Comparative Analysis of 3D Printed Bridge Construction in Louisiana

Project Number:

21STLSU04

Start Date:

08/01/2021

Principal Inverstigator(s):

Amirhosein Jafari

Louisiana State University

Lead Institution:

Louisiana State University

Funding Source(s):

Tran-SET

Louisiana State University

Total Project Cost:

$ 60,000

Analizing 3D printed bridge construction in Louisiana

Construction 3D printing (C3DP) technology is an emerging revolution in the construction industry with various application domains such as emergency construction and low-income housing. It has gained attention as an efficient, automated solution for dealing with tight schedules, waste reduction, design freedom, reducing human error, and fast production in construction projects. Although there has been a growing interest in building construction using C3DP, the application of this innovative tool for infrastructure development, particularly small to medium size bridge construction, is at very early stages and has not been investigated thoroughly. The objective of this research project is to study the feasibility of utilizing the innovative C3DP technology for segmental bridge construction in the state of Louisiana, to analyze different implementation scenarios, and to document the best practices for 3D printed bridge construction to maximize the advantages of this construction technology. The proposed study aims to study and document the best practices for utilizing the innovative C3DP technology for segmental bridge construction, particularly in the state of Louisiana. By advancing the C3DP technology, this project will take a significant step towards the realization of the potential of this technology to help automated, smart, and resilient infrastructure development in Region 6 and beyond.

Problem Statement

Despite the contribution of this technology to emergency construction and affordable housing, utilizing C3DP for infrastructure development seems to hold great potential as well. This automated and accelerated process is also promising for civil structures, including buildings and bridges, which require extensive labor. If successful, it is expected that 3D structural printing can significantly reduce the construction time and cost. However, unlike applications in other areas, civil structures are typically on a large scale, with length or height spanning hundreds of feet. They are subjected to complex loadings, including gravity, live, wind, seismic, etc. Therefore, it is challenging to develop suitable printing tools and materials. As a result, although there are limited 3D printed buildings, 3DP of civil structures is still at a primitive stage. C3DP technology has been used for bridge construction in a few demonstration projects in different countries. These are relatively small pedestrian and bicycle bridges. However, these demonstration projects highlight the massive potential of C3DP technology for accelerated bridge construction on different scales. Considering the recent emergence of the C3DP technology as well as the limited number of the (demonstration) projects on using C3DP for segmental bridge construction, there is minimal experimental and field data on this topic. The main challenges of using C3DP technology in civil infrastructure such as bridges are as follow: Automated fabrication is often not suitable for large scale products and conventional design approaches; The smaller ratio of automated products in comparison with other industries; Only limited material can be used by automated machines; Expensive automated machines tend to be unfeasible economically; and managerial issues and the increasing pressure towards environmental issues of construction materials. Therefore, there is a gap in terms of investigating the feasibility of using the C3DP technology for segmental bridge construction. More research is needed to investigate various sub-processes such as segment fabrication and prestressing, and also to analyze the impact of the C3DP technology on these project activities. To do so, different scenarios regarding the utilization of C3DP technology for bridge construction need to be defined.

Objectives

The main objective of this research project is to study the feasibility of utilizing the innovative C3DP technology for concrete bridge construction in the state of Louisiana, to analyze different construction scenarios, and to document the best practices for 3D printed bridge construction to maximize the advantages of this construction technology.

(a) (b) (c)

Figure 1. (a) 3D printed pedestrian bridge in Spain; (b) 3D printed bridge in China; and (c) 3D printed bridge in Netherland

Intended Implementation of Research

Workforce Development, Education, and Outreach: This research project is providing funding for one Ph.D. student in the Construction Management program at Louisiana State University (LSU). The goal is to help recruit and train future leaders in the Construction Sector specializing in the development of infrastructures and promotion of construction 3D printing technology. The research team will prepare educational materials on construction automation and sustainability of C3DP to be incorporated in courses at LSU and also to be shared with other universities. Upon successful implementation. The research team will arrange an online webinar towards the end of the project to solicit professionals' feedback on the conducted research results and to facilitate the transfer of new information to the industry to disseminate educational material to government entities and the industry. The results of this project will be published and presented at national journals and conferences such as TRB and ASCE. The research team will create and maintain a world-wide-web page that presents our latest findings and how the research project is advancing, including the application of the C3DP technology for bridge construction in the state of Louisiana. Such an effort can ensure the availability of the research outcome to be accessible to stakeholders who are interested in such a topic.

Anticipated Impacts/Benefits of Implementation

The following deliverables are expected from this research project:

- A research report describing in detail the complete description of the problem, objective(s), scope, methodology, results, conclusions, and recommendations developed as a result of the project. Furthermore, the report will include documentation of all data gathered, analyses performed, and the achieved results;
- A world-wide-web page that presents the findings, including the application of the results in the state of Louisiana to be used by public stakeholders;
- Several peer-reviewed journal papers, proceedings, and presentations in relevant and professional conferences;
- Integration of the result into the curriculum through designing educational materials in courses in the LSU Construction Management Department to educate; and
- An online webinar to disseminate the research results to professional engineers and state DOTD employees.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.