

# Cost Effective Housing with Modular Forms

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## Abstract

*It is a significant challenge to provide houses meeting certain basic standard to majority of the population, especially those who would not be able to raise sufficient funds for construction activities. For such segment of the society, various government sponsored schemes can be carried out generally with emphasis on multi storey blocks when dealing with cities. However, providing houses for rural population would need houses that could be constructed in a cost effective manner with least impact on environment. This research describes such a solution developed with housing consisting of a modular arrangement and also constructed with alternative building materials and methods.*

## 1. Introduction<sup>1</sup>

It is a primary requirement to provide a reasonably good housing for the majority of the population in any country. The type of housing selected could be apartments, attached houses, semi-detached houses or individual houses. The selection could be based on climatic condition and the availability of the land.

In countries with tropical climatic conditions, the provision of individual houses could be desirable from many points of view. One is the warm humid climate condition with low diurnal variation of temperature where the provision of thermal comfort would need the creation of microclimate around the house. For this, it is

desirable to consider two storey houses since the land can be used for planting of trees around the house.

### 1.1 Sustainability

In a two storey house, the walls would be major cost item. The reason is the number of operations involved to complete it. First, it would need the construction of the wall. Then, it would need plastering and painting. Hence, many operations are needed prior to completing the wall.

The other important aspect with respect to sustainability in the use of natural resources. Bricks are manufactures using clay that is extracted from earth. The construction of brick walls would need sand and cement. The natural resources are used without giving much consideration to the environmental costs associate with them.

The extensive uses of natural resources have caused many

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environmental problems and also caused a scarcity. The scarcity has driven the price upward and hence the affordability of building material has become low. Such situation could lead to proper houses being not affordable to majority of the population. Therefore, it would be important to develop cost effective alternative materials that could give a higher level of affordability.

### **1.2 The walling material selected**

The walling material selected for research is cement stabilized rammed earth (CSRE). Past research on CSRE has indicated that it is a strong material when cemented with laterite soil having lower clay and silt percentage [1,2,3]. The cement percentage recommended would be 6% to 10%. The compression strength values can be as high as 3.0 N/mm<sup>2</sup>. When constructed with adequate restrained, CSRE can demonstrate good flexural properties [4]. Enhancement of flexural properties will be increased with the provision of suitably selected tie beams. Since the CSRE walls are constructed by compacting moist cement soil in between strengthened and restrained plywood shutter, the wall would have a good finish. Hence, it would be possible to avoid plaster. This means that the number of operations needed to complete the house also could be reduced resulting in saving in material, labour and cost.

### **1.3 The modular form for house**

One of the key features needed from a house with CSRE as the walling material is the ability to use the same shuttering system. This can be achieved in many ways. One possibility is to develop a module that can be considered as the basic form. A house constructed this way is shown in Figure 1 and the basic module is shown in Figure 2. It can then repeated in an arrangement to form a house. This idea is demonstrated for a single storey house in Figure 3.

The house module consists of a room of about 3.0m to 4.0m. This module is selected considering the constructability and repeatability. It is possible to repeat the house module four times in a specially selected way so that a house could be developed. Within there, it is possible to arrange the preferred spaces of a single storey house.

It is also possible to extend this to a two storey house as well. These examples are indicators only and there could be many other variations when their modular concept is used.

## **2. Methodology**

Once a proper construction method is developed for a module, it could be possible to repeat it many other times. Hence, the construction technique for CSRE have been developed with trails on many different techniques. They are presented as options.

### *Option 1*

The use of a shuttering for the complete module: This appears to be a viable option. However, there could be some difficulties in maintaining the verticality.

### *Option 2*

The use of corner columns: In this method, the corner columns could be constructed first and then the wall in between could be completed. The corner column could be out of concrete or cement stabilized soil. The use of the cement stabilized soil columns could be the most cost effective way since concrete column would be more expensive and also would need some reinforcement.

## **2.1 The spacing of columns**

This can be a reasonable spacing. One option is the use of 2.1m spacing considering the size of the plywood sheet of 2.4m × 1.2m. The other option is the use of a spacing that would limit the module that has been repeated.

## **2.2 The method for proper bond**

There should be good bond between the corner column and the wall cast in between. This can be achieved with the provision of groove.

## **2.3 The issue of shrinkage**

This can be minimized by selecting laterite soil with many coarse particles

and also having a time gap between the casting corner column and the wall panels in between. Once the house is constructed, many types of natural material based coatings can be used for giving a very good finish [5].

## **3. Results and Discussion**

### **3.1 The Application**

A house constructed in this manner is shown in Figure 1. The materials used for corner columns is concrete. However, the use of soil cement column also can give same results. With cement soil column the size of the column can be made larger.

### **3.2 Tie beams**

It would be useful to provide tie beam in this structure at the window sill level and also above the windows.

### **3.3 Cost Aspects**

The methodology presented indicates a good possibility for creating a house with locally available materials with minimum number of operations at the site thus reducing the construction cost significantly.

## **References**

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Figure 1: The completed house

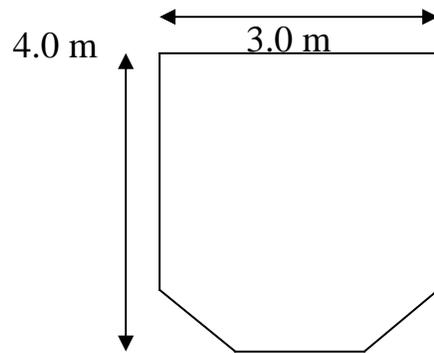


Figure 2 – The module used for a room

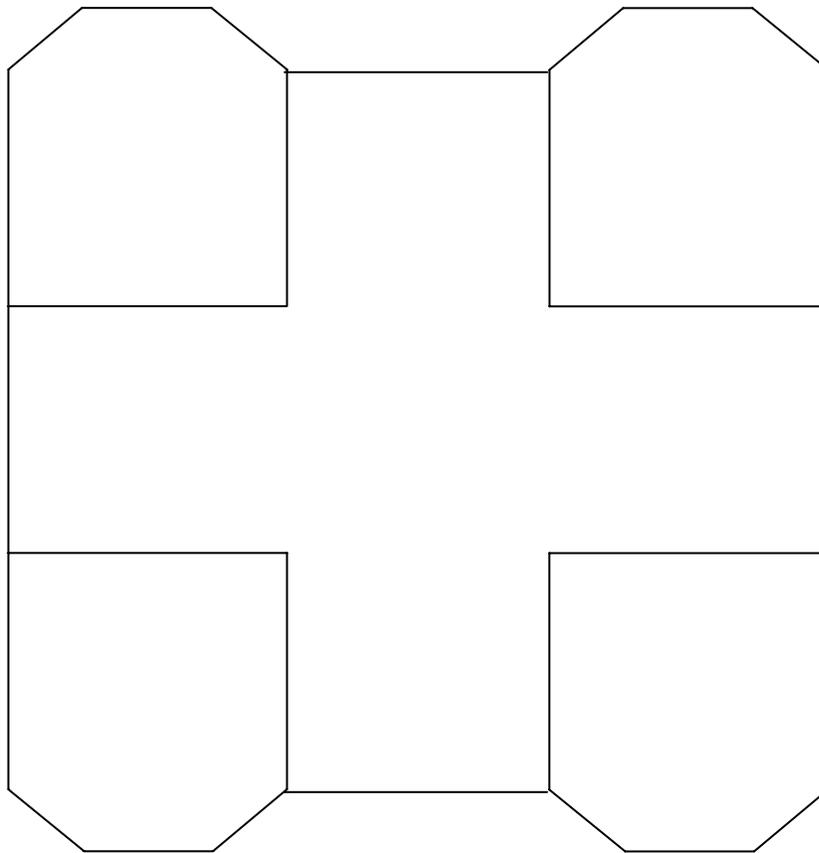


Figure 3 – The plan view with four modules