Affordable Housing Materials & Techniques for Urban Poor's

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Abstract: ***Affordable housing projects are characterized by an increasing demand mainly due to urbanization. The selection of building materials should meet the needs of local conditions to improve quality of life for the most needed ones by building new structures and/or by improving existing structures. This dissertation is a study on the use of building materials and engineering design in affordable housing projects in Maharashtra India. A field study was carried out in Dhule town between July and November 2012, comprising on-site and literature investigations in addition to interviews with key persons such as engineers from MHADA, who are involved in construction of affordable housing projects. Although this study attempts to cover most of the factors influencing the use of building materials& construction methods & techniques, the focus has been to investigate the impact of processed building materials for building construction & development of affordable housing model for urban areas.***

Keywords: Urban, demand, Life, Affordable, building Material

1. Introduction

A small house of his own to live in is the cherished dream of the little man in our country, whether he is a daily laborer, a small farmer, a low paid employee in Government or other service or a pretty merchant. More often his dream remains unfulfilled. This is mainly because of the high cost of house building. What contributes to this high cost is not only the high cost of materials and the high rates of wages prevailing especially in our State; It is also because of the insane craze for the so called 'new fashions' in house building which the large majority of our engineers are advocating and persuading their clientele to adopt. Very often the poor house holder is at the mercy of the 'all knowing' engineer and he cannot or dare not have his way as to what sort of house he really wants. The result is that houses are built with lavish use of steel and cement and painted all over in garish colors. It is hardly fit, to live in, because it is hot as an oven, during summer. And for this contraption the poor man has to spend his whole fortune. Such is the picture of the house - building activity in our State at the present time. People have begun to realize the folly of the whole thing and are seeking ways and means of building houses of reasonably good quality and capable of fulfilling their real needs.

2. Eco Friendly and Alternative Building Materials

In addition to the conventionally used materials there are various alternative technologies and materials developed by various research organizations, innovators and manufacturers in India that are beneficial in the housing construction. As part of this study these alternatives were researched and the information collected has been provided in the subsequent sections.

2.1 Structural materials

2.1.1 Pozzolona Material (fly ash/slag/calcined clay) as Blending Material with Cement

Up to 35% of suitable fly ash can directly be substituted for cement as blending material keeping the structural considerations. Addition of fly ash significantly improves the quality & durability characteristics of the resulting concrete. Use of blended cement has now become quite popular world over, from durability and environmental benefits point of view. The advantages achieved with the use of blended cement in concrete are quite well documented: Reduced heat of hydration, improved workability & ease of pumping, superior microstructure leading to lower permeability, higher long term strength, better performance in aggressive environment (Sulphates, Chlorides etc.), reduced risk of alkali silica reaction and higher electrical resistance leading to lesser chances of reinforcement corrosion are some of the benefits of pozzolona material blends. While portland pozzolona cement saves energy by 20%, lime pozzolona mixture shows up to 70% savings in energy.

2.1.2 Recycled Steel Reinforcement

Steel reinforcement can be made entirely of recycled scrap iron. This material is salvaged from automobiles, appliances, and steel-reinforced structures, which include reinforced concrete pavements, bridges, and buildings. In general, steel reinforcement bars can be rolled out from either of the following: used scrap rails, automobile scrap or defense scrap, defectives from steel plants, scrap generated from ship breaking or discarded structures, ingots from induction furnaces, tested billets from mini steel plants and main producers. The primary criterion to be satisfied by steel reinforcement bars is mass per meter run. The IS 1786 specifies batch rolling tolerances in the range of +/- 7 to 3 percent, depending on the diameter of the bar. It is very well possible to control the weight of the reinforcement bars within these limits and if it is specified that steel should be supplied in the minus tolerance range only then substantial savings in the weight of steel could be achieved. Though a premium of 1to 2 percent may be charged for this, it is possible to save up to 7 percent of the cost of steel. Steel bars may be purchased in standard lengths of 11 m, so that wastage can be reduced to a minimum. If the bars are purchased in random lengths (anything between 5 to 13 m) then wastage to the tune of 5 to 7 percent may be encountered. IS 1786: 1985 permits tolerances of +75/-25 mm when bars are cut to specified lengths but when minimum lengths are specified than minus tolerance is reduced to zero. About 40% of the world's steel is produced by electrically melting recycled steel. The key significance of recycled steel in the global steel industry has made it into a strategic raw material, and it has a price on the world market. Some steel products such as galvanized studs, cladding and roofing panels and tube assemblies may verifiably come from electric “mini-mill” processes where recycled content claims of 40% or more are justifiable. Strength is high, non-combustibility and the added advantage of not producing smoke or toxic gases when subjected to elevated temperatures, availability in a form that permits efficient and uniform application, sufficient bond strength and durability, resistant to weathering and erosion resulting from atmospheric conditions, resistant to termite infestation.

2.1.3 Ferro Cement and Precast Components

Precast Components are 85% recyclable, have low carbon dioxide generation and are energy efficient. They are eco-friendly, cost effective and easy to install. With use of precast components, wastes during operations are minimal, curing is not required, and structures are waterproof due to less water cement ratio, plastering is not required from the inner side of slabs and the components are corrosion proof. The components are also stronger than cast-in-situ structures, have longer life and have better load bearing capacity. Precast aerated/cellular concrete walling blocks and roofing slabs when used in multi-storied structures reduce weight, resulting in more economic design of structure, can be worked and handled easily, have high fire resistance rating and provide better insulation. Precast spacers designed as per I.S. code give benefits of improved performance of RCC due to exact position of reinforcements and larger life of the structure. Spacers are made of M30 grade concrete. Precast slabs and beams are designed to carry live load of 2kn/sq.m without any additional reinforcement; they can carry load up to 10kn/sq.m if additional reinforcement is placed while filling up joints, the slabs are provided with interlocking system to avoid independent displacement of slabs. Slabs are manufactured with M40 Grade concrete to give durable and stronger slabs than cast in situ slabs. No curing from inner side of the slabs is required which helps early utilization of construction. Precast brick panels used in combination with partially precast joists save in economic use of steel and cement and provide an alternative to reinforced cement concrete roofing/flooring where good quality bricks are available. Precast L- Panel Elements provide a better alternative to RCC sloping roofs. Water seepage can be eliminated in these panels where better quality control is possible. Precast technology also results in saving on expensive shuttering. Precast plank and joist for flooring/roofing consisting of precast RC planks supported over partially precast RCC joists with in-situ concrete are suitable up to a span of 4.0 m and ensure 12% overall saving in cost and 20% reduction in construction time. Precast chamber covers are provided with welded reinforcement to increase its life and avoid breakage at site after installation. They are cheaper and stronger than cast iron chamber covers. Precast waffle units provide speedy construction with overall saving of up to 10% besides avoiding shuttering work. The shape is like an inverted trough with a square or rectangular plan having lateral dimension up to 1.2 m suitable for large spans beyond 6m in either direction. Precast channel units are easy to construct roofing/flooring with an effective saving in cost and time. These units are reinforced cement concrete elements, channel shaped in section and 2.5 to 4.2 m long providing for ceilings that looks like one-way rib beams. Precast cored units are simple to manufacture and provide a speedy and economical flush ceiling. They consist of extruded concrete section units with circular hollows and can be used up to 4.2m span and can be used for floors or roof in load bearing walls and framed structures. Precast in-situ thin ribbed slab are available, which are made from precast/in-situ ribs provided at a spacing of 1.2 m with cast-in-situ RC flange. These can be used for floor/roof slab. As the ribbed slab is thin, roof treatment should be provided over the slab for better thermal insulation. It is cheaper and easy to construct in comparison to conventional cast-in-situ RCC slab.

2.1.4 Precast R.C.C. / Ferro-cement Frames

Precast R.C.C. frames are concrete doorframes with welded reinforcement. These are manufactured according to Indian Standards. These are economical, environment friendly and durable.

They are termite proof, fire resistant and corrosion proof. There is no bending or twisting, no warping, no shrinkage and no cracks. They are maintenance free and easy to install at site, provided with in-built high quality aldrop hold protector, stronger than other door frame material available in the market and are provided with two different types of hinge fixing arrangements to suite specific requirements. High quality plastic blocks for fixing hinges or arrangements for fixing stone hinges are available. Ferro cement frames are 1/3rd in cost, compared to even second grade timber. They can be manufactured at a small-scale level or for mass application, can be painted like timber shutters. They have higher strength to weight ratio than RCC and provide 20% saving on material and cost. Technical specification: 100 mmx60 mm section, grade of concrete M40, steel 6 mm dia, 3 no’s, and stirrups, 6mm welded to main reinforcement.

2.2 Bricks & blocks

Need for building materials is growing at an alarming rate and in order to meet the demand for new buildings, new ways and techniques must be evolved. Manufacturing of building materials like bricks/blocks, cement, steel, aggregates, etc. consumed in bulk quantities, puts great pressure on natural resources (raw materials) and energy requirements. The use of alternative materials for bricks should be encouraged in order to preserve precious fertile top soil. Described below are a few examples of alternative materials for bricks/blocks.

2.2.1 Fly ash – sand – lime bricks

To bridge the huge shortfall of bricks and to maximize reuse of fly ash waste, these fly ash- sand lime bricks should be used. These bricks provide the advantage of being available in several load bearing grades, savings in mortar plastering, and in giving smart looking brickwork.

2.2.2 Bricks from Coal Washery Rejects

Freshly mined coal is washed to remove impurities prior to its use or processing. This residual waste from the coal washery plants is a hazard to the environment and needs to be disposed or utilized in a manner which lessens its harmful effects on the natural surroundings. With a suitable binder such as cement or lime, bricks and blocks similar to those made using fly ash can be made using this coal washery reject material. These bricks are eco-friendly and waste utilizing. They reduce air, land and water pollution, are energy efficient and cost effective.

2.2.3 Building Blocks from Mine Waste and Industrial Waste

It is eco-friendly, utilizes waste and reduces air, land and water pollution. It is energy efficient and also cost effective. Majority of the large-scale industries and thermal power plants generate solid wastes in bulk quantities. Red-mud, coal ash, slag, fly ash, etc. represent such wastes *unutilized* for several decades. For example, more than 100 tones fly ash is produced annually in India (from thermal power plants) and only 2–3% is being utilized. Similarly millions of tones of red-mud is stored near aluminum manufacturing units (~ 20 × 106 tones of red-mud is heaped into hillocks at the aluminum manufacturing unit at Belgaum in Karnataka state). Such huge heaps of wastes concentrated in certain specific localities cause environmental and pollution hazards. Such wastes can be utilized for the manufacture of bricks/blocks, substitute for fine aggregates in concrete, partial replacement of cement in concrete, lime–pozzolona cements, etc. Huge quantities of solid wastes (generally known as mine tailings) are produced by the mining industries. Generally, mine tailings are accumulated in heaps near the mines resulting into huge hillocks. For example Bharat Gold Mines Limited at Kolar Gold Fields (KGF) has created 33 × 106 tones of tailings (which are non-toxic) heaped into 13 hillocks. Similarly, the iron-ore tailings of the Kudremukh Iron Ore Company in Karnataka, amounting to ~ 150 ×106 tones are stored in huge dams created for collecting the iron-ore slurry washings. Coal mines, copper mines, etc. generate and store huge quantities of solid wastes. There is a large scope for utilizing mine wastes for the manufacture of building materials and products. For example 33 × 106 tones of gold mine tailings at KGF can be converted into bricks/blocks, which can satisfy the demand for bricks at Bangalore city for the next 30 years or more. Similarly utilizing the 150 × 106 tones of iron ore tailings can meet the requirement of sand and bricks and blocks of Karnataka State for decades. Thus there is a great potential for utilizing industrial and mine wastes for the manufacture of building materials and products.(1)

2.2.4 C-Brick

These are bricks manufactured using the C- brick Machine developed by CBRI. The machine is available with BMTPC and is used for production of quality bricks using fly ash – sand –lime, fly ash –sand –cement and cement-sand-aggregate. The bricks manufactured have properties such as compressive strength of 40-80 kg/sq.cm, water absorption less than 20%, and efflorescence free product.

2.3 Plaster

2.3.1 Calcium Silicate Plaster

Calcium silicate refractories are usually derived from calcium silicate or silicate bearing minerals such as hornblende, epidotic and diopside, often with calcite or dolomite or wollastonite. Wollastonite is a naturally occurring form of calcium silicate commonly used as filler. Portland cements are also based on calcium silicate. Calcium silicate plasters are economic, eco-friendly, produce less wastage, have wide usage, give a smart finish, are less energy consuming, do not emit VOC and other toxic fumes and gases after application and are recyclable. They are safe in handling and usage, do not need skilled man power, are fast drying, durable, and have less water consumption.

2.3.2 Fiber reinforced clay plaster

Clay Plaster can achieve better sticking properties by reinforcing it with fibers. These fibers can be natural plant (cellulose) fiber or artificial fibers of polypropylene**.** Plant fibers in fiber reinforced plaster act as reinforcement and create voids thus controlling cracking due to drying shrinkage and thermal movements. The dried plaster is less brittle than conventional plasters and can withstand small movements of the substrate. Fibers made from 100% virgin polypropylene fibers are also available and can be used to achieve the similar properties. Use of these fibers can reduce plastic shrinkage, reduce permeability, and provide increased impact and abrasion resistance.

2.4 Roofing's

2.4.1 Bamboo matt corrugated roofing sheets

Roofing is an essential ingredient of any house and in India several roof cladding materials are in use including burnt clay / Mangalore tiles, thatch, corrugated sheets of galvanized iron, aluminum and asbestos cement, etc. Of these, for semi permanent structures corrugated sheets are preferred. However, one of the major roofing materials, viz., ACCS is being replaced with other alternative materials in many countries. Considering the need for developing alternate eco-friendly, energy efficient and cost effective roofing sheets, Building Materials & Technology Promotion Council (BMTPC) and Indian Plywood Industries Research & Training Institute (IPIRTI) have jointly developed a technology for manufacturing Bamboo Mat Corrugated Sheets (BMCSs).

2.4.2 Micro concrete roofing tiles

Micro Concrete Roofing (MCR) tiles are a durable, aesthetic and inexpensive alternative for sloping roofs. Micro Concrete Roofing (MCR) tiles are made from a carefully controlled mix of cement, sand, fine stone aggregate and water. MCR tiles undergo stringent quality control at every step. They are put through rigorous tests for water tightness, strength, shape and size. MCR technology is a result of global research and development effort. In India, TARA, Development Alternatives in association with SKAT of Switzerland, promotes MCR technology.

MCR tiles offer many advantages over other sloping roof materials such as G.I. sheets, Mangalore tiles, wooden shingles, slate and asbestos. MCR tiles are: highly cost effective, durable-they have the life of concrete, lighter than other roofing tiles-they require less understructure, easily installed, can be colored to specification, reduce heat gain, do not make noise during rains. Cost of roof varies according to span and roof form. A variety of roof designs for farm and country houses, bungalows, verandas and pavilions are possible with MCR tiles. They have also been used on industrial sheds, workshops and restaurants. MCR roofs are constructed in a conventional manner using rafters and purlins made from wood or steel. Rafters are typically spaced at 90 cm to 110 cm apart. The purlins are at a distance of 40 cm from each other. MCR tiles are secured to purlins by tying them to the purlins with G.I. wire. The angle of roof slope should be at least 22°. Greater inclination of up to 30° is preferred for more aesthetic appeal. Standard architectural details for gable and hipped roof ridges, eaves, side over-hangs and valleys can be used for MCR roofs. MCR technology has been validated and certified by: Building Materials and Technology Promotion Council, Ministry of Urban Development, Govt. of India. Certificate No. 95/1. Production of 200 tiles per day by four workmen, including one trained mason is achievable. The micro concrete tiles can be considered satisfactory against leaks as per the specifications of IS: 654, 1992. The average value of breaking load is 104.80kg. 10mm thickness tiles are 10% stronger and the life span of MCR tile is about 25 years.

2.4.3 Clay tiles

These tiles are uniform, more durable, fire resistant, environment friendly, energy efficient and low cost. Due to their low self-weight, the dead loading on the super structure reduces significantly, thus indirectly reducing costs. Tiles made using locally available clay should be encouraged rather than insisting only on the Mangalore pattern clay tile for the purpose of roofing. Fiber reinforced clay tile is a good alternative material, displaying high aesthetic performance and durability. The fibers could be any locally available agro waste.

3. Affordable Housing Techniques for LIG People

It is often hear people describing houses as “Modern” or “Old fashioned” The so-called “Modern house” is often merely fashionable but foolish, simply because it is expensive and does not take, into account the locally available inexpensive materials or the local climatic conditions or the actual needs of the occupants. Quite often the so-called “old fashioned” house demonstrates that the choice of building materials is important because it is less expensive and does not use up unnecessarily material that are in short, supply needed for other uses. It also copes effectively with weather hazards such as strong sun, heavy rain, strong winds, high humidity etc. all the following techniques are suitable for only LIG group & only for load bearing houses.

3.1 Technique no - 1

These two sketches in figure no 3.1 typify the small “Modern house” at the top and an old fashioned one below. The modern house is “cubist” in design and uses a lot of cement plaster & paint. The roof does not protect the walls from rain and sun with the result that it is not very comfortable or convenient to live in. The “Old fashioned” house has a sloping roof which quickly sheds heavy rain protects walls from getting damp and from absorbing heat from the sun. Some of the windows have been replaced with jalis, which are cheaper and give permanent – ventilation and light and protection or security building is near the edge of the terrace.

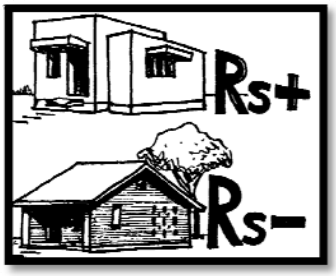


Figure 3.1 “Comparison of modern & old house”

3.2 Technique no -2

To build the house on a terraced site, it is less expensive to place it in the middle of the terrace. The lower picture in figure no 3.2 shows the extra and more costly foundation and basement wall that has to be built if the

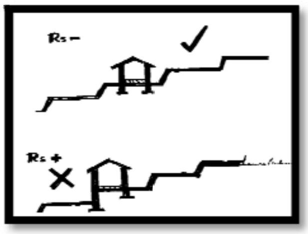


Figure 3.2 “extra and more costly foundation on terrace site”

3.3 Technique no -3

If the site is a sloping one, less excavation and less filling up is needed if it has to place the building parallel to the contours, as in the upper picture, and not cutting across the contours, as shown in the picture. Figure no 3.3

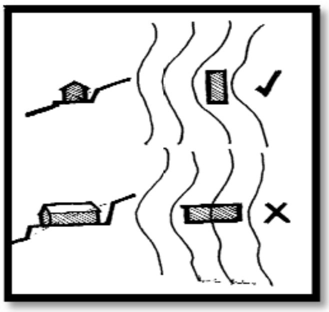


Figure 3.3 “site on a sloping ground”

3.4 Technique no-4

Exchanging the trenches for the house foundations, laborers dig out the soil and throw it in all directions, especially outwards. After the basement walls have been completed they then shovel all the soil back again as infilling. If they shovel the soil inwards it will already be where it is wanted for infilling and some of the expense of excavation and infilling will have been saved. See in figure no3.4

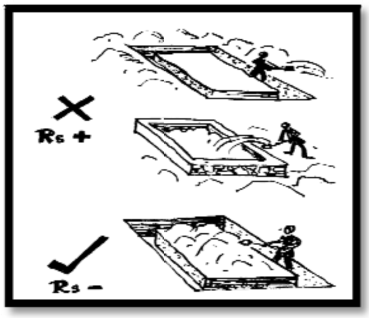


Figure 3.4 "Exchanging the trenches for the house foundations"

3.5 Technique no 5

A common practice is to have the main walls of a house in 0.23m thick burnt bricks, sitting on the top of a 0.45m random rubble (roughly shaped stones) basement and foundation. This means that there is a step where the 0.23m wall sits on the 0.45 wall below, and rainwater tends to seep in and weaken the lower stonewall, as shown in the upper picture in figure no 3.5. For single and double storey houses it is better to put the outer side of 0.23m brick wall flush with the outer side of the 0.45m stone wall so that rainwater running down the wall does not soak into the wall. This is also less costly because it will give additional useful area inside the room. (5)

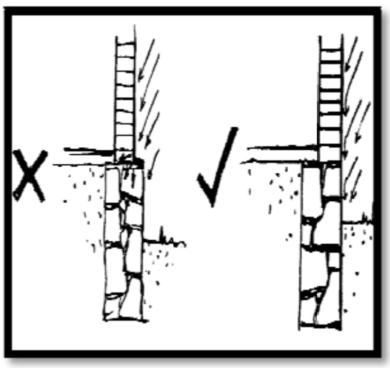


Figure 3.5"Flushing of water with comparison"

4. Model of Affordable Housing for Urban Poor's

4.1 Selection of materials for the project work

After study of different housing materials it is observed that concrete is versatile material and its ingredients are easily available in India and all over the world, for the project work major material is consider as wire mesh concrete, which is used in prefabricated concrete product as cement concrete door and windows frames ,prefabricated concrete ventilators, wall panels which is majority used in khandesh area .For this work precast concrete product factories in khandesh area are observed and from that observation one technique which is use in precast concrete compound wall panels is selected as the cost efficient technique for this project work, it is made up of wire mesh concrete techniques ,wire mesh of 2-3 mm diameter is used as reinforcement and the thickness of the panels of 5 to 10 cm depending upon its use in different situations, generally 5cm thick wall panels are used in precast compound walls ,use of wire mesh is reduce the cost of normal steel used concrete works. Following figures shows the casting and fixing of precast concrete wall panel products which are easily available in the khandesh area.

4.2 Development of three dimensional models for the project work

For development of three dimensional model the concept of compound wall panels are studied in detail and from this concept wall panels and slab panels of project work that is affordable house for urban poor's is developed . Different stages of project house for LIG group peoples are shown and describe in detail, for this work one room kitchen plan is taken in to consideration which has nearly same area of MHADA hosing constructed for LIG group at Dhule town on Chalisgaon road. Estimate of MHADA house of same area and estimate of precast house has shows the different in cost and time required for construction .This house is assumed to use at soil bearing strata which is generally available at maximum depth 0.9 m from ground level. This house is considered as ground floor house.

4.2.1 Footing stage

Footing for the house consider in this project is isolated column footing, which is precast concrete product has size 0.3m x 0.3m x 0.9 m (maximum),6mm steel 4 bars are used as main steel & stirrups for column and 4 bars of 16mm diameter are placed 0.18m c-c from bottom as anchoring purpose after placement of a particular column footing ,cement concrete is poured in pit as anchoring purpose and p.c.c for a level plain surface for the footing, footing has top grove(0.1mx0.1mx0.3m) for connection of ground beam and column above it.

Figure 4.2.1 "A footing level"

4.2.2 Footing and ground beam stage

Footing and ground beams are connected by columns, size of ground beam is 0.23mx0.23m in cross-section

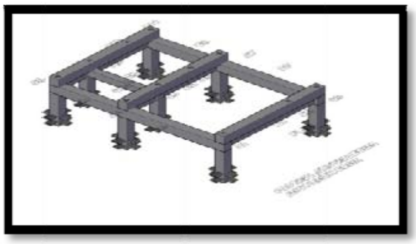


Figure 4.2.2 "connections of ground beam & footing"

4.2.3 Footing, ground beams, plinth beams, columns connections

This stage shows the detail connections of footings, ground beams, plinth beams, columns and the columns shows groves for fixing wall panels at different levels.

Figure 4.2.3 "connections of footings, ground & plinth beams, and columns"

4.2.4 Footing, ground beams, plinth beams, columns & wall panels connections

This stage shows how the footings, ground beams, plinth beams, columns, different wall panels are connected to each other at different levels.

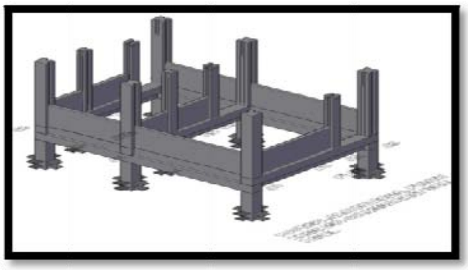


Figure 4.2.4 "connections of footings, ground & plinth beams, columns& wall panels"

4.2.5 Footing, ground beams, plinth beams, columns, wall panels, windows, doors &ventilators connections

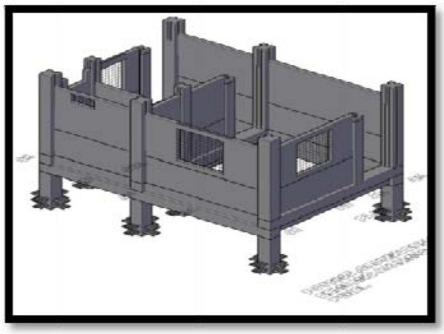


Figure 4.2.5 "doors, window& ventilators connections"

4.2.6 Footing, ground beams, plinth beams, columns, wall panels, windows, doors ventilators weather shade roof beam connections

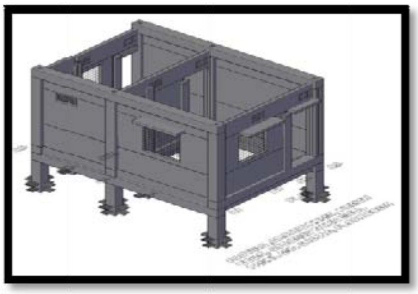


Figure 4.2.6 "connections of roof beams & weather shades"

4.2.7 Roof beams connections

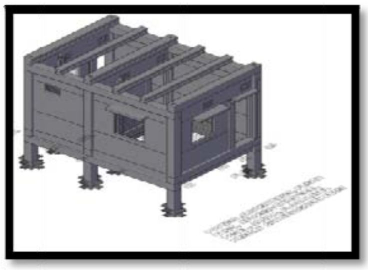


Figure 4.2.7 positions of roof beams for fixings slab panels

4.2.8 Complete view of roof beams & slab

The complete view show the slab panels connected with roof beams; this is the final complete view for this project.

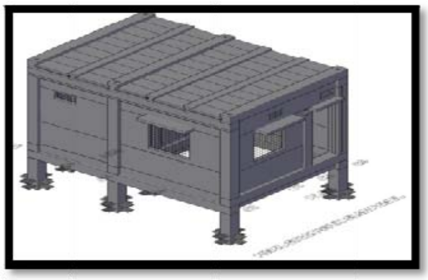
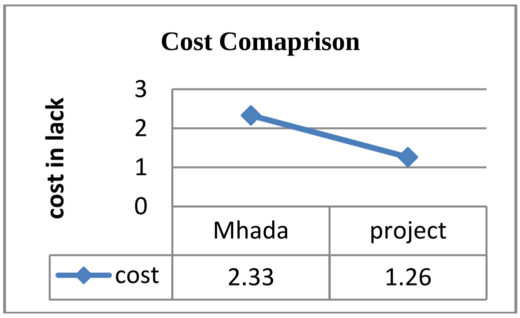


Figure 4.2.8"Final completed view of the project"

4.3 Comparison of final cost project building with Mhada project building for same area.

Detail estimate of Project Building is carried out ,(for this building area similar to Mhada building is consider for LIG housing) the project's cost is 121756 Rs and cost of Mhada project is 233178 Rs, for this estimate PWD DSR (2005-2006) is used .The figures shows that the estimate cost of project building is one lack twenty-one thousand seven hundred fifty-six and Mhada project building is two lack thirty three thousand one seventy eight, it is near about twice the cost of project building ,hence from the cost of Mhada project , two houses for proposed project building would be possible to construct .



Graph 6.1 "cost comparison between Mhada house & dissertation work"

5. Conclusions

Shelter is a basic human need next only to food and clothing. At the end of the 10th Five Year Plan, the housing shortage is estimated to be 24.7 million. However, urban areas in our country are also characterized by severe shortage of basic services like potable water, well laid out drainage system, sewerage network, sanitation facilities, electricity, roads and appropriate solid waste disposal. This is model developed in this dissertation would be helpful for construction of LIG group housing with in shorter time at affordable cost, normal traditional housing techniques are time consuming they will required minimum 4 to 6 months to construct small ground storied house again workmanship and quality is another aspect, but this factory made product will be of a particular expected quality and will required 2-3 days maximum to assemble at site .this fast casting and assembling techniques are helpful to reduce the construction time and cost of housing for urban poor's, planning of similar types of projects will reduce the cost of manufacturing and cost of assembling, because to manufacture similar components of factory products mold required to be same and design parameters and materials are also same ,this will helpful give the order of different materials on mass quantity will reduce the purchasing cost of materials. Labors are main persons who are involved in construction activity and now a days there is big shortage of labors in all types of industries, construction industry is the big industry in all over the world and, it has almost big potential to provide all type of jobs to the labor , but due shortage of labors the completion time and cost of construction is going on increasing ,replacement of labors in the form of machinery is very important , that's why factory made products will used to replaced labor.

In the comparison of cost of two estimates, it is found that the estimated cost of the project work is 1.26 lacks and the cost of MHADA project is 2.33 lacks, hence the proposed project work is beneficial as compare to the MHADA project.

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