Material Used in Low Cost Housing

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MATERIALS AND CONSTRUCTION METHODS USED IN LOW – COST HOUSING CONSTRUCTION IN DELHI

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DISSERTATION IN ARCHITECTURE

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ABSTRACT

"They are not houses, but a home where a happy community lives. That is what finally matters" - B.V Doshi.

Raising area costs is driving out oppressed individuals that serve advantaged individuals being dis-housed. The housing shortage has now become a major issue next just in significance to the food deficiency in India. This has been because of the mass neediness and financial backwardness, the two of which block the proficient usage of the current accessible assets for social housing and development on a satisfactory scale. Personal satisfaction is abominable for EWS (Economically Weaker Section) which presently represents 60% of the metropolitan populace constraining them to migrate further. In low – cost housing projects, there is a need to get inventive arrangements by thinking about the entirety of the issue.

This Dissertation delivers the way to deal with limit the expense of a unit in Low – Cost Housing development in Delhi by decreasing the length of the project by utilizing different strategies and materials without losing quality.

In research it came to know, three variables influence the expense of low-cost housing i.e., time, the material utilized, and methods that are used. These three variables were kept as the base of this whole research. The research was concluded by giving a cost analysis & comparison between Conventional and Alternative Materials.

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CHAPTER 1: Overview

1.1: Aim

To understand how various materials and construction techniques can influence the cost factor in low-cost housing projects in Delhi Region.

1.2: Objectives

a) To examine the present housing scenario in India.

b) To study various Construction techniques that can be used to reduce the cost of construction.

c) Study of alternative materials which can be used for Low-cost housing.

d) Cost estimation of normal building and identifying the percentage reduction in cost for the low-cost building.

e) To Understand the Low-Cost Housing parameters.

f) To deliver suitable housing for the EWS sector which accounts for 60% of the population.

1.3: Research Question

How to reduce the cost factor in Low – Cost Housing projects by using various types of construction techniques and materials in the Delhi region?

1.4: Research Gap

In affordable/low-cost housing, many types of research are being done but the following points are always neglected

a) The minimum volume of habitation that an occupant needs.

b) Provision of cost-effective amenity and construction

c) Exploration of new cheaper materials and construction techniques.

1.5: Scope

a) The cost estimation is done roughly by referring to standard rates and percentages for Low-cost techniques as per DSR 2019.
b) This may result in a lower degree of accuracy.
c) These results may not hold good in case of rural conditions. Thus there is a chance for deviation of results.
d) The cost is estimated assuming ideal conditions and may vary depending upon the suitability and availability.

1.6: Methodology

The research approach is Teleological (where the process is important) and hybrid methodology is adapted, of both quantitative analysis and qualitative analysis for the research in the low-cost housing for the EWS sector. The research approach will be as follows:

a) Literature study and data collection on low-cost housing.

b) Explorations of the present scenario in low-cost housing in Delhi.

c) Studying materials & techniques that are currently in use

d) Introducing new sustainable materials for fast construction

e) Interviews of the prominent people whose works include low-cost construction

f) Case study and its inference.

g) Determining the size of an EWS dwelling.

h) Analysis of the cost factor in traditional materials v/s new conventional materials that are used in the making of the dwelling.

i) Analysis of data and conclude inference.

Chapter 2: Introduction

In creating nations, for example, India, just 20% of the populace are high-pay workers, who can manage the cost of typical housing units. It is critical to have your very own shelter. The housing market has gone through a consistent change throughout the long term. And it has changed for the better. Endless housing projects are coming up in various nations. The low-pay bunches in creating nations are commonly incapable to get to the housing market. And therefore, low-cost housing becomes possibly the most important factor it is an overall idea and has more to do with planning and tries to decrease development costs through better administration, fitting utilization of nearby materials, abilities, and innovation yet without yielding the exhibition and structure life. (Tiwari 1999). It ought to be noticed that low-cost housing is not houses built by modest structure materials of inadequate quality. A low-cost house is planned and developed as some other house concerning establishment, structure, and quality. The cost decrease is accomplished through the powerful use of locally accessible structure materials and procedures that are solid, conservative, acknowledged by clients, and not needing expensive upkeep (Miles 2000). The economy is likewise accomplished by deferring completing and executing ease lodging advances in stages. High effectiveness of laborers, limit squander in the plan and apply great administration rehearses, can likewise be accomplished. It is more about the use of neighborhood and indigenous structure materials, nearby abilities, energy savers, and condition agreeable choices.

2.1: Housing Concept

Man is a creature contrasting from different creatures because of the sanity he has. The will to live or intuition for self-conservation is the most grounded intuition men have. The will to live subsequently implies over all the will to work, for, without work, there is no food, garments, cover, and, in this manner, no life. The asylum is the second significant component in the make-up of a town or network for what it's worth in a man's life. Henceforth the plan of an abode unit and its environmental factors are significant components. The primary reason for the residential unit is to store up man's substantial and otherworldly quality. It is undoubtedly a man's probably the best development for self-conservation.

The regular day to day existence of a normal man is brimming with work and he draws upon the quality picked up from food and rest at home. Henceforth after work, he should unwind and rest, secured from cold and inconveniences, from uneasiness and clamor. Hence, the sanctuary must be very much underlying every one of its parts and verification against approaching soggy from all sides and keep out the components that sap energy away.

Probably the most significant physical needs depicted previously must be fulfilled first. Be that as it may, man has a second existence of the soul, as well. The life of wants, feelings, recollections, and so on. The profound life, for all its impalpability, is the life we truly feel, and indivisible from the body, and should be given a proportion of independent definition in pondering desi and the network. All needs both physical what's more, otherworldly should be fulfilled in the network and town

2.2: Housing Problem in Delhi

Delhi is encountering the most elevated populace development rate among uber urban areas in India. By 2021 its populace is extended to associate with 27 million. The outcome of a quick increment in populace and the evolving financial example in Delhi has brought about an intense deficiency of housing and related infrastructure particularly for poor people and low-pay family units. Almost a large portion of the populace anyway lives in states of hopeless destitution, packed into stuffed ghettos and hutment. Delhi's informal housing is an impression of a poor and wrong metropolitan arranging framework, with an absence of public speculation and limitation in the proper land and lodging market. (Agarwal, 2018)

2.3: Housing Demand & Supply

The expansion in the populace has prompted ascent popularity for homes, particularly in the affordable housing category. The city faces a tremendous housing deficiency. Delhi has a novel issue of low Floor Space Index (FSI) proportion which implies that the potential for vertical advancement is restricted. There isn't a lot of land accessible in the city to create moderate lodging. This has prompted an expansion popular for lodging in Delhi's rural areas, for example, Gurugram, Noida, and Greater Noida. Be that as it may, as per the Delhi Master Plan, 2021, 20 lakh new dwelling units will even now be required in Delhi, to oblige the developing populace. (Agarwal, 2018)

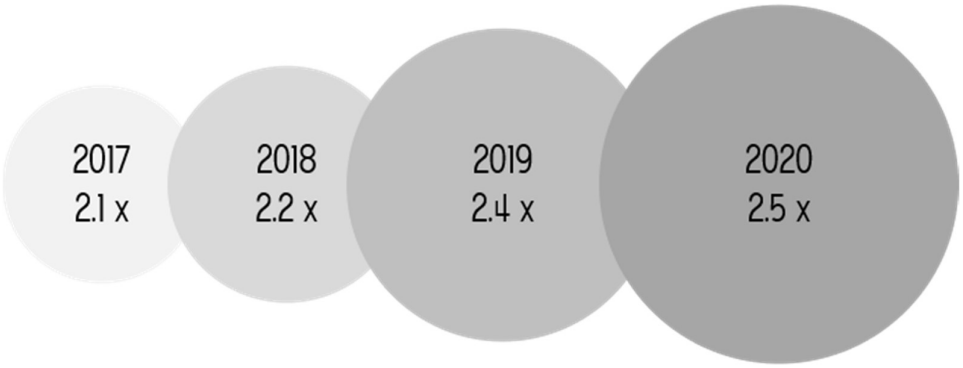

Figure 1 Year-wise demand-supply gap projected

2.4: Government Measures

The Modi administration is very much aware of this and in the 2017 Union Budget, it declared a few motivating forces to promote Low-Cost Housing. Foundation status was agreed to low-cost housing, which will make it simpler for designers of moderate homes to get back at appealing rates. In the ongoing area pooling strategy, the legislature has said that it will inform 89 towns as 'advancement territories'. This will open around 20,000-25,000 hectares of land across Delhi, generally in metropolitan towns and littler towns at the city's peripheries, for land improvement. Normally, 10 lakh lodging units will be created in Delhi in areas, for example, Bawana, Narela, Dwarka, and Rohini, out of which 2.5 lakh units will be in the reasonable lodging portion. These 10 lakh units will address the issues of around 95 lakh individuals (Agarwal, 2018)

2.5: Private Sector Participation

Government participation aside, the private segment has additionally begun looking into Low – Cost Housing. Numerous designers have declared designs to create moderate low – cost houses, after the Modi's administration boosted it through measures, for example, giving industry status to the low – cost housing segment and dispatching a moderate housing fund. It is assessed that the market size for reasonable low-cost housing in metropolitan India will develop to 38 million out by 2030.

In Delhi, measures, for example, the land pooling strategy will deliver great quality land for low–cost housing. A portion of the city's lodging deficiency will likewise be met by neighboring rural areas, for example, Noida, which are seeing a whirlwind of dispatches in the low-cost housing fragment.

Purposeful endeavors by the legislature and an expanded enthusiasm for reasonable lodging from the private part should help in facilitating the lodging deficiency in Delhi. In the long haul, in any case, measures, for example, opening unutilized/underutilized packages of land and conceivably expanding as far as possible in certain pieces of the city would be required, fulfill the developing need for housing. (Agarwal, 2018)

2.6: Delhi Development Authority

The Delhi Development Authority (DDA) was created in 1957 under the provisions of the Delhi Development Act "to promote and secure the development of Delhi". The DDA is responsible for planning, development, and construction of Housing Projects, Commercial Lands, Land Management as well as providing public facilities like roads, bridges, drains, Underground water reservoir, Community Centres, Sports Centres, Green Belts, etc. within the area of National Capital Territory of New Delhi, India.[1]

[1] 'About Us' *Delhi Development Authority* [Accessed on 28.09.2020]

2.6.1: Housing Schemes 2019 & 2020

In 2019

An all-out no of 20,980 flats are being offered out of which 3622 are for Janata or EWS (Economically Weaker Section), 16,298 for LIG (Low Income Group) pads, 579 for MIG (Middle Income Group), and 488 for HIG (high- income group) houses. The flats that were secured under the plan will be situated in territories, for example, Vasant Kunj, Kalkaji, Dwarka, Rohini Sector-34, Narela, Siraspur, and so forth. [2]

In 2020

The Delhi Development Authority (DDA) is intending to dispatch its housing plan before the finish of December 2020. Under the new housing plan, the DDA will assign extravagance pads and penthouses in Delhi in 14-story structures, with porch gardens and top tier wrapping up. The Authority will assign around 843 DDA flats in Delhi's Sector 19B, Dwarka, Manglapuri, and Jasola, the vast majority of them in the MIG class. there will be staggered underground stopping with up to three stopping openings for every level. Different highlights, for example, water collecting and a three-level, in-house water the board model, will likewise be inserted in the buildings. Aside from this, water produced from the rainwater harvesting technique will be provided in the washrooms and kitchens.[3]

2.6.2: Concessions

The DDA, on July 9, 2019, chose to lessen the expense of EWS flats in Narela, being offered under the new Online Housing Scheme 2019, by surrendering a concession of 40% to allottees. The choice was made, mulling over the salary models of allottees of EWS classification, which is Rs 3 lakhs for each annum just for affordable housing to financially more vulnerable workers, as a one-time measure.

[2] 'DDA Housing Scheme 2019' *WishFin* [Accessed on 28.09.2020]

[3] Gupta, S. (2020, September 29). *DDA to announce housing scheme 2020 in December*. [Accessed on 28.09.2020]

2.7 Builders in Delhi that specialize in Low – Cost Housing

2.7.1: Low-Cost Housing Solutions - *Suresh Chawala*

Background of the Company: Low-Cost Housing Solutions are dedicated to providing a pakka house complete with chulaha and toilet to common masses at an affordable cost with normal materials. Low-Cost Housing Solutions design and construct affordable houses by using an innovative technology invented by Mr. Suresh Chawla, who has always worked towards inventing new technologies that are not only most economical but are environmentally friendly as well. This housing is lowest in cost but longest lasting beyond 50 years due to its construction in R.C.C[4]

Construction Technology: This construction technique is not prefabricated, rather cast at a site in RCC to provide a natural feel to its users. The materials used are the same as conventional materials but the process has been so designed that it manages to save considerable time in construction. There is no change in materials but it is a change in process, which enables construction in less than 24 hours. The houses they built requires no foundation. They are earthquake resistant which is made of Removable and reusable materials comes with maintenance-free charges and part of cost recovery can be recovered after dismantling the construction

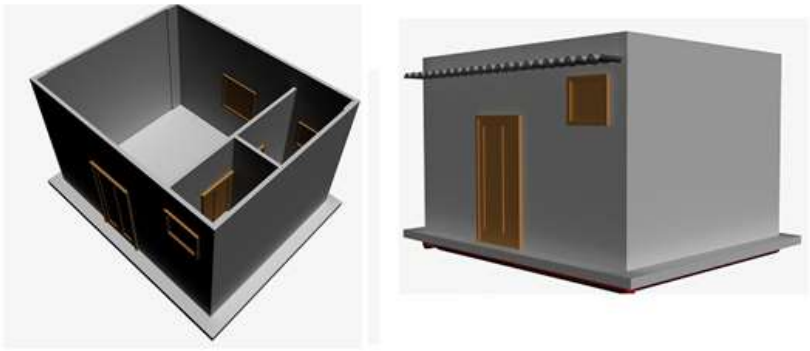

Figure 2 RCC House Sample by Low - Cost Housing Solutions

Figure 3 Labour Hutments by Low Cost Housing

[4] 'Home' *Low Cost Housing Solutions* [Accessed on 01.10.2020]

2.7.2: Nano Organization – *Octamec Engineering Limited*

Background of the Company: Octamec set up its housing division NANO with a view to cater to the acute shortage of quality housing for the low-income segments within the country. Over time Octamec has developed a variety of options for its customers which include fully fitted-out houses – an ideal housing solution for large-scale infrastructure projects and prefabricated Modular Building Systems - an ideal construction system for a variety of applications. NANO's structured town/colony planning skills coupled with its research in building techniques and materials have led to cost as well as time reductions - the two essential components our clients have in mind while implementing a housing scheme.[5]

Advanced Building Techniques: NANO adopts advanced building techniques and state-of-the-art machinery that increases speed and reduces costs. High quality yet affordable building material used for each construction. Improved and upgraded access to basic amenities in all houses. Adequate safeguard against the risk of fire and other natural calamities. Proper structured town/colony planning. Highly skilled and experienced team of professionals.

Figure 4 Maharashtra Housing Project by Nano Organization

Figure 5 Belgaum Housing Project by Nano Organization

[5] 'About Us' *Octamec* [Accessed on 01.10.2020]

Chapter 3: Parameters for Material Selection

The existing pattern of the structure is pre-building, building, and post building stages. Each phase of the structure ought to be with the end goal that they help preserve energy. These three phases demonstrate the progression of building materials through various phases of a structure.

The pre-building stage primarily comprises assembling which is partitioned into preparing, pressing, and transport. The structure stage chiefly comprises of development, activity, upkeep, and removal.[6]

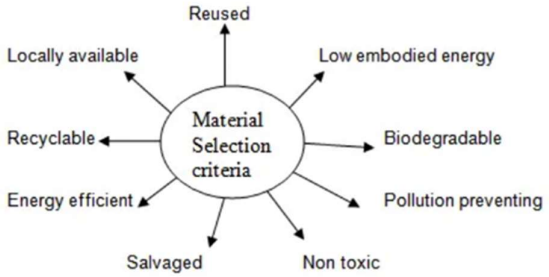

Figure 6 Depicting the material selection criteria

3.1: Environment Friendly

The assembling of building materials ought to be condition agreeable. Endeavors ought to be made to study and overhaul the innovations for delivering great quality assembling. effective structure materials and ought to improve the waste created during manufacturing.

3.2: Recycled Waste

The squanders which can be reused can be utilized in masonries while wooden squanders can be used in the assembling of compressed wood or delicate sheets.

3.3: Use of Natural Low Cost

The absolute energy needed to create material is called typified energy. The more prominent a material's encapsulated energy, it requires a more noteworthy utilization of non – inexhaustible sources. It is accordingly favorable to utilize materials or composite materials arranged from wastages.

[6] 'Building Material for Low – Cost Construction' *The Constructor* [Accessed on 20.08.2020]

3.4: Locally Available building materials

The utilization of neighborhood materials decreases the reliance on transportation whose commitment to the structure material expense is high for significant distances. The utilization of locally accessible structure materials decreases the development cost as well as is reasonable for the nearby ecological conditions.

3.5: Energy Efficient Building Materials

The energy effectiveness of building material can be estimated through different elements as its R-esteem, concealing coefficient, glowing productivity. Energy-effective materials must lessen the measure of created energy.

3.6: Non – Toxic Building Materials

The utilization of harmful structural materials can essentially affect the soundness of the development of individuals and the tenants of the structure. In this manner, it is fitting to utilize the non-poisonous structure materials for the development. There are a few synthetic compounds including ammonia, pitch resin chemicals in protection, plyboards which are available in decorations, and building material. The impact on the strength of these poisonous materials must be thought of while their choice and they ought to be utilized just where – ever required.

3.7: Longevity, Durability, And Maintenance

The utilization of tough development materials doesn't just improve the life of the structure yet, also, lessens the expense of support lower upkeep costs normally spare a ton of building working expense. The materials utilized in building decide the long haul can working.

3.8: Recyclability & Reusability

The material ought to be accessible in a structure that can be recyclable or reusable. For example –plastics waste can be utilized for reusing and creating fresher materials. The piece from steel can be utilized to fabricate the RCC bars, restricting spreads, and different incidental items in building development.

3.9: Biodegradability

The material ought to have the option to disintegrate normally when disposed of. Common materials or natural materials would deteriorate very It is additionally a significant thought whether a material decays normally or creates some poisonous gases.

Chapter 4: Classification of Materials

Low-cost Housing materials can be broadly classified into natural materials and manmade materials according to the source of the building materials.

NATURAL MATERIALS

4.1: Random-straw or coconut fiber stabilized soil

Straw-soil blend is an antiquated development material and has been utilized in numerous nations for quite a long time. The use of present-day geotechnical methods to this material can additionally improve both quality and solidness. From wet-dry test outcomes, the coconut fiber gives better strength. On the off chance that a sulfur covering is applied to the compacted straw-soil blend, better water resistance is picked up. Straw-soil blend can likewise reproduce the dirt root framework.

Figure 7 Random Straw

4.2: Corrugated bamboo roofing sheet

An effective roofing material with the improvement of conventional material comes from Bamboo Board. It is eco-friendly, lightweight, solid, and sturdy and has minimal fire danger when contrasted with cover and other roofing materials. These sheets can be utilized for roofing, walling, door and window shutters, and other components in building construction.

Figure 8 Corrugated Roofing Sheet

4.3: Earth

Earth is the most established structure material in the world. Be that as it may, its boundless use is ruined because of constraints like water entrance, erosion of walls at the level by splashing of water from ground surfaces, assault by termites and vermin, high maintenance requirements, and so on These constraints can be overwhelmed by utilizing compacted earth block and non-erodible mud mortar

4.3.1 Compressed Earth Block: The compressed earth block is the created type of molded earth block, ordinarily known as the adobe block. This innovation offers a monetary, climate amicable masonry. Balanced out earth blocks are produced by compacting raw material earth blended in with a stabilizer, for example, cement or lime utilizing a manual soil press.

4.3.2 Nonerodable Mud Plaster: Central Building Research Institute, India has built up a conservative however successful cycle to ensure mud walls by applying non-erodible mud plaster. Non-erodible mud is set up by blending bitumen reduction (Bitumen and Kerosene oil combination) with indicated mud mortar. Nonerodable mud-plasters walls are resistant to water disintegration. Center for Science for Villages, Wardha India has built up a strategy of giving potter-made tile lining to mud-walls shielding them from rain and dampness.

4.4: Straw

Straw is an agricultural by-product that involves just the plant stalks (generally cereals) after the expulsion of grain and chaff. Rice straw has the most noteworthy silica content creation making it the toughest among all other cereal straws. Straw has high potential as an alternative building material. It is also heatproof as it doesn't uphold burning, is thermally protected, has sound and dampness protection, and isn't harmful. Coming up next are the profiles of some construction alternatives built with straws and straw bales.

4.4.1 Life Extended Thatch Roofing: It is one of the locally accessible and environment-friendly alternatives for corrugated sheets. By treating it with copper sulfate solution, its life can be stretched out by diminishing the impact of biodegradability. An extra layer of treatment on the rooftop surface utilizing the phosphorylated spray or CNSL oil grants waterproofing, imperviousness to fire, termite sealing, and weathering resistance.

4.4.2 Improved Thatch Roofing: To diminish the fire risk of covering the rooftop and making it water repellent a treatment had been planned by the Central Building Research Institute. Its fundamentals the thatch layers are plastered with specified mud plasters making it solid and fireproof.

4.5: Wood

Wood has been used as a structural material for a large number of years in its regular state. Today, planned wood is getting very standard in industrialized countries. Wood is an aftereffect of trees, and a portion of the time diverse stringy plants, used for improvement purposes when cut or pressed into timber constantly, for instance, loads up boards, and relative materials. It is a nonexclusive structure material and is used in building pretty much any sort of structure in many atmospheres. Wood can be completely versatile under weights, keeping quality while twisting, and is phenomenally strong when pressed vertically. There are many shifting attributes of the different kinds of wood, even among the same tree species. This suggests explicit species are more equipped for different utilizations than others. Also, creating conditions are critical for picking quality. Raw wood (a log, trunk, bole) becomes timber when the wood has been "changed over" (sawn, sliced, split) in the sorts of inconsequential handled logs stacked on the head of each other chief issues with wood structures are a fire risk and dampness related issues.

Figure 9 Bark of Tree

MAN-MADE MATERIALS

4.6: Bricks & Blocks

The requirement for building materials is developing at a disturbing rate and to satisfy the need for new structures, new ways and strategies must be advanced. Assembling of building materials like bricks/blocks, cement, steel, aggregates, and so forth devoured in mass amounts, put great pressure on natural resources (raw materials) and energy requirements. The utilization of alternative materials for bricks ought to be urged to safeguard fertile topsoil. Depicted beneath are a couple of instances of alternative materials for bricks/blocks.

4.6.1 Fly Ash Bricks: Fly Ash Brick is a construction material, masonry unit including Class C Fly Ash and water. Because of the high convergence of calcium oxide in Class C Fly Ash, the block can be depicted as self-cementing. These properties make fly ash bricks energy productive, mercury pollution resistant, lower water infiltration, lightweight, thermal insulation, and cost-effective the main disadvantage of utilizing fly ash brick is that there is almost no data on its toxic fume emission.

4.6.2 Building Blocks from Mine and Industrial Waste: It is eco-friendly, utilizes waste, and lessens air, land, and water contamination. It is energy-efficient and cost-effective. Most of the enormous scope enterprises and power plants create strong waste in mass amounts. Red-mud, coal ash, slag, fly ash, and so forth speak to such waste unutilized for a very long while. Such waste can be used for the production of bricks/blocks, substitute for fine aggregates in concrete, the fractional substitution of cement in concrete, lime–pozzolana cement, and so on. Enormous amounts of strong waste (by and large known as mine tailings) are created by the mining industries.

4.6.3 Aerocon panels: Aerocon panels are the inorganic bonded sandwich panels made of two fiber-reinforced cement sheets. The property credits are eco-friendly, quicker construction, no wet plastering, and on-site curing, lightweight, high thermal insulation, fireproof, phenomenal sound decrease properties, water, and termite and climate-safe, appropriate for Seismic and Cyclone inclined zones, relocatable, thin walls (space-sparing), smooth finish, minimum foundation or ground preparation required and simple functionality.

4.6.4 C-Brick: These are bricks manufactured using the C-block Machine created by CBRI. The machine is accessible with BMTPC and is utilized for the creation of quality bricks utilizing fly ash – sand – lime, fly ash – sand – cement, and cement sand aggregate.

4.6.5 Ferro-Cement Blocks: Ferro-concrete can be characterized as a thin-walled adaptable high-quality cement-based composite material made of cement mortar strengthened with at least one or more layers of the wire mesh firmly bound together to make a hardened structure unit with superior, the gentility of structure, and quality.

4.6.6 Cement Concrete Hollow Blocks: Cement Concrete Block is a recently developed masonry unit of concrete. It works on the rule of densification of a lean concrete mix to make an ordinary formed, uniform, superior brickwork unit. They are a practical and better option in contrast to consumed burnt clay bricks because of their great toughness, imperviousness to fire,

fractional protection from sound, warm protection, small dead load, and high-speed construction.

4.7: Plasters

4.7.1 Calcium Silicate Plaster: Calcium silicate plasters are financial, eco-accommodating, produce less wastage, have wide use, give a smart finish, are less energy devouring, don't transmit VOC, and other harmful exhaust and gases after application, and are recyclable. They are sheltered in dealing with and use, don't require gifted labor, are quick-drying, strong, and have less water utilization.

4.7.2 Fibre Reinforced Clay Plaster: Clay Plaster can accomplish better-staying properties by strengthening it with fibers. These fibers can be natural plant (cellulose) fibers or artificial fibers of polypropylene. Plant fibers in fiber-reinforced plaster go about as reinforcement and make voids in this manner controlling breaking due to drying shrinkage and thermal movements. The dried plaster is less fragile than conventional plasters and can withstand small movements of the substrate.

4.8: Concrete

Concrete is the most typically used man-made material on earth. It is a critical advancement material used generally in structures, scaffolds, streets, and dams. Its uses reach out from fundamental applications to paviours, controls, lines, and depletes. Concrete is a composite material, including generally Portland concrete, water, and total (rock, sand, or rock). Exactly when these materials are mixed, they structure a useful paste which by then bit by bit sets after some time. There are a couple of special sorts of concrete, including

4.8.1 Ordinary Cement: This sort of cement is one of the most typically used, routinely for the improvement of asphalts and where structures needn't bother with high elasticity. The constituents are concrete, sand, and aggregate, mixed in with water, regularly in the extent 1:2:4. As it is unreinforced, this sort of cement is forbidden for certain structures as it is respectably poor at withstanding stresses impelled by vibrations, wind stacking, and so forth

4.8.2 Lightweight Cement: Otherwise called cellular concrete, this is a particularly 'flowable' material accordingly can be easily poured by using gravity and is self-leveling. It is normally used to create floor pieces, window sheets, and housetops. Such sums are used for lightweight cement fuse pumice, scoria, broadened shales, and dirt. It has low warm conductivity, by and large with a k assessment of around 0.3 W/mK, however, plain cement can be as high as 10-12 W/mK.

4.8.3 High-Density Concrete: This sort of heavyweight concrete has a more noticeable thickness than various sorts and is made using crushed rocks as coarse aggregate. As it gives extraordinary protection from x-beams and radiation, it is habitually used in nuclear power plants and other such structures.

4.8.4 Reinforced Concrete: Reinforced cement (RC) is a versatile composite and one of the most by and large used materials in the current turn of events. To extend its overall quality, steel bars, wires, work or connections can be introduced in concrete before it sets (or laid before the strong is poured). This help, often known as rebar, contradicts ductile forces, while solid restricts compressive powers (and is normally weak at contradicting elastic powers). By

outlining a strong bond together, the two materials solidify to restrict a combination of applied forces, effectively going probably as a single essential segment.

4.8.5 Precast Concrete: This is a kind of concrete that is orchestrated, anticipated, and diminished off-site, by and large in a controlled plant condition, using reusable molds. Precast strong segments can be joined to various segments to shape an all-out structure. They are ordinarily utilized for structural components, for example, wall panels, columns, beams, floors, staircases, pipes and tunnels, and so on.

4.8.6 Prestressed Concrete: Prestressed concrete is a basic material that considers predetermined, engineering stresses to be put in individuals to counteract the stresses that will occur when they are subject to loading. It consolidates the high strength compressive properties of concrete with the high tensile strength of steel. In reinforced concrete, stresses are conveyed by the steel reinforcement, though prestressed concrete supports the heap by initiated stresses all through the entire structural element. It is currently usually utilized for floor beams, piles, and railways sleepers, as well as structures such as bridges, water tanks, roofs, and runways.

4.8.7 Glass Reinforced Concrete: Glass-strengthened cement (GRC), or glass-fiber fortified cement (GFRC), is a construction material that is regularly used to form exterior cladding panels. GRC is made out of high-strength, alkali-resistant glass fibers embedded in a concrete matrix. The fibers go about as the chief load conveying segment, while the encompassing matrix keeps them in position, and moves load between the strands. The two fibers and matrix are fit for holding their physical and chemical identities while consolidating their properties to make a high-performance composite.

4.8.8 Air Entrained Concrete: This is a type of plain concrete that contains tiny air bubbles that range in size from a couple of thousandths of an inch in breadth to a couple of hundredths and regularly establish somewhere in the range of 4 and 7% of the complete volume of the solid. The air bubbles make chambers for water to venture into when it freezes, in this manner assuaging inward tension on the solid. It is fabricated by presenting air-entraining specialists as the solid is blended, or by utilizing air-entraining Portland concrete.

4.8.9 Concrete Fibre: It is a composite material comprising of a combination of concrete, cement, or mortar and discrete, irregular, equitably dispersed suitable fibers.

4.8.10 Polymer concrete: The polymer concrete market is divided into epoxy, polyester, vinyl ester, and others. Epoxy is the biggest class because of its expanding use in development and its boss properties of high impact strength, high vibration opposition, great holding with concrete and metal surfaces.

4.9: Roofing

4.9.1 Bamboo Matt Corrugated Roofing Sheets: Roofing is a basic element of any house and in India, a few rooftop cladding materials are being used including consumed burnt clay/Mangalore tiles, thatch, corrugated sheets of galvanized iron, aluminum and asbestos cement, etc. and so forth Of these, for semi-lasting structures, corrugated sheets are liked. Building Materials and Technology Promotion Council (BMTPC) and Indian Plywood Industries Research and Training Institute (IPIRTI) have mutually built up innovation for assembling Bamboo Mat Corrugated Sheets (BMCSs).

4.9.2 Micro Concrete Roofing Tiles: These are a solid, stylish, and reasonable option for slanting rooftops. Micro Concrete Roofing (MCR) tiles are produced using a painstakingly controlled blend of concrete, sand, fine stone total, and water.

FUTURE MATERIALS

The following are the future materials which are in development and will be made available for construction after a few years:

4.10 Smart Concrete

The innovation offers an alternative strategy for observing the well being of reinforced concrete structures. It works by adding a little amount of short carbon fiber to concrete with a conventional concrete blender which adjusts the electrical opposition of the concrete because of strain or stress. This can be utilized to screen pressure or strain in concrete structures, recognizing expected issues before the concrete falls flat. Smart concrete is fit for detecting exceptionally little auxiliary blemishes and consequently discovers application in checking the inward state of structures, especially after a seismic tremor. Smart concrete innovation has gone through broad research center testing yet will be yet to hit the market.

4.11 Translucent Concrete

Translucent concrete can assist with sparing your electric bills. It is made with a combination of optic ber strands, which makes a solid block that can be utilized for development. The blocks can uphold weighty burdens and their translucent nature considers more normal light subsequently lessening the requirement for electric indoor light utilization.

4.12 Self-Healing Concrete

Cement is one of the most generally utilized materials in construction. However it isn't indestructible and breaks in cement are a significant issue in construction. So specialists are investigating making self-healing cement. This cement is blended in with microcapsules that contain microbes that will sprout when water enters a break in the concrete to deliver limestone, fixing the break. This material can help save energy and costs on repairs.

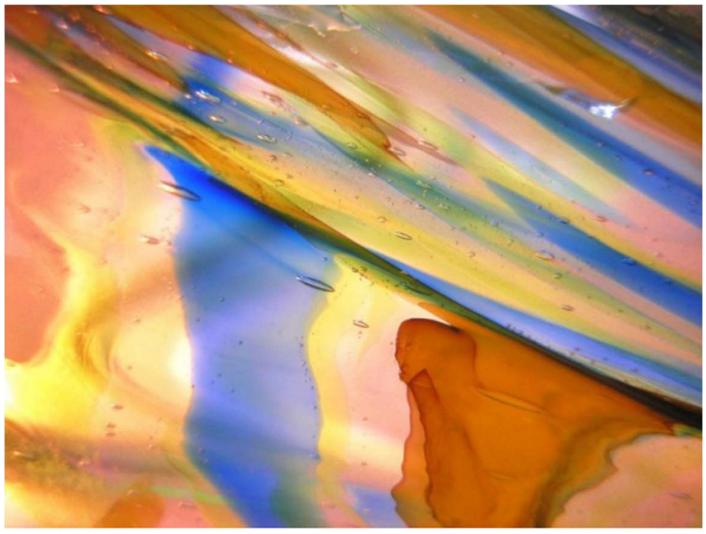

Figure 10 Self Healing Concrete

4.13 Aerogel

Heat protection materials are significant in construction, particularly in cold nations. Heat is sent through walls and will in general go straightforwardly through the structure envelope to the inner sash, for example, drywall. This cycle is designated “thermal bridging”. Another substance called Aerogel, which is an innovation created by NASA for cryogenic protection, perhaps one of the best warm protection materials accessible. It very well may be utilized to protect studs, which thusly can expand the general warmth opposition of a structure.

Figure 11 Aerogel

4.14 Paper Insulation

Another material that can be utilized for protection is paper insulation is produced using reused paper and cardboard. It is a more eco-accommodating answer for the synthetic froths, it is bug safe, re retardant and it very well may be blown into cavity walls toll every crack.

Figure 12 Paper Insulation

4.15 Carbon Fiber

An incredibly solid and lightweight material, carbon ber is many times more grounded than steel, yet just has 33% of the weight. In addition to the fact that it is solid it is adaptable and can be formed to any shape you may require. This makes it an ideal material for development ventures in regions that are presented to cruel breeze and climate conditions like cyclones and storms.

4.16 Photovoltaic Glazing

Building integrated photovoltaic (BIPV) coating can assist structures with creating their power through sunlight based force. Designers can utilize photovoltaic glass as a structure material, shaping windows, and rooftops. This kind of material can deliver energy, and it is identical to covering a whole structure with solar panels. This can enormously help in sparing energy costs just as help the climate in the long haul.

4.17 Liquid Granite

This material may simply supplant cement totally. It is lightweight, is made of reused materials, and can manage as much weight as ordinary cement. Liquid granite has none of the natural effects of cement constantly, yet has in no way different advantages. Being comprised of reused materials implies it can extraordinarily lessen the carbon impression of a territory. It is additionally very re safe, having the option to withstand temperatures up to 1100 degrees Celsius.

4.18 Electrified Wood

This material fuses a wellspring of power straightforwardly into furniture like tables and seats, disposing of the requirement for wires totally. It is made by squeezing two metal layers between the wood of the furnishings, making it conceivable to lead power through the whole household item. The force is taken care of into one connector, and different gadgets like lights can be associated with sources.

4.19 Low – E Glass/Films

Low-E Glass/Films is an exceptional kind of window glass that has been treated with a sort of metal oxide. This method creates it so the glass can dismiss heat while as yet permitting light to go through. This functions admirably as it prevents outside warmth from coming in, keeping an inside cool during sweltering climate, and can keep the glow inside, keeping an inside warm during chilly climate. Windows treated with Low-E coatings have demonstrated to diminish energy utilization and increment generally speaking solace in a structure.

Chapter 5: Traditional Construction Methods used in Delhi

The detailed procedures of each step used for the traditional construction techniques which are used in Delhi are as follow: (Tam, 2011)

5.1: Foundation

Foundation is the lowest part of the structure which is provided to distribute loads to the soil thus providing a base for the super-structure. Excavation work is first carried out, then earth-work is filled with available earth and ends with watering and compaction in a 6" thick layer.

5.2 Plinth

Plain cement concrete is used to form a leveled surface on the excavated soil. The volumetric concrete mix proportion of 1:4:8 (cement: sand: aggregate), with a 6" thick layer for masonry foundation and column footings is used. Plain cement concrete is finished on the excavated soil strata and mixed by manual process.

5.3: Wall Construction

Size stone masonry for the foundation is constructed for outer walls and burnt brick masonry of a 9" thick layer for main walls and a 4 ½" thick layer for all internal walls. Good quality table-molded bricks are used for the construction.

5.4: Slab and Beam

The normal procedure to cast reinforced cement concrete slab is to make shuttering and provide reinforcement and concreting. Good steel or plywood formwork is used, with proper cover blocks between bars. Both aggregate and sand used are clean, with aggregate being ¾" graded. After the concrete is poured, it is properly consolidated.

5.5: Plastering

Plastering is used for the ceiling, inside, and outside walls. Joints are raked before plastering and proper curing is ensured.

5.6: Flooring

For the flooring purpose, the earth is properly filled and consolidated in the ratio of 1:4:8 (cement: sand: aggregate) concrete.

5.7: Plumbing

Good quality plumbing materials are used and passed a hydraulic test before using it.

5.8: Painting and Finishing

Before the painting process, the surface is prepared with putty and primer and a ready-made paint is used.

Chapter 6: Conventional Construction techniques used in Delhi

Following are the most recent strategies which ought to be embraced for the development of Low-cost housing projects in Delhi which sought to ease the construction cost (Tam, 2011)

6.1: Foundation

Normally the foundation cost comes to about 10 to 15% of the total building and usually foundation depth of 3 to 4 ft. is adopted for single or double store building and also the concrete bed of 6" is used for the foundation which could be avoided. It is recommended to adopt a foundation depth of 2 ft (0.6m) for normal soil like grave soil, red soils, etc., and use the uncoursed rubble masonry with the bond stones and good packing. Similarly, the foundation width is rationalized to 2 ft. (0.6m).To avoid cracks formation in the foundation the masonry shall be thoroughly packed with cement mortar of 1:8 boulders and bond stones at regular intervals. It is further suggested adopt an arch foundation in ordinary soil for effecting a reduction in construction cost up to 40%. This kind of foundation will help in bridging the loose pockets of soil which occur along the foundation. In the case of black cotton and other soft soils, it is recommended to use under ream pile foundation which saves about 20 to 25% in cost over the conventional method of construction

6.2: Plinth

It is suggested to adopt 1 ft. height above ground level for the plinth and may be constructed with cement mortar of 1:6. The plinth slab of 4 to 6" which is normally adopted can be avoided and in its place brick on edge can be used for reducing the cost. By adopting this procedure, the cost of the plinth foundation can be reduced by about 35 to 50%. It is necessary to take the precaution of providing impervious blanket like concrete slabs or stone slabs all-round the building for enabling to reduce erosion of soil and thereby avoiding exposure of foundation surface and crack formation.

6.3: Walling

Wall thickness of 6 to 9" is recommended for adoption in the construction of walls all-round the building and 41/2" for inside walls. It is suggested to use burnt bricks which are immersed in water for 24 hours and then shall be used for the walls

6.4: Rat – Trap Bond Wall

It is a cavity wall construction with the added advantage of thermal comfort and a reduction in the number of bricks required for masonry work. By adopting this method of bonding of brick masonry compared to traditional English or Flemish bond masonry, it is possible to reduce the material cost of bricks by 25% and about 10to 15% in the masonry cost. By adopting the rat-trap bond method one can create an aesthetically pleasing wall surface and plastering can be avoided.

6.5: Concrete Block Walling

Because of high energy consumption by burnt brick, it is suggested to use a concrete block (block hollow and solid) which consumes about only 1/3 of the energy of the burnt bricks in its production. By using concrete block masonry, the wall thickness can be reduced from 20 cms to 15 Cms. Concrete block masonry saves mortar consumption, speedy construction of the wall resulting in a higher output of labor, plastering can be avoided thereby an overall saving of 10 to 25% can be achieved.

6.6: Soil Cement Block Technology

It is an alternative method of construction of walls using soil cement blocks in place of burnt bricks masonry. It is an energy-efficient method of construction where the soil is mixed with 5% and above cement and pressed in a hand-operated machine and cured well and then used in the masonry. This masonry doesn't require plastering on both sides of the wall. The overall economy that could be achieved with the soil-cement technology is about 15 to 20% compared to the conventional method of construction.

6.7: Doors and Windows

It is suggested not to use wood for doors and windows and in its place concrete or steel, section frames shall be used for achieving saving in cost up to 30 to 40%. Similarly, for shutters commercially available block boards, fiber or wooden practical boards, etc., shall be used for reducing the cost by about 25%. By adopting brick jelly work and precast components effective ventilation could be provided to the building and also the construction cost could be saved up to 50% over the window components.

Chapter 7: Modern Construction Techniques that can be used

Following are the modern construction methods that are widely used in developing nations:[7]

7.1: 3D Volumetric Construction

Utilizing this particular development innovation, 3D units are created in controlled processing plant settings utilizing needful development and building materials. Completed units are moved to the site in different modules, essential underlying squares, or last finished up units with all luxuries introduced, for gathering. Blocks can be raised quickly at the site and properties of solid-like fire retardant, sound resistivity, warm mass are held.

Figure 13 3D Volumetric Construction

7.2: Precast Flat Panel Modules

These are basically wall and floor modules that are made away from the genuine site and afterward moved to the site for erection. Load bearing components like decorative cladding and insulation panels can likewise be created. Likewise called cross-divider development, the innovation has picked up force because of consistent adherence to determinations and straightforwardness just as quickness of development.

Figure 14 Flat Panel Modules

[7] '8 Modular Construction Techniques' *Sancheti Builders* [Accessed on 10.10.2020]

7.3: Tunnel Formwork System

With this burrowing strategy, development is paced up for cell structures of redundant patterns through the structure of solid dividers or units in a solitary activity for each day. Speedy work is accomplished by sending formwork and prepared blended cement in with the comfort and spryness of industrial facility conditions. Formworks in the tunnel form are stacked and utilized at the site with cranes.

Figure 15 Tunnel Formwork System

7.4: Flat Slabbing Technology

This method uses the effortlessness of contemporary formwork for rapidly assembling flat slabs to facilitate the easy and swift placing of horizontal amenities and for partitioning. Expansion of pre-manufactured administrations happens as administrations can be completed uninterruptedly in zones underneath the floor slabs. Each first-rate building Construction Company is utilizing the very inside designs that can be helpfully adjusted for obliging changes sometime in the future. Further, fortification required is lesser which reduces down work expenses altogether.

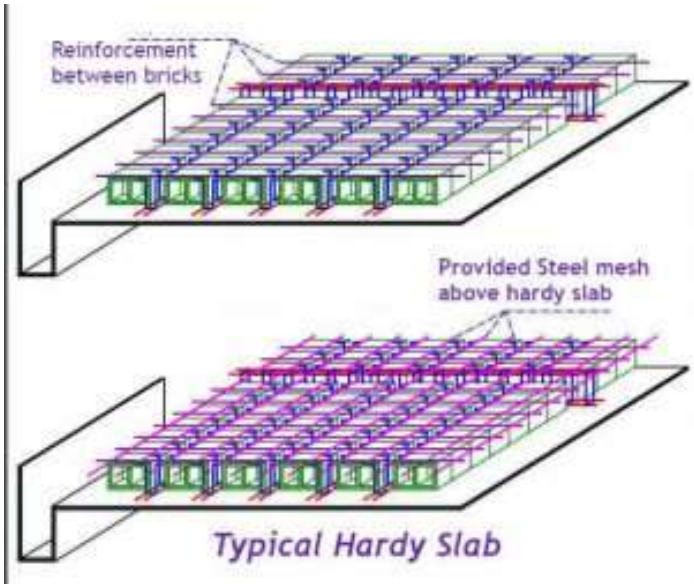

Figure 16 Flat Slabbing

7.5: Precast Foundation Technique

Foundations can be fabricated quickly with precast concrete units which are delivered in a production line and are high on the quality remainder. Strength is bestowed to foundation-related building construction materials through interconnected concrete piles. This strategy permits development work to advance even in severe climates and limits exhuming movement.

Figure 17 Precast Foundation

7.6: Hybrid Concrete Building Technique

This method assists development turnaround time by mixing the benefits of cement pre-projecting with in-situ construction. Quality improves, while the expense of development dives. Crossover concrete structures are anything but difficult to assemble, serious in nature, and perform reliably.

Figure 18 Hybrid Concrete Technique

7.7: Thin-Joint Masonry Technique

The use of this method prompts the decrease of the quantum of mortar applied by cutting its profundity from 10mm to lesser than 3mm. Therefore, mortar can be laid quickly with improved efficiency on the more drawn out wall panels. With huge measured concrete blocks, higher development proficiency alongside critical cost decrease can be accomplished. Inside a solitary day, the quantity of mortar courses laid is higher as restoring of mortar happens rapidly without settling on holding strength bringing about the disposal of the skimming issue.

Figure 19 Thin Joint Masonry Technique

7.8 Insulating Concrete Formwork (ICF) Technique

ICF method utilizes polystyrene obstructs that element twin walls and can be quickly assembled for making building wall formwork. The formwork is then siphoned in with great, prepared blended, the industrial facility made concrete. The structure development measure becomes idiot-proof and the resultant structure has a significant level of sound and warm protection.

Figure 20 Polystrene Formwork

Chapter 8: Case Studies

8.1 Tara Housing

Figure 21 Site Map of Tara Housing

Location: New Delhi, India

Architect: Charles Correa

Area: 3.7 Acres

The number of units: 160 units of 2 and 3 bedrooms.

Density: 375 people per hectare

Program: Residential centre for middle -class

Client: Tara Cooperative Group Housing Society

Cost: $ 1.48 million

Structural system: Reinforced concrete, brick walls

8.1.1 Introduction

The project is arranged along Guru Ravidas Marg Street which prompts two significant neighborhoods in the North and the South. It is in the suburb of the common laborers. Thusly, it makes an agreeable and balanced volume with the current surface as a result of confined height and the kind of the structure. More than that, the endeavor moreover affects associating these various structures with the neighboring park.

8.1.2 Materials Used

The ordinarily portrayed revealed brick and construction development reflects the planner dominating obligation to the trend-setter saying. The concrete pergola features the jiggered separate the structure surface as opposed to sketching out an amazing interminable pack.

8.1.3 Concept

Building grants people to get to authentically within the garden. More than that, everyone furthermore has their open-to-sky patios with full filled shadow. Betaking central purposes of sun, wind headings, and open spaces, consequently lighting access and ventilation to each house are extending. The homes are assembled into some little and medium squares. A few squares are gathered simply by two-room level; some are consolidated between two-room type and three-room type. It makes the variety of structure yet keeps up the rationale of dwellings" capacities. Nonetheless, there are only 16 three-room flats so it is adequate for families that have multiple individuals.

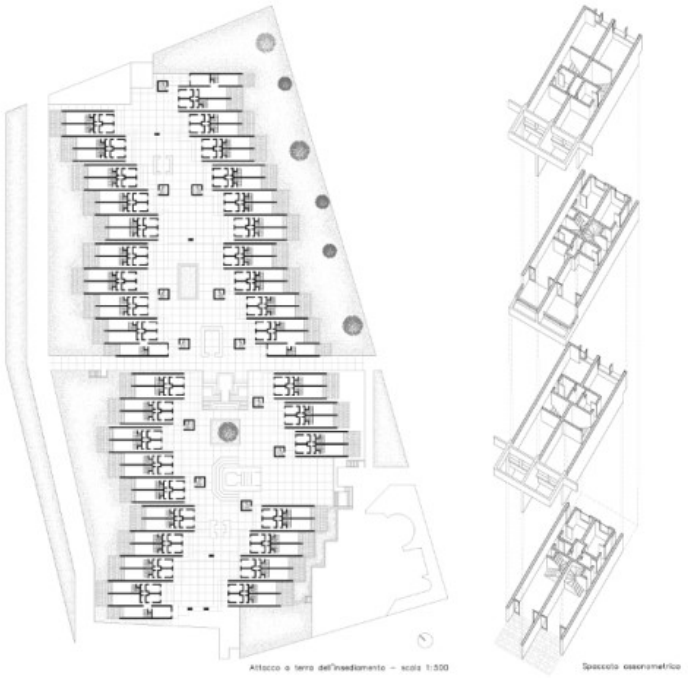

Figure 22 Site Plan with Axonometric Modules of Housing

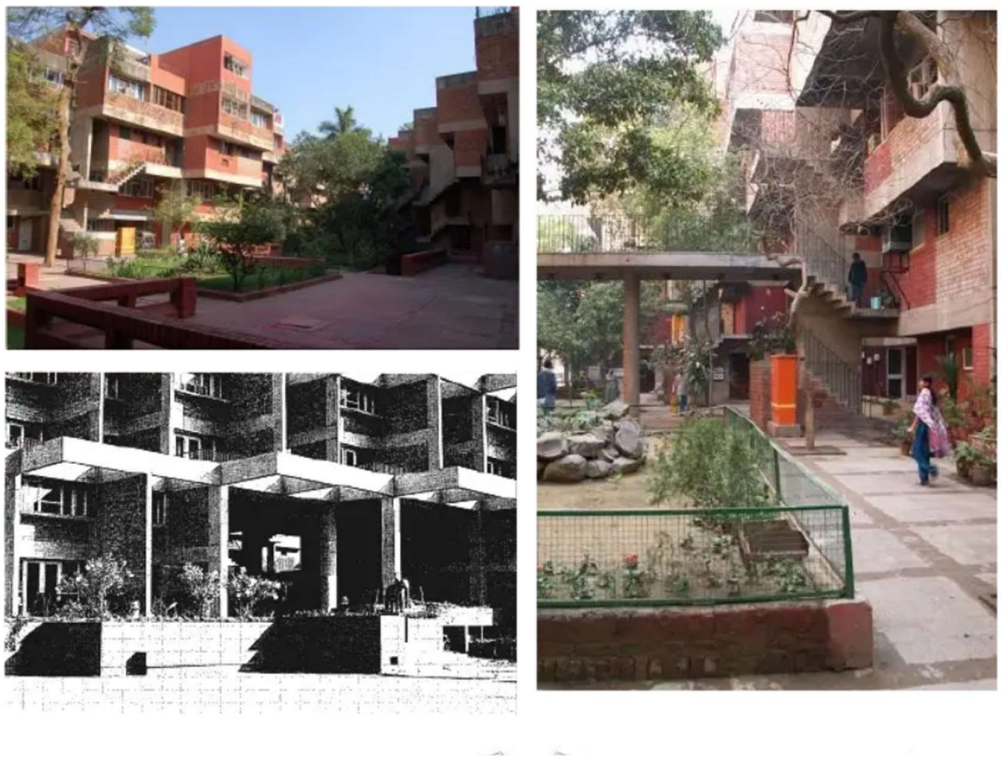

Figure 23 Current Images of Tara Housing

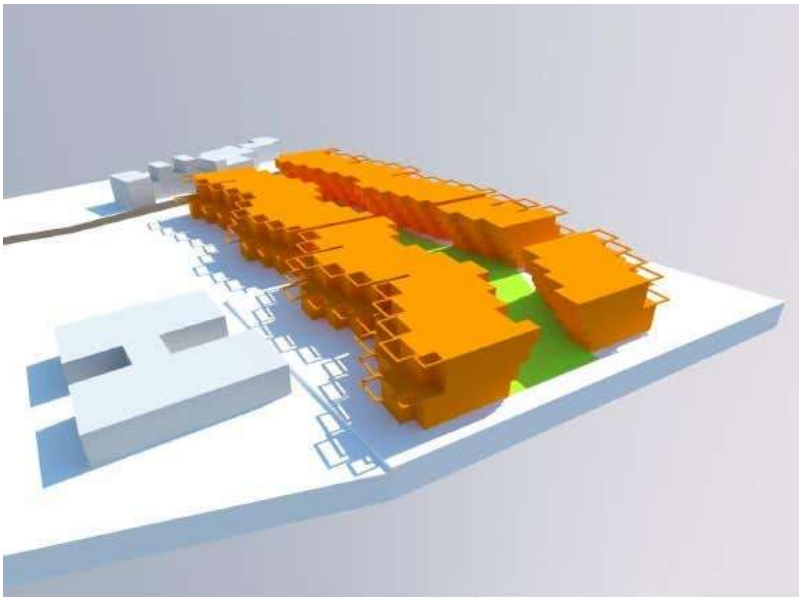

Figure 24 3D Model of Tara Housing

8.2 Sheikh Sarai Housing Complex

Figure 25 Site Map of Sheikh Sarai Complex

Location: New Delhi, India

Date: 1973 - 1982

Site: 3.82 ha

Program: Creating A Complex Consisting Of 550 Apartments

Client: Delhi Development Authority

Architect: Raj Rewal

8.2.1 Introduction

The Sheik Sarai Complex is the chief test finished by Raj Rewal on the subject of social housing applied to such an enormous degree site. It finds a way into a separating set by the nonappearance of delegate segments depicting the site, as it is periphery to the point of convergence of New Delhi. This intervention experienced improvement starting from 1970. For this circumstance Rewal works in the southern improvement zone of the city, making a complex containing 550 apartments and which may be done in 1982. Progressed by the DDA (Delhi improvement authority) Sheik Sarai is coordinated by current rules that attention on self-financing of private comfort is similarly as steady with pre-arrangement specific standards.

8.2.2 Material Used

There was a surface covering in plaster with slate powder, unpleasant completion, white shading done on the walls with white-hued wooden window frames, and utilizing outer flooring in the nearby stone square.

8.2.3 Design Concept

From a planning perspective, the association of the squares making up the arrangement discovers associations with the chronicled real factors of the urban areas of Rajasthan and Udaipur, which have described the metropolitan texture of India and which are recognized by the thickness of the possessed territory and for the cozy connection among open and shut spaces. It is a complex of 550 residential apartments, on a great deal encompassed by carports interfacing and circumscribing the Chirag Delhi private region and the public offices of the Nighurhard Park and Sheik Sarai Commercial Center.

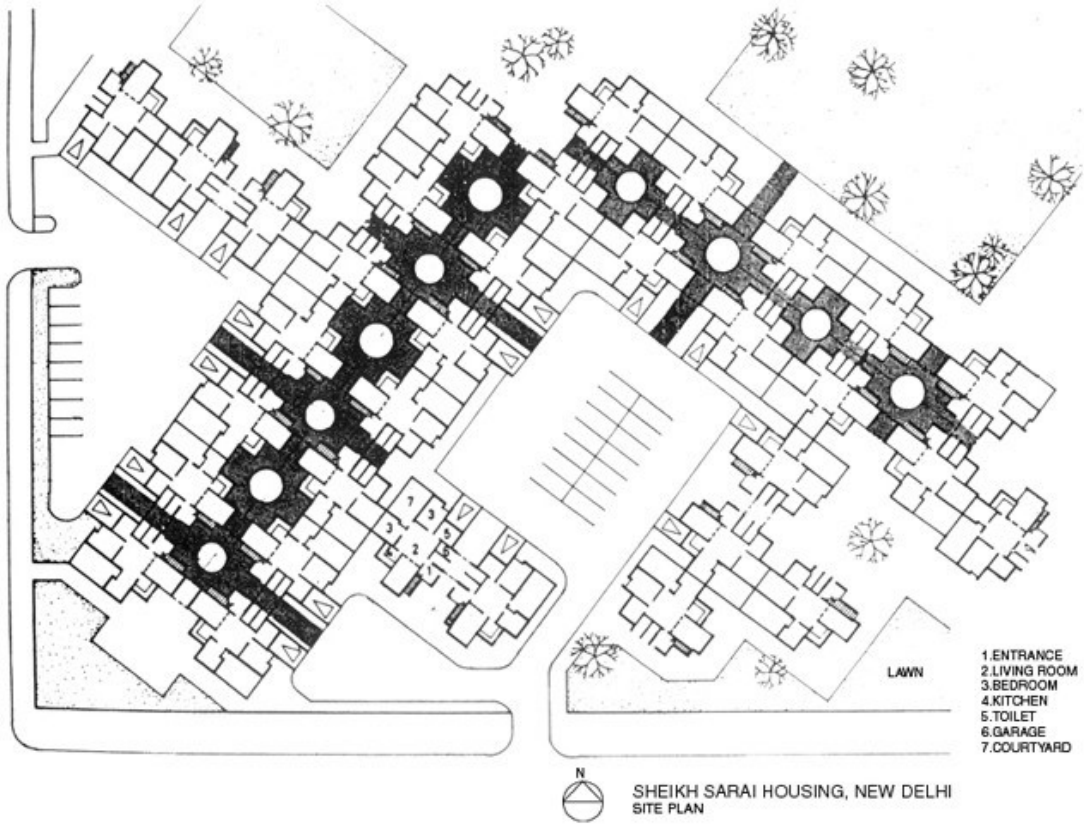

Figure 26 Site Plan of Sheikh Sarai Housing Complex

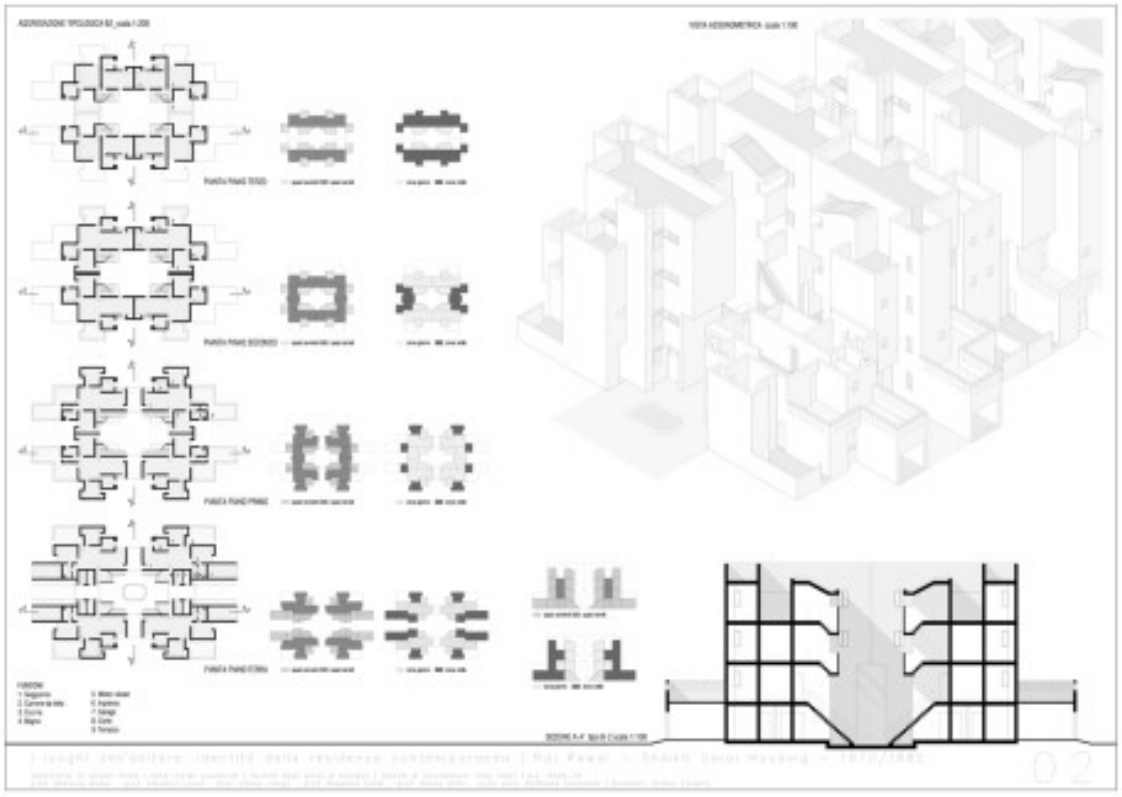

Figure 28 Plan of Individual Cluster along with a Typical Section

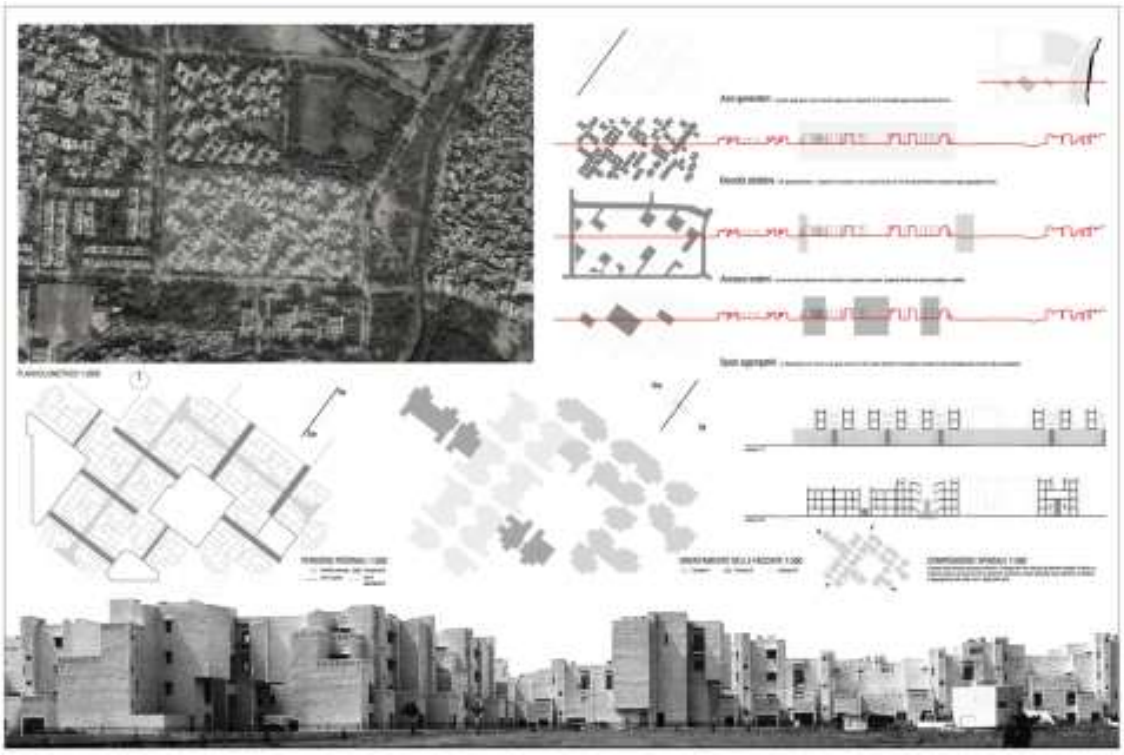

Figure 27 Site Spot Section

8.3 Aranya Community Housing

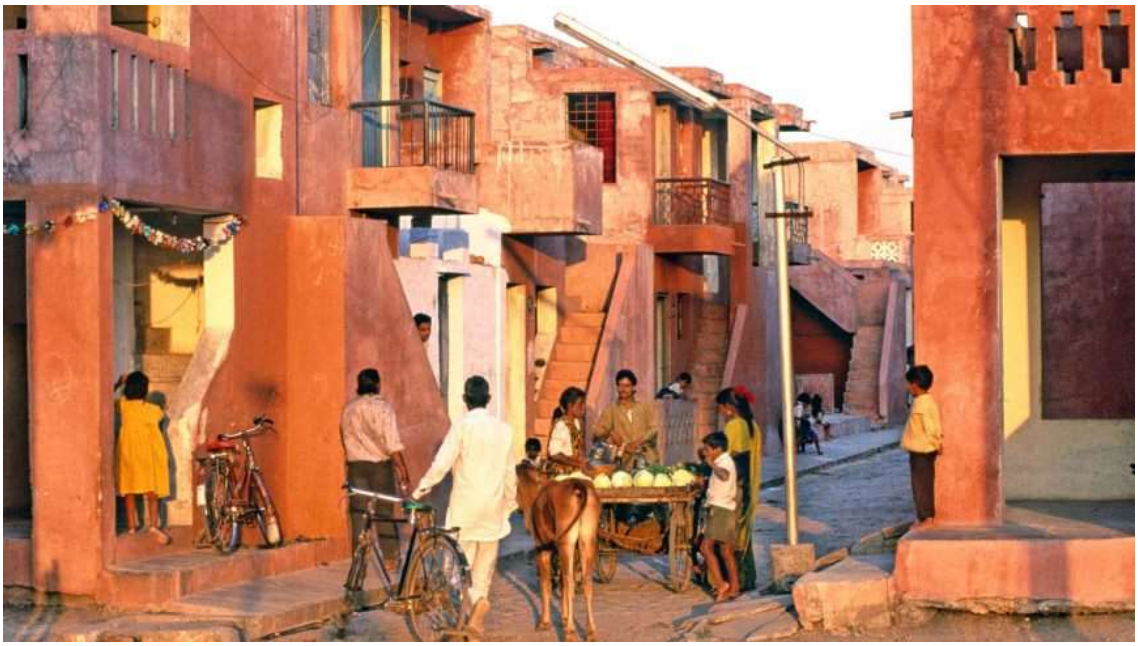

Figure 29 Street View of Aranya Community Housing

Architect: Balkrishna Doshi

Client: Indore Development Authority

Project Associate: Mr. Himanshu Parikh

Project Engineers: Environmental Engineering Consultants, Bombay

Total Built-Up Area: 100,000 m2

Project Cost: Rs. 100 Million

Year of completion: 1989

8.3.1 Introduction

The master plan of the township was casual and stressed advancement of spatial quality in the plot design plan with between connected space of social setting; support of a chain of command of street, open spaces, and business spaces; a focal area of essential network administrations, institutional, business, social offices; and the recompense of development of populace thickness and house augmentations with regards to the Indian way of life. At the six area level, the point was the arrangement of social similarity of an intelligent and incorporated pay/social gathering who have accomplished a practical network in each financial area; isolation of walker and vehicular development and great appropriation of land use and foundation; and to reflect neighborhood, verifiable trademark inbuilt structure by advancing different and covering intuitive land use, keeping in touch with fabricated and green land.

8.3.2 Planning

The High-Income group (HIG – 9 %), is along the outskirts of the public thruway and part of the southeast fringe of the arterial street in the south. The Middle-Income Group (MIG – 14 %) is arranged along the fringe of arterial streets on the northwest sides and part on the south arterial vessel street along with the piece of the spine. The Lower Income Group (LIG – 11 %) and the EWS (65 %) are situated in each of the 6 areas.

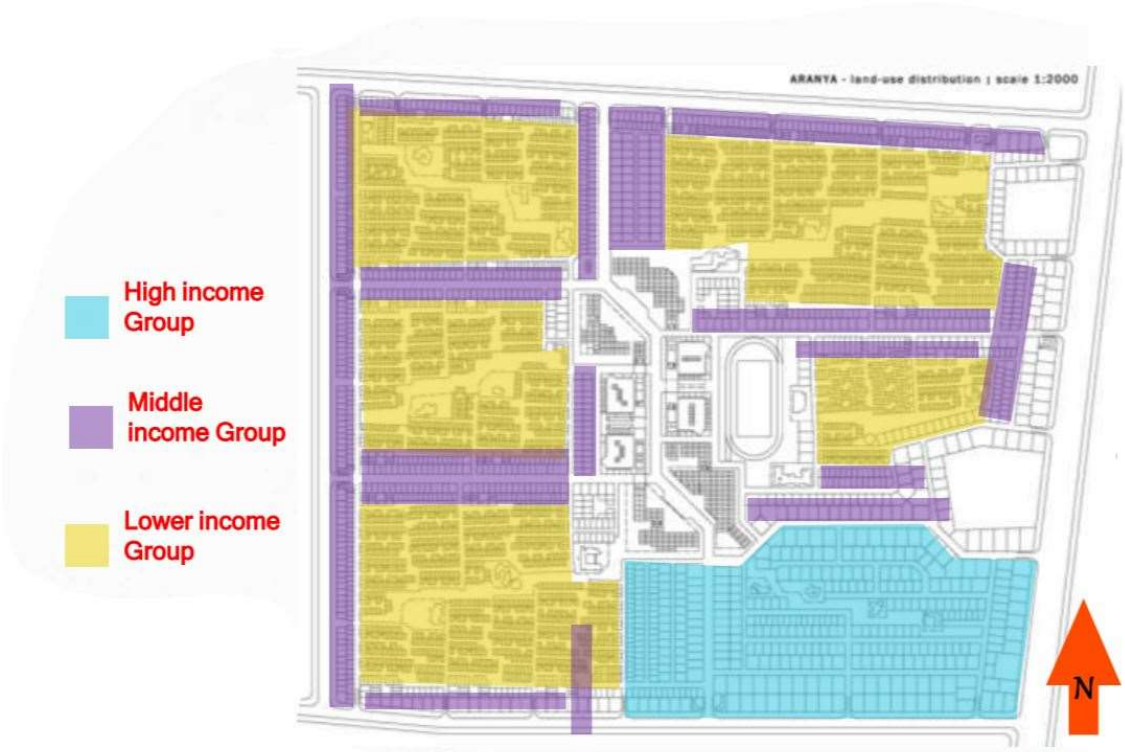

Figure 30 Distribution of Income Group in Aranya Housing

8.3.3 Income Group that was catered

Group	income	Plot size	no. Of plots	Population	Percentage
EWS I	200	35	1962	19620	66.35%
EWS II	300	35	1500	15000	
EWS III	400	35	800	8000	
LIG I	450	44	182	910	10.82%
LIG II	500	55	617	3085	
LIG III	600	93	265	2950	
MIG I	1100	139	626	6260	13.87%
MIG II	1800	223	265	2650	
HIG I	1800	325	180	1850	9.02%
HIG II	1800	474	75	750	

Table 1 Group Wise Income Tabular Chart

8.3.4 Materials used for construction

- Conventional and locally available building materials and construction techniques were adopted. The structures were constructed with load-bearing brick walls.
- Walls were plastered and painted.
- Floors were cement concrete.
- The CRC roof was always constructed at a later stage because it was a high investment item.
- The black cotton soil of the site necessitated a pile foundation even for simple and 2- story buildings.
- Low-cost handmade under-reamed CRC piles were built for the core house (latrine, washroom) and the residents were provided with ready-built foundations.
- The doors, windows, and grills were made on-site by all of the residents who made it their role.
- Railings, parapets, and cornices were made to ornament the house.

8.4 Belapur Housing

Figure 31 Aerial View of Belapur Housing

Architect: Charles Correa

Client: MHADA

Total Area: 5.4 hectare

Project Cost: 10 Million

Year of completion: 1983

8.4.1 Introduction

Belapur gradual lodging venture - a proposition for mass reasonable lodging in New Bombay (Navi Mumbai), which showed how high densities could be accomplished with low-ascent courtyard homes, worked with basic materials at a human scale. Because of groups of somewhere in the range of seven and 12 sets of houses organized around a public courtyard, the structures didn't share party dividers – permitting every family to broaden and adjust their own home autonomously. 550 families were gotten ready for in a 6 acre of land territory impediment.

8.4.2 Planning Spaces

Correa examined housing and the significance of individuals to be associated with deciding its plan and use. Moreover, he additionally underlined incremental housing as a highlight to any arrangement that was proposed for a spot like Dharavi. The impression of each arrangement shifts little in size (from 45 sq. m to 70 sq. m), looking after value (decency) in the network. The scheme caters wide range from the lowest budgets of Rs 20000, Middle-income groups Rs 30000-50000 and Upper-income Rs 180000.

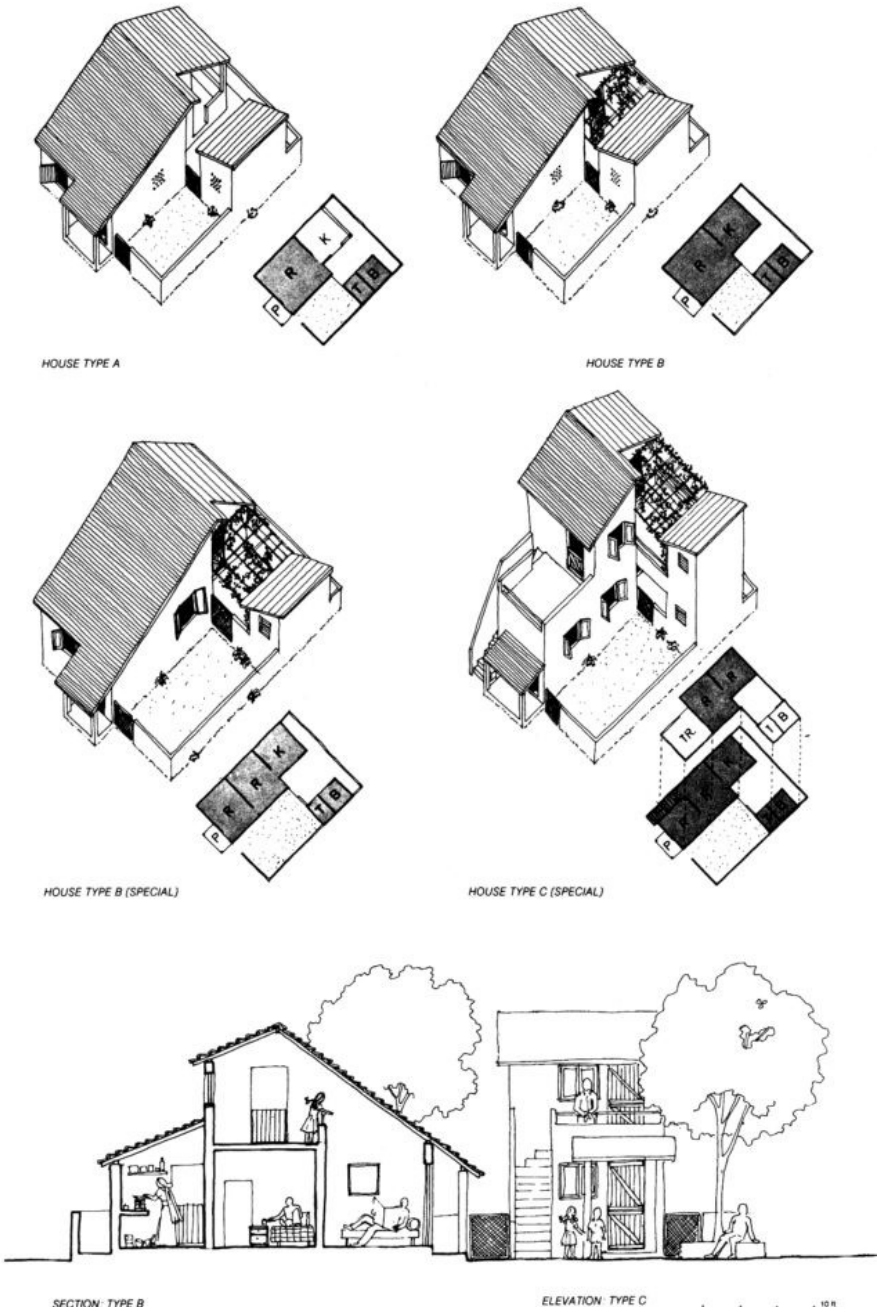

Figure 32 Individual 3D Units

8.4.3 Materials which are used for the construction

- Brick, plaster of white color, colorful wooden fixtures, outdoor paving stone blocks.
- Individual houses rely on simple floor plans and building methods, enabling local masons and craftspeople to construct them.
- The village was produced with the idea that the residents were going to alter it in many ways, making it truly their own, therefore homes are freestanding, so residents can add on to them as their families grow; and differently priced plans appeal to a wide variety of income levels.

Figure 33 Street View of Belapur Housing

8.5 CIDCO Housing

Figure 34 Aerial View of CIDCO Housing

Architect: Raj Rewal

Client: CIDCO

Total Area: 9.5 hectare

Project Cost: 10 Million

Year of completion: 1985 -1986

8.5.1 Introduction

CIDCO Housing worked in New Bombay in 1998 countenances the test of giving minimal low-cost housing to roughly 1000 units in Bombay. The expansion of ghettos in Indian urban communities is a typical element. The vast majority of the apartments worked in this complex are of a couple of rooms. The formation of another conscious home for extremely enormous numbers at the base expense was an astoundingly troublesome issue. Working for huge numbers resembles composing a long novel. The test of mass housing, similarly, can be either drawn closer as one long story or as a progression of interconnected scenes. Rather than building enormous monolithic parallel equal squares of terrible measurements, they decided on an alternate sort of settlement design. The plan for countless dwelling units is divided into more modest totals encasing an assortment of spaces, which can be firmly orchestrated on the inclining side of a hillock and hung along with passerby pathways.

8.5.2 Cluster Development

- Use of cross wall and grouping of toilets has resulted in cost reduction
- Have attached terraces on the upper floor.
- The units are arranged in such a way that it creates a network of courtyards and roof terraces fostering community interaction.
- The form of every block is different and it is patterned in different formations based on the typology of the site, to create squares and pathways.
- A sense of enclosure and continuity of movement is maintained throughout the scheme.
- The division of the site is accentuated by different types of building blocks designed based on dwelling unit areas.

Figure 35 Cluster Development Model

8.5.3 Building Materials

- Roughcast plaster punctuated with bands of cheap handmade tiles was chosen as the building finish keeping in the mind the meager budget and the brunt of Mumbai monsoons.
- Quartzite stone walls at ground level and a honeycomb lattice on the roof define private open spaces.
- Courtyards are semi-paved

Figure 37 Image Showing various Building Material Used

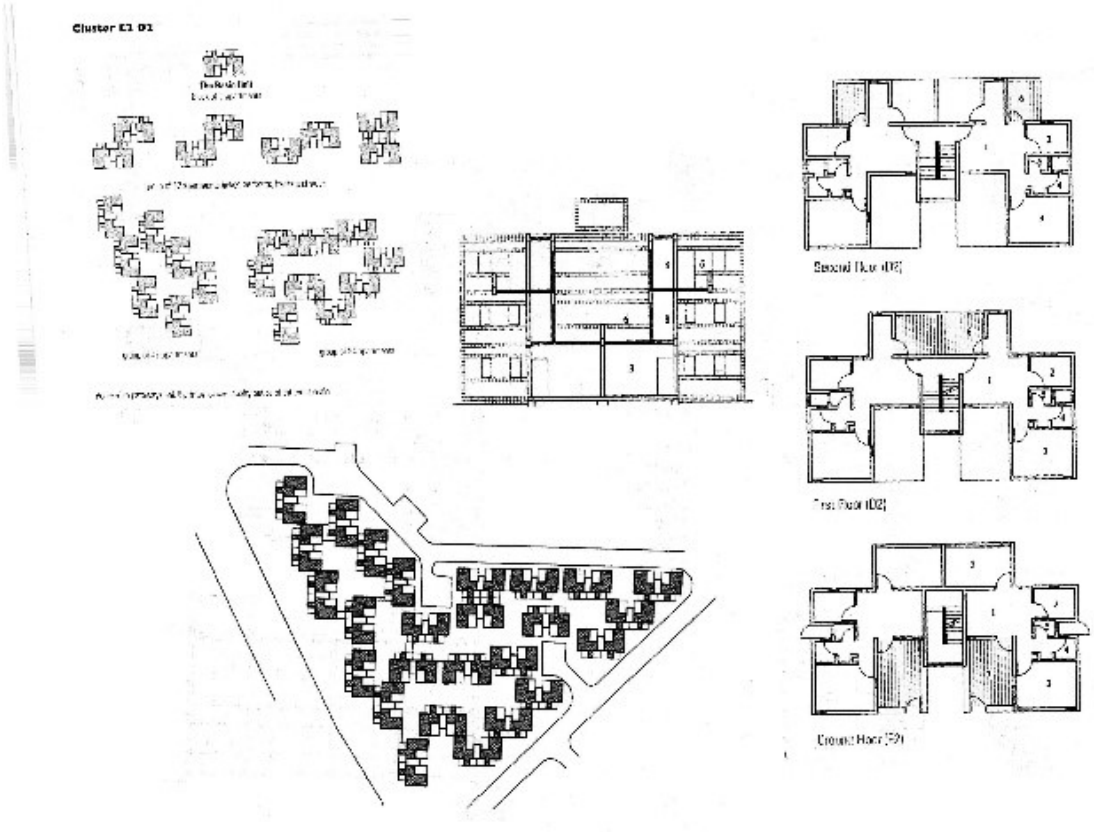

Figure 36 Cluster Plans at Various Levels

Chapter 9: Prominent People that have worked in Low – Cost Housing.

9.1.1 *Laurie Baker* – His Philosophy

Laurence "Laurie" Baker was known as the "Gandhi of Architecture", and which is just fine. Laurie Baker, a pioneer of traditional structure procedures, was known for his usage of locally open materials to build energy capable and ease structures. Laurie's basic style focused on basically workmanship advancement, ensuring security, and usage of block jali dividers for basic ventilation. Dough puncher s plans have customary inclining housetops and pottery Mangalore tiles and vents which license hot air to escape. The differentiation in temperature in these structures from the outside is up to 3 degrees Celsius. bread cook's development also costs considerably less on account of less intricate, standard techniques, like the usage of the Rat trap bond for block dividers and using turns in the divider to grow the quality. He progressed the usage of low energy consuming mud dividers, using holes in the divider to get light, simpler windows and an arrangement of housetop advancement moves close. He favored uncovered exposed block surfaces.

9.1.2 *Laurie Baker* – His Works

In works, for example, Indian Coffee House situated in Thiruvananthapuram's middle, Laurie Baker adequately utilizes the insignificant space accessibility with a Jali-lit, tube-shaped volume and twisting incline that would encourage the simple access of the clients in the midst of giving an extraordinary eating experience. The utilization of financially savvy methods has made the spot open to the 'normal populace

Figure 38 Indian Coffee House by Laurie Baker

His home arranged at Thiruvananthapuram, The Hamlet, reflects his ways of thinking and strategies through the volume of room under curvilinear revealed block dividers, heat-reducing Mangalore-tile housetop, and the remedial offices and the wood windows that shed light on the trademark amble furniture assigned the volume. The organizing of the residence on a very basic level incorporated the utilization of materials that would generally be excused as improvement waste. The entire volume is a sensible juxtaposition of materials from various sources. The usage of corbelled curves for openings avoids the utilization of R.C.C lintels, appropriately lessening structure cost. The organized furniture further adds to the cost-sufficiency. The trademark scene around the collected condition was left unaltered, with advancement done around the current scene. The greenery and the standard materials gave a blend that made any human entering the space to experience an indisputable move in temperature between the outside and within.

Figure 39 Laurie Baker House - Hamlet

9.2.1 ***Charles Correa –*** His Philosophy

Charles Correa, from the earliest starting point of his profession, was not intrigued by the International Style of Modernism in any event, being instructed in the west. He has consistently given more significance to customary or vernacular engineering over the global style because of two reasons, the primary he was attempting to set Indian personality for engineering for different state and local government, the subsequent he was more disposed to set jargon of plan components for his design practice. Correa had never attempted to simply duplicate the components of vernacular design or customary engineering yet he has taken the quintessence of these standards and changed these standards with regards to the site, atmosphere, social and social impacts. He changes these vernacular and customary components into another jargon of his own.

9.2.2 ***Charles Correa –*** Works

Charles Correa planned very nearly 100 structures in India, from low-pay lodging to extravagance apartment suites. He dismissed the glass-and-steel approach of some postmodernist structures and zeroed in on plans profoundly established in neighborhood societies, at the same time giving current auxiliary arrangements under his inventive plans. His style was likewise centered around once again introducing outside spaces and patios

- **Jawahar Kala Kendra in Jaipur, 1993** - Merging the mystic power of the navagrahas and the modernity of science, and built to mirror the structure of the city itself, an example of how Correa's buildings have always moved to context.

Figure 40 Jawahar Kala Kendra

- **Kanchenjunga Apartments, Mumbai, 1983** - Today one of the top luxury apartment blocks in India, the minimalist Kanchenjunga was used by Correa to open up to the sea breezes. Kanchenjunga uses balconies to model the old-style verandas of sea-facing bungalows as a mode of protection from sun and rain lashings.

Figure 41 Kanchenjunga Apartments

- **IUCAA, Pune, 1992 -** The Inter-University Centre for Astronomy and Physics is pretty much a model of the cosmos, an undertaking only a Correa could undertake. Two swerving lines of basalt stone, topped by cuddapah and glossy granite that reflects the sky - the black on the black template is reflective of outer space.

Figure 42 IUCAA

9.3.1 *Raj Rewal – His Philosophy*

Raj Rewal's building creations are not rented upon on a hypothesis: -

As indicated by him, a utilitarian plan ought to be engaged with a particularly enthusiastic kind of idyllic temperament to which he alludes as the "rasa" of the structure. His structures give the view of customary morphology into a contemporary same. He stressed basic masses and common material. His broad utilization of stone constantly matrices for structure ornamentation for an expressive reason for any auxiliary framework. His structure configuration incorporates unadulterated auxiliary articulations, cubic volumes, and trustworthiness in articulation. He generally utilized the stone as a cladding material and afterward as an autonomous compositional component.

9.3.2 *Raj Rewal – His Works*

His humanist approach to architecture responds to the complexities of rapid urbanization. Mr. Rewal's commitment to housing is also central to his built works.

- **Asian Games Village, New Delhi, 1982 -** Asian games village is located in New Delhi, India and is a family urban housing project. He was inspired by Jaipur and Jaiselmer's urban patterns. In all, some 500 housing units are compromising of 200 individuals and 300 apartments on two to four floors with each unit type having variations according to areas and function.

Figure 43 Asian Games Village

- **Shyam Lal House, New Delhi -** The design for Sham Lal house emphasized blending the entrance hall, dining and living room spaces with the front garden as much as possible. The large pivoting doors of glass and teak define the living room garden boundary and can be opened for social occasions. The house was designed by Raj Rewal for a leading journalist and writer. A double-height space contains the entrance hall and stairs to the first floor. A combination of modern and vernacular architecture can be observed.

Figure 44 Shyam Lal House

- **National Institute of Immunology, New Delhi -** The primary function of the institute is scientific research. The institute contains laboratories, study rooms, a library, an auditorium, a director's house, and lodgings for professors with families, married assistants, and unmarried researchers. Rewal conceived the ensemble as an analog of a traditional town with courts, galleries, level changes, and uniform use of materials and colors.

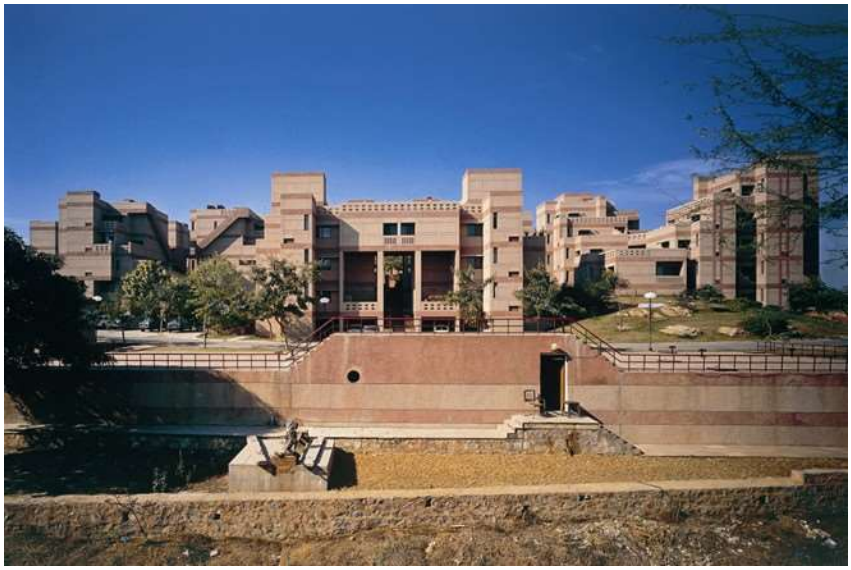

Figure 45 National Institute of Immunology

Chapter 10: Analysis

The primary objective is to assemble a practical development for cost-effective construction (EWS 60%) individuals without bargaining the quality of the structure. A portion of the practical materials like Flyash Bricks, Robo sand, Basalt Rebar, UPVC windows, and Vitrified tiles are utilized in this examination to diminish the expenses and results in the eco-accommodating undertaking. This research paper looks at the expenses of conventional and alternative materials utilized for structures. It was discovered that 20% of development cost has been diminished, by utilizing using low-cost materials.

10.1 Conventional & Traditional Materials used for the analysis

In this research, the basic thoughts are set up for embracing the alternative building materials for reinforced concrete frame construction utilized in huge designing projects. This paper analyzes conventional and alternative materials and reduces the expense in the spot of foundation, walling, roofing, flooring, and lintel. These alternative materials are been demonstrated by more reference journals, state that these alternative materials are acceptable in quality, solidness, and well-being. In light of these examinations, the plan, strategy, development procedures, and options were introduced. Estimation is done and found that about 20% of the construction price can be protected by using the given cost-effective materials. The cost reserves were determined as the premise of the real expenses and the related undertaking costs. A characteristic structure includes an assortment of building frameworks and materials that place the primary accentuation on manageability. The base of a normal structure is the need to lessen the natural effects of structures and other supporting frameworks, without losing comfort or wellness. To be more reasonable, the normal structure utilizes principally richly accessible, inexhaustible, reused, or reused materials.

10.1.1 Traditional Materials which are currently in use

According to conventional practice, we use the following things for construction:

- **Steel:** Concrete is powerless in tension and to provide rigidity and to remunerate to tensional forces steel utilizes. Since the beginning of concrete, steel goes with it. This holding can't be broken for heavy constructions yet with regards to rural housing there is another option. A few examinations are been going on to expanding the quality and toughness of concrete by adding a few admixtures and options alternatives for aggregates, and so on However, with regards to a rural housing, there is no requirement for such things as quality and other parameters required are not all that crucial and don't need a lot of consideration. Nonetheless, receiving such procedures goes about as just a fractional replacement and doesn't diminish the cost much convincingly. So the main way left is to locate an alternative option for steel.

- **Concrete:** The most noteworthy innovation of the nineteenth century is concrete. Since its origin, its utilization rate has never fallen. There are a few examinations that give advancements to expand the quality of concrete and utilization of non-renewable wastes. However, this may expand the total cost, this paper doesn't focus on its alternatives.

- **Bricks:** With regards to housing brick masonry is utilized to cover the faces of the structure. They might clay bricks or fly-ash bricks. Both these types are generally utilized nowadays. For a common house, around 25% of the complete expense is spent distinctly on bricks; if we could replace it with alternatives this could be economical.

- **Mortar:** This sort of mortar is utilized for plastering brick masonry. This is made out of cement and fine aggregates in the proportion of 1:6 (Depending upon the necessities). These days, the accessibility of fine aggregates has declined which expanded its expense. Lessen the utilization of fine aggregates will impact the complete expense of the development. Supplanting this with substitutes that diminish the utilization of fine aggregates and cement could improve for low-cost construction.

10.1.2 Alternative Materials which can be used

The research proposed the following alternative materials that can be used as the replacement of traditional materials:-

- **Fly Ash Bricks (FAB**) is a development material that gives similar properties as clay bricks and it is utilized for masonry work. These blocks are sensibly valued, lightweight, low ingestion of warmth, and so on Thus, no Plastering is required where the Fly Ash Bricks is situated.

- **Quarry Sand** is additionally called M sand which is taken from the Rock Dust at the spot of Quarry. This sand can be utilized rather than River sand. It invigorates more compressive in the concrete contrasted with ordinary sand and gives greater solidness, high quality, usefulness, and so forth.

- **Basalt Rebar** is a fiber material that is produced using Volcanic Rock. This is utilized in outside nations to manage down the construction cost. It invigorates high tensile strength contrasted with the ordinary steel bars. These are the alternative material for steel reinforcement which invigorates the same strength.

- **uPVC Windows** are stable material so it is seawater obstruction and contamination opposition. Most enduring material, solid and intense, simple to defending, lightweight, and it is extremely cost-fruitful material.

- **Vitrified tiles** are framed by the cycle of vitrification; henceforth it is exceptionally solid and homogeneous assets. Vitrified tiles are scratch and stain-safe. It is anything but difficult to keep up and these tiles are more grounded than different tiles.

- **Organic fibers** have numerous advantages, similar to low cost and prepared accessibility, their utilization for reinforcing cement-based materials is convoluted by their moderately low

elastic modulus, their water-retaining properties, vulnerability to fungal and insect attack, and variability of properties amongst fibers of the same type.

10.2 Plan of an EWS Building

Total carpet area (325sqft) accommodated with Living room, Bathroom, Bedroom, and Kitchen are shown in the below figure 46

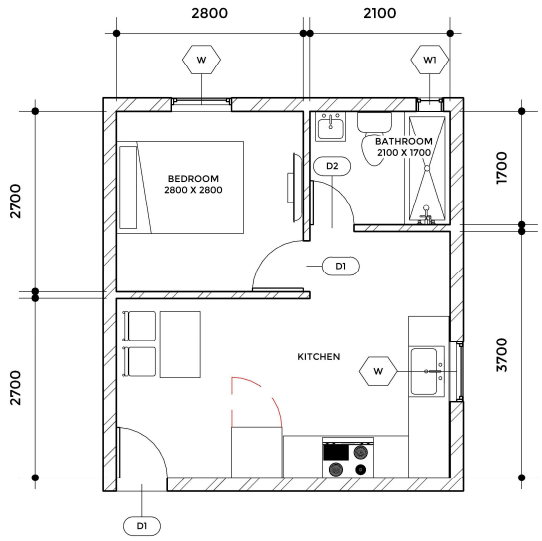

Figure 46 1BHK Apartment - 325 sq. ft

10.3 Scheduling work of a building

Scheduling is the project milestone list, actions, and deliverables with the proposed start and finishes dates. The start date and finish date of all the works and the total time duration of the project have been done.

SCHEDULLING OF WORK		
S.No	Description	Approx Days to complete the task
1	Site Clearence	2
2	Excavation	3
3	PCC Base	3
3.1	RCC Reinforcement	2
3.2	RCC Shuttering	1
3.3	PCC Concreting	7
4	Masonry Work	3
5	Flooring	3
6	Roofing GIC Sheets	1
7	Plastering	7
8	Painting	5
9	Electrical Work	1
10	Plumbing Work	3
11	Carpentry Work	2
13	Other Work	1
TOTAL		44

Table 2 Scheduling of Work

10.4 Cost – Estimate of Material and Construction

The following contains the total cost of material and construction rates all as per DSR 2019:

Low - Cost Housing						
ESTIMATED COST						
As per DSR 2019						
S.no	Description of Item	Qty.	Unit	Rate (INR)	Amount	Ref.
1.00	EARTH WORK					
1.10	Earth work in surface excavation not exceeding 30 cm in depth but exceeding 1.5 m in width as well as 10 sqm on plan including getting out and disposal of excavated earth upto 50 m and lift upto 1.5 m, as directed by Engineer-in- Charge:	33	sqm	92.55	3054.2	2.1
2	CONCRETE WORK					
2.10	Providing and laying in position cement concrete of specified grade excluding the cost of centering and shuttering - All work up to plinth level : 1:2:4 (1 cement : 2 coarse sand (zone-III) : 4 graded stone aggregate 20 mm nominal size)	21	cum	7296.35	153223	5.1.
3	BRICK WORK					
3.10	Half brick masonry with non modular fly ash bricks of class designation 10, conformingio IS :12894, in super structure above plinth and upto floor V level. *Cement mortar 1 : 4 (1 cement : 4 coarse sand)*	43	sqm	917	39431	6.45
4	FINISHING					
4.1	12 mm cement plaster finished with a floating coat of neat cement of mix. 1:6 (1 cement: 6 fine sand)	38	sqm	254.25	9661.5	13.1.2
4.2	White washing with lime to give an even shade : 13.37.1 New work (three or more coats)	39	sqm	28.55	1113.5	13.37.1
4.3	Finishing walls with water proofing cement paint of required shade : 13.44.1 New work (Two or more coats applied @ 3.84 kg/10 sqm)	26	sqm	91.25	2372.5	13.44.1
5	DOORS & WINDOWS					
5.1	Providing and fixing 35 mm thick factory made laminated veneer lumber door shutter conforming to IS : 14616 and TADS 15:2001 (Part B), fixing with butt hinges of required size with necessary screws, all complete as per directions of Engineer- in-charge and panelling with panels of : 12 mm thick plain grade -1, medium density flat pressed three layer particle board FPT - I or graded wood particle board FPT- I, IS : 3087 marked, bonded with BWP type synthetic resin adhesive as per IS : 848	1.0635	sqm	2636.3	2803.7	9.6.1
5.2	Upvc Casement Windows, Glass Thickness: 5-15 Mm	1.4	sqm	350	490	Pre - Fabricated
5.3	Providing and fixing steel roller for uPVC sliding window with necessary screws etc. complete	0.13	each	88.75	11.538	9.15.1
5.4	Providing and fixing ISI marked oxidised M.S. tower bolt black finish, (Barrel type) with necessary screws etc. complete. 100x10 mm	0.18	cum	39.1	7.038	9.63.4
5.5	Providing and fixing ISi marked oxidised M.S. door latches conforming to IS:5930 with screws etc. complete. 250x20x6 mm	0.00	cum	60.3	0.0651	9.65.2
5.6	Providing and fixing ISI marked oxidised M.S. handles conforming to IS:4992 with necessary screws etc. complete. 125 mm	4.50	cum	28.9	130.05	9.66.1
5.7	Providing and fixing oxidised M.S. hasp and staple (safety type) conforming to IS : 363 with necessary screws etc. complete. 90 mm	0.45	cum	17.45	7.8525	9.67.3
6	FLOORING					
6.1	Cement concrete flooring 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate) finished with a floating coat of neat cement, including cement slurry, but excluding the cost of nosing of steps etc. complete. 11.3.1 40 mm thick with 20 mm nominal size stone aggregate	30	sqm	498.35	14951	11.3
6.2	Providing and laying vitrified floor tiles in different sizes (thickness to be specified by the manufacturer) with water absorption less than 0.08% and conforming to IS: 15622, of approved make, in all colours and shades, laid on 20mm thick cement mortar 1:4 (1 cement : 4 coarse sand), jointing with grey cement slurry @ 3.3 kg/ sqm including grouting the joints with white cement and matching pigments etc., complete.	28	sqm	1267.8	35498	11.4.1
7	ROOFING					
7.1	Providing reinforced by organic fibres and/or inorganic synthetic fibres cement 6 mm thick corrugated sheets (as per IS: 14871) roofing up to any pitch and fixing with polymer coated J, or L hooks, bolts and nuts 8 mm dia. G.I. plain and bitumen washers or with self drilling fastener and EPDM washers etc. complete (excluding the cost of purlins, rafters and trusses), including cutting sheets to size and shape wherever required	33	sqm	453.25	14957	12.8
8	SANITARY INSTALLATIONS					

8.1	Providing and fixing white vitreous china pedestal type water closet (European type W.C. pan) with seat and lid, 10 litre low level white P.V.C. flushing cistern, including flush pipe, with manually controlled device (handle lever), conforming to IS : 7231, with all fittings and fixtures complete, including cutting and making good the walls and floors wherever required : W.C. pan with ISI marked black solid plastic seat and lid	1	each	5140.55	5140.6	17.2.2
8.2	Providing and fixing wash basin with C.I. brackets, 15 mm C.P. brass pillar taps, 32 mm C.P. brass waste of standard pattern, including painting of fittings and brackets, cutting and making good the walls wherever require: White Vitreous China Wash basin size 630x450 mm with a single 15 mm C.P. brass pillar tap	1	each	2751.3	2751.3	17.7.2
8.3	Providing and fixing kitchen sink with C.I. brackets, C.P. brass chain with rubber plug, 40 mm C.P. brass waste complete, including painting the fittings and brackets, cutting and making good the walls wherever required: White glazed fire clay kitchen sink of size 600x450x 250 mm	2	each	3163.25	3163.3	17.9.1
	TOTAL COST				288767	

Table 3 Cost Estimation for EWS

10.5 Total Cost for Alternative Building Materials

The total cost of the alternative building has been shown in the below table. As per the current market rates, the materials, men, equipment, etc have arrived and low-cost effective materials are selected to reduce the costs in construction.

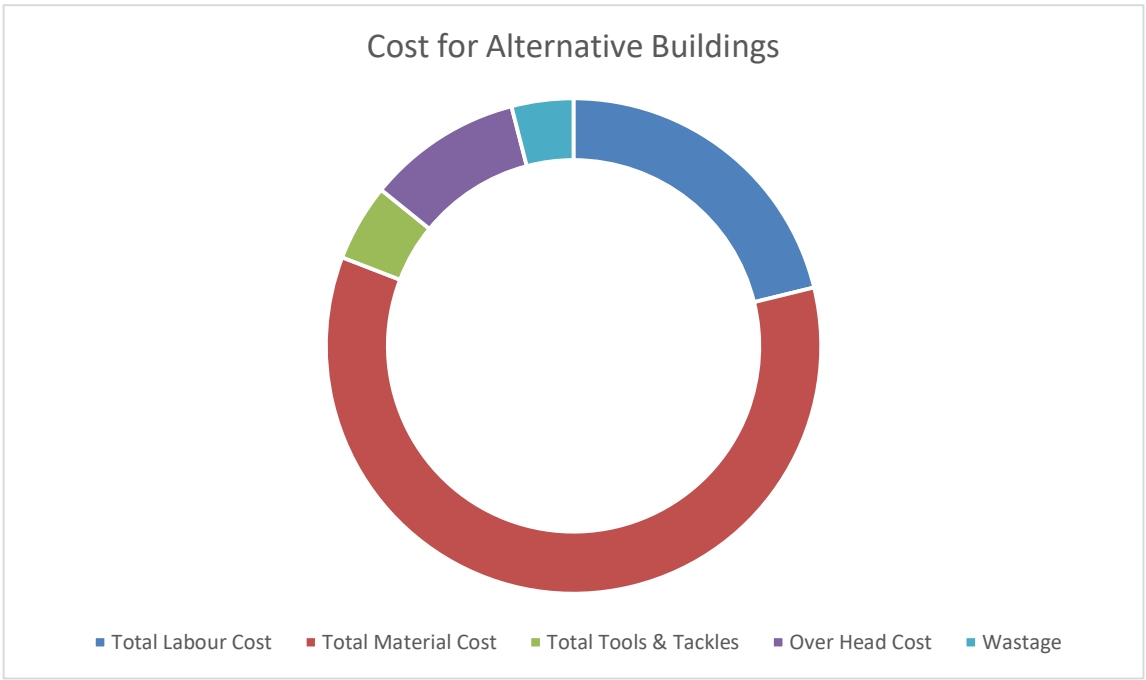

Figure 47 Pie Chart for Alternative Building Materials

10.6 Total Cost for Conventional Building Materials

The total cost of the conventional building has been shown in the below table. As per the current market rates, the materials, men, equipment, etc have arrived.

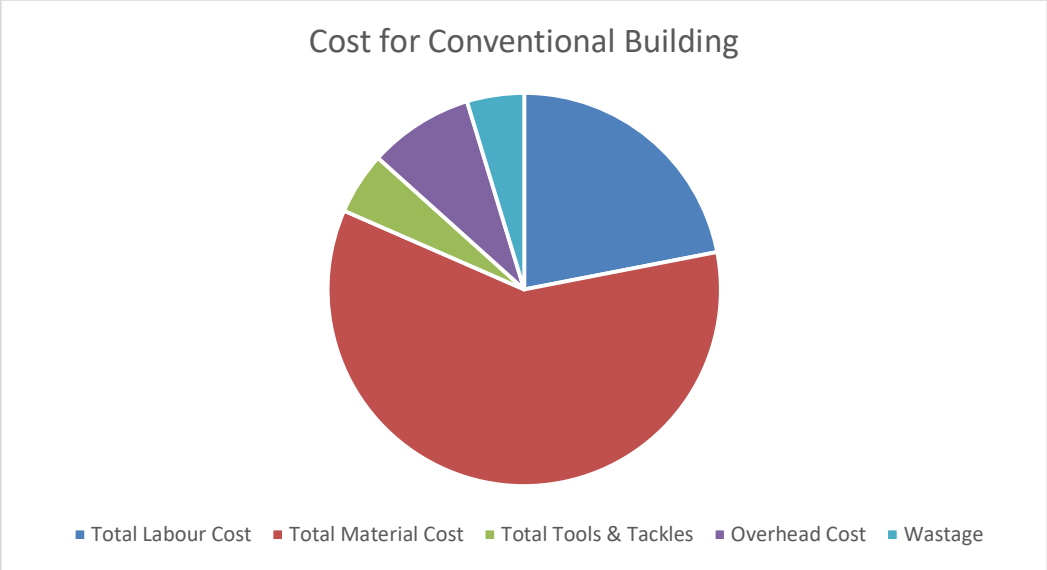

Figure 48 Pie Chart for Conventional Building Materials

10.7 Conclusion:

Beneath Figure 50 Shows, the cost examination of conventional and low-cost buildings. The expense has been turned out for both Conventional and for Alternative structures lastly, results have shown up. The outcome shows that, by utilizing ease materials like Flyash blocks, Robo sand, Basalt bar, UPVC windows, and Vitrified tiles, the expenses have been decreased and spared to 20% in any development without lessening its quality. Henceforth the recommendation from the work is to utilize acceptable quality ease materials for the structures for low-pay individuals.

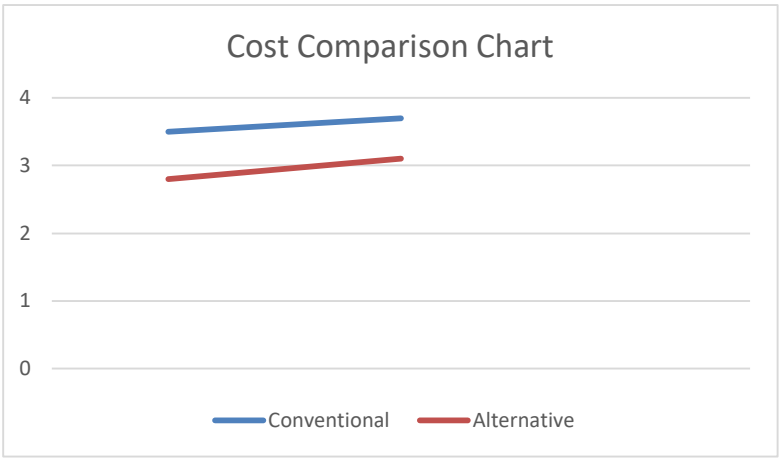

Figure 49 Cost Comparison Chart

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