Vault Roof and Mud-walled House

Problem/Need

The depletion of building resources like timber, bamboo and thatch have progressively made the village house-builder's jobs more and more difficult. Timber used to be the principal structural material while bamboo came in handy for almost everything. Shrinking forests have contributed to removing timber and bamboo from the reach of the poor. Even thatch has become scarce and the frequent repair require for thatch roofs make them problematic. Local mud fortresses or *garhis* furnished excellent building mud. These *garhis* are getting extinct and the resource drying out. Black cotton soil is unfit for wall making. The need therefore is to have a roof timber or thatch along with mud walls using ordinarily available soil.

Approach/Strategy

The above need was sought to be met through designing a low-cost house with an arched roof of hollow cylindrical clay tiles resting on a ring beam supported by brick pillars, while the non-supporting walls are made from non-erodible and rodent-proof mud walls using special techniques. This technique has been developed and propagated by Centre of Science for Villages (Wardha).

Technology Package

⇨ **Guna Vault Roof:** "Guna" in Telugu, is a tapering, burnt clay pipe. The familiar semi-cylindrical pan tiles are obtained by splitting such pipes vertically into two. These "Guna" tapering pipes can be socketed into one another forming an arch over a suitably curved shuttering. A series of such arches make a barrel vault capable of withstanding considerable loads – upto 1 ton/m2. The top of the roof is given a plaster finish. After joints are filled and topped with plaster, the roof becomes rigid and waterproof, doing totally without steel or timber. The cost of this roof works out to Rs. 20/sq.ft. It has the following advantages:

- Air inside the hollow-tiled roof protects from heat and cold. A 10^{o} temperature difference is observed in slab roof and guna vault roof.
- It has no under structure, yet can bear weight of 1000 kg/m2.
- It is fabricated and ready for use within 3 days.
- Requires no maintenance and has life span of more than 50 years.
- It is not affected by rain, hail or wind.
- Being light in weight (less than 12 kg/sq.ft). the vault roof is safe even in earthquakes.
- Even if the mud walls collapse, the roof remains intact residing on pillars and beams.

After construction of brick pillars, ring beams and gable walls, the M.S. trusses are placed in position above the opposite pillars held with guy ropes and timber poles. Now GI pipes (12 mm dia., 10 nos.) are placed on the trusses in the MS rings provided at specific points. They are supported by gable walls at both ends. Guna pipes are now laid dry on this skeleton shuttering in a plug-socket manner, completing the roof ring by ring. Lime/cement mortar is now poured on the roof, trowelling it into the gaps and leaving the top rough to receive the finishing coat. Care is taken to remove the skeleton support within 12 hours to allow natural setting.

⇨ **Tile-faced Mud Blocks:** Several combinations of the locally available Black Cotton (BC) soil, which has good binding properties, with bhaswa and murram (hard soil) are possible for making adobe blocks. One part of BC soil to four parts of murram makes strong blocks with reasonable stability through moisture cycles. However, the exterior face of a mud wall succumbs to

weathering and consequent erosion necessitating maintenance cycles beyond the time resources of poor daily-wage labourers. This enforced neglect is commonly noticed in dilapidated walls. CSV's Wardha Blocks have combined the low cost of mud with weather resistance of terra cotta. One face of the block is provided with a weatherproof skin, a bunt clay tile with a dovetail key at the back to anchor it to the block. Red clay pottery continues to be a traditional skill in the region. These tiles draw on these skills and resources, for this new product. The tiles are made with simple techniques using wooden moulds. The face tiles measures 9" x 4" x ½ " and has a key 1" key projection. Householders can also make it. One woman can make 250 such tiles a day, which can then be baked locally by the village potter. Each face tile costs 40 p. or less.

⇨ **Moulding the Mud Block:** Standard block size adopted at CSV is 225/300 x 100 x 225 mm (9"/10" x 4" x 9") taking into account ease of handling. One may use wooden or steel moulds, as available. A pair of workers usually produces 200-225 blocks per day. The facing tile is placed in the mould box with its face side touching the mould wall. Mud mortar (1 part BC soil to 4 parts murram) is poured at the back, working it well around the dovetail key.

⇨ **Rain-proof & Rodent-proof Mud wall**: With no need for a press or a ram or cement, the tile faced blocks are put out together to form walls that look and feel like pucca brick walls and do not allow water or rats to enter. In BC soil, 9" x 9" brick pillars support the roof usually at 5 ft. intervals. If required the inner surface of the wall can also be tiled to a height of 2-3 ft.

⇨ **Rain Beam**: The sideways thrust of the vault roof requires to be overcome by a ring beam of 3" thickness. This is reinforced by three 8 mm bars. Extending and adding 1 ft. around the house, the total steel used for a 250 sq. ft. house is less than 50 kg.

CSV has integrated these features into a twin house design and built a few hundred house dispersed in several locations in the district. At 1993 prices each house costs approximately Rs. 8500.

System Design

Given the raw materials, i.e. the guna roof tiles, wall tiles, bricks, cement and miscellaneous building materials as indicated above a team trained in these techniques can undertake construction of twenty houses (ten twin houses) in a month and a half. Local artisans and labour will be utilized. In each district 10 such teams can work simultaneously. To maintain a supply of tiles, 15 potters will be engaged all the year round. The techniques being simple for traditional artisans to learn, on-job training of masons and potters can be done in a short period. 2 masons and 1 potter may be trained at CSV for 3 months and they should subsequently train others.

Economics (Low-cost houses for landless labour under RLEGP/JRY)			
Description	**Quantity**	**Rate**	**Amt. (Rs.)**
Excavation for foundation	126 cft.	68.00/100 cft.	85.68
Foundation, uncrossed rubble masonry	160 cft.	19.20/cft.	3,072.00
Brick pillars	34 cft.	30.00	1,020.00
Wall of tile faced sun dried mud blocks	150 cft.	13.50	2,025.00
Ring beam	10.31	135.00	1,391.85
Gable wall	60 cft.	13.55	813.00
Guna vault roofing	201.25	25.50	5,131.88
Ordinary wood doors	2 nos	275.00	550.00
Window with grills	3 nos	35.00	105.00
Flooring	Lumpsum		180.00
Total			**14,374.41**

Helpline:

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