International Journal of Research in Engineering, Science and Management
Volume 5, Issue 5, May 2022
https://www.ijresm.com | ISSN (Online): 2581-5792

Affordable Housing Materials and Techniques

Vishal U. Misal[1], Haridas Arun Naik[2*], Harshal Sanjay Patil[3], Abhay Dhanesh Pawar[4], Sairaj Suresh Patil[5]
[1]*Assistant Professor, Department of Civil Engineering, A. P. Shah Institute of Technology, Thane, India*
[2,3,4,5]*Bachelor of Engineering, Department of Civil Engineering, A. P. Shah Institute of Technology, Thane, India*

***Abstract*: Low-cost housing is a new concept dealing with low budgeting and follow-up of methodologies that help to reduce construction costs by using local skills and technology without sacrificing the strength performance and structural life. The usage of locally available resources lowers shipping cost, the proportion of which to the cost of construction resources is large for long distances and therefore ideal for local places. Our further study deals with the extensive data collection of various materials and methodologies available for low-cost housing, and the development of a strategic action plan to implement the same in real life. The research further discusses the role of prefabricated concreting processes, along with 3D concrete printers and their use to reduce costing of house.**

***Keywords*: low-cost housing, 3D printers, local skills.**

1. Introduction

Houses are among the major investments that people make in their Lifetimes, and the worldwide demand for the affordable housing sector is the global gross domestic products and 7% of global jobs. The worldwide demand for affordable housing has rised in recent decades and is expected to continue to grow for few more decades. Moreover, the affordable housing sector has been regarded as one of the less penetrated markets by private companies as this sector is unexplored by them. Thus, the affordable housing sector provides a wide range of opportunities for development along with a series of challenges to be overcome. Several challenges to affordable housing have been discussed in the literature section. The following eight are highlighted as key challenges; scarcity of resources; lack of sufficient funds; shortage due to urgency of demand; shortage of skilled labour; quality control; wastage due to inefficiency; lack of added value creation; and quality control; and quality and location. Due to the inherent complexity of the affordable housing problem, it was proposed to have a steps approach. The first step, from which this paper presents the results, comprehends into three parts, first a global screening of construction technologies which will be used in affordable housing programs; second the development of an indicator-based assessment system; and third a technology's assessment and ranking. Further steps will consider the development of life cycle assessments for most promising technologies, considering local factors and climate. The final step will be a final selection process, carried out with specific communities and organizations interested in developing affordable and sustainable housing projects, to finalize with its implementation in the form of a pilot project.

A. Scope and Objectives

- Scope of the study is the consumption of building materials changes both quantitatively and qualitatively in the various stages of housing construction. Accordingly, the conventional and cost - effective technologies changes the cost of construction.
- Overall, this study will be very useful for the previous, ongoing, and upcoming future construction projects to minimize the cost, time and waste and also the enhancement of structure.
- By using techniques such as precast concrete construction, 3d printing etc., of similar building elements wherein there could be a huge repetition of moulds resulting in increased productivity and economy in cost.
- To outline effective planning means to reduce construction cost.
- To study different types of construction materials and techniques used, to reduce the cost of construction, time of construction.
- Alternate and low-cost construction materials and techniques used for sustainable development.
- To compare cost of construction of conventional method and 3d construction printing method.

B. Methodology

- Study collected research paper.
- To find different methods and technologies for effective low-cost house construction.
- separate and generalize materials on the basis of the use & properties of those materials.
- selecting out techniques on the basis of efficiency, cost-effectiveness, better design.
- To find present technique for construction in less time, less labour required.
- To compare cost of construction of conventional method and 3d construction printing method.
- To compare cost of construction of conventional method and 3d construction printing method.

*Corresponding author: naikhari61@gmail.com

2. Materials used for Affordable Housing

A. Pozzolana Material (fly ash/slag/calcined clay) as Blending Material with Cement

By the research up to 35% of suitable fly ash can directly be substituted for cement as blending material keeping the structural considerations. Addition of fly ash significantly improves the quality & durability characteristics of the resulting concrete. Use of blended cement has now become quite popular world over, from durability and environmental benefits point of view. While Portland pozzolana cement saves energy by 20%, lime pozzolana mixture shows up to 70% savings in energy. Blending materials with cement.

Fig. 1. Blended cements

B. Recycled Steel Reinforcement

Steel underpinning can be made entirely of recycled scrap iron. This material is rescued from motorcars, appliances, and steel- corroborated structures, which include corroborated concrete pavements, islands, and structures. In general, steel underpinning bars can be rolled out from either of the following used scrap rails, machine scrap or defence scrap, blights from steel shops, scrap generated from breaking of vessels or discarded structures/ structure, beams from induction furnaces, tested billets from mini steel shops and main directors. The primary criterion to be satisfied by steel underpinning bars is mass per meter run. The IS 1786 specifies batch rolling forbearance in the range of 7 to 3 percent, depending on the periphery of the bar. It's veritably well possible to control the weight of the underpinning bars within these limits and if it's specified that steel should be supplied in the disadvantage forbearance range only also substantial savings in the weight of sword could be achieved. Though a decoration of 1to 2 percent may be charged for this, it's possible to save up to 7 percent of the cost of steel.

Fig. 2. Recycled steel reinforcement

C. Fly Ash – Sand – Lime Bricks

Fly Ash Bricks are made of cover ash, lime, gypsum and beach. These can be considerably used in all erecting constructional conditioning analogous to that of common burnt complexion bricks. The cover ash bricks are comparatively lighter in weight and stronger than common complexion bricks. Ordinary Portland Cement can also be used in place of Lime and Gypsum. Owing to the high attention of Calcium Oxide in class 'C' fly ash, the slipup is described as "tone-cementing" It's a proven fact that Fly ash bricks which are made following the BIS norms in India are 100 dependable and long lasting than normal red complexion bricks of any other conventional structure material.

Advantages of using fly ash bricks:

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

Fig. 3. Fly ash-sand-lime bricks

D. Stabilized Mud Block

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

Advantage:

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

Fig. 4. Stabilized mud block

E. Calcium Silicate Plaster

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

Fig. 5. Calcium silicate plaster

F. Micro Concrete Roofing Tiles

Micro Concrete Roofing (MCR) penstocks are a durable, aesthetic and affordable volition for leaning roofs. Micro Concrete Roofing (MCR) penstocks are made from a precisely controlled blend of cement, beach, fine gravestone total and water. MCR penstocks suffer strict quality control at every step. MCR penstocks offer numerous advantages over other leaning roof accoutrements similar as G. I. wastes, Mangalore penstocks, rustic shingles, slate and asbestos. MCR penstocks are largely cost effective, durable-they have the life of concrete, lighter than other roofing penstocks-they bear lower under structure, fluently installed, can be coloured to specification, reduce heat gain, don't make noise during rains. Cost of the roof varies according to the span and roof form MCR technology has been validated and certified by Erecting Accoutrements and Technology Promotion Council, Ministry of Urban Development, Gov. of India. Certificateno.95/1. Product of 200 penstocks per day by four workmen, including one train mason is attainable. The micro concrete penstocks can be considered satisfactory against leak as per the specification of IS 654, 1992. The average value of retarding cargo is104.80 kg. 10 mm consistence penstocks are 10 stronger and the life span of MCR penstocks is about 25 times.

Fig. 6. Micro concrete roofing tile

3. Affordable Housing Techniques

A. Precast Techniques

There are numerous benefits associated with the use of precast concrete factors. Of course, these bear proper design, use of the correct accoutrements and manufacturing processes with professed and knowledgeable help. Duly designed and specified precast concrete go a long way toward reducing and barring numerous common mileage construction problems, while the economics of precast restate into briskly, further cost-effective systems. Benefits available include,

- Speed-to-request
- Quality and continuity
- Integrated design delivery
- Enhances safety
- Sustainability
- Optimization and inflexibility minimum conservation, aural sequestration, thermal indolence, colorful face homestretches, colours, etc. can also be profited as asked.

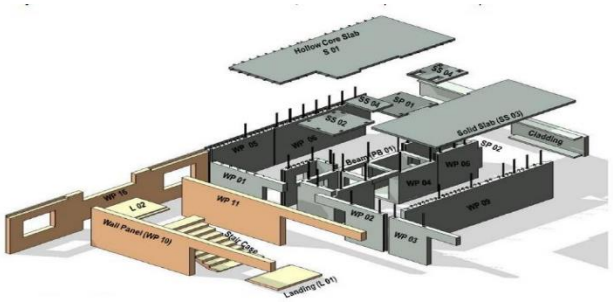

Fig. 7. Precast concrete structural elements for a typical residential unit

B. Rat Trap Bond

Rat trap bond is a brick masonry method of wall construction, in which bricks are placed in vertical position instead of conventional horizontal position and thus creating a cavity (hollow space) within the wall. Architect Laurie Baker introduced it in Kerala in the 1970s and used it extensively for its lower construction cost, reduced material requirement and better thermal efficiency than conventional masonry wall, without compromising strength of the wall.

Advantages of using rat trap bond:

1. Requires approximately 25% less bricks and 40% less mortar than traditional masonry.
2. Reduced material requirement results in considerable cost saving.
3. Strength of the wall is not compromised; it remains the

same as a traditional masonry wall.

4. Cavity induced in the wall provides better thermal insulation, resulting in cooler interiors during summer and warmer interiors during winter.

Fig. 8. Micro concrete roofing tile

C. Mivan Formwork Technology

Mivan is one of the sophisticated- engineered formwork fabricated in Aluminium Monolithic pouring. Walls, columns, slabs & beams are poured together in a particular system. The utilization of mivan formwork in the construction industry of India is comparatively very less as compared to the other developing or developed countries around the globe. The utilization of mivan formwork technology in the construction industry has the greatest potential. This formwork is a sophisticated construction material but it is also economical in heavy type of construction. This recent method of construction by this technology can appreciably increase the productivity of construction, built quality and durability of construction work through the use of efficient construction tools, construction materials, and time for construction saving compared to conventional technologies or methods. This technology is one of the recent construction technologies upcoming at the greater speed for the successful completion of various construction projects across the Indian construction industry, especially mass housing projects.

Fig. 9. Construction using mivan technology

D. 3D Printing in Construction

3D printing technology to use structures will increase sustainability. Houses can be erected grounded on the material life cycle that can be used in assessing the environmental sustainability of structure accoutrements. Creating the structures with complicated shapes, may come one of the biggest advantages for utmost engineers. Their imagination will be suitable to master former obstacles related to limitation of traditional ways of structure. 3D printing may transfigure currently armature, nonetheless, this fashion should be developed taking into consideration sustainability issues both for material selection and construction system. There are multitudinous advantages coming from developing 3D technology in construction and most important bones could be proceeded as Lower costs – the cost of publishing construction rudiments of houses is much lower than traditional construction styles, also material transportation and storehouse on spots is limited; Environmental friendly construction processes and the use of raw accoutrements with low embodied energy (i.e. construction and artificial wastes); Reduced number of injuries and losses onsite as the printers will be suitable to do utmost dangerous and dangerous workshop. Wet construction processes are minimized, so that erecting construction process induce less material wastes and dust compared to traditional styles; Time savings – time needed to complete the structure can be vastly reduced.

Design Styles:

The starting point for any 3D printing process is a 3D digital model, which can be created using a variety of 3D software programs. The model is also 'sliced' into layers, thereby converting the design into a train readable by the 3D printer. The material reused by the 3D printer is also concentrated according to design and process. In the construction assiduity, the most common software platform that's used is Building Information Modelling (BIM)

Building Information Modelling (BIM):

Building Information Modelling is an intelligent 3D model-grounded process that gives armature, engineering, and construction professionals the sapience and tools to more efficiently plan, design, construct, and manage structures. Every detail of a structure is modelled in BIM. The model can be used for analysis to explore design options and to produce visualizations that help understand what the structure will look like before it's erected. Traditional construction systems have formerly espoused the software and are using it for design purposes. In 3D Printing the CAD train attained from the BIM software should be converted to a machine language, The most common format is STL. BIM can grease a more intertwined design and construction process and induce substantial benefits. For case, smaller design collaboration crimes, further energy effective design results, faster cost estimation, reduced product cycle times.

3D printing Process:

Standard Triangulation Language (STL) Train:

Standard Triangulation Language is a 3D train format which uses a series or triangles to describe the external shells of a 3D model. STL train is generally generated by a computer backed design (CAD) program, as an end product of the 3D modelling process. This format describes only the face figure of a three-dimensional object without any representation of colour, texture or other common model attributes. The STL train format is the most generally used train format for 3D printing. When used in confluence with a 3D slicer, it allows a computer to communicate with 3D printer tackle.

Slicing (3D Slicers):

3D slicers define how a model is erected and instruct the 3D

printer how it's published. A slicer is a program that converts digital 3D models into printing instructions for a given 3D printer to make an object. In addition to the model itself, the instructions contain stoner- entered 3D printing parameters, similar as subcaste height, speed, and support structure settings. Slicer software nearly "cuts" 3D models into numerous vertical 2D layers that will latterly be published, one at a time.

4. Cost Comparison between Conventional and 3D Printing Method

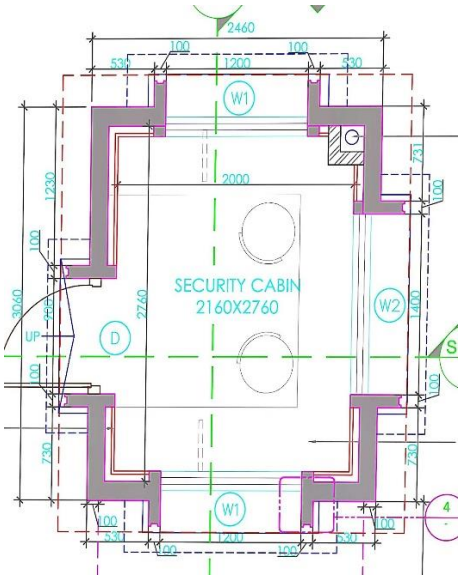

Fig. 10. Plan

A. *Cost of Construction by Conventional Method*

Sr. No.	Name Of Product	UOM	QTY	Rate	Amount	Taxable Value	CGST Rate	CGST Amount	SGST Rate	SGST Amount
1	Soling	SQM	15.054	115	1731.22	1731.22	9%	155.80942	9%	155.8094
2	Conventional Shuttering	SQM	121.550	350.00	42542.47	42542.47	9%	3828.8225	9%	3828.822
3	RMC	CUM	13.658	4350.33	59418.91	59418.91	9%	5347.7021	9%	5347.702
4	RCC (M25 GRADE)	CUM	13.658	800	10926.79	10926.79	9%	983.41085	9%	983.4108
5	PCC (M10 GRADE)	CUM	0.852	800	681.57	681.57	9%	61.34112	9%	61.34112
6	Plaster work (double coat)	SQM	142.968	250	35742.00	35742.00	9%	3216.78	9%	3216.78
8	Steel	KG	1257.967	54.32	68332.77	68332.77	9%	6149.9491	9%	6149.949
9	Reinforcement steel	TONS	0.992	9000	8928.00	8928.00	9%	803.52	9%	803.52
Total					228303.7	228303.7		20547.335		20547.34
Total Invoice Amount in Words:						Total Amount Before Tax :				228303.7
TWO LAKH SIXTY NINE THOUSAND THREE HUNDRED AND NINETY EIGHT						Add : CGST :				20547.34
						Add : SGST :				20547.34
						Total Amount After Tax :				269398.4

B. *Cost of Construction by 3D Printing Method*

Sr. No.	Construction by 3D-printing	UOM	QTY	Rate	Amount	Taxable Value	CGST Rate	CGST Amount	SGST Rate	SGST Amount
1	Soling	SQM	30.693	115	3529.64	3529.64	9%	317.668	9%	317.668
2	Conventional Shuttering	SQM	15.654	350.00	5478.76	5478.76	9%	493.0884	9%	493.0884
3	RMC 3D	CUM	8.190	7500.00	61425.00	61425.00	9%	5528.25	9%	5528.25
4	RMC	CUM	5.298	4350.33	23048.05	23048.05	9%	2074.3244	9%	2074.324
6	PCC (M10 GRADE)	CUM	4.122	800	3297.21	3297.21	9%	296.74886	9%	296.7489
7	Plaster work (double coat)	SQM	142.968	250	35742.00	35742.00	9%	3216.78	9%	3216.78
8	Steel	KG	199.000	61.33	12204.67	12204.67	9%	1098.4203	9%	1098.42
9	Reinforcement steel	TONS	0.199	9000	1794.92	1794.92	9%	161.54316	9%	161.5432
Total					146520.3	146520.3		13186.823		13186.82
Total Invoice Amount in Words:						Total Amount Before Tax :				146520.3
ONE LAKH SEVENTY TWO THOUSAND EIGHT HUNDRED AND NINETY THREE						Add : CGST :				13186.82
						Add : SGST :				13186.82
						Total Amount After Tax :				172893.9

5. Result

- Total cost of construction by conventional method = Rs. 269398 (Rs. 3324 per sq.ft.)
- Total cost of construction by 3D printing method =Rs. 172893. (Rs. 2133 per sq.ft.)
- As a result, 3D printing reduces construction cost of structure. Equipment's cost, construction time were not calculated herein since they depend on the required size and speed of printer for the project.
- There is 35.82% reduction in the cost of construction by using 3d printing method.

6. Conclusion

- The dream of owning a house particularly for low income and middle-income families is becoming a difficult reality.
- It is necessary to adopt cost effective, innovative and environment friendly housing technologies for construction.
- From the study and detailed calculation, we can conclude that 3-D printer is best suitable technique for affordable housing construction for low rise structure such as G+1 structure.
- By the adopting 3D printing in a construction field will made affordable housing for low income and middle-income families.
- Labour cost and wastes of material can be control by 3D printing method.
- 3D printing is highly economical, time saving and easy to use.

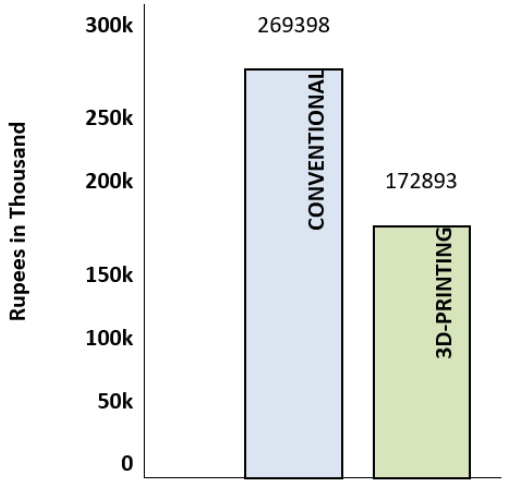

Fig. 11. Conventional and 3D-printing price

References

[1] Tam V.W.Y. (2011), "Cost effectiveness of using low-cost housing technologies in construction", Procedia Engineering.
[2] Luisa F. Cabeza, et al., "Affordable construction towards sustainable buildings: Review on embodied energy in building materials,"
[3] Choudhury S. and Roy S. (2013) "Prospect of low-cost housing in India" geomaterials.
[4] A.B.Y.S.S. Shinde, "Affordable Housing Materials & Techniques for Urban Poor's," International Journal of Science and Research, vol. 1, no. 5, p. 7, May 2013.
[5] Raspall F. and Arora M. (2014), "Building from the end of life: an alternative approach for low-cost housing."
[6] Ugochukwu (2015), "Local Building Materials: Affordable Strategy for Housing the Urban Poor," Journal of Building Construction and Planning Research
[7] D. B. Ali Haider Jasvi, "Sustainable Use of Low-Cost Building Materials in the Rural India," International Journal of Research in Engineering and Technology, vol. 4, no. 13, p. 14, December 2015.

[8] Bredenoord J. (2016), "Sustainable Housing and Building Materials for Low Income Households," J Archit Eng Tech.
[9] Ram Kumar, Manoj Jain (2013), "Study on use of Precast Technology for construction of buildings."
[10] Syed Humayun, Pasha Hemant and Kaushik. (2015), "Evaluation of nonlinear property of fly ash brick masonry under compression and shear," Journal civil engineering.
[11] Mehmet Sakin & Yusuf Caner Kıroğlu (2017), "3D Printing of Building: Construction of sustainable houses of the future by BIM".
[12] Akshay Ghulghane, "Time and Cost Optimization of Construction Project Using Mivan Technology," International Journal of Engineering Research and Applications, vol. 8, no. 8, 2018, pp. 70-74, 2018.
[13] Shankar Chavan, Vishwajeet Shah, Gaurav Tiwari, Rooman Iqubal, Milind. M. Darade, "A Survey on Alternative Low-Cost Construction Materials & Techniques," International Journal of Scientific Research and Innovative Technology. vol. 8, no. 5, 2019.
[14] Elshada Baja (2020), "Local Construction Materials for Affordable Housing".