

The Sustainable And Cost Efficient Materials In Pre Fabricated Shelters For Slum Dwellers In The Case Of Chennai

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ABSTRACT:

This study is to adopt sustainable and cost efficient materials in prefabricated shelters for slum dwellers in the case of Chennai.

Using prefabrication in a project, allows the time spent working on site to be reduced. This means that the impact of the site, on the local environment is for a shorter period of time. Site work is traditionally vulnerable to disruption from extremes of weather. By using prefabrication, the site will be vulnerable for less time and so the risk of delay and requirements for protection will be reduced for a given project.

Some major retail clients are actively targeting continual reduction in the site development time, with an overall reduction of 50% in project time being believed to be a realistic goal, prefabrication is an active part of the process that will help to deliver these savings.

Where prefabrication is being used in a project it is important to include it in the process as early as possible, and ideally at concept design stage. Careful quality control of manufacturing processes enables waste to be controlled and minimised through appropriate design and recycling opportunities. In addition the use of prefabricated components should cut the volume of site spoilage associated with current practices of over-ordering and poor site handling for the equivalent traditional processes.

The Chennai city is growing rapidly and it in turn paves the way for increased percentage of urban poor. Tamilnadu government has framed Tamilnadu Slum Clearance Board to eradicate the existence of slums by the year 2022. The Slum Clearance Board also has the scope for using innovative prefabrication technologies.

Therefore, **“combination of sustainability components and prefabrication construction method can be adopted for better cost effective strategy and for the healthy living.”**

1. INTRODUCTION

A century of industrialization and technical advancement has brought in rapid urbanization. The proportion of urban population in India has gone up from 11% in 1901 to 18% in 1951 and to 32% in 2001. Rapid urban growth resulted into mushrooming of slums of varying sizes in the towns. Undoubtedly, slums have become the most vulnerable and blighted areas of cities.

There appears to be no improvement in their basic level of living, despite several decades of programmes for the environmental improvement and for providing better quality of life.

The spread of slums leads to multitude problems mainly the poverty. Towards understanding the slum and poverty and their consequences on urban economy, it is essential to assess and analyze the socio-economic dimensions of slum dwellers. Improving the quality of life and slum dwellers is the most demanding task of the present urban planning and development on point of health background.

2. SCOPE AND LIMITATIONS OF THE STUDY

Public-Private Partnerships will be facilitated to enhance capacity of construction industry to deliver housing for EWS and LIG through prefab and other innovative technology routes.

The finding of sustainable and cost efficient material will be limited to the wall components of prefabrication structure.

3. JUSTIFICATION OF THE STUDY

The final solution will be the usage of innovative prefabrication technology. The material specified at the completion of this study will be highly sustainable and

cost efficient. It will also render great market feasibility and good productivity for their inhabitants.

Thus, the standard and quality of life of the people will be increased and that will make them live a healthy life. The solution would be the way to improve the Quality of life of the people at a reduced expenditure from the management side.

This makes it more feasible for the management and construction companies to incorporate the design ideas in the reality scenario.

4. LITERATURE STUDY

4.1 ANALYSIS OF MATERIAL STUDY:-

| Sl. No | Type of Material | Materials Used | Salient features |
|--------|---|---|---|
| 1. | Panel Building System using Steel Mesh, Polystyrene Core and Chipping Concrete. Cost: Rs. 180/- Per Sft.; Life time: 40 years. | (a) Meshes manufactured using high resistance steel bars of da. 2.5–5mm, (b) Self-extinguishing Polystyrene core (min. density 15kg/ cu.mts.), (c) Chipping Concrete having characteristic strength 30Mpa. | (a) Good heat and sound insulation properties. (b) Versatility in construction. (c) Light weight but strong. (d) Resistance to seismic, hurricane/ tornado forces including blast explosion of 50 psi. (e) Fire rating of 60 minutes. (f) Cost effective building system utilizing local raw materials and labour force. (g) Speed of construction (30% less than conventional construction system). (h) Environment friendly being CFC free and non-toxic, (i) Highly energy efficient. |
| 2. | Technology Using Expanded Steel Mesh Panels, Polystyrene Beads & Alleviated Concrete. Cost: Rs. 190/- Per Sft.; Life time: 50 years. | Expanded steel type of galvanized steel mesh panels, cast and expanded in continuous process from a 1.6mm thick and 30 cm wide galvanized steel sheet coil and Alleviated concrete made up of cement; fiber; sand and expanded polystyrene beads (1-4mm). | (a) Well insulated. (b) Earthquake/ Hurricane/ Tomado resistant. (c) Fire and Termite resistant. (d) Built on site in less time. (e) Minimal manpower. (f) Equipment and logistics. (g) High quality and durability. (h) Cost effective. (j) Sound, safe, healthy, energy efficient, environment friendly, architectural flexibility. (k) Higher strength of walls and roof, wires and pipes embedded in the walls. (l) No forms, shuttering frames or casings. |
| 3. | Pre-stressed Precast Prefab Technology Using Hollow Core Slab, Beams, Columns, Solid Walls, Stairs, etc. Cost: Rs. 230/- Per Sft.; Life time: 60 years. | (a) Cement concrete, (b) Steel strands & (c) Reinforcing steel. | (a) Saving in Cost: Precast Prefab buildings can be constructed in less than half the time it takes to construct using conventional construction. (b) Material Savings: Precast pre-stressed technology results in 40% reduction in slab weight. (c) Savings in Exterior Painting & Finishing: All exterior surfaces can be provided with aggregate or other such coloured finishes which require no additional painting. (d) Increased Carpet Area: Because of the high strength of the concrete structure small sized walls can be used in lieu of thicker ones. (e) Energy Savings: Hollow core slabs act as a natural insulator & there by result in savings in air conditioning cost. Additionally, walls can have in-built foam insulation resulting in increased savings. (f) Environmental Benefits: Prefab concrete can have fly ash as a ingredient in the concrete mix. This results in higher strength concrete while at the same time utilizing an otherwise waste product. (g) Long Life Cycles: As buildings components are manufactured & cured in controlled conditions the resulting elements have better strength & durability. This results in buildings having much longer life cycles than conventional in-Situ construction. (h) Water Savings: Water requirement for curing of elements is minimal as compared to in-situ construction. Also in the factory the water is recycled there by saving this precious commodity. |

| Sl. No | Type of Material | Materials Used | Salient features |
|--------|---|---|--|
| 4. | Glass Fibre Reinforced Gypsum (GFRG)/ Rapid wall Building System Technology | Gypsum plaster reinforced with glass fibres. Cost: Rs. 325/- Per S.ft.; Lifetime: 40 years. | (a) Substantial reduction in the structural weight of the building. (b) No plastering requirement for walls and ceiling. (c) Increased speed of construction with less man power. (d) Saving of cement, steel, river sand, burnt clay bricks/ concrete blocks and hence saving of energy and reduced CO2 emissions. (e) Contributing to environment protection and mitigate climate change. (f) Use of reprocessed/ recycled industrial by product, Waste gypsum, to manufacture GFRG panel, helping to abate pollution and protect the environment. |
| 5. | Pre FAB Concrete Panels Using Concrete, Welded Mesh And Plates, Polystyrene Core. Cost: Rs. 240/- Per S.ft.; Life time: 60 years. | (a) Cement, (b) Aggregates, (c) Sand with additives, (d) Welded mesh and plates, (e) polystyrene core | (a) Reduced labour cost due to quicker/ easier assembly, in some cases no mason is required. (b) Tornadb/ hurricane damage resistance, fire, termite and dry rot resistance. (c) Requires less insulation. (d) Low maintenance and improved sound proofing; can be erected in cold temperature. (e) Preventing concrete pour delays. (f) Buildings constructed using the system are resistant to earthquakes measuring up to 6 on Richter Scale. (g) Save air conditioning energy. (h) Higher up front cost, (j) Requires on-site crane including certified installer sometimes offers a 10 year warranty on the structure using the technology. |
| 6. | Industrialized Structural System Using Cellular Light Weight Concrete Slabs & Precast Columns | (a) Concrete, (b) Cellular light weight concrete Slabs, (c) Precast column. Cost: Rs. 250/- Per S.ft.; Lifetime: 60 years. | (a) As per relevant Indian Standards; IS 2185-Part 3 specification for auto claved cellular concrete blocks, (b) IS 6041 construction of auto claved cellular concrete block masonry, (c) IS 6072SP auto claved reinforced cellular concrete wall slab, (d) IS 6073 autoclaved reinforced cellular concrete floors and roof slab. |
| 7. | Structural Insulated Panels. Cost: Rs. 180/- Per S.ft.; Life time: 60 years. | 1. The board can be sheet metal, plywood, cement, magnesium oxide board (MgO) or oriented strand board (OSB) and 2. The core either expanded polystyrene foam (EPS), extruded polystyrene foam (XPS), polyisocyanurate foam, polyurethane foam or composite honeycomb (HSC). | (a) Fast construction: SIPs can cut construction time (saving 30%+ labour cost). (b) Durability: More than 7 times stronger than timber frame construction; 8 times stronger than traditional construction in the event of earthquake/tremors. (c) Excellent sound proofing: provide significant resistance to airborne sounds; ensures privacy and quiet. (d) Environmental advantages: Superior to concrete and conventional methods (e) Low material wastage: Pre-engineering create less waste; recyclable waste (f) Design flexibility Can be used for a wide variety of applications (floor, wall, roof) to meet design (g) Temperature moderation: Ensures a more stable and moderate temperature; locks out moisture, condensation and drafts; no added insulation cost required (h) Extra space: Does not require roof trusses; smaller walls ensure that more interior floor space is available (j) Resale value: given long-term durability of the panels, banks are likely to provide longer term loans and future buyer appeal will remain high. |

| | | | |
|----|--|--|---|
| 8. | Brick wall construction. Cost: Rs. 300- Per S.ft.; Lifetime: 50 years. | 9 inch brick work using 1:5 Cement Mortar ratio. | (a) Strong and Durable. (b) Low Maintenance. (c) Thermal Performance. (d) Acoustic Performance. (e) Fire Resistance. (f) Design Flexibility. |
|----|--|--|---|

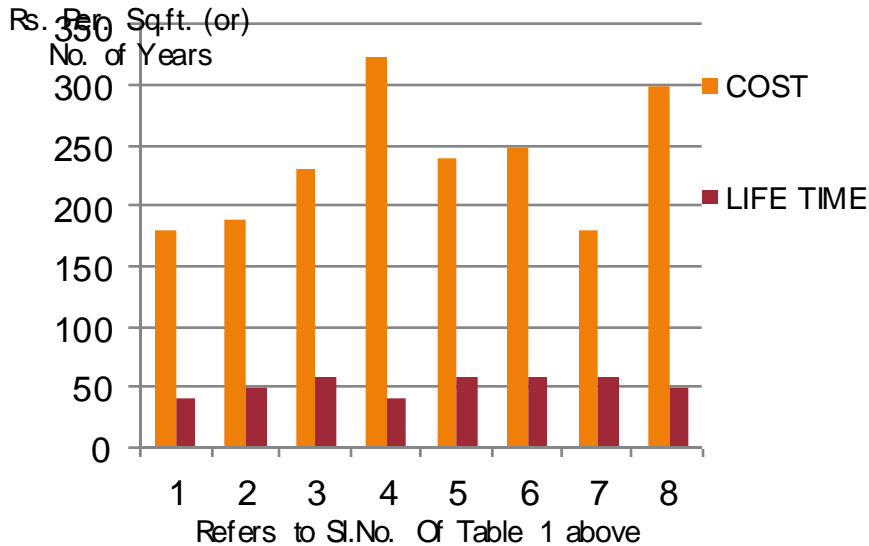


Fig 1: Chart Showing the Analysis of Material Study

4.2 INFERENCE OF MATERIAL STUDY:-

The material analysis was made based on the various different parameters and it is found out that, **THE STRUCTURAL INSULATED PANELS**(Sl. No. 7 of Table 1) are the best sustainable and cost efficient material which can be incorporated flexibly in the erection of prefabricated shelters.

5. CASE STUDY

5.1 PERUM BAKKAM SLUM HOUSING PROJECT, CHENNAI.



Fig 2: Site Plan of Perumbakkam Slum Housing Project

LEGEND

| | |
|---|-----------------------------------|
|  | BLOCK TYPE - A; Area = 36.22 Sq.m |
|  | BLOCK TYPE - B; Area = 28.87 Sq.m |

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PROJECT INFORMATION



BLOCK TYPE – C; Area = 37.18 Sq.m.

1. **Authority:**TAMILNADU SLUM CLEARANCE BOARD.
2. **Fund allocated for constructing the houses:**1084 Crores @ Rs.1,500/ Sq.ft.
3. **Fund allocated for overall project:**1200 Crores.
4. **Total Built-up area of the site:**77,43,159 Sq.ft.
5. **Extent of the Site:** 81.20 Hectares.
6. **Plot Coverage:** 10.70 %
7. **F.S.I:** 0.833
8. **Facility allocated for no. of people:**80,000 Nbs.

Table 2: Floor Wise Area Details of Perumbakkam Project

| FLOOR WISE AREA DETAILS | | | |
|--------------------------------|------------------------------|------------------------------|-------------------------------|
| NAME OF THE FLOOR | 7/2008 (A) (sq.m) | 9/2008 (B) (sq.m) | 7A/2008 (C) (sq.m) |
| G. FLOOR | 639.06 | 532.54 | 328.94 |
| 1st FLOOR | 806.74 | 670.95 | 414.41 |
| 2nd FLOOR | 806.74 | 670.95 | 414.41 |
| 3rd FLOOR | 806.74 | 670.95 | 414.41 |
| 4th FLOOR | 806.74 | 670.95 | 414.41 |
| 5th FLOOR | 806.74 | 670.95 | 414.41 |
| 6th FLOOR | 806.74 | 670.95 | 414.41 |
| 7th FLOOR | 806.74 | 670.95 | 414.41 |
| TOTAL | 6286.24 | 5229.19 | 3229.81 |

| Type | Blocks | Units | Tenements |
|-----------------|----------|----------|-------------------|
| A (G+7) | 11 Nos. | 186 Nos. | 2046 Nos. |
| B (G+7) | 21 Nos. | 186 Nos. | 3906 Nos. |
| C (G+7) | 154 Nos. | 93 Nos. | 14322 Nos. |
| Total Tenements | | | 20274 Nos. |

Table 3: Tenement Details of Perumbakkam Project

5.2MOORTHINGAR STREET, VYASARPADI, CHENNAI.



Fig 3: Site Plan of Moorthingar Street, Vyasarpadi

PROJECT INFORMATION

1. **Project Started on:** 4th October, 2015.
2. **Estimated period of completion of project by conventional method:**18 Months.
3. **Estimated period of completion of project by Pre cast method:** 15 Months.
4. **Authority :**TAMILNADU SLUM CLEARANCE BOARD.
5. **Fund allocated for constructing the houses:**58 Crores @ Rs. 1,500 / Sq.ft.
6. **Fund allocated for overall project:**96 Crores.
7. **No. of floor :** Ground + 7 floor.
8. **Plinth Area /Unit:**37.22 Sq.m.
9. **Total No. of blocks:**10 Nos. (96 Units/Block)
80 Units for Block 6; 112 Units for Block 9.
7. **Total No. of units:** (768+80+112) = 960 Nbs.
8. **Facility allocated for no. of people:**3,900 Nbs.
9. **Total Extent :** 2.6927 Hectares.
10. **Area of future Development :** 0.4039 Hectares.
11. **Density :** 457 / Hectare.
12. **F.S.I. :** 1.36
13. **Plot coverage :** 19.56

TECHNICAL SPECIFICATION

1. Type of Foundation : Pile Foundation (Value of Safe Bearing Capacity is very low in the area)
2. M 30 Grade of concrete – Up to Foundation.
3. M 35 Grade of concrete – Construction of Super structure.
4. Fe 500D – Steel rods.
5. Partition walls – Aerated Autoclave Blocks.
6. Material of the door & window shutters – Steel.
7. Door & Window frames – R.C.C. pre cast.
8. Doors for bathrooms – P.V.C. Doors.
9. Tanks – P.V.C. Tanks.

METHOD OF ERECTING PRECAST COLUMNS

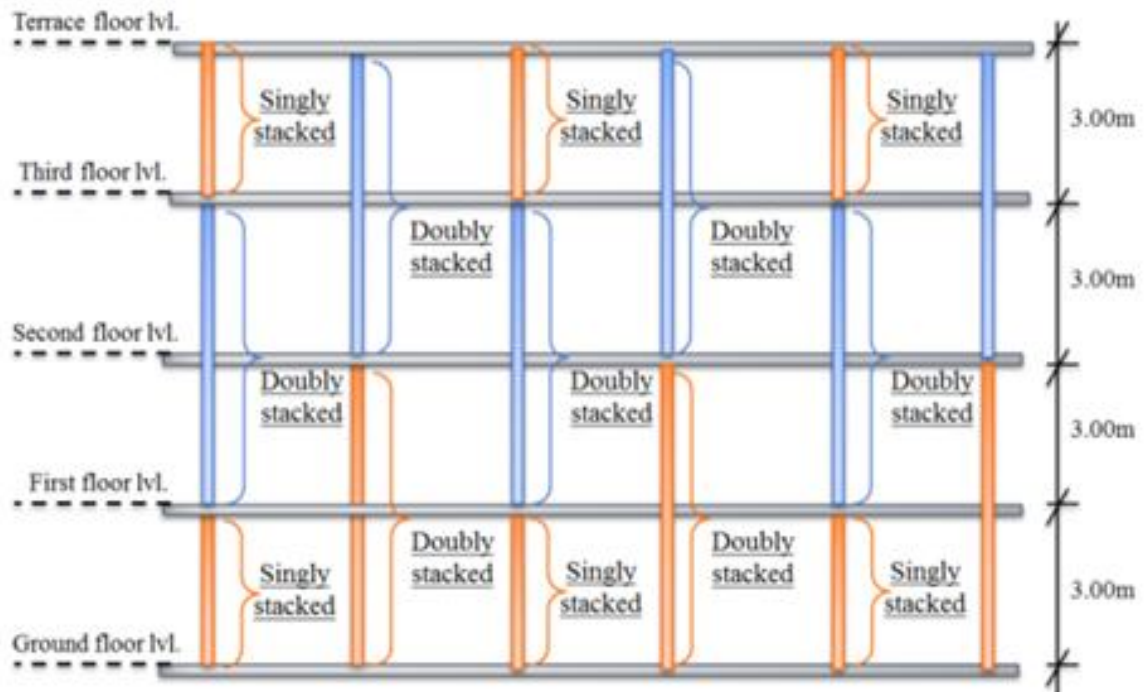


Fig 4: Columns Are Placed in an Alternative Arrangement of Single And Doubly Stacked Columns

6. OBSERVATION,CALCULATIONS& INFERENCE

6.1 OBSERVATIONS FROM THE CASE STUDY:-

1. Cement concrete 1:5:10 (Cement: Sand: Hard broken stone jelly) using 40mm size hard broken granite stone jelly for foundation inclusive of shoring & strutting, ramming, curing.
2. Providing & laying in position READY MIX CONCRETE M25 grade using Ordinary Portland cement with minimum cement content by 370kg/cu.m. with water cement ratio not exceeding 0.45 including the use of plasticizer of approved make and dosage.
3. Brick work in in cement mortar 1:5 (Cement Sand) using ground moulded 2nd class chamber burnt bricks in foundation & basement.

4. Brick work in in cement mortar 1:5 (Cement: Sand) using ground moulded 2nd class chamber burnt bricks in super structure.
5. Brick partition wall 12cm thick in cement mortar 1:5 using 2nd class bricks.
6. Brick partition wall 7.5cm thick in cement mortar 1:5 using 2nd class bricks.
7. Plastering in cement mortar 1:4; 20mm thick including band cornice, smooth finish, settling, curing, etc.
8. Cement concrete 1:2:4 using 20mm gauge hard broken granite stone jelly for precast cement concrete jally ventilator.
9. Supply of M.S. DOOR of size 910mm x 1980 mm with suitable G.I. sheet shutter door with required hold fast 6 nos.
10. Fixing of MS. Grill door.
11. Plastering with cement mortar 1:5.
12. Usage of 110mm dia. PVC rain water down fall pipe.
13. Usage of 75mm dia. PVC soil pipe of 6 kg/sq.cm.
14. The houses constructed by Slum housing board have the maximum life time period for only 40 years.
15. The structural components will become weak and dilapidated during the termination of life time period.
16. The water leakage often happens at all the pipes. This in turn weakens the columns, beams, floor slabs & wall component.
17. Air cracks will be evolving immediately after 6 months from the period of completion of construction.
18. After 35 years staircase between the floors are becoming very weak and gets damaged to a greater extent.

6.2 CALCULATIONS:-

- Applying the best material which was found out from Material study into the Moorthingar street, vyasarpadi – project.

| Sl. No. | Block Type | Area of the wall in one typical floor | Area of the wall in one block | Total no. of blocks | Total area of the walls |
|---------|------------|---------------------------------------|---|---------------------|---|
| 1. | Type – A | 4,020 sq.ft. | 4,020 sq.ft. x 8 storey = 32,160 Sq.ft. | 8 Nos. | 32,160 Sq.ft x 8 blocks = 2,57,280 Sq.ft. |
| 2. | Type – B | 3,620 sq.ft. | 3,620 sq.ft x 8 storey = 28,960 Sq.ft. | 1 No. | 28,960 sq.ft.x 1 block = 28,960 sq.ft. |
| 3. | Type – C | 4,440 sq.ft. | 4,440 sq.ft. x 8 storey = 35,520 Sq.ft. | 1 No. | 35,520 sq.ft.x 1 block = 35,520 sq.ft. |
| Total | | | | | 3,21,760 sq.ft |

Table 4: Table Showing the Calculation of Wall Area of Moorthingar Street Project

| | |
|--|--|
| Structural insulated panels can be erected at the rate of Rs.180/- Per sq.ft | Brick work can be erected at the rate of Rs.300/- Per sq.ft. |
|--|--|

❖ $3,21,760 \times \text{Rs. } 180 = 5,79,16,800/-$

❖ $3,21,760 \times \text{Rs. } 300 = 9,65,28,000/-$

6.3 INFERENCE:-

“Therefore, the usage of **STRUCTURAL INSULATED PANELS** as a wall component is very much sustainable and cost effective when comparing it with a conventional brick work”.

7. CONCLUSION

1. The Chennai city is growing rapidly and it in turn paves the way for increased percentage of urban poor.
2. Tamilnadu government has framed Tamilnadu Slum Clearance Board to eradicate the existence of slums by the year 2022.
3. The Slum Clearance Board also has the scope for using innovative prefabrication technologies,
4. The detailed study about prefabrication technology in terms of,
 - (a) Reduced project budget,
 - (b) Flexibility in incorporating sustainable design and components,
 - (c) Product lifetime up to 70 years.
 - (d) Early project schedule,
 - (e) Minimal usage of resources,
 - (f) High potential for safety on site,
 - (g) Less scope for making error during construction,has made prefabrication has the potential method for construction.
5. Whereas, the conventional method of construction is not withstanding for more than 50 years. Therefore, **combination of sustainability components and prefabrication construction methods can be adopted for better cost effective strategy and for the healthy living.**

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