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Comparative study of Roof Heat in Buildings with Concrete Facia and Buildings with Exposed Eaves in Umuahia, Abia State, Nigeria

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Abstract: The rate at which concrete facia buildings are replacing the climate responsive projected eaves types, without regards to its impact on its indoor thermal environment, should concern the architect on whose shoulders the design of buildings lie. This paper compared heat generated in the two buildings chosen on purpose in Agbama Housing Estate, Umuahia. One with concrete facia (A) and another without (B) The aim was to determine the quantity of heat in each of the roof shells. Thermal comfort devices (data loggers) were installed at 1.5m height, inside the roof shells of both buildings, while sensors hung at same height at four ends of the roof. The study lasted between January 1st to March 31st, 2016. The result revealed that the daytime temperature in the concrete facia building was higher 81.33°C and 24.26°C at night. While the building with eaves was 43.1°C in the day and 24.13°C at night.The difference in the day and night temperatures is an indication of heat transfer. In building (B), lower day temperature recorded was because of ceiling vents at the eaves. The study recommended that buildings with concrete facia buildings be designed to have ducts for venting out heat. The relationship between the high degree of heat generated in the concrete facia roof and its indoor thermal environment be investigated. In conclusion, architects were advised to introduce vents through ducts in the buildings with concrete facia.

Key words: Architects · Concrete facia · Eaves · Thermal comfort · Thermal mass and roof heat

INTRODUCTION

It has become a trend and almost a mark of wealth in recent years for buildings in South-Eastern States of Nigeria and Umuahia urban environment in Abia State in particular to have concrete facia replace the century old passive architecture eaves.

Eaves are roof end projections from the wall, ranging between 300-500mm [1]. Eaves prevent rain from having direct impact on outside walls, while enhancing the beauty of the facades. In the tropics, where much heat is stored in the roof environment, it is a convention to vents provided at intervals within the eaves region, to help reduce the heat stored in the roof during the day [2].

Concrete facia is an architectural term for vertical freeze or band under a roof edge or which forms the outer cornice, visible to an observer [3]. Concrete facia when used hides the rafter projections carrying the eaves and like the eaves it extends out 300-500mm and replaces the visible eaves as featured in free gable roofs [4].

According to [5], the use of concrete facia in buildings is capital intensive and most times defeat the purpose of beauty for which most home owners in Abia State request for it in their design briefs. [6], further noted that some other architectural defects arising from the use of concrete facia in warm humid locations such as in Umuahia Abia State include the increase in structural load of buildings and concluded that concrete facia creates the use of multiple storm water drain pipework, which not only add to construction cost, but defaces the buildings, unless ductedor conduit. The storm water drain pipesmost often undergo recurrent repairswhichadd to maintenance cost of the buildings. However, buildings with concrete facia when finished properly, appear beautiful. Concrete facia also prevents and protects the roof from strong winds and storms, a feature which have encouraged its usein arid regions.

It is the view of this study that temperature in the roof environment of buildings with concrete facia is likely to be high, especially during the day, with the roof shell providing a heat storage tank.

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The paper therefore measured the heat in the roof environment of the two buildings, one with concrete facia (A) and another with eaves (B). The study compared the heat generated in both roof environments.

Literature Review

Thermal Comfort: Indoor thermal comfort is achieved when occupants pursue without hindrance activities which the building is intended to [7, 8] align well with [9] who defined thermal comfort as a state of being able to carry on any activities without being either chilly or too hot. Both definitions are rightly acceptable to this study, however the study adopted the definition by American Society of Heating, Refrigerating and Air conditioning Engineers. ASHRAE's definition because it quantified thermal comfort. ASHRAE (2004) defined thermal comfort as that express satisfaction within the thermal environment, in which at least 80% of the sedentary or slightly active persons find their environment thermally acceptable.

Thermal Mass: Thermal mass can be defined as a material that absorbs or releases heat from or to an interior space. It can delay heat transfer through the envelope of a building and help keep the interior cool during the day when the outside temperature is high. Moreover, when thermal mass is exposed to the interior, it absorbs heat from internal sources and dampens the amplitude of the interior temperature swing.

Thermal mass can be utilized in several ways. The mass may be integral to the building envelope to provide direct cooling, or it can be remote, such as the earth under or around a building, through which fresh air is passed and cooled before entering the occupied space.

Traditionally, thermal mass is used in warm humid climates predominantly in public buildings of social and religious importance such as temples, whose heavy masonry envelopes also satisfy the need for durability. Appreciable reduction of the indoor temperature can be achieved in such buildings, with indoor air maxima about 3°*C* below outdoor air maxima having been observed in some cases; [2]. For modern buildings in warm humid climates, small-scale experiments; [3]; suggest that thermal mass can make an appropriate envelope material for spaces used primarily during the day, example living rooms, since it can help the interior cool during the occupied period. However, thermal mass is inappropriate for spaces used mainly at night, example bedrooms, as the mass usually releases heat to the interior during that period and may warm the space to an uncomfortable temperature.

To optimize the daytime cooling capacity of thermal mass, the mass should be ventilated at night to allow relatively cool night air to remove heat absorbed in the mass during the day.

Such use of nocturnal ventilation in conjunction with thermal mass is more common in hot dry climates, which relatively high diurnal temperature swings and low minimum night-time temperatures. Nevertheless, computer simulations by [5] and by [6] suggest that this technique may also have potentials; in warm humid climates where night-time temperatures are generally higher. A reduction in the indoor temperature of about 3-6°*C* below the exterior air may be achievable, depending on the local climate, the amount of mass, its distribution and the ventilation details.

Methodology: The buildings used for study are located in Agbama Housing Estate, Umuahia North Local Governments area of Abia State. Both buildings have common architectural features, such as site and plot shapes and sizes, building type, percentage of built up area and orientation. They were selected on purpose due to their common design features which supported the study. One of the buildings (A) hasconcrete facia and the other (B) hasits eaves projecting 0.5 meters from the wall plate.

Data loggers were hung inside the roof shellof each of the buildings. One central data logger was hung at 1.5 metres from the King Post and sensors were at the four ends of the buildings. The sensors send data to the central logger which was calibrated to read-off and store data at every eight hours. By 6.30-9.30 am when humidity is highest, 2.30-3.30 pm at the peak of the sunshine and 6.30-9.30 pm when the sun has set. The study lasted for 3 months between 1st January to March 31st 2016. This period was to ensure unlimited hours of sunshine.

RESULTS

Building with Concrete Facia (A) and Building Withoutconcrete Facia (B):

Table 1: Temperature values in °C

Month	Daytime	Nighttime
January	78	24.5
February	86	23.8
March	80	24.8
Total	244	73.1
Average	81.33	24.33

Table 2: Temperature values in °C

Month	Daytime	Nighttime
January	41.2 25.8	
February	41.3	22.8
March	40.8	24.8
Total	123.3	73.4
Average	41.3	24.43

The result revealed that the daytime temperature for both buildings varied. The building (A) concrete facia had an average daytime roof temperature of 81.33°C and average nighttime temperature of 24.33°C, while Building (B) one witheavesrecorded an average day time temperature of 41.1°C and an average night time temperature of 24.33°C.

Analysis: The study revealed that the temperature or heat generated in the building (A) with concrete facia in the daytime was high, 81.33°C, 18.67°C less the temperature of boiling water. This temperature could be harvested for domestic hot water usage in residential homes and thus save a lot in energy cost, while contributing to the attainment of sustainable green environment. The night time temperature however was low 24.26°C indicating that there has been heat loss to other environments.

The building with eaves (B) has vents in the ceiling at intervals and recorded an average lower daytime temperature of 43.1°C and 24.43°C in the nighttime. The lower day temperature was due to the vents, recommended in Alozie (2014) as a passive feature for achieving indoor thermal comfort in buildings in this region.

Recommendation: The study recommended that further studies be conducted on the heat transfer from the roof during the night and the relationship of the heat transfer with indoor thermal comfort of the building. The study also suggest solutions to any findings from the recommendation be sorted and finally, challenged Engineers to convert the heat generated in the roof of buildings with concrete facia to economic uses, like heating of domestic water and the heating of the indoor environment in cold periods.

CONCLUSION

In conclusion, the paper underscored The need for adoption of passive design measures in buildings, as this will not only reduce cost of heating and coolingin homes where applicable but will facilitate the development of energy efficient buildings and sustainable green environment.

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