Design-Build Capstone Projects: Continuing the Poly Canyon Legacy of Learn-by-Doing

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Abstract

In the 1960s around ten acres of land behind the main campus of California Polytechnic State University in San Luis Obispo were set aside for students from the College of Architecture and Environmental Design to experiment with structural forms, materials, and construction methods. The publicly accessible Poly Canyon site has amassed a collection of structures: bridges crossing a seasonal creek, caretaker housing, a greenhouse, multiple sculptures and observation structures, among others. There were ebbs and flows of construction activity in Poly Canyon, often seeing a decade of activity with as much time dormant in between.

This paper focuses on the execution of six restoration and new construction projects that have taken place in Poly Canyon since 2017. These recent senior capstone projects mirror the process practitioners follow in a design-build project and helps students develop a host of technical engineering, construction, and management skills. The typical workflow is:

1. (a) Investigation and documentation of the structure's as-built condition to determine necessary repairs to achieve structural/safety compliance (for restoration), or
   (b) Site selection, surveying, and conceptual design (for new construction);
2. Preparation of a professional structural drawing and calculation package in accordance with applicable building codes;
3. Revisions per their faculty advisor, licensed structural engineer reviewer, and permitting official with Cal Poly Facilities;
4. Solicitation of funds, services, equipment, and building materials from engineering firms, contractors, and manufacturers;
5. Execution of the repair or erection of the new structure, often a combination of modular fabrication in the CAED machine shop and on-site construction in the Canyon; and
6. Documentation of all these efforts through a senior project report published to the Cal Poly Digital Commons.

The six featured capstone projects represent various material types, structural systems, and construction challenges. This paper will present a summary of each project based on detailed review of available project reports and surveys of the student team members. Through these projects, students have successfully approached an open-ended design problem and worked with a team to deliver a variety of permanent on-campus structures.

Course and Institutional Context

The Cal Poly College of Architecture & Environmental Design (CAED) houses the disciplines of architecture (ARCH), architectural engineering (ARCE), construction management (CM), city and regional planning (CRP), and landscape architecture (LARCH). As a result, both senior project course options – ARCE 412 and 453, described below – for architectural engineering students are interdisciplinary in ways unique to its location in the CAED. This can be attributed to: ARCE faculty member(s) that lead the capstone have their PE or SE license and have experience working with other disciplines on industry projects; the course curriculum and project is co-developed and taught with colleagues from other CAED departments; ARCE students have past exposure to ARCH studios and CM courses; and that these students get to collaborate with peers from other majors on their senior projects.

ARCE 415: Interdisciplinary Capstone Course

The ARCE 415 course is the most common senior project option ARCE students take as it is a single quarter experience on a preselected topic. The 4-unit capstone meets three times a week, four hours per session during the 10-week quarter. Enrollment is capped at sixteen students per section and divided into small groups for project deliverables. The instructor team selects the course topic, which is often a specialized structural system not necessarily covered in prior material design courses. While writing this paper the ARCE 415 section has seven students focusing on mass timber, and in the past thin-shell concrete designs and other complex building typologies have been explored. The class consists of assorted lectures focused on teaching the ARCE students about the structural design for this new material or form, group meetings with students from the other disciplines, and a comprehensive team project that the ARCE students contribute to by producing the structural system calculations and construction drawings. These technical deliverables are reviewed by the ARCE course instructor and revised to produce a final report package as well as presentation. Often the class includes site or office visits as well as guest lectures and reviews to connect the student experience with industry.

ARCE 453: Interdisciplinary Senior Project

The same learning outcomes are also true of ARCE 453 which can be substituted for ARCE 415. The difference is that this is an independent study that students can elect to participate in focusing on a research topic with faculty members or working on a student-driven project. Recently, traction has been growing for these student-driven projects to be for restoration or new construction of permanent structures in Poly Canyon. For the Poly Canyon projects, student teams have consisted of 2-9 ARCE and CM students advised by 1-3 ARCE faculty (at least one with PE or SE license) and/or 1 CM faculty (with a General Contractors license). The ARCE students still receive 4 units of credit, but the projects can last 1-1.5 years to complete the design, permitting, and construction phases. During this time, students set their own group meetings to complete intermediate tasks with weekly meetings with their faculty advisors to provide updates and have deliverables reviewed. Later in the process students meet on occasion with Cal Poly Facilities staff as needed for permitting, inspection, and final turnover to the university. These projects have often sought technical expertise from industry members (most notably, licensed *and insured* PE/SE providing review and stamp) and material or financial donations from industry members. The overarching goal of these projects is for students to investigate material, form, or construction methods with the guidance of their faculty/industry advisors while restoring or creating a structure that will remain an icon on campus for decades to come.

Outline for Paper

The remainder of this paper starts by sharing some educational context by highlighting long-lasting design-build student project programs at other institutions with similar learning objectives to what is being done at Cal Poly. Then a history of design-build senior projects in Poly Canyon since the 1960s is provided, followed by a focus on six senior projects that have been executed in Poly Canyon in the last decade. Subsequent sections break down the types of tasks that are involved in the workflow doing these types of projects. Finally, survey results from past students reflecting on the educational value are summarized.

Structural Design-Build in Studio and Capstone Projects

This section summarizes an effort to investigate and highlight long-standing design-build projects at institutions with accredited undergraduate and/or graduate programs in architecture or engineering. Specifically, examples were sought out that would be similar to the Poly Canyon senior projects where students are engaged with the entire production process from design to construction of permanent structures and are intended for use by members of the public, either on or off campus. These examples have been categorized into projects in experimentation and community service. Additional programs with design-build projects are listed in Wills et al. [1] which readers can use as a starting point to investigate the characteristics of each program.

Projects in Experimentation

The following examples represent senior and graduate level capstone design-build projects that have a decades long history allowing students to experiment with materials, form, and construction techniques. They are designed and built on campus affiliated land (educational), are expected to be semi-/permanent (durable), and can be occupied or visited by the public (safe). They also are under the constraints of limited budget, time, and space. These would be the most like the types of projects that have been built and restored in Poly Canyon since the 1960s.

The School of Architecture Shelter Thesis program [2-3] is a year-long culminating experience for architecture graduate students that continues the Taliesin Fellowship tradition that began in the late 1930s. Each student develops their own semi-permanent dwelling design that is responsive to the desert climate and landscape. They select the site, research materials and fabrication approaches, design, and construct a small structure that they will inhabit. This has encouraged students to experiment with materials like rammed earth, thin-shell concrete, inflatable or tensile forms, and bio-based products. In some cases, students have reused and reimagined existing student shelters. The project also involves the exploration of forms through earth excavations and structural geometry to achieve lighting, ventilation, and site integration goals. For their thesis, students are also challenged with considering how the design could scale.

La Pontificia Universidad Católica de Valparaíso (PUCV) Ciudad Abierta in Ritoque, Chile [4-5] was founded by the Amereida collective of architects, artists, and poets in the 1970s. Thus, architectural design on the site has always centered around poetry. The permanent structures constructed using experimental materials and forms serve as lodging, fabrication shops, public meeting and educational spaces. The site is now managed by the Amereida non-profit with weekly PUCV School of Architecture classes where students contribute to installation and building projects. One example of a recent restoration project that was completed for a capstone architecture studio was the design and construction of a bathroom, kitchen, work benches, and electrification of the Taller de Prototipos (Prototype Workshop) [6]. Ciudad Abierta also hosts workshops and collaborative projects with faculty from notable international institutions.

Projects in Community Service

The examples in this section are hallmarks of service design-build projects from programs that have had a decades long legacy and inspired the creation of similar educational experiences at other institutions. These share the technical and professional learning outcomes of senior projects that are carried out in Poly Canyon where the student is engaged from conceptual design, construction, to project turnover. The differences are that in most cases these projects are built off-campus with an external client such that the fundraising process is the responsibility of another party, stakeholder engagement has a greater emphasis, and the permitting process is a municipal rather than university one. Additionally, the projects seem to be delivered within the primary faculty member(s)' architecture firm or non-profit center established with the university.

For the Poly Canyon projects, the civil and structural engineering calculations and drawings are part of the team's deliverables, as is review by a professional engineer and approval by Cal Poly Facilities. These example programs consist of predominantly architecture students, and in reviewing their project descriptions it is unclear whether the engineering deliverables are completed by licensed engineers based on student architectural plans, or the students are themselves responsible to some degree. Regardless, these programs represent some of the most notable collections of student design-build projects that have had significant positive community impact that would be informative and aspirational to other engineering and design educators.

Yale University's First-year Building Project [7] is mandatory for all first-year professional architecture master's students. Established in 1967, this design-build program was intended to not only impart on students the mechanics of constructing their designs but engaging in positive social action through architecture. As such, this serves as inspiration for many of the studios discussed later in this section. At present day, the project is typically a single-family dwelling and starts in spring semester with the cohort of about 60-70 students that are divided up into teams. They receive the project brief and visit the proposed site, developing and refining a conceptual design that they present at the end of the term. Together with the faculty the client selects the winning design, and a sub-group of around 15 student interns work on construction during summer and fall. Since 1989, the program has delivered over fifty affordable homes in New Haven, CT.

The University of Washington Neighborhood Design/Build Studio [8] is offered to typically a total of sixteen senior undergraduate and graduate architecture students during the spring quarter. The earliest project affiliated with the studio was completed in 1988. Since then, over 40 projects have been realized from park installations, play structures, and community facilities in the Seattle area as well as health and school buildings in Morelos, Mexico among others. The students undertake site analysis, project design, preparation of construction drawings, acquisition of materials, and construction of projects for their non-profit clients.

The University of Kansas' (KU) Studio 804 [9] is a two-semester graduate level architecture course conducted since 1995 involving client selection, schematic design, production of construction documents, material acquisition as well as budgeting, fabrication, and code inspection. It typically enrolls around twenty students in the final year of their graduate studies to provide design-build experience collaborating with clients, suppliers, engineers, and permitting officials. Studio 804 has delivered nearly 30 projects centered around sustainable, cost-effective, and creative design including contemporary LEED-certified private residences, a tiny home community for housing insecure families, along with buildings and additions at KU.

Auburn University's Rural Studio [10] is a design-build studio started in 1993 which annually has around fifty undergraduate architecture students, either for one semester of their third year or their entire fifth year. They participate in architectural design, prototyping of scale mock-ups, presenting and responding to feedback from industry consultants and clients, along with construction. The off-campus program in rural Western Alabama has delivered over 200 projects including affordable and sustainable homes as well as public park and community facilities. Rural Studio also conducts research into applications and design with locally sourced timber as well as barriers to equitable housing access and affordability. Through their outreach arm Front Porch Initiative, they have developed nationwide partners focused on housing access that have implemented their affordable product line houses in FL, GA, LA, NC, and TN.

The University of Utah's Design Build Bluff (DBB) [11] is a two-semester, sixteen student graduate level architecture program established in 2000 that annually delivers a single-family home for a Navajo Nation client. It is modeled after Rural Studio and executed in collaboration with Yestermorrow Design/Build School [12]. The first semester consists of learning green building techniques as well as Southwestern and indigenous architecture practice, followed by design and production of construction drawings. In their second semester, students move off-campus to live in Bluff and construct the home. During this time, they also conduct educational outreach about architecture through hands-on activity sessions at an elementary school and career fairs at two high schools. Their design journal and video deliverables disseminate information about this service design-build program, which over the years has amassed a portfolio of nearly 20 homes and several other community installments.

Introduction to Poly Canyon

History of Structural Design-Build in Poly Canyon

In its early days, the Cal Poly Architecture program was located on the hill in the northern portion of main campus. Students were able to practice the school's philosophy of "Learn by Doing" by building their construction senior projects around it. Space to continue this practice was no longer available when the program moved to its present-day location on the southern edge of campus in the 1970s. To continue with these structural design-build projects, an agreement was developed to utilize approximately ten acres of the university's land in Poly Canyon about two miles from main campus. This area is shared with agriculture, where horse and cattle are free to graze.

The first structures in Poly Canyon appeared in the early 1960s. Relocated from main campus was the Geodesic Dome, inspired by Buckminster Fuller's design. New construction of senior projects included the post-tensioned concrete Blade Structure, Bridge House with its steel truss system spanning a small ravine, Modular House constructed of steel, as well as Shell House and the Gunite Bridge both with thin concrete shells of pre-tensioned steel and shotcrete. Progress continued with additional student projects in the 1970-80s with the Technite Bridge using fiber-reinforced plastic tubing as supports, a restroom with a thin curved concrete roof using earth as formwork, an entry arch, greenhouse, and more. There was water and electrical infrastructure that supported residency in multiple houses by student caretakers, public gathering spaces at the BBQ Pit and Poly Pavilion, and notable outlook points at Cantilever Deck and Fratessa Tower. Further details on the 30+ historic and existing project structures are available online through the CAED's webpage on the site [13], a library research guide [14], as well as a new smartphone application being developed by a current computer science student [15].

The underlying theme among all these senior projects was that students could experiment with new materials, geometric forms, and construction methods to produce real-world permanent structures. This exposed them to the many facets of the design-build process which included site selection, architectural and structural design, production of calculations and drawings, construction approval by the university, fundraising, material acquisition, and construction.

Other Design and Restoration Activities in Poly Canyon

Aside from the permanent senior projects constructed in Poly Canyon since the 1960s, Cal Poly's Architecture program has been hosting the annual juried Design Village competition in that location for nearly fifty years. For the competition, student teams are challenged with designing and fabricating inexpensive, lightweight, temporary structures that can be transported by hand into the canyon and house the team over the weekend. This activity is undertaken by all architecture and architectural engineering students in their freshman studio but is also open to other Cal Poly and community college students. Details are available on the Design Village website [16].

Formed in 2014 to preserve the permanent Poly Canyon structures as examples of Cal Poly's "Learn by Doing" philosophy, the Canyon Days Committee (CDC) consisted mostly of CAED students and were advised by a college administrator. From 2015-17 they were active, organizing a few workdays annually with classmates and faculty to upkeep the structures and adjoining pathways. This included painting over graffiti, general maintenance, as well as clearing vegetation and trash. During the year, CDC members also conducted research into the structures' history to help develop the CAED's Poly Canyon webpage and give tours. Since 2022, interest in CDC has reemerged, likely motivated by a past member serving as a part-time ARCE lecturer,. Beyond annual workdays, the CDC has recently assisted with structural condition assessments, preliminary conceptual design, and temporary restorations that have paved the way for new senior projects.

Both the Design Village and Canyon Days events are critical to Poly Canyon outreach by raising student and public appreciation for the structures. The space is also open year-round for the public with trails frequented by hikers, trail runners, and mountain bikers. This range of positive interactions with the space have motivated recent students to take on senior projects that ensure the vibrancy of existing projects or add their own to be visited for generations to come.

Introduction to Poly Canyon Senior Projects

The following sections introduce the six Poly Canyon senior projects carried out in the last decade. These include significant restorations of Modular House, Bridge House, Cantilever Deck Structure and new construction of the Observation Deck, Tensegrity Structure, and Moment Monument (see Figure 1). The recent senior projects highlighted in this paper were completed by architectural engineering and construction management students in Cal Poly's College of Architecture & Environmental Design.

The project deliverables are the final structural calculation and drawings package that are reviewed and stamped by a licensed engineer and Cal Poly Facilities for permitting. Teams prepare a safety plan along with receiving necessary training from environmental health and safety department prior to beginning construction, undergo inspections during the build, and provide a maintenance plan when the structure is completed and turned over to the university. The six stages in the project workflow to arrive at these deliverables are described with examples in the later section titled ‘Examination of Project Workflow Mirroring Engineering Practice’.

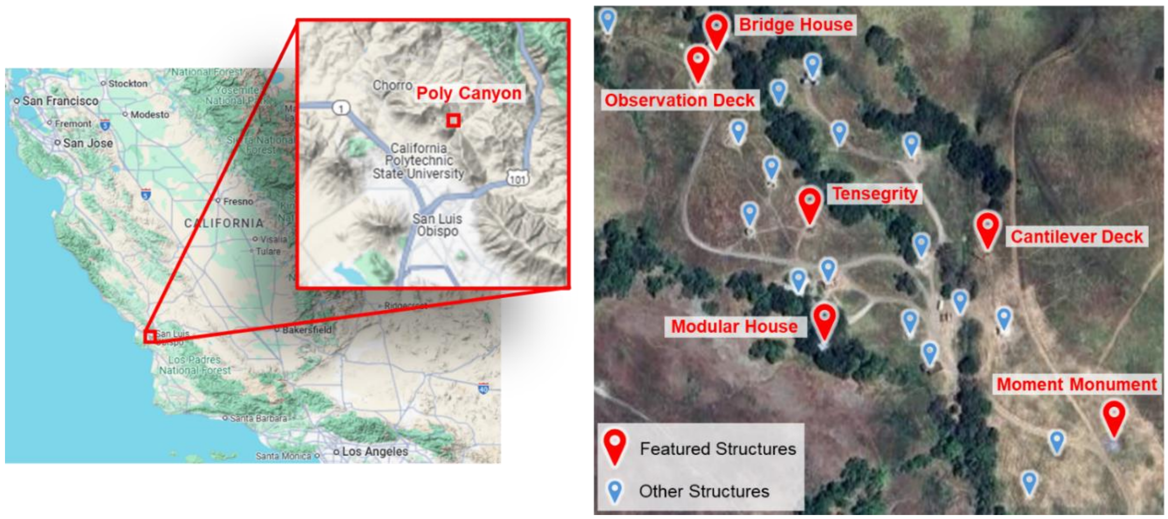


Figure 1. Poly Canyon: (Left) Location and (Right) Structures
Note: Some structures located outside of map boundaries

Restoration Projects

Through review of available senior project reports and project team member accounts, this section summarizes the original design intent as well as major construction and restoration activities undertaken for the Modular House, Bridge House, and Cantilever Deck Structure. Information from 1965-1990 is presented as ‘history’ and the ‘recent efforts’ is the work documented in reports published since 2017. Notably the projects discussed that had enclosed structures for residential or classroom use had multiple phases of modifications to accommodate human occupancy, which has not been necessary for open-air structures.

Modular House (originally Space Module)

History: The 1965 senior project team [17] envisioned the two-story structure would serve as a seminar area and lodging for visiting lecturers. For economy and constructability, they developed 8 ft-4 in HSS steel frame modules positioned at different heights to accommodate the sloped site with a seasonal creek. In addition to the HSS steel, they secured donations for Plexiglas wall panels as well as materials to fabricate structural insulated panels (SIP) for the floor and roof. Their report includes architectural and structural drawings with calculations for gravity and lateral loads. They completed construction of most foundation piers and the steel frame for the seminar area. It remained an open skeleton until a 1969 senior project team [18] enclosed the structure. This team redesigned the panel connection details, finished un-grouted foundation piers, fabricated and load tested a prototype SIP before producing them in bulk. Finally, they installed the Plexiglas and SIP panels. Their report includes updated construction details and a new architectural drawing proposing how the seminar area would be converted into living space. The next reported changes [19] were renovations in 1982-84 by about ten students per quarter in an architecture/construction course to make the structure more livable for the student caretaker resident. This included replacing un-insulated and cracking Plexiglas wall panels as well as the roof, updating electrical and plumbing, adding windows and a solar chimney, installing a subfloor and oak linoleum floor, hanging cabinetry, and painting walls among other tasks. There was a kitchen and bathroom along with other living spaces, over time the facade came to be replaced by street signs and was closed off to entry (see Figure 2).

Recent Efforts: In 2017, a senior project team of eight ARCE and one CM students [20] set out to restore Modular House which had stood neglected and vandalized due to its secluded location and the discontinuation of the residential caretaker program around 2011. The team reconfigured the structure as an observation deck, producing gravity and lateral structural calculations along with construction drawings to document these changes. For safety and visibility, they removed and replaced deteriorated exterior walls with guardrails that they prefabricated with infill panels of reclaimed street signs previously used for the structure's facade. To improve durability, they demolished the existing first floor and installed a new steel deck with concrete topping. A second phase that they designed, but never constructed, was a new exterior staircase between floors and several interior stairs between the modules on each floor.

In 2018, a second senior project team of two ARCE students [21] addressed the remaining structural and safety concerns. They designed and installed two custom steel staircases to span the first floor's elevation changes, learning to plasma-cut and weld to produce stiffened components for strength and durability. The team also constructed an interior guardrail and stair handrail for code compliance. To ensure weather protection, they replaced the damaged ceiling with a corrugated metal roof (see Figure 3). These efforts enhanced the Modular House's safety so it could be opened to the public, while being intentional to preserve and highlight features that made the existing building unique – the staggered steel frame modules and street-sign cladding. This work exposed students to the practice of adaptive reuse which they had not encountered in their studies. Ultimately, they transformed a deteriorating structure into a peaceful space nestled between trees and crossing a seasonal creek that looks out onto the hills of Poly Canyon.

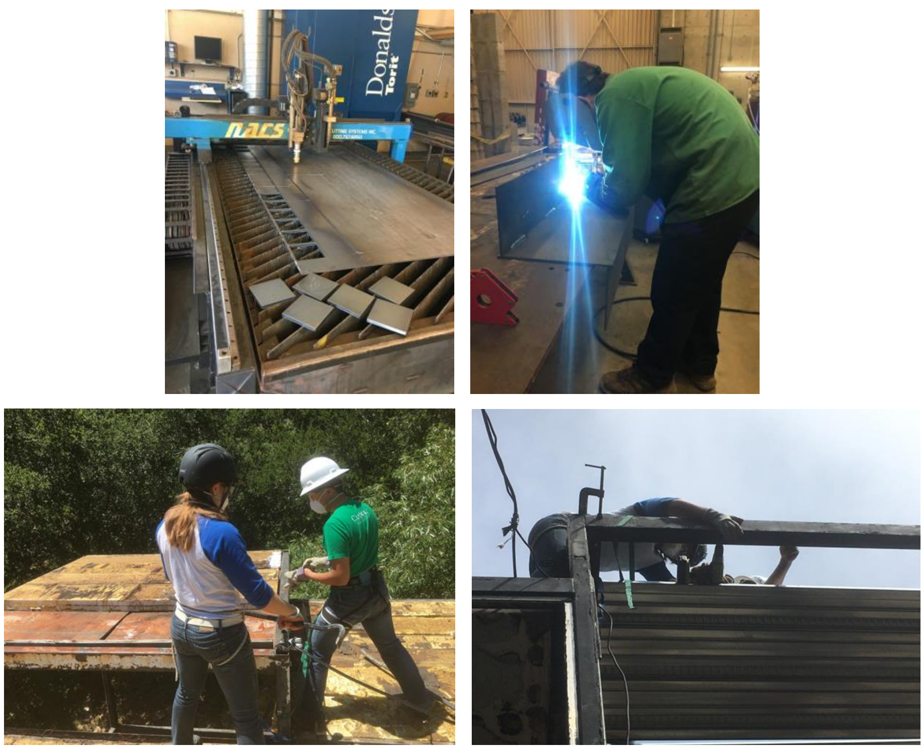
(a) While Inhabited, In 1998 [22]

(b) Prior to 2017-18 Restoration [13]

(c) Post-Restoration, Circa 2024 [15]

Figure 2. Modular House Over the Years

Phase #1: (Top) Fabrication/Installation of Rail Infill, (Bot) Floor Removal/Replacement [23]



Phase #2: (Top) Fabrication of Steel Staircases, (Bot) Roof Removal/ Replacement [21]

Figure 3. Modular House Restoration

Bridge House (also Bridge Lab)

History: The 1966 senior project team report [24] describes inspiration from Los Angeles designer Craig Ellwood who experimented with exposed steel and had proposed a house concept with a truss type bridge on four isolated point footings to enable construction in challenging terrain. Thus, site selection considered views of Poly Canyon and the presence of a small ravine the house would span. The team produced structural calculations and drawings for decking, beams, trusses, and foundations. They also conducted a survey, excavation, pre-fabrication of trusses, and on-site construction of footings and steel superstructure. Notably this project marked the first use of Cor-ten weathering steel on a large scale donated by Kaiser Steel Co.

The subsequent 1969 senior project team report [25] describes enclosing the structure. For the roof and floor, they installed decking, insulation, waterproofing, and poured concrete; for walls they installed glass windows panels and doors (see Figure 4). Electrical was also added. Though the original intent was to use the structure as lodging for guest lecturers, a 1971 report proposed conversion into a teaching lab with a small library and discussion area [26]. Other project reports show varying uses: in 1987 it was being used by a fourth-year architecture design studio [27] and in 2000 served as a residence for a student caretaker [28]. In the early 2010s, the structure was instrumented with accelerometers and a low-amplitude mass shaker (now removed), which allowed for structural dynamics research to be conducted by ARCE master's students which as later incorporated in the senior-level seismic analysis and design course [29].

Recent Efforts: A senior project team of five ARCE students [30] completed restorations of the Bridge House in 2019 to achieve a safe, code-compliant outcome allowing public access to the structure while paying homage to its original design. The project involved removal of perimeter walls and replacing them with steel guardrails (see Figure 5). The team adapted and refined a guardrail design by Canyon Days Committee members, who had installed several as a temporary measure [31]. This design proved challenging to manufacture in bulk within their timeline, so revisions were made for ease of constructability while retaining the original aesthetic. The redesign used cold-rolled steel frames with diagonal square tube infills matching the angles of the building's structural braces, which they prefabricated as units on campus.

On-site demolition followed, which involved the team dismantling the Bridge House's perimeter plywood on light-gauge steel walls, window frames, and doors. Team members received training in environmental health and safety to carefully remove paint to prepare surfaces for welding along with other waste management strategies. The subsequent installation of the guardrail units involved in-field welding them to steel mullion columns. Safety measures were taken including watering nearby vegetation and maintaining a fire watch. Students were able to secure funding for this project by applying for a grant from the Foundation for Interdisciplinary Studies along with solicitation of alumni donations. The project combines craftsmanship, collaboration, and environmental stewardship to revive a significant architectural landmark for the campus.

(a) In 1968 [32]

(b) Prior to Renovation, circa 2015 [31]

(c) After 2019 Renovation [30]

Figure 4. Bridge House Over the Years

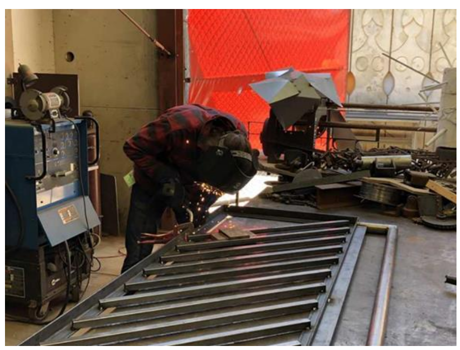


Figure 5. Bridge House Restoration:
(Left) Shop Fabrication of Railing, (Right) Field-welding to Install Railing [30]

Cantilever Deck Structure (originally MasterBuilders Project)

History: The hillside project completed in 1990 [33-34] was inspired by works of engineer-architect Santiago Calatrava who often employed cable-stayed systems with leaning towers. The original team envisioned that this canyon overlook structure would enclose an amphitheater and a movie screen could be attached to its masts. The design features tapered screw-laminated timber beams shaped like a ship's prow. The finger-jointed beams intersect to form a diamond lattice when viewed from beneath and span between an HSS steel frame topped with metal deck grating. The cantilevered system is connected to the concrete abutment and supported via steel cables that extend over the two masts to anchorage points on concrete piers. The team executed on-site tasks including excavation, and pouring of the concrete foundations. They prefabricated structural components (steel masts, HSS frame, and timber beam assembly) on main campus and

transported them to the site, placed using a crane. Cables were attached and tensioned, and for nearly 35 years the structure remained in its original state.
Recent Efforts: In May 2022, the Canyon Days Committee members, aware of deficiencies in the structure due to weathering and age, conducted a condition assessment. A further screening was completed in February 2023 by CDC alumni. By Spring 2023, a senior project team ultimately comprised of two ARCE and one CM student began to form. As documented in their project reports [35-36], they completed their own condition assessment identifying delamination and deterioration of the screw-laminated Douglas Fir beams, inadequacy of the loose cable guardrail, and corrosion of painted steel members (see Figure 10). An early challenge in the project was the lack of existing documentation, aside from a report focused on welding of steel members [33].

The team decided to take in-field measurements to develop a 3-D Revit model but encountered difficulties due to limited access on the steep hillside site. They were able to recruit a local architecture firm to donate LiDAR scanning services to address this. The structural redesign exposed students to new products: Alaskan Yellow Cedar to improve weather-resistance of the beams; Simpson Strong-Tie Strong-Drive wood screws and TECO timber tooth plate connectors to meet shear demands; and a wire mesh and cable infill for the guardrail. Their structural calculations and drawings were reviewed and stamped by a licensed engineer from a local firm to acquire a permit from the university. Through writing grants and soliciting corporate donations, students were able to rent scaffolding and purchase timber for shoring and beam restoration, along with other materials and equipment needed for the project. By Fall 2024, they removed and replaced the timber beams and cable handrails, as well as completed rust removal and repainting of steel members (see Figure 6). At the rededication event, it was rewarding to have original designers and family members present who shared stories, photos, and drawings.

Figure 6: Cantilever Deck Structure Restoration [37]

New Projects

The new projects discussed in this section are permanent structures designed and constructed as senior projects since 2018 that underwent the rigor of the Cal Poly Facilities permitting process including review of calculations and drawings by a licensed engineer. This includes the Observation Deck, Tensegrity Structure, and Moment Monument. Project teams consisted of architectural engineering and construction management students. Discussion of the Observation Deck is based on review of available senior project reports, while the other projects are described by paper co-authors that were themselves members of the senior project teams.

Observation Deck

The Observation Deck was conceived in 2017 by a team of two ARCE and one CM students seeking an interdisciplinary senior project that would help revive construction efforts in Poly Canyon [38-39]. This would be the first new permanent structure built on the site in nearly fifteen years. The pergola structure, with elegant and weather-resistant redwood timber posts and braces, provides a unique viewpoint of the canyon while offering a shaded resting place for hikers and mountain bikers who complete the trek up the hill. The initial phase of design and permitting took a year for the first team of three students. This included conducting gravity and lateral calculations for the structure and producing construction drawings for the concrete foundation as well as timber floor and roof framing, columns, kicker braces, connection details, and built-up benches. As the original team graduated, two CM students learned of the project and committed to completing its construction for their senior project [40].

They noted that some of the major challenges in delivering the project were budget constraints and site characteristics. Though awarded a grant from the Foundation for Interdisciplinary Studies, the original estimate was significantly lower than actual costs due to a price increase in lumber. The team overcame this by additional fundraising efforts. Other logistical trials they faced included that the site was at the crest of the canyon, complicating site access and preparation of a level foundation. Ultimately, they completed construction efforts of surveying, digging and pouring concrete piers, constructing the timber structure with stairs, benches, and vertical trellis in June 2019 (see Figure 7). Two years of perseverance paved the path for future students to carry out new design-build senior projects in Poly Canyon.

Figure 7. Observation Deck: (Left) During Site Work, (Right) Completed [41]

Tensegrity Structure

The team was inspired by their interdisciplinary high-rise building studio that brought together engineering and architecture concepts. Tensegrity is a structural system whose stability is derived from continuous tension and discontinuous compression load path elements, which makes it appear to float mid-air. The goals of the senior project were to create a series of table-top models to experiment with this structural phenomenon and ultimately build a permanent large-scale structure to showcase the tensegrity in Poly Canyon.

The project began in Summer 2019 with the five ARCE student team members [42] building models, followed by many design charrettes to finalize the structure's form and structural design. They arrived at a structure that would be approximately 10-ft tall and 20-ft wide to be able to convey their design concept, while at scale manageable to construct. It was a learning opportunity when the first calculation and drawing package submitted to Cal Poly Facilities was not accepted. The team then focused on understanding their structure's behavior and construction: building mockups of the complex connections and producing shop drawing level steel construction details. The students performed calculations to design all the welds, steel nodes, steel pillars, concrete foundations, and timber beams spanning between steel nodes. After these efforts, their stamping licensed SE and Cal Poly Facilities were satisfied with the design and the building permit was issued. The students began construction with excavation and pouring of concrete footings. They preassembled the canopy unit consisting of timber beams with the steel node connections and steel infill sunshades as well as the steel pyramid pillars on main campus. On-site erection was rapid, on a weekend the prefabricated components were transported up to the canyon and installed with the necessary cabling to achieve a tensegrity system. The project was completed in January of 2021 and has inspired many viewers with its gravity-defying floating appearance (see Figure 8).

Figure 8. Tensegrity Structure: (Top) During Site/Shop Work [42], (Bottom) Installation and Completed Project [Images: W. Adam]

Moment Monument

The Moment Monument was completed in 2023 by four ARCE students [43] and is the newest senior project structure in the canyon to date. It serves as a functional teaching aid for future students on the design of special steel moment frame connections and embodies the team's appreciation for the architectural engineering program. The monument features a radial concrete slab representing the "right-hand rule" used to determine the sign of a moment in statics. The six steel moment frames showcase nine prequalified seismic moment connections per AISC 358-16 [44] and one experimental beam-column connection under development by an architectural engineering faculty member [45].

The project team began work in Spring 2022 with several site visits and iterations of conceptual designs with different frame orientations. They built a scale model after selecting the final design and began production of structural design calculations and construction drawing set. After various rounds of document review and final stamp from a licensed SE and Cal Poly Facilities, the permit was approved. The team started on site surveying, excavating, construction of formwork and pouring concrete. Entering the Winter, several storms flooded the site multiple times, but they were able to maintain schedule. While concrete cured, the team prefabricated the moment frames in the CAED machine shop utilizing grinders, plasma cutters, and a flux-core welder. In Spring 2023, they transported and erected the frames at their site in Poly Canyon (see Figure 9). This project is another step in reviving the hands-on learning legacy of senior projects in Poly Canyon. It aims to inspire future students by illustrating innovative lateral system solutions and fostering a deeper understanding of steel design, constructability, and connection detailing. The project blends practical application, creative problem-solving, and a commitment to advancing structural education at Cal Poly.

Figure 9. Moment Monument: (Top) During Site Work, (Bottom Left) Shop Welding, (Bottom Right) Team with Completed Product [43]

Examination of Project Workflow Mirroring Engineering Practice

The educational value of the design-build projects described previously is that the technical and professional demands on the students approximate industry as closely as possible. The ARCE 415 senior capstone course has students work in small groups designing an entire structure and involves extensive design calculations and drawings with revisions to be responsive to instructor review. However, delivering a built product in Poly Canyon through the ARCE 453 senior projects requires students to focus on budget, scheduling, permitting, safety, durability, environmental impact, and constructability. They must work cohesively as a team to function as architect, engineer, project manager, contractor, and client; there is no one more motivated to realize their vision that will live on for decades. Everything begins to matter to them during this process.

This following describes how the Poly Canyon senior project workflow simulates industry with representative examples from 1-2 projects for each of the six major tasks that occurred in all the restoration and new construction projects. This discussion is based on review of project reports, other provided project files, and firsthand experience of the authors who were on the Tensegrity, Moment Monument, and Cantilever Deck project teams as a student member or faculty advisor.

1. *(a)Investigation and documentation of the structure's as-built condition to determine necessary repairs to achieve structural/safety compliance (for restoration)*

Cantilever Deck: As previously described, this structure was inspected on three separate occasions. The first was May 2022 by students in the Canyon Days Committee who took extensive photographs and hand measurements to describe the as-built geometry of the structure as well as the various signs of deterioration. This was followed by an inspection in February 2023 by two CDC alumni, one of whom practices locally and is a part-time lecturer in Cal Poly ARCE who would ultimately serve as a faculty co-advisor on this project. The ARCE members of the student team were able to use these prior efforts as a basis to document their own observations of the deficiencies they would need to address, and measurements needed to develop a 3-D Revit model needed for the structure's analysis and redesign.

These students finalized the 11-page assessment report in October 2023 and included in the appendix of their final project report [34]. Over the subsequent weeks of their project, they revisited the project site multiple times to confirm hand measurements needed for their model. They came to the realization that, for a cantilevered structure on a steep slope without existing construction drawings, a 3-D point cloud would be essential. The team was able to work with a local architecture firm to conduct a LiDAR scan to generate a file that they could access anytime they needed clarification on existing dimensions (see Figure 10).

Other Projects: Note that while student teams conducted on-site assessments to determine deficiencies that required structural restorations to the Modular and Bridge Houses, LiDAR scanning was not necessary to be conducted to collect measurements to enable these restorations. Both of these structures have a very regular geometry and construction, are located on sites such that structural system is more easily accessible, as well as being well documented in senior project report drawings in the Cal Poly library archives ([17-18] and [23-24,27], respectively).

Figure 10. Cantilever Deck Condition: (Left) Deficiencies with Timber Beams & Guardrail Infill, (Right) Conduct of LiDAR Scanning [34]

1. (b) Site selection, surveying, and conceptual design (for new construction)

Tensegrity: In terms of site selection, the team chose to locate the structure about a third of the way up the west hill below the Poly Pavilion and Hay Bale Arch, see Figure 1 for these two other equally spaced structures on a northwest diagonal from Tensegrity. This location was attractive to them for two reasons: (1) it appeared to already be graded nearly level, perhaps in consideration for a project site or use as a staging area by a previous build team and (2) it would position the structure to appear to float above the landscape, even by viewers perceiving it at a great distance.

The group's conceptual design was informed by an architecture studio one of their team members participated in the prior year which inspired him to examine the concept of tensegrity. This concept involves reversing the common approach of having continuous compression elements and instead replacing each compression element with two tension elements which requires a thoughtful and innovative approach to create a stable structure. The entire team embraced this as an exciting engineering challenge. Their preliminary stages of work consisted of drawing and constructing conceptual models to experiment and create what the group felt achieved the purest tensegrity structure while still maintaining stability (see Figure 11).

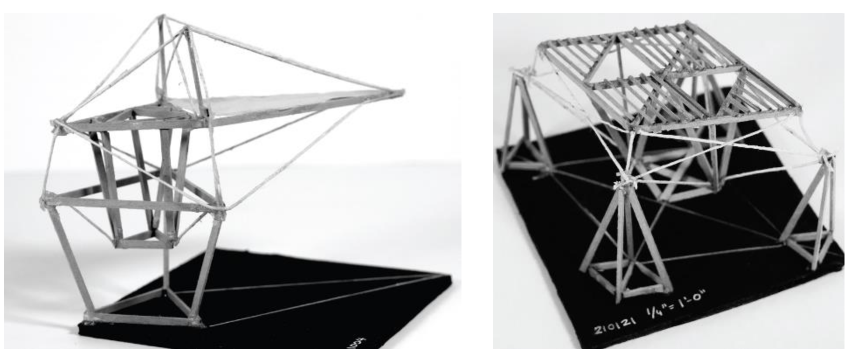


Figure 11. Tensegrity Structure Scale Models: Various Early Concepts [42]

2. Preparation of a professional structural drawing and calculation package in accordance with applicable building codes

- and -

3. Revisions per their faculty advisor, licensed structural engineer reviewer, and permitting official with Cal Poly Facilities

Tensegrity: The students prepared a package consisting of a narrative, foundation and structural calculations, and construction drawings for the review and stamp from a licensed SE before submission to Cal Poly Facilities who required a peer review of the design by a licensed SE member of the California State University (CSU) Seismic Review Board. Since the structure was irregular, the team was asked by the licensed SE reviewers to revisit their original package to provide a more descriptive explanation with diagrams of the structure's load path, additional analysis using ETABS software, and more detailed construction drawings. In this process, the team had to evaluate more than just the typical wind and seismic loads, but scenarios where people might climb on top of or hang from the structure. The students responded rapidly to this request for revisions, motivated by their desire to be approved for a work permit for the project. Though challenging at the time, it was in the process of completing these revisions where much of the learning took place for their project team. Their final report reflects the required changes and has served as an example for later teams [42].

Moment Monument: This structure consisting of six isolated steel frames illustrating nine special moment frame (SMFs) connections was able to be considered a 'sculpture/art piece' for permitting purposes, so the design and construction needed not be as extensive as an actual SMF used as a lateral force resisting system in a high seismic region. For seismic, in-plane analysis was conducted as if the system was an ordinary moment frame and out-of-plane as an inverted pendulum type structure; wind loads were based on a solid freestanding walls/signs to consider if the frame was covered by a sign, tarp, or student project; and live loads considered multiple people climbing and sitting on top of the frame's beam using code values for 'other assembly areas'.

Like all Poly Canyon senior projects, the team is responsible for considering how future visitors may interact with their structures and design for those loads. The Moment Monument team conducted preliminary structural analyses via hand calculations followed by modelling using SAP2000 software. The team produced a package consisting of foundation and structural calculations as well as construction drawings. While some of the connections were developed by the students following prequalified seismic moment connection design per AISC 358-16, some connection details were proprietary and provided by industry collaborators from Durafuse, Simpson Strong-Tie, and SidePlate. After various multiple rounds of revisions, their calculation and drawing package was stamped by a licensed SE and proceeded to Cal Poly Facilities for review for permitting. The final documents are included in their project report [43].

Other Projects: While the two prior examples focus on concerns with loads and stability that had to be addressed by all projects, there were additional considerations such as stair heights and railings, guardrail loads and spacing, maximum occupancy, livestock safety, durability for weather and visitor use, among other design considerations that were incorporated through the licensed engineer's review and Cal Poly Facilities permitting phases of design.

4. Solicitation of funds, services, equipment, and building materials from engineering firms, contractors, and manufacturers

Observation Deck: The second team of two CM students brought the permitted design completed by the first team into physical reality. Their initial fundraising task was to apply for an external Foundation for Interdisciplinary Studies (FIS) grant. Once notified of their approved grant application, they developed a Facebook page to inform family, friends, alumni, and other potential donors about the project. Though they had not yet secured the full funding they needed to finish the work, they began with site surveying and construction, actively updating their Facebook page with photographs and work summaries every couple of weeks to generate momentum around project. Another avenue that they were able to secure support was through corporate contacts provided by the College's Director of Development. The project's dedication plaque acknowledges eleven corporate sponsors ranging from Simpson Strong-Tie, CalPortland, Largo Concrete, and Kiewit among others. Additionally, the team was able to negotiate with material suppliers to secure educational discounts and donations. Despite facing setbacks like rising lumber costs, the students successfully raised the necessary funds to complete the project. This was a noteworthy effort as the first new structure in fifteen years that had been built in Poly Canyon, paving the way for future projects' fundraising and industry engagement efforts.

Cantilever Deck: The student team connected early with an alumnus at the mass timber fabrication company Timberlab to discuss construction means and methods for replacing the tapered screw-laminated timber beams, further complicated by the cantilevered structure's location on a steep slope. They were able to solicit Timberlab's support to cover the expense of all the timber needed for shoring the structure during demolition as well as for construction of the new beams. They connected with contacts at Clark Construction to secure funds for the scaffolding rental, and Simpson Strong-Tie for the hundreds of exterior grade structural wood screws necessary for fabrication. Their additional outreach to the local Studio Prime Architecture and Engineering firms provided them with LiDAR scanning services to collect as-built dimension data to develop their 3-D Revit model and the support of the licensed and insured professional engineer that ultimately reviewed and stamped their drawings.

The students also successfully applied for three grants: the Cal Poly Construction Management Council (CMAC) senior project grant, the Cal Poly CAED CSI Structural Resiliency Grant, and the Alliance Foundation for Interdisciplinary Learning (previously FIS). These funds supported the significant costs of renting of a shipping container, purchasing the guardrail infill system, and acquisition of many other necessary materials/equipment to complete the restoration project.

5. Execution of the repair or erection of the new structure, often a combination of modular fabrication in the CAED machine shop and on-site construction in the Canyon

Modular House: The project involved a demolition and restoration phase. The first team started with on-site work, essentially removing all the non-structural components in the building on the first two floors. This included demolition of the bathroom and kitchen, removal and disposal of drywall, wood stud framing, floor finishes and ceiling tiles, any structural insulated panels used for the wall or floors, ductwork and electrical wiring,, windows, doors, and an exterior lean-to shed. Then a portion of the team began working in the CAED machine shop cutting, welding, and painting steel L-shape sections to form the borders into which they installed street-signs to serve as the guardrail infill panels.

Concurrently, the rest of the team was addressing preparations to install the corrugated deck which involved cutting and welding any partial steel HSS members to restore the full 8 ft by 8 ft grid structure. They were also grinding, painting, and drilling guardrails to prepare them to accept the prefabricated infill panels. Deck installation occurred next, during which students learned to use side lap button punch tools to join the deck sheets over which they placed welded wire mesh. Then guardrail infill panels were installed around the first-floor perimeter of the structure and finally on pour day the students worked alongside concrete finishers to screed, and float the first-floor slab surfaces in the project. These demolition and construction tasks were completed in about 40 days.

The second phase of the project involved prefabrication in the CAED machine shop of stair modules as well as hand and guardrails, with precision tools like plasma cutters and welding machines were used to create the necessary elements. These parts were transported to the site. On-site work included demolition of the existing roof, installation of the new roof decking, final welding and assembly of the stairs, and guardrails.

Bridge House: Construction began with the prefabrication of the steel guardrails in the CAED machine shop. The team utilized a variety of tools, such as metal cold-saws, grinders, and MIG welders to fabricate the guardrails that would then be installed into the existing Bridge House structure. Before the installation could occur, a round of demolition at the structure took place to remove all existing doors, windows, and plywood siding. Following demolition, and after fulfilling the prescribed training and ensuring the protocols provided by the university's environmental health and safety department were met, the existing paint was stripped away, and the guardrails were able to be successfully welded into place. With one last inspection to ensure that the building still met code-compliance for a fall-protection on a structure that could be accessed by pedestrians, the Bridge House restoration was complete.

6. Documentation of all these efforts through a senior project report published to the Cal Poly DigitalCommons.

A senior project report was completed for all six projects. In fact, it has been a requirement to provide proof of receipt of this report by the Cal Poly Library Digital Commons and approval by the faculty advisor before the ARCE department head certifies course substitution for ARCE 415 senior project credit. This requirement has helped ensure documentation. All reports contain at least an executive summary with calculations and drawings to describe the structure, or structural modification, of the project. Additional report content typically also includes some combination of: introduction of team members, acknowledgements of donors and advisors, site and as-built assessments, sketches and scale models from the iterative design phase, schedule and budget, team meeting summaries, description and photographs of construction, as well as works cited.

Both the ARCE and CM reports for these recent Poly Canyon senior projects are included in the references section of this paper: Modular House [20-21], Bridge House [30], Cantilever Deck [35-36], Observation Deck [38-40], Tensegrity [42], and Moment Monument [43].

Student Survey Results

Details on Survey Distribution

Surveys were conducted to examine the educational impact of participating in the recent Poly Canyon design-build senior projects described earlier in this paper. These consisted of 15 free response questions organized under six themes to target different types of skill development and learning outcomes. Respondents were requested to provide 1-3 sentence answers for each question, and if they felt a question was answered in a previous response to indicate as much so they did not feel the need to repeat themselves. These instructions were intended to help balance the effort required to respond to numerous open-ended questions, without overtaxing those surveyed. The list of questions is included in the following section.

The surveys were emailed out in early January 2025 to the fifteen ARCE team members listed as senior project report authors for Modular House, Cantilever Deck, Moment Monument, and Tensegrity. Updated contact information for the Bridge House and Observation Deck team members was not available at the time of distribution, so they are not represented in the survey data. Also, Moment Monument and Tensegrity Structure are each represented by a co-author of this paper who was on those senior project teams, and as such did not complete a survey themselves. Twelve completed surveys were returned. Nine of the respondents are currently practicing in structural or forensic engineering fields, while three are attending graduate school. This is an important note since some of the questions relate to how this design-build experience has impacted their technical and professional skills in ways that translate to industry projects.

Survey Questions

The survey questions are listed below:

1. Project Involvement and Learning Outcomes
    a. Can you describe your role in the design-build or restoration project?
    b. What were the most significant challenges you faced during the project, and how did you overcome them?
    c. How did this hands-on experience deepen your understanding of structural engineering design and construction?
2. Technical Skills Development
    a. In what ways did the project enhance your skills in project management, such as budgeting, scheduling, and resource allocation?
    b. How did collaborating with faculty advisors, licensed structural engineers, and permitting officials influence your professional development?
    c. Can you share an instance where you had to adapt your design or approach based on feedback from stakeholders?
3. Interdisciplinary Collaboration and Communication
    a. How did working with a diverse team of students and professionals improve your communication and teamwork abilities?
    b. What strategies did you employ to effectively present technical information to non-technical stakeholders?

4. Practical Application of Academic Knowledge
    a. How did applying theoretical knowledge to a real-world project enhance your problem-solving skills?
5. Personal Growth and Career Impact
    a. In what ways did this project influence your career aspirations or professional goals?
    b. How did this experience prepare you for the challenges you have faced in your professional career?
    c. What personal qualities or skills do you believe you developed or strengthened through this project? (i.e. time management, communication, etc.)
6. Project Outcomes and Reflection
    a. Looking back, what aspects of the project are you most proud of?
    b. If you could change one thing about the project, what would it be and why?
    c. How do you think this project has contributed to the Cal Poly community or the broader field of structural engineering?

Summary of Student Survey Responses

There were four common themes that were observed in the alumni survey responses, the value of these projects as an opportunity to: develop professional skills and engineering communication, practice empathic leadership, solve technical problems given incomplete as-built drawings, and deliver innovative solutions for complex structural load paths.

Theme #1: Develop Professional Skills and Engineering Communication

There was a prevalence in student survey responses underscoring how the Poly Canyon projects contributed to their professional skill growth in areas such as engineering communication, visual graphics, team management and collaboration through difficult situations. In industry, these skills are invaluable to a successful design practitioner particularly as they progress from the technical responsibilities of an entry level engineer of design calculations and drawings, to overseeing a team of staff and developing business relationships with company clients. Often, this transition in roles is expected to be seamless, but being a manager of people and a communicator to a non-engineering audience is not a natural quality for most engineers. These design-build senior capstone projects importantly bolstered students' leadership and management skill development which otherwise has limited presence in the typical engineering curriculum.

While sound engineering was always at the forefront of students' senior project designs, it was the communication of these concepts that proved most useful in the actual execution of constructing and rehabilitating the structures. Survey respondents discussed communicating their design concept with project donors for funding, materials, and services as well as Cal Poly Facilities officials to demonstrate a safe and long-lasting project for permitting. While both donors and permitting officials actively practice in the industry, it was necessary for the teams to distill complex structural engineering concepts into concise information packages (calculations, drawings, and narrative) along with non-technical visual presentations and physical models to provide these stakeholders with a succinct and thorough understanding of the projects. The process of preparing these communication deliverables was noted as deepening the students' own structural engineering understanding. This skill directly translates to professional practice since structural engineers need to effectively communicate their technical solutions to their project partners in other disciplines to execute their projects effectively.

Theme #2: Practice Empathic Leadership

Another important skill developed through these senior capstone projects as showcased in the survey results was leadership, and specifically self-aware and empathic leadership. Some of the surveys spoke of understanding their group mates' strengths, weaknesses, and capacities. Their responses detailed learning how to utilize each group member's skills, time, and abilities to make the project more successful. One survey response described optimizing students' project work schedules based on their respective course loads and availability. Consideration of teammates' goals and boundaries helped foster team camaraderie. This type of empathic leadership is also important in the professional setting where managing the expectations for all team members promotes a healthy workplace culture. The students often had different strengths and interests which all benefited the team in unique ways. Though not all students served as leaders of the group, their responses indicated that they found ways to appreciate and leverage the other students' skills to collectively achieve their project goals.

Theme #3: Solve Technical Problems Given Incomplete As-Builts

Engineers who work on retrofit projects understand that knowledge of the existing conditions is the most valuable given information but is often incomplete or uncertain. It is rare for students in their engineering education to encounter problems of this type; moreover, they are used to arriving at a discrete solution that can be verified as correct. With an existing building, solutions are determined from existing conditions which are constantly being challenged by new information. Students surveyed who have rehabilitated existing Poly Canyon projects indicated facing the real-world challenge of historic drawings of their structures not being available in the library archive. This lack of documentation raised uncertainties about broad concepts like architectural intent, original construction methods, and load path to technical details like member dimensions, material strengths, and connections. To fill these gaps in knowledge about the structure, the students developed new engineering skills such as conducting on-site condition assessments and producing as-built drawings from their own measurements (or in one case LiDAR scans taken by a third party). Engineers in these situations must use their best judgement and plan for unforeseen problems. Students who worked on restorations of Poly Canyon structures gained this experience through their projects and many have continued to pursue this passion in their current careers.

Theme #4: Deliver Innovative Solutions for Complex Structural Load Paths

Prior to a senior capstone project, students within the Cal Poly ARCE program are exposed to coursework in steel, concrete, timber, and masonry at both the element and systems level. They complete group projects in gravity and lateral design of buildings in each of these material types. However, these assignments typically have students consider load paths for buildings with a very regular geometry that follow conventional building code practices. Being challenged to design a structure with greater complexity in a capstone project can help students develop greater structural intuition and have a better grasp of the fundamentals. Amongst the survey respondents, students commonly reported that since their Poly Canyon projects were experimental in nature they had irregular shaped forms resulting in complex load paths and conditions that fell outside of code-based methods. Teams explored their various load path possibilities through a hands-on tangible process with scale models or computer analyses. Students worked with faculty and industry advisors to use their collective engineering judgement to design a safe structure for the public. The students gained exposure to decision-making behind conservative assumptions in their load paths when the answer does not readily present itself. This same skillset and thought process is prevalent in the engineering profession. There are few by-the-book answers to real world construction projects, instead an engineer must use practical experience and their ingenuity to address challenges that are outside the code-based approaches to design.

Other Noteworthy Responses

A few other noteworthy responses received for the surveys are as follow:

The first was from the Modular House Revival project where students expressed their gratitude and pride in giving back to the community of San Luis Obispo and the future students at the Cal Poly through the restoration of this historic structure. Though practicing engineers do have the opportunity to give back to their communities, these opportunities often must be sought out and are not a part of the most common career paths. Having an experience of serving their community early in their academic career primes these students to seek out opportunities to give back using their structural engineering expertise in the future.

Another was from across the rehabilitation teams' surveys who indicated their desire to continue lessons learned from their projects of adaptive reuse in their careers. In typical engineering education there are few opportunities to re-envision the architectural program of an existing building and conduct the structural engineering design to enable this. New buildings, though necessary for serving the needs of society are one of the largest contributors to carbon emissions mainly due to their embodied carbon of the building materials and their transport to site. Yet, through adaptive reuse, the embodied carbon is greatly reduced. With the on-going global climate crisis, there is significant value in more students becoming familiar through their education to adaptive reuse and serving as future proponents for this way of building to become mainstream in the way the industry creates spaces.

Survey Conclusions

As a collection, these surveys were informative to the deeper and more personal learning that students have experienced through their participation on the recent Poly Canyon senior capstone projects. The students' responses show how this work exposes them to technical challenges unique to designing and building a permanent structure within the public domain; instilled in them passion for fabrication skills such as woodworking, welding, and building with their hands; and provided them with experiences that have influenced the trajectory of their career paths.

Reflections

The process of writing this paper revealed that several of the alumni, even from the earliest of the six projects, still maintain active connections with their fellow team members and desire to support current developments in Poly Canyon. Although they were only asked to provide very brief answers to the survey questions, many went into great detail and a few even volunteered contact information for alumni they knew from other projects and more photographs than could be found in their project reports.

An out-of-state alumni even requested that if there was a special event taking place in the canyon that they would be interested in travelling to campus to participate. There is something intangible about the value of these projects that these survey responses and subsequent interactions with alumni have shown to the authors, that this experience is transformative not only to their technical and professional skills, but the experience has bonded them very strongly to their team and the Cal Poly ARCE program. In fact, past Poly Canyon senior project members, now licensed themselves and with several years of industry experience, have come back to inspect deteriorating structures in advance of new students taking them on as a project. Others have provided guidance to the teams that followed them. One alumni from the second phase of the Modular House restoration is now a part-time faculty member who co-advised the Cantilever Deck restoration. The cycle continues in the revitalization of the site and the experimental learning originally envisioned there.

The continued passion of the alumni demonstrates that, although their constructions are complete, their dedication to preserving this important part of Cal Poly's legacy endures. All projects discussed in this paper – and those that continue to stand in Poly Canyon – are testament to the passion and commitment of students, faculty, and supporters who believe in the "Learn by Doing" philosophy that has defined the Cal Poly experience and continues into the future.

Acknowledgements

This paper celebrates the recent restoration and construction of structures in Poly Canyon, as such a great deal of gratitude goes to the senior project students that accomplished these monumental projects with the guidance of their faculty/industry advisors and donors – individually credited in the respective final reports. From this group of faculty advisors, the authors would like to give especially acknowledge Cal Poly ARCE Professor and current CAED Interim Dean Kevin Dong. His significant advising efforts on the projects and the Canyon Days Committee as well as fundraising through the CAED Poly Canyon Fund has enabled the revitalization of this experimental learning space. Thanks also to the CAED Support Shop staff (David Kempken, Tim Dieu, and Vince Pauschek) for countless hours of supporting student fabrication work; ARCH faculty Danny Wills and his architecture studio students for providing archival materials on the history of the existing structures; and all the past students who participated in the surveys regarding the value of their experiences with these legacy capstone projects. Finally, thank you to George Hasslein, CAED Founding Dean, and advocate who in the early 1960s secured the land agreement with the university that enabled Poly Canyon to exist as a space for students to experiment with structural material, form, and construction.

Dedication

To one that wholly embodied the polytechnic engineering ethos:

who travelled to many countries to learn textile and automotive manufacturing
by training in the spaces where innovations were being made,
who spent a lifetime embracing the value of creating new and restoring the old
with one's own intellect and hand,
who inspired others to learn by doing and to always remain curious.

In loving memory of Kouroush Behrouzi
1935-2025

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