# Rocking Structural Components Fabricated Using Modular and Reusable 3D-Printed Formwork : Proof-of-Concept

**Rhowen Frakt, Georgios Tsampras, Kaixin Chen**

UC San Diego
JACOBS SCHOOL OF ENGINEERING
Department of Structural Engineering

GEAR
Guided Engineering Apprenticeship in Research
IDEA Engineering Student Center

## Background

**Rocking is an effective method to modify the seismic response of a structure in the event of strong ground motion. Post-tensioning is an effective self-centering method that helps reduce permanent damage. 3-D printing has the potential for the rapid fabrication of reusable and modular formwork for structural and non-structural components. This study covers (1) the feasibility of 3-D printing reusable and modular formwork for structural components (Figure 1) and (2) the seismic response of small-scale structural models of bridge pier-deck systems (Figure 2).**

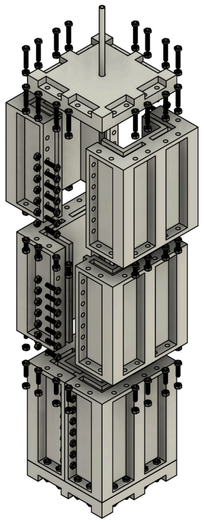


**Figure 1**: Exploded view of modular formwork

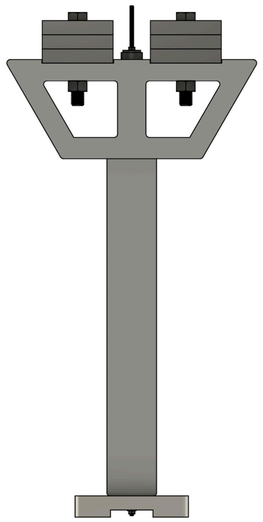


**Figure 2**: Post-tensioned monolithic pier setup

## Methods

### Design

**The adapter plate (Figure 3) clamps to a small shake table and has a shear key recess to prevent slipping of the pier. The top mass (Figure 4) allows for steel plates to be attached to adjust weight. A post-tensioned threaded rod will run through the ends of each part.**

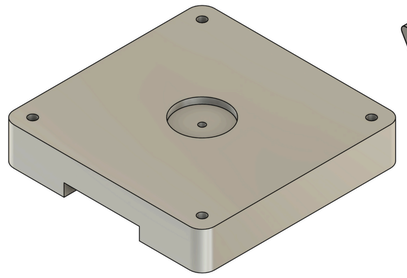


**Figure 3**: Aluminum adapter plate

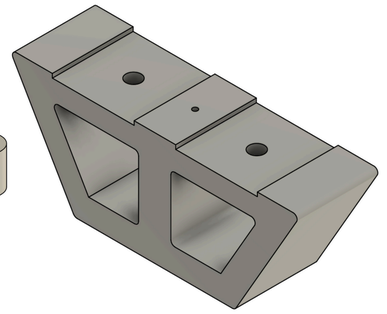


**Figure 4**: Concrete Top mass

### Fabrication

**Formwork was sliced in Bambu Lab and 3D printed using PLA plastic in a Bambu Lab X-1 Carbon (Figure 7). Steel bolts were used to connect the modules.**

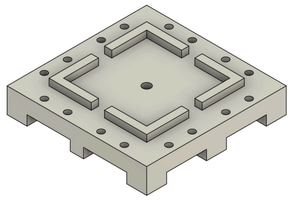


**Figure 5**: Top of pier formwork

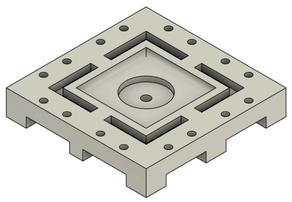


**Figure 6**: Bottom of pier formwork



**Figure 7**: Assembled formwork

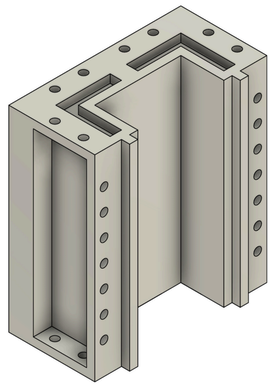


**Figure 8**: Positive side of pier formwork

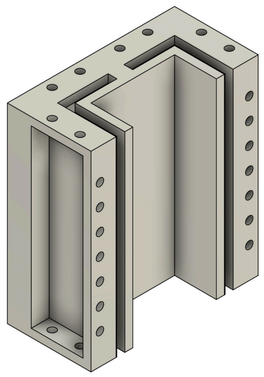


**Figure 9**: Negative side of pier formwork

**For the fabrication of a bridge pier, high-strength grout was used for greater detail and a cleaner process. A steel cage was constructed to reinforce the grout (Figure 10).**



**Figure 10**: Pier fabrication with grout and steel reinforcement



**Figure 11**: Condition of pier after one day of resting

## Future Work

- **Increase scale**
- **Multipurpose formwork**
- **Implementation of energy dissipation methods**

## Next Steps

- **Fabrication of top mass formwork, top mass, adapter plate, and piers of various slenderness ratios**
- **Shake tests**

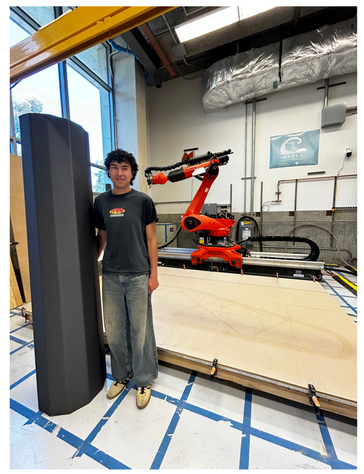


**Figure 12**: Increased scale using recycled thermoplastics