



COMPARATIVE ANALYSIS OF CONVENTIONAL BUILDING WITH 3D-PRINTED BUILDING HAVING CONSIDERATION OF ITS ADVANCED COMPACT MOBILE ROBOT TECHNOLOGY.

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Abstract : *Technologies have a noticeable impact on our evolving business system, It has changed the way, we people do business. Now, here comes the word 3D printers, wherein the last 3 decades, we have noticed its remarkable growth in the additive manufacturing industry. The new technology of 3d printing of buildings for the sustainable houses of the future. 3d printing building technology is a new construction technique started with the invention of 3d printer. All Industries must adapt themselves to this new system so that they could survive in the rapidly changing ruthless habitat. There is huge pressure, emerging in the Construction Industry to adapt to the new technological developments. Hence, 3D printing technology has gained a lot of attention in the Construction Industry as a new technological change that needs to be implemented in the industry, for its survival. The main objective of this paper is to review the factors affecting the 3D printers to evolve in the construction industry, Comparing cost between the traditional method and 3D-Printing technology of a single storey house, Current Market of 3D Printing, Literature Review. Despite of many advantages, the limitations of this technology is also summarized in conclusion.*

IndexTerms - 3D Build Printing Technology, Cost, Market of 3D Printing.

1 INTRODUCTION

3D printing is computer-controlled technology that is helping us to build a three-dimensional object by the process of additive manufacturing, which creates objects by adding layers to them. Additive manufacturing allows us to create complex designs and the best part is that it takes very little time to build and it builds houses with very few labourers, and the cost estimation for construction is very low. Contour Crafting is an additive fabrication technology using computer control. CC is a layered fabrication method which combines ancient Surface forming concept with modern robotics Technology. 3d Printing (3DP) Commonly Known as Contour Crafting(CC), Prototyping, Additive Manufacturing (AM).Initially AM technologies were developed in the 1980s.. In this research paper, we had worked on three major areas of 3d printers considering their work in the construction industry It was developed in the early 80s but at that time, it was of no use because it was very costly and expensive to use.In 2000, it became relatively friendly to use, as it allows to create the design on the computer and the cost comparison was very less as it uses plastics and waste materials to form the concrete of 3D houses. And suddenly it became affordable and became viable for a wide range of design, models, etc.

2 Literature Review

2.1 Izabela Hager, et al. (2016)

They have studied regarding the history and an overview about the concrete printing technology. And also they mentioned some case studies regarding the application of this technology. In1983, Charles.W introduced the first 3D concrete printing technology. He used STL (stereo lithography) technology for this. Then later, another technology named as FDM (Fused deposition modelling) was introduced by Scott crump in 1988.The first case study was in 2014, Dutch architects built a house using concrete printing. They built the house with individual components. It took around 3 months for construction. The second

case study was Winsum Company built a model house using their own software. Then later, they built a 5 storey building using concrete printing with the same software. And the building was the tallest construction with concrete printing technology till now in the world.

2.2 Antony Thorpe, et al. (May, 2014)

They developed a concrete printing machine using additive manufacturing (AM) technology. They printed a Wonder bench using concrete printing technology. First they designed a 3D cad model for the bench, later it was converted into STL (stereo lithography) format. Then printing path was generated. After that they developed a Gcode for printing process, then printing of bench was done. In this project, they used a concrete made with both cement and gypsum materials. The concrete density was 2400kg/cubic meters. The concrete was 3 times stronger in compression and flexure when compared with normal concrete. The strength of this concrete was found around 100-110mpa. In this project they used 9 mm nozzle for printing operation. And it prints 1.4kg/minute. The bench height was 0.8 m and it weighs 1 tonne. They provided functional voids in bench construction and later they post tensioned the voids such that the bench would be strong in tension also.

2.3 Byung Wan Jo, et al. (2020)

They printed a hollow concrete wall using 3D concrete printing technology. First they developed a prototype model for checking its performance before developing full size model. Using that prototype, they printed the wall. The prototype model was 1Mx1Mx1M in dimensions. The study was mainly focused with 3 targets. 1) 3D space motion control. 2) Properties of concrete material. 3) Material dispensing process. In motion control, they used FDM technology with help of software which they personally developed. In material properties, they used conventional concrete with a small size of aggregates. In the dispensing process, they used a screw type nozzle for the extrusion process. The diameter of the nozzle is 50 mm. They did a compressive strength test on printed models on different mix designs. And it's average compressive strength is obtained around 61Mpa.

2.4 Rabab Allouzi, et al. (April 2019)

This paper proposes the use of nanotechnology in real structural engineering projects with the 3D printing construction procedure. They suggested the use of graphene nanomaterial for 3D printing of concrete structures. Recently, it is getting more attention due to its remarkable properties including its tensile stress of 130GPa at strain of 0.25 and Young's modulus of 1TPa. While traditional types of concrete is not convenient for 3D printing and due to the extraordinary properties including its tensile strength, compressive strength, and Young's modulus, this paper suggests the use of treated graphene oxide as nanomaterial for 3D printing of Concrete structures.

2.5 Manju.R, et al. (August 2019)

They have studied on the process of additive manufacturing (AM) and explained the detail procedure of working of 3D printers where they use g-codes. Here, for the machine the x, y and z coordinates are given and the printer is connected with a robotic arm setup and nozzle across printers. Also gave the details about softwares for slicing which were the details required by the printers. Mentioned about the stepwise process of 3D printing which the structure was built under the given program. Took some case studies regarding 3D printing around the world. Finally they concluded by giving an idea about the future scope of 3D printing.

2.6 Behzad Nematollahi, et al. (2017)

They mainly focused on the techniques through which 3D printing is done and categorised as extrusion-based technique and powder-based technique and further classified both regarding those techniques among them under extrusion-based technique, concrete printing was mentioned where they made a bench of length 2m, width 0.9m and a height of 0.8m which comprised of 128 layers with 6mm thickness which included 12 voids. Under powder-based technique, powder-based 3DCP using geopolymers was mentioned where they analysed the strength of structure regarding its orientation. They found that orientation by X-axis had 20% green strength more than in orientation by Z-axis. Also the percentage change between the strength in orientation by X-axis and orientation by Z-axis was decreased to 12% and 5% for 1 and 7-days post-cured samples, respectively and finalised that post-curing procedure in 3D printed geopolymers structures reduces the anisotropic phenomenon.

2.7 Amitkumar D. Raval, et al. (March 2020)

They discussed the risks and challenges, even having many benefits of this technology as the technology is in the initial stage and has many limitations. Environmental concerns are also discussed in the paper. They demonstrated many processes involved in concrete printing. Formulating computer models plays a crucial role in implementation of this technology. Development in 3D computer graphics makes it possible to fabricate such digital models easily using commercially available as well as open-source software packages. They concluded that the investigation required in the printing technique includes selection new nozzle with optimum size and shape, a novel method of extrusion and also a new method of delivery that enhance the overall quality of the printing.

3 FACTORS AFFECTING THE 3D PRINTERS TO EVOLVE IN THE CONSTRUCTION INDUSTRY

Global Impacts

The global construction industry is the cause for the highest carbon Impacts which results in :

- 40% of global energy consumption
- 38% of carbon emission
- 12% of water eutrophication

Therefore, Decarbonization is a great way in the Construction industry to lower down the emission of carbons. 3D printing or additive manufacturing has evolved as a potential solution to lowering down the energy needs, water wastage and carbon emissions.

3D printing in the construction context is a futuristic technology that creates 3D objects by the recurring process of the physical objects with continuous layers being formed up. Freshly, from polymer and steel, the industry has leapt forward utilizing concrete with potential implementation in construction engineering. Anecdotally, these technologies proved to lower the production time, shrink wastage and reduce labour costs remarkably. The provocation which circumscribed the 3D printing incorporate lack of standard building codes, great scale investment, effective execution and architectural designs.

4 ADVANTAGES AND LIMITATIONS

❖ Advantages

- Environmentally friendly: We can utilize raw soil and natural waste from the rice manufacturing chain for 3D printing. In theory, the substance for a 3D printed house can also be plastic and we've got an abundance of that
- Affordable: Big-scale industrial buildings can be constructed for a comparatively low price
- Unusual shapes: 3D printing can produce shapes that are impracticable or too costly to manufacture otherwise.

❖ Limitations:

- Though the charge of construction may be reduced by 3D printing the cost of printers are expensive and a major disadvantage.
- Skilled labours are required as the knowledge of CAD and 3D Printing software are required.
- 3D printers consume way more energy than what we can think of as according to a research it consumes 100 times more electrical energy compared to conventional methods.

4 COST COMPARISON BETWEEN TRADITIONAL METHOD AND 3D-PRINTING TECHNOLOGY OF A SINGLE STOREY HOUSE

Quantity, Rate and Cost Estimation Of a 600 SQFT House In India

Planning and estimating the quantity of cost of a house that you are planning to construct is extremely note worthy. If we start building a house without any pre-planning, we will find it very difficult to do it. Therefore, it's necessary to first estimate the rate, quantity and total cost of the building materials, labours and some other resources that we are going to use in the construction of our house.

600 sqft is not a big area. That's why we must use this small area in a very progressive and efficient way. In this project, we have shown you the building materials and other resources that one should be in needs to build a 700 sqft house.

Details

Plot Area: 600 Square Feet

Total Bedrooms: 1

Type: Modern

Building Material in House Construction

The material used in construction for building houses in the building material. These are the main house building materials: Concrete, Steel, Sand, Bricks, Ceramic Tiles, Granite. Kota Stone, wood, river sand, Door, Window, timber, Painting & granite, Plumbing, Electrification, composite material and Filling well as the increase in population. This growth has donated notably to waste generation .To build a 600 sqft house, we need to use the following materials. The rate of each material, as well as their total costs, are mentioned below.

1. CEMENT: One bag of cement costs approx 300 rupees. Construct a house of 600 sqft, we require 260 cement bags, which costs 78,000 Rs.
2. STEEL: Steel Is priced at 45 Rs/kg approx. We need approx 1.5 metric ton of steel, Total costs = 67,500 Rs.
3. SAND: The price of sand is 50 Rs/cubic ft and we need 1250 cuft. Total cost= Rs 62500.
4. AGGREGATE: Priced at 22rs/cuft. We need 750 cuft. Total amount = 16,500 Rs.
5. LABOUR RATE: Average rate of single labour is 250 rs/sqft. We are working to construct a 600 sqft house. Hence, Total amount= 1,50,000 Rs.
6. BHISHTY: Priced at Rs 250/day. Required for 6 months. Total amount- 33,750 Rs.
7. BRICKS: We require 15,000 bricks Units. The rate of 1 brick is Rs 9. Total amount= 1,35,000 Rs.
8. VATRIFIED TILES: Priced at 37rs/sqft. vatrified tiles needed is 420sqft . Total amount= 15,540 Rs.
9. GRANITE: Priced at Rs160/sqft and the Quantity needed to construct is 190sqft. The total amount is Rs. 30,400.
10. KOTA STONE: Priced at 22/sqft. The quantity needed to be constructed is 270 sqft. Total amount required = 5,940 Rs.
11. WINDOW GRILL: priced at 1950/grill. The quantity needed for construction is 4 units. Total amount- 7,800 Rs.
12. DOOR: Priced at Rs3650/unit. The quantity needed to be constructed is 6 units. Total amount= 21,900 Rs.
13. SLIDING WINDOW: Priced at Rs3500/unit. The quantity needed to be constructed is 4 units. Total amount= 14,000 Rs.
14. WATER TANK: Priced at Rs8/ltr. The quantity required for construction purpose is 1000L. Total amount= 8,000 Rs.
15. PAINTING & WALLPUTTY: Rate-19/sqft. Quantity needed to done altogether is 2850sqft. Total cost- 54,150 Rs.
16. ELECTRIFICATION: Total amount= 45,000 Rs.
17. PLUMBING: Total amount- 17,000 Rs.
18. CEREMIC TILES: RATE- 22rs/sqft. Total sqft needed to be constructed is 250 sqft required. Thus, Total amount= 5,500 Rs.
19. EXCAVATION: Rate- 7rs/cuft. Quantity needed to be excavated is 1950 Cuft. Total amount= 13,650 Rs.
20. DOOR FRAME: Door framed is priced at 1950/unit. Quantity required for construction is 6 units. Total amount= 11,700 Rs.

21. OTHER ITEMS: cost- 17,500 Rs TOTAL COST OF BUILDING - Rupees. 8,11,330 PER SQUARE FT. COST= Total Cost of the Building/ Total sqft of the building = (Rs 8,11,330/600)Rupees/sqft = [1352 Rupees/sqft].



Fig.1. As per Tvasta, the cost of constructing a 3D printed house is approximately Rs 5.5 lakhs. By considering numbers, we have calculated the difference in the Cost of 3Dprinting to a Convention method constructing of a One-Storey building of a 600 sqft house in India.

Difference:

- 1) Total cost of construction of a One-Storey building using Conventional Method = RS. 8,11,330 approx
- 2) Total cost of construction of a One-Storey building using 3D Buildprinting = RS. 5,50,000 approx

Subtracting [2] from [1] we get:

[Rs 8,11,330 – Rs 5,50,000] = Rs 1,00,500 approx

So, Rs 2,61,330 approx is saved if we use to construct a One-Storey building using 3D printers compared to the conventional method of construction.

India's First 3D Printed House



Fig 2. India's first 3D-printed house

India's first 3D-printed house is built by alumni of IIT Madras. India's first 3D-printed house is now ready. Taste's first structure is a single-storey house. The house was built in just 106 hours. Tavasta's official blog states, When it comes to waste materials, this technology creates the only 1/3rd of the waste generated using conventional building methods. The cost reduction is because it increases in labours demand. A structure takes almost a year but 3d printing technology takes few days to complete entirely. There is a saving in on amount and the waste material is also less and it takes a lot less in the number.

5 CURRENT MARKET OF 3D PRINTING

Current market of 3D printing stands for about \$7.3 billion according to the eponymous wohlers report 2018 which is predicted to grow to \$32.78 billion by 2023 according to the report "3D Printing Market by Offering (Printer, Material, Software, Service), Process (Binder Jetting, Direct Energy Deposition, Material Extrusion, Material Jetting, Powder Bed Fusion), Application, Vertical, and Geography - Global Forecast to 2023" According to a research report by UPS and the Consumer Technology Association (CTA) in their report "3D Printing: The Next Revolution in Industrial Manufacturing" western countries contributes to two-thirds (68%) of the 3D printing revenue while Asia pacific has a share of 27% , where out of this 68% splits into 40 % from North America and 28% from Europe. When it comes to the industry wise share the consumer and automotive industries contribute 20% of the total revenue generated by 3D printing Industry. Medical Industry is the third largest contributor to 3D printing industry with a revenue share of 15%. The major use of 3D printing goods has been in Functional Part, Fit and finish component, Molds and tooling and visual proof or concept. Steel and plastic were the most used 3D printing material in 2016 where Plastic hold the first and steel hold the second position. We have also observed an increasing growth of biomaterial in 3D printing industry and other materials like lay wood wax and paper are being used. Construction sector is also growing rapidly in 3D printing industry.

6 CONCLUSION

- Usage of 3D printing concrete technology is an upcoming technology in future.
- The literature discussed in the present paper has given an overview of the basic process involved in this technology and the application of this technology.

- This 3D concrete printing technology has a wide range of advantages like Time efficiency, Freedom of building any geometrical design, environmentally friendly construction, Economy etc. Although it has disadvantages like Accuracy in the work need skilled labour etc.
- 3D printers are effective as compared to the old conventional method of construction.
- 3D printers use waste material for construction.
- As a result, the cost of labours are reduced as well as it is environment friendly.
- As we can see that 3D printing technology is booming all over the world, especially in India.
- Here we are concluding that this is a secured construction technology and we all need to accept this technology in the construction field.

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