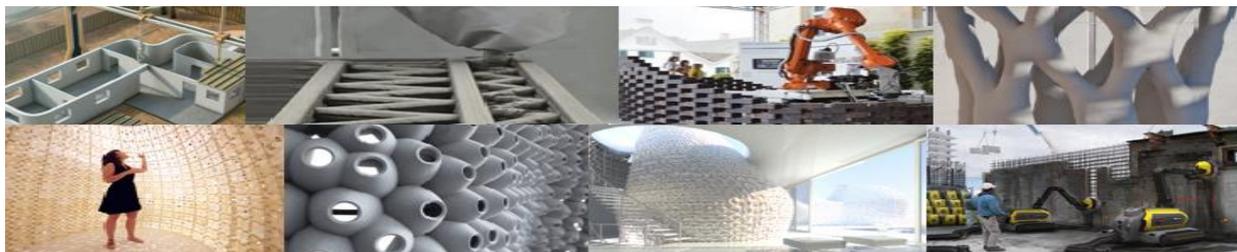# 3D Printing for Civil Infrastructure Construction

A healthy infrastructure is critical to a nation's economic vitality. Infrastructure is the blood supply and nervous system that enables trade, supports businesses, maintains quality of life, and provides security against unpredictable events. Keeping our infrastructure in working order requires constant reinvestment in capital projects and maintenance. The *2017 Infrastructure Report Card* published by the American Society of Civil Engineers states that failing to address these problems can pose serious economic consequences, including **$3.9 trillion in losses** to the US GDP and **2.5 million lost American jobs** by 2025. However, the US construction industry suffers severe problems regarding inefficiency and low productivity. Indeed, an article published in the *Economist* in 2017 states that productivity in the US construction industry has **plunged by half** since the 1960s.

Although concerns regarding the affordable construction and rehabilitation of civil infrastructure have long been discussed, very little has been done to address them. Recent advances in manufacturing technologies, such as 3D printing (additive manufacturing) can potentially address some of these concern. For example, the capability of 3D printing to produce freeform surfaces without the need for part-specific tooling can improve throughput. A 2017 report by *McKinsey* highlights that transitioning from a project-based approach to a manufacturing-system approach can boost productivity by **up to 10 times**— essentially constituting a Henry Ford moment in the construction industry. Additionally, emerging 3D printing processes offer unique capabilities including geometric freedom, material-saving through design optimization, and functional complexity. As for the latter, it is even possible to produce structural forms that respond to varying external stimuli in their surrounding environment.

The burgeoning field of 3D printing for infrastructure and the building environment. *Image sources available upon request.*

There is an urgent need to rethink the design and construction of infrastructure, and develop and test new cost-effective manufacturing methods and materials. Not only would large-scale 3D printing capabilities offer the potential to revitalize aging infrastructure, but also would it strengthen national resilience through enabling rebuilding with speed and quality, and offer the potential to accommodate shifting and growing populations with agility. Other countries are already investing in advanced digital manufacturing (e.g. robotics, 3D printing, etc.) as viable solutions to infrastructure challenges. The US—once a research powerhouse— is slipping behind and has recently been categorized as a "declining leader" from a construction productivity standpoint in the 2017 *McKinsey* report. Recent advances reported by other countries include: Europe's first 3D printed house to be unveiled in Milan's design festival (April 2018), the first 3D printed pedestrian bridge in Madrid (December 2016), and the first large scale 3D printed building part by the French company XtreeE (September 2016). For the US to attain a global leadership role in 3D printing for civil infrastructure, investment needs to be made in multidisciplinary research that spans the disciplines of manufacturing science and engineering, civil engineering, architecture, materials science and engineering, computer science, and construction science.