THANK YOU CLARE, ED, AND OUR REVIEWERS FOR ALL THE GUIDANCE WE RECEIVED TO MAKE THIS PROJECT POSSIBLE. THANKS TO THE ARCE DEPARTMENT FOR YOUR DONATION. AND THANKS TO THE CAED SUPPORT SHOP FOR YOUR RESOURCES. WE LOVED HOW OUR SHELL TURNED OUT.

CALVIN VERONICA TUNMI ELI
Provide an aesthetically beautiful funicular structure that houses a performance pub in Portland’s growing art and craft beer scene.
1. TILIKUM CROSSING

2. ROSS ISLAND BRIDGE

"MAX" RAIL LINE

ARTS GALLERY / BREWERY
LOUIS SIMON / FELIX CANDELA
Royan Market Hall / Textile Factory - Los Manantiales

LOCATION
Royan, France / Mexico City

LIGHTING
Royan Market Hall (left) scatters light into central space through slits. Textile factory (right) uses many oculi to define sun information

ARCHITECTURAL SIGNIFICANCE
The push for modernism helped establish new exciting forms such as this one that were considered previously impossible.

CONSTRUCTION MATERIALS
Shell, Reinforced Concrete

ADDITIONAL NOTES
1950s Interior / Exterior showed possible new
2002 Candela is known for advancements
Throughout the quarter, using rhino and grasshopper as form finding tools, we developed several iterations of our shell, ultimately focusing on four key objectives to drive our shell design, outlined above. We struggled, learned, and worked hard with grasshopper to develop our finalized scheme.
Programmatically, we designed a seamless floor plan to ensure free-flowing circulation, while maintaining a separation between the amenities and entertainment spaces. From our programmatic studies we designed a rectangular floor plan with a square cut out to create outdoor seating with a view of the river. The subtracted rectangle lent anchor points for the shell which we input into grasshopper. A catenary surface was inflated, baked and punctured with 6” inch oculi to mimic a starry sky.
ENTRY
KITCHEN
BATHROOMS
STANDING / DANCING AREA
OUTDOOR SEATING
UPPER SEATING
PERFORMANCE STAGE
5,800 SQ FT
In the design development stage, it was essential for the shell to accommodate the two-story amenities island. To achieve this, we played with various forces in Grasshopper to provide a seamless undulating curve in section. As you can see, the view from the upper level to the dancing/stage area is clear and unobstructed.
The 3” concrete shell meets the foundation at finished grade where it is attached by a reinforcing steel that is connected to a reinforcing mesh to distribute the loads to the footing. The footing has a key to prevent the structure from sliding due to the thrusting force.

**FIG 1 THRUST CONTAINMENT**

- Reinforcing Steel: A
- Reinforcing Mesh: B
- 2” Gravel: C

ENGINEERED FILL VERIFIED BY GEOTECHNICAL ENGINEER
An array of 6” diameter oculi are spread out on top of the shell to portray a stary-night experience within the shell. The oculi are casted in place when pouring the concrete, and then formed with an acrylic glass to protect the interior of the shell from rain. The oculi are flush with the shell to allow the rainfall to flow directly off the shell and into the ground.

**FIG 2 Oculi**

- **A** ACRYLIC GLASS
- **B** 3” CONCRETE SHELL
- **C** WIRE MESH
- **D** STEEL SHEET
- **E** LED PLACEMENT
SOUTH WEST EXTERIOR RENDER
Starry-like oculi permeates indoor and outdoor through curtain walls
INTERIOR RENDER
Bar adjacent to seating area
AERIAL VIEW
upper standing area with view of stage and dance floor
AERIAL VIEW 2
upper standing area with view
of stage and dance floor
Due to the complexity of our structure our structural analysis was computed through the program SAP. Our buckling analysis showed that our shell would want to fail in the area highlighted if it experienced a force that was 30.6 times our building weight which is 644 kips. In our gravity analysis our shell showed a maximum deflection of 0.28", and our gravity plus lateral analysis gave us a thrusting force of 193.3 kips.
We also ran a time history analysis with the magnitude of the famous Northridge earthquake 6.7 showing that our shell would have survived the earthquake with little to no damage.
Funicular form lands on 4 points; reasonably difficult to build; spatially interesting.
LYCRA CLOTH
EMBEDDED IN FORMWORK ✗
RELATIVELY INEXPENSIVE ✗
FORM ADAPTABLE ✗

PLASTER FABRIC
EMBEDDED IN FORMWORK ✓
RELATIVELY INEXPENSIVE ✓
FORM ADAPTABLE ✓

FUNICULAR FORM LANDS ON 4 POINTS
REASONABLY DIFFICULT TO BUILD
SPATIALLY INTERESTING

CAL POLY SECTION
For our construction methods we wanted to achieve a pillowed effect on the inside of our shell with a glossy finish. We tried lycra cloth, plastic sheets, and wire mesh as a layer of our formwork, with the plaster fabric imitating the concrete. From these trials we found that the plastic layer gave us the best control on the pillowed texture, and also gave us the glossy finish we wanted.
POLYETHYLENE PLASTIC IS USED AS WATER BARRIER
SPILL EDGES ARE DEFINED USING POLYURETHANE TUBING AND PVC PIPES
CONCRETE Poured WITH THRUST CONTAINMENT
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>COST</th>
<th>AMOUNT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLYETHYLENE PLASTIC</td>
<td>$0.04 per SQ FT</td>
<td>17,284 SQ FT / 100 SQ FT</td>
<td>$700 / $5</td>
</tr>
<tr>
<td>3” THICK CONCRETE</td>
<td>$3.30 per CUBIC FT</td>
<td>4321 CUBIC FT / 25 CUBIC FT</td>
<td>$14,400 / FREE</td>
</tr>
<tr>
<td>WIRE MESH</td>
<td>$0.15 per SQ FT</td>
<td>17,284 SQ FT / 100 SQ FT</td>
<td>$2600 / $20</td>
</tr>
<tr>
<td>WAFFLE FORMWORK (PLYWOOD/ MDF)</td>
<td>$2.00 / $0.08 per SQ FT</td>
<td>26,500 SQ FT / 200 SQ FT</td>
<td>$50,000 / $16</td>
</tr>
<tr>
<td>SHORING [2X’S/ CMU BLOCKS]</td>
<td>$2.00 per 8 FT / FREE</td>
<td>1000 FT / ABOUT 8 BLOCKS</td>
<td>$2,000 / FREE</td>
</tr>
<tr>
<td>LED BULBS/LIGHTS</td>
<td>$50.00 per BULB / $0.03 PER LIGHT</td>
<td>80 BULBS / 33 LIGHTS</td>
<td>$4000 / $12.00</td>
</tr>
</tbody>
</table>

**CAL POLY SUBTOTAL**

$53.00

**CAL POLY TOTAL**

$119

+ SHOP SUPPLIES

$50
“THIS INTERDISCIPLINARY PROJECT TAUGHT US HOW TO COMMUNICATE AND COLLABORATE. THROUGH THE SMALL SCALE CONSTRUCTION OF A FURNICULAR STRUCTURE, OUR GROUP LEARNED THE COMPLEXITIES OF CONCRETE FORMS INCLUDING WATER BARRIERS, FOUNDATION SUPPORTS, AND FINISHING TECHNIQUES.”

CALVIN VERONICA TUNMI ELI
AN EXPLORATION OF FUNICULAR GEOMETRY TO PRODUCE A VISUALLY AND ARCHITECTURALLY STRIKING PERFORMANCE CENTER IN PORTLAND. A PLAY OF SCATTERED LIGHT THROUGH OCULI. A LIGHT AIRY INTERPRETATION OF A PERFORMANCE PUB. A HIPSTER PLACE FOR GATHERING!