ZoomSEs:

Prototyping a Consultancy Design Studio Model for Advanced Structural Integration in Architecture

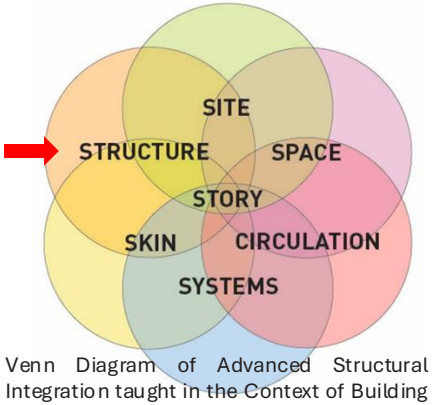
Abstract: This program is a consultancy model where industry-leading **structural engineers (SEs)** are invited into the architecture design studio (first as consultants in 2023 and then as instructors in 2024), virtually via **Zoom** (plus periodic in person feedback sessions) as collaborative-partners, working with third-year faculty and students (160 students at this year level) on capstone comprehensive building design projects for the integration of advanced structural systems. In 1963, 17 years after architectural engineering started in 1946, the architecture department was founded and benefited from the strength of this foundational relationship for many years.

This consultancy model evolved out of a desire to strengthen this foundational connection that the architecture department was founded on, along with responding to departmental faculty and students expressing concerns over limited experiences in the five-year curriculum for the creative application and synthesis of the vast knowledge of structural systems into building design projects. Additionally, over the years the architectural engineering department is hiring less faculty who have an interest in structural systems integration into buildings and in a small rural town of San Luis Obispo, CA there is a limited depth of practicing structural engineers to connect with.

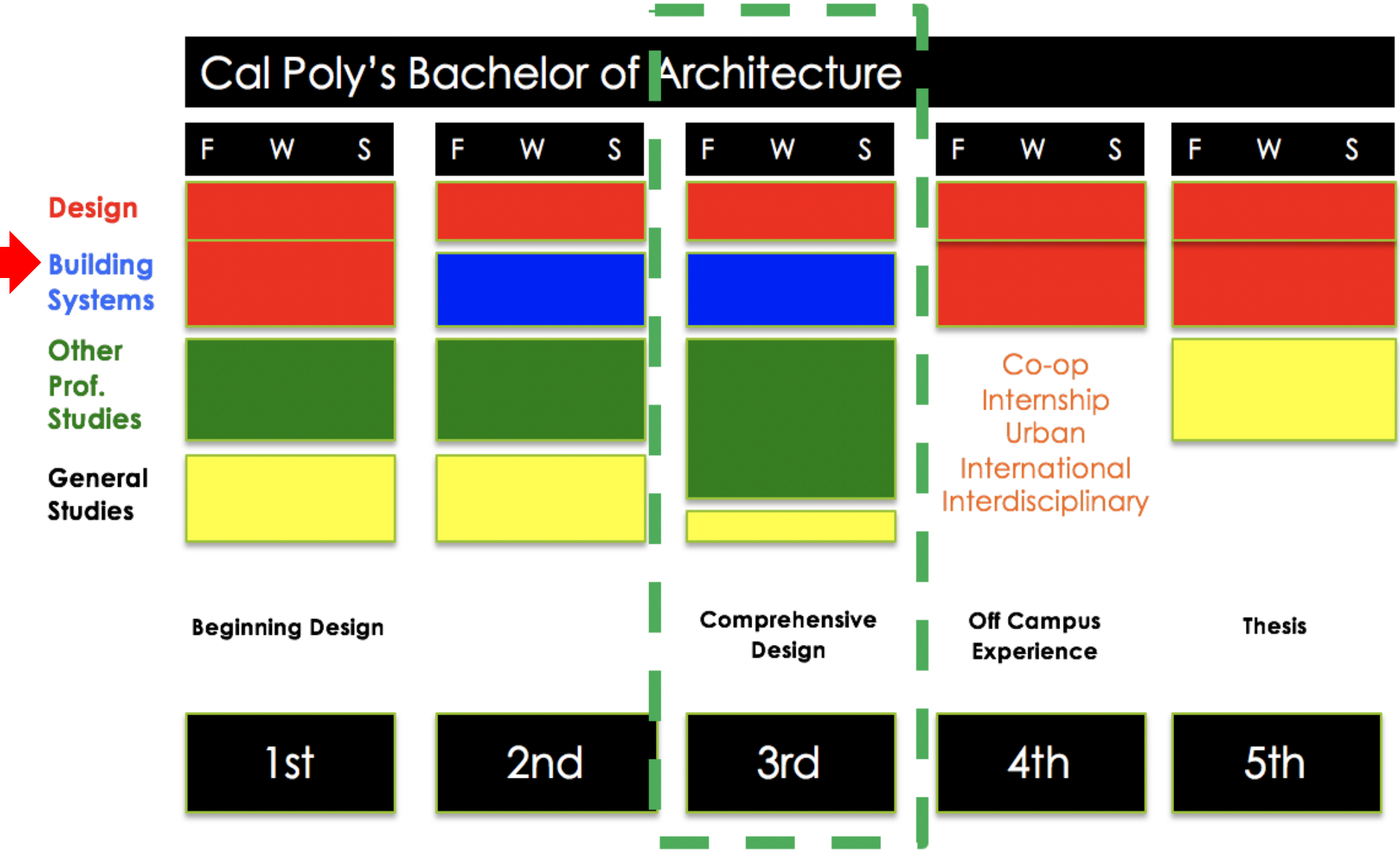
Developing this consultancy model provides a connection to the actively practicing structural engineers working on large scaled and complex/innovative projects located in major cities.

This consultancy model improves the integration of the teaching of structural systems for buildings within the architecture design studio, during the comprehensive design year of the program (see pages 2 & 3), and is taught in the context of the other building design components: site, program, circulation, envelop, and mechanical/environmental systems (see diagram page 1).

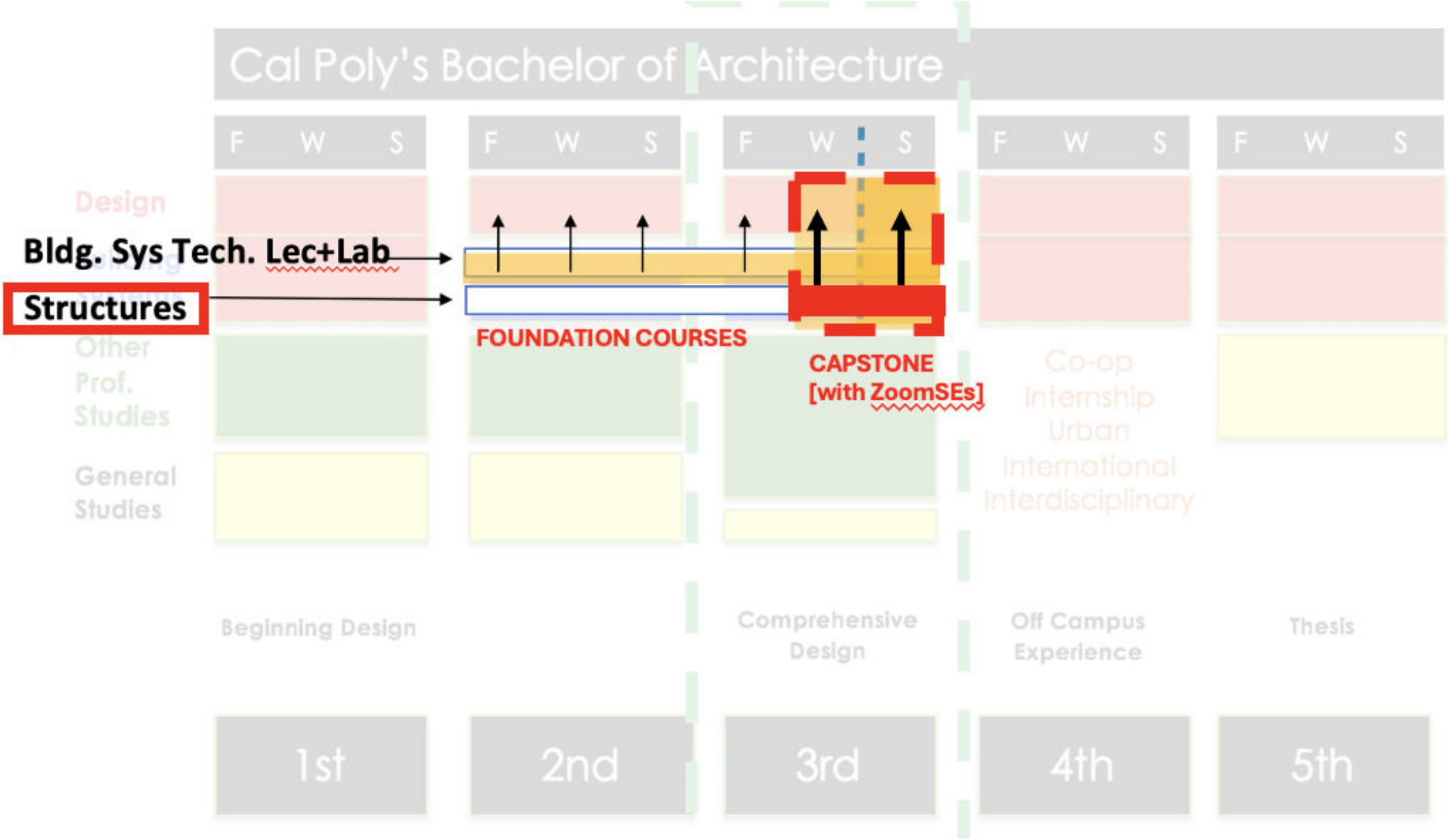
Month Year Completed: *June 2024*
Role of Nominee: *(in the project): Thomas Fowler IV, FAIA, DPACSA created this program by authoring the ZoomSEs 1.0 $20,000 Consultancy Grant for the College of Architecture and Environmental Design (CAED) Scholarship in Teaching Fund, and collaborating on ZoomSEs 2.0. Professor Fowler selected the ZoomSE instructors and teaching assistants (TAs) assigned to each of design studios and in addition taught one of the design studio sections that was involved with this program.*
Collaborators/Partners & Funding Sources for Expenses: Collaborators: *Cal Poly's College of Architecture and Environmental Design (CAED): Professor Jeff Ponitz (Architecture) & Professor Brent Nuttall (Architectural Engineering);* ***Structural Engineers / Companies & Collaborative Partners: Eric Long, SE, SOM/SF; Jonas Houston, SE / Holmes/SD;*** *Alloy Kemp, PE / RA; Thorton Tomasetti/LA & Jose Machuca, SE, Holmes/SD/LA;* ***Funding Sources:*** *2023 - $20,000 CAED's Scholarship in Teaching Fund for ZoomSEs 1.0 honoraria for 9 ZoomSE Consultants for each architecture building design studio; 2024 architecture department hired 4 ZoomSEs to teach advanced structural systems in the design studio, and provided funds for ZoomSEs to visit campus in person for mid and final reviews, and compensated the 8 Teaching Assistants (1 for each of the 8 design studios) for 6 hours a week (4 hours to assist students in the class rooms during structures lectures / workshops) and up to 2 hours a week to collaborate with architecture faculty instructors to assist students with structural systems feedback on their evolving capstone building design projects in the design studio.*



Venn Diagram of Advanced Structural Integration taught in the Context of Building Systems


Cal Poly's Bachelor of Architecture
F W S
F W S
F W S
F W S
F W S
Design
Building Systems
Other Prof. Studies
General Studies
Co-op
Internship
Urban
International
Interdisciplinary
Beginning Design
Comprehensive Design
Off Campus Experience
Thesis
1st
2nd
3rd
4th
5th

Curriculum Detail (Location of Capstone ZoomSEs Structural Integration)



2024

ZoomSEs 02 [As Instructors]

20 Weeks

ZoomSEs Hired as Instrctors Weeks 1-20

ZoomSEs Introductory Lectures on Topic Areas

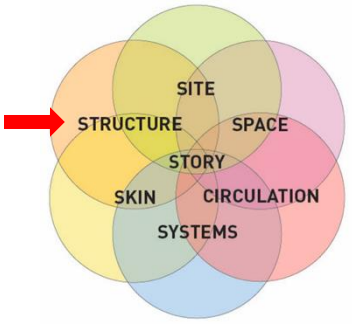
Week 10 SEs In person Mid Reviews

10 Weeks

ZoomSEs as Instructors w/ Support of 8 TAs (one For each Design Studio)

Week 17 SEs In person Final Reviews

10 Weeks



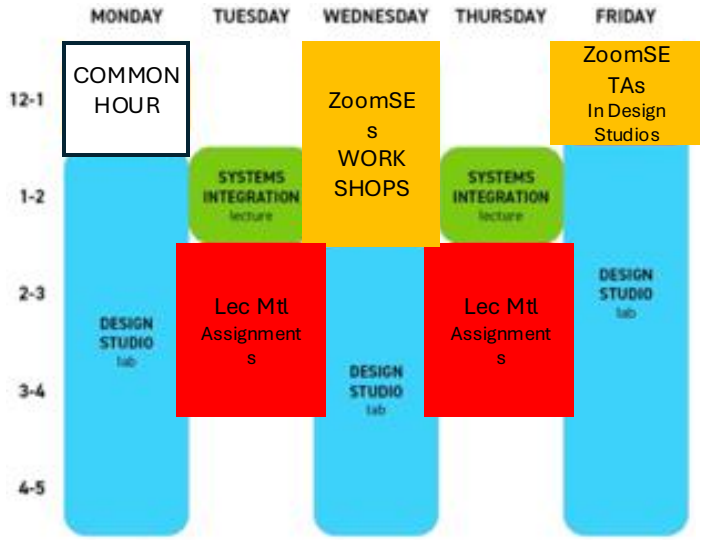
Teaching Context

4 ZoomSE Lectures:

1. Structural Story [Eric Long]
2. Structural Patterning [Jose Machuca]
3. Structural Patterning Long Span [Jonas Houston]
4. Secondary / Tertiary Systems of Envelops [Alloy Kemp]

2024

ZoomSEs 02 [As Instructors]



ZoomSE Instructors

Eric Long SOM

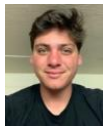
Alloy Kemp TT

Jonas Houston Holmes

Jose Machuca Holmes

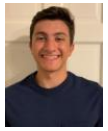
ZoomSE TAs

Matthew Sloss



Payton Filippin

Kira Tolman



Tom Sesin

Ashlynn Mathews

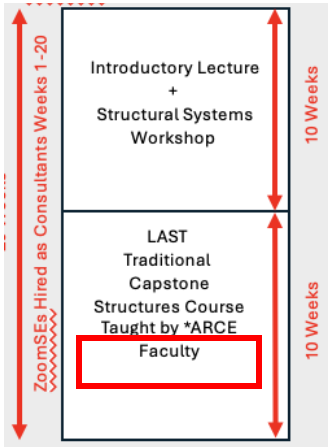
Brayden Martinez

Elizabeth Splees

Anna Cooper

2023

ZoomSEs 01 [As Consultants Only]



*ARCE Faculty NOTE: Given the success of this ZoomSEs 01 Consultancy Model, this traditional structures course taught by part & full time department faculty, will no longer be taught.

Course: ARCH 470 Structural Integration Architecture [New Course Developed for ZoomSEs 2.0 to Teach]

Learning Outcomes: 1. Describe the structural story for your architectural design project; 2. Select a structural system for an architectural design project with consideration of the story, regulatory requirements, sustainability, human health, spatial characteristics, and performative properties; 3. Develop a whole-building structural configuration for an architectural design project, including gravity and lateral load resisting systems. 4. Develop a structural concept for a long span or cantilever structure in an architectural design project; 5. Develop secondary and tertiary structural systems to support the building envelope in an architectural design project; 6. Communicate the design of structural systems story using disciplinary terminology and professional graphic standards.

WEEK 1: Lecture: The Structural Story: Design Integration and Decision-Making; ***Assignment:*** *Written Narrative describing guiding design principles, and the criteria for what structural system(s) were selected for the project. Structural Concept Drawing or Model illustrating the structural concept.*
WEEK 2: Lecture: Structural Patterning: Grids and Load Flow (1); ***Assignment:*** *Structural Grid Drawing including gravity and lateral systems. Structural Framing Plans for at least two floors (ground floor and typical upper floor).*
WEEK 3: Lecture: Structural Patterning: Grids and Load Flow (2): ***Assignment:*** *Structural Framing Plans for at least two floors (ground floor and typical upper floor). Structural Building Section including sized beams and slabs.*
WEEK 4: Lecture: Long Span Systems; ***Assignment:*** *Structural Model of Long Span System, including its connection to standard structural system and the ground. Axonometric Structural Configuration Diagram showing long span system in relation to whole building structural configuration.*
WEEK 5: Lecture: Cantilevers; ***Assignment:*** *Structural Model of Cantilever, including its connection to standard structural system and the ground. Axonometric Structural Configuration Diagram showing long span system in relation to whole building structural configuration.*
WEEK 6: Lecture: Secondary Structure for Building Envelope (1); ***Assignment:*** *Structural Bay Model including first attempt at secondary structure for building envelope.*
WEEK 7: Lecture: Secondary Structure for Building Envelope (2); ***Assignment:*** *Focus Area Section Drawing and Axonometric Drawing showing secondary structure to support building envelope, and its connection to primary structure.*
WEEK 8: Lecture: Structural Integration; ***Assignment:*** *revised drafts of Written Narrative, Structural Concept Drawing/Model, Structural Framing Plans, Structural Building Section, Axonometric Structural Configuration Diagram, Focus Area Section Drawing and Focus Area Axonometric Drawing.*
WEEKS 9&10: Lecture: The Structural Story, Revisited ***Assignment:*** *Final Project Presentation summarizing structural design and integration in the final architectural design project, which develops and refines each of the weekly topic areas.*
EXAM WEEK: ***Final Project Portfolio Submission consisting of weekly assignments documenting the iterative design process & final presentation.***

Assessment Methodologies:
***Weekly Assignments*:** students will incrementally develop and communicate the structural system for their architectural design project, following the weekly topic areas, with the assistance of TAs providing feedback in the classroom, plus the 2 visits by ZoomSEs to campus for reviews (mid & final reviews).
***Final Project Portfolio*:** students will submit a graphic and written summary of structural design and integration in the final architecture design project, which further develops and refines each of the weekly topic areas.

Readings: Balmond's Informal; Sarkisian's Designing Tall Buildings

ZoomSEs Do Show Up In Person

A VISIT FROM THE 'ZOOMSEs'

Structural Engineers Enrich Architectural Engineering and Architecture Students' Design Studio Experience

ARCHITECTURE (ARCH) PROFESSOR Thomas Fowler infused fresh insight into ARCE 316: Structural Integration in Architecture, a unique course in which faculty from the Architectural Engineering (ARCE) Department and ARCH collaborate to integrate structural design into the third-year studio projects of architecture students.

Fowler collaborated with ARCE Professor Brent Nuttall and architecture Professor Jeff Ponitz to add working structural engineers (SEs) from around California to each of the nine design studios. The structural engineers provided students with the latest in structural integration knowledge by showing sample case study projects and reviewing the emerging architecture students' building design projects.

▲ ARCE faculty member and local structural engineer Justin Wolfe offers project input to ARCH students enrolled in ARCE 316: Structural Integration in Architecture.

"We affectionately referred to these industry engineering practitioners as ZoomSEs because the iterations with the design studio were primarily via Zoom," said ARCE Department Head Al Estes. "In a stroke of genius, Tom was able to bring five of the nine ZoomSEs to campus for an afternoon hands-on workshop with 150 students from nine sections of design studios. All third-year architecture faculty and many of the ARCE faculty who teach ARCE 316 participated in this session.

"This was a massive structural system/building design critique in which structural engineers shared their knowledge and best practices," Estes continued.

The visiting SEs wrapped up the workshop by highlighting what was successful in a few of the students' projects from each of the design studios.

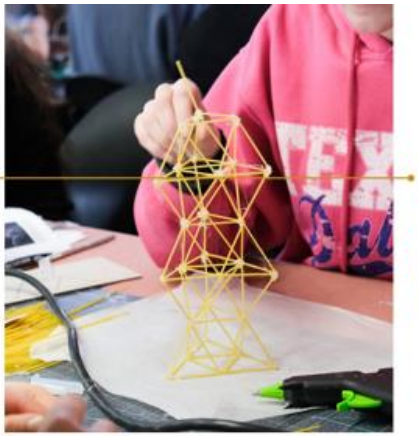
Funding for the course was provided from the 2022-23 College of Architecture and Environmental Design's Teacher and Student Scholar Support Program. ■

▲ ARCH students discuss their model with ARCE Professor Brent Nuttall.

◀ ARCE lecturer Andy Guyader reviews a student team's project.

BUILDING STRUCTURES & RELATIONSHIPS

BY BRIANNA GROSSMAN



"I think it gets students to understand that, you know, collaborations are more than just the project, you should build relationships"

Far Left: Students huddle around their structures as they work to complete the final steps of the project.

Left: A nearly-complete structure as time winds down for students to finish their projects.

Winter 2023 kicked off a new interdisciplinary program for the Architecture Department called "ZOOMSEs," where industry-leading structural engineers guide architecture students in the studio using the video conferencing service Zoom.

The idea to bring in ZOOMSEs was spearheaded by architecture faculty member and program organizer Thomas Fowler, who saw an opportunity to improve collaboration and engagement among student architects and structural engineer professionals. He also wanted to better prepare architecture students with structural system integration knowledge before reaching their spring capstone course.

Fowler began planning summer of 2022 when he asked Alloy Kemp, a façade engineer and vice president at Thornton Tomasetti, if she would be interested in helping with the program. Kemp agreed right away saying she enjoyed working with Cal Poly architecture students because of the program's strong reputation. She also recruited other structural engineers to join the effort.

"All of a sudden, I have all these people emailing me [saying] 'I want to be a part of this," describes Fowler, who was encouraged by the outpour of positive feedback and willingness to engage in deeper interdisciplinary relationships. He was able to hire nine structural engineers, one for each studio.

The studios participating in the ZOOMSEs program were a part of ARCH 352/353 during winter and spring quarter. ZOOMSEs also supplemented material covered in ARCE 316. As students worked on projects in their respective studios, structural engineers telecommuted into the classroom once a week to review their work and give advice. ZOOMSEs also attended in-person sessions to fortify their collaboration with students.

In February, the Architecture Department had its first in-person, studio-wide event. The Berg Gallery buzzed with anticipation as dozens of excited architecture students packed into the room to take their spots with their studios; each table stacked with cutting boards, hot glue guns, X-ACTO knives, drawing tools, digital models and of course, eight ounces of family-size spaghetti.

The spaghetti prologue model workshop — which was initially scheduled for the first week of winter quarter to coincide with the start of ZOOMSEs but had to be rescheduled due to heavy rain storms and flooding — was an introductory warm-up event inviting internationally acclaimed architecture and engineering firm Skidmore Owings and Merrill (SOM). The workshop challenged third-year architecture students to design and build a 13-inch-tall structure using store-bought spaghetti, all in under two hours. Fowler's graduate students who attended the event served as the final judges of the projects.

Following a brief introduction from Fowler, students immediately got to work.

Third-year architecture student Kate Hilgendorf liked the hands-on approach the prologue model challenge provided.

"You can actually test and see designs in real situations and it's just different than modeling something on your computer and assuming it holds up weight," she said.

Not only were students given an opportunity to test their designs, but they also engaged directly with industry leaders who were excited to connect with students.

Dylan Cloonan, third-year architecture student, appreciated being able to get real-time structural engineering advice from the industry experts.

"It's really a lot more impactful, I think, than just learning about it or like seeing it on a screen," Cloonan said. "It really sets us up for success in the future with employers because you always are working with structural engineers."

Collaboration was an essential part of ZOOMSEs for Fowler, who described the process of design as multi-dimensional rather than a "cookie cutter linear process." The process of designing a structure requires people from different disciplines to work together at every stage.

"I think it gets students to understand that collaborations are more than just the project, you should build relationships," Fowler said.

Students witnessed these interdisciplinary relationships firsthand from SOM partners Mark Sarkisian and Leo Chow, who were at the event offering advice and gave the keynote speech. Both Chow and Sarkisian have worked together for years, and as Fowler importantly noted, the respect between the two has allowed for more seamless collaboration.

Eric Long, a structural engineer and partner at SOM in San Francisco, echoed the sentiments of fruitful collaboration with architecture students over Zoom.

"I really enjoy working with students and being able to hopefully bring a sense of both curiosity and awe to the design process," Long said.

Long noted understanding the types of questions or suggestions that may come up from other disciplines during a project are a valuable skill practiced in these workshops.

The prologue challenge ended excitingly as students observed their classmates perform load tests with bricks and weights. The most successful structures held up as many as three bricks, while others were crushed holding one — both outcomes prompting loud cheers from onlookers.

Several students, like Hilgendorf and Cloonan, left with a greater awareness of how interdisciplinary relationships play out in real time.

"You can't just have an architect, you can't just have an engineer, you need to have both, and you need to have the mindset of both," Hilgendorf said.

Another in-person event in April welcomed five of the structural engineers to meet with all third-year architecture students face-to-face and offer guidance on their projects. The engineers gave introductions to all the combined studios, then broke off to consult with students and do comprehensive reviews. With the ongoing help of the ZOOMSEs, architecture students worked through the rest of spring quarter to conclude their projects.

ZOOMSEs served as proof of concept as to why structural engineer and architect relationships are essential to the design and building process. Considering that Cal Poly's Architecture Department originated from the Architectural Engineering Department, the ZOOMSEs, as Fowler notes, brought architecture students back to the program's founding principles.

Structural Systems Conceptualization

WARM-UP ASSIGNMENT
PROLOGUE MODEL

Structural Systems Conceptualization
[Initial Agnostic Approach to Materials]

WARM-UP ASSIGNMENT

PROLOGUE MODEL

OBJECTIVE
The act of construction at its most fundamental level is one of lifting and supporting a mass above the ground. Whether this is for a sheltering roof, a raised platform offering a vista, or multiplying floor areas, the challenge for the architect/engineer is to accomplish this with the minimum expenditure of material and maximum artistry and functionality. For this exercise, you are to design a structure to support a standard American construction brick (3-5/8" x 2-1/4" x 8"; 4.5 lbs.) that is 18 inches tall.

This task must be expanded beyond the functional to incorporate a design idea, tectonic requirements, and craft. The design idea not only emphasizes the aesthetic, but also becomes the driver for how all decisions are made.

FOUR CRITERIA FORM THE BASIS OF EVALUATION
• Concept - Is there an idea that goes beyond simply supporting the brick that may engage the viewer to contemplate the structure more deeply?

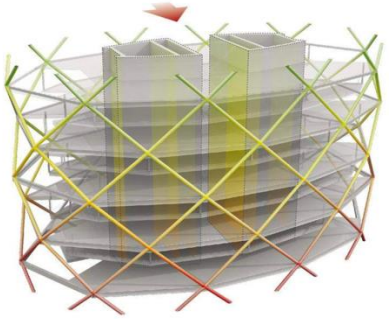
• Aspect Ratio - Proportion is a significant consideration in the aesthetic evaluation of an object. Here, it is measured as:
the Ratio = Height ÷ Base Width. Measures both delicacy vs. robustness (esthetics)

• Weight - It also causes efficiency, an important measure of resource use:
weight supported ÷ weight of structure

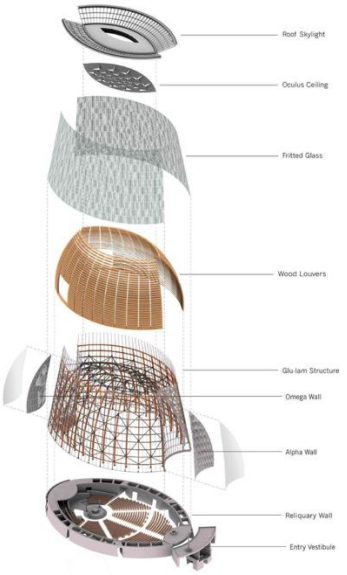
• Story - What is the BIG design idea of your project? What is the source of your BIG IDEA (nature, etc.)

Lectures + Readings

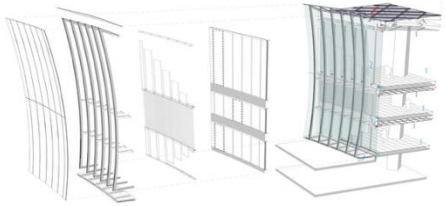
Lectures [Selected Highlights]



SOM's Poly International Center

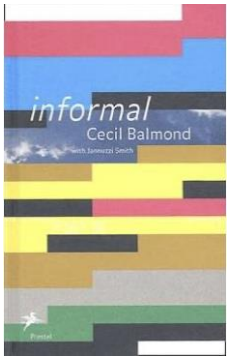


SOM's Christ the Light

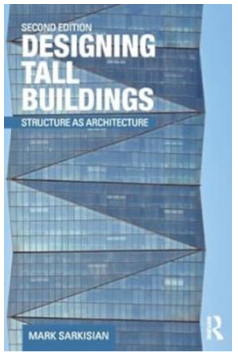


Thornton Tomasetti, Cladding System Layers (Secondary / Tertiary Structural Systems)

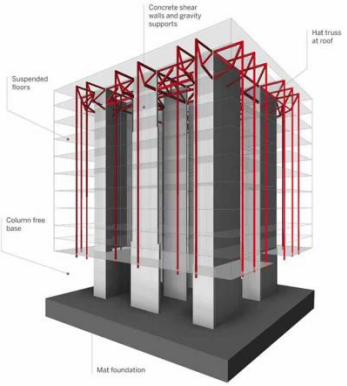
+ Readings + 3D Conceptual Structural Diagraming Example



Balmond

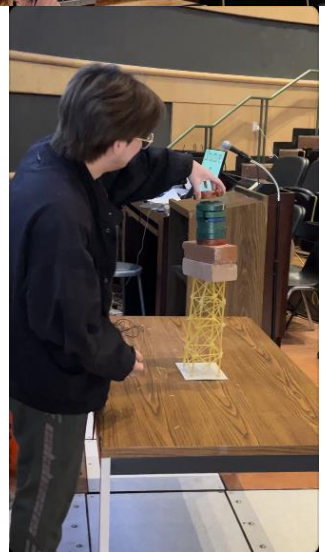


Sarkisian



Long's Lecture (SOM's Courthouse, LA)

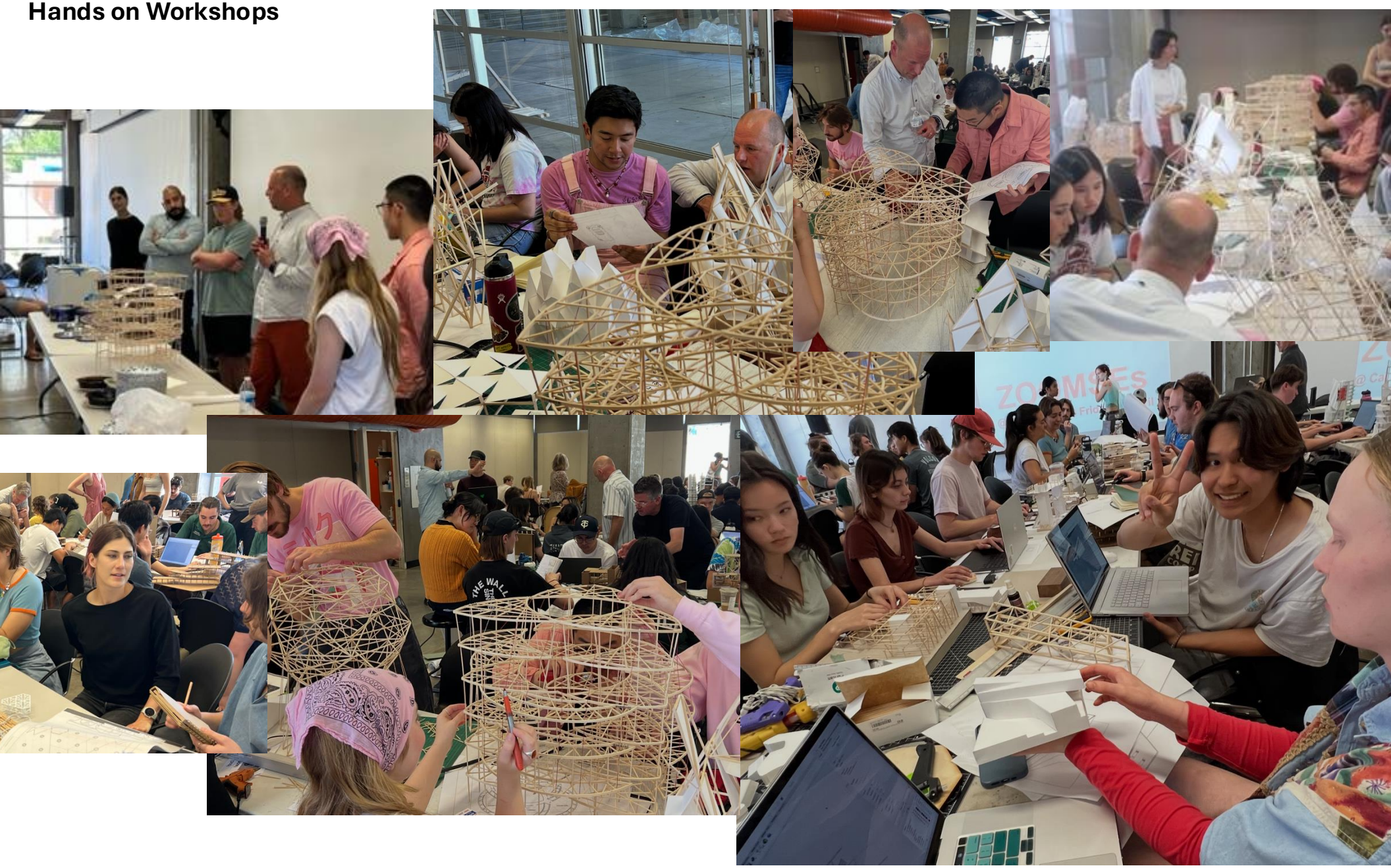
Interactive Lectures (live weight testing / discussion)



POETIC TECTONICS
STRUCTURE = ARCHITECTURE

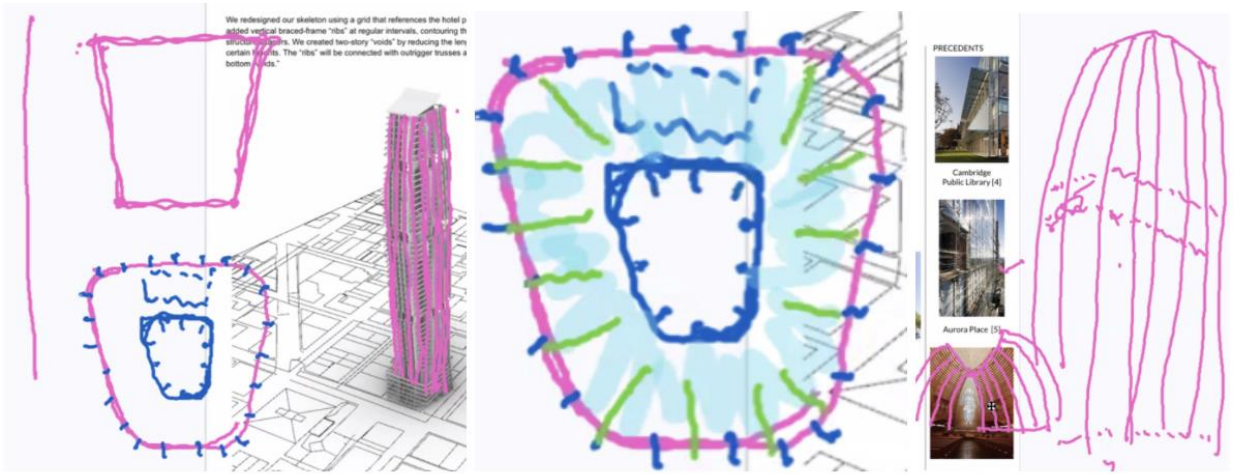
Introductory Lecture by SOM/SF:
Mark Sarkisian, SE, Partner
Leo Chow, FAIA, Partner

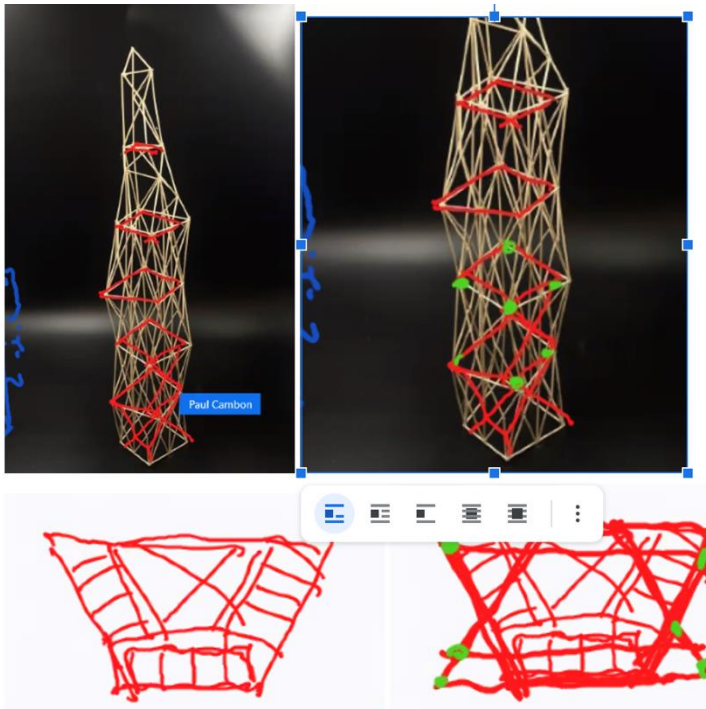
Hands on Workshops



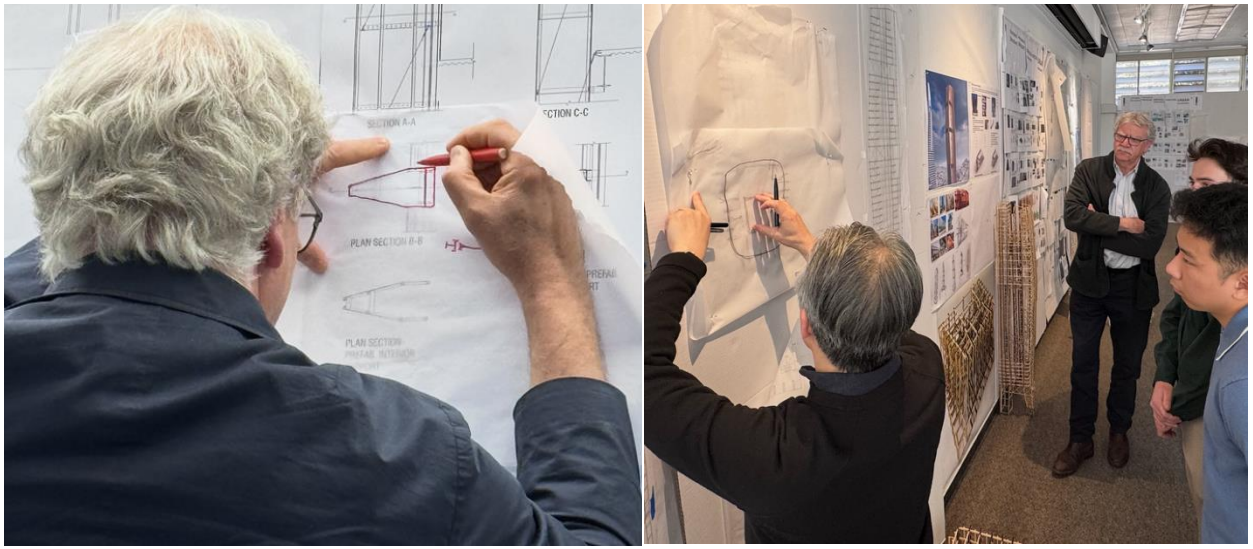
The Importance of Engineers Drawing with Architecture Students online and in person

Online Sessions





In Person



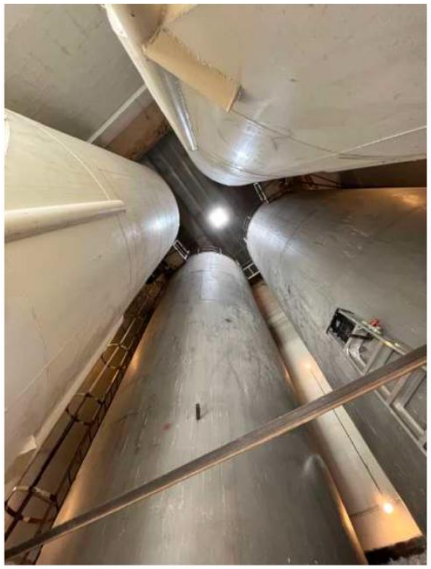
Sample In Person Review and the Importance of Drawing

[(left bottom image) Mark Sarkisian, SE, Partner SOM/SF ; (right bottom image) Leo Chow, FAIA, Partner SOM/SF (w/ Mark S in the background with students]

Student Work Samples
[All the work samples that follow were completed over the double quarter winter & spring 2024]

Project Title: Former Bread Factory Inspired Artist Housing [USA, San Diego, CA]
Winter / Spring 2024
[Student Work Highlights from Professor Thomas Fowler's Design Studio]

160 students total in 8 sections of design studio, each taught by an architecture instructor who was able to work with a teaching assistant from the architectural engineering department (most were graduate masters student with a few that were in the 4th year of program



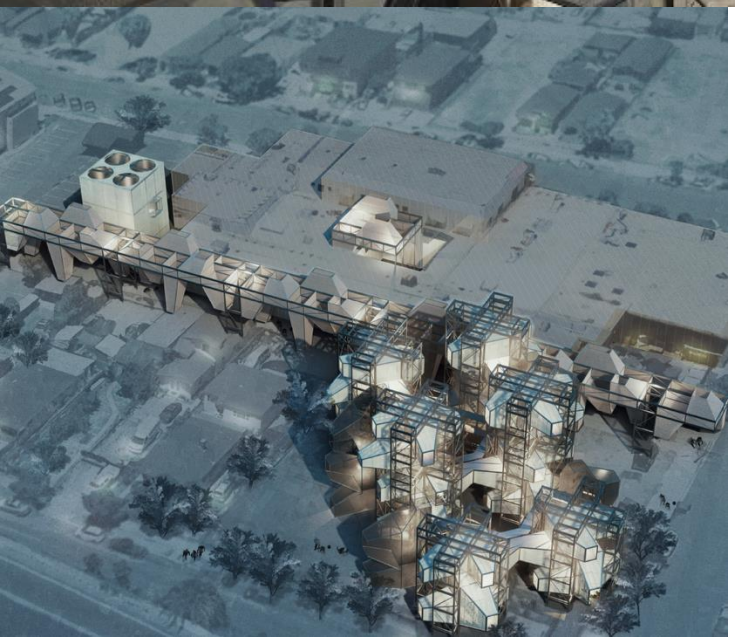
Bread Baking Cylinders

Facility

Context (Over Head Freeway)

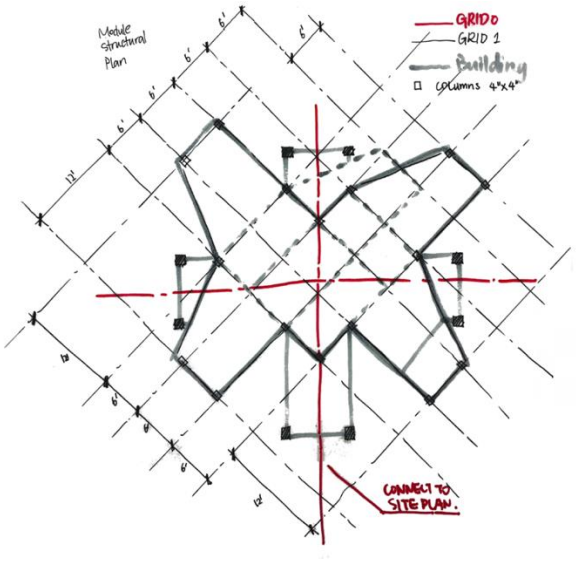
Student Work Samples [Final Outcomes w/ Design Process Documentation]

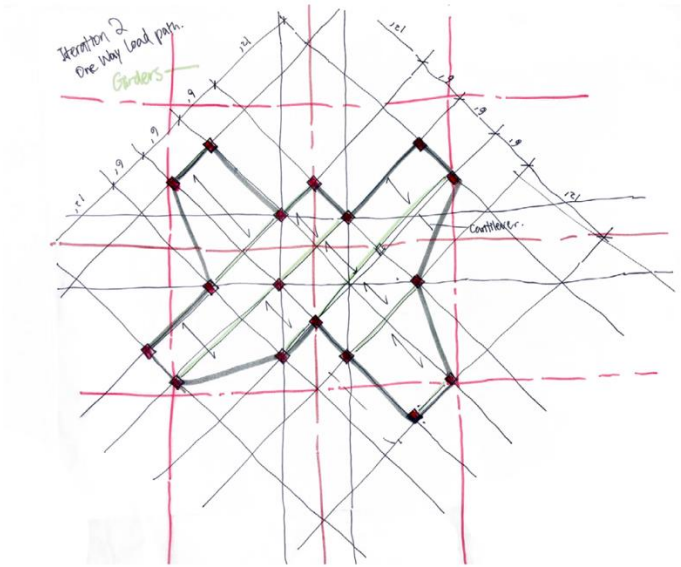
EXOSKELETON FRAME: Hanging Truss Boxes
Student Team: Rovinsky & Wu



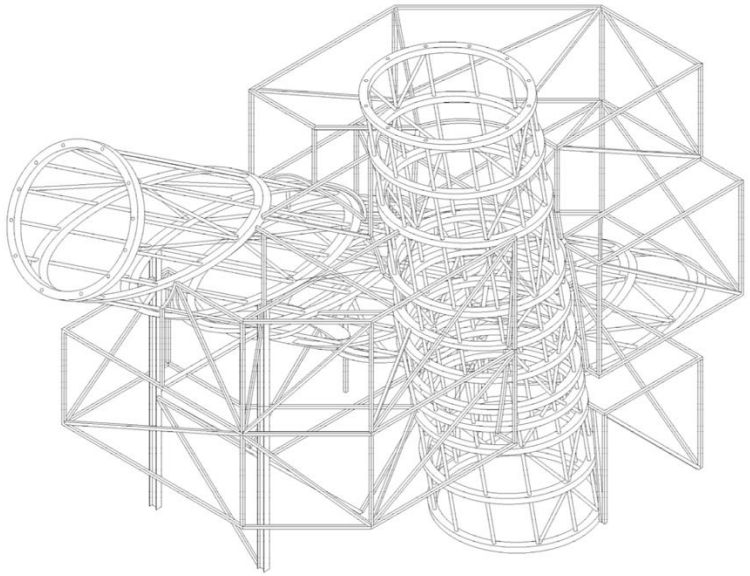
CELESTIAL SILOS: Tube Trusses
Student Team: **Nordstand** & Bouhadana

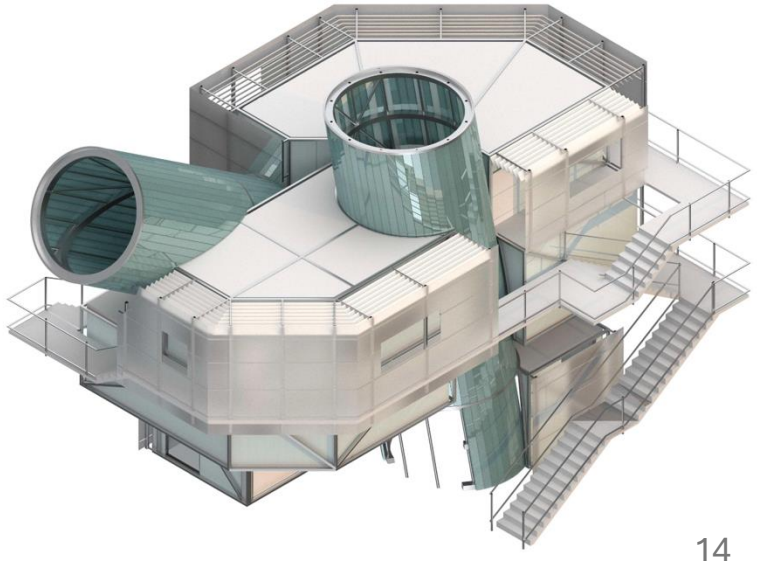
EXOSKELETON FRAME: Hanging Truss Boxes
Student Team: Rovinsky & Wu



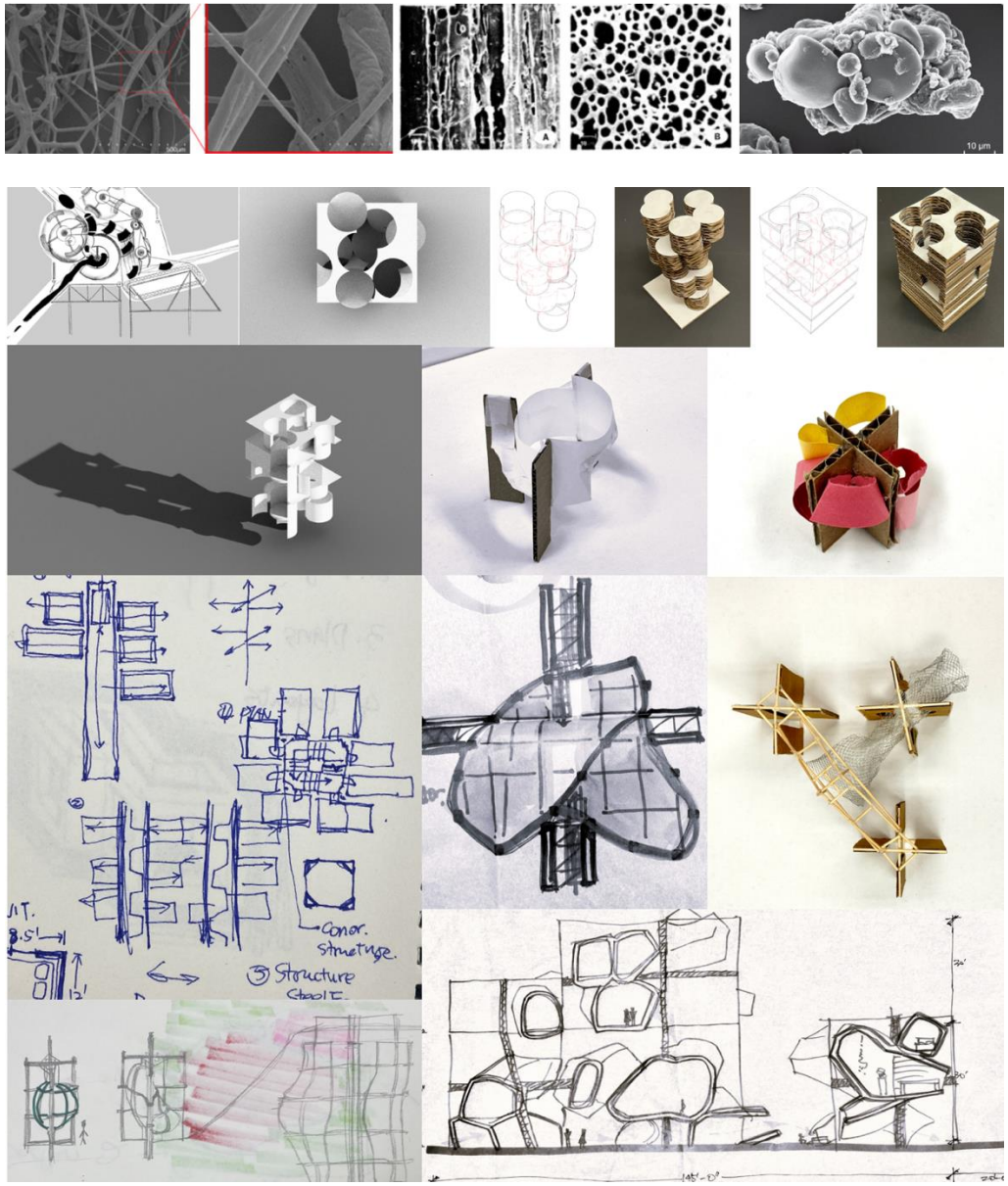


CELESTIAL SILOS: Tube Trusses
Student Team: Nordstand & Bouhadana

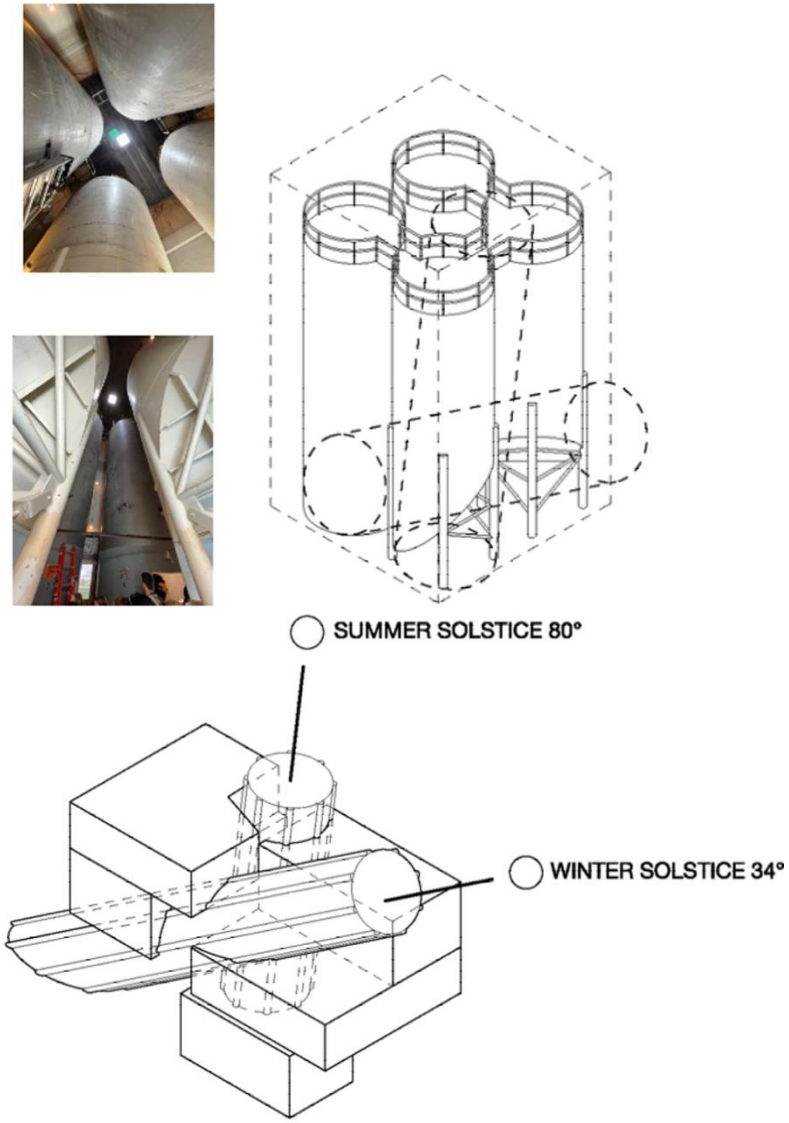




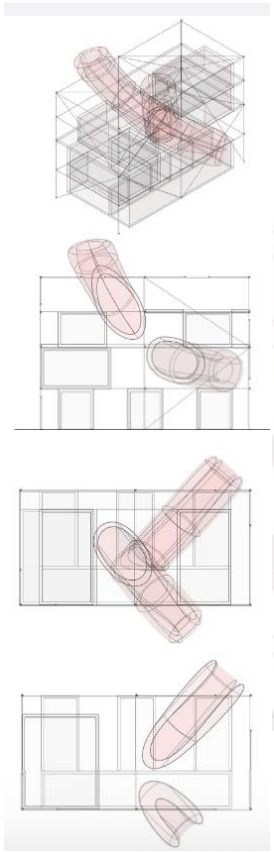
EXOSKELETON FRAME: Hanging Truss Boxes
Student Team: Rovinsky & Wu

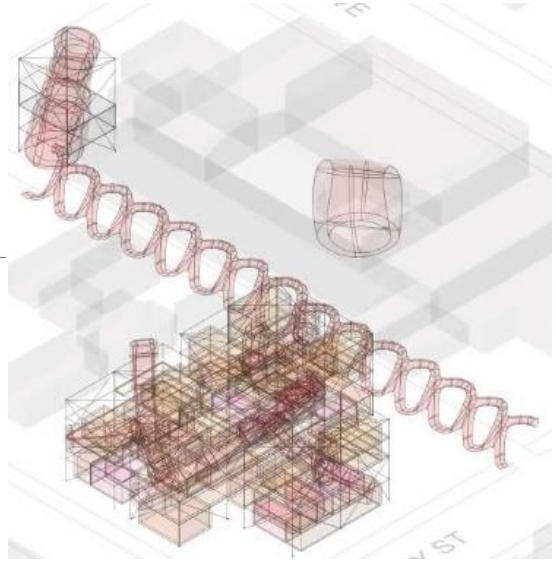


CELESTIAL SILOS: Tube Trusses
Student Team: Nordstand & Bouhadana

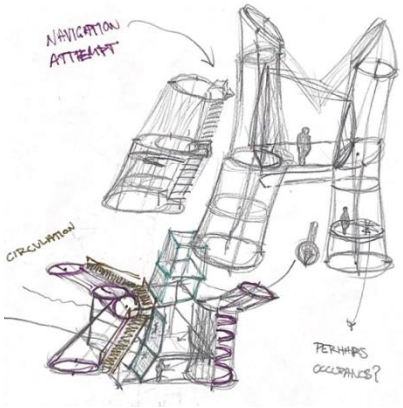


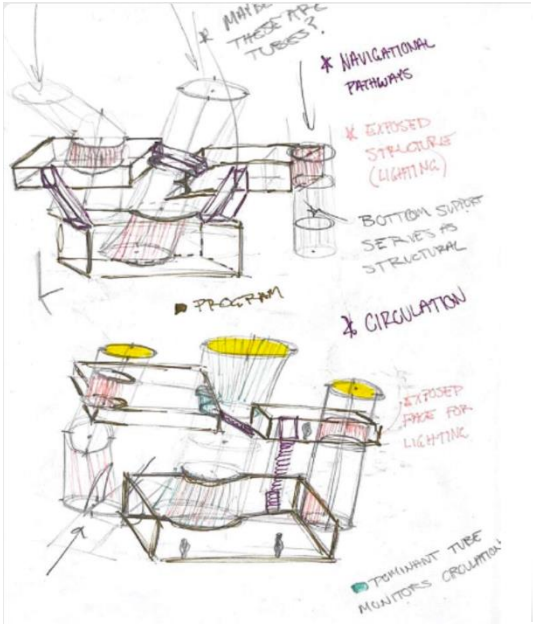
EXOSKELETON FRAME: Hanging Truss Boxes
Student Team: Rovinsky & Wu

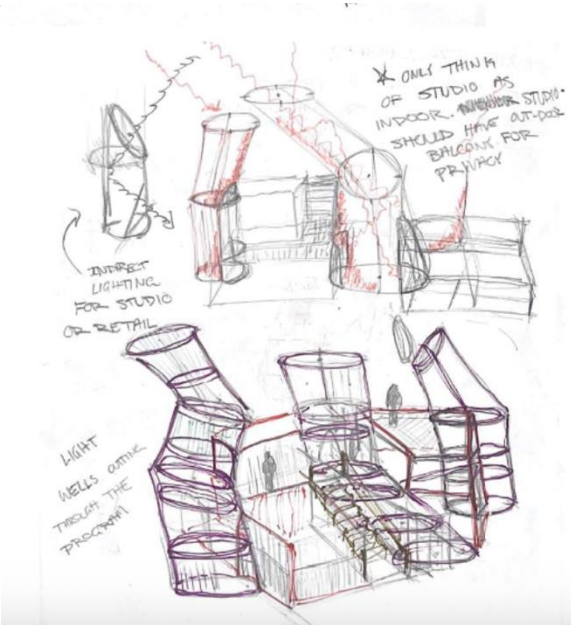




CELESTIAL SILOS: Tube Trusses
Student Team: Nordstand & Bouhadana

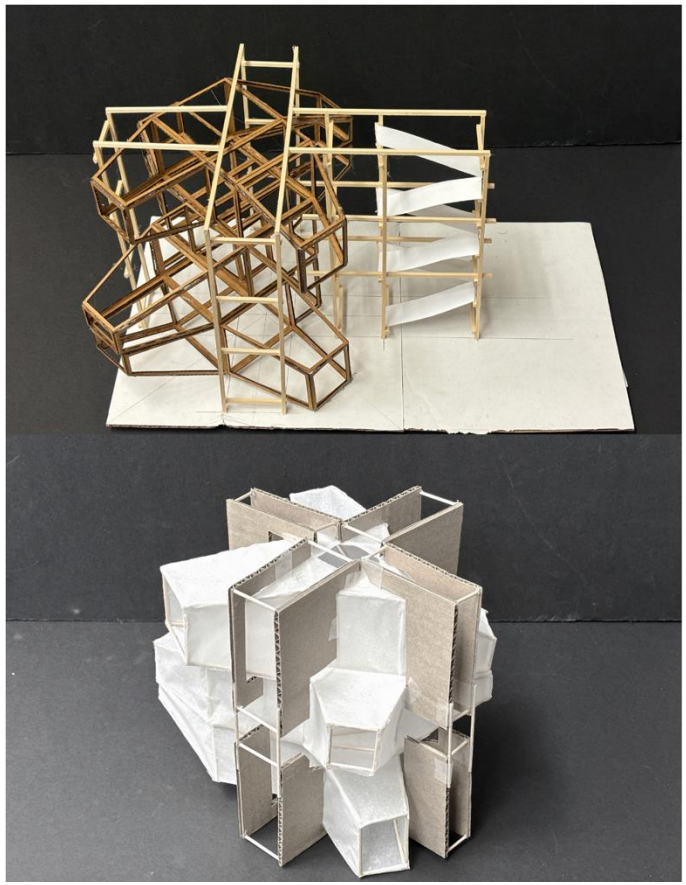


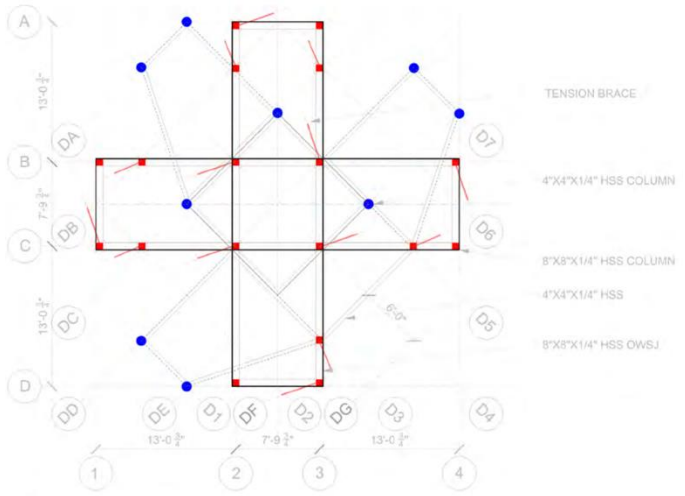




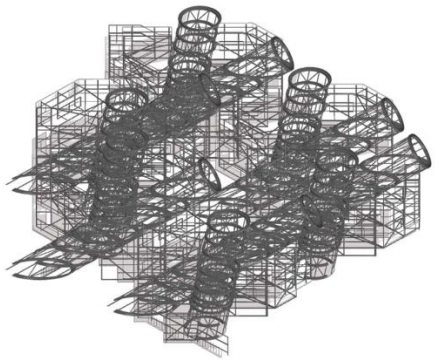
Student Work Samples [Design Development]

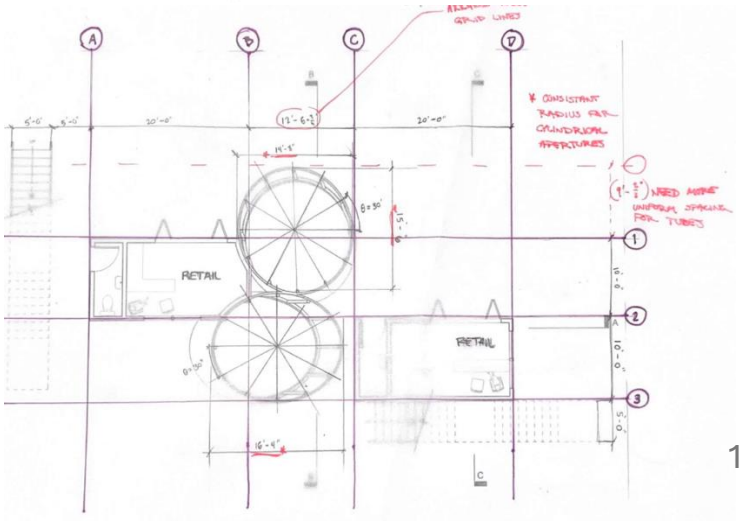
EXOSKELETON FRAME: Hanging Truss Boxes
Student Team: Rovinsky & Wu





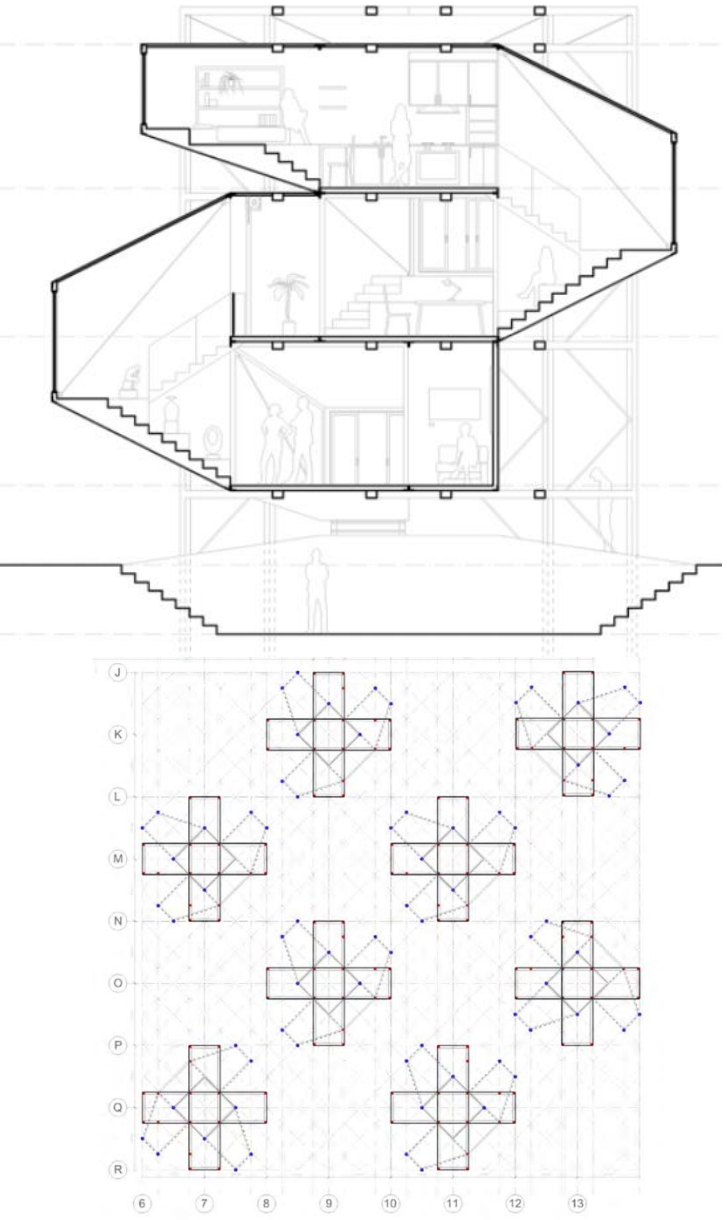
CELESTIAL SILOS: Tube Trusses
Student Team: Nordstand & Bouhadana



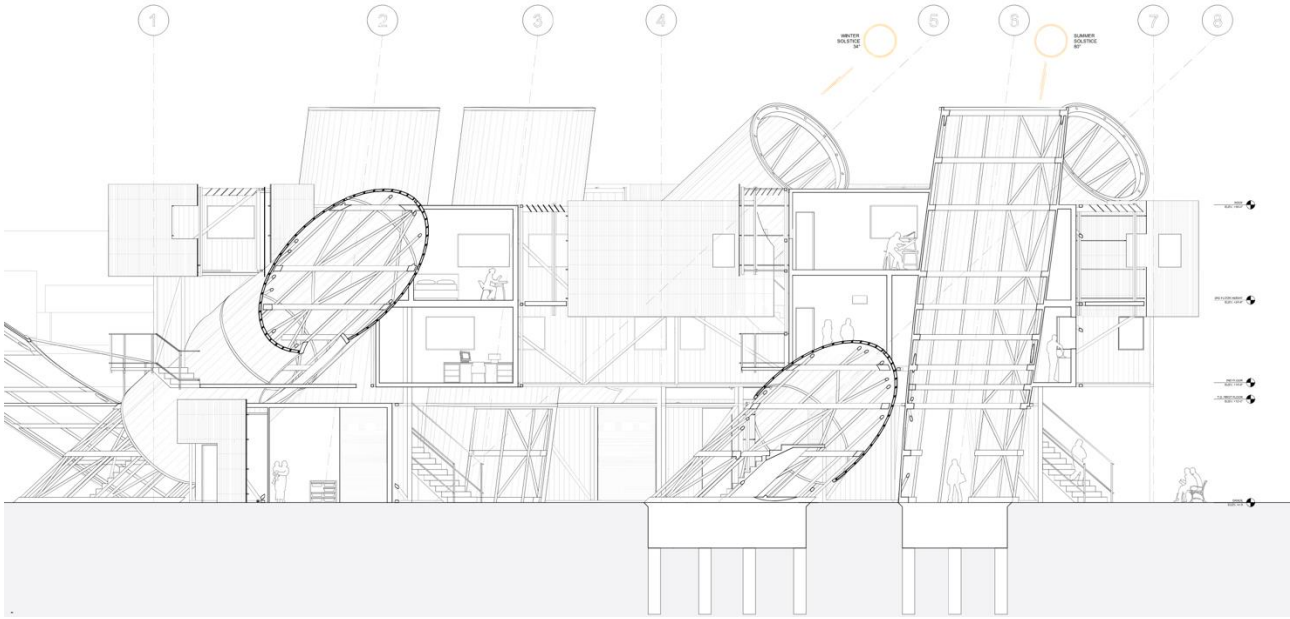


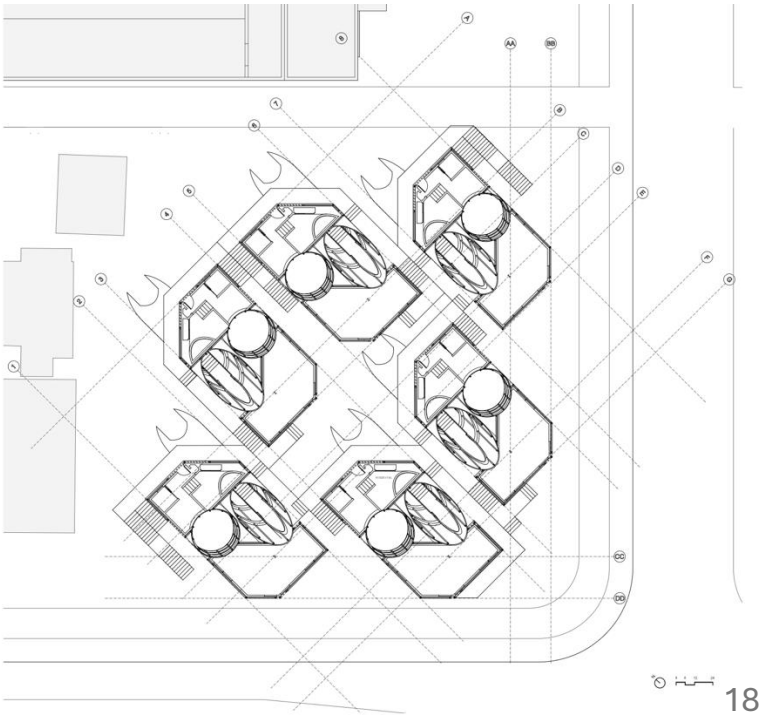
Student Work Samples [Design Development Showing Vertical Cross-Sections & Plans]

EXOSKELETON FRAME: Hanging Truss Boxes
Student Team: Rovinsky & Wu



CELESTIAL SILOS: Tube Trusses
Student Team: Nordstand & Bouhadana





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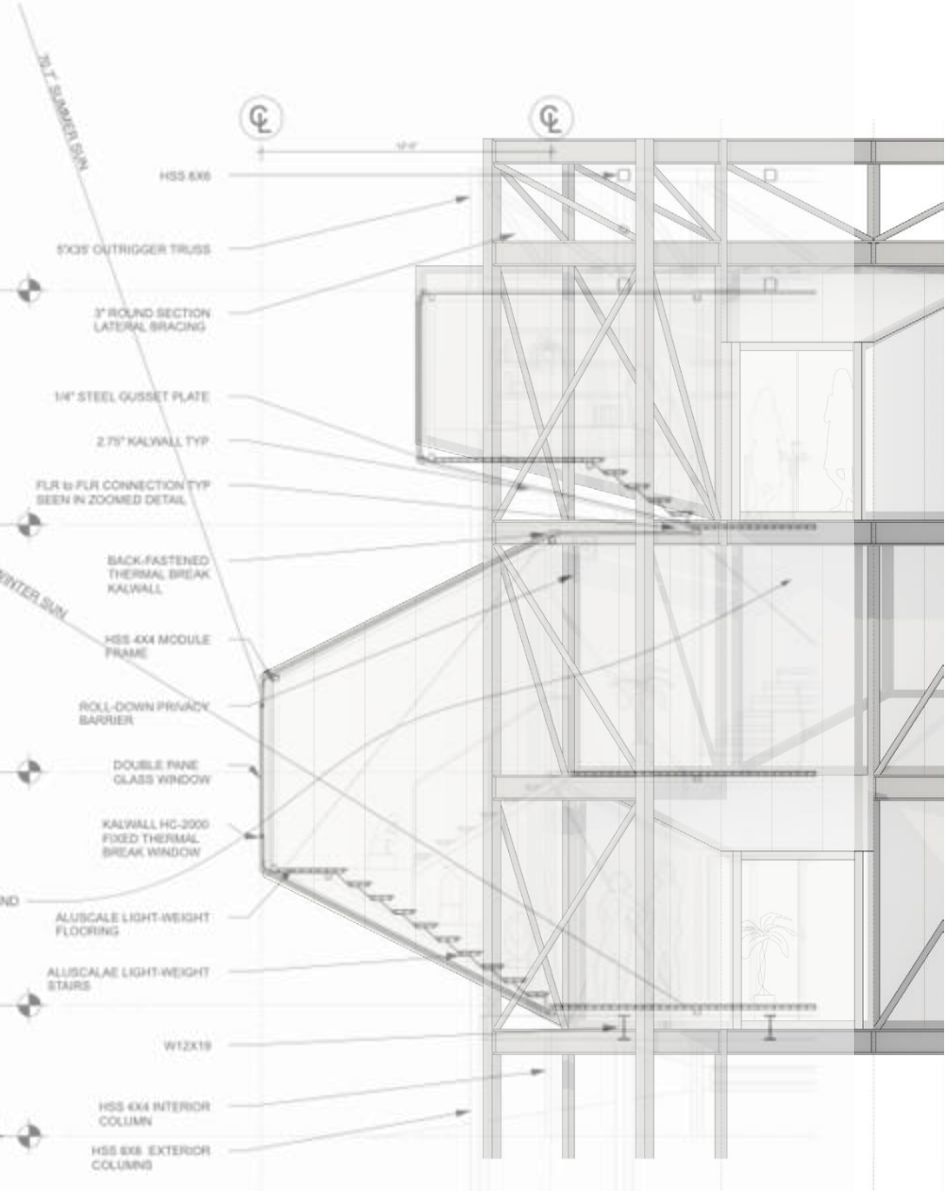

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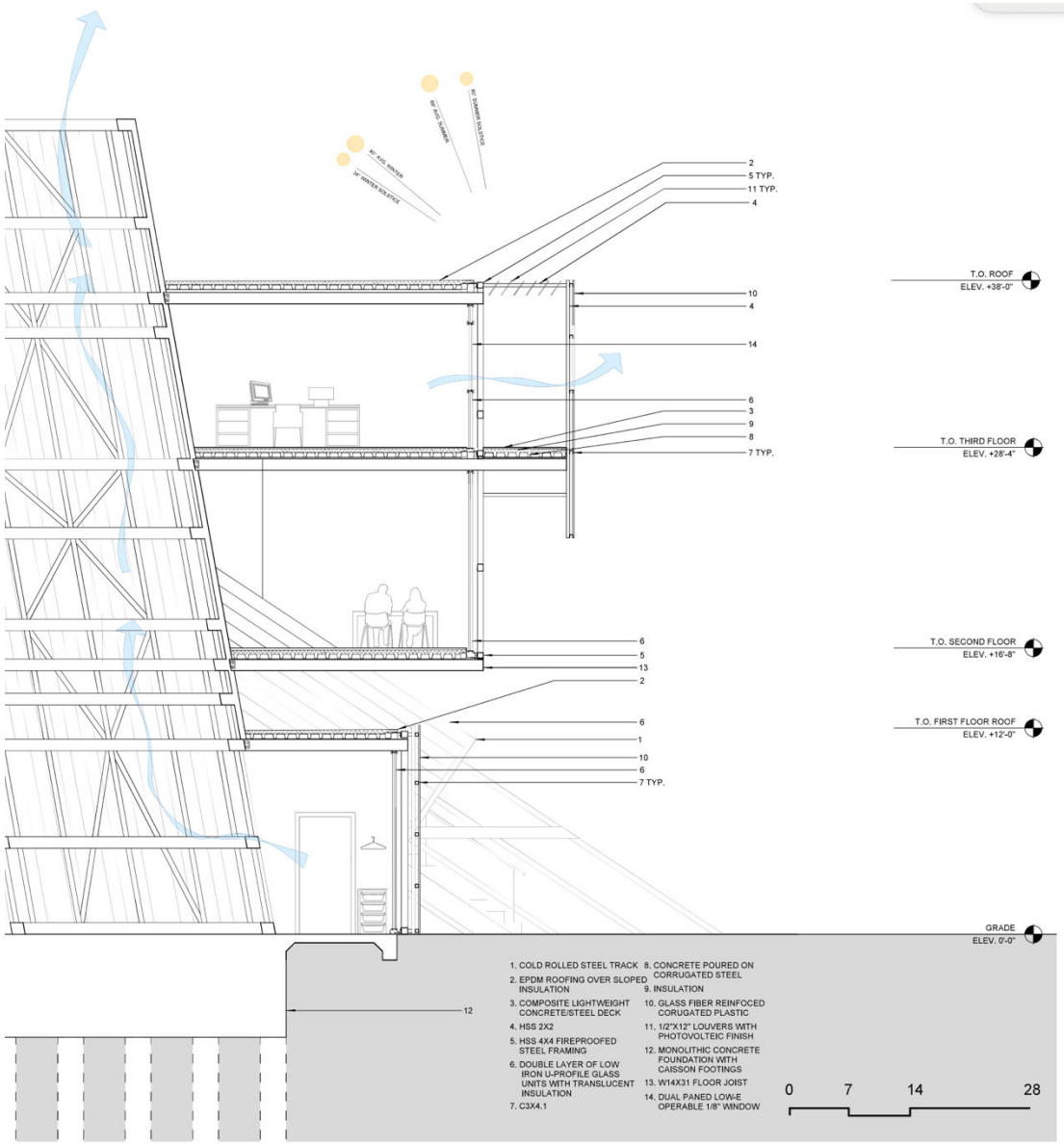

Kudos
Many thanks to architectural engineering & architecture department heads, faculty & students, teaching assistants and the generosity of the numerous consulting structural engineers (ZoomSEs) who went well beyond their initial time commitments to test these prototype teaching models, and working around their hyper busy international travel schedules and deadlines.

A big surprise from a number of SEs that we worked with, they saw value in this interdisciplinary collaborative process since an opportunity for getting newly hired structural engineers involved with the design review discussions with architecture faculty and students to improve their understanding and appreciation for the collaborative process with architects on multi disciplinary teams in their actual project work.

Take Aways and Next Steps

Take Aways
Teaching structures in the context of the other building design components and systems is vitally important, since this projects provide the actual real-life context for integration. Stand alone structures courses do not make sense in terms of applying systems thinking to projects.

Working with structural engineers that enjoyed the iterative back and forth with drawing exchanges with students during the building design process (architecture students loved this part of the consultations) dramatically improved the confidence level and excitement of the students which elevated the level of advanced structural systems integration.

Linking the conceptual story of project design helped to focus the evolving structural system to be an integral component with the design of the building and overall parti.

Students enjoyed the real-time story telling from the perspectives of the engineers on the creative collaborative approaches with architects in practice, since architecture students only know and hear from the side of architects (who rarely, if ever talk about the engineer's role).

Next Steps
Currently the department, with the leadership of the department head Mark Cabrinha, is continuing to refine and improve the structures consultancy model, based on lessons learned from these 2 years of prototyping. In addition, exploring the expansion of this Zoom consultancy model to the other disciplines that architects collaborate with on building systems integration (i.e., mechanical engineers, landscape architecture, etc.)