EFFECT OF PASSIVE TECHNIQUES IN OLD BUILDINGS IN SRI LANKA

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Abstract

Sri Lankan old buildings are having better indoor comfort relative to the new and remolded buildings in the world .The main objective is to identify the effective passive techniques and to identify the effective usage. This paper describes the specific passive techniques in Old buildings in Sri Lanka and provides a life cycle cost analysis at the end of research project. Sri Lankan old buildings have thicker wall and special walling and roofing materials. Several properties from those properties have been analyzed deeply with considering the environmental background. Inside thermal comfortable of old buildings must be checked to apply those techniques to new buildings. This paper shows the inside conditions of analyzed buildings as numerical values after taking temperature and humidity measurements of the building in day time. This research paper presents the DEROB temperature results with adding old and new building properties to typical building and then it compares the results obtained from computer modeling. Life cycle cost analysis is carried out to compare the results in economical manner for each selected passive techniques. It is used to identify the most effective passive techniques. Final analyzing has been done with numerical values of temperature and cost for construction and maintaining. Some restrains are occurred when adopting old passive techniques to new buildings. This research has been discussed the possibilities and limitations when those properties are adding to new buildings, at the end of the research project.

1. Introduction: the Overall Context

Thermal comfort is varying one country to another country because some countries have hot and humid environment and some countries have cold environment. Some countries that are closed to equator like Sri Lanka, are trying to keep cold environment inside the building but some countries are trying to keep inside in worm condition when the outside background is very cold.

This research is pointed to develop passive building with sustainability. This has been given more attention for sustainability, so sustainable previous designs were more important in the literature review. Some researches had tried to study passive control method in several countries. These types of researches have been reported Korea, Zambia and China in 1996[1-3],followed by countries such as Japan, France etc., in the last few years [4-9].

A qualitative analysis discussing in detail about the passive concepts adopted and the materials used in traditional buildings was reported based on Kerala, India and the real need for such investigations for a climate responsive design for comfortable living in warm- humid climate was also reported [10-11].

This paper is based on full analysis of several passive techniques and finally cost comparisons of those passive techniques are presented to select the most cost effective passive technique.

2. Objectives

- To study on various passive techniques used in old buildings.
- To measure the comfortable conditions inside the building.
- To find out the possibilities and limitations of adopting these techniques in modern buildings.

3. Method

First surveying part was carried out to cover the large area related to the research specially Climate in Sri Lanka, Human thermal comfortable and passive techniques. By literature surveying, it was recognized the present development of the passive buildings and the importance of the passive houses to the new generation. Using the literature surveying, suitable areas were selected for the research and measurements were taken based on selected buildings.it was needed to verify the thermal comfortable of those buildings. Then the passive techniques used for those buildings were identified and those were taken into account for future analysis.

DEROB software was used to analyze the old buildings that measurements were taken and it was showed whether it was thermally comfortable. Then the actual temperature values were compared with result obtained from the DEROB.A new building was modeled using DEROB and that building was also modeled with adding passive techniques one by one. Life cycle Cost analysis was carried out based on building properties.

4. Experimental investigation

4.1. Building Selection

The buildings selected for the study is located at Matara and Galle districts situated in the southern part of Sri Lanka having tropical climate. When the buildings were chosen, priority was given for the buildings which were built in Dutch season. Because those are old more than 150 years and those buildings can be easily available in selected area for the research.

Five buildings No: 07 ,Chando Street ,Fort , Galle / Catholic Church, Fort, Galle/ No :15,Parawa street,Fort,Galle/ No: 75 ,Pedler Street , Galle/ Catholic Church, Fort, Matara were selected. Thermal comfortable measurements were measured in selected five buildings and out of those five two buildings were selected for the full analysis with considering the maximum thermal comfort, the maximum number of passive features availability and current conditions of the buildings. Following figure 1 and 2 are plan views of the selected buildings.

a) No: 07 ,Chando Street ,Fort- , Galle- Building 1

A two story residential building with a courtyard.

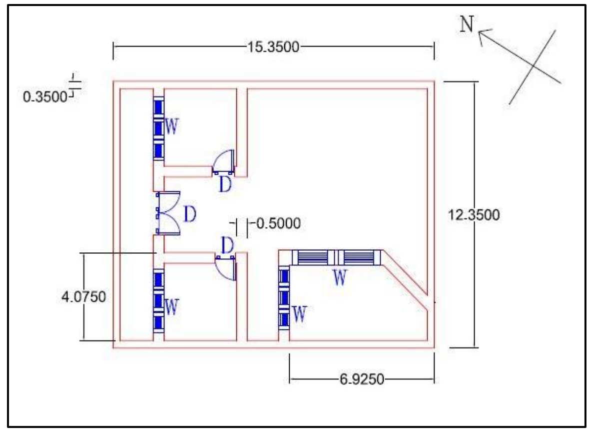


Figure 1Plan view of building 1

b) Catholic Church, Fort, Galle- Building 2

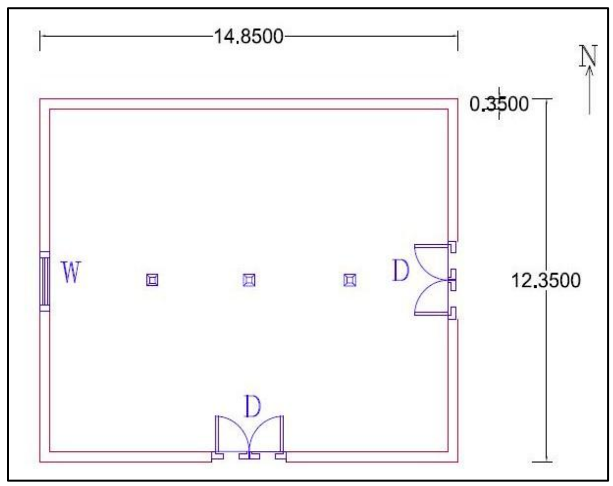


Figure 2Plan view of building2

4.2. Field measurements

Temperature and Humidity were measured from 07.00 to 17.00. Inside and outside temperature variations are in figures 3 and 4.

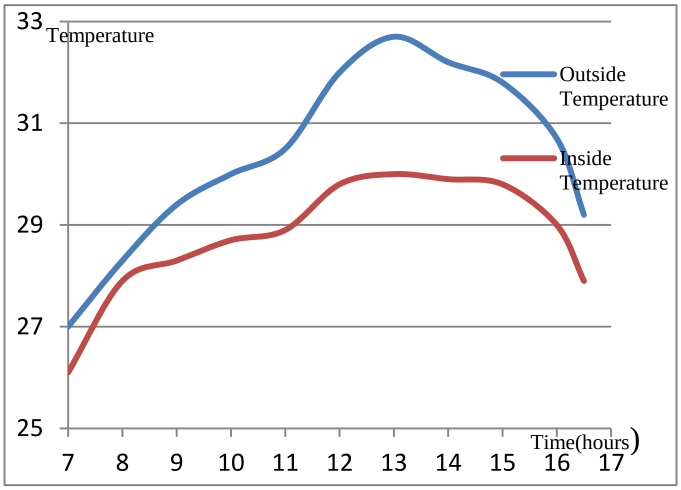


Figure 3 Actual Inside and outside temperatures of building 1

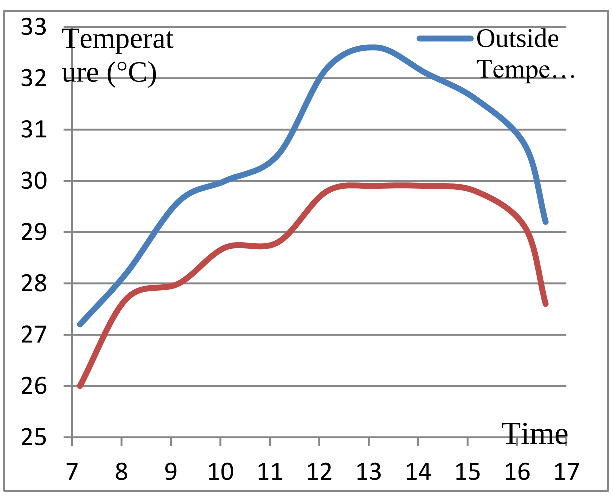


Figure 4 Actual Inside and outside temperatures of building 2

5. Computer Modeling

5.1. Investigation of old building Material properties

In this research it was difficult to find out what are the suitable material properties for the old building. This problem was solved by calibrating the actual temperature readings with the model created by DEROB software. Results are given under section4.

5.2. Investigation of New building with old building Material Properties

It is compared the thermal comfortable of a typical Sri Lankan modern house building before and after adding the passive techniques using DEROB modeling. First thermal comfortable has been checked using the software and after thermal comfortable comparison has been done with changing some properties of the building.

Selected building is a two story residential building with 3-4 bedrooms, office room, and 2 bath rooms in both up and down stairs.

Features of New building:

- Roof is covered with clay tiles and there is a roof mounted ceiling made by asbestos ceiling sheets painted with light green.
- Surrounding ground of the building is paved with concrete paving blocks

- For the first floor it is used tiles of light Brown and for the soffit of the slab it is used light grey
- Both external and internal walls are of 230mm thickness and made out of normal bricks
- All the doors are made out of 30mm thick hard wood and windows are made out of plain glass of 3-6mm thick.
- Ground floor is finished with concrete

The layouts of the building is given in figure 5 and 6.

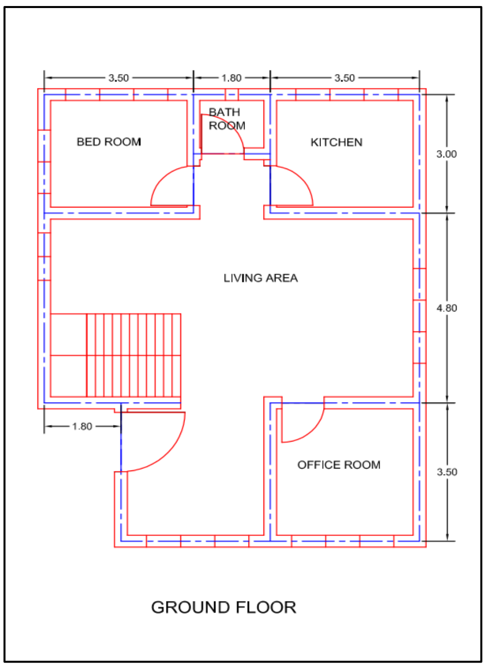


Figure 5 Ground Floor plan

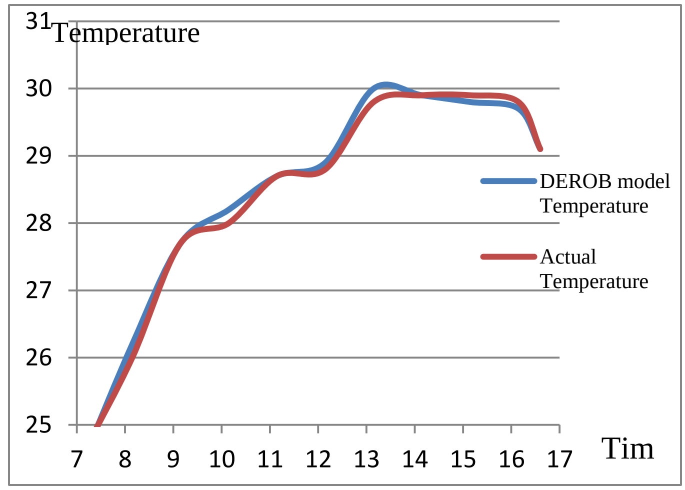


Figure 6 Calibration of Building 2

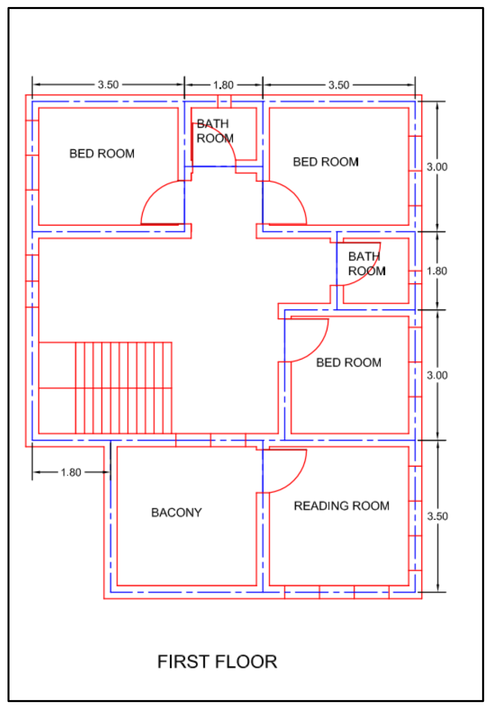


Figure 7 Upper floor plan

6. Results

6.1. Investigation of old building Material properties

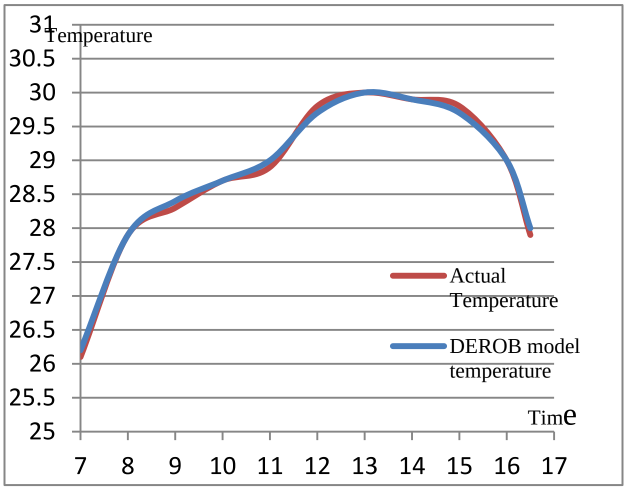


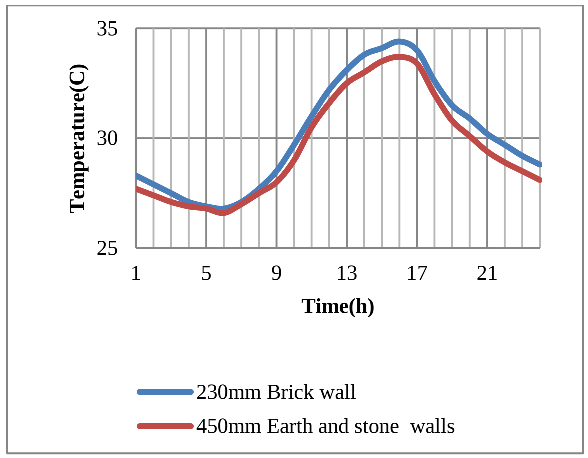
Figure 8 Calibration of Building 1

Table 1 Material Properties Obtained by Calibration of Models

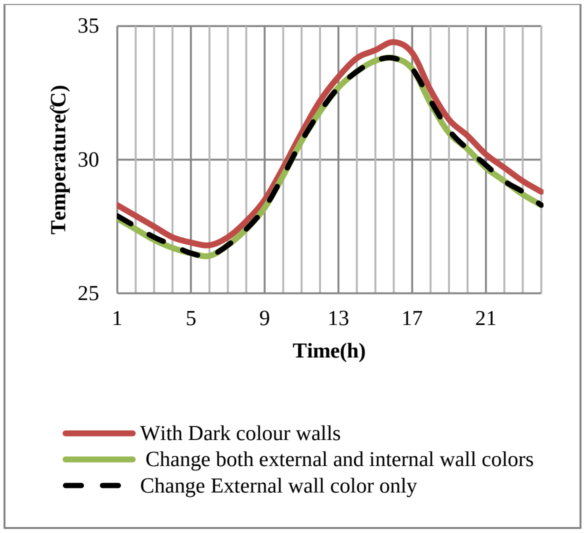
Name	Conductivity (W/m.K)	Specific heat (Wh/kg.K)	Density (kg/m^3)
Gypsum	0.22	0.23	900
Earth	1.40	0.22	1300
Earth Blocks	1.40	0.22	1300
Roof Tile	0.95	0.27	2000
Hard Wood	0.16	0.70	800
Glass	0.05	0.21	150
Floor Tile	0.95	0.30	2000
Air Space at 21°C	0.024	0.280	1.201
Granite	3.20	0.23	2700
Light wood	0.15	0.7	600

6.2. Investigation of New building with old building Material Properties

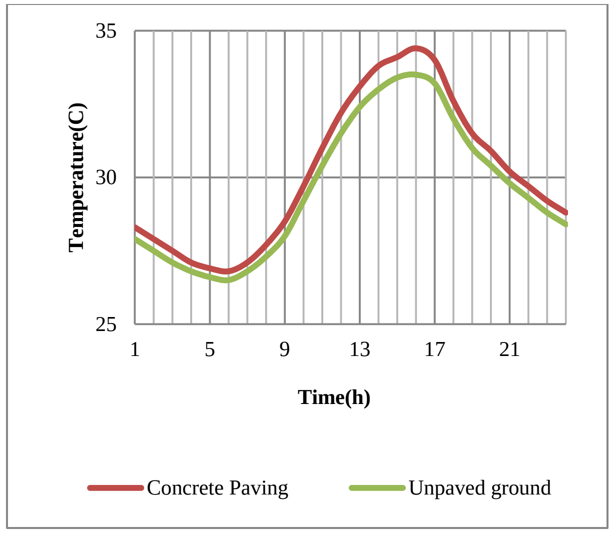
Wall material and thicknesses of the wall, Color of the walls, Ground Properties, Window material, Courtyard, Floor to floor height, Slab material, Roofing material are the properties have been changed to compare the thermal result with outdoor comfortable of the building.



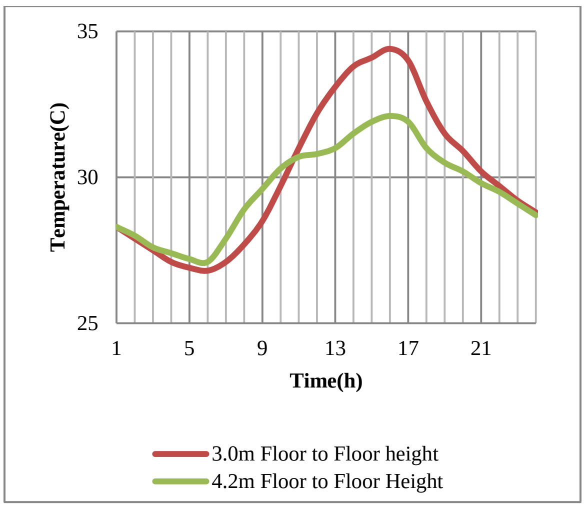
Graph 1 Effect of wall material



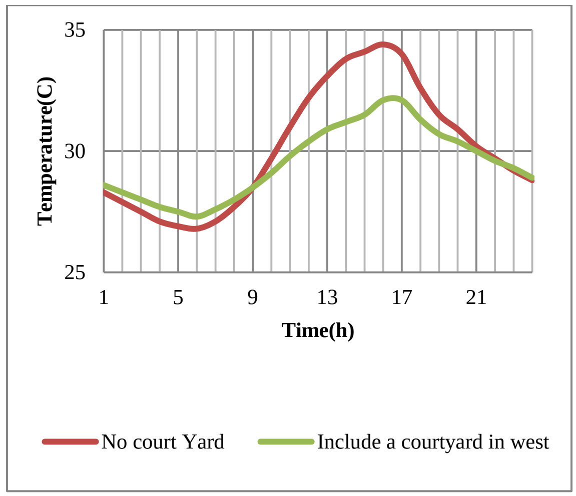
Graph 2 Effect of Wall color



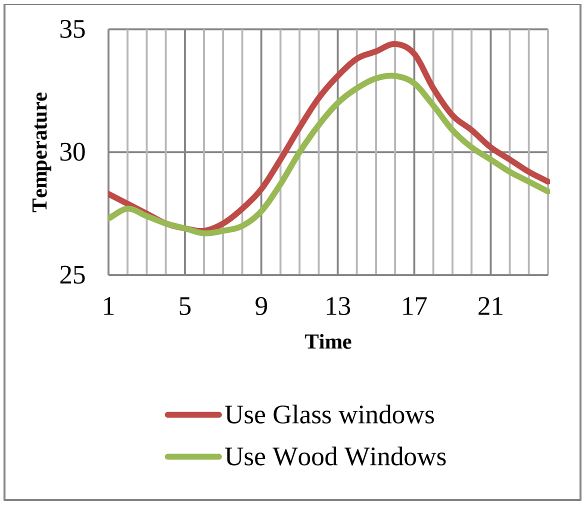
Graph 4 Effect of Ground



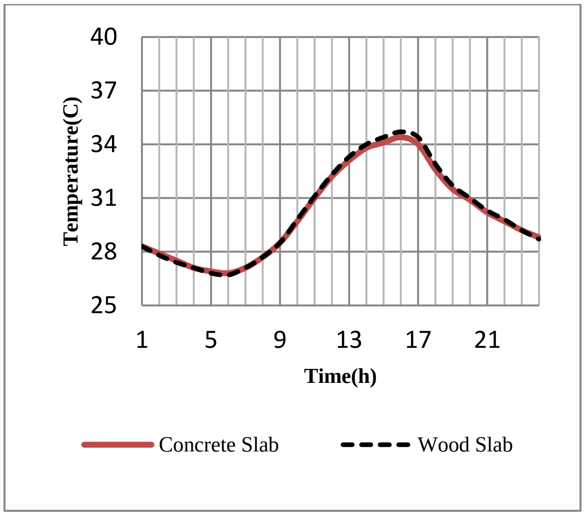
Graph 3 Effect of floor to floor height



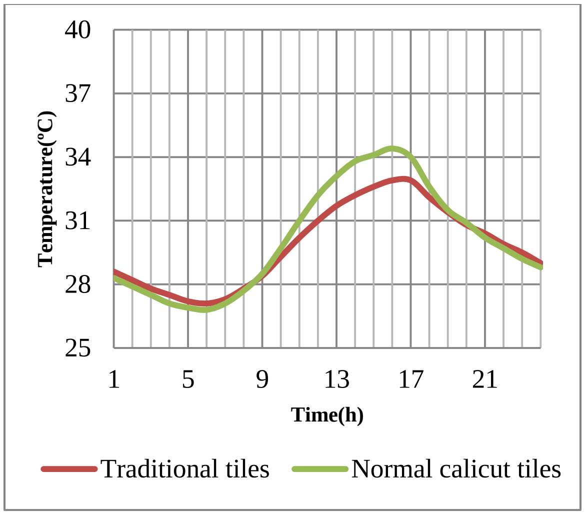
Graph 5 Effect of courtyard



Graph 6 Effect of window Material



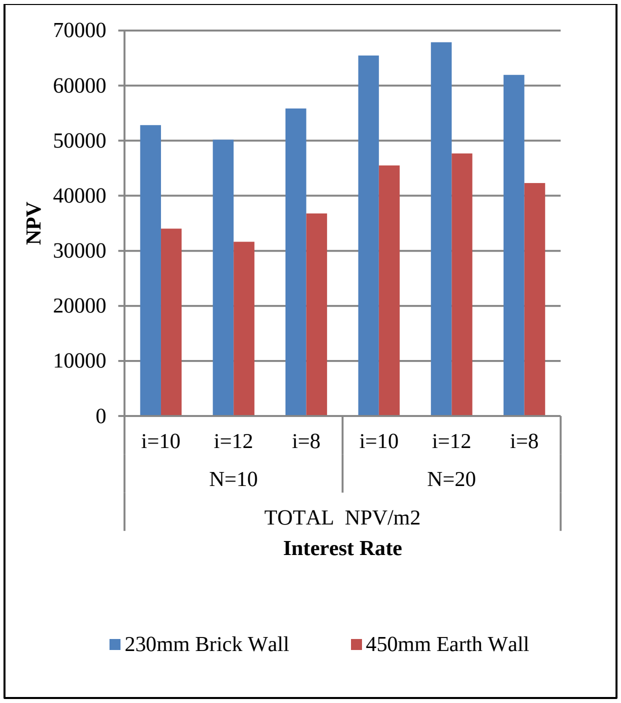
Graph 7 Effect of Slab



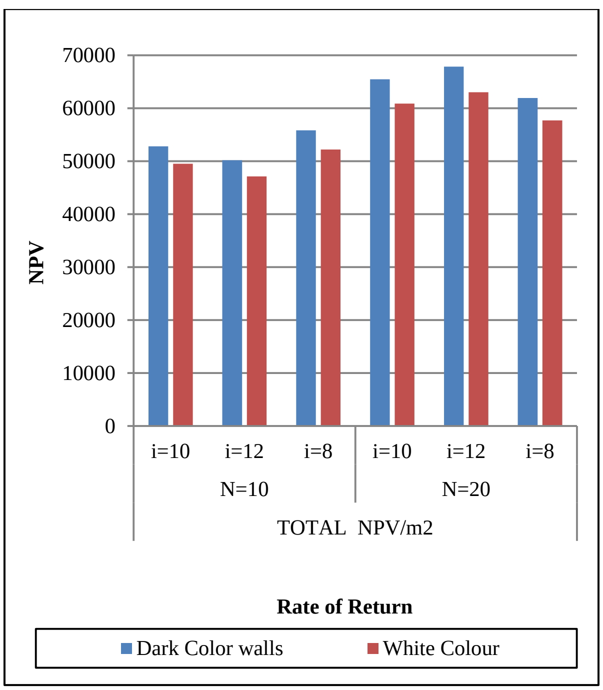
Graph 8 Effect of Roof

6.3.Cost Analysis

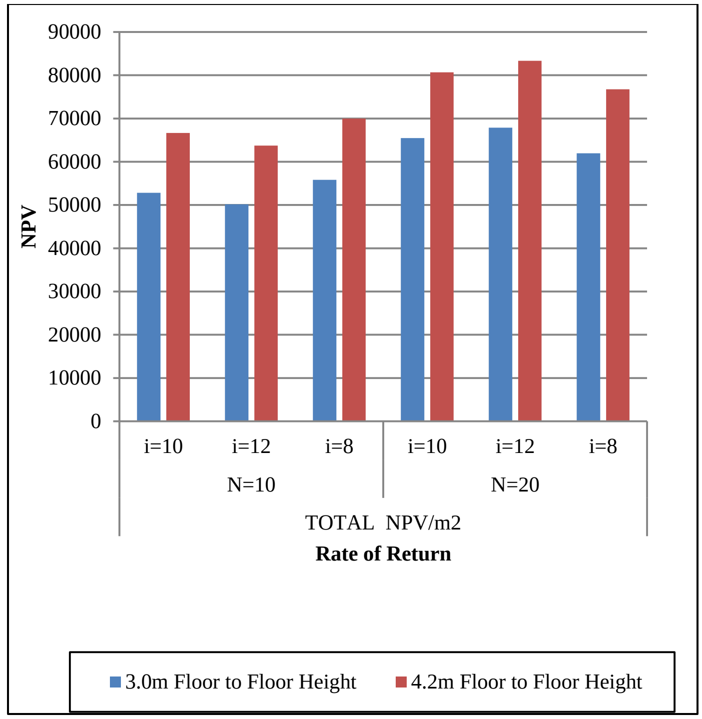
First, costs of the house building without the selected passive feature and with the passive features are calculated using BSR 2011. Here only the cost for each feature is calculated. Then cost for air conditioning is calculated with and without passive features. Finally Net present values (NPV)for Total NPV values and Total NPV value for unit floor area are calculated for interest rates 8%, 10% and 12% for design lives of 10years and 20years and compare the NPV values. Selected features for cost analysis are Wall material and thicknesses of the wall, Color of the walls, Window material, Floor to floor height.



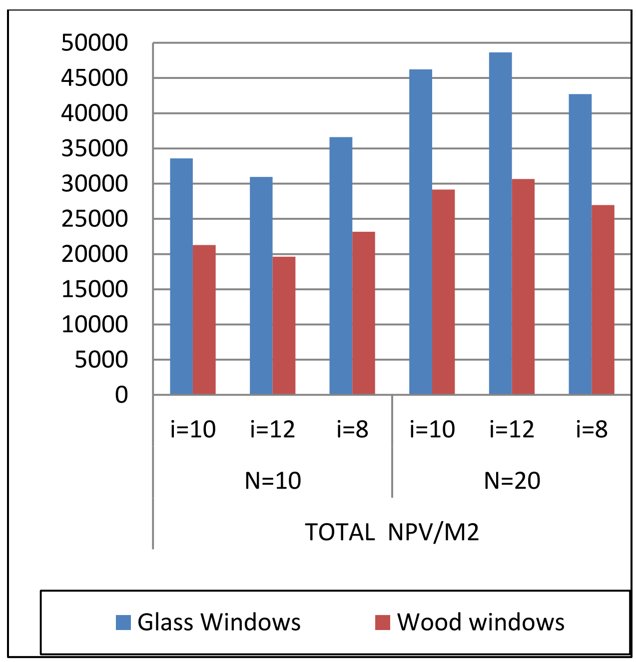
Graph 9 NPV variation per 1m² of Floor area for wall thickness and material



Graph 10 NPV variation per 1m² of wall for wall color



Graph 11 NPV variation per 1m² of Floor Area for Floor to floor height



Graph 12 NPV variation per 1m2 of floor area for window material

7. Conclusions

The world trend is sustainable development. So the low energy consuming buildings plays a leading role of sustainable development. Most of Sri Lankan old building had built as environmental friendly manner and also the thermal comfortable of the old buildings have higher than the new buildings. This research has taken a successful attempt to catch up the possible passive techniques which are used in old buildings in low country and figure out whether they are economical to add to a new building.

In this research temperature variations of a new house building after adding passive features and without adding passive features are obtained from DEROB software. Then costs of construction and A/C costs are calculated for NPV calculations

After replacing 230mm thick brick wall with 450mm earth wall, it can be identified that temperature was dropped by about 1.1^0C.Construction cost is also less than construction cost of earth wall per $1m^2$ is less. A/C cost is reduced because temperature is reducing. Total NPV is lesser for 450mm earth walls. 450mm earth walls can be used in modern houses as they are thermally comfortable and economical.

After replacing dark color brick walls by white color brick walls, it can be identified that temperature is dropped by about 1.3^0C.Construction cost for both are less and same. A/C cost is reduced because temperature is reducing. Total NPV values are lesser for white color walls than dark color walls. White color walls can be used in modern houses as they are thermally comfortable and economical.

After replacing 3.0m height wall by 4.2m wall it can be identified that temperature is dropped by about 1.7^0C.Construction cost is higher when walling area is increasing. Although temperature is reducing, A/C cost is increasing due to increase in volume to be air conditioned. Total NPV values are higher than 3.0m height walls. If air conditioning is not going to be done, increasing floor to floor height can be adopted so that indoor temperature will be reduced although construction cost is higher.

After replacing glass windows by wood windows it can be identified that temperature was dropped by about 3.8^0C.Construction costs are also lesser for wood windows. A/C cost is reduced because temperature is reducing. Total NPV values are lesser for wood windows than glass windows. But visual comfort can be affected by wood windows. Relevant actions should be taken when adopting these wood windows for modern houses. If enough courtyards can be provided, visual comfort can be achieved with wood windows. Also wood windows can be used only in east and west directions so that indoor thermal and visual comfort can be achieved.

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