Preconstruction Services for the Modular House

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The "Modular House", originally named for its composition of 8x8x8 foot steel framed modules, has experienced a rich history of tenants, additions, and tourism. This structure was one of the first to be erected in California Polytechnic's Poly Canyon. After many great years as a residence and iconic structure the house was ultimately abandoned in 2010. Since then, the building and the canyon have seen increased vandalism and weathering backed by minimal maintenance, resulting in unsafe conditions for the general public. Our mission was to allow this structure to be enjoyed by the public while highlighting its initial architectural features. Our remodel included a removal of all non-structural components and the addition of a new flooring structure and guardrail system that incorporated the iconic road sign exterior siding. This report will walk through the timeline of the building, the proposed new design, building materials, project costs, construction process and the tough logistics of working on a remote site location in Poly Canyon.

Key Words: Poly Canyon, Modular Building, Renovation, Unforeseen Conditions

A Brief History

The Modular House project was conceived in the year 1964 and embarked on a five year design process that changed hands through various students and faculty leaders. The residence was ultimately constructed by a mix of students, volunteers and local contractors. After nine year of planning and hard work, the house was inhabited full time by Glen Jackson, who decided to live there after vandalism had run rampant in the Canyon. Glen became the first caretaker of the canyon, working 50-60 hours a week on top of his school work to ensure the canyon was maintained as it was originally intended. The House was off to a good start of residents that began to rotate every two years or so and lead to its first addition in 1982. The original 8x8 foot square grid received an addition of a few forty-five degree triangles that expanded the kitchen and living room, creating the as-built drawings we used in our design process that began in the spring of 2017.

The modular house kept on in its cycle of caretakers and occupants, but was beginning to show signs of age. In 2000, with the help of a Caltrans donation the structure was upgraded with the iconic road signs acting a sheet metal siding to help waterproof the south and west side of the building's exterior. The structure has seen little changes since this time and was finally abandoned in 2010 after the California Building Code (CBC) required expensive utility upgrades in order to qualify as a viable living space. With outdated electrical and a slew of necessary upgrades during the height of an economic recession, the structure and the canyon slowly became a ghost town. Today the canyon is referred to as the "Architectural Graveyard", a derogatory term to those who worked so hard to complete their projects and make the canyon such a spectacular place. The Modular House was boarded up to the public, vandalized, slowly deteriorating from years of weathering, and inhabited only by termites and rodents.

Our Mission

With the push of several leaders in the College of Architecture and Environmental Design (CAED) and the pressure from California Polytechnic Facilities Management, the 2016-2017 school year marked the beginning of revival process to the so-called architecture graveyard. A team of undergraduates comprised of eight Architectural Engineering students and one Construction Management student took on the task of reviving the structure and hopefully sparking many more renovations projects within the canyon. The Modular House is an easy first choice as it has seen some of the worst vandalism and thought to benefit the canyon most by its renovation. The existing Modular House held two very significant architectural features in its heyday: The 8x8x8 foot frame of the structure and the hundreds of road signs that made up the south and west faces' exterior siding. As a project team we decided to do our best to incorporate them in the final product of the revival.

Design

Highlighting the structural frame of the project was a simple task on paper, remove all nonstructural elements and don't touch the 3x3 inch Tube Steel. Confidently, we brushed over demolition planning and began designing our additions. This paper is from a construction management perspective, thus we will not discuss the calculations and structure analysis specifics; however, suffice to say there were a great deal of iterations before we arrived at our final permit set of drawings. Notably, we were able to recycle the road signs to act as panels within the guardrails, shown as stop signs in the detail below.

Design completion marked a milestone and allowed for a final decision on our materials:

- Hollow Structural Steel (HSS), 3x2x3/16"
- Steel Angle (L), 1.5x1/8"
- Formlock Steel Decking, 18 gauge
- Lightweight Concrete, 3000 psi
- Recycled and additional road signs
- Gallon cans of black oil-based paint
- Connection bolts, rivets and welding wire

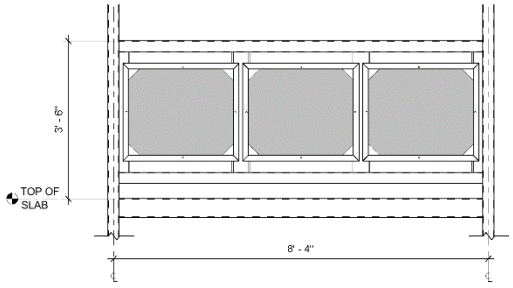

Figure 1: Exterior Guardrail (Typical)

Preconstruction and Funding

Once the design was reaching its final iterations the material quantities and pricing was narrow enough for an initial project estimate. Using the Revit model from the design drawings, we were able to push the 3D model to Assemble systems (a estimating plug-in for Revit). Once in Assemble, the quantities were three dimensionally represented very clearly and simply needed the cost factor to produce an estimate for the materials. Combining this cost with the general conditions expenses, we were able to ballpark a bid that opened the door for soliciting project funding.

We found that funding from a local contractor, Robert J Lis (RJL) Construction who was connected by one of the team members on the project. With some money in our pocket we updated our project dates and finalized our quarter-long schedule. The critical path of the three month schedule was driven by design, permitting, demolition, prefabrication, and installation - each broken down to many smaller parts worked into specific days on the master schedule.

The project was lean in cost, time, and especially site logistics. Working a mile into the canyon, accessed only by a rough dirt road and bracketed by two gates. We needed to make the most of each trip to visit the site. Due to the nature of the self-performed construction, material staging was a hurdle, given we did not have access to a commercial vehicle. With a mixture of personal vehicles and the occasional U-Haul rental loaded with hundreds of pounds of steel we were able to transport all of the materials effectively.

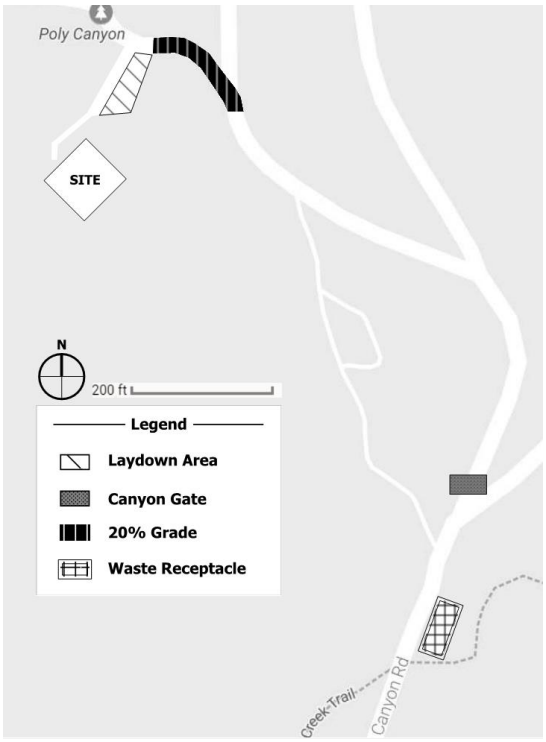

Figure 2: Project Site Logistics

Leading up to our site was a twenty-percent grade, spanning fifty yards to gather the elevation equivalent to our project. We staged our materials in a laydown area roughly fifty feet from the structure across a narrow, steel grated bridge. The building itself sits on rectangular footing foundations that cantilever it above a sloped hillside and nearby creek to create the tiered, flat, floor elevation. Tiered, because of the offset in modules that created two-foot drop and rise areas in the ground floor level and a two-foot rise area in second level of the building (left).

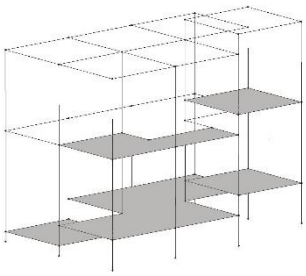

Figure 3: Generic Perspective

Site Investigation and Demolition

Loosening the twelve hex-bolts that attached the three-quarters inch plywood sheet to the frame of the most recent access point to the building marked our first peek inside the building's walls. We stepped through a hole in the wall, pulling the collar of our shirts up over our mouth and nose to mask the smell, onto shards of glass, debris and copious amounts of rat droppings. At this moment, is was apparent that the project would be far from a walk in the park through the demolition phase.

Unforeseen Conditions

Our first step to stripping the building down to its bare metal frame was a training session working in confined spaces and using our facilities-provided, half face respirators. The rat feces presented the potential risk of Hantavirus, our solution was a chemical called Versatile. Spraying the contaminated areas prior to beginning our demolition allowed us to work safely as we began removing the rubble.

We were enlightened as we chipped away at the walls and floors, exposing a substantial amount of wood wrought and unexpected construction methods that complicated the surface removal. The real surprises however, came when we exposed the lateral beams that were drawn as uninterrupted tube steel in the as-built drawings. The floor beams had multiple cutouts and welded additions to account for the mechanical venting and connection of floor joists that were not depicted in any drawing set in our possession.

This unexpected discovery prompted multiple generators running on site as we cut, spliced and welded the beams to match the desired conditions. The first step in this process required paint stripping of the existing lead-based paint to avoid airborne lead particles during the welding process. We prepped the members with a four-inch barrier of exposed metal that served as a radius around any weld point. Field dimensioning and steel grinding got us our perfected sizes and the welds were made. The same paint removal and welding precautions were taken on the columns while we field dimensioned our 3x2x3/16" lateral guardrails.

Prefabrication and Construction

Meanwhile in the College of Architecture and Environmental Design shop we were busy welding the steel angles into rectangular frames and laying out our collected road signs to fill the voided space. Each of the thirty total panel was created by four angle welds, a paint job, five or six road signs and ten to twelve rivets keeping them in place. The typical column bays held three panels between columns with a few bays holding only one or two panels. We drilled and tapped the HSS that was field welded to the columns to allow for a drop down bolt connection between the HSS and the steel angles that enclosed the guard panels.

On-Site Construction

After removing the flooring entirely in the demolition phase we quickly turned around our steel decking to aid as a temporary platform for the aforementioned guardrail installation. Verco Steel was a large proponent for the success of this project as they donated roughly 600 square feet of steel decking and sent a company representative to showcase their patented PunchLok process. The deck was connected and installed in eight-foot spans that would keep the floor beams of the 8x8x8' module exposed after we poured the concrete. Although a bit more difficult in our means and methods, the exposed design accentuated the modules that the house was named after and aligned with our initial project goals. The completion of steel decking allowed for a semi-rigid diaphragm that was structurally sound enough to stand and work on until we poured the concrete infill.

Learn by Doing

The Modular House project truly tested the skills learned through undergraduate education and applied classroom knowledge directly to the field. Teamwork experience developed through multiple major and interdisciplinary labs made for a smooth transition as we developed our roles and delegated tasks within the project team. Foundational knowledge of preconstruction principles like estimating, scheduling, and logistics served as solid benchmarks for which our project was methodically built upon during the planning phase. This capstone project fulfilled and enriched the Cal Poly *Learn by Doing* experience gained throughout the Construction Management undergraduate degree.