The rise of 3D printing in ABC

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Prefabricated bridge elements and systems (PBES) are key technologies used in accelerated bridge construction (ABC). These elements are prefabricated—or made beforehand—at what is known as a “fabrication plant." PBES are then brought to a bridge site for final construction.

When the pieces are brought to a site, they can be assembled piece by piece (as shown in Figure 1), similar to a LEGO set. Prefabricating not only enables the construction time to be greatly decreased but also the quality of the pieces to be significantly enhanced.

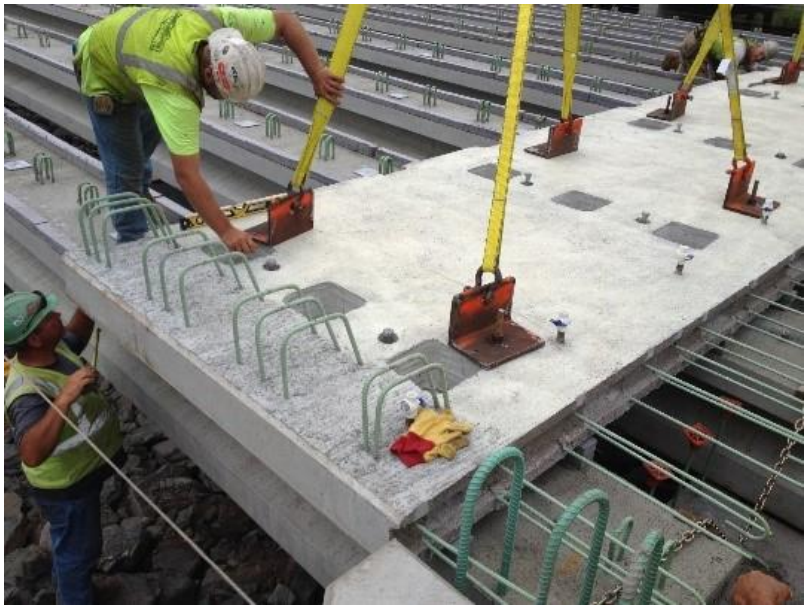

Figure 1. A prefabricated deck being placed on bridge girders

There are a wide variety of prefabricated bridge elements and systems used in ABC. These elements can be used for all components of bridge construction, from the substructure (or underlying supporting structure) to the superstructure (a structure built on top of something else). Some common prefabricated elements include parapets (or bridge railings), bridge decks, girders, column caps, columns, and footings or pile caps (See Figure 2).

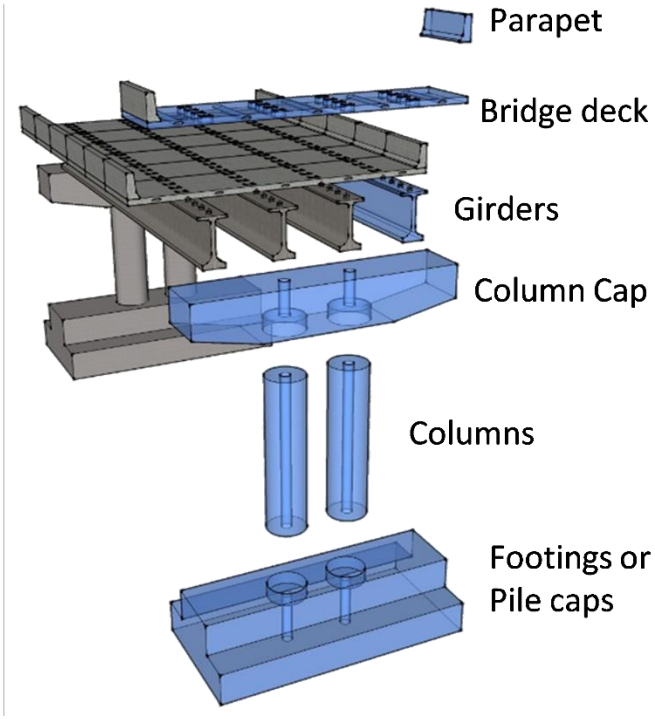

Figure 2. Commonly prefabricated bridge elements

In recent decades, 3D printing has gained in popularity. 3D printing is a process for making a physical object from a three-dimensional digital model, typically by laying down many successive thin layers of a material.

A number of research areas (like transportation engineering) have started adopting the 3D printing technique to help bring their ideas into the real world.

An Accelerated Bridge Construction–University Transportation Center (ABC-UTC) research team at Florida International University (consisting of Dr. Seung Jae Lee, Dr. David Garber, and an undergraduate civil engineering student named Nerma Caluk) recently used 3D printers to perform a "physical" simulation of ABC, prior to any field construction. Using 3D printing technology, the team was also able to provide more hands-on opportunities for students to study ABC without resorting to "computer" simulation.

The goal of the project was to determine if 3D printers could be used for prefabricating full-scale bridge elements and specialized connections in the future.

Currently, the research team is investigating ways to create an entire bridge using a 3D printer on a small-scale (See Figure 3) by exploring different connection options. The team wants to see if the bridge can be customizable!

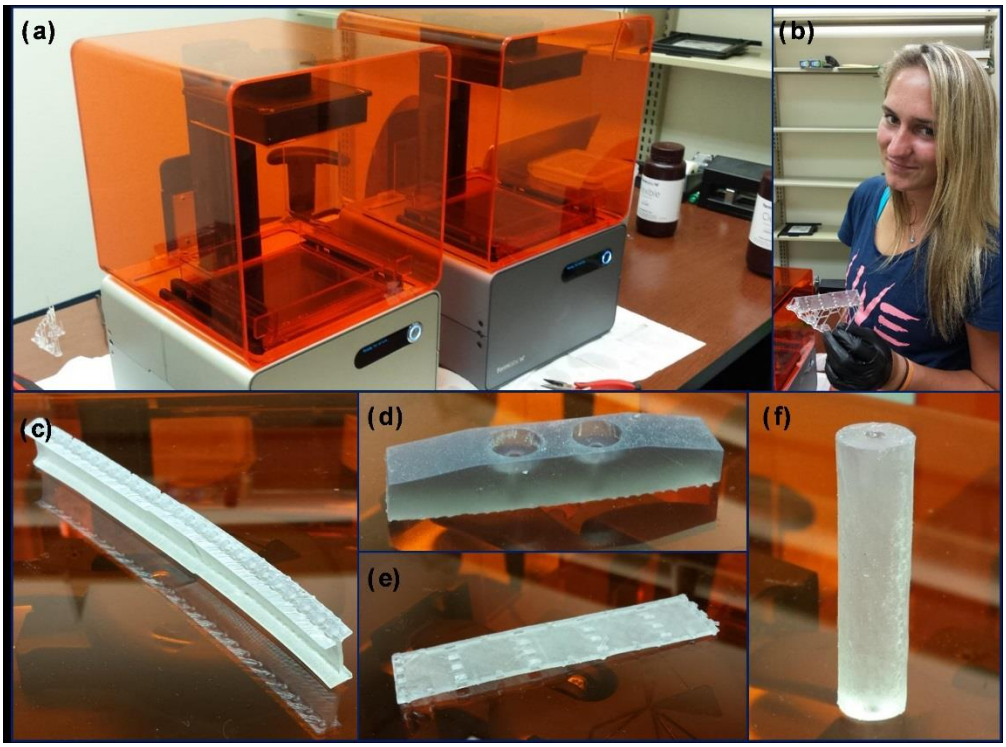

Figure 3. A small scale ABC study through 3D printing of bridge elements (a) 3D printers used for the study
(b) Research student holding a 3D printed bridge element (c) girder (d) column cap (e) bridge deck (f) column

They used a Form 1+, a stereolithography (SLA) model 3D printer, which was adopted to obtain a very high-level of accuracy for the shape and size of the actual printed connections.

Two different types of resins (a common 3D printing material) were adopted for the test printing: a bridge tendon (made with a stiff resin) and a bridge girder (made with flexible resin). As expected, these products resulted in relatively stiff and flexible elements. Additionally, the team found that ultraviolet light could be shown on the printed objects to increase the materials' strength.

The research team believes that the developed methodology and approach can be extended for laboratory testing of small scale bridges made of 3D printed elements to further test possible bridge performance. Obviously, the implementation of 3D printing on a full-scale level will be dependent on the availability of materials with specific properties and affordable prices, but the researchers believe that such materials are beginning to surface. Future phases of this research will begin to look at how these materials could be used with the techniques and details investigated in this project.

If you or your school has access to 3D-printing technology, this project is even doable in the high school classroom! The result? What students may find could significantly broaden their interest in bridge engineering.

Take-home activity

1. <u>Challenge #1: Identify other "Prefabricated" Elements around your house</u>:

The bridge construction community are not the only ones who have utilized the benefits of "prefabricated" elements. Have you or your family ever bought furniture from IKEA or Target? See what other items around your house may have utilized the concepts of prefabrication.

2. <u>Challenge #2: Research Connections and Elements</u>

The ABC-UTC has an incredible resource to allow anyone to research currently constructed bridges that have utilized ABC technology (see our project database at http://utcdb.fiu.edu/). Look through what elements and connections have been used in the past and see if you can think of any other ways bridges could be prefabricated. Sketch your ideas or even build them out of LEGOS.

Please email Dr. Lee (sjlee@fiu.edu) and Dr. Garber (dgarber@fiu.edu) at FIU with pictures and descriptions of any of your findings. We would be excited for you to take part in our research too!

Related links

- Check out the ABC-UTC homepage.
- See the Federal Highway Administration initiative to promote ABC (scroll to bottom of page for videos, photos, and more).