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Cost-Effective Construction Technology

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Abstract—*Cost efficiency is one of the major concerns with the country having millions of homeless families, it is imperative that what money is available must be used only for essentials, and none of it for needless doing. Choice of building materials, methods & technologies are the factors that must be kept in mind. Laurie baker, an architect from Birmingham, had effectively combined traditional techniques with indigenous innovations and has managed to bring down the cost of construction by half. His techniques, which have been elaborated not only use cheaper materials but also eliminate redundant details from the design.*

The paper aims to point out the various aspects of building methodologies for low cost construction, and the economic advantages achieved by its adoption. In a building the foundation, walls, doors and windows, floors and roofs are the most important components, which can be analyzed individually based on the needs thus, improving the speed of construction and reducing the construction cost. The materials and current methods of construction systems considered here are namely, Arch foundation; Stone foundation; Bamboo and coconut piles; Mud wall /Cob wall; Wattle and daub wall; CEB wall; Rat-trap brick bond; Four and half inch or half brick walls; Funicular roofs; Ferrocement channel/shell unit. And cost-effective appropriate materials like stabilized compressed earth blocks; non erodable mud plaster; fly ash gypsum; stabilized mud blocks; flyash-lime gypsum products; clay red mud burnt bricks; precast stone blocks; precast concrete blocks and various natural stabilizers and also few effective techniques to save material in foundation and plinth construction are elaborated.

Pointing, Lintels, Corbel arch, Articulated slender masonry wall, Frameless doors and windows, Honeycomb brickwork brick jail, Bamboo mat boards for flooring, walling, structural membrane, false ceiling, door/window frames; RCC filler slab, Fencin / compound wacortlls are also important considerations to achieve cost-effective construction.

1. INTRODUCTION

Housing is an indispensable need after food and clothing. As economic growth is the primary objective of India's overall development. Various actions, initiatives, policies are being undertaken to set up an environment for low cost housing. Pradhan Mantri Awas Yojana launched in 2015 providing Housing for all is an enterprise taken by Prime Minister Narendra Modi.

In addition to these government interventions, there is a need of innovative construction practices and use of contemporary technologies to lower the cost of construction of a house for fulfilling our vision of achieving economic growth.

A compendium of different substitutes both in terms of materials and technologies is discussed which are cost effective and energy saving following the principles of construction methodologies by Architect Laurie Baker who revolutionized the world by his sustainable architecture that moved an adroit and novice alike.

2. COST-EFFECTIVE APPROPRIATE MATERIALS:

2.1 Stabilized compressed earth bricks

These are made of mud balanced out with 5% bond/lime and so forth and compacted in brick making machine with no consuming. It is a decent walling material as burnt bricks and is sparing, more grounded, vitality sparing and easy to fabricate.

2.2 Fly ash gypsum stabilized mud bricks

The bricks are considerably more grounded with less water retention and less expensive than bond settled pieces with 5 to 10% fly ash, 30% sparing in concrete could be accomplished not withstanding usage of the waste item like fly ash.

2.3 Fly ash- lime gypsum products

The products are fabricated by mixing fly ash lime and calcined gypsum for making a helpful item named fal-g, and can be utilized a cementations material for mortar/mortar and for stone work pieces of any coveted quality. It can likewise be utilized for street asphalts and plain cement as fal-g concrete.

2.4 Clay red mud burnt bricks

Delivered from alumina red mud or bauxite, a modern misuse of aluminum creating plants in blend with mud. Having all the physical properties of typical mud bricks it also takes care of the issue of transfer of the waste item and natural contamination. Moreover it has great engineering an incentive

as confronting bricks because of the satisfying tints of shading.

2.5 Precast stone bricks

They have bigger size than ordinary bricks and are produced by utilizing waste stone bits of different sizes with lean bond concrete and empower a legitimized utilization of normal locally accessible materials. molding stones in this way empower quick development, saves money on bond, decreases thickness of stone walls and impacts general sparing by dispensing with mortars on inner/outer divider surfaces.

2.6 Precast concrete bricks

Bricks made to comparable measurement of bricks without substantial size stone pieces, yet utilizing coarse and fine evaluated bond. They have first-grade properties tantamount to other stone masonry bricks, are less expensive and encourage fast development and particularly reasonable where quality earth for bricks making is not accessible.

2.7 Stabilizers

- In mud soils, the straw appears to limit breaking and nearness of straw tends to make the soggy bricks more utilitarian. Like straw, individuals in various territories utilize chaff (bhusa) and different fibres.
- Cow fertilizer contains a considerable measure of stringy material and generally is regularly utilized as a part of a wide range of mud work.
- Urine is likewise utilized as a result of the urea content which goes about as a binder.
- Sugar, molasses and rough waste jaggery is a valuable binder and water sealing material.
- Tannic corrosive and its squanders, utilized as a part of other provincial ventures are also used.
- Oil is utilized chiefly for water sealing the surface of walls. Presently squander motor oil or sump oil. This functions admirably as a waterproofing in bond concrete and in addition in mud walling.
- Plant juices like sisal, desert flora and so forth.

3. COST-EFFECTIVE APPROPRIATE TECHNOLOGIES:

3.1 Foundations

Ordinarily the foundation cost comes to around 10 to 15% of the aggregate building. At the point when soil is poor and delicate it is normal to burrow a wide trench and cover the base with cement. On this a wide stone divider 50-60cm is based on top of that. At the point when the dirt is solid and hard there is no requirement for either to concrete or form a layer of thick stone work. For small shelters there is no compelling reason to assemble the upper brick walls over the center of the foundation wall. Set the upper divider over the external portion of the foundation walls. It anticipates rain leakage. When uncovering the trenches for the foundation walls, the dirt should not be scrambled everywhere, it should be kept and large in the center as it will be required for infilling in the middle of the plinth wall from ground level to floor level. It is prescribed to receive a foundation profundity of 2 ft. (0.6m) for ordinary soil like gravely soil and red soils.

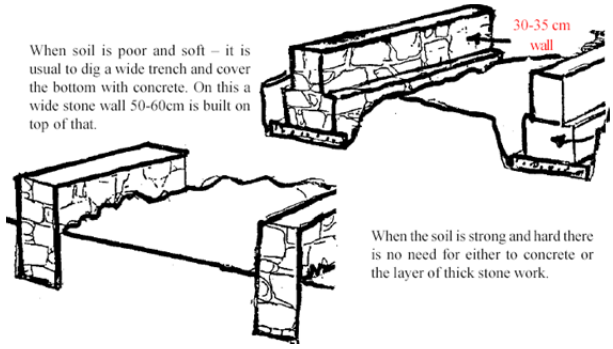

Fig. 1: Former shows the use of wide stone in case of delicate soil while in latter one, wide stone is not used because of strong soil

3.2 Arch foundation

It is proposed to receive arch foundation with replacement of spread foundation for common soils. Upto 40% construction cost is diminished, benefits of this is in delicate soils that the profundity of foundation can be enormously lessened; drawback is that the end piers must be exceptionally fortified by buttress to stay away from the thrust to arch activity inclined to rapture piers intersection.

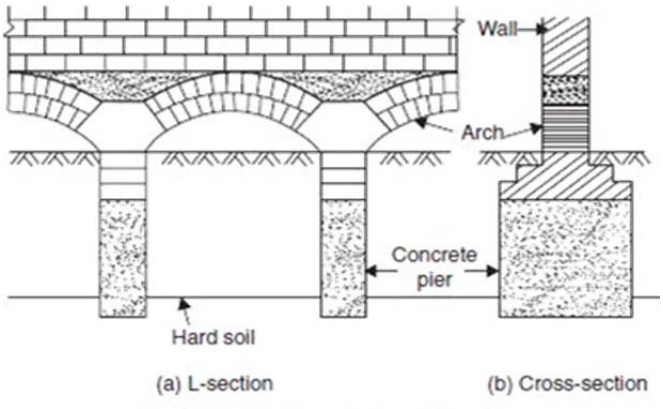

Fig. 2: L-section and cross section of an arch foundation

3.3 Stone foundations

Dry stone brick work loaded with local soil/stone masonry in mud mortar: Random rubble: 45 cm wide foundation is normally adequate for 2 storey structures in soils with 10mt/sqm safe bearing capacity. Stone foundations stop few times at floor level i.e. 30 or 40 cm over the ground level, take them 45 cm higher and you have an instant bed or seat.

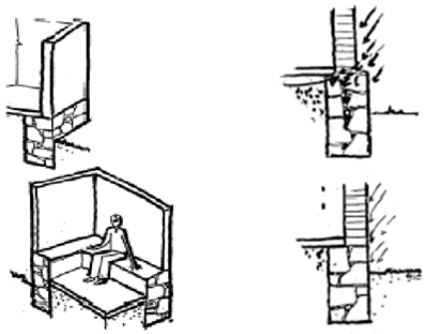

Fig. 3: Space for sitting in stone foundations

3.4 Bamboo, coconut piles

Another utilization for split building bamboo in lime cement is for foundations, particularly in sandy regions along the ocean drift. Concrete or the reinforcement are not affected by salt and saline. While, common foundations will break with moving sands.

3.5 Plinth

It is prescribed to embrace 1 ft. height over the ground level for the plinth and might be developed with a concrete mortar of 1:6. The plinth section of 4 to 6″ which is generally accepted can be maintained a strategic distance from and in its place brick on edges can be utilized for lessening the cost. This method the cost of plinth foundation can be lessened by around 35% to half.

3.6 Mud wall/Cob wall

Shielding is required for the base of mud walls from rooftop rain water sprinkling up from the ground. Cob is framed with blending soil with a little water - getting it as much as you can in your two hands and making a 'roll', these rolls firmly put together in lines; then smooth one of the closures. It is useful for curved walls and circular walls yet are not high walls.

3.7 Wattle and daub wall

This arrangement of utilizing mud for house building is more common in India's eastern states. Often used in bamboo developing zones. It is durable and "safe" in ranges inclined to earth tremors. It is likewise versatile to any state of building.

3.8 CEB wall

Brick work units delivered by mechanically compacting a blend of an appropriate soil balanced out with concrete or lime, standard stabilizer rate 5 to 8%, may require expansion of coarse sand in a few soils. Worthy soil – sandy soil with 10-15% dirt. Benefits include:

- It can be extremely financially savvy, particularly when the pieces are created at the site of utilization.
- Soil is an accessible asset in rural housing.
- provides a strength quality of around 50 kg/cm2
- Thermal comfort can be achieved.
- Provides aesthetical divider, no mortar required.

3.9 Rat-trap bond

The rat trap bond is a stone work strategy, primarily obscure in India, however utilized as a part of England for as long as a few hundred years. It is as solid as alternate bonds yet utilizes 25% less bricks and mortar. Bricks are laid around edges, not flatten, making a cavity. The cavity in the rat trap bond guarantees great protection from warmth and cold. This can be demolished by a poor artisan recklessly slopping mortar into the pit while he is building.

To maintain a strategic distance from this:

1. Ensure the mortar is not very wet, and

2. Use of 3" wide segment of wood, laid over the cavity and placing the mortar on both sided of it. (No mortar is required on the center of the cross brick.) When laying out a brick wall of a particular length, constantly first lay out one column of bricks. This may leave a little crevice, or over-run end of the wall. Try not to embed a little piece – by doing as such you will make holding issues up the entire height of the wall. Just by moving every brick a small portion one can make the correct number of bricks that fit effectively into the length of the wall required.

3.10 Four and half inch or half brick walls

Assuming legitimately and very much built and reinforced, in short extends, (up to 2 m), are sheltered, solid, and generally fit for carrying an upper story. A decent rooftop overhang (50 cm) will provide protection to the walls from driving precipitation and sodden. Straight, long, thin walls can't be relied upon to carry rooftop stacks and should be required to lump, split and break, if not very much arranged.

3.11 Funicular roofs

A funicular rooftop is a substitute to rcc rooftops. The funicular shell rooftop is one such compressive structure, which guarantees protection of regular assets by using waste materials adequately and upgrading the utilization of costly steel and bond. Further, the arch circulates the point stack toward all path. Similarly in this way, it can withstand impact load anytime. Edge to edge framework of funicular shell gives the illusion of a bigger space and limits necessity of inside mortars.

3.12 Ferro cement channel/shell unit

It provides a financial answer for RCC piece by giving 30 to 40% cost lessening on floor/rooftop unit over RCC slabs without trading off the quality. These being precast, development is quick, practical because of shirking of covering and encourages quality control.

4. IMPORTANT CONSIDERATIONS

In a few regions granite is part from extensive rocks to give posts and slabs. You can consolidate these stones as shelves, lintels, window "grills" and furniture. Short broken posts can as a rule be had at low costs. Damp proof course (DPC) a blend squander engine oil (25% of cement by volume) in mortar for first course of brick work. Such considerations can greatly impact the construction cost. The methods mentioned below can be helpful for the same.

4.1 Pointing

It gives an even finish to an unplastered wall and is typically made as an addition showing extra potential after the wall development is finished. Considerably less exorbitant is to lay the mortar followed by placing on it the bricks, giving a gentle blow with clench hands to the brick and after that pressing in the swelling mortar with trowel.

4.2 Lintels

A ton of superfluous steel and bond cement is utilized for lintels. Rather, placing one line of bricks on the edge over the casing (or space) and above it, one on each side, a column of more bricks on edge. The space between these upper two columns of bricks then filled with cement in which a small steel rod is set. The main weight of the lintel is eventually carrying a small triangle of brickwork. All other weight of walls/floors above are conveyed by the wall along the edges of the opening.

4.3 Corbel Arch

The standard round and segmental arches require covering or support during construction. The corbel arch needs no support and is to a great degree and simple to make. One fourth of a brick is stretched out from the brick underneath it. The essayist effectively utilized such "Arches" over openings up to 5 meters wide.

4.4 Arches

Arches can be of various shapes and sizes and are considerably less exorbitant than RCC lintels. Be that as it may, while building them, some kind of edge work or, on the other support is vital. In one building there might be arches of various sizes so make the casing for the smallest – and include a line or two of dry bricks (no mortar) for the bigger arches. Squandering of bricks as often as possible should be done when assembling a brick wall, a half brick is required. Use and cut waste pieces of bricks as they are increasingly costly. Laying broken bricks close together, mixing on top a weak lime mortar and brushing it in shall give an excellent base for the tile or plaster flooring. For leech pits broken pieces can be placed in a circle with dry joints. Then a layer of horizontal mortar – and another layer can be made.

4.5 Articulated slender masonry wall

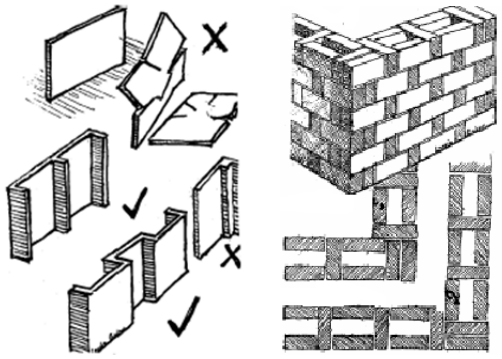

Fig. 4 : Dos and don’ts while laying slender masonry wall

4.6 Reconstituted stone blocks /stone filler blocks

If small pieces are accessible, reconstituted stone bricks give the best alternative masonry brick which can be utilized for establishments and walls. Squandering material substance 30-40% by volume of brick. then filling the stones of 50-70mm size and filling in lean cement in the middle of the stones and compressing with plate vibrator will give the desired results.

1. Frameless doors and windows

2. Door screens made of brick-board, ply, and molecule sheets make great other options to timber door shutters.

4.7 Honeycomb brickwork Jali

"Jali" - formerly punctured stone boards – is one of India's most established techniques for letting into a building filtered light and ventilation yet keeping up protection and security. Brick jali can work similarly – either as boards or as a total load bearing wall. There is the old "honeycomb" example of "jali" brick work. The openings can be augmented vertically. Floor to roof and segment to section, extensive boards can be "corrugated" or "folded" (for quality – and for four and half inch brick walls) and given top notch lighting and ventilation to passageways, classrooms, and for vast corridors and auditoria. Bay "windows" make astounding beds in the hot climate. Or, then again there can be rotating areas of one row of gaps taken after by 2 or 3 rows of openings, at that point the single gap line again and so on. Once the patterns have been utilized – a great artisan can devise and appreciate doing many other patterns.

Mortar usage must be avoided unless it is truly fundamental. Put everything over a building and it represents around 10% of the aggregate cost. Fungus growth develops on it outside. Individuals finger it, and incline toward it. It either looks grimy and revolting or there is a need to repaint it consistently at significant cost. There are a couple spots where it is valuable - kitchen, lavatories, however somewhere else, neat brick work looks better. Mortars and mortars cement (1 section) and sand (8 sections) utilize concrete just if nothing

else is accessible. it is an ‘energy intensive' material. lime (1 section), concrete (4 sections) and sand (14 sections) 1 section) and sand parts) useful for a wide range of brick and stone work. (The setting time is slower than concrete). Lime (1 section), cement (4 sections) and sand (14 sections) this sets practically as fast as concrete. Lime (1 section), surki (2 sections) and sand (6 sections) this is somewhat more grounded than lime alone and sets more rapidly. Lime (1 section), surki (2 sections), cement (4 sections) and sand (20 sections) this sets practically as fast as concrete. Mud utilizes a similar mud that mud bricks are made of. Filtering it and blending it with sufficient water to makes it plastic and usable.

4.8 Doors and Windows

Doors don't need to have frames, boards, and so forth a few planks can be settled together with strap hinges to shape a solid door. A tad bit of cutting can give a small example. The cost will be significantly less than a large portion of the cost of a typical door. A window with a frame and a shutter, with glass, and maybe a metal grill, is exorbitant. A standard 1" thick, 9" wide plank of wood, with an adjusted protrusion at both closures, will fit into 2 segments of wood (30 or 35 cm long, 8 cm wide) and you have a 'window'! Even when it is open, nobody can move through the two 4 inch openings, so no grill is required, if a bigger window is required, put 2 or 3 consecutively in a row.

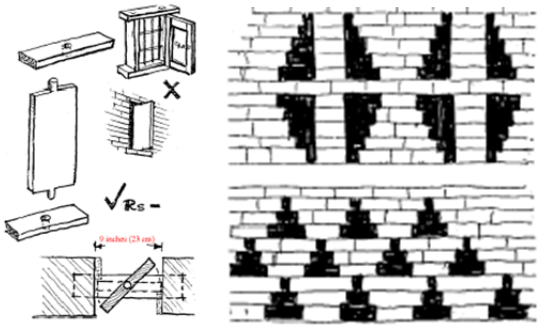

Fig. 5: Frameless door and honeycomb brick jali

4.9 RCC filler slab

Filler slab is a variation of reinforced cement solid section in which part of the concrete is supplanted with a filler material which can be a waste material to guarantee sparing preferred standpoint over a RCC chunk. The fundamental standard in a filler slab is that, considering a RCC slab of a given thickness, the solid in the base portion of the section is just dead weight and does not play a part in taking up compressive load, which is regularly taken up by cement in a RCC slab. Along these lines, concrete can be supplanted by a reasonable lightweight filler material which can be suited in the base portion of the slab. The design of the filler slab depends on similar methodology which are embraced for outline of regular fortified concrete slabs. The fundamental guideline of the filler slab is that for rooftops which are just upheld, the upper part of the slab – over the neutral axis - is subjected to compressive strengths and the lower part of the slab encounter tensile force in reinforced solid section the dead weight of its solid is heavy. This weight can be reduced by putting light weight material between the steel rods. The simplest "filler" is to utilize Mangalore tiles. These have no structural strength value – they are simple 'fillers'. Utilizing them spares around 30% dead weight of the "section" so less steel is required thus much steel, sand, concrete metal and cost is spared.

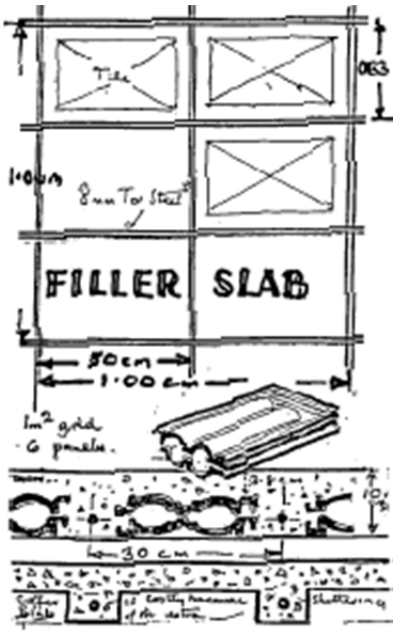

Fig. 6: Filler slab plan and section

4.10 Ferrocement channel

Reinforced concrete having numerous beddings of steel mesh or rods of small diameter which are filled with cement mortar when placed in close proximity has better reinforcing properties. Such an arrangement is Ferrocement channel. Synthetic, organic and natural fibers along with wire mesh for better reinforcement. Space in between channels can be utilized for intermediate floors. It leads to lessen the section thickness by 25 to 30 mm and steel by 50%. Its advantages are that it saves time, better control of quality, mechanized manufacturing and eliminate the need of intermediate beam up to span of 6 m.

Different profiles of ferrocment roofing channels

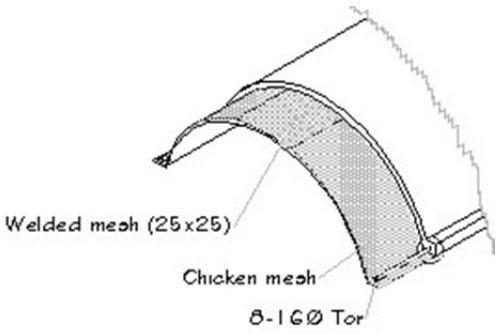

Fig. 7: Profiles of Ferrocement Channel

4.11 Thin RCC ribbed slabs

It comprises of reinforced cement concreter ribs of 110x200 mm2 placed at 1200mm per cubic centimeter which either is cast in situ or pre cast. A flange of thickness 50 mm flange is above. It reduces the cost by 22%.

4.12 Funicular shell

It is a shell made up of stones or bricks with two layers having curved profile with a small rise midway. Beam around it take up the horizontal thrust. Rise to span is in a ration of 1:6. To achieve flat surfaced roof, light weight material is packed and surface is layered with screed concrete. Various advantages includes efficient utilization of steel and cement, due to uniform distribution of load wall can be located anywhere on the floor above, aesthetically pleasing and possibility of artistic appearance and craftsmanship.

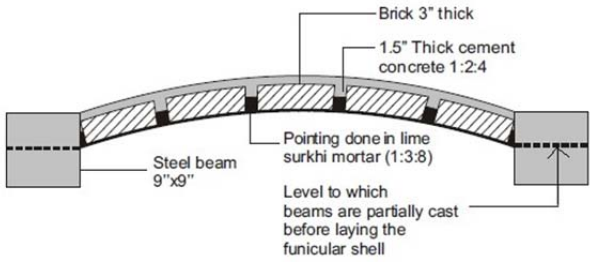

Fig. 8: Section of funicular shell

4.13 Flooring

For flooring, use of cemented floors laid above broken bricks or rammed laterite soil, recycled timber, terracotta tiles minimizes the cost. Special attention is to be drawn on wiring, reducing cable length, earthing and point locations for safety.

A mixture of bitumen and kerosene kneaded with soil mortar and straw when applied on wall surface, 12mm thick, helps reducing the erosion of mud walls during monsoon and thus decreases cost of repair. Double coating of cow dung slurry is put on once plaster dries. Due to high durability, maintenance cost come down.

5. CONCLUSION

Thus, for economizing the construction costs various techniques and technologies discussed should be practiced. Ambient climate, gradients, contours are to be given special attention to achieve cost effectiveness. Studying endemic architecture, principles and using energy conserving materials will aid in reducing cost and preserving environment. There's a need of spreading awareness among people to follow these ideas. Innovative technologies in addition to government interventions will prosper the economic growth and boost overall development of the country.

REFERENCES

[1] Costford, A manual for cost cuts for strong acceptable housing

[2] Ashish Batra, ArchiStud - where creativity takes shape of Cost Efficient construction Techniques, May 28,2008

[3] Devalt, Material and Technologyan inventory of selected materials and technologies for buildingconstruation.pdf

[4] Tara, Knowledge Development and Dissemination for Promoting Low Carbon Construction in the Rural Areas and Small Towns of India and South Asia.

[5] Sustainable Building - Design Manual: sustainable building design practices - TERI

[6] http://lauriebaker.net/

[7] Mahammad Shaik, Design analysis of low cost multi stored building using Staad Pro.