Design and Manufacturing of The First Freeform 3D-Printed House

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Abstract

Branch Technology has developed a novel additive manufacturing process for construction applications called Cellular Fabrication (C-FAB™). This technology enables a "Freeform" extrusion process wherein material solidifies in open-space to create a lattice structure at record breaking scale and geometric complexity. To date, Branch Technology has completed several lattice shell structures using C-FAB™— that are the largest Freeform 3D printed structures in the world. This paper documents the next generation research and development to unite the novel technology with existing construction methods— ultimately creating a high-performance building enclosure system. C-FAB™ construction holds the potential to transform the nature of grid-shell and light-weight spatial structure solutions currently available in the AEC industry.

This paper presents findings on a case study— a demonstration structure that encloses over 3000sqft— as it relates to the manufacturing of geometrically complex building forms. The structure represents the future of construction, combining additive manufacturing, industrial robotics, conventional building materials, and prefabricated modular construction methodologies. Organized in 3 sections, this paper will begin with the process of characterizing the material properties of Branch Technology's patented composite assembly. It includes the 3D-printed lattice that serves as formwork for expandable foam and concrete— creating the assembly's structure and insulation. Because composites are inherently complex and include many variables, it is key to quantify structural boundary conditions, load cases and long-term assumptions. Subsequently, this case study required a new digital discretization process for complex geometries. Where prior shell structures have been created using finite linear and brick elements as well as recent slicing methods, this process three-dimensionally wire-cuts monolithic volumes into uniquely shaped large-scale volumetric panels. The panels are then programmed using proprietary software that translate volume into lattice and code for industrial robotic manufacture. Finally, this paper will discuss the design and finishing of the composite as a prefabricated building element as it relates to on-site installation. This discussion entails the development of inter-panel connectivity, water mitigation, architectural finishing and more. Each of these details initially borrows from existing construction methodologies but must be optimized for integration into complex geometric forms enabled by additive manufacturing.

With the convergence of conventional materials and C-FAB™, full composite structural assemblies are created that, through the direct digital fabrication design process, are tailored to specific geometric and engineering parameters. This process is a unique addition to construction of spatial structures and shells because it capitalizes on the inherent logistical efficiency of prefabrication as well as the resource efficiency of additive manufacturing.

References

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