LESSONS FROM USED LOW COST HOUSING METHODS

by

Dr. A.A.D.A.J. Perera

Abstract

Results of an analysis of 73 low cost houses is presented. A survey was held to evaluate the used building materials, successes and failures, acceptance and rejection by the users etc. The survey included in detail 12 soil based wall houses, 24 cement based wall houses, 13 coir fibre sheets/tiles houses, 23 houses with concrete doors and windows and without traditional timber roof structure and 3 houses without door and window frames.

Low cost houses cost Rs.25,000 or more, however available loans for low cost house constructions fell well below Rs. 25,000/-. Satisfactory walls were observed with 1:12 cement quarry dust with coir fibre, rammed earth and stabilised earth blocks. Satisfactory low cost coir fibre cement mortar sheets/tiles and cement mortar micro tiles were observed. Satisfactory arrangement to fix doors and windows was observed. Approximately 25% cost of walls, 10% to 30% cost of roofs can be saved by the use of low cost methods. A maximum of 40% of the cost compared to owner supervised houses can be saved by the use of low cost housing methods.

1.0 Introduction

Results of an analysis of 73 low cost houses is presented. This includes 12 soil based wall houses, 24 cement based wall houses, 11 coir fibre cement tile houses, 2 coir fibre cement sheet houses and 3 houses without traditional doors and window frames. The 73 houses were from all over Sri Lanka; i.e. 10 from Deberawewa, 1 from Badulla, 6 from Nikeweratiya, 23 from Maligawatte, 3 from Minuwangoda, 1 from Panadura, 5 from Grandpass and 12 from Nawagampura (Colombo 9).

The occupants of the houses were interviewed using a questionnaire and data related to house size, land size, cost, year of construction, user comfort, maintenance cost, defects were recorded.

2.0 State of Low Cost Houses in Sri Lanka

The field survey was held to collect the information related to the following aspects of low cost houses in Sri Lanka.

- The used building material for walls, foundation, roof, doors and windows etc.
- The design and construction aspects.
- Financing aspects i.e. construction costs, income of users etc.
- Services i.e. water, sanitary, electricity etc.
- Failures and maintenance.
- User comfort, socio economics of occupants.

2.1 Building Materials

Most of the owner build houses have used rubble for foundation (31 out of 73) while few houses have used concrete. Few houses were observed with bricks (10 out of 73) and unburnt bricks (5 out of 73) and clay (4 out of 73) for foundations.

Brick was the predominant material used for walls while few houses were observed with cement sand blocks, unburnt bricks (10 houses), rammed earth (4 houses), clay (1 house) and cement and quarry dust mix (1:12) with coir fibre.

Asbestos sheets were the widely used roofing material and two good houses were observed with coir fibre cement sheets and more than 30 houses were observed with coir fibre cement sand tiles. Further three houses were inspected with cement sand micro tiles. Few houses were with clay tiles.

2.2 Design and Construction

Except the owner built houses all the other houses were designed and built by governmental organisations (NERD, SEC/NBRO, ICTAD etc.) or by non-governmental

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Actively involved in the construction of Low Cost Houses through NGO's such as World Vision Lanka, LEAD etc.
organisations (NGOs) such as USA Save the Children Fund, LEADS etc. Many owner built houses were designed by the owners and have high wall/floor arcas ratios (2.5 to 3.9) while low cost houses by governmental organisations have low wall/floor arcas ratios (around 2.3). Therefore owner designed and built houses are less cost effective.

2.3 Financing aspects

Almost all the houses inspected were totally or partially financed by the government. In some houses financing was by a non governmental organisation. Most of low cost material based houses (cement;quarry dust and coir fibre, unburnt bricks, rammed earth) were totally funded by the government. Many recent low cost houses have cost more than Rs. 75,000/- per unit (Rs. 200/- per sq.ft.). At present NHIDA gives a maximum of Rs. 15,000/- housing loan for very low income groups but all the low cost houses inspected have cost more than Rs.15,000/- (at least Rs. 25,000/-). However the occupants of low cost houses pay less than Rs.250/- per month as capital payment. Generally this payment does not include interest for the capital and usually the loan is a long term loan. In some houses the owner who obtained the house from the government has rented for a rent in the range of Rs. 500-1000.

Fairly good incomes were observed among the occupants of low cost houses as given below.

<table>
<thead>
<tr>
<th>Monthly income</th>
<th>Percentage of occupants</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than Rs. 1000</td>
<td>18.3 (13)</td>
</tr>
<tr>
<td>Rs. 1000 to Rs. 1500</td>
<td>19.7 (14)</td>
</tr>
<tr>
<td>Rs. 1500 to Rs. 2500</td>
<td>40.8 (29)</td>
</tr>
<tr>
<td>Rs. 2500 to Rs. 3500</td>
<td>12.7 (9)</td>
</tr>
<tr>
<td>Rs. 3500 to Rs. 5000</td>
<td>8.5 (6)</td>
</tr>
</tbody>
</table>

2.4 Services

Mixed state of services were observed with low cost houses in Sri Lanka. Majority enjoys (50%) pipe water in the house (tap water) while considerable percentage (35%) have stand posts and generally rural low cost houses have well water.

Majority of the low cost houses do not have electricity eventhough they have been promised by the authority. The low cost houses with electricity were generally Gam Udawa houses or related to Gam Udawa projects.

Almost all the low cost houses possess their own sewerage system. Recent houses have inside toilets while majority of the houses in Colombo city have common toilets and generally rural houses have outside toilets.

2.5 Maintenance and Failures

Generally low maintenance cost was recorded; i.e. less than Rs. 1000/- per year or no maintenance (60%). Few recorded with maintenance cost of more than Rs. 2000/-. Foundation failures were minimum (12%) while in many occasions wall cracks (62%) and floor cracks (45%) were observed. 62% complained about some roof leaks and 53% complained about shortcomings in doors and windows (mainly concrete doors and windows).

2.6 User comfort and other aspects

All the users of low cost houses recorded physical comfort inside the house during evening, night and morning. However, many stated discomfort during daytime.

Fairly high number of occupants were recorded as given below in low cost houses in Sri Lanka.

<table>
<thead>
<tr>
<th>Number of occupants</th>
<th>Percentage of houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>less or equal to 3</td>
<td>9.8 (7)</td>
</tr>
<tr>
<td>4 to 5</td>
<td>31.0 (22)</td>
</tr>
<tr>
<td>6</td>
<td>23.9 (17)</td>
</tr>
<tr>
<td>7 to 9</td>
<td>25.4 (18)</td>
</tr>
<tr>
<td>more than 9</td>
<td>9.9 (7)</td>
</tr>
</tbody>
</table>

3.0 Houses with Low Cost Walls

3.1 Cement Based Walls

Thirty houses out of 36 houses at Maligawatte which were constructed using NERD method were inspected : i.e. 1:12 cement and quarry dust mix and slipform technique. Cracks observed in few houses specially at the centre of middle walls and near door frames. It was not possible to judge the type of cracks; shrinkage, settlement or other reason. In one isolated place disintegration was observed. Few organisatins have constructed low cost walls using cement sand blocks.

3.2 Earth Based Walls

3.2.1 Soil Blocks

A very satisfactory house made of stabilised earth blocks inspected in Badulla. The walls have a very high strength and even a nail was difficult to be driven in. This house was constructed in 1978 and not a single crack was observed. Satisfactory as well as unsatisfactory houses made out of stabilised Earth blocks were inspected in Deberawewa (near Tissamaharama). The owners have supervised the construction of their houses. Very unsatisfactory houses made of unburnt large bricks were observed in Nikaweratiya. Wide cracks were observed in
Nikaweratiya houses. All the failed Earth based walls (Nikaweratiya & Deberawewa) high percentage of sand was observed in bricks. Further it was noticed that construction had been completed in a hurry (Nikaweratiya Gam Udawa 1983, Deberawewa related to Kataragama Gam Udawa) carried out without proper testing and quality control. All soils are not suitable for soil blocks and for soil blocks high percentage of clay is important (70%). Therefore both in Nikaweratiya and Deberawewa Earth based walls have been a failure due to wrong soil and bad construction. However, house in Badulla proves that good quality soil blocks can be made in Sri Lanka. Therefore it is possible to conclude that low cost soil block walls were possible in Sri Lanka, however testing and quality control should be maintained.

3.2.2 Rammed earth walls

One successful rammed earth house was inspected in Kirulapana Army camp. The walls are strong and no cracks were observed. Further 39 Similar houses are being built in Udupila by the Sri Lanka Army. One storey with concrete column and two single storey rammed earth wall houses were inspected in Minuwangoda. The two storey house is satisfactory but one crack was observed near a window. One of the two single storey houses in Minuwangoda had collapsed. The house which is still standing is supported by corner burnt brick columns. During the construction of Minuwangoda two single storey houses load tests held at Moratuwa University proved earth walls with very unsatisfactory compressive strengths (less than 1.4Xdead load stress). The good rammed earth wall house constructed by Sri Lanka Army has demonstrated that good rammed earth walls can be constructed with correct techniques. However proper selection soil and stabilisation method, good quality control are required to obtain a good earth rammed wall.

3.2.3 Cost savings from low cost walls

Walls can cost 20-40% (Sceley 1976) of the total house. Therefore cost savings in walls can produce a good low cost house. In many published research cost savings from new methods were not given. Therefore in this study special effort was made to establish cost savings from various low cost housing methods.

The cost savings given in the paper were calculated by comparing the cost of owner supervised houses with traditional building materials; i.e. burnt bricks for walls. Whenever possible the priced bills of quantities related to the new low cost methods were collected. It was not possible to obtained the priced bills of quantities or actual costs of walls incurred for unburnt brick houses (Nikaweratiya, Deberawewa, Badulla) as well as rammed Earth houses (Kirulapana, Sri Lanka Army & Minuwangoda houses). However, prices of unburnt bricks were obtained from Kalutara where unburnt bricks are available for sale. Further prices of large burnt bricks which are available in Ampara & Bandaraduwa were obtained. The information obtained are as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unburnt brick 135x265x90 (Kalutara)</td>
<td>Rs.0.75</td>
</tr>
<tr>
<td>Burnt brick large 150x230x130 (Bandaraduwa)</td>
<td>Rs.2.00</td>
</tr>
<tr>
<td>Burnt brick large 130x225x90 (Ampara)</td>
<td>Rs.1.80</td>
</tr>
<tr>
<td>Clay (Kochchikade) - 1 cube</td>
<td>Rs.200.00</td>
</tr>
</tbody>
</table>

Using above information collected, priced bills of quantities and BSR of Building Department the following cost savings for different methods were obtained.

<table>
<thead>
<tr>
<th>Method</th>
<th>Percentage of cost saving in walls compared to 4.5' brick wall</th>
<th>4' block wall</th>
<th>9' brick wall</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Unburnt bricks with clay mortar</td>
<td>68%</td>
<td>79%</td>
<td>83%</td>
</tr>
<tr>
<td>2. Large burnt bricks with cement mortar</td>
<td>18%</td>
<td>51%</td>
<td>56%</td>
</tr>
</tbody>
</table>

The analysis on Nikweratiya houses proved that the use of unburnt bricks can save approximately 26% of the total cost.

3.2.4 Recommendations

Successful soil blocks have been recorded in Sri Lanka. For good soil blocks good soil and suitable stabilisation may be required. This should be researched and good soil blocks should be introduced to house construction. A total of 65% to 85% wall cost can be saved using soil blocks for walls.

Successful rammed earth walls had been used in Sri Lanka. The constructed houses have proved good strength and quantity walls are possible using rammed earth techniques. Selections of correct soil is important and for the good quality control and testing are required during construction till the construction industry get familiarised to select suitable soil, stabilisation method and construction techniques.

In some places in Sri Lanka large good burnt bricks are available. These large bricks can be produced much cheaper walls than blocks or standard bricks. Introduction of large brick in Colombo and other places should be studied.

Walls of 1:12 cement:quarry dust with coir fibre are satisfactory and could be used in much wider application.
4.0 Houses with Low Cost Roofs

4.1 Low Cost Roofing Materials

Two houses, one in Panadura and one in Badulla inspected with coir fibre cement sand mortar roofing sheets. Sizes of sheets are 3'6" x 8' (width x length, Badulla) and 3'6" x 6' (Panadura). Badulla house had been constructed in 1979 (13 years old) while Panadura house had been constructed in 1984 (8 years old). Except for one crack with no leaks of Panadura house no other crack was reported. Coir fibre cement sand mortar sheets had been experimented with the use of cattle sheds in Nikeweraliya Gam Udawa project. Since sheets had been used in cattle sheds without proper support, all the roofing sheets had been cracked. It is important to note that both Panadura and Badulla houses do have good roof structure; i.e. 2" x 4" timber purlins. Considering Panadura and Badulla houses it is possible to conclude that coir fibre cement sand mortar sheet are durable and suitable as roofing sheets in Sri Lanka. As stated by Dias et.al. (1986) an Rai and Dave (1991) significant cost savings (30 to 50%) can be achieved by using coir fibre cement sheets.

Several houses (more than 30) inspected in Kirulapana with coir fibre cement sand mortar tiles. These houses had been constructed in 1985. 20% (6 out of 30) reported some water leaks while 26% (8 out of 30) reported minor leaks, others (54%) reported roofs as satisfactory. Tiles are in good condition and fibres also in good condition. Furthermore Sarvodaya have used a similar tile in their training workshops in Peradeniya. These coir fibre cement sand mortar tiles are available from Sarvodaya. It is possible to conclude that coir fibre cement mortar tiles are suitable for roofs in Sri Lanka. Micro tile roofs made out of cement sand mortar produced by ICTAD was inspected at Maligawatte and Kandy-Pallekele Gam Udawa project. These tiles are similar to Sarvodaya and Kirulapana tiles but without coir fibre.

4.2 Low Cost Roof Structures

Asbestos sheets without the traditional timber roof structure have been used a housing scheme in Maligawatte. The structural arrangement is given in detail by Kulasinghe (1989a, 1989b, 1989c). Eventhough NERD Centre has given a guarantee for safety the occupants of Maligawatte houses are not yet accepted the roof as safe; i.e. they still live in fear and some are planning to put some supporting structure for the roof. NERD Centre has demonstrated the use of pre-cast pre-stressed concrete and clay rafters and pre-cast concrete reepers. These should be applied for wider use.

4.3 Cost Saving from Low Cost Roof Methods

It is very difficult to forecast the exact cost savings from different low cost roofing methods. However, considering the published information and data from bills of quantities the following cost savings can be predicted. The cost savings given are compared with normal asbestos sheet roof.

<table>
<thead>
<tr>
<th>Method</th>
<th>Cost saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Coir fibre cement mortar sheets</td>
<td>10 to 30%</td>
</tr>
<tr>
<td>2. Coir fibre cement mortar tiles</td>
<td>10 to 25%</td>
</tr>
<tr>
<td>3. Cement mortar micro tiles</td>
<td>0 to 20%</td>
</tr>
<tr>
<td>4. Asbestos roofs without timber structure</td>
<td>30%</td>
</tr>
</tbody>
</table>

4.4 Recommendations

Coir fibre cement sand mortar sheets and tiles are durable and satisfactory and 10 to 30% cost saving can be achieved compared to asbestos roofs. Therefore steps should be taken for wider application of coir fibre cement mortar tiles and sheets. Since asbestos is cancer causing (both blue and white fibres) and banned in many developed countries coir fibre cement sheets will be a good substitute for asbestos sheets.

The cost of coir fibre cement mortar sheets/tiles and micro tiles can be reduced by mixing rice husk ash (Ranasinghe 1986) with cement. This should be investigated.

The use of pre-cast concrete and clay elements in the roof have high potential for cost savings as timber prices are increasing continuously. Therefore steps should be taken to apply these for a wider use.

5.0 Houses with Low Cost Doors and Windows

5.1 Door and Window frames

Several houses in grandpass, one house each in Panadura and Badulla had been constructed without door and window frames while 30 houses in Maligawatte have concrete frames. Grandpass, Panadura and Badulla houses are satisfactory except for supporting arrangement of one window shutter of Panadura house. Some Maligawatte houses reported defects related to locking arrangements and difficulty in closing and opening. Some houses (6 out of 30) of Maligawatte scheme have fitted with traditional timber windows.
5.2 Windows and doors

NERD has used pre-cast concrete frame glass windows. In some windows fine cracks (could be shrinkage) were observed. Further NERD has used concrete doors and some doors showed cracking near supports. NERD has proved that 50% cost can be saved by using their doors and windows.

5.3 Recommendations

Satisfactory arrangement to have doors windows without frames is practically possible. This reduces the cost door and window frames. Pre-cast concrete related doors and windows need improvements with respect to fixing arrangements.

6.0 Conclusions

Successful soil stabilised blocks and rammed earth wall houses had been constructed in Sri Lanka. Successful and unsuccessful earth based wall methods have proved that correct selection of material and good quality control are required for good earth based walls.

Cement:quarry dust (1:12) mix with coir fibre and slipform technique can produce satisfactory low cost walls.

Cost effective large burnt bricks are available in some parts of Sri Lanka.

Coir fibre cement sand mortar sheets and tiles are satisfactory and durable for roofs in Sri Lanka. Mixing cement and rise husk ash could produce much cheaper tiles.

Satisfactory methods have been developed to reduce the use of timber in roofs.

Door and windows can be fixed to walls without frames. Concrete doors and windows need improvements.

Materials such as treated rubber wood bamboo, sugar industry residue, rise husk ash etc. can be used to produce low cost houses.

Approximately 25% total house cost saving can be achieved using unburnt bricks, soil blocks or rammed earth method. The use of coir fibre cement sheets or tiles can save approximately 10% to 30% of the roof cost. Considering feasible low cost housing methods approximately 40% cost compared to owner supervised normal houses can be saved.

The survey proved that most of the owner supervised and constructed house have poor cost effective designs. Therefore for low cost houses optimum designs should be used, i.e. low wall/floor area ratios.

7.0 Acknowledgement

I would like to acknowledge the help received from the following organisations and persons.

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- Mr. Sanjeewa Nishantha and Mr. Dinuka de Silva for assisting me in the field survey.

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