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CHANGE OF FACADE PATTERN AND FACADE MATERIAL FOR ENERGY EFFICIENT COMMERCIAL BUILDINGS IN THE CLIMATIC CONTEXT OF DHAKA, BANGLADESH

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ABSTRACT
The research focuses the importance of energy efficient buildings in the climatic context of Dhaka to reduce the electricity consumption through decreased use of air conditioning units in commercial buildings. The focus has been facilitated by the fact that change of building façade materials and façade patterns can have a significant contribution in reducing the cooling demand of a building. And the fact has been represented in the research through a comparison on the basis of annual electricity consumption and annual cooling load demand of four building orientations, likely- a typical concrete façade, a single glass façade and a totally new concept of building façade in Bangladesh named as 'Double Glass Façade' including its two ventilation techniques as well as relevant theories. As, the trend for glass buildings in Dhaka city is growing day-by-day, the need for electricity and cooling requirements are also in an increase. The research shows that only shifting from single façade to double façade, 37% of the cooling load of a twelve storied building may reduce whereas 47% of electricity consumption reduces while using double façade compared to a typical concrete façade.

Keywords: Energy-efficient; Double facade building; Commercial buildings; Climate of Dhaka

1. INTRODUCTION

Dhaka, known as a fast megacity of Asia carries a good numbers of buildings that hardly satisfy the requirement of sustainable energy concept. This research focuses the commercial building sector which uses only 7% of the electricity but the prime user of air conditioning (Tahmina Ahsan, 2009) unit resulting huge electricity consumption and considerable amount of CO_2 emission. The goal of the research is to make our architects, engineers and policy makers concern about the importance of energy efficient buildings as well as introduce a careful and new design process to produce buildings that use substantially less energy without compromising occupant comfort or the building's functionality, changing its material and façade pattern. Keeping the importance of energy efficient buildings in mind, changes and modifications have been suggested in BNBC 1993(Update version) for use of energy saving appliances and passive energy design features by Bureau of Research Testing and Consultancy (BRTC) from Bangladesh University of Engineering and Technology (BUET) and this research can be a guideline for our engineers and architects to take a step towards planning and designing sustainable buildings to combat energy crisis in the country.

The research leads to the development of commercial buildings in Bangladesh including,

- The study has improved the understanding of a commercial building (case study buildings) in Dhaka, including its energy use.
- The study has determined the amount of electric energy used for cooling and lighting in typical commercial buildings (concrete façade, single glass and double glass façade) of Dhaka.
- The study provides a comparison showing which material and façade pattern lead to less energy consumption (among the case study buildings) leading a way while designing energy efficient commercial buildings in future.

2. ENERGY EFFICIENCY OF MATERIALS AND FACADE

Dhaka has a tropical climate and most of the commercial buildings in the city are mainly of glass façade now-a-days. Our motive is to find out whether this trend is decreasing the consumption of electricity, and if not, what can be the possible alternatives for less energy consumption.

The energy efficiency of building materials can be measured using factors such as R-value, U-value, shading coefficient, depending on type (Harris Poirazis, 2004). Building envelops are normally rated for their insulation property. The higher the R-value, the better is the material. Materials having insulation minimize the flow of energy through the surface of buildings. This includes materials to reduce both conduction and energy radiation. As it is a measure of heat loss then the lower the U-value the better it is for building comfort (BBRI, 2002). Concrete has low R-value compared to glass and is not a good insulating material. The lower R-value of concrete has made it less popular as green material as it consumes more heat compared to glass and other insulating material. The use of glass facade brings in lot of light that helps in giving a high amount of natural day lighting instead of depending solely on artificial lighting thus reducing considerably electricity consumption. Though, single clear glass facade allows almost 90% or more of the energy to pass through and then traps the resulting heat leading an increase in interior temperature, but use of low emissivity (low-E glass) glass facade has a positive effect as it acts as a radiation mirror, reflecting heat back to the source (Harris Poirazis, 2004). This prevents solar heat gain in the summer while keeps the heat to retain within the building in winter. The trend of using low-E and lower SHGC (Solar Heat Gain Coefficient) glass in Dhaka is still in initial stage.

In climatic conditions like Bangladesh, 80% of the total heat gain is due to direct solar radiation and the rest is due to temperature difference between the exteriors and interiors (Grass is Green: Role of Glass in Green Architecture, 2011).Thus to reduce the overall Relative Heat Gain (RHG) in tropical climates, it becomes necessary to curtail the incoming solar radiation by the use of double glazing. Double glazing is good because of the presence of air gap between the two panes of glasses that blocks the transfer of heat, acting as a good insulator, either naturally or by forced ventilation. The most important criteria is the reduction of cooling demand in summer and the reduction of heating demand in winter, that has made it popular worldwide.

3. RESEARCH METHODOLGY

Basically, three hypothetical model buildings were analyzed for the study changing their facade material (ASHRAE 90.1) and facade pattern as well as using weather data of Dhaka city.The first model is a twelve storied building with 8 in thickness external wall of heavy weight concrete with full air conditioning units. The second model is the similar building, with full single glazed façade system (minimum R value) without changing any other internal configuration of the building. And the third one is double glazed facade (maximum R value) system with full ventilation effect. External heat absorption glazed layer was added 1 m from inner façade. Energy Plus, building energy simulation software has been used in this study to investigate the impacts of façade and material change in energy consumption. Mainly, electricity consumption of these three types of building was determined and a comparison was found depending on their cooling loads.

4. RESULTS AND DISCUSSION

The lighting requirements, electricity consumption and cooling load requirement of four facade orientations, got from simulation results are given below:

4.1 Annual Energy Consumption for four building types

The key finding from this result is (Table 1), The annual electricity demand column shows that the electricity consumption is highest for a façade made of concrete, while the demand has been significantly reduced in case of double facade buildings with natural ventilation as well as with natural and forced ventilation. The cooling load column shows that cooling load requirement is highest for single façade building which represents an exception from the electricity consumption plot as well as the lighting requirement of the model buildings shows that it is highest in a typical concrete façade building compared to glass buildings as glass buildings don't need to use lights in the day time as they allow the access of natural sunlight to the interior, reducing both electricity consumption and dependence on artificial lighting

Table 1 Electricity Consumption, Cooling Load and Lighting Requirement

Energy Consumption(Kilowatt-hour)			
Building Orientation	Electricity Demand(Light, cooling & others)	Cooling Load Requirement	Lighting Requirement
Building with8in concrete	1295059	883469	401468
Single Facade	880000	1007440	44000
Double Facade (natural ventilation)	688000	644844	44000
Double Facade (natural + forced ventilation)	599100	507886	44000

4.2 Result Interpretation

After comparing the plots of Figure1 & Figure2**,** we found the single façade building having highest cooling loads but less consumption of electricity in comparison with the concrete façade. It was unexpected as it is obvious that high cooling demand will lead to an increase in electricity consumption. But the reason behind this is the use of glass façade that allows daylight to reach the interiors of buildings, reducing the need for artificial light. As Bangladesh is a tropical climate, we have abundant sunlight and the less use of artificial lighting in case of a glass building mainly leads to the decreased use of electricity consumption.

In our study, approximately 31% of electricity has been used in the lighting requirement (Figure3) of the concrete façade building where the single glass façade building's lighting facilities need only 5% of the total electricity.

Again in case of double façade building, though the lighting requirement remain the same but as the total electricity consumption has been reduced, so percentage of lighting has been reduced.

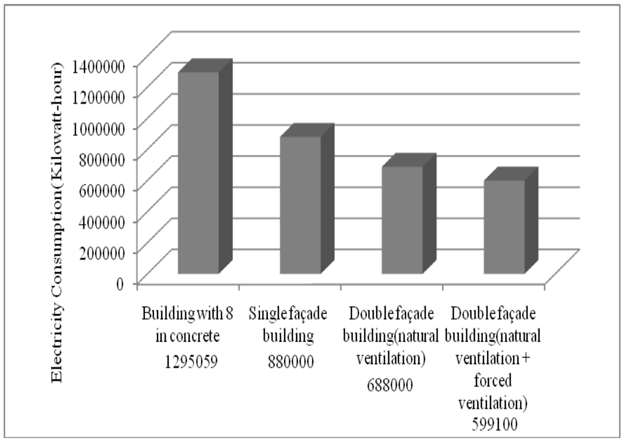

Figure 1 Annual Electricity Consumption for four building scenarios

It can be seen that the cooling load has been drastically reduced in double facade building from the Figure 2. This can be attributed to two factors. One is high reduction of solar heat gains and the other one is the ventilation of the facade to extract heat and cool down the internal surface temperature.

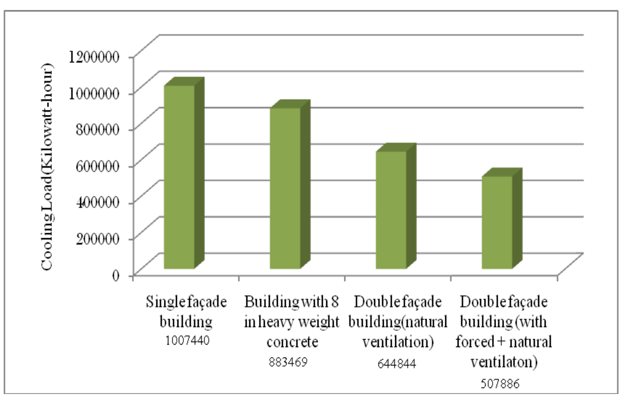

Figure 2 Annual Cooling Loads summaries for four building scenarios

However, it is interesting to see that there is not much difference in energy consumption (Figure1) between double façade with natural ventilation and double façade with forced ventilation. There is a small cooling load reduction (about 11.41 MW/hr) with the combined aid of mechanical and natural ventilation from which it seems that ventilation has not very much impact on the decrease of cooling load.

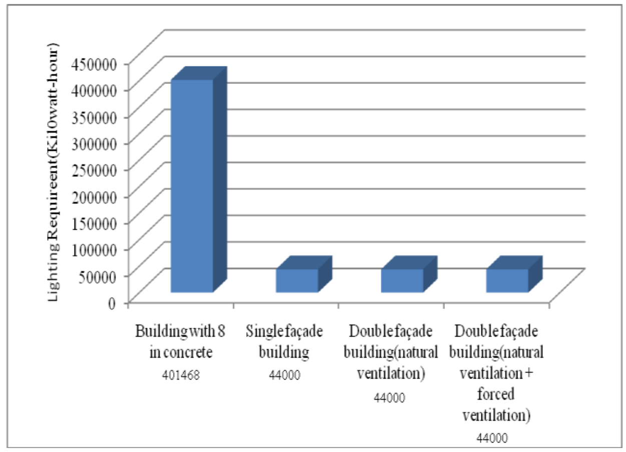

Figure 3 Annual Lighting Requirements for four building scenarios

The reason behind the negligible energy saving in forced ventilated façade compared to natural ventilation may be its installation and maintenance process.

- The cooling load results satisfy the basic principles of insulation defined by the R-value. An energy-efficient facade has much higher insulation R-values than required by most local building codes. It has already been said that in our study single pan glass has the minimum and double pan glass has the maximum R-value which defines that single façade building will have the maximum and double façade will have the minimum cooling load.
- One of the objectives of our study was to investigate whether double façade building represents a valid approach to energy efficient and environmentally responsive design or not. And the result shows that the natural ventilation of double façade building has a positive impact over mechanical means of air conditioning by reducing the energy consumption of buildings. Figure1 shows, use of double façade with natural ventilation has decreased the electricity consumption to about 47% in comparison with the concrete façade building where Figure2 shows, cooling load has been reduced to 37% compared to single façade building.

5. CONCLUSION

The study has identified the following conclusions for making commercial buildings energy efficient in Dhaka.

- Use of high performance glass that possesses high R-value, in single façade building.
- Incorporating Double Façade Building pattern in Dhaka for commercial zones to reduce the cooling load and electricity consumption that

will solve the load shedding problem of the country to a great extent.

- Concrete is a high insulating material than clear glass and it can contribute in reducing cooling load, but not the total electricity demand.

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