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LOW COST HOUSING: NEED FOR TODAY'S WORLD

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ABSTRACT

Low cost housing construction technologies aim to cut down construction cost by using alternatives to conventional methods and Input. "It is effective budgeting and technique which help in reducing cost of construction through use locally available material along with improve skills and technology without sacrificing the strength, performance and life of structure. ''Low cost housing merely satisfies the most bottom and fundamental human needs for shelter and neglects other needs that people aspire home including psychological, social, and aesthetic needs and ultimately, need for self-actualization. Construction cost in India is increasing at around 50 per cent over the average inflation levels. It have registered increase of up to 15 per cent every year, primarily due to cost of basic building materials such as steel, cement, bricks, timber and other inputs as well as cost of labour. As a result, the cost of construction using conventional building materials and construction is becoming beyond the affordable limits particularly for low-income groups of population as well as a large cross section of the middle - income groups. Therefore, there is a need to adopt cost-effective construction methods either by up-gradation of traditional technologies using local resources or applying modern construction materials and techniques with efficient inputs leading to economic solutions. This has become the most relevant aspect in the context of the large volume of housing to be constructed in both rural and urban areas and the consideration of limitations in the availability of resources such as building materials and finance. This study makes an overview of the housing status in India and adoption of appropriate and cost effective technologies in the country. By using Low Cost Housing Technologies we can reduce approx. 25% of the total cost of housing.

Keywords: construction, low cost housing

I. INTRODUCTION

Affordable housing is a term used to describe dwelling units whose total housing cost are deemed "Affordable" to a group of people within a specified income range. In recent years, there has been considerable debate over the definition of low cost housing, low cost housing may be defined as a provision of housing which caters to the requirements of masses within their income capabilities, without sacrificing the strength, performance and life of the structure. India is a developing country having only 20% population of higher income group, who are able to afford normal housing units. The low-income group in developing countries are generally unable to access the housing market. As the three basic needs of people are food, clothes and shelter so main objective is to provide one of the basic need i.e. shelter to low income earner. Low cost housing is a relative concept and has more to do with budgeting and seeks to reduce construction cost through better management, appropriate use of local materials, skills and technology but without sacrificing the performance and structure life. Low cost housing technologies aim to cut down construction cost by using alternatives to the conventional methods and inputs. There is a huge misconception that low cost housing is suitable for only substandard works and they are constructed by utilizing cheap building materials of low quality. It should be noted that low cost housings are not houses which constructed by cheap building materials of substandard quality. In India it is estimated that in 2009–10, approximately 32% of the population was living below the poverty line and there is huge demand for affordable housing. The deficit in Urban housing is estimated at 18 million units most of which are amongst the economically weaker sections of the society. Some developers are developing low cost and affordable housing for this population. The Government of India has taken up various initiatives for developing properties in low cost and affordable segment. They have also looked at PPP model for development of these properties.

II. LITERATURE REVIEW

Sunil Kumar (2002) studied the production of fly ash–lime– gypsum (FaL-G) bricks and hollow blocks to solve the problems of housing shortage and at the same time to build houses economically by utilizing industrial wastes and investigated the compressive strength, water absorption, density and durability of these bricks and hollow blocks. He observed that these bricks and hollow blocks have sufficient strength for their use in low cost housing development. Tests were also conducted to study the influence of type of curing on the increase in strength and hardening of the bricks and blocks with time. It was observed that the hot water curing leads to a greater degree of hardening and higher strength, earlier compared to ordinary water curing.

P K Adlakha and H C puri (2003) studied prefabrication building methodologies for low cost housing by highlighting the different prefabrication techniques, and the economical advantages achieved by its adoption.

Vivian W.Y. Tam (2011) compared the construction cost for the traditional and low cost housing technologies. He compared the construction methods of walling, roofing and lintel. Strength and durability of the structure, stability, safety and mental satisfaction are factors that assume top priority during cost reduction. He used the case studies for investigation. It was found that about 26.11% and 22.68% of the construction cost can be saved by using low cost housing technologies in comparison with the traditional construction methods in the case studies for walling and roofing respectively.

A K Jain and M C Paliwal (2012) gave an overview of the housing status in India and adoption of appropriate and cost effective technologies in the country.

SenguptaNilanjan and Roy Souvanic (2013) studied the acceptability and adaptability potential of different Eco-friendly Construction Technologies through field survey, literature study and technical calculations and tried to find out the most appropriate one among those. From the study and analysis concluded that Rat-trap bond wall and Filler Slab roof would be the most appropriate and acceptable CECT among people belonging to Middle Income Group and below in India as they are satisfying all their guiding criteria.

Amit D Chougule et al. (2015) described the literature review studies and various results with context to embedded energy, Design and durability, Cost effective, Design optimization for filler slab. Compared to conventional in situ RC slab, this technique is economical and will result in saving of cement and steel and is an ideal step towards generation of affordable housing, for developing countries.

P PBhangale and Ajay K Mahajan (2015) examined the cost effectiveness of using low cost housing technologies in comparison with the traditional construction methods. It was found that about 26.11% and 22.68% of the construction cost, including material and labour cost, can be saved by using the low cost housing technologies in comparison with traditional construction methods for walling and roofing respectively.

III. CONSTRUCTION TECHNIQUES FOR LOW COST HOUSING

Several state governments, Building Centres and Building Material and Technology Promotion Council (BMTPC) have been playing stellar roles in evolving and promoting low cost housing technology which has helped to solve the problem of housing to masses through provision of house at affordable prices by adopting appropriate and cost effective technologies. As a result of number of innovations in the field of low cost housing technology, it is now possible to achieve an overall saving to the extent of 10% to 30% in the total cost of construction compared to the cost of traditional houses. Various technologies adopted are mentioned below:

A. Prefabrication : Prefabrication is the practice of assembling components of a structure in a factory or other manufacturing site, and transporting complete assemblies or sub-assemblies to the construction site where the structure is to be located. Concept of prefabrication/partial prefabrication has been adopted for speedier construction, better quality components & saving in material quantities and costs.

1) *Advantages of Prefabrication:*

- In prefabrication construction, as the components are readymade, self-supporting, shuttering and scaffolding is eliminated with a saving in shuttering cost.
- In conventional methods, the shuttering gets damaged due to its repetitive use because of frequent cutting, nailing etc. on the other hand, the mould for the precast component can be used for large number of repetitions thereby reducing the cost of the mould per unit.
- In prefabricated housing system, time is saved by the use of precast elements which are casted off-site during the course of foundation being laid. The finishes and services can be done below the slab immediately. While in the conventional in-situ RCC slabs, due to props and shuttering, the work cannot be done, till they are removed. Thus, saving of time attributes to saving of money.
- In precast construction, similar types of components are produced repeatedly, resulting in increased productivity and economy.
- In prefabricated construction, the work at site is reduce to minimum, thereby, enhancing the quality of work, reliability and cleanliness.

2)*Precast Roofing Systems :* Structural floors/roofs account for substantial cost of a building in normal situation. Therefore, any savings achieved in floor/roof considerably reduce the cost of building. Traditional Cast-in-situ concrete roof involve the use of temporary Shuttering which adds to the cost of construction and time. Use of standardized and optimized roofing components where shuttering is avoided prove to be economical, fast and better in quality. Some of the prefabricated roofing/flooring components found suitable in many low- cost housing projects are:

a)*Precast RC Plank and Joist System:* This system consists of precast RC planks supported over partially precast joist. RC planks are made with thickness partly varying between 3 cm and 6 cm. There are haunches in the plank which are tapered. When the plank is put in between the joists, the space above 3 cm thickness is filled with in-situ concrete to get tee-beam effect of the joists. A 3 cm wide tapered concrete filling is also provided for strengthening the haunch portion during handling and erection. The planks have 3 numbers 6 mm dia MS main reinforcement and 6 mm dia @ 20 cm centre to centre cross bars. The planks are made in module width of 30 cm with maximum length of 150 cm and the maximum weight of the dry panel is 50 kg. Precast joist is rectangular in shape, 15 cm wide and the precast portion is 15 cm deep (Figure 2). The above portion is casted while laying in-situ concrete over planks. The stirrups remain projected out of the precast joist. Thus, the total depth of the joist becomes 21 cm. The joist is designed as composite Tee-beam with 6 cm thick flange comprising of 3 cm precast and 3 cm in-situ concrete. This section of the joist can be adopted up to a span of 400 cm. For longer spans, the depth of the joist should be more and lifting would require simple chain pulley block. The completely finished slab can be used as intermediate floor for living also. The savings achieved in practical implementations compared with conventional RCC slab is about 25%.

b) *Precast Brick Panel System:* The system comprises of prefab brick based components and partially precast RC joists. Panels are laid over partially precast RC joists. Brick panel is made of first class bricks reinforced with two MS bars of 6 mm dia and joints filled with either 1:3 cement sand mortar or M-15 concrete. Panels can be made in any size but generally width is 53 cm and the length between 90 cm to120 cm, depending upon the requirement. The gap between the two panels is about 2 cms and can be increased to 5 cms depending upon the need. A panel of 90 cm length requires 16 bricks and a panel of 120 cm requires 19 bricks. Partially precast joist is a rectangular shaped joist 13 cm wide and 10 cm to 12.5 cm deep with stirrups projecting out so that the overall depth of joist with in-situ concrete becomes 21 cm to 23.5 cm, it is designed as composite Tee-beam with 3.5 cm thick flange. The saving in materials and cost as compared to the traditional RC slab are of the order of about 30 percent.

c) *Precast RC channel roofing*: Precast channels are trough shaped with the outer sides corrugated and grooved at the ends to provide shear key action and to transfer moments between adjacent units. Nominal width of units is 300 mm or 600 mm with overall depths of 130 mm to 200 mm (Figure 6). The lengths of the units are adjusted to suit the span and generally kept between 2.5 m to 4.2 m. The flange thickness is 30 mm to 35 mm. Where balcony is provided, the units are projected out as cantilever by providing necessary reinforcement for cantilever moment. A saving of 14% has been achieved in actual implementation in various projects. RC channel units are cast in well-seasoned timber moulds with M-15 concrete with 10 mm and down aggregate. The concrete is consolidated using plate vibrator to prevent any honeycombing. The units are cured for 14 days keeping the trough filled with water and then air cured for another 14 days before placing in position.

d) *Precast hollow slabs roofing:* Precast hollow slabs are panels in which voids are created without decreasing the stiffness or strength. These hollow slabs are lighter than solid slabs and thus save the cost of concrete, steel and the cost of walling and foundations too due to less weight. The width of a panel is 300 mm and depth may vary from 100 mm to 150 mm as per the span, the length of the panel being adjusted to suit the span. The outer sides are corrugated to provide transfer of shear between adjacent units. Extra reinforcement isprovided at top also to take care of handling stresses during lifting and placement. There is saving of about 30% in cost of concrete and an overall saving of about 23%.

Fig. 1 Precast hollow slab

3)*Thin Precast RC Lintel:* Normally lintels are designed on the assumption that the load from a triangular portion of the masonry above, acts on the lintel. Bending moment will be WL/8 where W is the load on the lintel and L is the span assumed for the design purpose. By this method, a thickness of 15 cm is required. Thin precast RCC lintels are designed taking into account the composite action of the lintel with the brick work. The precast thin lintel 75 mm thick, and 230 mm wide with 3 numbers of 10 mm dia MS bars could be used for opening upto 1.8 m provided bricks used have minimum crushing strength of 10 N/mm2 and mortar is not leaner than 1:6 cement-sand and the height of masonry above the lintel is at least 45 cm. Use of precast lintels speeds up the construction of walls besides eliminating shuttering and centering. Adoption of thin lintels results in upto 50% saving in materials and overall cost of lintels.

4) *Precast RC frames for Doors and Windows:* Precast RC frames are alternate to traditional timber frame for doors and windows and economical compared to frames made out of traditional timbers like teak and deodar. They are more suitable than timber frames in wet areas like lavatories, bathrooms and kitchens and are better resistant to fire as compared to wooden frames. Precast RC frames are recommended for a maximum opening of 2.25 m with cross section 60 × 100 mm or 70 × 75 mm for single shutter doors and 60 × 120 mm for double shutter doors. Three bars of 6 mm dia. are provided as minimum reinforcement which are firmly held by means of 3 mm dia. steel bars spaced at not more than 20 cm c/c. The frames are cast in M-15 concrete.

5) *Concrete hollow blocks for walling and roofing:* Concrete hollow blocks could be ideal substitute for the conventional clay bricks whose production destroy fertile top soil to the extent of 50,000 acres every year in the country. These blocks are also suited for the region like the southern states of the country where soil of requisite grade is not available for manufacture of good quality bricks.

In India, a plant for manufacturing concrete hollow blocks was set-up in Madras as early as late 40s. In USA and Canada, more than 80% of walling is currently done using concrete masonry blocks, and manufacture of concrete masonry units in an established business in these countries. In Europe too, there has been immense increase in block masonry constructions in recent years. Such blocks have been used for load bearing construction upto 10 storeys. Concrete masonry unit is a modular concrete product. The reasons for its popularity in the western countries are its various advantages like durability, strength, structural stability, fire resistance, thermal and acoustical characteristics, attractive appearance and, above all, economical and faster construction. There are, at present, quite number of manufacturers of hollow block making machines in India, the Minasto Shrike and Gospel to name a few. The Zipbloc system in prefabrication, promoted by M/s CVG Shelters, Madras, utilises precast hollow concrete blocks of 600 × 200 × 150 mm size for walling, and precast hourdi type hollow blocks of 530 × 250 × 140 mm as filler material for roofing with partially precast joists for floor or roof slabs. The zipbloc system using walls could be used for construction of houses upto three storey. It has already been successfully tried out in the construction of several two storeyed houses in Madras. Plastering can be avoided by application of this system of construction. Moreover, formwork is eliminated as the zipbloc roofing is supported by partially precast joists, and by utilizing precast lintels and sunshedes.

B. Economical Walling System: Wall is the one the important structural elements in building and housing construction which, on an average, accounts for 25 to 30 % of the cost of construction in civil work. As a result of research work undertaken at the CBRI, Roorkee, several innovation in design construction of load bearing brick masonry have been evolved. These innovations have been experimented with under the Experimental Housing Scheme of NBO. These include single brick load bearing masonry wall for four and five storey construction, nineteen centimetre thick wall for upto two storey construction, half brick thick walls and fly-ash gypsum brick masonry. Adoption of these systems has not only resulted in economy but also in less consumption of bricks and mortar, utilisation of industrial waste and saving in time.

1) *Single Brick Thick Load Bearing Wall:* Design of load bearing walls was earlier made on empirical methods based on the established experience of architects/engineers. For example, wall thickness for a four storeyed construction as per the empirical method was kept as 46 cm, 34 cm, 23 cm and 23 cm for ground, first, second and third storey respectively. Through a rationalised design method, it has now become possible to construct single brick thick load bearing wall in multi-storeyed construction through use of better quality brick. In

present construction practices, single-brick thick load bearing walls could be adopted for construction of four and five-storeyed residential building provided brick of good quality having compressive strength of 7-10.5 N/mm2 are available. Apart from saving in consumption of bricks, cement and steel, such types of load bearing brick structures provide more covered area, resulting in upto 15% economy in cost of construction. Construction of four-storeyed residential buildings having single brick thick load bearing walls have been extensively adopted by the CPWD and also by the various other construction departments such as MES, DDA, ONGC, IDPL, etc. Recently, 400 four-storeyed tenements were constructed with single brick thick load bearing walls in Erode town in Tamil Nadu.

2)*Nineteen Centimetre Thick Load Bearing Brick Masonry Walls :* It has been a common practice these days to adopt 23 cm thick load bearing walls using conventional bricks for normal house construction. However, by a rational design of structure it is possible to construct 19 cm thick load bearing walls for up to two storey using burnt clay bricks. In ordinary brick masonry construction, English Bond and Flemish Bond are generally adopted for getting the required wall thickness. In case of 19 cm thick walls a different type of bond is adopted and construction also differs from the traditional type. Under this technique of all construction, bricks are laid on edge as well as flat. In order to obtain a height of 23 cm, three bricks are placed on bed whereas adjacent to its two bricks are placed on edge. The next 23 cm height is obtain by placing two bricks on edge and three bricks on bed on the same side of the wall. The pattern is then repeated to obtain full height of the wall. Corners and junctions of such walls are also constructed in a different manner to break the continuity of joints. Such walls can be designed according to the provision of IS: 1905-1980. A saving to the extent of 16 % has been achieved in cost of bricks and mortars employing this technique. However, there has not been a saving in the labour component, the reason being that the two masons are employed in the construction of such walls as both its sides are to be constructed independently with bricks on edge as well as flat. As masons work on both faces of the wall a smooth face is obtained on each side as a result of which the thickness of plaster required is less.

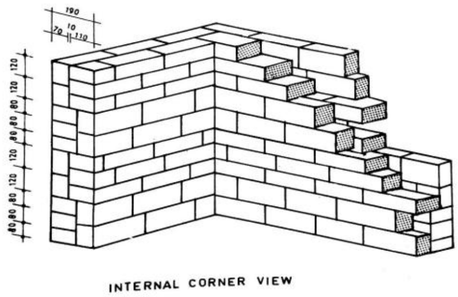

Fig. 2 Nineteen centimetre thick load bearing wall

3) *Half Brick Thick Load Bearing Wall :* Generally half brick thick walls are constructed as non-load bearing walls. But with proper planning, it is possible to put half brick thick walls behaving as load bearing walls. In construction of such walls, over-lapping of half brick thick walls at regular intervals act as pilasters of 23 cm × 23 cm size. These pilasters transfer the load of roofing system to the foundation. Masonry work in brick of 10 N/mm2 strength in cement sand mortar 1:4 is generally adequate for constructing such walls. A ring beam of 23 cm width and 7.5 cm depth with 10 mm dia MS bars is required to provide bearing for the roof. Saving to theextent of 15% is achieved when compared to the traditional 23 cm thick load bearing walls.

4) *Fly ash Gypsum Bricks for Masonry:* Fly ash gypsum bricks are good substitute for burnt clay bricks for the areas in which fly ash is readily available. For economy, the fly ash content of these bricks should be kept as high as possible. It was observed that in the case of mix proportion with fly ash content as high as 90%, the bricks easily breaks into pieces during handling and completely crumble even by a free fall from moderate heights. The compressive strength of these bricks with proportion of 80% fly ash, 10% Lime, 10% phosphor gypsum, was obtained as 5.9 N/mm2 after 96 days of casting. The minimum average crushing strength prescribed in the Indian code for burnt clay bricks are 3.5 N/mm2. Therefore, these bricks can easily replace the burnt clay bricks, as they have sufficient

strength for their use in low cost housing or non-load bearing partition and curtain walls of framed structure. (Sunil Kumar, 2002) The method of manufacturing of these bricks is very simple and does not required elaborate arrangements. Flyash kankar, lime and gypsum are powdered and mixed in the desired proportion volumetrically in dry state. A measured quantity of water is then added and mixing is done in a pan till the mixture forms a stiff paste. The paste is poured into the steel moulds. The mould is released when the mix has hardened sufficiently. The bricks are then cured for at least 10 days by stacking them properly and occasionally sprinkling water in order to keep them wet. The brick are subsequently subjected to curing by air for about a fortnight. These bricks do not require to be burnt in kiln.

Advantages of Fly ash bricks over clay bricks:

- Fly ash bricks are light weight material compared to clay bricks, so it is suitable for multi storey building, less weight means less stress on building, safety assured.
- Low absorption of heat, FAB (fly ash bricks) absorbs less heat than normal bricks, it keeps your building cool even in summer, hence most suitable for Indian conditions.
- Uniform shape, hence plaster thickness required will be less compared to clay bricks, thus saving of cement mortar
- The bricks are uniform in shape and size, therefor require less mortar in brick work.
- Less porous, absorbs very little water, whereas burnt clay bricks absorbs more water during construction. Saves money on water during construction and even keeps your building strong during rainy seasons.
- These bricks are environmental friendly as:
    I. It uses fly ash, which is by-product of thermal power plant.
    II. Saves agricultural land which is used for manufacturing clay bricks.
    III. Less energy intensive compared to clay bricks and helps in keeping clean environment.

C. Rat Trap Bond for Low cost housing

A "Rat-Trap Bond" is a type of wall brick masonry bond in which bricks are laid on edge (i.e. the height of each course in case of a brick size 230x110x75 mm, will be 110 mm plus mortar thickness) such that the shinner and rowlock are visible on the face of masonry. This gives the wall with an internal cavity bridged by the rowlock. This is the major reason where virgin materials like brick clay and cement can be considerably saved. This adds this technology to the list of Green building technologies and sustainability for an appropriate option as against conventional solid brick wall masonry. This cavity adds an added advantage as it adds a Green building feature of help maintain improved thermal comfort and keep the interiors colder than outside and vice versa. The Rat trap bond construction is a modular type of masonry construction. Due care must be taken while designing the wall lengths and heights for a structure. The openings andwall dimensions to be in multiples of the module. Also the course below sill and lintel to be a solid course by placing bricks on edge. The masonry on the sides of the openings also to be solid as will help in fixing of the opening frame.

1) *Advantages of using rat trap bond technology*

- By adopting this method of masonry, you can save on approx. 20-35% less bricks and 30-50% less mortar; also this reduces the cost of a 9 inch wall by 20-30 % and productivity of work enhances.
- Rat trap bond wall is a cavity wall construction with added advantage of thermal comfort. The interiors remain cooler in summer and warmer in winters.
- Rat-trap bond when kept exposed, create aesthetically pleasing wall surface and cost of plastering and painting also may be avoided.
- Rat trap bond can be used for load bearing as well as thick partition walls.
- All works such as pillars, sill bands, window and tie beams can be concealed.
- The walls have approx. 20% less dead weight and hence the foundations and other supporting structural members can suitably be

designed, this gives an added advantage of cost saving for foundation.

- Service's installations should be planned during the masonry construction if not exposed.
- Virgin materials such as bricks, cement and steel can be considerably saved upon by adopting this technology. It will also help reduce the Embodied Energy of virgin materials and save the production of Green House Gases into the atmosphere.
- In case for more structural safety, reinforcement bars can be inserted through the cavity till the foundation.

D. Filler Slab technology

Filler slab technology is a simple and a very innovative technology for a slab construction. 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 compressions as well as tensile. Tension in a slab is on the bottom fiber and compression on the top fiber. That means if we want to optimise the structure we can remove concrete from the tension zone where it is not much needed. That's the key behind filler slab construction. Filler slab is a very cost effective roofing technology. It is not easy to remove, the concrete from the tension zone, hence concrete can be replace (partially); that part of concrete using light weight and low cost filler material. This method of construction is called filler slab. Filler slab technology is being used across India, but substantial amount of work on the successful promotion and mostly adopted in South India. These filler materials are so placed as not to compromise the structural strength, stability and durability, resulting in replacing unwanted and non-functional tension concrete, from below and thus resulting in economy of high energy material consumption and respective cost savings and decreased dead load of the slab and resulting in economy of high energy materials consumption and considerable cost saving and decreased dead load of the slab. An internal cavity can be provided between the filler material which adds an extra advantage; other than cost savings and energy savings; improved thermal comfort for the interiors. Also an added advantage of lower dead weight transferred to the supporting elements and finally onto the foundation to further adds up cost saving in design of these elements.

Fig. 3 Filler Slab

1) *Materials selection for Filler Slab*

Light weight, inert and inexpensive materials such as low grade Mangalore tiles, Thermopolis Burnt Clay Bricks, Hollow Concrete blocks, Stabilized Mud blocks/ Hollow Mud blocks, Clay pots, Coconut shells etc. can be used as filler materials. These materials are laid in the grids of steel reinforcement rods and concreting/concrete topping is done over them.

The following points should be considered for filler material selection:

- Filler material should be inert in nature. It should not react with concrete or steel in RCC slab constructed.
- Filler materials water absorption should be checked for as it will soak the hydration water from concrete.
- Filler material should be light in weight, so that overall weight of the slab reduces and also the dead load onto the foundations is reduced.
- Filler material should be low cost so that it cost is much lesser then the cost of the concrete it replaces. This is very important to achieve economy.
- Filler material should be of a size and cross-section, which can be accommodated within the spacing of the reinforcement and also thickness wise could be

accommodated within the cross section of the slab.• Filler material texture should match with the desired ceiling finish requirements so as not to provide an ugly ceiling pattern.

2) *Advantages of filler slab technology*

- By adopting RCC filler slab construction compared to a RCC solid (conventional) slab in case where manglore tiles are used as a filler material, we can save on approximately 19% of the total concrete and including the cost of filler material, we can save around 5-10% of concrete cost.
- Another advantage is, if the filler material is just a waste i.e. for ex temporary manglore tiles that are removed from the roof to construct a pukka roof, can save upon nearly 15% on roof concrete construction cost.
- Building a 25 sq. m slab can save approx. Rs. 5000 from concrete cost.
- Filler slab technology can also be applied to mass housing projects and township projects to gain high cost saving and also saving in high energy consuming materials.
- Another advantage can be of a better thermal comfort if a cavity is kept between the filler material or the filler material itself has a cavity. For example tow manglore tiles/Clay tiles can be kept one over the other to form an air cavity thus keeping the interiors of your house remain cooler in summer and warmer in winters.
- Filler slabs can be kept exposed (with proper workmanship) to create aesthetically pleasing ceiling with a view of filler material from below and thus the cost of plastering and/or painting also can be avoided.
- RCC being made of cement, steel, sand and aggregates, is a very high energy intensive material. So reduction in concrete quantity compared to conventional slab construction adds this technology to the list of sustainable and environment friendly technologies and corporating green building features.

IV. CONCLUSIONS

In the present study various technologies have been studied such as Prefabrication, Economical Walling System, Rat Trap Bond and Filler Slab Technology. Mass housing targets can be achieved by replacing the conventional methods of planning and executing building operation based on special and individual needs and accepting common denominator based on surveys, population needs and rational use of materials and resources. Adoption of any alternative technology on large scale needs a guaranteed market to function and this cannot be established unless the product is effective and economical. Partial prefabrication is an approach towards the above operation under controlled conditions. List of suggestions in this study for reducing construction cost is of general nature and it varies depending upon the nature of the building to be constructed, budget of owner, geographical location where the house is to be constructed, availability of the building material, good construction management practices etc. however it is necessary that good planning and design methods shall be adopted by utilizing the services of an experienced engineer or an architect for supervising the work, thereby achieving overall cost effectiveness to the extent of 25 % in actual practice.

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