Introduction of 3D Printing in Construction Industry

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Abstract: 3D printing is Additive manufacturing technology and will be quite wide spread industry. 3D printing technology print shapes or solid material from a digital Computer Controlled process to a physical 3D object. The process of Printing is done layer by layer (Additive manufacturing) using various types of material such as plastic, metal, nylon, 3D printing Concrete and many more Hundreds with hundreds of materials. 3D printing is useful in almost every sector such as manufacturing, industrial design, footwear, architecture, engineering and construction, automotive, aerospace, dental and medical industries, education, geographic information systems, etc. It is fast and cost-effective Technology. The applications of 3D printing are increasing and are very reliable. In this paper there is an Overview of the 3D printing Technology in Construction Sector.

Key words **- 3D printing, additive manufacturing, layer by layer, applications, technology, cost effective.**

INTRODUCTION

Concrete is the most generally used artifact within the world. There is two times more concrete used than any other material wood, steel, plastic even aluminium, concrete in its basic form consist of cement, sand, aggregate and water which come together to form a slurry. now this slurry has no form of its own when its wet it has to be cured or hardened in a formwork which is made of wood or metal, this formwork actually constitutes half of the total cost of typical cast in place concrete construction. In addition to that cost being a disadvantage its extremely wasteful typical formwork is made of timber or plywood and this can be reuse to maximum of five times after which it has to be disposed of and it just adds to the construction waste.

3D Printing Technology (occasionally mentioned to as Additive Manufacturing (AM)) is the computer-controlled consecutive layering of ingredients to create three-dimensional shapes. It is mostly useful for prototyping and for the production of geometrically multifaceted components. It was first developed in the 1980s, but in that period was a problematic and expensive process and so had few applications. It was since 2000 that it has become comparatively forthright and cheap and so has become feasible for a varied variety of uses in various sectors. The sales of AM machines, or '3D printers' has grownup quickly and since 2005, the home use of 3D printers has converted hands-on.

3D printing systems developed for the building industry are mentioned as 'construction 3D printers'.

A 3D digital pattern of the item is formed, either by computer-aided design (CAD) or by means of a 3D electronic scanner. The printer then reads the design and lays down successive layers of printing medium (this can be a fluid, residue, or sheet material) which are combined or bonded to produce the piece. The procedure can be sluggish, but it allows nearly any shape to be created. Based on the method accepted, printing can produce numerous components concurrently, can use numerous resources and can use numerous colours. Precision can be improved by a high-resolution subtractive procedure that eliminates material from an oversized printed item. Some methods comprise the usage of dissoluble resources that support overhanging features throughout construction. Resources such as metal can be exclusive to design, and in this situation it may be extra profitable to design a mould, and then to use that to generate the item.

METHODOLOGY

What is really exciting is the innovation in structure design that's happening because of this technology. Typical structural members made of concrete have been the same foe hundreds of years. We have pre cast concrete slabs which can be solid, hollow core, double T or single T and also precast beams and girders which can be rectangular, I shape, L shape, inverted etc. you usually have to have steel integrated in these structure members to reinforce them.[1]
3D printed concrete differs compositionally in 3 ways in addition to the base ingredients you also have reinforcing ingredient like carbon fiber and an adhesive ingredient like water putty and a hydrator like sodium silicate this produces a very different concrete one that can maintain its shape when wet its also very rapid hardening material with high strength capabilities.
With the concept of 3D printing your whole mindset has to be changed when it comes to structural member. You start off with a 3d model which is digitally sliced in layers from this model you obtain X, Y, and Z coordinated these coordinates are then converted into code and fed into your 3D printer these coordinates dictate the movement of the robotic arm. Since you can't integrate steel into these 3D printed walls you almost have to integrate the design of a truss into these walls. Your wall is no longer comprised of layers the structural element and the skin are one. Fig1

Fig1 architecture and 3D printing

Types of 3D Printers

FDM is the main technology in 3D printing. Which is known in the 3D printing biosphere, recognized by the name of 'Fused Deposition Modeling' or FDM or FFF for short. S. Scott Crump developed FDM in 1980s and was marketed in 1990 by Stratasys. Alternative important year in the progress of FDM was 2005 when Professor Adrian Bowyer initiated the RepRap project, presenting the global drive to replicate self-replicating printers that are open-source. [2]

How Fused Deposition Modeling Works

FDM is the most elementary 3D printing technique. FDM contains 3 main fragments: a printing plate on which the portion is printed; a filament coil that helps as printing material, and an extrusion skull, called an extruder. The filament is molten by the extruder of the printer, which deposits the solid layer-by-layer on the plate.

The 3D modelling procedure includes designing the item by means of a CAD 3D software (such as SolidWorks, Tinker CAD or Self CAD). When designed, the 3D model (likely a .STL file) is riven into numerous coatings through a 'slicer' before the parameters of the printing are chosen. Fig 2

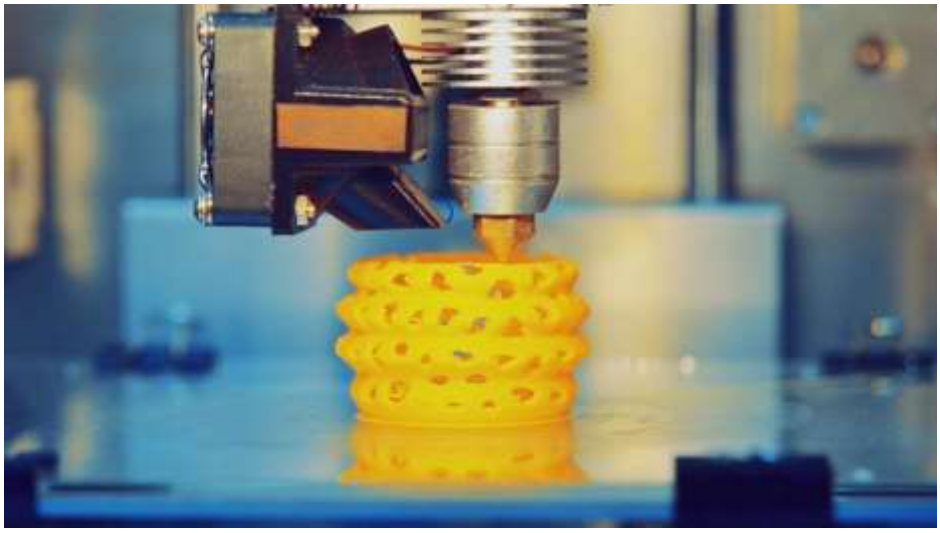

Fig 2 FDM

Types of FDM 3d Printers

1. **Cartesian FDM 3D Printers**

Cartesian 3D printers are the most communal FDM 3D printer found in the bazaar. Constructed on the Cartesian organize structure in mathematics, this technology practices three-axis: X, Y, and Z to regulate the precise locations and path of the design skull. By this kind of printer, the printing couch typically travels only on the Z-axis, by the print head, employed two-dimensionally on the X-Y plane. Fig 3

2. Delta FDM Printers

This technique is being perceived additional and more on the FDM 3D production bazaar, with a fresh addition which was advanced by two Swiss scholars, which involved of a six-axis 3D printer that was built on the Delta technology. These technologies function through Cartesian coordinates. This includes a circular printing plate that is joint through an extruder that is static at three triangular points. Individual of the tri points then travels up and down, thus defining the location and direction of the print skull. Fig 3

3. Polar FDM Printers

In Polar 3D printer location is not determined by the X, Y, and Z coordinates, but with angle and length. which means that the plate rotates and moves at the similar period, by the extruder moving up and down.

The benefit of Polar FDM 3D printers is there are only two machines, while Cartesian printers want at minimum three. In the extensive period, the polar printer has better energy productivity and can make greater stuffs though using less space. Fig 3

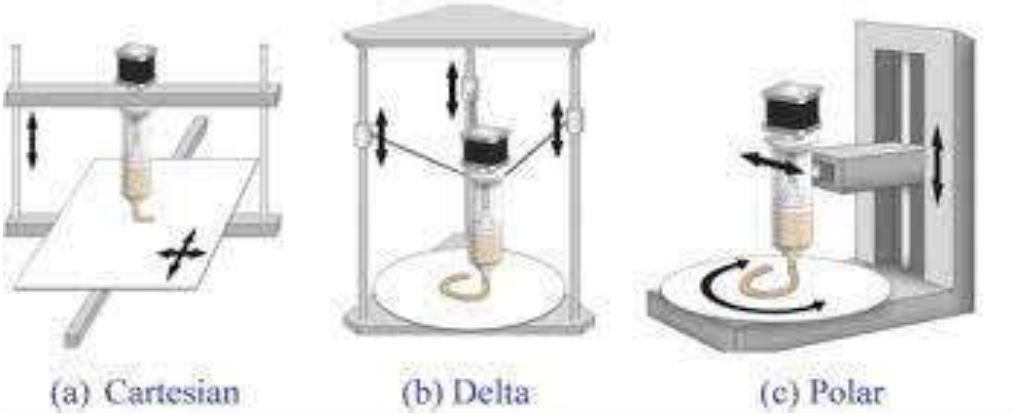

Fig 3 Cartesian, Delta and Polar 3D Printers

4. Robotic arm FDM 3D Printing

Robotic arms are maximum normally recognized for assembling mechanisms on manufacturing production lines, particularly in big automotive plants. While 3D printing has initiated to integrate robotic arms into their manufacture procedure, most particularly seen in the 3D printing of homes and structures, this technology still remains in the development phase.

Though not a usually used printing procedure, this FDM printing method has started to see an upsurge in use. This is since the procedure is not fixed to a printing plate, creating it much more mobile. Thanks to the flexibility when aligning the FDM 3D printer head, it is easier to make compound structures. Fig 4

Fig 4 Robotic Arm Extruder

1. Robotic arm Extruder

The Crafting technique includes the structure material being dropped to produce a large-scale 3D model by a even surface texture. Rails are fitted around the construction ground that will perform as a structure to direct the robotic arm. It travels back and forth to extrude the concrete, layer-by-layer. Trowels located on the side and overhead the nozzle to level the extruded layers and confirm the model's strength.

In this procedure, conventional concrete cannot be castoff as it would need to strengthen before you could continue the procedure. If it was 3D printed it thus wouldn't be able to support its own mass. Hence, concrete is used with rapid setting properties. [3]

2. Sand Layers Liked Together

Enrico Dini initially created waves as the 'man who 3D prints houses.' He demonstrated an interesting 3D printing procedure by means of his 'D-Shape' 3D printer. This mechanism depends on the binding of powder which makes it likely to harden a layer of material with a binder. Layers of sand are placed according to the wanted thickness before a print head pours dews to harden the sand. Fig 5

Fig 5 The print site where the D-Shape will 3D print a concrete structure.

3. Metal for Solid Structure

Dutch company MX3D have developed a sole building technique called WAAM (Wire Arc Additive Manufacturing), which allows you to 3D print metal structures with a 6-axis robot that beads 2 kilos of material per hour. This robot was the result of association with Air Liquide and ArcelorMittal and is armed with a welder and a nozzle to weld, layer-by-layer, metal rods. This process is additionally compatible with other metal alloys like chrome steel, bronze, aluminium and Inconel. The machine can be associated to a sort of giant soldering iron.

Fig 5 MX3D are one of a number of innovative start-ups in the 3D printed house sector.

Advantages

1. Reduced Injury

One of the main profits that 3D printers have offered to building workers is a reduction in injuries on the ground.

2. Reduced Material Wastage

Considerable reduction of material waste. 3D printers use the exact quantity of concrete required for the wall, floor, or whatever it is that you want to construct.

3. Fast Construction

Where a plan may take weeks–or months-to finish, 3D printers can often finish a plan in a matter of hours or days. An entire house was constructed in 24 hours with the 3D printing Technology. [4]

Disadvantages

1. Margin of Error

3D printed concrete is so rapid hardening that if you make a mistake in the print, you just have to discard the whole design and start again.

2. Size

Limited by the size of the printer and also the size of the object being printed.

3. Cost

The cost of the Printer, the materials being used and the research and development.

4. Nature of print

The hurdle to overcome with this technique is the appearance of the final product it has a lot of striation on its surface because of the nature of the print so we either embrace it or spend a lot money polishing it

These Disadvantages are expected as it's a fairly new technology the cost of the machine will just keep going down in time. [5] [6]

RESULT

In the building industry, 3D printing can be used to 'print' entire buildings. Construction is well-suited to 3D printing as ample of the data necessary to create an item will exist as a result of the project process, and the industry is already experienced in computer aided manufacturing. Building 3D printing may permit, quicker and extra precise building of composite or personalized items as well as dropping labour costs and creating less waste. It might also enable construction to be accepted in strict and hazardous surroundings not suitable for a human workforce such as in space.

CONCLUSION

The 3D printing industry is set on a progress trajectory as evidenced by the growth forecasts. The applications of 3D printing are increasing as more and more research is carried out in this field. either way 3D printed technology has a lot of potential in the construction industry and is the future.

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