Chapter 1

INTRODUCTION

1.1 General

A building is generally to ensure four types of safeties. Those are the structural safety, the fire safety, the health safety and the construction safety. However, these safeties, though necessary, do not necessarily ensure "livability" of the building in all its aspects. Though livability cannot be defined, it is understood as providing a comfortable and acceptable built environment.

Generally, buildings should be passively adopted to the climate as much as possible. This means that is the building should provide a reasonable indoor climate with little or no energy input. For this, the best use should be made of the thermal properties of materials. The placement and orientation of building is critical to make best use of solar energy and other natural characteristics such as topography and vegetation.

1.2 Energy crisis

In Sri Lanka, the demand for electricity is rapidly increasing. In 1998/99, the percentage increase in the electricity sales was 6.4%. The corresponding figure for 1999/2000 was 9.3%. The increase in the number of consumer accounts was 10.8 % and 10.2% for 1998/1999 and 1999/2000 respectively (Statistical Digest, 1999 & 2000). For the supply of this demand, Sri Lanka depends primarily on hydropower and thermal power.

Hydropower is renewable, but not reliable. Therefore, hydropower is not a sustainable solution to the increasing demand for electricity, not only, because new development is unlikely to occur, but also due to its drop in capacity during dry seasons. In Sri Lanka, Petrolium is not available. Thus, Sri Lanka has to import the entire Petrolium requirement. Owing to the price hikes, CEB is faced with a big problem of increased cost of thermal power generation. Therefore, it is required to determine immediate solutions for the energy crisis.

One of the solutions available for this problem is the energy conservation in buildings using passive elements. The energy required for air conditioning and heating can be minimised with good understanding of the difference between an air-conditioned building (actively climatised house) and a building climatised only by natural means (passively climatised house). In the actively climatised building, the indoor temperature is kept within comfort limits by the occupants who set thermostats to a desired temperature. The building envelope has to be designed to give the most economical investments and annual costs.

Among other measures, this requires airtight houses with the ventilation supplied by the air-conditioning systems. A passively climatised house depends on natural means, such as solar shading, cross ventilation and appropriate building design.

Passive techniques represent a broad term used to introduce a wide range of strategies and options resulting in energy efficient building design and increased comfort for occupants. The concept emphasises architectural design approaches that minimise building energy consumption by integrating conventional energy efficient devices, such as mechanical and electrical pumps, fans, lighting fixtures and other equipment with passive design elements, such as building location, an effective envelope, appropriate amount of fenestration, increased day lighting design and thermal mass. In short ***"Passive elements balance all aspects of the energy use in a building for lighting, cooling, heating and ventilation".***

In Sri Lanka, house construction methods usually adopted in various parts are dictated by the availability of construction materials and the aesthetics rather than the thermal comfort of the houses. However, according to past research, thermal comfort is one of the primary objectives of built environment to its occupants. Sri Lanka consists of three climates; dry zone, wet zone and tropical uplands. For dry and wet zones of Sri Lanka, the duty of the passive techniques should have a different goal than the duty of the passive techniques applicable to upland area. For dry and wet zones, minimizing the solar gain storage and maximization of the ventilation and structural cooling are important.

The climate in upland areas of Sri Lanka is completely different to the climate in dry and wet zone. This type of climate is the most complex one from the designer's point of view, because the building must satisfy conflicting needs in daytime with the nighttime. In the upland areas, the designer must consider the principles of heat conservation and solar heat gain and some times, active heating as well. As a consequence, solutions are often a compromise between these conflicting needs. Wherever incompatible needs arise, a careful analysis of balanced design is required.

Therefore, the thermal performance of houses of high altitudes of Sri Lanka should be paid some attention at the planning stages, so that desirable features could be incorporated at the initial stages. To fulfill this requirement, it is necessary to determine the desirable passive features on the basis of qualitative and quantitative studies. But, not sufficient research has been conducted for tropical upland areas of Sri Lanka during past years. This research was aimed to fulfill this need.

1.3 The Objectives

The main objective of this research is as follows:

1. To identify suitable passive features that can be introduced to houses at tropical uplands of Sri Lanka.

2. To determine the effect of such features on the thermal performance of houses in high altitudes areas of Sri Lanka.

3. To develop conceptual passive houses for tropical uplands of Sri Lanka.

1.4 Methodology

The following methodology was adopted for the research:

1. Climate data and climatic factors relevant to tropical upland of Sri Lanka were determined.

2. Various passive features that could be used for single and two storey houses were identified.

3. Effect of those passive features on indoor thermal comfort was quantified using DEROB-LTH.

4. Desirable features were presented as guidelines so that designers can adopt them at the initial stage.

5. The thermal efficiency of those guidelines was investigated by modelling a conceptual house using DEROB-LTH.

1.5 Main Findings

Design guidelines for houses in tropical uplands of Sri Lanka.

It is found that a two-storey house or a single storey house could not give the optimum thermal conditions for tropical uplands. Thus, both are not desirable. However, a house where half is two storey could be a better solution. The following design guidelines are suggested to improve the thermal performance of such houses.

1. The orientation of the house could be such that the front faces either south or north. This will allow the protection for most of the openings from direct solar radiation.

2. Use of darker colours such as green, blue or grey for interior and exterior surfaces of the houses could have a desirable effect than using light colours such as white.

3. The use of extra protection with windows to reduce infiltration of cold air during the night time is desirable.

4. It would be advisable to provide a ceiling for the house so that heat loss and infiltration through the roof could be reduced as increased infiltration during night is not so desirable.

5. Additional windows could be provided facing east since the penetration of morning sunlight is highly desirable. This would not have any undesirable effect on the indoor temperatures, both daytime and night time.

6. Providing additional windows facing west is possible. However, it is better to avoid this since direct solar radiation could penetrate into the house, when the indoor is also warm. Thus, causing warm discomfort in certain days with long hours of sunshine.

The following findings show the effects of roof orientation, roof material and shading devices on indoor thermal comfort in tropical uplands of Sri Lanka.

1. For the houses in tropical upland areas, there is no significant effect of roof orientation.

2. The thermal performance of roof materials for high altitudes area will gradually increase for burnt clay tiles, old cement fiber sheets, painted GI sheets and new GI sheets. All these houses should be provided with timber or cement fiber ceiling.

3. According to the results obtained, the effects of shading devices are quite negligible.

1.6 Over view of the Thesis

A brief outlook of the thesis is mentioned below:

1. Chapter 1 presents the overview of the research including an introduction highlighting the problem.

2. Chapter 2 presents the literature survey carried out for this study. At the end of the literature survey, the reasons for this research study are summarised.

3. Chapter 3 describes the computer software used (DEROB-LTH) and validation conducted for that software for the tropical upland climates.

4. Chapter 4 presents the research work conducted to investigate the effect of roof for houses in tropical uplands of Sri Lanka.

5. Chapter 5 presents the research work conducted to investigate the effect of colour, ventilation and the window orientation for houses in tropical uplands of Sri Lanka.

6. Chapter 6 highlights the thermal efficiency of above passive features using a conceptual house, located in tropical uplands.

7. Chapter 7 presents the conclusions and the future work.