Chapter 4

Proposed Model House for the Low-income Parents of Samanera Theros in Rural Villages in Sri Lanka: An example of village culture, construction system, and micro-climate simulations integrated in architectural design

YAMADA Kyota, SEEKKUARACHCHIGE Mihiri Hirudini, JIANG Guangbo

1.Background

The aim of this project was to develop a model house for the low-income parents of Samanera Theros in rural villages in Sri Lanka. In 2021 this project was introduced to YAMADA Kyota laboratory in University of Tsukuba by a Sri Lankan thero, who is the chief monk in Sri Sambuddhaloka Vihara, Tsukuba, Japan. As per the thero, the construction of these model houses is funded by the donations of the Sri Lankan Buddhists living overseas.

When developing the model house design, there were three key factors which needed to be considered.

- Designing a model house addressing the village culture
- Construction system
- Micro-climate simulations integrated in architectural design

The micro-climate formation mechanism of the model house was devised, and micro-climate simulations were carried out using the findings of the climate-responsive dwelt environment database and the simulation program discussed in Chap. 3.

1.1 Designing a Model House Addressing the Village Culture

When designing a model house for the low-income families in rural villages in Sri Lanka, their social, economic, and cultural lifestyle had to be considered to understand their spatial needs and

Figure 1 3D Image of the Proposed Model House

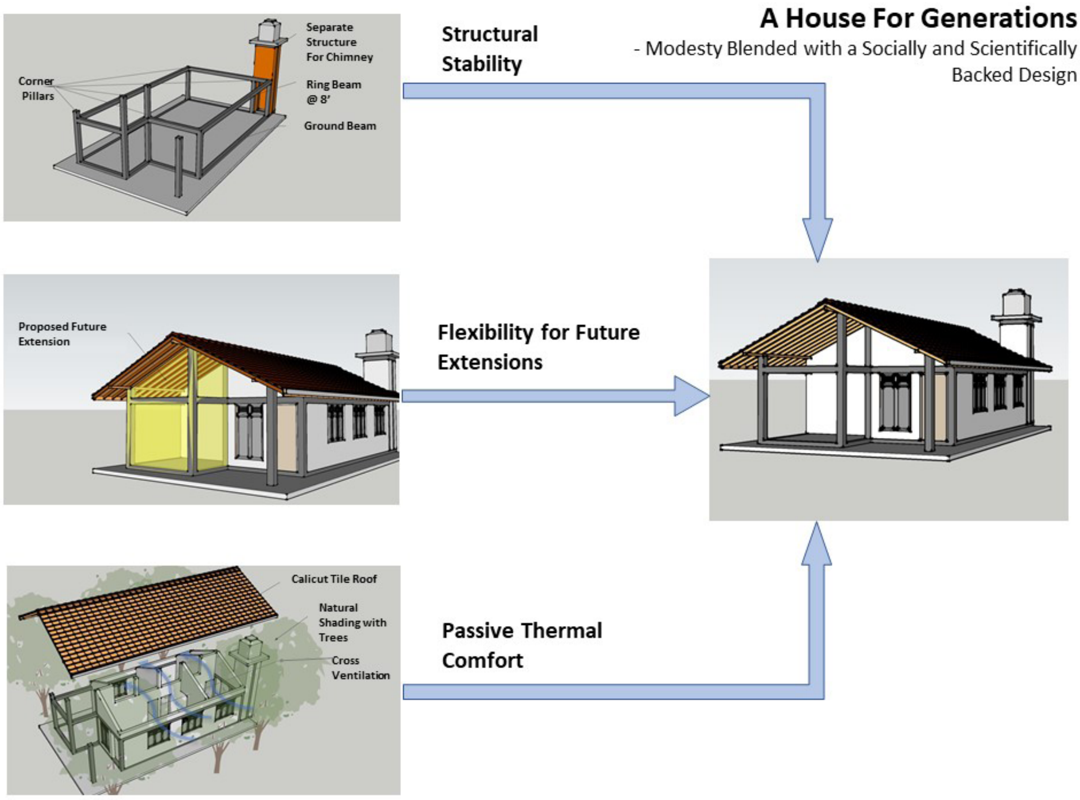

Figure 2 Overall Design Framework for the Proposed Model House

priorities. The facts that they are living in rural villages, and one of their children have become a Samanera Thero, indicated that these families are traditional Sinhala Buddhist families with traditional Sinhala Buddhist cultural values.

Hence a special attention was given to their needs and preferences when designing this house and with that, following spatial requirements were incorporated to the design brief.

- Verandah
- Livingroom
- Kitchen
- Master bedroom 1
- Guest bedroom / children's bedroom 1
- Bathroom

Verandah

A verandah was incorporated into this house, because verandah is a prominent and a required part of Sri Lankan traditional architecture. The main need of a verandah in a rural Sri Lankan house is to welcome and converse with the informal visitors, neighbors, or acquaintances. Hence, verandah is essential as it is a place which enhances interpersonal relations, which the residents value and depend on.

Livingroom

A comparatively large living room was provided in this house design, as in the rural Sri Lankan context, living room is the place where the family gathers, watch TV, study as well as where they entertain formal or important guests. Furthermore, living room is used for special functions such as alms giving, new year festivals, house weddings and funerals which are a part of the Sri Lankan Sinhala Buddhist rural lifestyle.

Kitchen

In the design, a traditional kitchen with a chimney for a firwood stove was proposed as in this rural set up, gas cookers or electric induction cookers are very rare. Moreover, by considering the traditional lifestyle, the kitchen was placed at the back of the house, which is closer to the family well and the backyard, which are excessively used in rural cooking.

Two Bedrooms

Two adjoining bedrooms were designed, as one

Figure 3 Proposed Plan for the Model House

room is for the parents and the other room is for the children or occasional visitors.

Bathroom

An attached bathroom was provided to the house design, but it was located at the back of the house design, next to the rear door. This was due to the fact that, in rural traditional setup bathrooms in the midst of the house or at the front of the house are considered as inappropriate.

1.1.1 Providing Flexibility for Future Extensions and Personalization

In this house design, due to the project budgetary restrictions and the low-income of the families only two bedrooms were provided in the initial design.

When the local village culture was taken into consideration, it was noted that, the villagers tend to add unplanned extensions to their houses when their children grow and they need an additional space and when the family's economy improves. These unplanned extensions are very common in rural context as the land areas are big and there are no governing laws pertaining to the residential constructions in rural areas. But these unplanned extensions most of the time look haphazard and unfinished.

By considering these factors and to give the residents an opportunity to add a part to their house when their children grow up and their economy is improved, which gives them a sense of ownership and a sense of personalization, the design gave provision for a future extension. (Refer Figure No.2 and Figure No. 3)

This future extension was facilitated both in the spatial composition (in plan form) as well as in the structural design.

1.2 Construction system

In the design process of the model house, special attention was given to the structural stability of

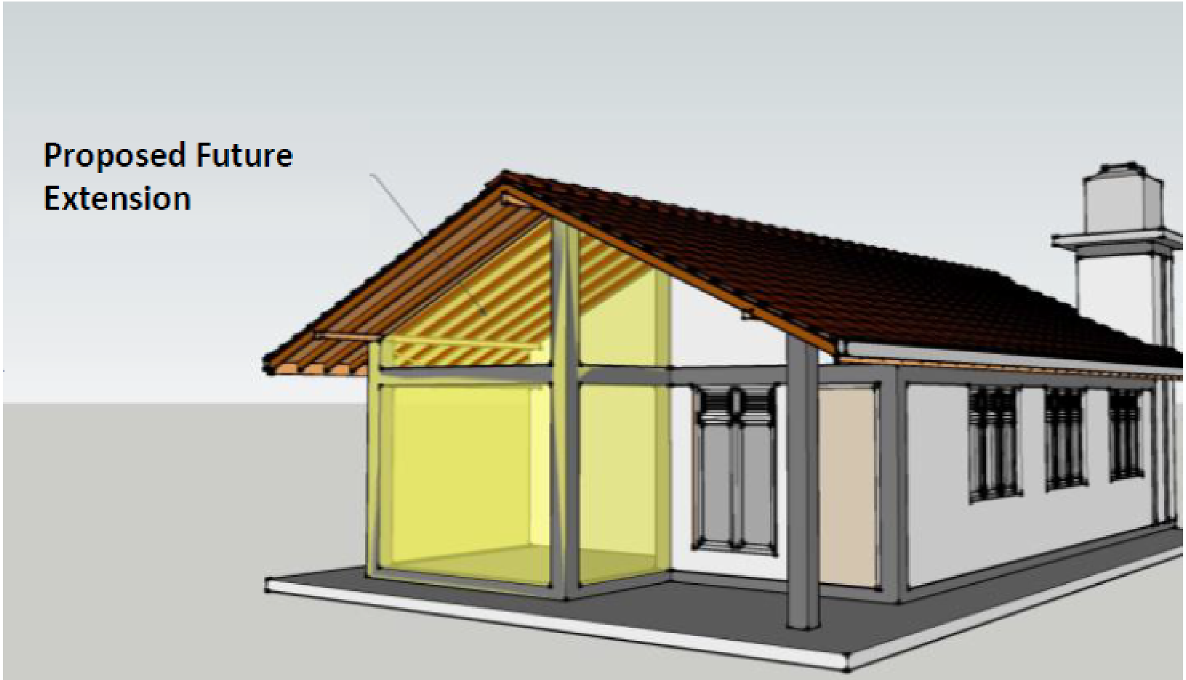

Figure 4 Proposed Future Extension of the House

the building. For the structural stability, corner pillars, a ground beam, and a ring beam at the height of 2450 mm (8') were implemented in the structural design.

It should be noted that the ring beam and the corner pillars of the future extension part was proposed to be constructed in the first stage itself. With that the house structure is tied as one structure from the beginning onwards and any future extension part will not have to be connected to the structure separately. This will prevent any damages on the building structure and weakening of the structural stability.

Moreover, for the safety measures, the chimney in the kitchen, which bears the load of the water tank, at the back of the house was designed as a separate structure. Therefore, the chimney structure had separate corner pillar, a

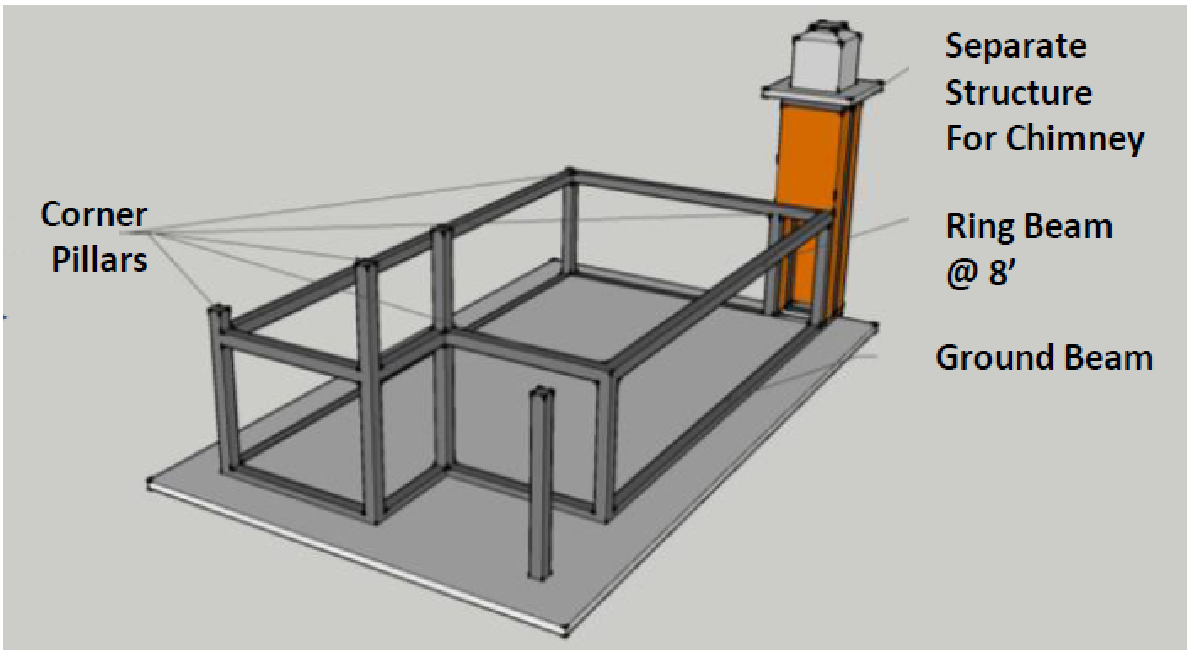

Figure 5 Structural Design

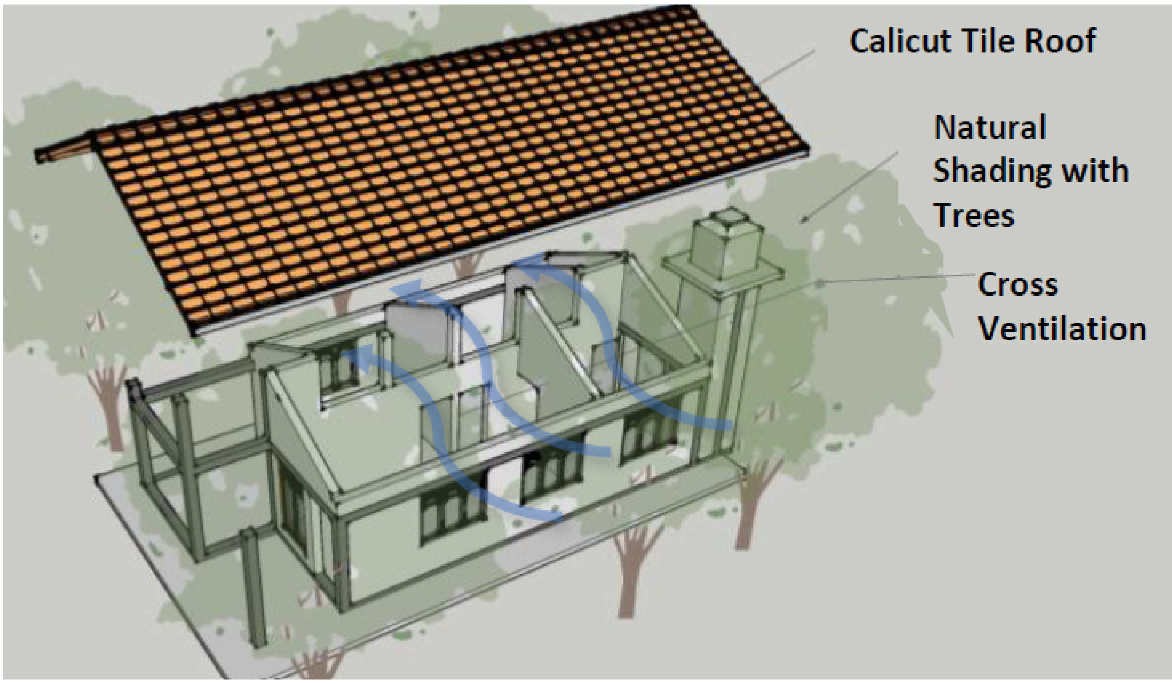

Figure 6 Design strategies for indoor thermal comfort

ground beam and a ring beam at the height of 5200mm (17'). Not connecting the chimney to the main structure allows chimney structure to independently bear any unforeseen soil settlements under the chimney structure due to the weight of the water tank, without damaging the main structure.

1.3 Micro-climate Simulations Integrated in Architectural Design

When designing the house, special attention was given to the indoor thermal comfort also. As Sri Lanka is a hot and humid tropical country, indoor thermal comfort is a very important aspect.

The house was designed allowing natural ventilation and cross ventilation by providing an effective number of openings and keeping the internal partition walls short without sealing or separating each room.

Furthermore, the building materials were selected by considering their cooling effect and the support for indoor thermal comfort. Hence, for the walls mud bricks were selected to minimize the concrete mass, and for the roof Calicut mud roof tiles were selected.

Moreover, the surrounding was proposed to be covered by natural shading from big trees and the ground to be covered by greenery to minimize the daytime heat reflection, resulting in a low reflective albedo, to support the indoor thermal comfort.

The design effect on thermal comfort was analyzed through a computer-generated indoor air temperature analysis. For this, a program for a 3D model simulation was constructed by Grasshopper software.

In the indoor air temperature analysis, two 3D models with two different roof types were simulated to understand which type of roof design is more suitable for the hot and humid tropical Sri Lankan climate.

For both of the roof design types (Option 1 and Option 2), an indoor air temperature analysis was run and the indoor air temperature of each space was analyzed under different conditions.

These different conditions include,

- indoor air temperature when all windows are closed for the whole day – when building is located towards North South Orientation – without 15m height tree shade
- indoor air temperature when all windows are closed for the whole day – when building

is located towards East West Orientation - without 15m height tree shade

- indoor air temperature when all windows are opened from 7 a.m. to 5 p.m. – when building is located towards North South Orientation - without 15m height tree shade
- indoor air temperature when all windows are closed for the whole day – when building is located towards North South Orientation - with 15m height tree shade

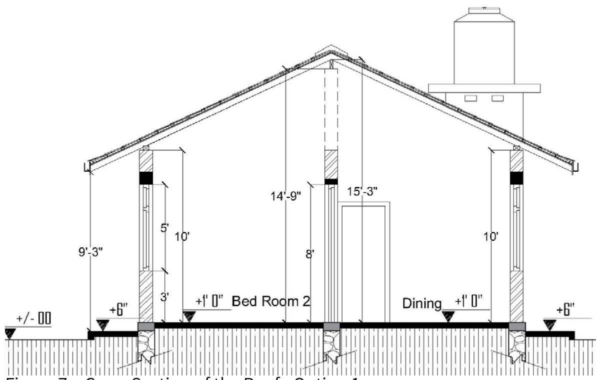

Figure 7 Cross Section of the Roof - Option 1

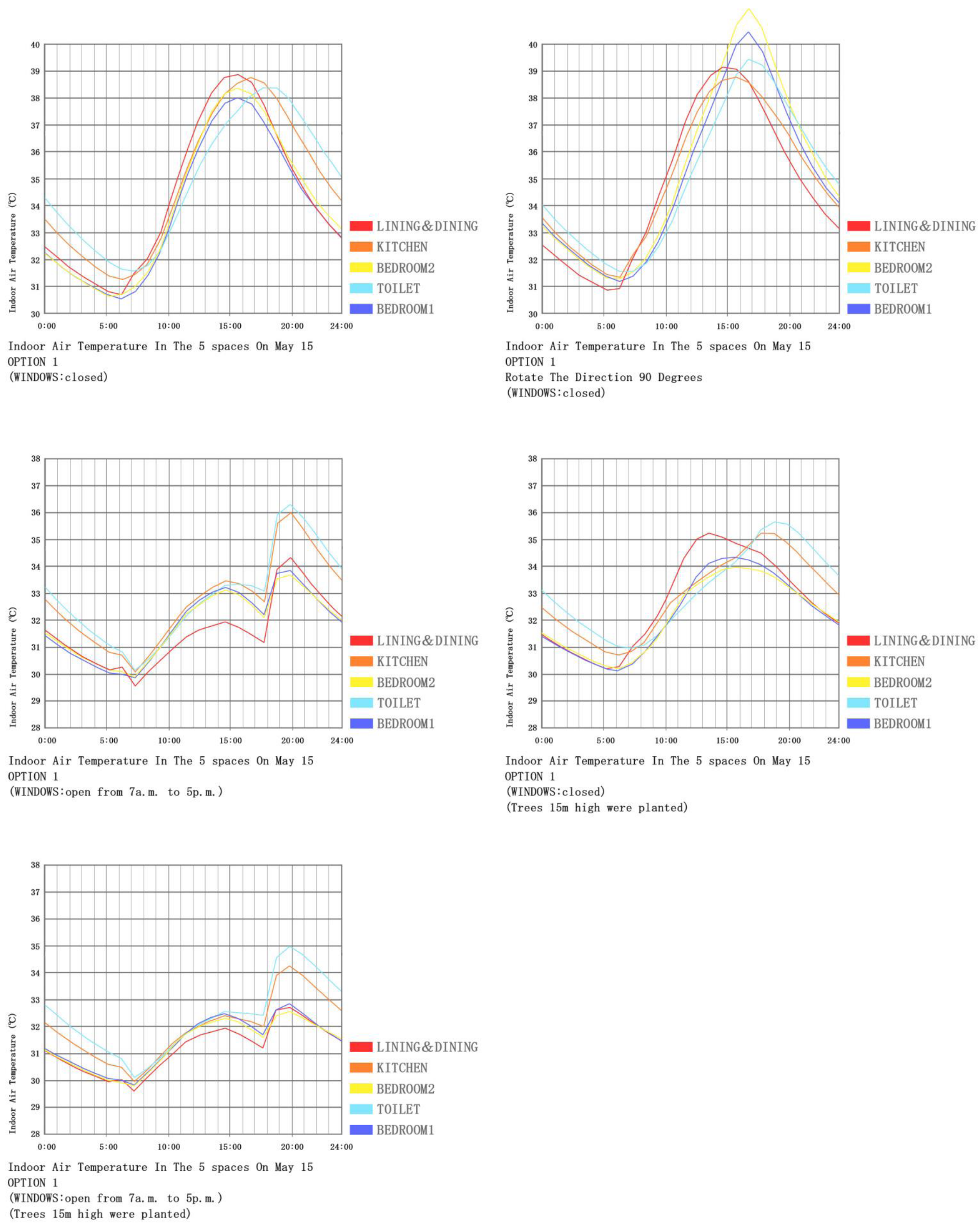

Figure9 Indoor air temperature analysis of option 1

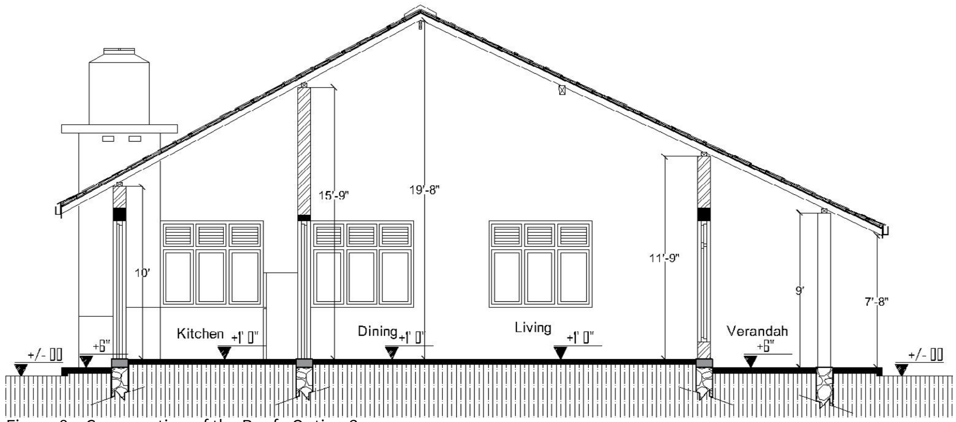

Figure 8 Cross section of the Roof - Option 2

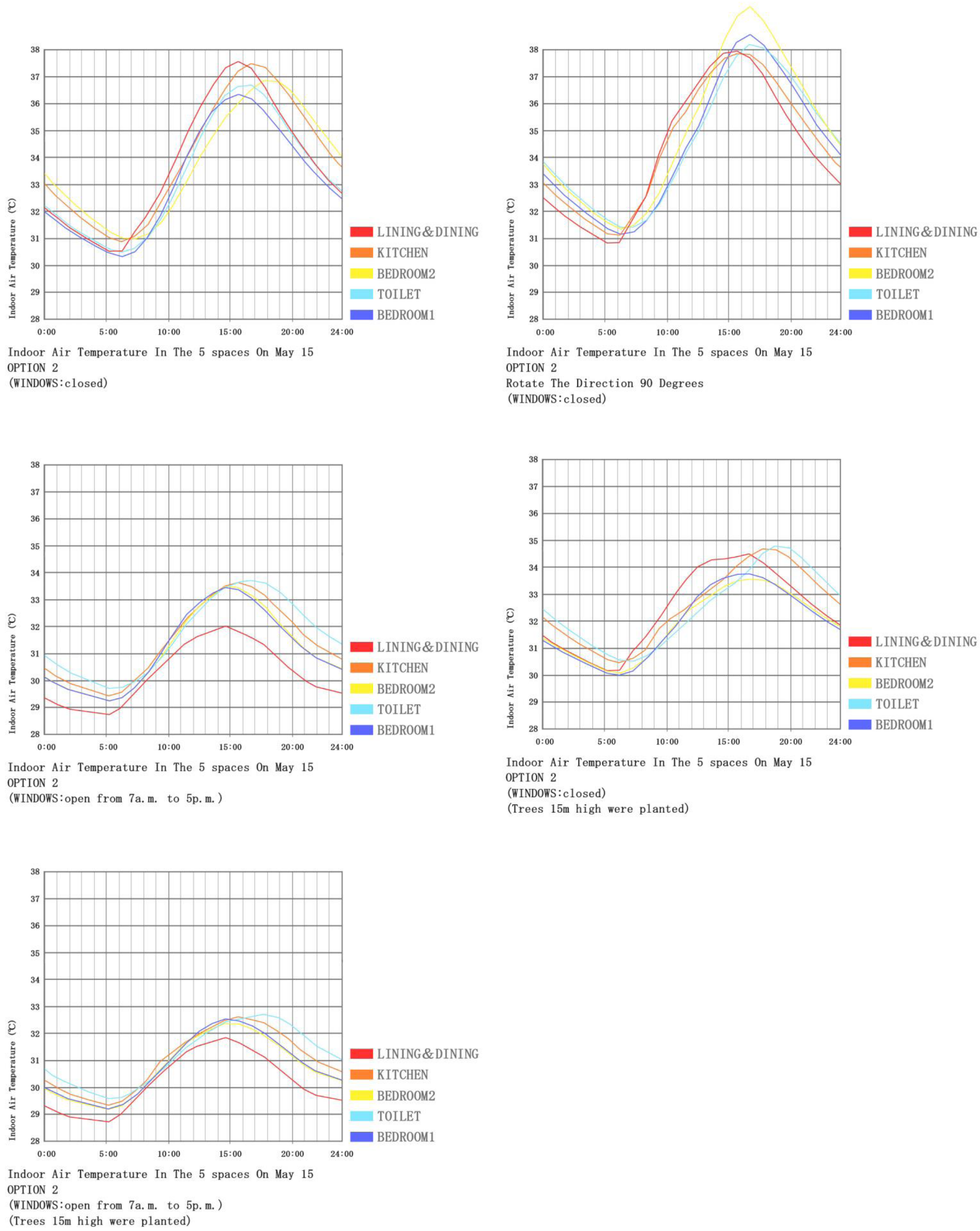

Figure10 Indoor air temperature analysis of option 2

- indoor air temperature when all windows are opened from 7 a.m. to 5 p.m. – when building is located towards North South Orientation - without 15m height tree shade - with 15m height tree shade

Indoor Air Temperature Analysis Results

In the indoor air temperature analysis of both the design options, following results were observed.

The highest indoor air temperature is created in the condition when all windows are closed for the whole day and when the building is located towards East West Orientation - without 15m height tree shade.

The second highest air temperature is noticed when all windows are closed for the whole day and when the building is located towards North South Orientation - without 15m height tree shade.

The third highest air temperature is noticed when all windows are closed for the whole day and when the building is located towards North South Orientation - with 15m height tree shade.

The fourth highest (the second lowest) air temperature is noticed when all windows are opened from 7 a.m. to 5 p.m. and when building is located towards North South Orientation - without 15m height tree shade.

The lowest air temperature is noticed when all windows are opened from 7 a.m. to 5 p.m. and when building is located towards North South Orientation - with 15m height tree shade.

Furthermore, the indoor analysis of roof type option 1 and roof type option 2 shows that Option 2 with the split-level roof has a lower indoor air temperature under all the conditions. Therefore, it is anticipated that this type of roof is more suitable for this climatic condition. But as this project was under tight budgetary restrictions, roof type option 1 with a simple gable roof was selected as it is more cost effective.

This analysis clearly indicates that following three key factors are very important for the maximum effective indoor thermal comfort in a Sri Lankan house.

- Correct building orientation
- Openings for proper ventilation and cross ventilation
- Adequate level of natural shading with trees
- A suitable building form design with special reference to the roof shape and the height

2.Conclusion

When all these aspects are considered, it can be concluded that when developing a house design for a rural setting in Sri Lanka, following four key factors must be given special consideration.

- Designing a model house addressing the village culture
- Providing flexibility for future extensions and personalization
- Ensuring the structural stability of the house
- Providing passive thermal comfort inside of the house