Cost Effective and Innovative Housing Technology

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Abstract— Shelter is amongst the three basic human needs but now-a-days, about two-third of the total Indian population does not have their own shelter. This two-third population belongs to the middle and lower income class. These people find it difficult to construct their houses at an affordable cost by using conventional construction technology. It is found in many cases that people serve their whole life constructing their own house, but fail. The mission and dream of these people can be achieved by appropriate use of cost effective and innovative construction technology. As a whole, the housing shortage of the country can be overcome within lesser funds, without compromising with the quality control and structural stability of the structure.

Note: This technology is only applicable for single or two storied buildings and can be applied in most of the soil and climatic conditions.

Key words:

- **R.C.C.:** Reinforced Cement Concrete is the combination of steel and cement concrete used in building construction.
- **Brick Arch:** An arch is a structure that spans a space and supports structure and weight above it. An arch is a pure compression form.
- **Corbel:** Corbels are the projections in walls to support a structure over it.
- **Slab:** A large, thick, flat piece of stone or concrete, typically square or rectangular in shape.
- **Superstructure:** The part of the structure above the surface of the earth is superstructure.
- **Foundation:** The part of the structure below the surface of the earth that transmits the total load of the structure to the soil is known as foundation.
- **Brick Masonry:** A type of construction that has units of baked clay or shale of uniform size, small enough to be placed with one hand, laid in courses with mortar joints to form walls, pillars and various structures.

I. How to reduce the building cost without compromising its quality control and structural stability:

This can be done at four different levels in the structure, starting from slab at the top to the foundation at the bottom.

A. Slab:

In our work we have used filler-slab technology. Filler-slab technology is nothing but an alternative of R.C.C. slab. The reason why, concrete and steel are used together to construct RCC slab, is in their individual properties as separate building materials and their individual limitation. Concrete is good in taking compression and steel is good in tension. Thus RCC slab is a product which resists both compression as well as tension. The basic concept behind the use of filler-slab technology is to reduce the use of substantial portion of concrete below the neutral axis. A lot of concrete below the neutral axis does not contribute to the tensile properties, hence serves only as filler material. Concrete below the neutral axis serves the only purpose of resisting the shear force and connecting the bars to the compression zone. This portion of concrete can be replaced by locally available and light weighted filler materials such as double-layer mangalore tiles, hollow burnt bricks or conventional bricks, hollow concrete blocks, etc., which are less costly, locally available and possess better thermal insulation properties. It reduces the dead load of the slab as these materials are light in weight as compared to the conventional R.C.C. slab that use concrete only. This in turn reduces the quantity of reinforcement used in the slab thereby reducing the cost of the slab. Filler slab technology is being used across India, but substantial amount of work on the successful promotion and transfer of this technology was done by Ar. Laurie Baker in South India. It is one place where filler slab has crossed the boundary of research and controlled implementation to being one of the regular options of construction by both government and private sector and also architects and designers have been promoting this technology.

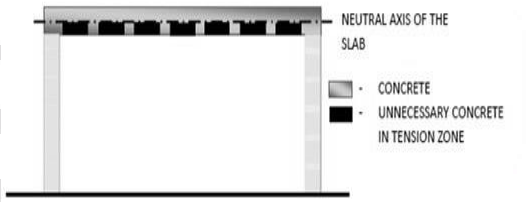

Fig. 1: Demonstration of neutral axis and unnecessary portion of concrete in R.C.C. slab

Fig. 2: Snapshot showing the masonry construction of Filler-slab technology

Fig-3: Demonstration of arrangement of filler material (here bricks) in filler slab

B. Doors/Windows/Ventilators/Veranda openings:

As compared to the total cost of brick masonry work, these are about 10 times much costlier. By effectively using brick arches, brick corbels and simple jaali works, the need of reinforcement can be minimised at some places as well as totally avoided at other. Brick arch is much less costly, have better look and can be made in a variety of shapes and sizes.

Corbels are the projections in walls to support a structure over it. Corbels can be made in a variety of shapes and by a variety of materials, but here as far as cost efficiency is concerned, we can use simple brick masonry corbels. At some places, the cantilever beam or projection can be converted into a simply supported by the effective use of corbels. This reduces the use of reinforcement, cement and concrete thereby reducing the total cost of construction. This is highly cost effective as well as highly stable and durable because all the structural members are converted into compression zone.

Fig. 4: Picture showing one of the structures which is sconstructed for testing the complete work

Fig. 5: Simple brick corbel plastered to give a finished look in the interiors

Fig.6: Effective use of corbels in the exteriors to completely avoid the cantilever projections

Fig. 7: Combined use of projected brick arch and corbels over window opening

C. Superstructure walls:

For Superstructure walls, we have used rat-trap bond brick masonry work. This is also 9 inches (23 cms) thick, load bearing wall but in this type of wall construction, bricks are used in such a way that it creates a cavity throughout the wall height. As far as load bearing is concerned, it has 25% more load bearing capacity as compared to that of conventional English or Flemish bond brick masonry work. By using this technology, we can save 25% of total number of bricks used as well as 33% of the total mortar used. In addition to these, it has better thermal insulation properties between exteriors and interiors, i.e., 4-5 degrees cooler in summers as well as 4-5 degrees warm in winter. This thermal insulation property is developed because of cavity present in the wall.

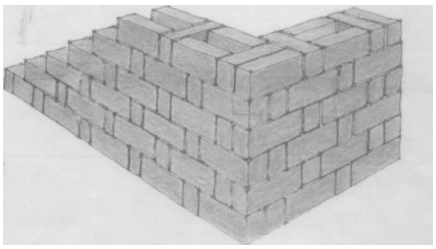

Fig. 8: Rat-trap bond brick masonry work

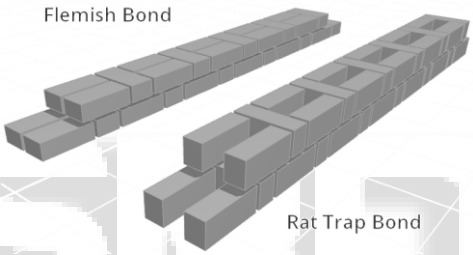

Fig. 9: Rat-trap bond brick masonry and its comparison with conventional Flemish bond brick masonry work

D. Foundation:

For single or two storied buildings, 18 inches (46 cms) thick foundation is adequate when we use the above mentioned criteria. This is very less as compared to that of conventional building construction system (in conventional building construction system, the thumb-rule used for calculation of width of the foundation is, width of foundation (cms) = [2T+30] cms, where T is the thickness of wall in centimetres). By comparing both, it is found that about 40% of the total brick masonry is saved in the foundation as well.

Material	**Rat-trap bond**			
	Unit	Quantity	Rate	Amount
Bricks	Number	370	6 per unit	2200
Cement	Kg	30	5.6 per kg	168
Coarse Sand	m^3	0.142	1050 per m^3	149.1
Mason	Number	1	300	300
Labour	Number	1.50	250	375
	Total			3192.1
	Water charges at 1.5%			47.88

	Total Expenditure=	3239.98

Table 1: Cost approximation of Rat-trap bond brick masonry wall of one square meter

Material	**Solid English bond**			
	Unit	Quantity	Rate	Amount
Bricks	Number	487	6 per unit	2922
Cement	Kg	62	5.6 per kg	347.2
Coarse Sand	m^3	0.227	1050 per m^3	238.35
Mason	Number	0.82	300	246
Labour	Number	1.32	250	330
	Total			4083.55
	Water charges at 1.5%			61.25
	Total Expenditure =			4144.8

Table 2: Cost approximation of solid English or Flemish bond brick masonry wall of one square meter

Adding other charges (including scaffolding charges, water charges, etc.) to both Rat-trap bond and solid English bond, the cost of Rat-trap bond does not increase 3350/- and that of solid English bond does not increase 4400/-

On comparison of data in the above two table (cost approximation of walls only), it can be calculated that about 24% of the cost is lesser in Rat-trap bond masonry work as compared to that of solid English bond masonry work whereas when all other technologies are also combined, the overall saving increases upto 30-35%.

II. Conclusion

By using the above mentioned technologies, about 30-35% of the total cost of construction of a single or two storied building can be saved without compromising its quality control and structural stability. Although, there is reduction in the use of costly building materials, the used materials are compiled in such a way that the structural strength and its durability increase as compared to the conventional building construction technologies. We have converted the tension members to the compression members which themselves are highly stable. The total cost of construction of a building can be broken into two parts, i.e., material cost which is 70% of the total cost and labour cost which comprises the remaining 30% of the total cost. By effective use of all the above mentioned technologies, we make a huge savings in the material cost. Even though the labour component increases slightly but then too about 25-30% of the total cost is saved, keeping in concern the structural stability and quality control of the structure.

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