A brief introduction to 3D printing technology

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Abstract

With the progressing of 3D printing technology, not only small articles can be printed but also a whole building, which will doubtlessly make a change to the traditional construction industry. The building is printed using a giant printer measuring 32-meters long, 10-meters wide, and 6.6m deep and specially made high-strength glassfibre reinforced printing ink. A 3D model created by designers is imported to the printer and converted to the printer readable program, the rest of the work is to wait until the printer completes everything. What is designed is what will be obtained. Thanks to the digital control, there is no need to worry about various unpredictable factors occurred in the traditional construction technologies. The quality and construction time is ensured and at the same time, the cost of labour is also reduced. Therefore, 3D printed Building is a high-efficiency, environmentally-friendly and cost-effective building technology.

Keywords: 3D printing, building material printing ink, building printer, high-efficiency, environmentally-friendly, cost-effective

INTRODUCTION

As the world's first high-tech enterprise in the field of 3D printed building and printing building materials, WINSUN has developed integrated 3D building printing system which has made breakthrough in 6 areas and now entered the production stage.

Since 2002, when Winsun became the first company manufacturing Glassfibre Reinforced Gypsum (GRG) in China, the company has always been devoting itself to the research and development of new building decoration materials. In 2003, thanks to the digital mould making technology, the manufacturing method of GRG was changed from manual to fully automatic. The company has a number of technological breakthroughs in the field of GRG, which makes China reach international level in GRG production, design and construction. So far, the company has completed 95% of all theater projects in China. The 2600-seat conference hall project [Figure 1] in 2010 Shanghai World Expo is believed to be one of the most difficult GRC projects in the world. In this project a 12mm thick hyperboloid GRC panel with perforation rate up to 38% was produced via using advanced 3D printing and fibre waving technologies, it was strong enough to support a person walking on the top.

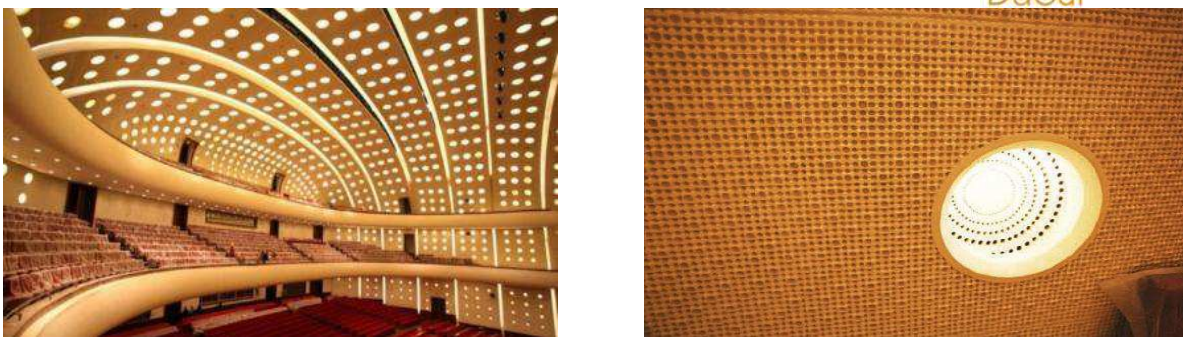

Figure 1 *Conference hall in 2010 Shanghai World Expo*

In 2006, 3D printed GRC and Fibre Reinforced Polymer (FRP) art furniture [Figure 2] was developed based on the technologies and experience accumulated from production of GRC. The digital manufacturing technology successfully met the various needs of designers, enabling the spacial lines they created extended to furniture.

Figure 2. *3D printed GRG and GRP furniture*

In 2007, building materials printing ink was patented and at the same time, 3D printed GRC artificial stone under the trade name “Yingheng Stone” was developed. The 3D printing ink is made mainly from high-performance mortar and alkali resistant chopped glass strands and has the following characteristics,

- Physical solidification from liquid state, zero energy consumption and emission;
- Reasonable cost, mass production to meet the timescale of project;
- High elasticity and mouldability, meet the demands of various moulding features;
- Inorganic formula and zero radiation, no harm to human body and no pollution to the environment;
- Light weight, possible insulation integration to reduce building energy consumption;
- Raw materials locally available, industry byproducts like rock slag and dust, mine tailing etc. can be used.

The above characteristics of printing ink meet the requirements for strength, durability, energy saving and environment protection of building printing technologies. This pushed one step further of 3D building printing. Four automatic 3D printing production lines has been set up to produce “Yingheng Stone”. The product [Figure 3] has the characteristics of rich textures and colours, high strength, large dimension and mass production and is an ideal “green building materials” used indoor and outdoor, on the wall and as flooring etc.

***Figure 3**. Applications of "Yingheng Stone"*

In 2013, after the perfection of the manufacturing technology for digital 3D printer, a printer at 10m wide, 6.6 meter high and up to 150m long, which is believed to be the world largest 3D building printer, was developed. Combined with Winsun universal printing ink and continuous printing technology, the first batch of 3D printed houses in the world, the Resettlement Project Headquarter of the Third Phase of Minghui Estate in Zhangjiang, Qingpu District, Shanghai [Figure 4], was completed.

***Figure 4.** 3D printed houses*

The noisy and dusty image of traditional construction sites is turned over by the 3D printing construction technology. A habitable house can be completed in a short time simply via a drawing, a completer and a printing nozzle. Like squeezing toothpaste out of a tube, the building printing ink is squeezed out of the printing nozzle and it is continuously overlaid layer by layer with thickness of each layer at 20mm or so thanks to the fast-consolidation and high-strength characteristic of printing ink. A several meters high building element is formed by multi-layers and a complete house is thereafter assembled from various building elements [Figure 5]. It is normally to print the wall elements into hollow shape. This not only reduces the building self-weight, but also creates a space to place insulation materials. Various wall elements are designed according to different requirements. Certain space in the wall elements is reserved to cast the beams and columns, hence providing a one-off solution for load-bearing structure.

Figure 5. *Various printed building elements*

Since the printing process solely replies on the computer and the fetters of the moulds are shaken off, not only standardized building elements can be printed, but also intricate ones like corrugated or vaulted shape etc.

Winsun has so far acquired 98 national patents from the above technical breakthroughs which help and inspire us to continuously develop new products. Winsun has to date successfully printed out a 1,100 high-end villa in Suzhou [Figure 6] and the world's highest 3D printed Building (one underground story and five stories above the ground, see Figure 7).

A complete 3D printed building comprises the following parts: building elements produced by 3D printing ink and large 3D building printer, decoration and insulation materials used on exterior wall and interior wall that exclusively come with the building elements, cast- in-situ concrete beams and columns, preformed holes for plumbing, lines, doors and windows. It enables all construction processes integrated, turning the complex into the simple. It can improve the construction efficiency, shorten the construction period and reduce the cost. Once used in an industrialized level, it's likely to bring about subversive innovation to the traditional construction industry.

***Figure 6**. 3D printed villa*

Winsun dry construction system minimizes the dust and noise pollution, at the same time brings about unprecedented construction efficiency. It could reduce construction period by 50%-70%, save materials by 30%-60% and save labour by 50%-80. For printed buildings using dry construction system, test results show that ones at height less than 100 metres meet the acceptance standard of reinforced masonry, ones at height over 100 meters meet acceptance standard of reinforced concrete shear wall.

***Figure 7.** 3D printed 6-story building*

This technology means that future building no longer produces construction waste, what is more, it can even use surplus construction material, building demolition waste, industrial waste and mine tailing as raw materials in 3D printed building. After scientific sorting and processing, these materials can be used in wall, insulation, filling, road, planting and other areas to realize energy

saving and environmental protection, resources regeneration and sustainable economy. Winsun fully implements energy saving and environmental protection strategies throughout the whole process, from raw materials use to production process then to building printing, thereafter the production energy consumption is reduced from 70% to 30%. Using this revolutionary construction method, it is anticipated that contribution will be made to future construction industry by reducing environmental pollution and improving utilization rate of the global resources.

Followed the strategy of energy saving, environment protection and resource regeneration, 3D printing technology is also being tried out experimentally in controlling desertification. A prototype desert 3D printer has been developed to print sand stabilization wall [Figure 8], vertical green wall [Figure 9] and special buildings used in desert etc. This technology is expected to help control the desertification, turn the desert to oasis and build cities in the desert.

Figure 8. *Sand stabilization wall*

Figure 9. *Vertical green wall*

CONCLUSION

In the future, Winsun will carry on research and development in more construction areas. Winsun is dedicated to making breakthroughs in high-rise building printing, minimizing the damage to the environment caused by extracting construction materials. We will endeavor to change the outmoded construction methods and become the world advanced manufacturer and intelligence manufacturer. With our efforts, construction waste, industrial waste, mine tailing and other solid wastes will be recycled and go back to the building as raw materials to realize sustainable economy. It is possible to reduce building energy consumption and reduce building cost significantly by up to 50%. We aim to let more people reside in low carbon footprint, energy saving and environmentally friendly houses, reduce pollutant and build an environment in which there are blue sky, clean water and green mountains.