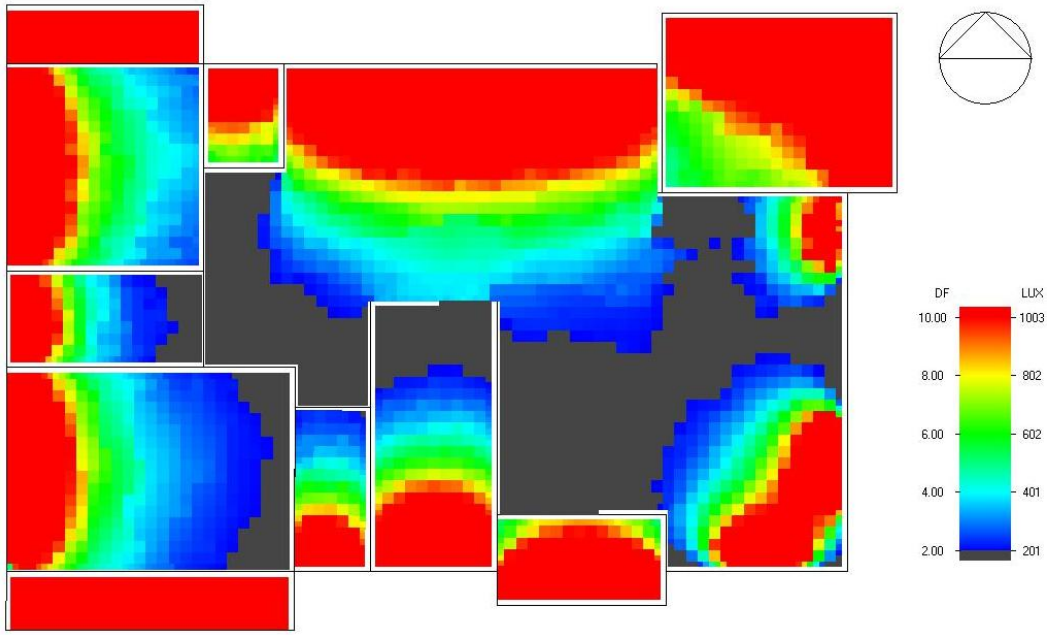

Fig.5. Daylight analysis for 40% w/w ratio

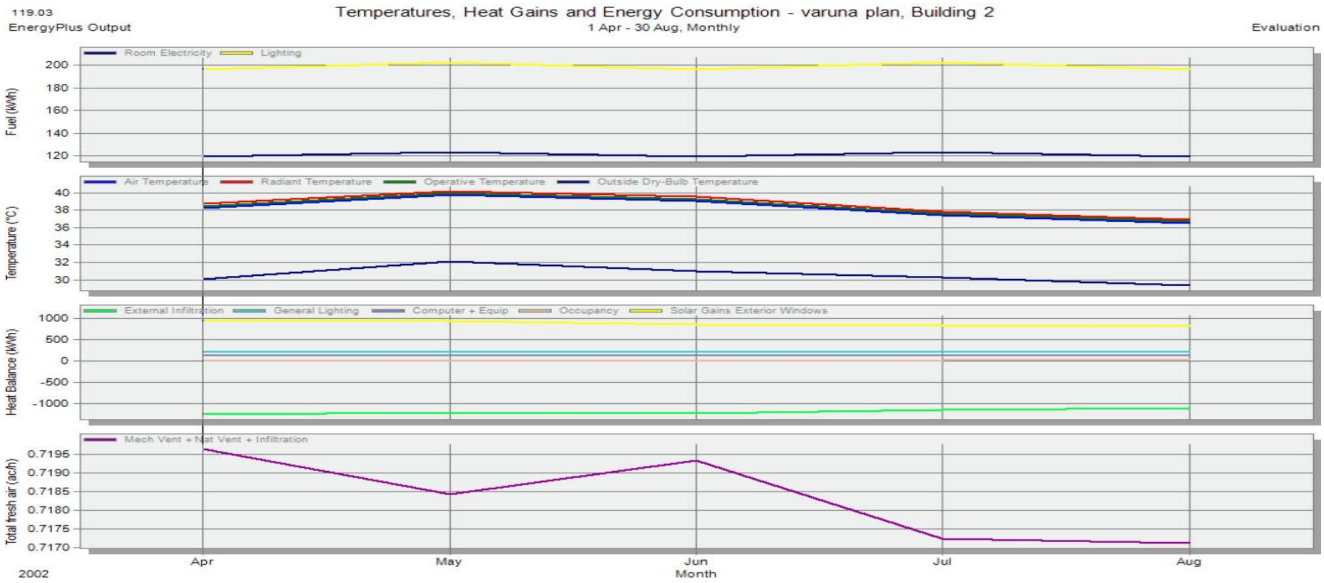

Fig.6. Monthly heat gain simulation for 40% w/w ratio

V.CONCLUSION

From the above results, it is evident that as the widow to wall ratio increases from 20% to 40%, thermal comfort diminishes and daylight quality is boosted in the enclosed area. Also, with this rise in this ratio the quantum of fresh air escalates and thus indoor air quality is enriched. The scope of this study is limited in this paper and can be extended to the point of optimizing the opening and use of different materials. To conclude on this study, improvement in the living condition inside the building can be achieved with changes in the material and the orientation of the structure. Artificial lighting is harmful to the eye sight and thus increase in w/w ratio is preferred. This in turn augments the heat gain inside the structure which has to be balanced with more cooling load. Air conditioners are in a way good to human health as they condition the natural polluted air outside thereby rising cooling load. Therefore window to wall ratio of each surface of the structure can be optimized to have better ambient conditions over daylighting and upholding energy conservation.

REFERENCE

1. Aflaki, A., Mahyuddin, N., Mahmoud, Z. A. C., & Baharum, M. R. (2015). A review on natural ventilation applications through building façade components and ventilation openings in tropical climates. *Energy and Buildings*, *101*, 153-162.
2. de Wilde, P., & Tian, W. (2009, September). Identification of key factors for uncertainty in the prediction of the thermal performance of an office building under climate change. In *Building Simulation* (Vol. 2, No. 3, pp. 157-174). Tsinghua Press.
3. Dubois, M. C., & Blomsterberg, Å. (2011). Energy saving potential and strategies for electric lighting in future north european, low energy office buildings: A literature review. *Energy and Buildings*, *43*(10), 2572–2582.
4. Eskin, N., & Türkmen, H. (2008). Analysis of annual heating and cooling energy requirements for office buildings in different climates in Turkey. *Energy and Buildings*, *40*(5), 763–773.
5. Ghisi, E., & Tinker, J. A. (2005). An ideal window area concept for energy efficient integration of daylight and artificial light in buildings. *Building and environment*, *40*(1), 51-61.
6. Gratia, E., & De Herde, A. (2003). Design of low energy office buildings.
7. Inanici, M. N., & Demirbilek, F. N. (2000). Thermal performance optimization of building aspect ratio and south window size in five cities having different climatic characteristics of Turkey. *Building and Environment*, *35*(1), 41–52.
8. Kontoleon, K. J., & Eumorfopoulou, E. A. (2008). The influence of wall orientation and exterior surface solar absorptivity on time lag and decrement factor in the Greek region.
9. Lee, J. W., Jung, H. J., Park, J. Y., Lee, J. B., & Yoon, Y. (2013). Optimization of building window system in Asian regions by analyzing solar heat gain and daylighting elements.
10. Nadia, S., Noureddine, S., Hichem, N., & Djamila, D. (2013). Experimental study of thermal performance and the contribution of plant-covered walls to the thermal behavior of building. *Energy Procedia*, *36*, 995-1001.
11. Rahman, M. M., Rasul, M. G., & Khan, M. M. K. (2010). Energy conservation measures in an institutional building in sub-tropical climate in Australia. *Applied Energy*, *87*(10), 2994-3004.
12. Breitenbach, J., Lart, S., Längle, I., & Rosenfeld, J. L. J. (2001). Optical and thermal performance of glazing with integral venetian blinds. *Energy and Buildings*, *33*(5), 433-442.
13. Susorova, I., Tabibzadeh, M., Rahman, A., Clack, H. L., & Elnimeiri, M. (2013). The effect of geometry factors on fenestration energy performance and energy savings in office buildings. *Energy and Buildings*, *57*, 6–13.

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