

Three-Dimensional Printing Trends in Building and Construction Industry

Mahesh Pandhare¹, Chetan Manusmare², Nileshkumar Meshram³, Palash Waghmare⁴,
Mohammad Aatif⁵

*Bachelor of Engineering in Civil Engineering [1][2][3][4]
Assistant Professor in Civil Engineering Department [5]
Nagarjuna Institute of Engineering Technology and Management
Satnavari Nagpur, Maharashtra India*

Abstract - Three-Dimensional printing alludes as 3D printing or 3DP and is commonly known as Additive Manufacturing may be a innovation which is utilized to print 3D model with the assistance of Computer Aided Drawing [CAD] software. Presently this 3DP innovation is trending in building and development industry all over the world. 3D printing is regarded as an development that contributes to mechanization in civil designing and offers benefits in plan, greenness, and effectiveness. In expansion, non-specialized challenges and trends from the financial, natural social, and legislative viewpoint are proposed. All businesses must adjust themselves to this unused frameworkso that they seem survive in the quickly changing merciless living space. There's huge pressure, developing within the Construction industry to adjust to the unused innovative improvements. In this paper we are going to talk about its history, benefits. Advantages, disadvantages later improvements and future of this technology.

Key words- Computer Aided Drawing [CAD], Advantages, Disadvantages, Future of Technology, Innovation Trends.

1. INTRODUCTION

3D printing is an computerized. Aided substance fabricating prepare for creating 3D strong objects from a computerized (i.e. CAD) model. In other words, in a 3D printing prepare, the 3D CAD model will be cut into a arrangement of 2D layers, which is able afterward be stored by the printer to build the model. Depending on the advances utilized within the 3D printing process, there are five primary sorts of 3D printing forms. The primary sort of innovation is called stereolithography, which more often than not incorporates a punctured stage, a container of a fluid UV-curable polymer and a UV laser. Ordinary development prepare shows up to be generally straightforward and orderly; requiring two-dimensional (2D) drawings and scale models (for assessment of the building plans), cumbersome formwork and much skilled labour to construct any kind of freeform structures. Work related wounds and sicknesses posture a proceeding danger to the wellbeing and well-being of construction workers Development industry proceeds to

have higher rate of casualty, damage and sickness than any other businesses. This compels the presentation of 3D printing to be coupled with building data modeling (BIM) for following and observing unused factors presents in a energetic working environments such as a construction location to extend working environment security. Combining BIM and 3D printing would also make it simpler to form exceedingly customized building components and encouraging complex and modern plan be that as it may, there are still various challenges related to scale, materials, conveyance framework and reasonableness to antagonistic situations. The 3D printing innovation employments a little sum of fabric and thus presents delicacy into the items and empowers the plan of multi-functional component astounding data performed shows that development is taking charge of for producing approximately 80th of casting concrete into formwork confines designers' auxiliary flexibility of design in different geometries, unless the cost of customized formwork is exceptionally tall. Rectilinear shapes not as it were hinder architectural development, but due to stretch escalated, they are too fundamentally weaker than curvilinear shapes. The moderated rate of development (i.e. long and troublesome to oversee lead time) is another impediment. Concrete development too requires a stages, counting the preparing of materials. Transport and on-site production. Using concrete development 3D printing procedures maybe help to illuminate the same challenges as of late, one by one 3D printing innovation is picking up more notoriety in the construction industry. A few methods for 3D concrete printing {3DCP} have been examined in past a long time.

2. 3D CONSTRUCTION PRINTING

The first manufacturing systems developed for concrete 3D printing - by precursors such as J. Pegna (Pegna, 1997); Contour Crafting (Khoshnevis, 2004); Loughborough University (Buswell et al., 2007); D-Shape (Cesaretti et al., 2014) - are based on a variety of manufacturing systems, for both the printing nozzle and the motion system. A review of the various 3D printing manufacturing systems developed so far can be found in Duballet et al., 2017. The detail explanation of these types are as follows:

2.1 Contour crafting (CC)

Contour Crafting (Lim et al. 2012), a layered Contour Crafting (Lim et al. 2012), a layered fabricating framework with automated arms and expulsion spouts, is one of the major improvements in AM advances within the development industry. Khoshnevis & Bekey (1998) (College of Southern California) to begin with utilized the Contour Crafting (CC) method, which is one of the roots of 3D concrete printing and is still utilized. From at that point until presently the improvement of this technique was basic.. Within the layered generation strategy utilized to make large-scale objects with a smooth wrapped up surface, polymer, ceramic glue, cement, and various other materials and blends were utilized (Wolfs 2015). The CC prepare could be a prepare that simulates, but is performed with a few robotization, the conventional development handle. The CC prepare is an curiously plan, the form isn't evacuated and gets to be a portion of the divider, needs three diverse steps as a forming, fortifying and arrangement. Distinctive materials can too be utilized with the CC prepare, such as ground totals, reinforcing filaments and added substances, and the spout may moreover be diverted to make non-orthogonal surfaces like arches and vaults. NASA was moreover inquisitive about the administration of space investigate with Form Making. It has been observed from the tests on the CC that the strategy is additionally promising in conceivable moon buildings (Khoshnevis and Zhang et al. 2018).

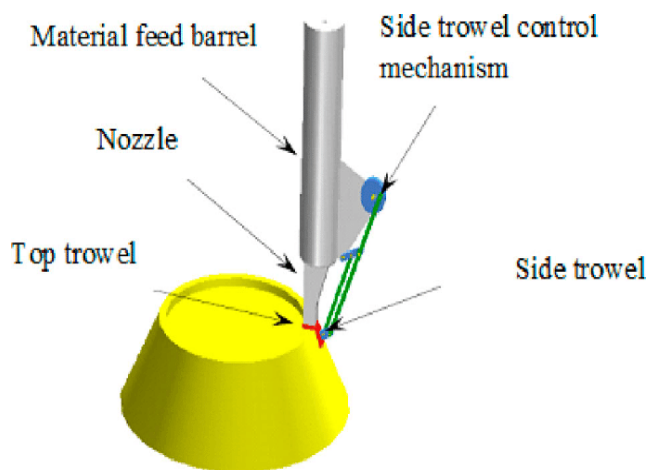


Fig -1: Contour crafting process

2.2 D-shape

Italian civil engineer Enrico Dini designed a D-shaped three-dimensional printer. It was established in 2004 and claimed the world's to begin with 3D printing innovation to solidify crushed calcareous dolomite into a fabric of strong stone. The objective of Enrico was to make 3D printed structures with nearby materials. It was a common analyzer with a wide cluster of pulverized shake totals, like volcanic shake and marble, effectively tried (Nadarajah 2018; Mysterious

2019(a). The D-fit prepare is based on the infusion of the cover into the material's surface. Typically expecting to print works utilizing an inorganic sand cover in 5-10 mm layers. It employments an headway process same to the powder-jet printing process within the folio so that the specified layers of the fabric are shaped (Cesaretti et al. 2014). The method is based on a powder testimony prepare. The downside of those forms is that the ultimate structure must be cleaner from the leftover tidy into the after-treatment shape which more care, cleaning and control is required. The extraction of the unused item tidy and the crushing and cleaning of the ground frame portion of the post-processing cycle (Lim et al. 2009). The D-Shape could be a enormous, numerically made 3D printing framework from the underpass to the roof with establishments and allotments ceilings, staircases, holes.

2.2 Inkjet powder

Another sort of 3-D printing prepare is ordinarily alluded to as inkjet powder printing prepare which uses stick or folio to bond progressive powder layers together. Inkjet powder printing can utilize metal as the printing fabric. Metal (e.g. steel or bronze) within the powder form is stored within the to begin with layer. The printer head will splash folio fabric which can at that point be warmed and dried by a light (de Gans, 2004). When all layers are printed, the product will be cured in an broiler. Agreeing to Castrejon-Pita et al. (2013, p.546), the most 108 obstruction to actualizing inkjet strategy is the necessity for an ink (i.e. the printing fabric) that's secure to ingest, has no smell, moo movement of monomers and other components, palatable scraped spot resistance for the bundling and dispersion handle, capacity to warm seal, penetrate and die-cut without chipping, whereas still giving the seriously colours and tall definition required for essential retail bundling on a grocery store rack.

Selective laser sintering (SLS) may be a layer fabricating prepare that permits producing complex 3-D parts by solidifying progressive layers of powder fabric on best of each other (Kruth et al., 2005). In SLS, the union prepare is conducted employing a focused laser pillar. When SLS is utilized to create metal items, the method is as a rule alluded to as specific laser melting (SLM) or coordinate metal laser sintering (DMLS) (Kruth et al., 2004). For illustration, within the SLM prepare, the metal powders are completed liquid by the laser bar. As such, the printed items have much higher thickness than the items printed by SLS. In spite of the fact that SKS and SLM are able to print high-strength item, these technologies face challenges include temperature sensitivity and print size. To avoid oxidation of materials during the printing process, the material fusing temperature should be hold to just below its 2010). In addition, the print size is usually small when using SLS.

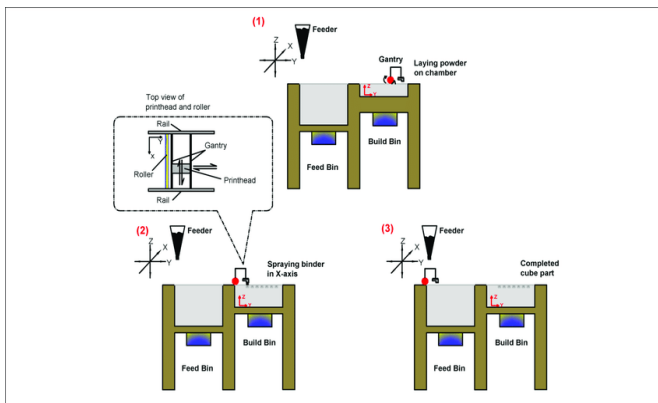


Fig -2: An illustration of the components and processes in inkjet powder printing.

3. HISTORY OF 3D PRINTING

Traditionally, the utilize of 3-D printing was confined to the fabricating segment. It was utilized to 211 deliver models with moo generation volumes, little portion sizes and complex plans (Berman, 2012). As such, the 3-D printing innovation was as a rule alluded to as Fast 213 Prototyping (RP) innovation amid that time. The primary 3-D printer, utilizing stereolithography innovation, was created by Charles Body in 1986 (Body, 1986). Within the taking after a long time, other RP advances have too been presented into the advertise. For illustration, both SLS and FDM 216 were presented into the showcase in 1989. At this arrange, RP innovations were used to deliver models for items primarily utilized within the fabricating division. For illustration, Arthur et al. (1996) utilized RP innovation to create electrical release machining anodes. The innovation kept on play an critical role within the fabricating industry within the 21st century. Vinodh et al. (2009) examined the selection of 3-D printer to create the model of a handle of an hardware switch. By utilizing 3- D printing, it is accepted that the capabilities of quick prototyping can be consolidated with the high-volume throughput of customary fabricating (Bak, 2003). Whereas the use of RP advances was primarily limited to the fabricating segments, there were a couple of endeavors that utilized development- related materials which illustrated the pertinence of the innovations within the development industry. For illustration, Hinczewski et al. (1998) utilized stereolithography to deliver ceramic three-dimensional parts. A complex ceramic portion was delivered utilizing stereolithography in spite of the fact that the mechanical properties of the portion were not optimized (Hinczewski et al., 1998). Additionally, Khoshnevis et al. (2001) utilized form 11 making and illustrated that it can be utilized to create mortar portion in case constrained drying by warming was received. The investigate group at Loughborough College has taken an activity to create a 3D concrete printing handle that can deliver freeform building component. These pilot considers illustrated that 3-D printing advances can be utilized to deliver development

components as long as fitting quality control procedures were received

4. METHODOLOGY

The essential technique I utilized in this paper was subjective inquire about taken from huge scale ventures that utilized 3D printing as their primary implies of development to pick up understanding to the considerations and conclusions of the utilize of 3DP within the industry nowadays. My investigation incorporates a nitty gritty case think about of the two ventures, distinguishing proof of the preferences and impediments of the innovation, and an assessment of the finest hones for the utilize of 3DP in development nowadays.

The objectives of this case study are as follows:-

- To describe the various 3DP means and methods used for each project.
- To highlight the time, cost, and materials savings associated with using 3DP.
- To highlight the limitations associated with using 3DP.
- To point out the future development in 3DP

4.1 Testing procedure

The choice of the ideal blend requires a few tests to be conducted, keeping in intellect the target parameters to be accomplished. These variables together contribute in rise to significance to the composing. Firstly, preparatory trial tests are done that center on extrudability, a basic parameter that guarantees the proper printing out of the spout. usually regularly fundamentally tormented by the amounts and dispersions of the dry constituents inside the blend. to see the beginning blend extents, the concept of slip-form concrete plan, which contains a self-compacting property and doesn't require advance solidification, was taken after. Once the gotten glue is found extrudable, a few tests were performed to fulfill the inverse necessities The amounts of added substances at that point begin to play the conspicuous part. Underneath may be a depiction of the tests performed to affirm taking after target criteria are met:

- **Extrudability:** It alludes to the capacity of the concrete to be expelled out of the nozzle is surveyed on the preface of the hole over which the glue can be printed without blocking the spout. Moreover, the printed glue ought to be past splits and separations.
- **Compressive strength:** The target quality of the concrete is set utilizing BS 1881- 116:1983 and 5x5 concrete 3d shapes. Quality is particularly critical since what's printed is that the structure in layers rather than its aggregate without delay. Since setting time ought to be expected to be

momentary, and since the printing happens as it were in an awfully matter of minutes, the target quality and quality pick up ought to be high.

- **Flow capacity:** Estimation of stream capacity is accomplished by performing the droop stream test. The concrete is confined of an rearranged cone. The time required for the combo to spread by a chosen distance across is measured conjointly the rate of streaming can in this way be gotten. An easily extending blend compares to a more prominent flowability and workability. Buildability: usually frequently measured by the sum of layers of the printing example which can be accomplished without collapse. The target normal number of layers is 5.

- **Open Time:** This basis is exceptionally imperative the standard strategy. inside the last mentioned, the beginning and last setting times are more agent but do not have much significance in concrete printing representation of the concrete workability alter with time. it's calculated utilizing the droop stream test to initiate the stream capacity over particular 3D Concrete Printing presents itself as a promising instrument inside the lodging industry. With a combination that fulfills different plan and operational imperatives, houses are frequently built utilizing this imaginative procedure without the utilization of formwork. 3D concrete printing offers investment funds in terms of long-term taken a toll, time, labor and complexity, which are crucial current components inside the lodging industry. Moreover, it's less destructive to the environment than more conventional development strategies. Furthermore to being a promising apparatus to engineers in terms of auxiliary plan, 3D concrete printing is additionally a possible tool for architects in architectural design. As the method is not limited by any type of formwork or manual labor, designers will have much more design flexibility in that scope

4.2 Benefits of 3D Printing

- Fast production
- Almost zero material waste
- Cost-effectiveness of 3D printing in the construction industry
- Innovative design

4.2.1 Almost zero material waste

The main advantage of using 3D printing within the construction industry is sparing a parcel of generation costs on fabric squander. That's since a 3D printer, such as mechanical arms employments precisely the sum of fabric they require. Creating buildings layer by layer and with grid structures interior permits for a gigantic fetched diminishment. Not as it were that, but they are too able of utilizing reused materials. This factor too benefits the

environment. 3D printing includes a much littler affect than conventional ways of fabricating. An Italian company called WASP took 3D printing into an incredible improvement and outlined one of the biggest 3D printers within the world able of creating homes out of neighborhood materials and using green energy (hydro, wind or solar power). This means much smaller emission, which is a big problem in today's construction industry. Last year we talked about the first family to move into a 3D printed house The house in question was produced in Nantes, France and is called the Yhnova project. It took only 54 hours to print the house and the overall cost was about 20% cheaper than building a traditional house. Additive Manufacturing can really help to build a better future for the construction industry.

5. DEVELOPMENTS OF 3D PPRINTING

In 2013 a Shanghai based company called Winsun created 10 little full-size pre-assembled homes in fair one day. Each domestic measured 215 square feet, and taken a toll \$4,800 to construct. The printer utilized to manufacture the dividers stands 20 feet tall and 40 feet wide and moves along a 120-foot long track. The fabric that's extruded from the printer's spout may be a trademarked mixture consisting of concrete, cement, glass fiber fortified gypsum, and fiber fortified plastics bonded beside a exclusive added substance that empowers the concrete to completely remedy inside a few of days (depending on compressive quality). 50% of this fabric is sourced from reused development squander (Millsaps, 2016). The key to this blend is finding a adjust between flowability and construct- capacity so that the concrete can back itself without the require for formwork, whereas too keeping up a adequate compressive quality.

In spite of the fact that Winsun does not discharge their particular plan, an ideal blend plan for such a fabric encompasses a fine total to cement proportion of 1.28, a fine total to sand proportion of 2, and a water to cement proportion of .48 (Hachem et al.,16). This (a)C-Fab Wall Partitions, (b)3D concrete printed storm drain, (c)WASP 3D Shelter mix design is capable of reaching compressive strengths of up to 8,000 psi which is well above the International Building Code's 2,500 psi minimum strength for structural concrete (IBC Concrete Manual, 2017). Three years afterward, Winsun utilized the same printer and fabric to create the worlds' to begin with 3DP office building for the Joined together Middle easterner Emirates National Committee as their base camp for the Dubai Future Establishment (DFF).

This 2,700 square foot building was moreover printed offsite in a manufacturing plant, cut in half for shipping purposes, and gathered onsite. The whole team comprised of 18 laborers, counting one printer administrator, seven laborers for gathering, and ten laborers for mechanical and electrical (Change, 2016). The full venture term from starting of printing to wrapped up gathering took as it were 17 days for

a add up to of \$140,000 in development and labor costs (Dalton, 2016).



Fig -3: Internal reinforcement of 3DP



Fig -4: 3D printed office in Dubai

5.1 Global 3d Printing

Market Forecast 2019-2027 Global 3D printing market is estimated to grow with approximately 17.00% CAGR during the year 2019-2027 and is expected to gain \$44,390 million till the year 2027. 3D printing is a groundbreaking and innovative technology with the potential to bring intermediate changes in manufacturing, society, and business. It emerged as a crucial medium connecting the virtual and actual world. It enables transforming the digital files into tangible objects, and assists in designing, scanning, sharing, and sending digital creations of real objects anywhere aiding the printing of 3D printing objects. 3D printing has embarked significant progress from the initial stages of production of simple plastic models to producing useful components, in the fields of fashion, surgical implants & prosthetics, batteries, robots, cloth, and others. It witnessed a rapid development subject to the increasing

advancements. Furthermore, a wide range of 3D printing materials and high speed of manufacturing are gaining acceptability across various industries, and its applications are increasing drastically. The 3D printing industry visualizes a world where the 3D printer will be used in every home.

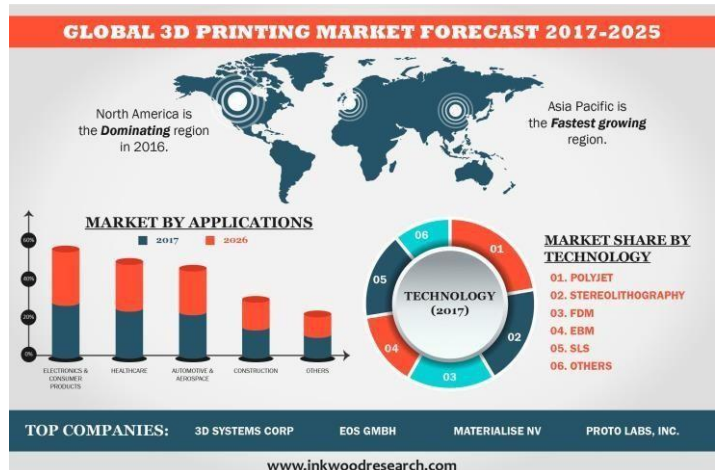


Chart -1 Market forecast 2019-2027

3D printing is a vital element of umbrella term additive manufacturing, which aims at creating a three-dimensional object by laying down many thin layers of material over each other. In contrast to the traditional production or printing activities, it involves no drilling, or different kind of processes involved making it an efficient and enhanced manufacturing process with optimum utilization of resources. Its applications are extended to sectors such as automotive, construction, jewelry, and others. Some of the most popular technologies used in 3D printing include PolyJet, Selective Laser Sintering (SLS), and Stereolithography (SLA), among others. The use of 3D printing in healthcare has been gaining remarkable momentum.

CONCLUSIONS

In this paper I have studied about the term called 3D printing technology also known as "Additive Manufacturing". This technology is far better than regular conventional process. I also learn the history of 3D printing and its benefits. This technology is most promising technology for better future of construction industry, specially for our earth greenness and to reduce wastage of materials.

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