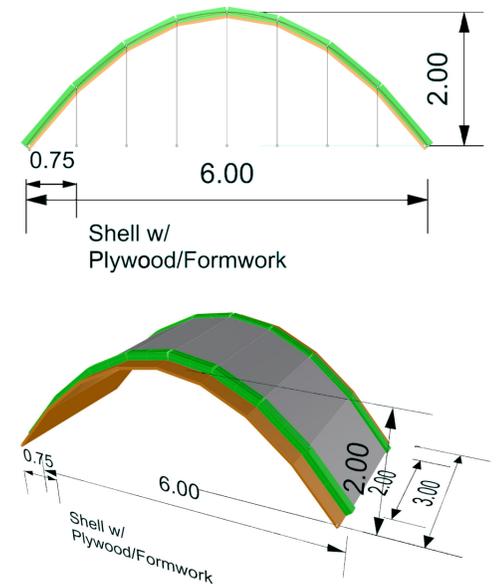


Concrete Shells & Funicular Structures

- Shell structures are thin curved plate structures shaped to transfer applied forces by compressive, tensile and shear stresses.
- The ideal shell structure is something funicular, a structure which acts in pure compression or tension.
- Since concrete performs better in compression, a concrete shell structure should ideally be subject to pure compression.
- This project aimed to develop a methodology for casting concrete shell structures by suspending formwork from above.

Form Finding

- A parabolic barrel vault shape was chosen. A parabolic arch subject under a distributed load (i.e. self-weight), is a funicular shape purely in compression.
- The model had a 6' span, 2' rise, 2' width, and 1" thickness. It was discretized into 8 straight-line segments.



Prototype Components

Plywood Structure



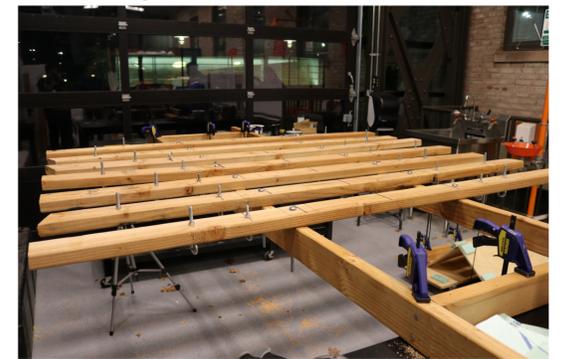
- Consisted of 8 plywood pieces and attached with door hinges to shape the parabolic arch.

Base Structure



- Plywood panels formed an "H" shape with wheels attached at the bottom for easier mobility.

Suspended Structure



- Two wooden beams spanned two tables with seven smaller beams and hooks attached.

Lifting

- 14 buckets connected the plywood and suspended structures, each loaded with 15 lb weights.
- Cables were tied to the door hinges on the plywood structure and fed through eye hooks to create a pulley system.
- Weights lifted the plywood structure into shape.



Casting

- Formwork was topped with a plastic sheet and foam walls to close gaps.
- Concrete was poured on formwork then spread using trowels.
- Approximately 1.25 ft³ of concrete was used.
- Concrete mix:
w/c ratio = ~0.35
Water: ~20 lb
Cement: ~57 lb
Sand: ~167 lb



Results & Conclusions

- Formwork was removed 5 days after casting, when the concrete hardened. The concrete shell managed to support its own self-weight.
- Using suspended formwork appeared to be a viable method for creating concrete shell structures.
- Future work could involve using a similar methodology to form shapes other than the parabolic barrel vault.

