ISSN:2348-2079

Volume-5 Issue-1

International Journal of Intellectual Advancements and Research in Engineering Computations

Construction of building using 3D printers

Mrs V.Jayanthi[1], K.Chandru[2], S.Mehala[3], D.Divya[4] Dr. B. Soundara[5]

[1]Assistant Professor, Department of Civil Engineering, Bannari Amman Institute of Technology,Sathyamangalam

[2, 3,4]Third Year B.E Civil Engineering, Department of Civil Engineering, Bannari Amman Institute of Technology, Sathyamangalam

[5]Associate Professor, Department of Civil Engineering, Bannari Amman Institute of Technology,Sathyamangalam

E – Mail: jayanthiv@bitsathy.ac.in

Abstract— **'3D printers' has grown rapidly and since 2005, the home use of 3D printers has become practical. Systems developed for the construction industry are referred to as Construction 3D printers(Construction3Dprinting).Researchers are experimenting with different types of 3D printers and a range of raw materials and fabrication techniques to advance the technology and expand the range of potential applications to include structural building components and even whole buildings. Current research includes experimentation with a variety of raw materials including recycled plastic, bio plastics, concrete and a synthetic "stone-like" material created from a combination of sand and chemicals. Advanced 3D printers capable of extruding multiple materials. One of the advantages of 3D printing building construction is that the fabrication of reinforced concrete beams either done at site or in factories.**

Key words*: *3Dprinting, Stereolitography, recycled materials, fabrication

I. INTRODUCTION

3D printing, also referred to as additive printing or additive manufacturing, is a revolutionary production technique capable of creating solid objects from a digital file uploaded to a 3D printer. Chuck Hull invented the first 3D printing process called 'stereo lithography' in 1983**.** The printer reads the file and lays down successive layers of materials, such as plastics, resins, concrete, sand or metals, until the entire object is created .In the construction industry, Construction 3D printing can be used to create construction components or to 'print' entire buildings. Construction is well-suited to 3D printing as much of the information necessary to create an item will exist as a result of the design process, and the industry is already experienced in computer aided manufacturing. The recent emergence of building information modelling (BIM) in particular may facilitate greater use of 3D printing. . Demonstrations of construction 3D printing technologies to date have included fabrication of housing, construction components (cladding and structural panels and columns), bridges, artificial reefs, follies and sculptures.3D printing at a construction scale will have a wide variety of applications within the private, commercial, industrial and public sectors. Development has been slow and sporadic, since its development in the mid 1990s, where initially it was explored as a scaled version of mainstream 3D printing, having both novelty value and early research funding in both the US and Europe. The term 'Construction 3D Printing' was first coined by James B Gardiner in 2011.

II. 3D PRINTING TECHNOLOGY

Stereolitography was the first technology of rapid prototyping which means fast, precise and repeatable production of elements usually with computer support. First step in creating the technology was invention of additions to the synthetic resins that after lightening of the resins were causing start of the polymerization process. Stereolitography is a technology that can build objects with a high precision and extremely complicated geometry. Ductile materials which are hardening itself during cooling process are extruded through double headed nozzle. Both, modeling and supportive materials are being deposited according to the cross-section layers, generated from digital model supporting the printer. The nozzle contains resistive heaters that keep the filament in appropriate melting point, which allows it to flow easily through the nozzle, in case to form the layers. Like in the other technologies, after creating one layer, a platform is being lowered and next layer is created. This process is repeated until the whole object is completed. Materials usually used in FDM technology are called filaments and are used in printers as rolls of thermoplastic materials like ABS (Acrylonitrile Butadiene Styrene) or PLA (Polylactic Acid) – which is a completely different kind of thermoplastic. It's being made from corn starch or sugar cane and is biodegradable, so it is considered as greener as and more sustainable than ABS. Concrete water and other admixtures are used.

III. ADVANTAGES OF 3D TECHNOLOGY

There are numerous advantages coming from developing 3D technology in construction and most important ones could be resumed as:

Lower costs – the cost of printing construction elements of houses is much lower than traditional construction methods, also material transportation and storage on sites is limited;

Environmental friendly construction processes and the use of raw materials with low embodied energy (i.e. construction and industrial wastes) reduced number of injuries and fatalities onsite as the printers will be able to do most hazardous and dangerous works;

Wet construction processes are minimized, so that building erection process generate less material wastes and dust compared to traditional methods;

Time savings – time required to complete the building can be considerably reduced.

IV. CAIXIN BUILDINGS IN CHINA USING 3D PRINTER

While architectural firms compete with their designs for 3D-printed dwellings, one company in China has quietly been setting about getting the job done. In March of last year, company Win Sun claimed to have printed 10 houses in 24 hours, using a proprietary 3D printer that uses a mixture of ground construction and industrial waste, such as glass and tailings, around a base of quick-drying cement mixed with a special hardening agent.Now, WinSun has further demonstrated the efficacy of its technology -- with a five-storey apartment building and a 1,100 square metre (11,840 square foot) villa, complete with decorative elements inside and out, on display at Suzhou Industrial Park.

Fig.1.Caixin building

The 3D printer array, developed by Ma Yihe, who has been inventing 3D printers for over a decade, stands 6.6 metres high, 10 metres wide and 40 metres long (20 by 33 by 132 feet). This fabricates the parts in large pieces at WinSun's facility. The structures are then assembled on-site, complete with steel reinforcements and insulation in order to comply with official building standards .Although the company hasn't revealed how large it can print pieces, based on photographs on its website, they are quite sizeable. A CAD design is used as a template, and the computer uses this to control the extruder arm to lay down the material "much like how a baker might ice a cake," Win Sun said. The walls are printed hollow, with a zig -zagging pattern inside to provide reinforcement. This also leaves space for insulation. This process saves between 30 and 60 percent of construction waste, and can decrease production times by between 50 and 70 percent, and labour costs by between 50 and 80 percent. In all, the villa costs around $161,000 to build .And, using recycled materials in this way, the buildings decrease the need for quarried stone and other materials -- resulting in a construction method that is both environmentally forward and cost effective in time; the company hopes to use its technology on much larger scale constructions, such as bridges and even skyscrapers.

Fig.2. Process of Caixin building

V. THE TOP FIVE POTENTIAL OF 3D PRINTED CAIXIN STRUCTURES

1. Major potential for **environmentally friendly** construction projects. There are efforts to use the plethora of plastics floating in our oceans or lying around in waste dumps that could be used. Also, concrete and other materials can be better recycled and used more efficiently.

2. Large-scale industrial 3D printing can be used to build **inexpensive** 3D printed houses in developing countries.

3. Enables **short construction periods**, meaning simple 3D printed houses or shelters can be constructed quickly. This could be especially useful after an earthquake, a tornado, or another type of natural disaster.

4. Construction 3D printing allows for the production **shapes** that are either impossible are too expensive with conventional methods.

5. Otherworldly potential. NASA already has plans to use 3D printing for colonies on Mars. The ESA recently enlisted architect Norman Foster to design a moon research base that would be 3D printed from lunar soil. If and when we ever migrate to another planet, there are good odds that 3D printing will be a primary construction tool.

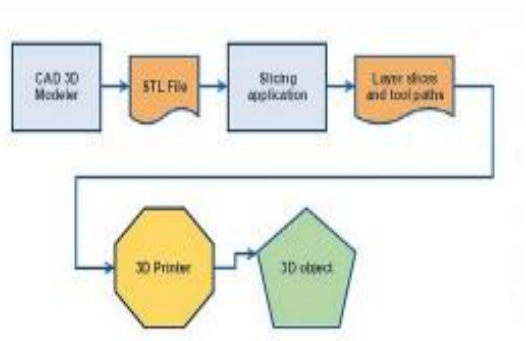
VI. PREPARATION OF COMPUTER MODELS FOR 3D PRINTING

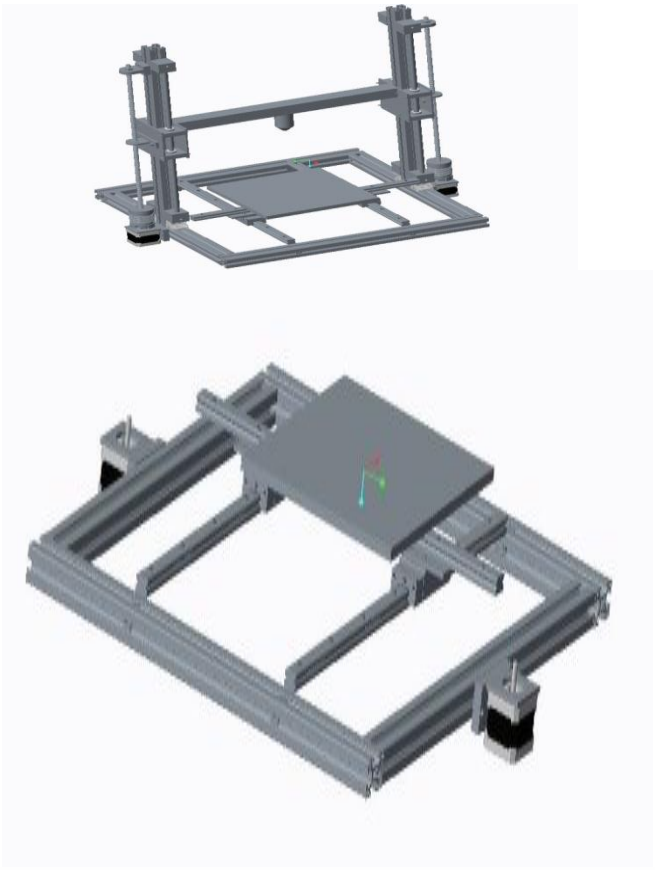
These are of course the key issues for the adoption of 3D printing technology. An important element is however also preparation of computer model for the parts to be manufactured. Fortunately, the level of 3D computer graphics

both in terms of software and hardware makes it possible to build such digital models without many difficulties. It can be done using many commercial as well as Open Source software packages.

A.3D PRINTING WORK-FLOW

The typical work-flow for 3D printing is illustrated in the figure





STL data format Transferring model data via STL format requires constructing a triangulation of all boundary surfaces as illustrated in Fig.4. This is most easily done if the solid model is build using B-Rep (boundary) representation, as for this representation the solid boundaries are stored explicitly within the model. The key element of exporting such representation to STL format is triangulation of curved surfaces. For CSG (Computed Solid Geometry) models, in order to save them in STL format, additional processing steps are needed to recover model boundaries.

B.PREPARING 3D MODELS

In most cases in order to send digital model for printing it is enough to save it in STL format. Many 3D computer graphics programs can export models in STL. However, one should be careful using them, because many of these programs are designed to be used primarily for screen rendering of 3D models. It means that they can tolerate specific features of the models that are non-essential for rendering but that will be crucial for 3D printing. The main points to pay attention to are: x 3D printing is a physical process contrary to screen rendering. Thus one has to obey physical constraints. Designing a model for printing one has to ensure that all elements of the model are physically realizable. This means for instance that free 1D edges and 2D faces are not allowed in the model; x Printing is done in the presence of gravity. One has to consider stability of the model and the Staircase

VII.3D PRINTED BRIDGE

In December 2016, the world's first pedestrian **3D printed bridge** was inaugurated in the urban park of Castilla-La Mancha in Alcobendas, Madrid.

The Institute of Advanced Architecture of Catalonia (IAAC) was in charge of the architectural design of the bridge, which was printed using micro-reinforced concrete and has a length of 12 m and a width of 1.75 m. It represents a milestone for the construction industry, and, for IAAC, it is the culmination of 15 years' work.

The **3D printed bridge** was developed through parametric design, which allows the optimisation of material distribution and minimises the amount of waste by recycling the raw material during manufacture. The computational design also allows the structural performance to be maximised, thanks to the application of generative algorithms and challenging the traditional techniques of construction.

The project, led by ACCIONA, was developed by a multidisciplinary team of architects, mechanical engineers, structural engineers and representatives of the municipal administration, among them Enrico Dini, an expert inventor in large-scale 3D manufacturing and IAAC collaborator.

Fig.6 Potential Implications of 3D Printing For the Home Building Industry

Although still in its early days, 3D printing could offer the following benefits:

Onsite or factory applications.

1. Printed products only use as much material as needed to form them. This means fewer resources are required and less waste is generated.
2. Reduced transportation costs if products are printed on-site (although the cost of transporting the printer can be expensive due to the size of printers currently needed for construction).
3. Potential to create more efficient and interesting designs as 3D printing can achieve shapes that conventional techniques cannot.
4. Lower labour costs.

VII. PREPARATION OF COMPUTER MODELS FOR 3D PRINTING

Construction 3D printing may allow faster and more accurate construction of complex or bespoke items as well as lowering labor costs and producing less waste. It is hard to imagine so far that 3D printing could replace traditional construction in next few years. It is more possible, that both technologies will be present in the industry and 3D printing may be developed along with the traditional techniques, supporting them, especially in case of more sophisticated building projects. As for the software an important issue will be ensuring interoperability of the applications used at the architectural design, structural analysis and printing process

REFERENCES

[1] Z. Maleah, H. Aachen, A. Tourbah, T. Maalouf, N.E. Zaria, F. Haze, "3D concrete printing: Machine and mix design", International Journal of Civil Engineering and Technology 2015.
[2] B. Khoshnevis, Automated construction by contour crafting – "related robotics and information technologies, Automat. Constr." – Special Issue: The best of ISARC 2002, 13 (2004) 5–19.
[3] R.N. Grugel, H. Toutanji-" Sulfur concrete for lunar applications – Sublimation concerns," Adv. Space Res. 41 (2008) 103–112;
[4] G. Cesarettietal, E. Dini, X. De Kestelier, V. Colla, L. Pambaguian,-" Building components for an outpost on the Lunar soil by means of a novel 3D printing technology", Acta Astronaut. 93 (2014) 430–450.
[5]"3D PRINT CANAL HOUSE", http://3dprintcanalhouse.com/construction-technique, (2016).
[6]"3D Concrete House Printer", www.totalkustom.com/,(2016).
[7]Wikipedia: https://en.wikipedia.org/wiki/Chuck_Hull (2016).