A Project Report on

ALTERNATE LOW-COST CONSTRUCTION MATERIALS

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BACHELOR OF ENGINEERING

in

CIVIL ENGINEERING

by

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CERTIFICATE

This is to certify that project entitled named **“Alternative low-cost construction”** is bonafide work of Ansari Musharraf Qayyum, Malik Sohail Yunus, Pathan Salman Noor Mohammad, shah Mohammad Rahim. Submitted to the university of Mumbai in partial fulfillment of requirement for award of the degree of “Under graduate” in “Civil Engineering”

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ABSTRACT

Low cost housing is a different concept which deals with effective costing and following of techniques which help in reducing the cost of construction through the use of faraway available material beside with and technology improved skill without losing the power, performance and life of structure. There is huge misconception that low cost housing is suitable for only subnormal works and they are built by using cheap building material of low quality. The fact is that low cost housing is done by proper management of resources. Economy is also achieved by postponing finish work or implementing them in phases. Cost of reduction is achieved by selection of more efficient material or by an improved design. Construction of low cost housing by using low cost construction material increases the access to building by low income group peoples. Advantage of low cost building material are pollution prevention, reducing energy consumption and use of natural materials, and reusability of building materials. The review on various low-cost building design management are presented in this paper.

Keywords: Low cost, building materials, construction.

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Chapter 1

Introduction

1.1 General

Low cost housing can be considered affordable for low and moderate-income earner if household can acquire a housing unit for an amount up to 30% of its household income [miles,2000]. In developing countries such as India, only 20% of total population are high income earners, who are able to afford normal housing units. The low-income groups in developing countries are generally unable to access the housing market. Cost effective housing is an relative concept and has more to do with budgeting and seek to reduce the construction cost through better management appropriate use of materials, skills and technologies but without sacrificing the performance and structure life. It should be noted that low cost housing are not the houses which are constructed by materials of substandard quality. A low-cost housing is designed and constructed as any other house with regard to foundation and structural strength the reduction in cost is achieved through effective utilization of locally available building materials and techniques that are durable economical, accepted by user and not requiring costly maintenance, Economy is also achieved by postponing, finishing and implementing low cost housing technology in passes.

1.2 Low cost housing

Low cost housing is an new concept which deals with effective budgeting and following if technique which help in reducing construction cost through use of locally available materials along with improved skill and technologies without sacrificing strength, performance and life of structure (Kumar,1999; Civil Engineering portal, 2008).

Like any other developing country, India too is presently passing through a phase of acute housing shortage. As per National Buildings Organization (NBO) estimates, in 2015, there was a shortage of 31 million dwelling units in the country out of which shortage of 10.4 million units existed in the urban sector and the remaining 20.6 million units in the rural sector. The backlog of housing is expected to mount up to 41 million by the turn of century. The picture is abysmally dismal at the lower end of the economic ladder. According to an UN estimate, over 33 per cent of the population in developing countries is houseless. A recent study undertaken by the UNCHS reveals that over 100 million people live in a state of absolute homelessness, while in excess of one billion people are forced by circumstances to reside in desperately inadequate housing conditions which threaten their health, security, safety.

To overcome such difficulties, Managements are looking for new alternative construction materials and techniques approaches and one such approach is the use of low cost construction. In this approach the phases of the project are accomplished concurrently instead in series. The complexities that arise in managing projects are tackled through proper restructuring of project organization; upgrade management commitment, Proper materials 3 selection and planning of activities, safeguard project quality, managing project risk equitably. and managing the cost reduction techniques employed in housing construction (Baker,1986). The Council for Works and Housing (CWHR) is an R & D organization under the aegis of the ministry of science and technology. The main function of this council is to promote scientific research on problems related to different types of civil engineering structures such as buildings, roads, bridges, dams, harbors, treatment plants etc.

As far as Maharashtra state is concerned the gap between both the aggregate demand for and aggregate supply of housing is highly relevant. This causes a high level of housing inadequacy in the state. Due to the escalating rise in price of building materials the housing has become totally in accessible to many. Now, the price of building materials alone

contributes to 60-70 percent of the cost of construction. The predominant use of conventional construction materials like steel, cement, burnt clay bricks and timber clearly shows an increasing trend in the construction costs over the years. The cost of construction is increasing 4 by 13-15 percent each year even when the inflation is less than double digit. Therefore, the most important subject with immediate interest is the reduction in building costs. The Cost-Effective Environment Friendly (CEEF) technology is making sustained efforts to implement advance programming and architectural planning, rational and structural designs, organization, execution and management of works and using new materials and construction device.

1.3 Aims and Objective

House is one of the biggest need and low-cost housing gives the houses to people at reasonable rate. Pursuant to this, following objectives are proposed in the present investigation.

- To study different types of construction materials and technique used, to reduce the cost of construction.
- Alternate and low-cost construction materials and techniques used for sustainable development.
- To identify total cost required for completing a project using conventional and cost-effective technology.
- To compare cost and time reduction by adopting different materials and techniques for large scale project.

1.4 Scope of Project

In view of the fore mentioned problem as specified from the literature review following scope is outlined for the present investigation.

1. Scope of the study is the consumption of building materials changes both quantitatively and qualitatively in the various stages of housing construction. Accordingly, the cost of construction also changes between the conventional and cost - effective technologies.

2. Overall this study will be very useful for the previous, ongoing, and upcoming future construction projects of high scale area to minimize the cost, time and waste and also the enhancement of structure.

Chapter 2

Literature Review

2.1 Overview of Literature

Harry and win (1998) showed that new ductile hybrid FRP bar is developed, this new reinforcement has bilinear stress strain characteristic that facilities use in concrete structure. It has high strength, light weight and non-corrosivity property. An approximate sample beam each of 50*100mm cross section and 1.2m long with 5mm dia hybrid reinforcement 3 such beam was produced and were tested in 44.5 KN capacity displacement-controlled bench type universal testing machine. test result showed that ductile behavior was obtained with good reproducibility and failure of beam occur after considerable inelastic deformation.

Tam (2011) explained the cost effective of using low cost housing technology in construction. It is found that 26.11% and 22.68% of building cost can be saved by consuming low cost housing technologies in assessment with traditional construction method.

Fei and Dale elaborated that glass fiber reinforcement is new technology which is precast. In which glass fiber reinforced are hollow wall panels with or without reinforced with concrete this type of wall are widely used in Australia and wall when tested have high axial and shear carrying capacity.

Chowdhury and Roy (2013) explained prospect of low cost housing in India, it is observed that in this paper alternative construction material mainly natural material such as bamboo, straw, bagasse, manmade material like fly ash , aircon panels were studied and potential of these material to be used as an alternative building material is brought out.

Najjar et al (2014) investigate the use of natural hemp fiber in improved load response of compacted clay, total 6 sample of unconsolidated undrained sample having 7.1cm dia and 14.2cm length was prepared with reinforcement of hemp fiber of 0, 0.15, 0.3, 0.4, 0.5 and 1% in PVC pipe, the sample was compacted and was cut and tested in triaxial testing machine the result showed that inclusion of hemp fiber has positive impact on ductility and shear strength increased from 015% to 1% when effective content of fiber was (0.5to 1%).

Mangesh and Sachin (2010) explained that SBA which is otherwise landfilled was utilized in a construction material. SBA was tested and it proved its suitability as pozzolanic and Cementous material with thermal stability of 650 degree. SBA brick was prepared with constant composition of limit and was tested for physiochemical. the test result showed that brick was lighter, durable and energy efficient.

Taur and Devi (2009) explained low cost housing. It is observed that, this paper goal to argument out the various aspect of prefabricated construction methodologies for low cost housing by highlighting different prefabrication technique and economical advantage accomplished by its adoption. In building the foundation wall, flooring, column, slab, are important component. The major construction method's here are namely structural block wall, mortar fewer block wall, precast RC planks, precast concrete/ Ferro cement panels are considered.

Huma Yun and Pasha (2015) studied about sundried Fly ash brick the aggregate binder ratio used for fly ash brick was given as 1:4. The average size of fly ash brick was 230*110*75mm and mortar joint of 10 to 12 mm was used. And was tested using uniaxial monotonic compressive displacement loading with actuator of 250KN. Result showed WA was 18.3% higher, failure modes in masonry showed that good bond can be achieved by higher grade of mortar.

Caponetto and Francis (2013) explained ecological material and technologies in low cost building system, it is observed that high recyclability of natural materials that can be used in low cost building associated with construction technique capable of exploiting the principle of

bioclimatic architecture for liveliness needs allow us to create building environmentally conscious and responsible. At same time the project of special block was developed to meet need of sustainability and ease of construction.

Zami and Lee (2009) have reported that the economic benefits of contemporary earth construction in low cost urban housing state, It is observed that stabilized earth is an alternative building material on each continent and in each age. This article reviews and argues the economic benefits of using earth as a building material and describes the associated construction techniques for urban housing provision in developing countries.

Hutcheson (2011) studied the project management of low cost housing in developing countries, it is observed that the study of this paper includes designs, cost control systems, communications, contract law and planning. An appreciation of the evidence compounded from the problems portrayed throughout the paper leads to decisions of the need for simplifications of designs, the impact of inadequate local support and hence the need for detailed and complete advanced planning. In addition the conclusions stress the need for the careful collection of self-supportive teams of multi-disciplined professionals and sub professionals.

Ugochukwu (2015) explained the local building materials, It is observed that the paper recognizes the problem of inadequate housing as a critical challenge to sustainable urban growth and cities development. Extensive use of recycled materials help conserve restores and preserves the ecosystem. Green buildings wastes management ensures resources and energy efficiency. The closeness of materials saves cost and decreases pollution by fuel through transportation.

Jasvi and Bera (2015) studied on sustainable use of low cost building materials in the rural, It is observed that, The main challenge is to use the materials in structural constituent for low cost housing and their adaptation to influences like – technical, social, ecological, physical – through different products. It encounters the idea about the need of housing in country side India and explains different uses of materials and the techniques of building construction for LIG people, urban poor‟s in different aspects of building. It covers the use of local materials in the building to reduce cost and it makes affordable houses for low income people.

Bredenoord (2016) explained sustainable housing and building materials for low-income households, It is observed that sustainable goals for low-cost housing and applications are achievable. Measures concerning the physical development of neighborhoods, such as urban density and connectivity are equally as important as measures concerning community development. The final comprise support for community built organizations, small housing cooperatives (or similar forms of cooperation) and individual households or small groups – that build and increase their houses incrementally. Adequate design and social organization and support are preconditions for achieving sustainability in incremental housing.

Tapkir et al (2016) explained the study and analysis of low cost housing based on construction techniques. It is observed that, there are three factors that affecting the cost of project time, materials used and techniques. In this paper different methods were discussed for cost control and reduction.

Pachecotorgal and Jalai (2012) explained earth construction and building materials, it is observed that in this paper earth construction has a major expression in less developed countries, on the other hand the mimetic temptations near more poisoning construction techniques based on reinforced concrete and bricks that fired up are likely to favor a change near a clear unsustainable design. In order to disclosure and highlight the importance of earth construction this article reviews some environmental benefits such as non-renewable resource consumption, waster generation, energy consumption, carbon dioxide emissions and indoor air quality.

Salem (2000) showed that reinforced concrete is very common building material. But these steels are subjected to oxidation when exposed to marine area. Therefore, new material is made which is fiber reinforced polymer composite made of resin fiber having potential to overcome performance and cost void. The properties compared to common steel bar are susceptible used in various bridge structure.

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2.2 Summary

The above discussion of various aspect of housing in general and housing finance in particular has been a modest attempt to develop a structure for present study. The chief contention of this conceptual frame work is that housing scenario in a developing country with its complicated structure cannot be explained with single theory. A synthetic approach which take into consideration the impact of urbanization, decentralization views of housing, cost analysis and indigenization of house design, alone can-do justice to housing sector which is being investigated.

Chapter 3

Materials and Methodology

3.1 General

- Like any other developing countries, India too is passing through a phase of acute housing.
- There are generally two methods of construction I e. 1. conventional 2.non conventional.
- Conventional method generally consists of old and traditional methods of construction.
- Non-conventional method consists of use of advanced materials.
- Both this method is generally compared on the basis of parameter like time, cost, quality, maintenance, etc.
- Based on the above concluded observations the method which is more suitable can be adopted so as to save both time and money.

The work is generally organized in following stages.

Whole project is carried out by finding out alternative method of construction rather than conventional method in each step with main aim focusing toward low cost.

3.2 Site selection

Cost of site plays an important role in overall construction cost as total cost generally depends upon land if the cost of land on which construction need to be carried out is high then the total cost of construction will also high.

3.3 Foundation

It is lowest part of the structure on which entire structure rest. The main function of foundation is to transfer complete load of structure uniformly to the soil bellow it. About 10% to 15% of total cost is spend in foundation. Therefore, alternative methods like micro piles instead of H piles are generally used to lower the cost.

3.4 Column

Columns are generally compression member. They are structural element that transmit through compression, the weight of structure above to other structural element below. The cost of construction of this vertical member are generally reduced by using FRP or other natural material like bamboo.

3.5 Flexural members

A flexural member are the members which are subjected to tension and compression. The beam is an flexural members. It is the most important part of structure in which cost is reduced by using alternative material rather than conventional steel reinforcement.

3.6 Plastering and other work

This generally first consist of construction of wall by using fly ash brick or other low cost brick and then providing it finishing by application of plaster on the wall surface.

3.7 Site Selection

While considering low cost construction, one of the major activity that consume major cost is the cost of land. Hence, we need to focus on the land which are easily available and mainly affordable and of low cost. Site selection indicates the practice of new facility location, both for business and government. Site selection involves measuring the needs of new project against the merits of potential locations. The practice came of age during the 20 centuries, as government and cooperate operations expanded new geographies on national and international scale.

Following are various source where low cost land is available.

In a bid to boost affordable housing projects in private sector, the Maharashtra government has decided to adopt a policy of offering incentives by allowing 2.5 Floor Space Index (FSI) to all the low-cost housing projects taken up under the Pradhan Mantri Awas Yojana (PMAY) across the state. Moreover, the projects on agriculture land and no development zone have also been permitted with 1 FSI for constructing affordable houses. Such projects also shall avail subsidy of Rs2.5 lakh per home from the government and all the other benefits prescribed under PMAY.Floor Space Index (FSI) typically indicates how high a developer can build on a plot. It is the ratio of total built-up area to the size of the plot. The notification said 2.5 FSI will be allowed to the development projects undertaken under PMAY where tenements shall be constructed for the economically weaker section (EWS) and LIG (lower income group), subject to the certain rules and regulations such as the approaching road shall be of 15-metre. The project shall not fall on forest land, environmentally sensitive zone or having coastal regulation restrictions. The notification further permits affordable housing projects on agriculture land and plots coming under no development zones with 1 FSI for constructing the small houses.

The ‘housing for all mission’ is one of Prime Minister Narendra Modi’s pet projects and the PMAY was launched in 2015. The Devendra Fad Navis-led Maharashtra government has set an ambitious target of constructing 19 lakh low-cost houses under the scheme by 2022.The PMAY permits private developers to sell 50% houses at the rates of their choice while the rest of the houses have to be sold at the rates determined by the government agency — Maharashtra Housing and Area Development Authority (Mhada).

Easier availability of land in the suburban areas along with infrastructural connectivity, availability of facilitating and financing agencies such as the National Housing Bank, international developmental organizations, international NGOs, micro finance institutions and private equity players, economies of scale and first mover advantages have also propelled this interest. From 2009 onwards, real estate developers have launched projects across Indian cities in locations which are away from the core central business/secondary business districts where land prices are affordable Such targeted growth is seen in over 15 projects including Karjat, Palghar and Boisar in Mumbai; Marol and Vatwa in Ahmadabad; and Anekal in Bangalore. The more prominent developers include Tata Housing (Shubh Griha), VBHC, Foliage, DBS Affordable Home, Nirman Group, HDIL, TVS Housing, S. Raheja, Mahindra Life spaces and Usha Breco Realty. Typically, the projects are located 20–25 km from the city Centre, cover 15–35 acres and have 1500–3500 units. The projects are characterized by limited options, closeness to industrial or commercial hubs, reduced area, low construction cost, shorter period of construction and provision of basic social amenities. The pre-tax internal rate of returns (IRRs) in a low-cost housing project can range from 40 to 45 percent with gross profit margins of 15–20 percent, which is slightly reduced compared to the 30–40 percent margins available in high-end real estate projects. While there are instances of several AH projects that were sold out within days or weeks of launch, unavailability of suitable land, low value of returns, and scarce financing make it imperative for developers to shorten construction time, lower cost, de risk from land acquisition costs and adopt a working capital model with assured and faster cash inflows.

Low cost land can also be obtained if the land area is situated in the place which required less levelling or less clearance so that material moving cost are reduced. Cost of land is also low in an area where there is mountains.

Low cost land can also be obtained if the land having weak soil or soil which is of low quality. For eg. Land area near dumping area, near costal area etc.

3.8 Foundation

A foundation is a lower portion of building structure that transfer its gravity load to the earth. Foundation are generally broken into two categories: shallow foundations and deep foundations. A building must have strong foundation to stand for longer life time. **Out of total construction cost 10% to 15% of the cost is spend under foundation.**

Therefore, for an economical construction of foundation alternative techniques shall be used.

3.8.1 Deep Strip Foundation

Deep strip foundations are least expensive and are used when ground conditions are good. The key sizes of strip foundation for concrete cavity wall construction and timber framed cavity wall construction are similar. The size and position of strip is directly related to overall width of wall. Strip foundation can be used for most sub soil but are most suitable for soil which is of relatively good bearing capacity. they are particularly suited to light structural loading where mass concrete strip foundation can be used.

Advantage

- Ability to withstand great load
- Easy to build no special training requirement
- Very long service life
- The price is much lower then that of cast in situ structure
- You can insulate the floor much better if you use a strip foundation

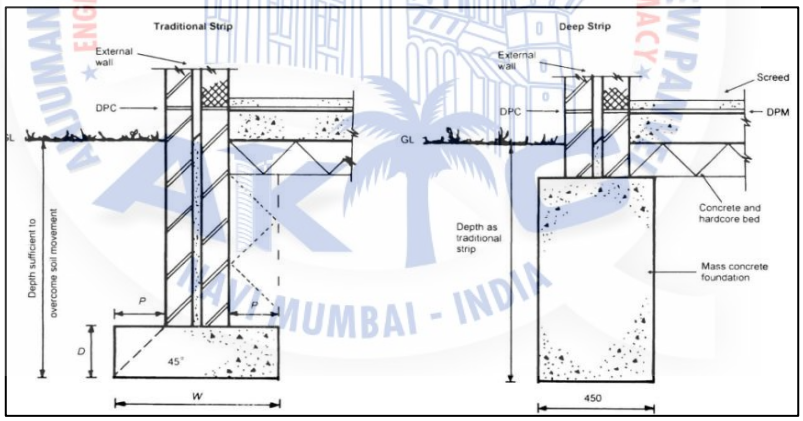

Figure 3.1 Deep strip foundation

3.8.2 Helical Pile Foundation

Helical Piles are steel shafts with a series of low-pitched circular steel helical plates welded at strategic positions along the shaft. The plates give the foundation both tension and compression bearing capacity which enables them to be used for a wide range of applications across many industries and sectors.

The piles can be connected in groups using a steel load transfer grillage and are screwed directly into the ground by machine-mounted hydraulic or electrically powered drilling equipment. Helical Piles make the use of concrete for foundations a thing of the past.

Advantage

- Cost effective, rapid installation
- No concrete required, saving both curing time and money
- Small base construction for use in restricted areas
- Removable and reusable
- Low noise and minimal vibration during installation.

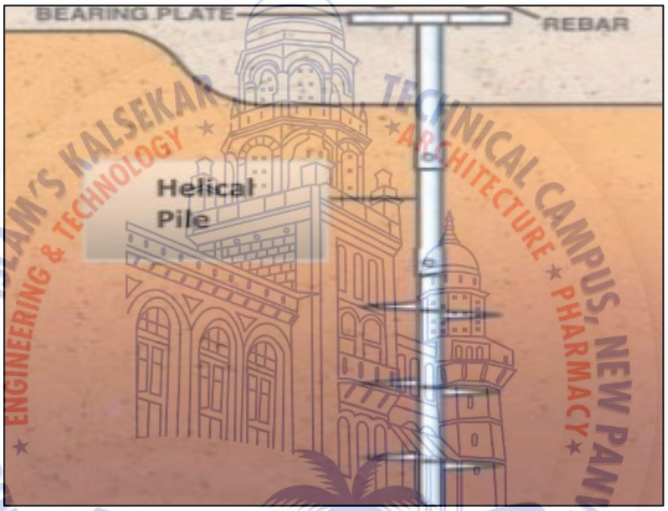

Figure 3.2 Helical pile foundation

3.8.3 Driven Pile Foundation

A driven pile is a relatively long, slender column, provided to offer support or to resist forces, made of preformed material having a predetermined shape and size that can be physically inspected prior to and during installation, which is installed by impact hammering, vibrating or pushing into the earth. Driven piles are usually the most cost effective deep foundation solution. You pay only for what you need. There are no hidden extra costs or added expenses for site clean-up. The wide variety of materials and shapes available for driven piles can be easily fabricated or specified for high structural strength, allowing them to be driven by modern hammers to increased working loads thus requiring fewer piles per project, resulting in substantial savings in foundation costs.

Advantages

- Driven piles may conveniently be used in places where it is advisable not to drill holes for fear of meeting groundwater under pressure.
- Driven piles are the most favored for works over water such as piles in wharf structures or jetties.
- Driven piles maintain their shape during installation. They do not bulge in soft ground conditions and are typically not susceptible to damage from the installation of subsequent piles.
- Driven piles require no curing time and can be driven in natural sequence rather than skipping alternate piles, thus minimizing the moving of the equipment and speeding up installation time.

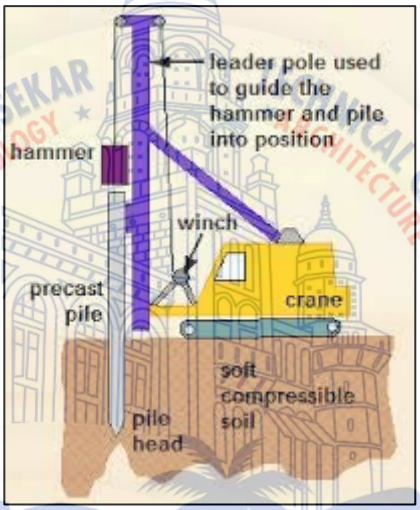

Figure 3.3 Driven pile foundation

3.9 Column

A column in structural engineering is a structural element that transmit through compression, the weight of structure above to the structural element below. Column are generally compression member.

Column are important part of the structure as entire load of slab and beam are transfer to the column. Therefore, it is necessary to construct the column with necessary strength and striving towards the economy.

Different methodologies of column construction are.

Bamboo reinforced column.

With advancement of science and technology, it has found that some species of bamboo have ultimate tensile strength same as that of mild steel at yield point. Experimentally it has found

that ultimate tensile strength of some species of bamboo is comparable to that of mild steel and it varies from 140N/mm sq to 280N/mm sq bamboo is versatile material because of its high yield strength to weight ratio, easy workability and availability. It is also found that bamboo act very well in buckling but due to low stress then compared to steel due to it not being straight it may not be very good. Further it is established that failure of bamboo is very less as maximum absorption of energy is at joint.

Some specific property of bamboo is given below.

1. Specific gravity- 0.575 to 0.655
2. Average weight- 0.625 Kg/m
3. Modulus of rupture -610 to 1600 Kg/cm sq
4. Ultimate compressive stress --794 to 864 Kg/cm sq
5. Safe working stress in compression- 105 Kg/cm sq
6. Safe working stress in tension -160 to 350 Kg/mm sq
7. Safe working stress in shear-115 to 180 Kg/cm sq

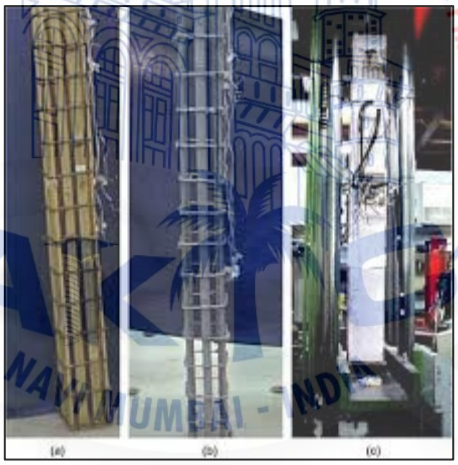

Figure 3.4 Bamboo reinforcement

3.10 Fiber reinforcement.

FRP reinforced concrete column are defined as concrete structure that are reinforced with FRP. Such reinforcement may come in various type and shape. But commonly used material are the GFRP, CFRP, and AFRP. Among this reinforcing bar, CFRP is most expensive as compared to glass and aramid. When cost become major consideration in project, GFRP reinforcing bar are more applicable. Many conventional steel concrete structures faced with steel corrosion problem due to exposer to corrosive environment it was more critical for

marine structure. Most of them will exposed to chloride sulphide etc. for those reason FRP become an alternative reinforcement. Nowadays, internal reinforcing technology with FRP composite become more popular and many research been carried out to prove that they can be successfully replaced by conventional steel reinforcement.

3.10.1 Method

Column are strengthened by making groove in column in bottom side. After grove were cleaned and primer on concrete face. The base and hardener of primer was mixed together in bucket proportion of 100:35. various size of (8mm, 10mm, 12mm) of GFRP bars were placed in groove. After that specimen were tested un UTM.

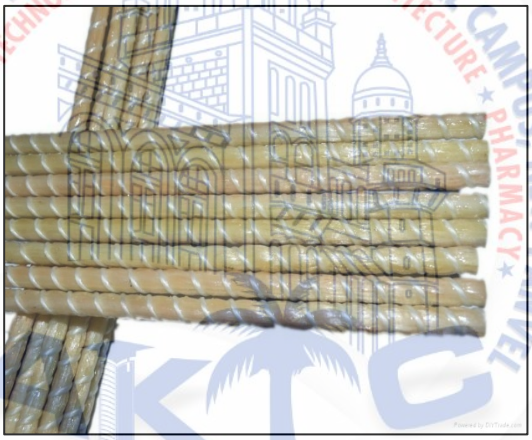

Figure 3.5 FRP reinforcement

3.10.2 Prefabricated fiber reinforcement.

These are special type of reinforcement in which reinforcements are pre-fabricated in factory itself and are then sent to site for its installation. They are available in different sizes and also saves lot of time as it is prefabricated.

Figure 3.6 Pre-fabricated reinforcement

3.11 Flexural members.

A flexural member is the member which is subjected to both tension and compression within its depth. A beam is usually a flexural member as the load applied will usually cause the bottom flange to go into tension and top flange to be compressed. Most column are not flexural member as they are loaded at the top that means whole column is subjected to compression.

As tensile load is also carried by flexural member along with compressive load it shall be designed is such a way that it can withstand all the forces satisfactorily.

3.11.1 Pre-cast T beam.

This floor system is very simple and easy to construct and has been successfully used in number of construction in India. It is of two types ordinary and hollow. For all spans, these unit have uniform flange width of 12”. The depth of rib and reinforcement are adjusted to suit the span. After unit are set into position, the joint are grouted to make them water proof with cement mortar 1:2 mixed with 10% crude oil.

The hollow type of floor, although more expensive provide better heat insulation and also have added advantage of better appearance due to flat ceiling. the t beam unit are cast in simple mould either of wood or steel. If the number of unit are small, an adjustable mould can be made to make t beam of different depth.

Figure 3.7 Precast beam

3.11.2 Bamboo reinforced beam

One of the property of bamboo as a good substitute to steel in reinforced concrete is its strength. Bamboo is easily accessible as it grows in almost every tropical and subtropical region, this lower the cost of construction and increase the strength of building that would be unreinforced. One of the major problem is that it attracts living organism.

Method (performance and evaluation of bamboo reinforced beam, Lena khare)

As bamboo was used as an reinforcing material, it was necessary to compare its behavior with steel , therefore the beam was designed in accordance to ACI and ASTM standard and specification

In beginning of the beam design the width to depth ratio was 0.4 assumed along width of bar (19mm) as suggested by reference. As per ACI spacing was in between 1.5 to 2 inch. both cover and spacing was chosen as 1.5 inch. And then the span of beam was determined which was found out to be 2.13m. and were tested by subjecting four point bending to determine ultimate load.

Stress strain curve (alternative low-cost building materials)

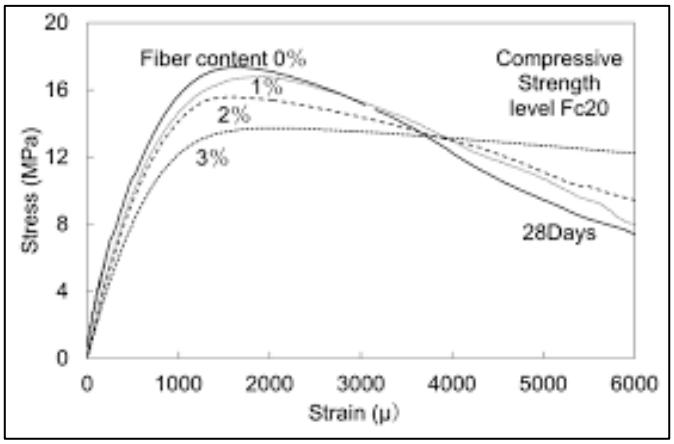

Figure 3.8 Stress strain curve of bamboo reinforcement

3.12 Plastering and other works (walls).

3.12.1 Walls

Walls are built to partition living area into different parts. They impart privacy and protection against temperature rain and theft. Walls may be classified as.

Load bearing walls

Partition walls

Load bearing walls: if beams and column are not used, load from roof and floor are transferred to foundation by walls. Such walls are called load bearing walls. They are to be designed to transfer the load safely.

Partition walls: in framed structure partition walls are built to divide floor area for different utility. They rest on floors. They do not carry load from roof and floor. They have to carry only self-weight. Hence normally partition walls are thin.

3.12.2 Fly ash bricks

Fly Ash Bricks are made of fly ash, lime, gypsum and sand. These can be extensively used in all building constructional activities similar to that of common burnt clay bricks. The fly ash bricks are comparatively lighter in weight and stronger than common clay bricks. Ordinary Portland Cement can also be used in place of Lime and Gypsum. Owing to the high concentration of Calcium Oxide in class ‘C’ fly ash, the brick is described as “self-cementing”.

Properties:

1. Size: Machine Made Modular size 20 cm x 10 cm x 10 cm
2. Weight: 2.5 Kg to 3 Kg.
3. Compressive strength: 100 to 120 Kg/cm^2
4. Water absorption: 15 to 20%

It's a proven fact that Fly ash bricks which is made with following the BIS standards in India are 100 % reliable and long lasting than normal red clay bricks of any other conventional building material.

3.12.3 Advantages of using Fly Ash Bricks:

1. Fly ash bricks are light weight material compared to clay bricks, so it is suitable for multi storey buildings, less weight means less stress on building, hence safety assured.
2. Fly ash bricks absorb less heat than normal bricks; therefore, it keeps your building cool even in summer, hence most suitable for Indian conditions.
3. Due to its uniform and even shape, less mortar is required in construction. Also plastering can be avoided if used for compound wall.
4. Plaster of Paris can be applied directly without a backing coat of plaster.
5. The compressive strength of Fly ash bricks is high compared to normal bricks, Therefore, less wastage occur during transportation.

Figure 3.9 Fly ash bricks

3.12.4 Rice Husk (effect of rice husk ash to properties of brick)

India is one of the largest producer of rice. The combination of different proportion of rice husk ash is determined. The percentage of rice husk, rice husk ash varied from 2, 4, 6, 8 and 10 by weight the product was examined for various property which showed that increase in proportion of rice husk increase the compressive strength of the brick

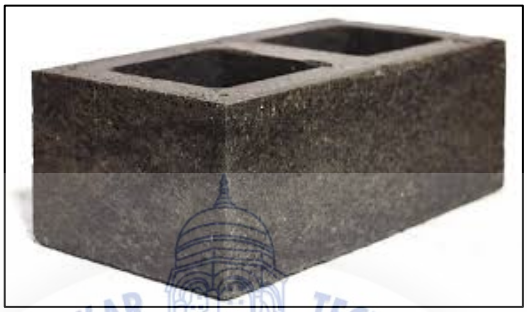

Figure 3.10 Rice husk brick

3.12.5 Straw bale brick

Straw is natural fiber which we get from byproduct from the agriculture. We can get this from wheat, rice. Straw bale are simply compressed bundle of straw arranged in square, rectangular, round shaped attached with wire straw bales are light in weight approximately 65% less then equivalent brick wall and 62% less than concrete block wall.

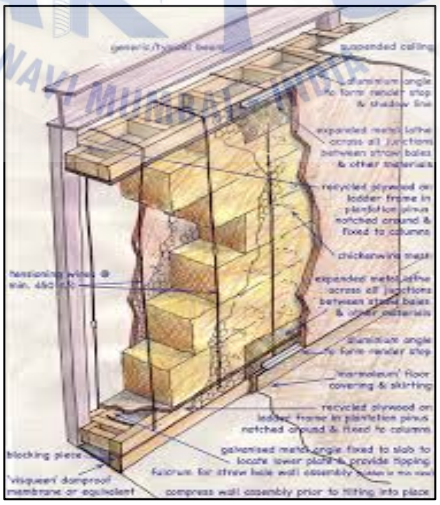

Figure 3.11 Straw bale bricks.

3.12.6 Stabilized mud block

Stabilized mud block technology is simple, cost effective, environmental friendly technology developed by center of science and technology, it uses locally available material and reduces energy consumption and thus, reduces the cost.

Advantage

- 70% energy saving when compared to burnt bricks.
- 20 to 40% more economical as compared to brick masonary.
- Better finish hence plastering of wall can be eliminated
- Highly decentralized production
- Aesthetically pleasing

3.13 Plastering.

Plastering is generally the mixture of cement, sand and water. Which is generally mixed in appropriate proportion to achieve the desired grade of mortar. Plastering is used for ceiling, inside and outside wall. Joints are generally raked before plastering and proper curing is ensured. plastering can be avoided if brick used are of great quality.
Plastering can be done in different ways.

3.13.1 Gypsum plaster.

- Availability of River sand has become a major issue in most of the states in India. Time and again National Green Tribunal (NGT) has taken action against illegal sand mining which are harmful to nature.

Also consider the fact that non-availability of river sand significantly increases the prices while also impeding the construction speed.

Compare this with use of **Gypsum plaster**, which are completely recyclable and hence pose no threat to the environment. Gypsum plaster main constituent is Plaster Of Paris or POP(stucco) which is obtained after heating the gypsum rock. Upon addition of water it goes back to its original form providing required strength.

- Sand Cement plaster require at least 7 days of water curing. Water is slowly becoming a very valuable resource and the amount of water saved in curing can have a significant impact on your cost.Compare this with **Gypsum plaster** which doesn't require any water curing thus saving you the time of waiting for further work while also saving money.
- You may have observed shrinkage cracks on a Sand Cement plastered surface. It occurs because of the heat of hydration released during drying of sand cement plaster leading to hairline cracks formation in medium term (8-10 months) **Gypsum plaster** doesn't have any heat of hydration and hence doesn't have any crack formation.

3.13.2 Methodology to apply plaster

- Plaster Mortar needs to be mixed in 1: 4 (Cement : Sand) proportions. Ensuring appropriate mix is a big challenge. While mixing of material there is a high probability of contamination, loss of cement paste, and incorrect water cement ratio. **Gypsum Plaster** needs to be mixed with water and can be applied directly to any surface (bricks, blocks and RCC) thus providing you with uniform mixture for the whole construction time giving you control over quality.
- Sand Cement Plaster requires at least fifteen days for plaster to set and attain full strength; this includes drying time of sand cement plaster post adequate curing. Sand screening is also a major challenge at construction site. Gypsum plaster sets within 30 minutes, attains full strength in 78 hours.
- Final finish of sand cement plaster is rough, coarse and requires to be further finished to make it line leveled and smooth enough to receive paint over it.With Gypsum Plaster the surface is already line and leveled, and is smooth enough to receive paint over it.

3.13.3 Copper slag plastering

Copper slags (studies on use of copper slag as replacement material for river sand in building construction) are generally the byproduct obtained through manufacturing of copper. large amount of copper slag is generated as waste worldwide during copper smelting process. This copper slag can be used as partial replacement in cement concrete and building construction. Cement mortar mixture prepared with fine aggregate made up of different proportion of

copper slag and sand are tested for mortar and plastering. Three masonry wall panels of 1 * 1 m were plastered.

The study showed that although copper slag based mortar are suitable for plastering, with increase in copper slag content. The wastage due to material rebounding material from plastered surface increase. It is therefore suggested that copper slag can be used for plastering up to 50% mass by aggregate and for vertical surface it can be used up to 25%.

Chapter 4

Results and Discussions

4.1 General

In order to achieve economy in construction it necessary to select the most suitable method. While considering economy we shall also remember the strength of the structure. On the basis of above mentioned method of construction we came to know that. Site selection can be done at low cost for construction of a structure in city by selecting area in the vicinity of the city or in the suburban areas.

4.2 Foundation

Foundation is an important part of the structure as 10-15% of total construction cost is considered under foundation according to the data given in table (foundation construction cost comparison) which give the comparison of different foundation system.

Table 4.1 Comparison of foundation

	Deep strip foundation per m sq	Helical pile foundation per m sq	Driven pile foundation per m sq
Cost (INR)	100	40	50
Duration	Moderate	Less than driven pile	More than both

Hence, from the comparison given in the table above for low cost foundation construction Helical pile foundation is most suitable.

4.3 Column

Most of the structural failure occur due to various failure in column. Hence it is necessary to construct the column with proper strength

Table 4.2 Comparison of column

Column	**Steel (per m sq.)**	Bamboo (m sq.)	FRP (m sq.)	Prefabricated reinforcement (200*200*300)
Cost (INR)	50	20	21.2	2900
Tensile strength	200-2100 Mpa	160 N/mm sq.	150 N/mm sq.	200 N/mm sq.
Advantage	High tensile strength	Emit less carbon	cheap	Time and labour saving

Column construction cost can be reduced up to 10% by making use of bamboo reinforcement. Cost can also be reduced by making use of FRP reinforcement.

4.4 Beam

Beams are generally flexural member as it is subject to both compression and tension and entire load of the slab is transferred to the beam. Comparison of different Beam construction technique is give in the table below.

Table 4.3 Comparison of beam

Beam	Steel beam	Precast T beam	Bamboo reinforced beam
Cost (Rs/m)	1300	450	150

For beam construction use of precast beam can save labour cost while bamboo reinforcement can save up to 9 to 10% of total reinforcement cost.

4.5 Wall

Wall is a structure that defines an area, carries a load or provide shelter or security. Hence for the economical construction of the wall followings are the options

Table 4.4 Comparison for wall

Wall Material	Fly ash brick	Rice husk brick	Straw bale brick	Mud block brick
Cost per m sq. (INR)	63	50	60	20
Thermal	excellent	Moderate	Moderate	Excellent
Water resistance	good	Depend on composition	Depend on composition	Good
Advantage	Reduce pollution	Corrosion resistant, light weight	Stable load, high bearing power	Economic and energy efficient

For wall construction fly ash brick can be used in high polluted area, for higher strength straw bale bricks can be used and with the use of mud brick large amount of cost can be saved.

4.6 Plastering

From this study the comparison between various plastering technique is given below.

Table 4.5 Comparison for plaster

Plastering	Conventional plaster	Gypsum plaster	Copper slag plaster
Cost per sq. ft (INR)	33-35	30-31	25-26
Curing	Required	Not required	Required
Compressive strength (MPa)	35	40	43

In plastering copper slag plastering is most favorable though initial cost is 2 – 3% more then gypsum plastering but because it doesn't require water for curing large amount of material and labour cost can be saved.

Chapter 5

Summary and Conclusions

5.1 Summary

Using modern technology which can improve the strength and durability of much of existing low-cost material should be encouraged. In this study, alternate construction material was studied and potential of this material to be used as an alternative building material is bought out.

5.2 Conclusions

- The dream of owning house particularly for low income and middle-income families is becoming a difficult reality.
- It is necessary to adopt cost effective, innovative and environment friendly housing technologies for construction.
- This study examined the cost effectiveness of using low cost housing technologies in comparison with traditional construction method.

- Two case studies were conducted it was found that about 22% to 26% of construction cost, including material labour cost can be saved using low cost housing technique in compare to traditional method of construction.
- This prove the benefit and trends of implementing low cost housing technology.

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