**3D PRINTING TECHNOLOGY IN CONSTRUCTION INDUSTRY****A. P. Domale*¹, Danish Ali², Anuj Adhav³ and Vedprakash Varma⁴**

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ABSTRACT

Civil engineering is a really fast developing field in today's world. Emerging of new technology in construction industry is very helpful for the society. Nowadays we use Artificial Intelligence and Robotics in 3D printing technology for construction. 3D printing depends upon various factors of the machine used. Different types of machines have different specifications and different capacity. The parts like nozzles

are responsible for stability of concrete and it is a very important part of the printer. Stability of the building depends on reinforcement and properties of concrete used. In this paper we present about the current situation of 3D printing technology in Construction Industry and 3D printing technology is better compared to conventional method of construction with some current examples of 3D printing.

KEYWORDS: 3D printing technology, 3D concrete printing, Concrete, Conventional method.

1. INTRODUCTION

In today's construction industry use of concrete is in such a mass quantity that concrete is the most used material on earth after water. But in this process of use of formwork in construction is very tedious and the major drawback of formwork use according to 'Research

Gate' is that the formwork is responsible for about 75% to 85% waste product in construction, 20-30% of total cost is just for formwork processes in small scale construction. Most buildings or structures are aesthetics and their aesthetical appearance to building, using formwork is very difficult it limits the creativity of architectures because in formwork we can provide only linear or straight appearance to building other issues like time consumption labour efficiency and environmental impacts. 3D printing solves all these problems and is becoming popular these days. The most commonly used 3D printing technique in Civil Engineering is 3D concrete printing technology.

2. 3D concrete printing use in today's world

Every person dreams to have his own house. Many government schemes provide houses to poor people under slum clearance or slum rehabilitation process. If they use 3D concrete printing technology then they can provide a greater number of houses in less time and at very low cost. Any house which is single stored and area is 55-75 sq meter can be constructed within 24 hours at 3 lakhs to 6 lakh INR which is very low compared to normal concrete houses with same area. 3D concrete printing can be used in government housing schemes like Pradhan Mantri Awas Yojana (PMAY) or NTR Urban Housing Schemes or Maharashtra housing and area development authority (MHADA) etc. for providing affordable houses to poor people and invery less time.



Figure 1: 3D Printed Row Houses.

3. Different Types of 3D printers

At present there are three categories of 3D printers made and successfully executed on site they are Gantry- It is a type steel structure which consists of steel beams and columns fitted to

each other with motorized wheels which move the steel frame in linear direction. The size of gantry printers differs from small laboratory version to a large version of dimension 40m x 10m x 6.6m.



Figure 2: 3D Concrete Gantry Printer.

Robotic Hand- It is a combination of 3D printing head or nozzle and a multi axis robotic arm which manufactures more efficient 3D printing Structures than other types of 3D printers. Due to complex fittings in the arm this type of printer is able to print from any angle which helps to design complex geometric curves very easily. It can print larger objects up to 30 m.

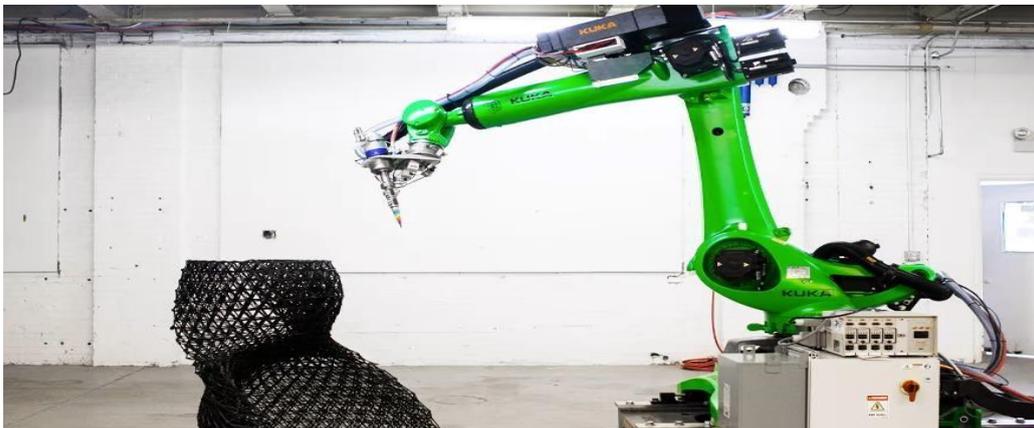


Figure 3: Robotic Arm Printer.

Crane- it is a type of robotic arm but on a large scale. Crane has a centrally fixed support which holds the horizontal steel arm of crane. The arm moves in back and forward direction for printing. The whole support rotates from the central support.



Figure 4: Crane Printer.

Nozzles-End part of the printer head that is nozzle is very important part as it forms the required shape and size of the layer. It is very necessary to have an appropriate nozzle for 3D concrete printers. It should be such that it should provide stability to each layer of concrete and avoid it from collapsing. A study by 'Kwon' states that circular nozzles are difficult to use than square nozzles. However, smaller contact surface between layers or bends may disturb stability of layers in construction.

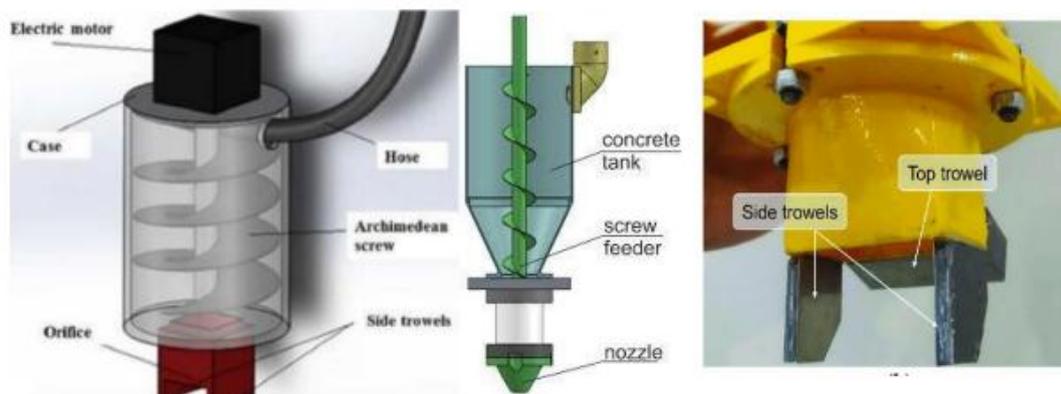


Fig. 5: 3D Concrete Printing Nozzles.

3.1 Slum Value of Concrete

The concrete used in the 3D concrete printer is difficult than the regular concrete used in current construction method.^[8] The concrete used in 3D printing should have zero slump value or low viscosity concrete should be used for better pumping and chemical accelerators are added, for quick setting once printed. To avoid collapsing of the concrete layers, filament layers are printed in zig-zag pattern between the gaps of walls.



Figure 6: Zero Slum Cone Value.

3.2 Reinforcement in 3D concrete printing

For better structural performance and flexibility, concrete structures are added with reinforcement. In 3D printing steel bars are used in columns and beams and steel plates and small steel hooks are used in walls for stability of the wall. Steel bars are used as reinforcement in columns and 3D printed concrete layer is used as formwork and after it hardens concrete is poured in it.



Figure 7: Reinforcement in 3D Concrete

4. Comparison between 3D printing and Conventional method

Table 1: Comparison between 3D printing and Conventional method.

Sr. No.	3 D Concrete Printing	Conventional Concrete
1.	Construction time reduce by 90 %.	Construction time required more.
2.	80% Wastage reduced.	Wastage is more.
3.	No formwork required.	Formwork required
4.	Easy to design any geometry of structure	Difficult for geometrical design of structure
5.	Group of technician required	Less technician are required

5. CONCLUSION

The newly introduced technology of 3D concrete printing is widely spreading its hands in modern construction industry. Construction industry with the help of AI and robotics data science has designed many machines used for 3D printing. 3D printing is the future of construction industry and in upcoming years 70% structures would be build by 3D concrete printing and remaining 30% would be precast concrete structures.

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