



Semester : II

Course : Introduction to civil engineering

Course Instructor : Aryada Deshpande

Note: In addition to this handout students must read textbooks and reference books as suggested.

UNIT 2

3-D PRINTING IN CONSTRUCTION

Introduction

Construction 3D printing is a method for manufacturing construction elements or entire buildings by means of a 3D printer, printing concrete, polymer, metal, or other materials, layer-by-layer. The most common type of printer is based on a robotic arm that moves back and forth while extruding concrete. A construction 3D printer is a machine that can build houses by depositing a material (concrete for example) layer by layer. It thus, refers to various technologies that use 3D printing as a core method to fabricate buildings or construction components. Alternative terms are also in use, such as additive construction, Autonomous Robotic Construction System (ARCS), Large scale Additive Manufacturing (LSAM), or Freeform construction (FC), also to refer to sub-groups, such as '3D Concrete', used to refer to concrete extrusion technologies. There are a variety of 3D printing methods used at construction scale, with the main ones being extrusion (concrete/cement, wax, foam, polymers), powder bonding (polymer bond, reactive bond, sintering), and additive welding. 3D printing at a construction scale will have a wide variety of applications within the private, commercial, industrial and public sectors.

Number of different approaches have been demonstrated to date, which include on-site and off-site fabrication of buildings and construction components, using industrial robots, gantry systems and tethered autonomous vehicles. Demonstrations of construction 3D printing technologies to date have included fabrication of housing, construction components (cladding and structural panels and columns), bridges and civil infrastructure, artificial reefs, follies, and sculptures.)



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Advantages

- Concrete 3D printing in the construction industry helps save time, effort and material compared to traditional construction methods
- Faster construction
- Lower labour cost
- Fewer people means more safe construction
- Less material used
- New designs are possible as the 3D printer can create complex surfaces.
- It might also enable construction to be undertaken in harsh or dangerous environments not suitable for a human workforce such as in space.

Disadvantages

- The method and resulting physical properties of the printed construction elements are not yet recognized by building standards.
- High cost
- Not many regulations
- Needs constant monitoring for quality control.



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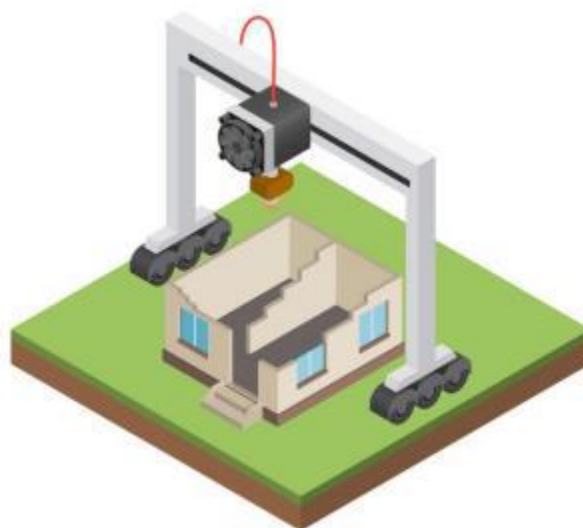


Figure: 3D printing in construction

Examples of projects

1. Shanghai firm WinSun Decoration Design Engineering has used large 3D printers to spray a mixture of quick drying cement and recycled raw materials. This has enabled them to construct 10 small demonstration 'houses' in less than 24 hours.
2. In Spain, the first pedestrian bridge printed in 3D in the world (3D BRIDGE) was inaugurated on 14 December 2016 in the urban park of Castilla-La Mancha in Alcobendas, Madrid. The bridge has a total length of 12m and a width of 1.75m and is printed in micro-reinforced concrete.
3. Professor Behrokh Khoshnevis at the University of California has developed a process of 'contour crafting' using concrete to produce small-scale models of the external and internal walls of houses and is testing a giant transportable 3D printer that could be used to build the walls of a house in 24 hours.
4. A Dutch project is fabricating a full-sized printed house over a period of years in order to demonstrate the potential of the new technology.
5. Also in **2016**, the Dubai Future Foundation built its Office of the Future via 3D printing, a major milestone for the technology in the commercial construction sector. The fully functioning 2,700-square foot building was built by a large 3D printer that measured 120 x 40 x 20 feet. Construction took just 17 days.
6. In **2016**, a 3D-printed mansion was completed in China.



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LEAN CONSTRUCTION PRACTICES

Introduction

Lean construction is a way of designing production systems in a construction environment with the aim of decreasing time, effort, and a waste of materials. Moreover, lean construction is aimed at maximizing value and minimizing costs involved during construction project maintenance, design, planning, and activation, and it helps to achieve and maintain sustainability objectives in all three dimension of planet, people and profit across the entire construction supply chain. Using the principles of lean-construction, the desired outcome would be to maximize the value and output of a project while minimizing wasteful aspects and time delay. This outcome is produced when standard construction approaches are merged with a clear and concise understanding of project materials and information and planning and control. The basic principles include: creating a predictable atmosphere based on planning and data, reducing the overflow of waste from careful planning and increasing the communication flows between the customer and the project at hand.





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Advantages:

1. Using fewer materials and having less waste can greatly reduce all around costs. Although the philosophy of lean construction is focused on overall reduction, not just for profit, utilizing this methodology has shown to increase the bottom line.
2. Construction time can greatly be reduced by increased planning and strategic vision.
3. Fewer accidents and a higher rate of safety through increased worker focus and understanding.
4. Increased schedule reliability and predictability.
5. Improved overall results due to increased communication and fewer workers.
6. Decreased stress for workers and management due to fewer workers.
7. Increased productivity all around due to a higher rate of planning.
8. Increased profits and turnovers, with increased customer satisfaction.
9. Increased worker accountability.
10. Increased job satisfaction resulting in more performance commitment.

Disadvantages

1. In order for this method of construction to be effective, all areas of management, along with the workers, have to be in accordance with the plan.
2. Getting everyone onboard with a new production method isn't easy.
3. In order for successful implementation, management officials must be able to guide employees directly and efficiently.
4. Training and educating employees in the lean method takes time and dedication.
5. Staying on course with a new system of operation can be difficult for some managers, and some may grow frustrated.

6. Each worker has to be well versed in his position or a breakdown will occur as all workers rely on one another.
7. Training employees with a new system can take some time, and this could decrease the overall time on a project or design.
8. Management has to be astute to all production issues as a breakdown in the system can easily occur.
9. Suppliers and distributors have to be notified of the change in production, and this could cause problems.
10. A temporary decrease in employee morale might be noticed due to the change in policy.