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PRIORITIZING EFFECTIVE MEANS OF RETROFITTING FLAT SLABS TO MEET PUBLIC DEMANDS IN ORDER TO PROMOTE SUSTAINABLE BUILT ENVIRONMENT

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Abstract: Global warming is one of the major challenges that the current world is facing. Sri Lanka, being a small island, is inevitably undergone by the adverse impacts of it. Hence, it is significant to implement strategies to adapt that, while aiding to mitigation of global warming. In this context, flat concrete roof slabs is a viable option pacifying those two ends. However, it is not so popular among the general public yet and this study was carried out to identify the reasons behind that. It has been found out that Calicut tiles is the most preferred material for roof covering material, particularly due to the thermal comfort that it possesses, over the high initial cost and serviceability issues. Furthermore, flat concrete roofed buildings use, higher amount of energy for active cooling, which is adverse as far as sustainability is concerned. Hence, it is important to retrofit flat slabs so that it is thermally comfortable. In this process, priority should be given to address the issue of thermal discomfort.

Keywords: Global warming, Thermal comfort, Disaster resistance, Energy, Retrofitting flat slabs

1. Introduction

Global warming and associated climate change have been identified as the biggest issues that the world will be facing in the immediate future [1]–[3]. Quantifying that, It has been found out that temperature has risen between 0.40C - 0.80C during the 20th century, and even from that the temperature rise from 1980s is alarming [2]. It has been found out that ten warmest years in last century has occurred in last fifteen years of the century [4], and further, it is estimated that the temperature could rise about 20C - 40C by the end of the 21st century [1].

Global warming itself and the associated climate change has caused many issues to the world, sea level rise being the major of them. The prediction is so that the sea level could rise between 18cm – 59cm during this century [1]. Matsui et al have estimated that for a 50cm sea level rise, Japan itself will lose more than 7500km2 of land, which would influence a population of more than 12.3 million [5]. Other than this, there are some other adverse effects of global warming. Such as,

- The uncertainty climate projections has improved drastically due to global warming, causing many imbalances in many fields, particularly in agriculture [1]
- Temperature rise has increased evaporation of sea water and given more energy to tropical cyclones, increasing the degree of destruction [6]
- Carbonation and chloride ingress are highly influenced by environmental and climatic conditions of the surrounding environment – i.e., atmospheric CO2 concentration, temperature, and humidity [7]. This can reduce the time to failure by up to 31%, or shorten service life by up to 15 years for moderate levels of aggressiveness [8]

Sri Lanka, being one of the smallest islands in the world, is inevitably affected by these adverse scenarios. Hence, it is a wise approach to adapt these as well as contributing to the mitigation as much as possible.

One of the best techniques of adapting to global warming is to make structures robust. For buildings, this can be achieved by flat concrete slabs.

Due to the self-weight of that, the buildings become more cyclonic resistant comparingly [9], [10]. This facilitates a better means of adapting, and further, due to the reduction in embodied and operational energy usage for reconstruction and rehabilitation after a massive natural disaster, this indirectly contributes to the mitigation of global warming as well.

On the other hand, flat concrete slabs can contribute to the mitigation of global warming to a great deal. One of the major reasons to the exponential increase in global warming is the lack of greenery, particularly in urban areas [11]. Multi-storey construction has been identified as a better solution as it provides a higher residential and workable are for a small footprint, of which flat slabs play a major role. In addition, it enables the vegetation to be grown on top as well [12]. Besides, a flat concrete slab increases the lifespan of the structure drastically [13].

However, there are associated drawbacks in this option as well, higher energy consumption for thermal comfort being one of the major among them. Higher energy consumption and subsequent greenhouse gas emission is the major reason for global warming [14], [15]. Generally, buildings account for 40% of total energy usage and 50% of that is used for causing thermal comfort [16]–[21]. Due to the long wave solar radiation of heated slabs, the spaces underneath become more thermally uncomfortable, demanding more energy for cooling in the forms of fans and air-conditioners [22]. This is highly undesirable in the context of sustainability [23], [24]. Other issues those should be under the telescope are, high requirement of capital cost and serviceability issues, particularly cracking.

Those issues have been identified by means of an international literature survey, and the applicability of those into the local context is questionable. Furthermore, it is necessary to prioritize the issues to be addressed if it is attempted to promote flat concrete slabs.

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In this study, a questionnaire survey was carried out to identify the public perspective towards the available roofing materials and their expectation out of selecting a roofing material.

2. Objectives of the study

The main objectives of this study are,

- To identify the preferred roofing material and the reasons for that choice
- To find out the reasons that the roof slabs are not popular among the general public
- To prioritize the issues to be addressed in order to make roof slabs more public
- To identify the issues associated with roof slabs
- To find out the effect of roofing material used to the energy usage for thermal comfort in buildings

3. The sample selected

A sample of 65 has been selected for this questionnaire survey, representing various fields of work and different parts of the island. The distribution of sample is as shown in Figure 1 and majority represents the civil engineers and then research personals and quantity surveyors.

Figure 2 shows the distribution of the existing roofing material of the selected sample. It was found that more than half of the sample uses the asbestos roofing and very less number of people lives in the houses with concrete roof slabs.

It has been observed that even the majority of the people those who have concrete roof slabs currently have it with the intension of future extension. There are hardly any people who intend to use a concrete slab as a roof.

It is very significant to figure out the major reasons for the concrete roof slabs to be not so popular among the public.

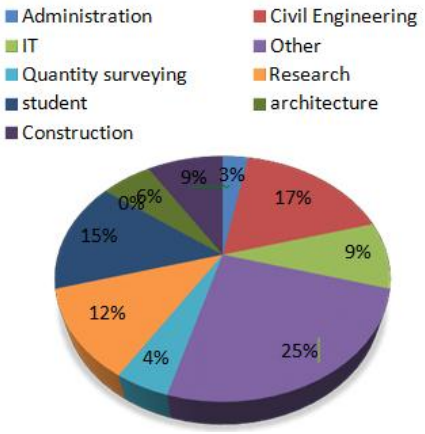

Figure 1: The distribution of field of work

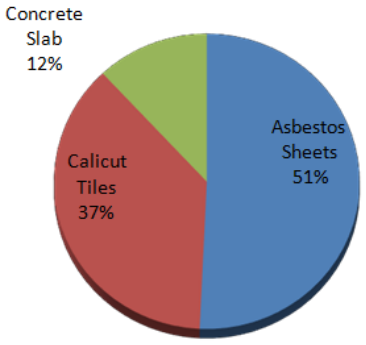

Figure 2: the distribution of the existing roofing material

4. Results

The first question was that whether they are satisfied with their existing roofing materials. The analysis on that of Calicut tile users are shown in Error! Reference source not found. It clearly shows that a vast majority of them are satisfied with what they have. The same analysis for the users of asbestos sheets and concrete slabs are shown in Figure 4 and Figure 5 respectively. It can be clearly seen that those who have concrete slabs as roofs are the people with least satisfaction of what they have.

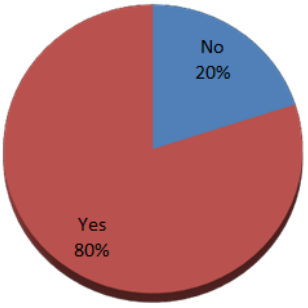

Figure 3: The satisfaction on Calicut tile users on their existing roofing material

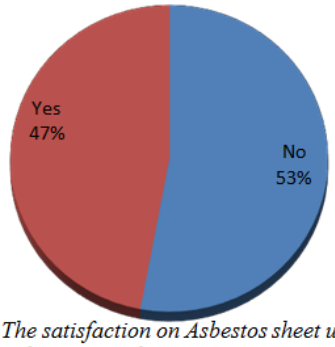

Figure 4: The satisfaction on Asbestos sheet users on their existing roofing material

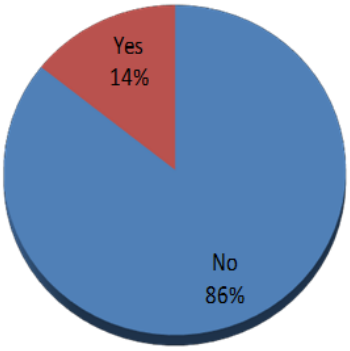

Figure 5: The satisfaction on concrete slab users on their existing roofing material

The analysis on the results obtained for the question 'What is the roofing material that you prefer?' is depicted in Figure 6. Around 75% of the selected sample prefer to have Calicut tiles as their roofing material. Their reasoning behind it is shown in Figure 7 and it was found that the public is more worried about the comfort and aesthetics.

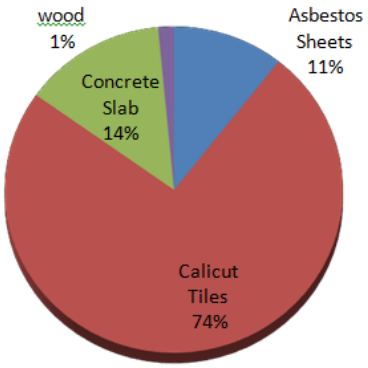

Figure 6: Preferred roofing material of the selected sample

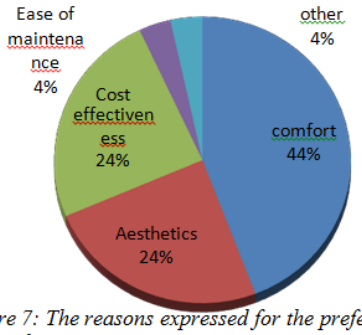

Figure 7: The reasons expressed for the preferred roofing material

Figure 8 and Figure 9 explain the reasons for majority preference on asbestos sheets and Calicut tiles, not concrete slabs. According to the analysis, due to thermal discomfort that feels underneath, had become the key reasons for their adverse thinking on concrete roof slabs. This further proved that, public has more concerned on thermal discomfort than cost.

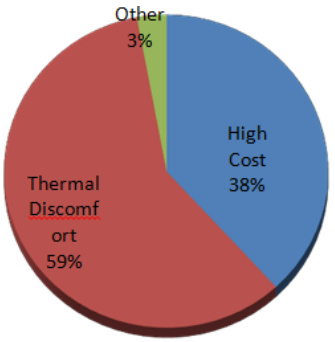

Figure 8: Users of Asbestos Sheets: Reason for not going for concrete slabs

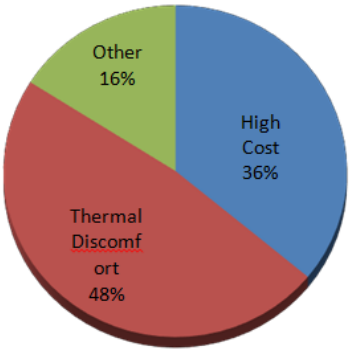

Figure 9: Users of calicut tiles: Reason for not going for concrete slabs

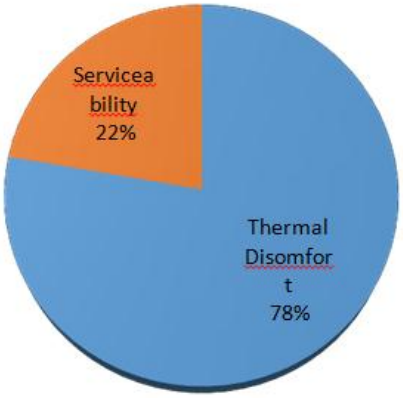

Figure 10: Issues associated with concrete slabs

Figure 10 shows that the issues associated with the concrete slabs at the operational stage. Two major issues have been identified. Thermal discomfort and serviceability issues, particularly cracking. In the operational stage too, thermal discomfort does have a higher impact on the users' minds.

Figure 11, Figure 12 and Figure 13 shows the analysis on user preference on the actions taken to address the thermal comfort. There are two main means that this can be done; active cooling and passive cooling. Active cooling is basically by fans or air-conditioners, which is adverse as far as the sustainability is concerned. Almost 60% of those who have Calicut tiles as their roofing material say that it is sufficient to just open the windows to make the building comfortable. However, 64% of those who have concrete slabs do use active cooling as the increase in air velocity by opening the windows is not sufficient to make the building comfortable.

This is further emphasized by the stats in Figure 14, which shows the number of hours that they use fans daily (in machine hours). It is clearly shown that around one-third of the people who have Calicut tiles as their roofing materials don't need to use fans, whereas those who have concrete slabs use more than nine hours daily.

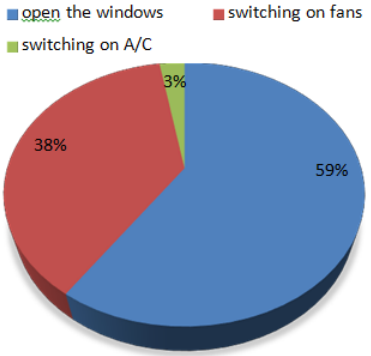

Figure 11: Action for thermal discomfort for those who have calicut tiles as roofing material

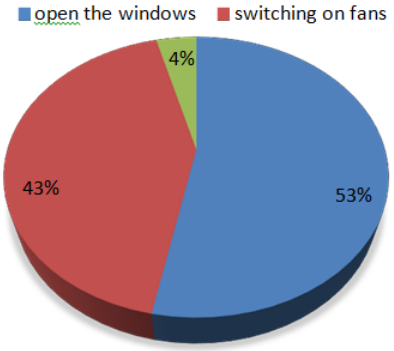

Figure 12: Action for thermal discomfort for those who have Asbestos sheets as roofing material

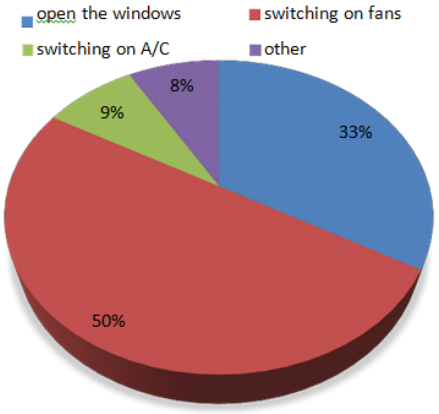

Figure 13: Action for thermal discomfort for those who have concrete slabs as roofing material

5. Discussion

From the above analysis, it was clear that the general public prefers Calicut tiled roofs over asbestos sheets or concrete slabs, mostly due to the thermal comfort that it possesses, due to the clay in Calicut tiles itself acts as a thermally resistive layer and acts as insulation to the building envelope.

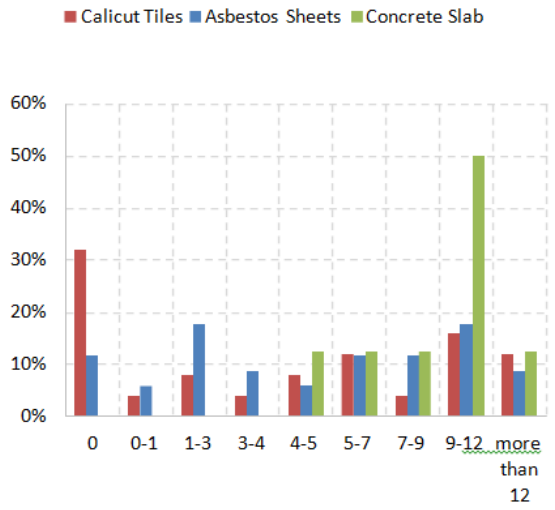

Figure 14: Number of hours that fans are used in homes vs. roofing materials

Furthermore, because of the slope of the roof and orientation, only a portion of the roof is exposed to sun at a time. Consequently, the operational energy of the buildings is much less in Calicut tile roofed buildings than the buildings with concrete slabs.

Nevertheless, it doesn't have many advantages that concrete slabs possess, such as possibility of future extension, possibility of using as a workable space. More importantly, concrete slabs are much durable, which subsequently reduces the energy usage for reconstruction and rehabilitation.

Retrofitting Calicut tiled roofs to gain the advantages of flat slabs or retrofitting concrete slabs in such a way that it is thermally comfortable is much desired in the context of sustainability. Currently, the researchers are focusing on the latter as it seems to be more feasible.

Since, the public is concerning about the thermal comfort than the cost or aesthetics, the best approach in retrofitting concrete slabs is to develop a thermally effective system first and then address for the cost optimization and the aesthetics later.

6. Conclusions

Following conclusions can be made out of this study;

- Out of Calicut tiles, asbestos sheets and concrete slabs, Calicut tiles is the preferred material, dominantly due to the thermal comfort that it possesses.
- There are three major reasons for the concrete slabs to be not so popular, thermal discomfort, high initial cost and serviceability issues, particularly cracking of slabs.
- Among those issues, thermal discomfort is dominant.
- Concrete roof slabs use highest amount of energy for active cooling whereas Calicut tiled buildings use the least among above mentioned three materials
- In retrofitting roof slabs to promote it, addressing thermal discomfort should be given the top priority.

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