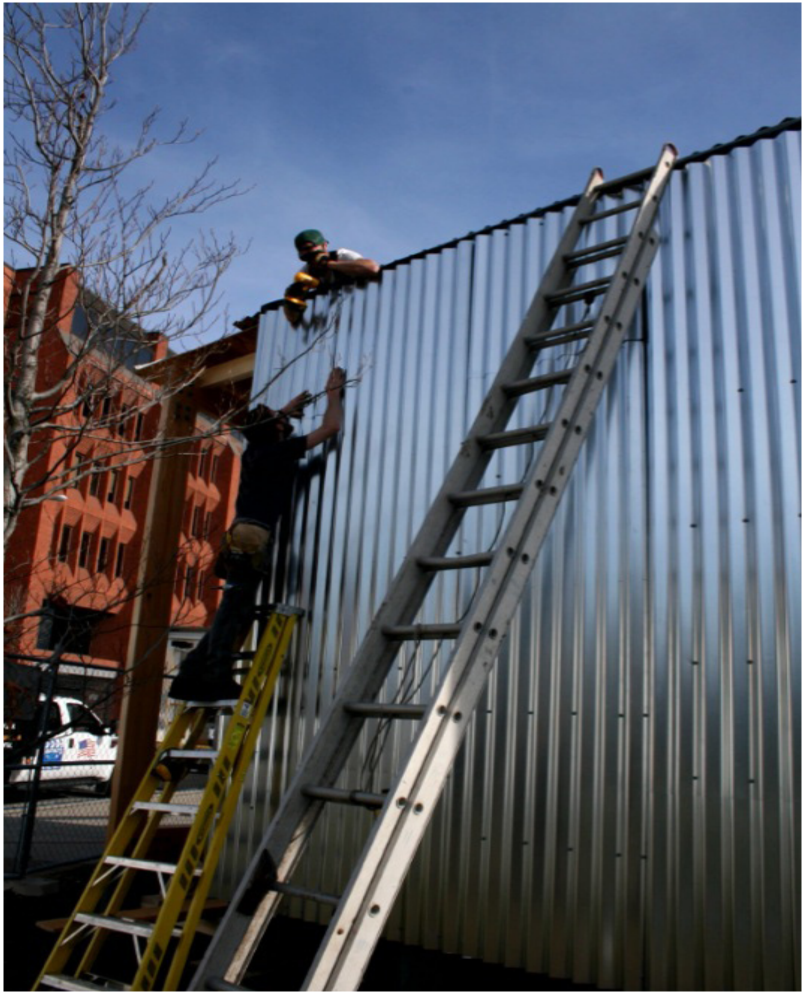
The RISD-Brown Solar Pavilion
Providence, Rhode Island

The Rhode Island School of Design

Portfolio

By

Raymond Gabriele



Above: Corrugated metal sheathing installed on North facade of Solar Pavilion

Table of Contents

Project Team

Project Team

Rhode Island School of Design, dept of Architecture ....Architect

Brown University, dept of engineering...M.E.P Engineer

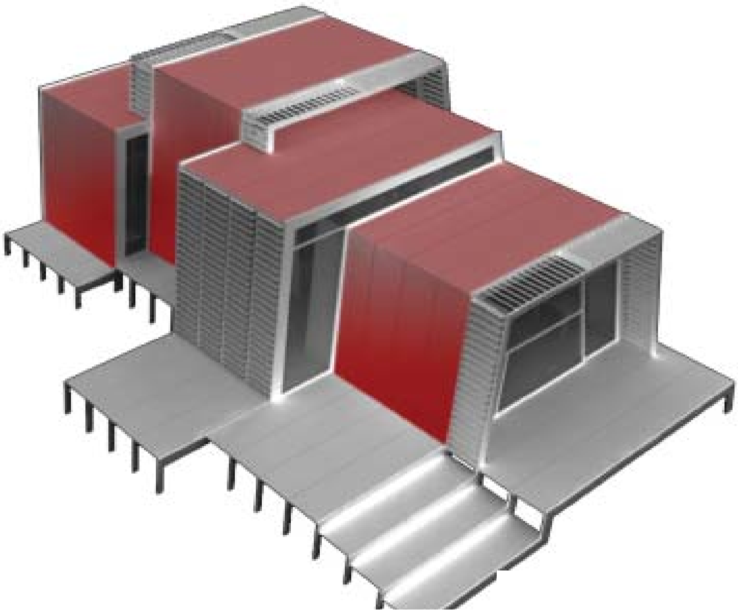
Viessmann...M.E.P. & Technical Consultants

Wilbur Yoder P.E. ....Structural Engineer

Jonathon Knowles R.A. ....RISD Coordinator

Christopher Bull.. Brown Coordinator

Background & Context



Background

Originally created as a studio course for the National Renewable Energy Laboratory's Solar Decathlon Competition in Washington DC, the RISD Solar program has since grown into a collaborative workshop between RISD's Department of Architecture and Brown University's School of Engineering. By working off of earlier conceptual designs for solar-thermal enclosures, the workshop has become focused on designing and building an off-grid, solar thermal pavilion built entirely of a custom fabricated rib and panel system.Taking advantage of both passive and active conditioning strategies, the RISD-Brown Solar Pavilion is intended to be erected as an inspiring proof of concept, to stoke both public awareness and interest in sustainable design while also serving as an invaluable learning and fund-raising tool for both schools to take advantage of.

Top Left: Model diagram of Solar Skin House illustrating solar thermal panel envelope
Bottom Left: Model diagram of Solar Skin House illustrating release of stored thermal energy.

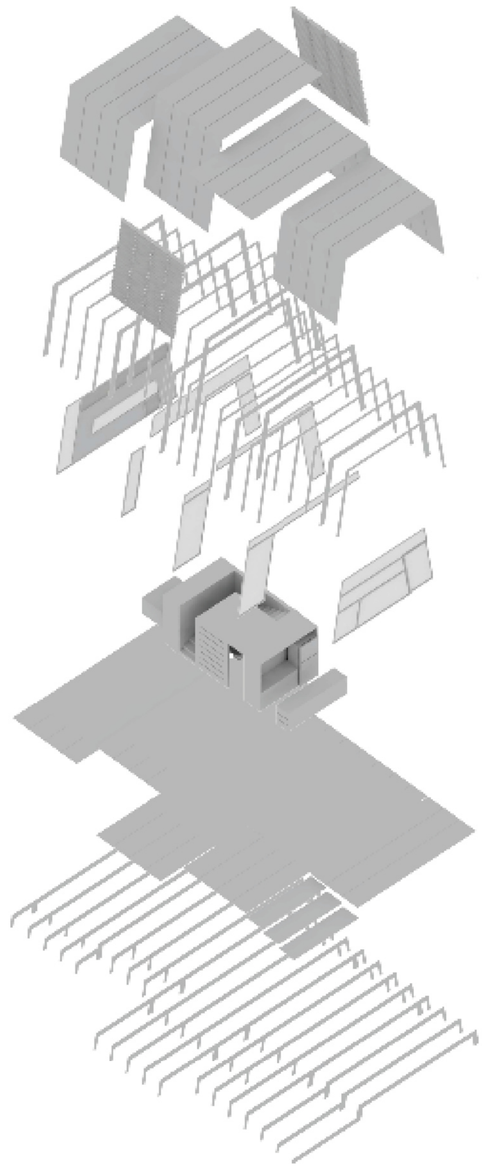
Early Precendents

The Solar Skin House

The Solar Skin House is a heroic, and ground-breaking proposal for the Department of Energy's 2009 Solar Decathlon Competition. Designed around the program's three most fundamental principles of efficiency, transportability and flexibility, the house introduces an entirely new way of thinking about and designing solar powered buildings.

Composed of four trapezoidal volumes, the Solar Skin House pioneers revolutionary solar-thermal technology in a schematically efficient and formally engaging way. The Solar Skin House is the result of the development of the industry's first fully integrated construction-energy system. The house's solar thermal panels clad and enclose the entire house, taking advantage of both direct and ambient solar energy to generate power for itself.

The four distinct modules are canted outwards to expose the entirety of the panel wall to the sun, to increase the panels' absorptive efficiency. The house's open plan is designed to maximize both passive and mechanical conditioning and lighting strategies, and with no interior partitions, the scheme encourages both effective cross-ventilation, and top-lighting from the clerestories revealed between the modules' connections.



Right: Exploded Axon illustrating how the four trapezoidal volumes are assembled with a custom rib and panel system

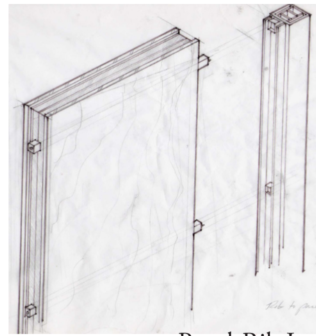
Designing A Solar Envelope

Much of this project was spent investigating, and developing an entirely new type of solar-thermal technology -- one that would promise to be the industry's first fully integrated construction-energy system.

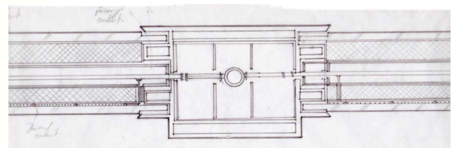
The design of the Solar Skin House involves using the structure's exterior finished surfaces as the system's solar-thermal collectors, absorbing both direct and ambient radiant solar energy through a laminated, thermally conductive substrate, that would transfer the absorbed energy to a heat sink underneath the house. The stored energy would then be used to heat a closed-loop system of glycole solution, that would effectively power a hydro-electric turbine.

The house's solar-thermal panels (illustrated to the right), have been conceived of as having a rigid transverse member running the width of the panel approximately every three feet in length and extending approximately 3 inches beyond the panels finished width. This member would serve as the panels's connection to the building's structural rib system and the conductive intermediary between the panel's absorptive surface material as well as the structure's thermal delivery conduit into the heat sink.

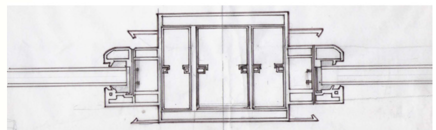
Right: Conceptual panel-rib assembly sketches



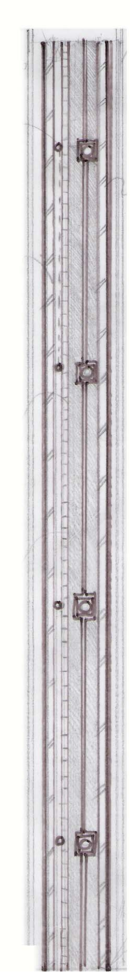
Panel-Rib Iso.



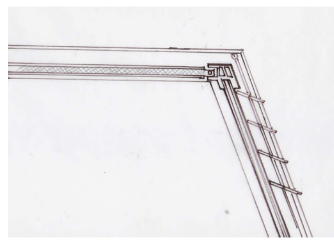
Panel to Rib Detail



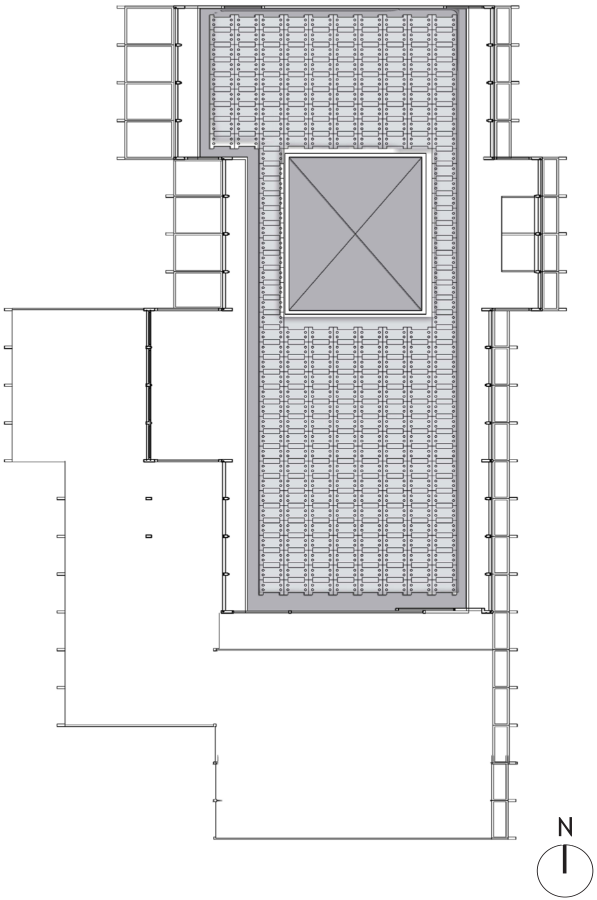
Glazing to Rib Detail

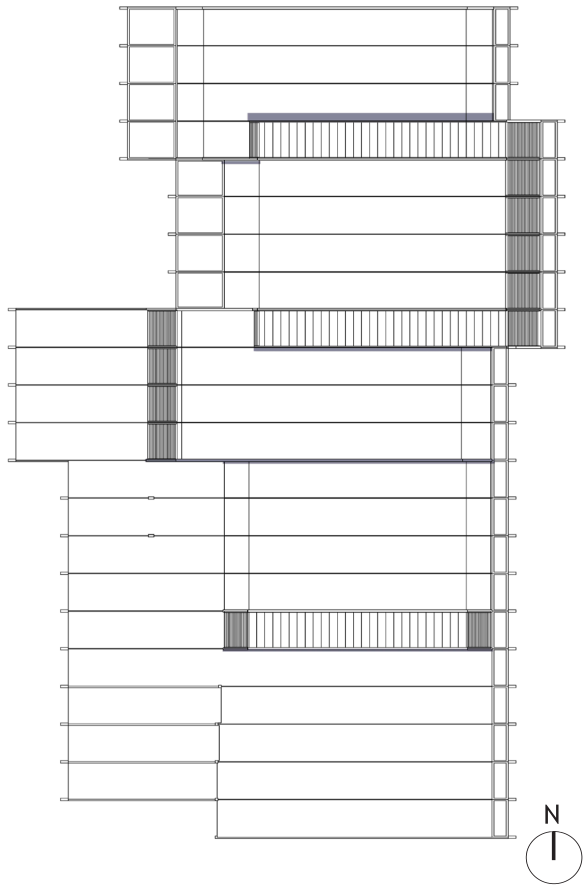


Panel Cross Section

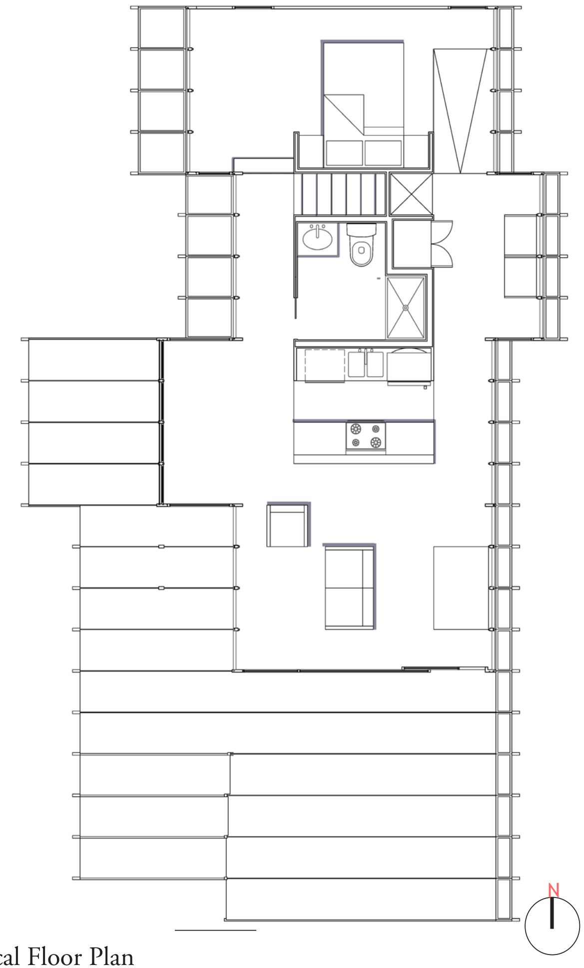


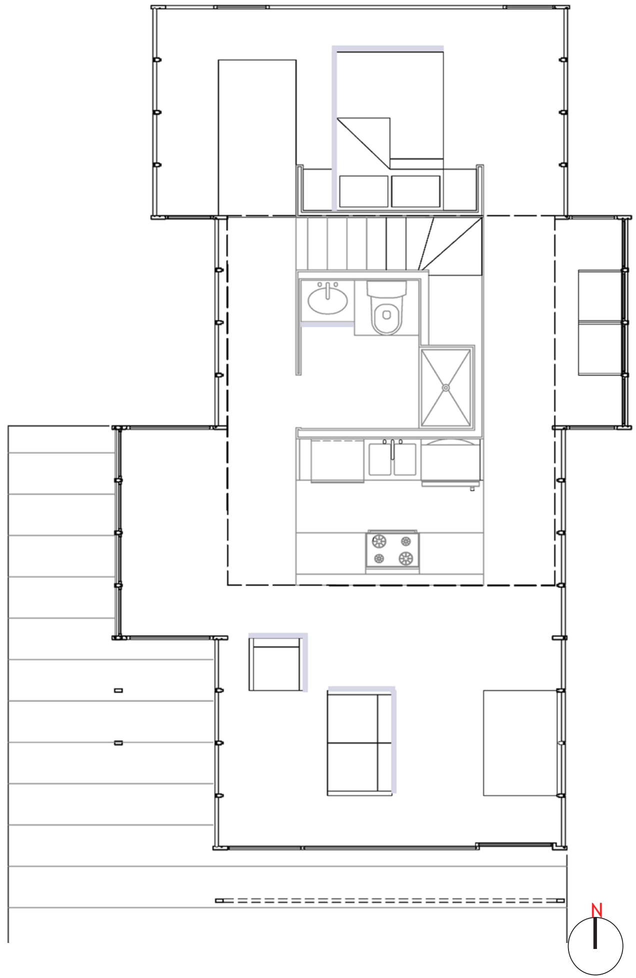
Louver-Rib Section





Left: Foundation Plan, Showing location and quantity of saline bricks
Right: Roof Plan

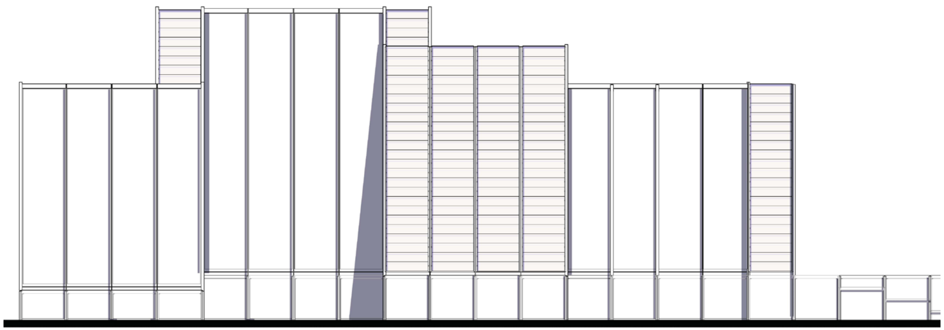




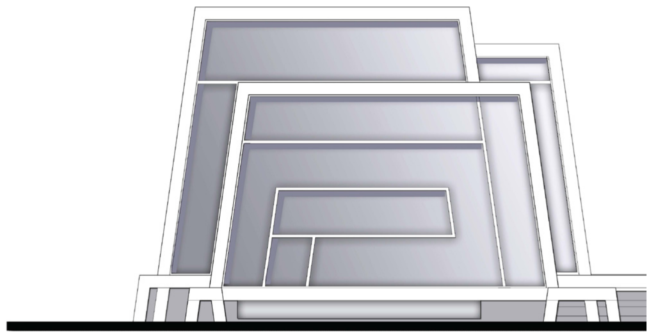
Left: Typical Floor Plan
Right: Two Bedroom Floor Plan

East Elevation

North Elevation



West Elevation



South Elevation

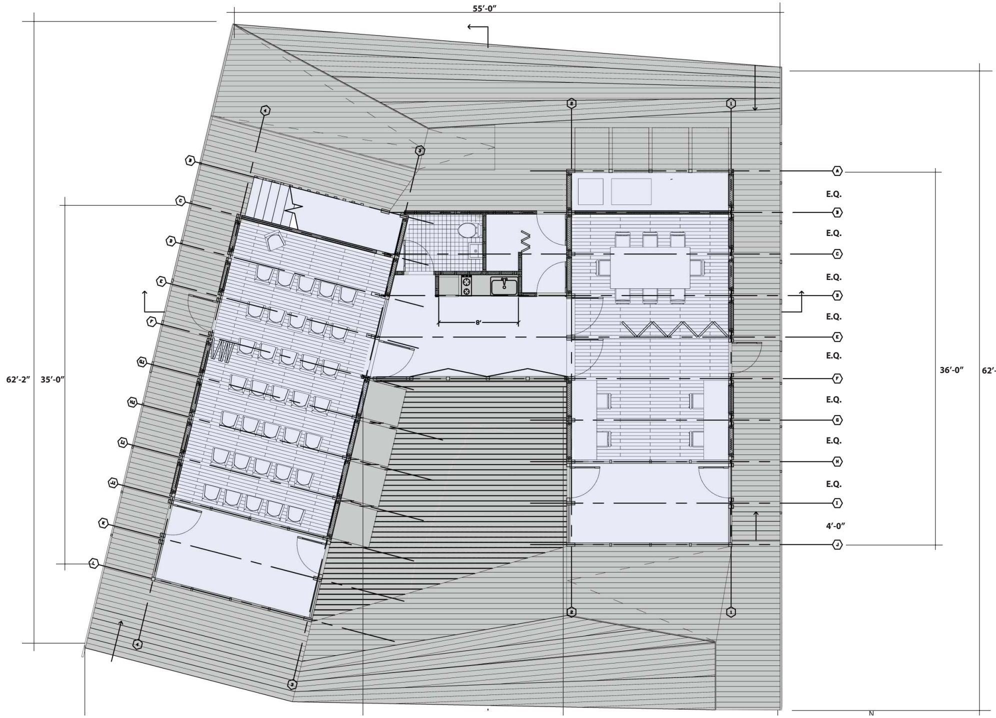
Rendering of Southern Exposure

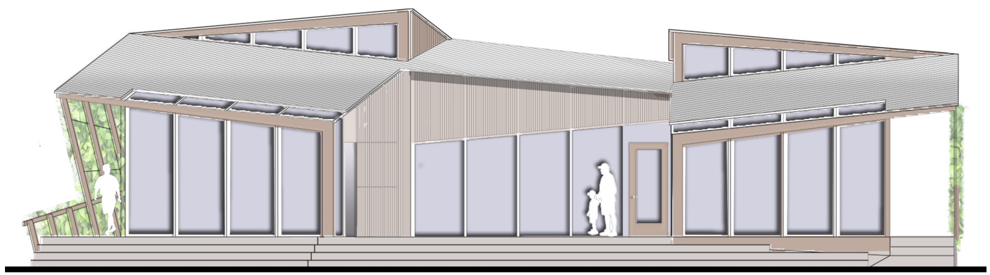
Re-Programming Conceptual Precedents

The Pardon Grey Learning Center

Building off of both the tectonic and aesthetic typologies of the Solar Skin House, the project eventually grew in both scale and complexity with the generous patronage of the Tiverton Land Trust, a nonprofit property trust in Tiverton Rhode Island which had expressed great interest in bankrolling the research and development of the Solar Skin House in order so that the building might be realized and utilized as an inspiring community learning center in Tiverton.

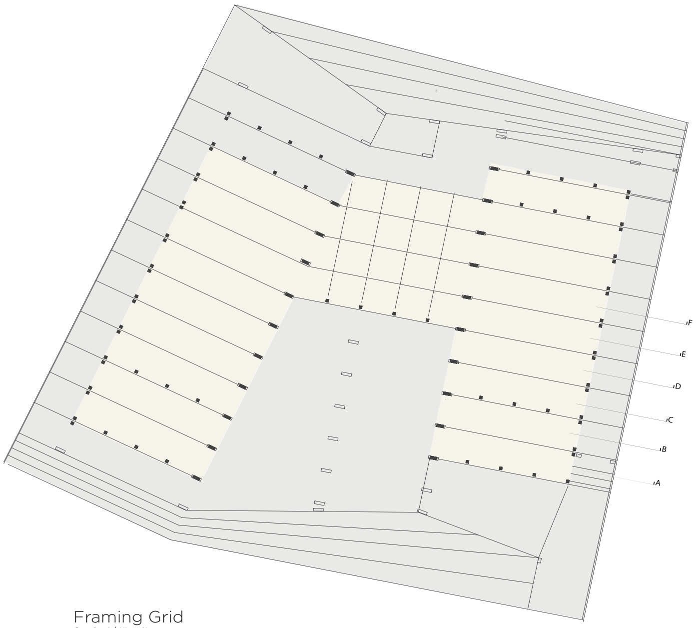
Working off of the same basic structual rib and absorptive panel system as the Solar Skin House, the design for the Pardon Grey Community Center appropriated the panelized volumes of the Solar Skin House, into a compelling courtyard scheme made of much larger volumes. The new scheme was designed to accomodate two classrooms, office space, a perfomance kitchen, bathroom, and outdoor learning/ gathering spaces. Together with the uniquely reconsidered rib-panel system and innovative use of more conventional passive conditioning strategies, the Pardon Grey Community Learning Center came together in a promising and exciting potential proof of concept.



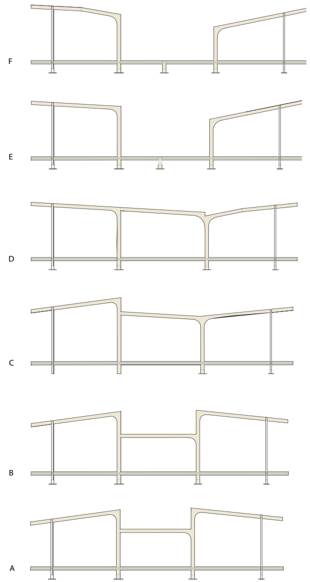


Top Right: Proposed Floor Plan
Bottom Right: Proposed South Elevation

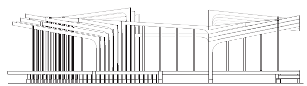
Rendering of Proposed Southern Exposure



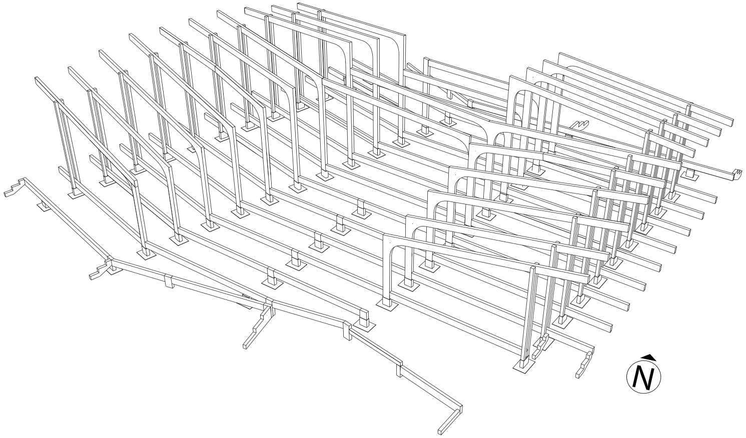
Framing Grid
Scale 1/4" = 1'



Section Cuts
Scale 1/8' =1'



South Elevation

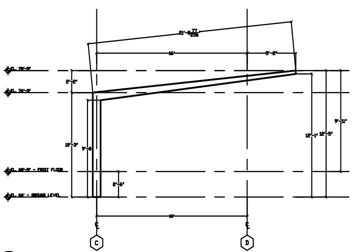


Reengineering Conceptual Structure

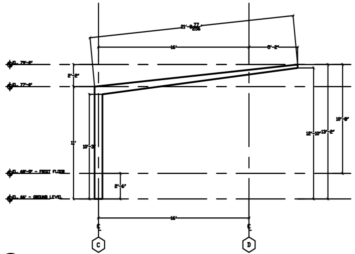
The structural rib and performative infill panel system introduced by the Solar Skin House, was reinvented to accomodate a more complex plan and building section thought to me more conducive to the building's new program. The rib schedule chronicled on the opposite page, illustrates how carefully considered the prefabricated, Glulam ribs were used to articulate the roof's compound slopes and clerestories.

Each Glulam rib was designed to sit in the same standard, welded metal boot, hidden underneath the building's deck skirt. The laminated infill panels were then designed to be press-fit and sealed between the erected ribs.

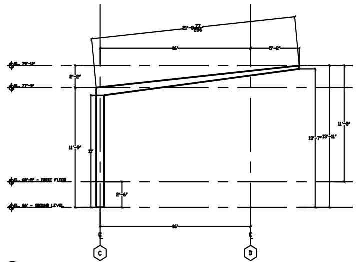
Top Left: Framing Plan
Bottom Left: Rib and Floor Framing Axon
Top Right: Assembled rib section cuts
Bottom Right: South elevation of assembled rib components.



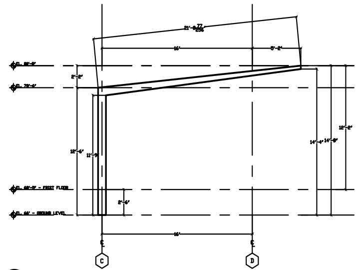
EAST WING - RIB 11



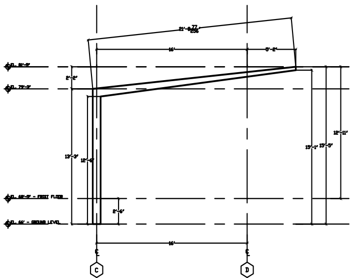
EAST WING - RIB 10



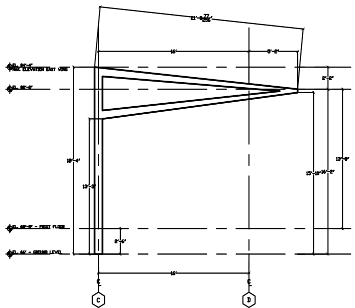
EAST WING - RIB 9



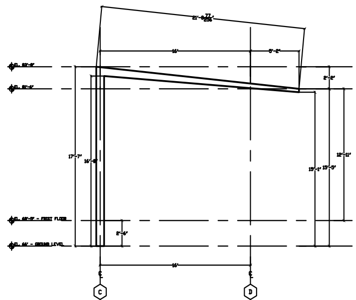
EAST WING - RIB 8



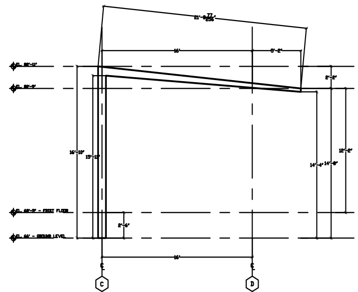
EAST WING - RIB 7



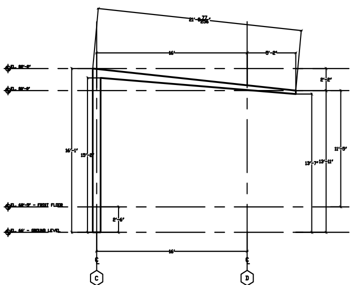
EAST WING - RIB 6



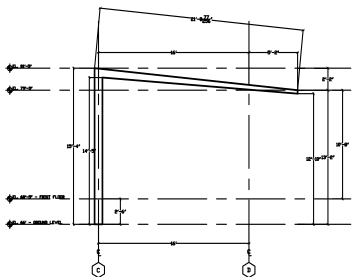
EAST WING - RIB 5



EAST WING - RIB 4



EAST WING - RIB 3



EAST WING - RIB 2

Above: Rib schedule for west wing of Pardon Grey Learning Center.

Prototyping and Prefabrication

The structural ribs and infill panels were prototyped by hand in the model shop prior to finalizing and submitting the shop drawings and schedules to the manufacturing company. The images to the right illustrate the early fabrication process of the 1:1 mock-up.

Once a panel bay had been assembled, problem areas such as the roof panel to rib detail and vertical glazing element to glulam detail were more clearly identified and studied. Several other critical details were identified as potentially severe thermal bridges as well, namely more basic mock-up conventions such as lagged timber connections and joist-footing connections. These details were thus revisited to reduce the incidence of thermal bridging and to prevent obvious areas for leakage.

Top: Erected Glulam Ribs, showing column space for vertical glazing
Bottom: Panel Prototype

1:1 Mock Up of single Rib and Panel Bay.
Installed in the RISD Museum of Art.

Existing Conditions on Site.
View from Main Road looking North

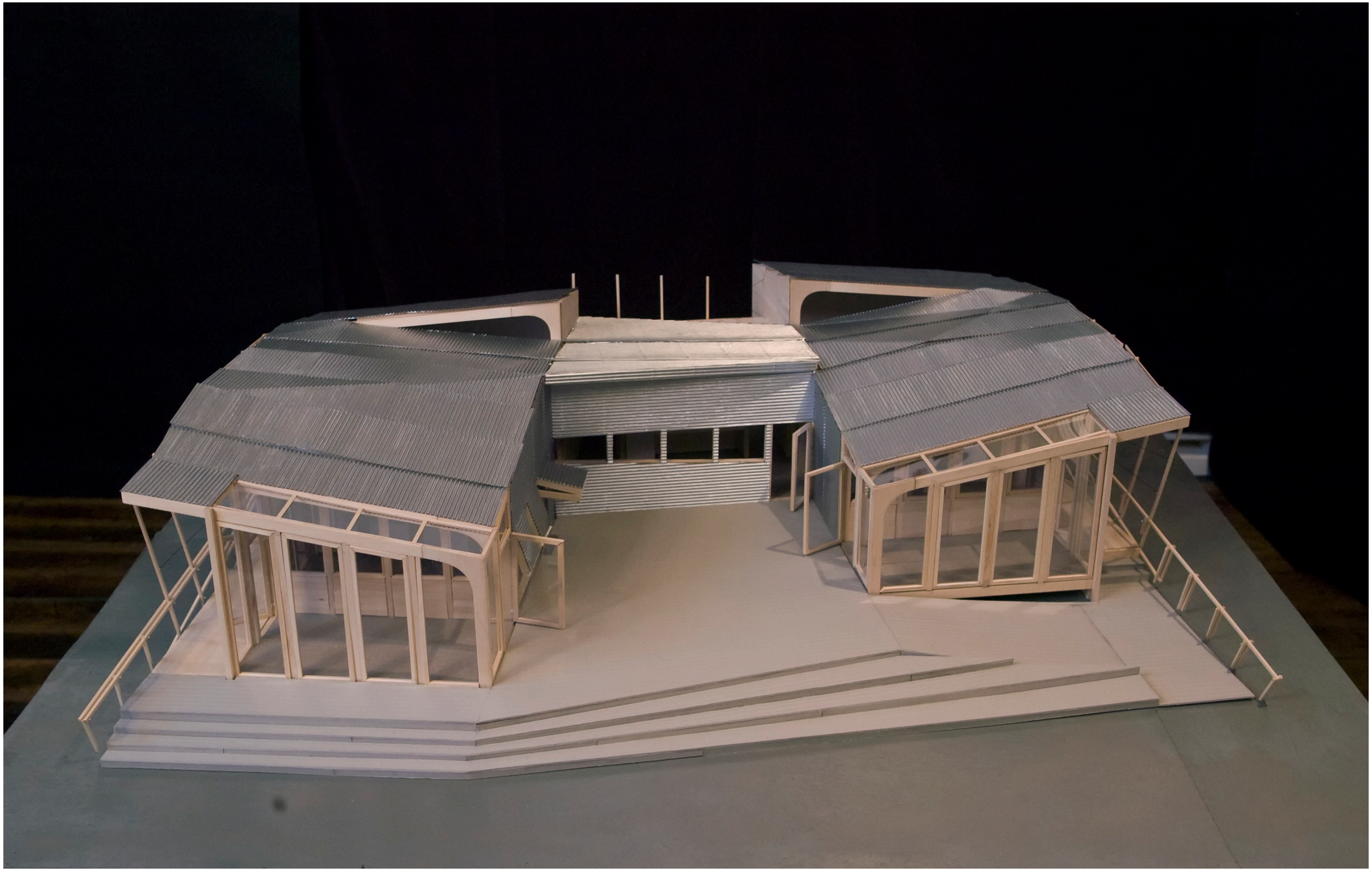
Proposed Construction.
View from Main Road looking North

Site Planning & Implementation

The proposed learning center was designed in an efficient, innovative modern idiom, intended to call attention to the ground-breaking and unique construction and energy technology it pioneers. More "tradtional" materials, more characteristic to the New England town were later considered as viable finish materials so as not "offend" neighbors and to help the building blend more naturally into the landscape.

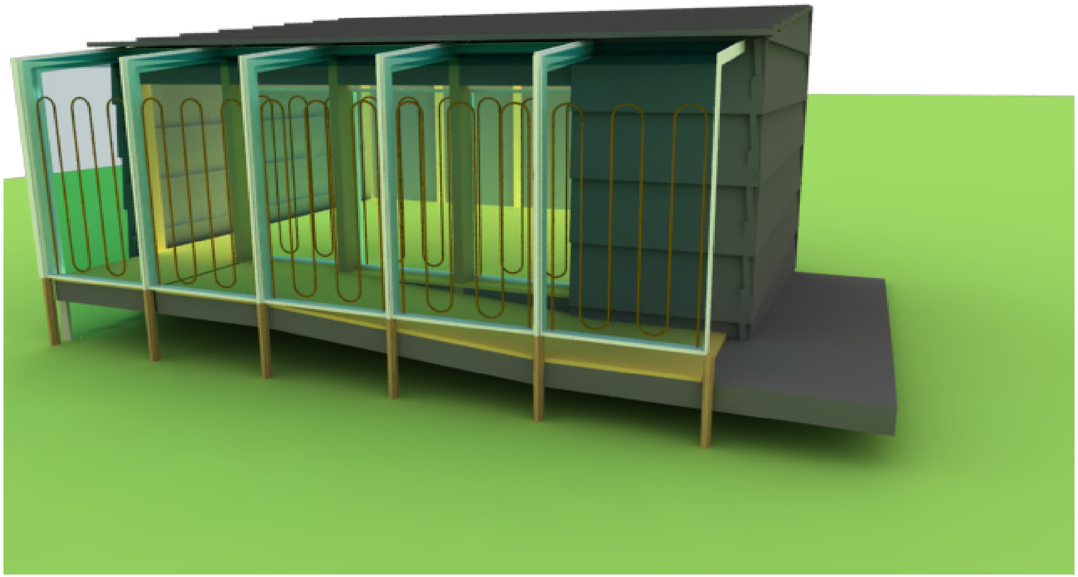
The panoramas to the left illustrate the predicted impact of the proposed design on the site from one of the main roads in town. The implication is that while the proposal is certainly unique, its impact would not be distracting or in anyway offensive.

Ultimately however, persistant opposition from neighbors and other community members to the proposed design made moving forward with this particular rendition impossible, and the Tiverton Land Trust decided against funding the project, initiating a third round of redesign for the solar-thermal skin system.



Bass Wood Model, 1/2”=1’-0”

Redesign & Development



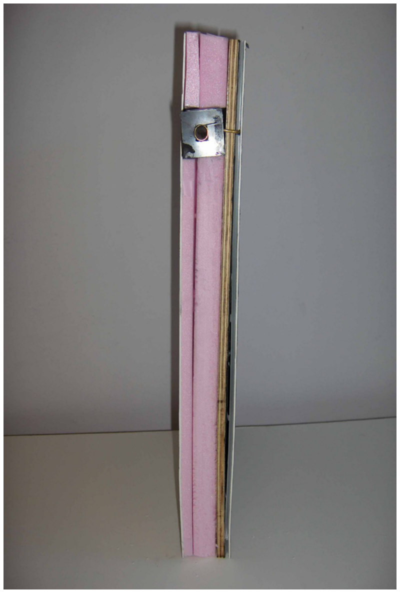
Above: Conceptual model of pavilion with radiant glazing

The Solar Pavilion

With the Tiverton Land Trust rescinding funding for the Pardon Grey Learning Center, alternative financing was secured from both RISD and Brown University to keep the RISD-Brown Solar project from receeding into theoretical obscurity. Working off of the schematic design and system details of earlier renditions, the studio's goal quickly moved towards the modest redesign and construction of what would have effectively been one of the wings of the Pardon Grey scheme.

Focusing on only one small modular component of larger previous proposals, offered the studio a unique opportunity to carefully research, prototype and detail the structure in a more managable and empirical way, offering more immediate opportunities to study and observe the building's performance.

Numerous alterations to the earlier proposals had been discussed, including crude ealry ideas for radiant glazed enclosures, as is illustrated in the model to the left. Ultimately however, the Solar Pavilion came together in a meticulously detailed proof of concept, derivative of the earlier promise of the solar thermal panel system pioneered by the Solar Skin House.



Re-Appropriating Conceptual Systems

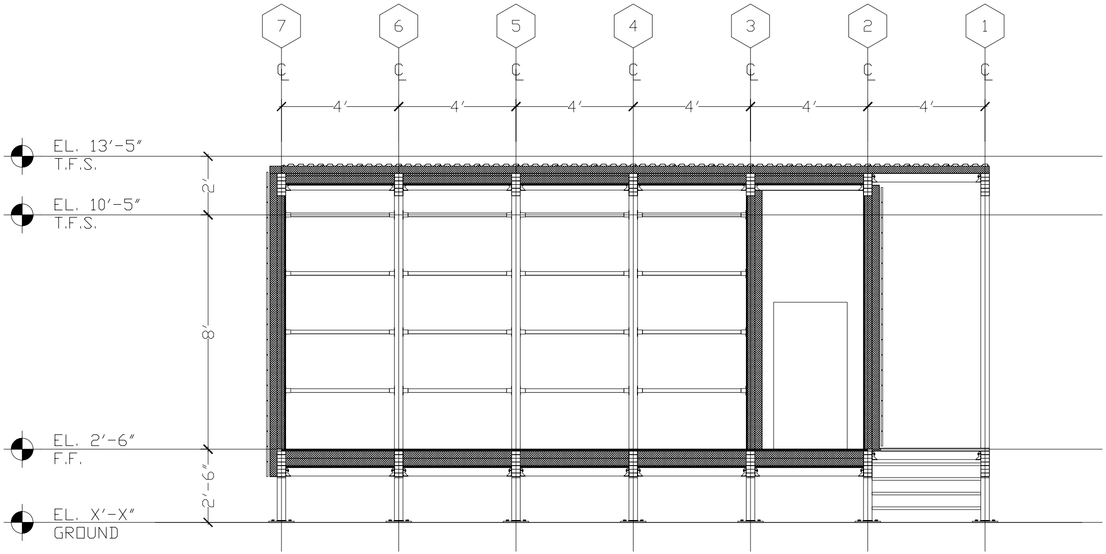
The conceptual prototypes for the absorptive panel system were re-examined, altered to allow for assembly with more accessible materials, and ultimately reinvented into a larger "wall-system" rather than modular panel system. In an effort to keep construction and prototyping within the studio's reduced budget, the thermally-absorptive enclosure system was re-designed along the same principles as the light-weight bay-panels proposed by the Solar Skin House, into a more easily assemblable wall unit constructed of appropriated Structural Insulated Panels (SIPs). The larger SIP panels were purchased off of the shelf, and the styrofoam insulation was manually routed out to accomodate the glycole tubing that would ultimately absorb and transfer solar-thermal energy to the structure's mechanical equipment.

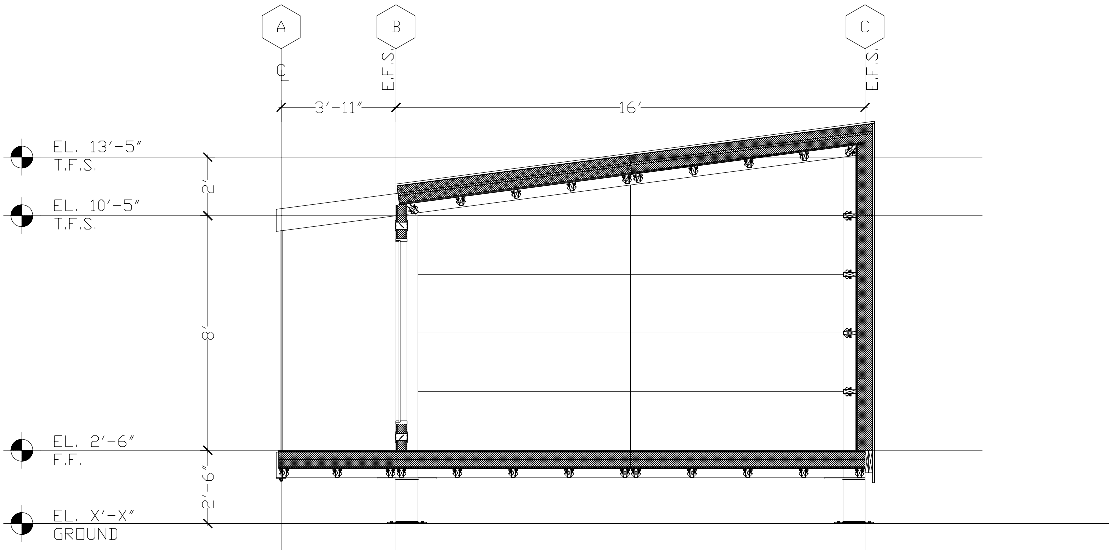
Several areas, including the roof extension over the pavilion's south facing entry corridor, were custom made to accomodate concealed window frames on the underside, and more importantly to accomodate the building's evacuated tube collectors. These panles had to mantain a low profile with the addition of the the tube collectors along the length of the overhang while still effectivley shading the pavilion's southern exposure and maintaining an operative angle of incidence.

Top: Front view of cut-away section of early Mock-up of laminated solar-thermal collecting infill panel.

Bottom: Side view of panel mock-up

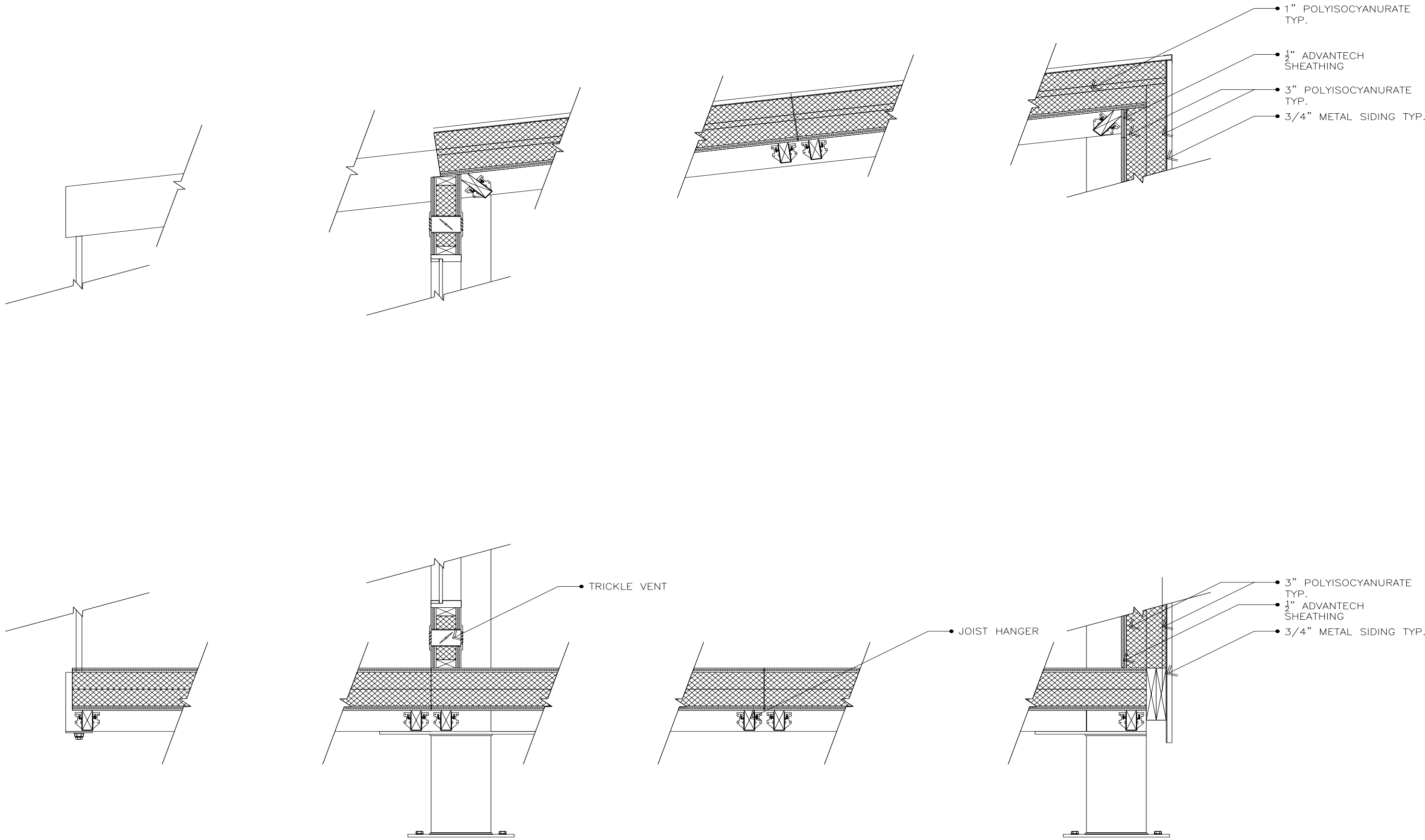
Schematice Design & Construction Detailing



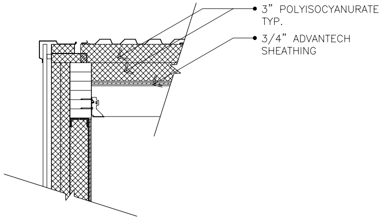


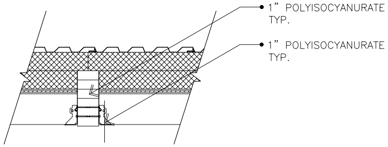
While earlier schematic renditions of this energy-construction relied on planometric and sectional conditioning strategies such as courtyard circulation, solariums and clerestory and stack ventilation, this more modest pavilion offered less room to work with in both plan and in section. Consisting of only one open room and a small mechanical closet, the square plan did not have the benefit of relying on strategically placed or generously insulated service areas or operative clerestories. Instead the pavilion's wall panels and rib system were meticulously detailed to make as tight an enclosure as possible, with access circulation designed as far away from the main conditioned space as possible.

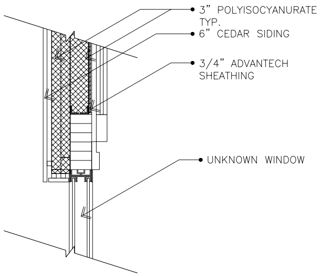
Top: North Section
Bottom: West Section

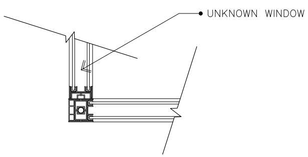


Oriented West Cross-Section

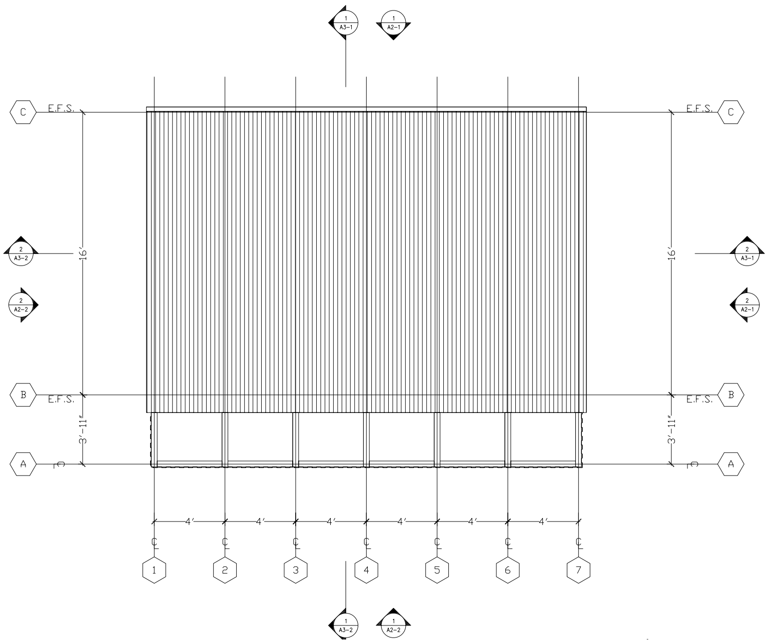




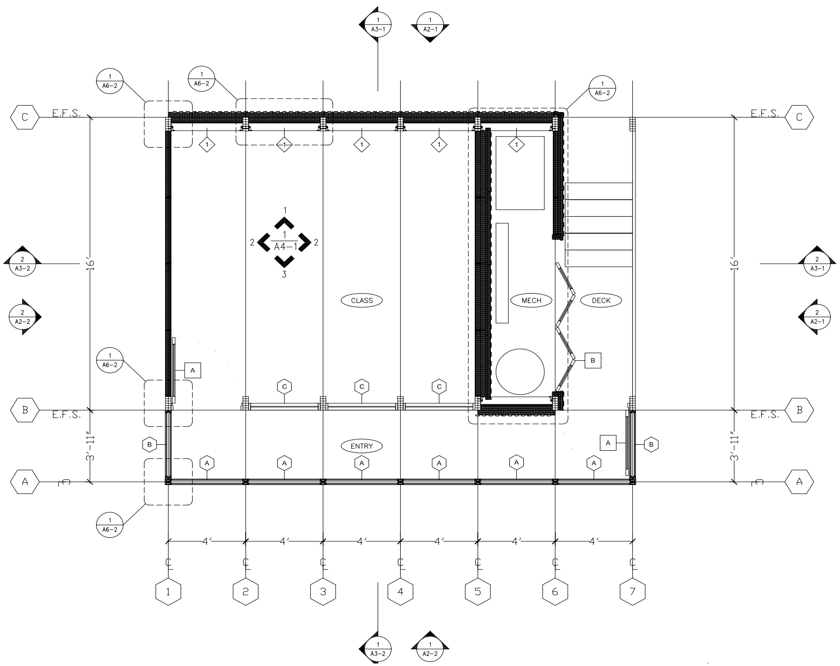




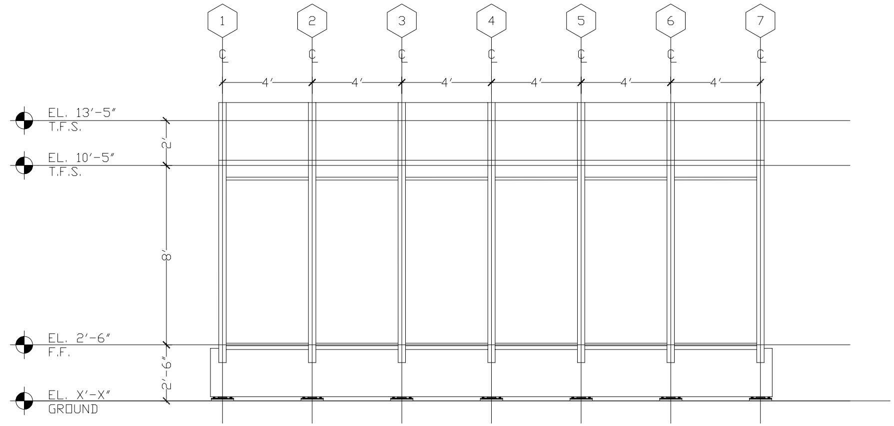
Above: Oriented Plan Section
Top Right: Prototype detail of Rib-Floor Panel Connection
Bottom Right: Prototype detail of Rib-Roof Panel Connection

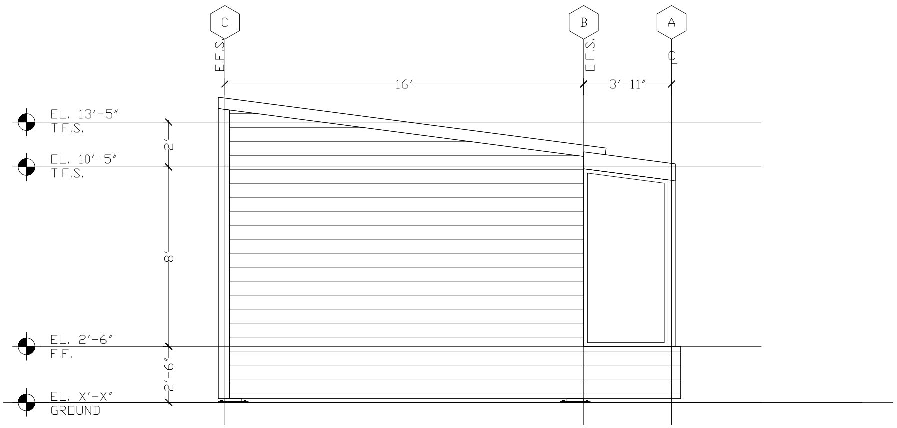


Roof Plan



Pavilion Floor Plan





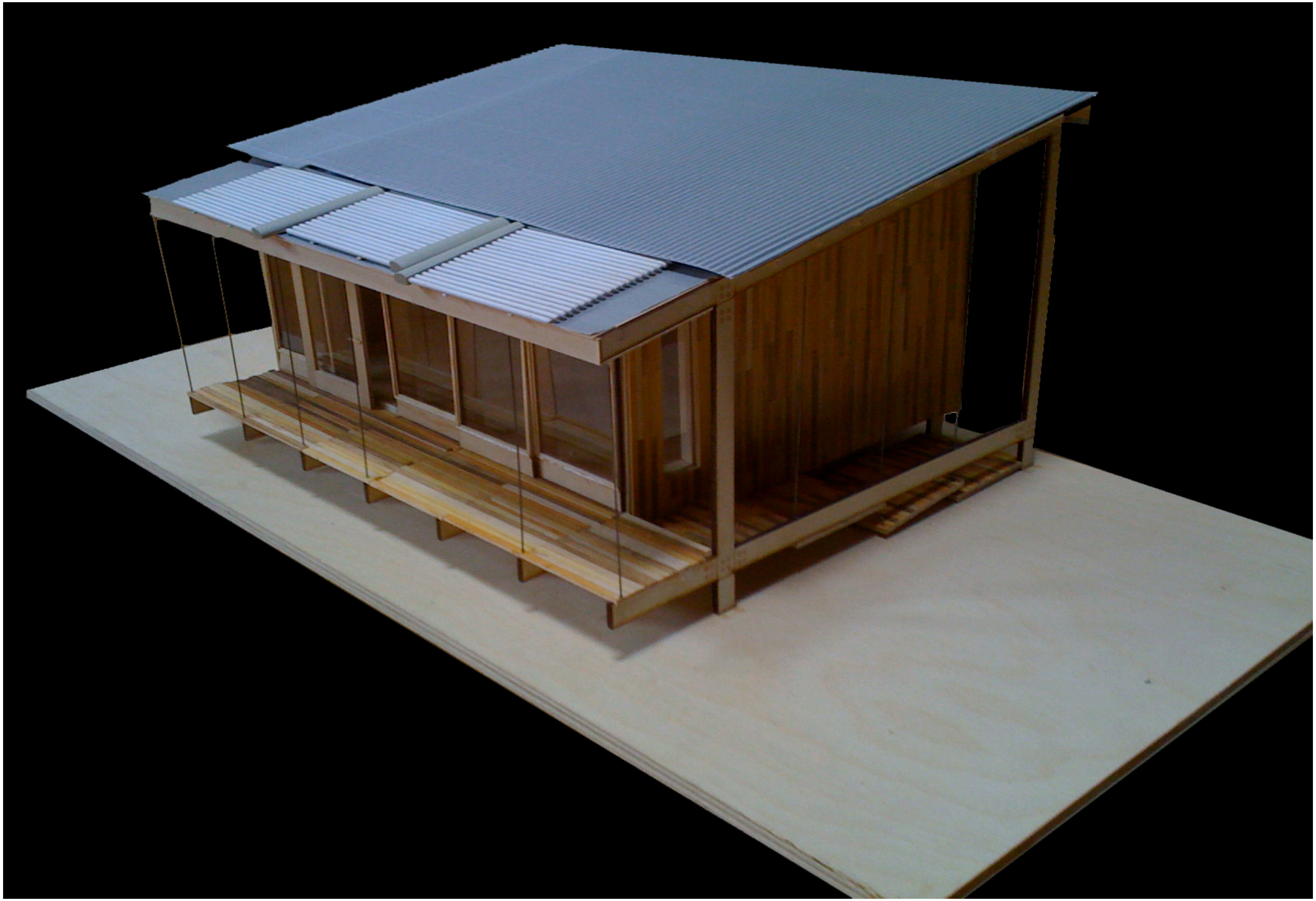
Performative Finishes For A Solar Envelope

While modest in both scale and mien, the pavilion's fundamental form is tailored to maximize performance while demonstrating the viability of the unorthodox construciton and conditioning systems the structure was designed to debut.

The south elevation is entirely glazed along the entry procession while a carefully detailed overhang both shades the window wall and houses the building's evacuated tube collectors. The glazed walkway that is the entry corridor is suspended from the ends of the enxtend Glulam ribs with simple tie-rods to create a dramatic, floating facade that facilitates ventilation around the building's entire envelope.

Old wood siding was reclaimed to finish both the east and west facades of the pavilion to create a compelling graphic texture on both infill walls on either side of the building. A thin corrugated metal finish along the north facade and over the roof panels define a simple juxtaposed border along the wood elevations.

Top: South Elevation
Bottom: East Elevation



1/2" Bass Wood Model

Reinventing Conventional Solar Technologies

Integrating the evacuated tube collectors on top of the overhang above entry corridor proved more difficult than originally planned. With such a shallow pitch, the three standard size Viessmann panels originally specified proved inadequate to effectively manage and condition the amount of fluid running through the absorptive panels. The overhang was tirelessly redesigned in efforts to provide additional space for a fourth panel of equal size. However in the end, the most efficient solution came in simply butterflying the panels so that two panels could work off of one manifold. This required only two manifolds to be mounted to the overhang rather than the four that would have originally been required for four panels. This innovation freed up enough space along the overhang to accommodate the fourth panel that was required without having to redesign or enlarge the roof overhang.

Top: South view of 1/2" bass wood model
Bottom: West view of 1/2" bass wood model

Building Construction

Building Construction & Troubleshooting

After two uncertain years of design, redesign, and unorthodox financing strategies, construction of the solar pavilion finally began in the fall of 2009. With the solar thermal panels still in their prototypical stages, the Glulam ribs were fabricated and erected into their light-weight steel boots. The pavilion was fabricated and erected close to campus along the Providence River for careful study and observation berfore it would be dissassembled and transported to its permanent site at the Roger Williams Zoo. Volunteer teams of RISD and Brown students were the primary force behind most of the physical construction work for the pavilion and will continue to be the force behind the creation of the mechanical equipment that will eventually be machined and housed in the pavilion.

Left: West Glulam Rib being erected

Installation of first three Glulam ribs in footings: View looking west

Completed erection of Glulam ribs: View looking west

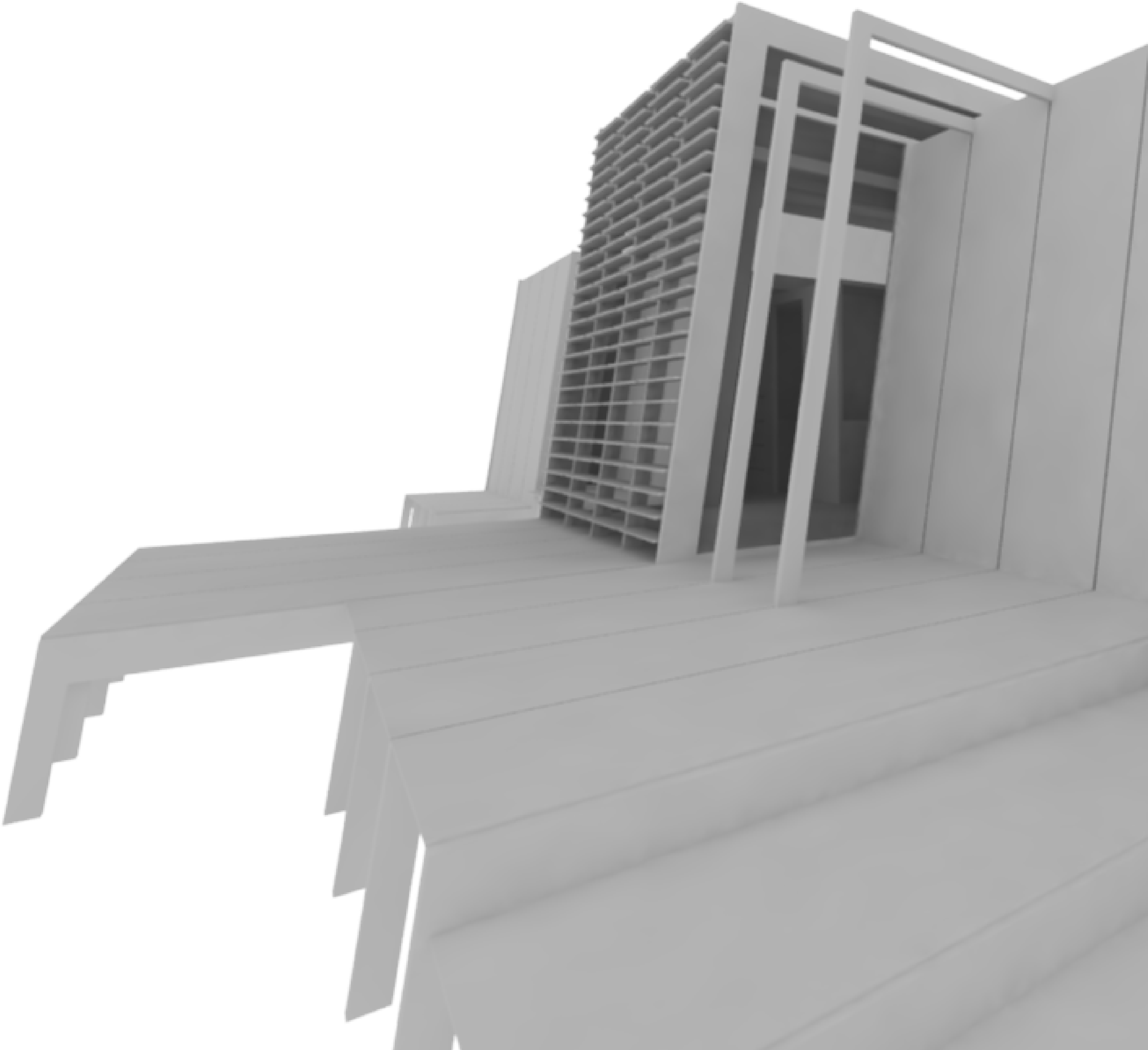
Frame with recovery-board sheathing between ribs: View looking north

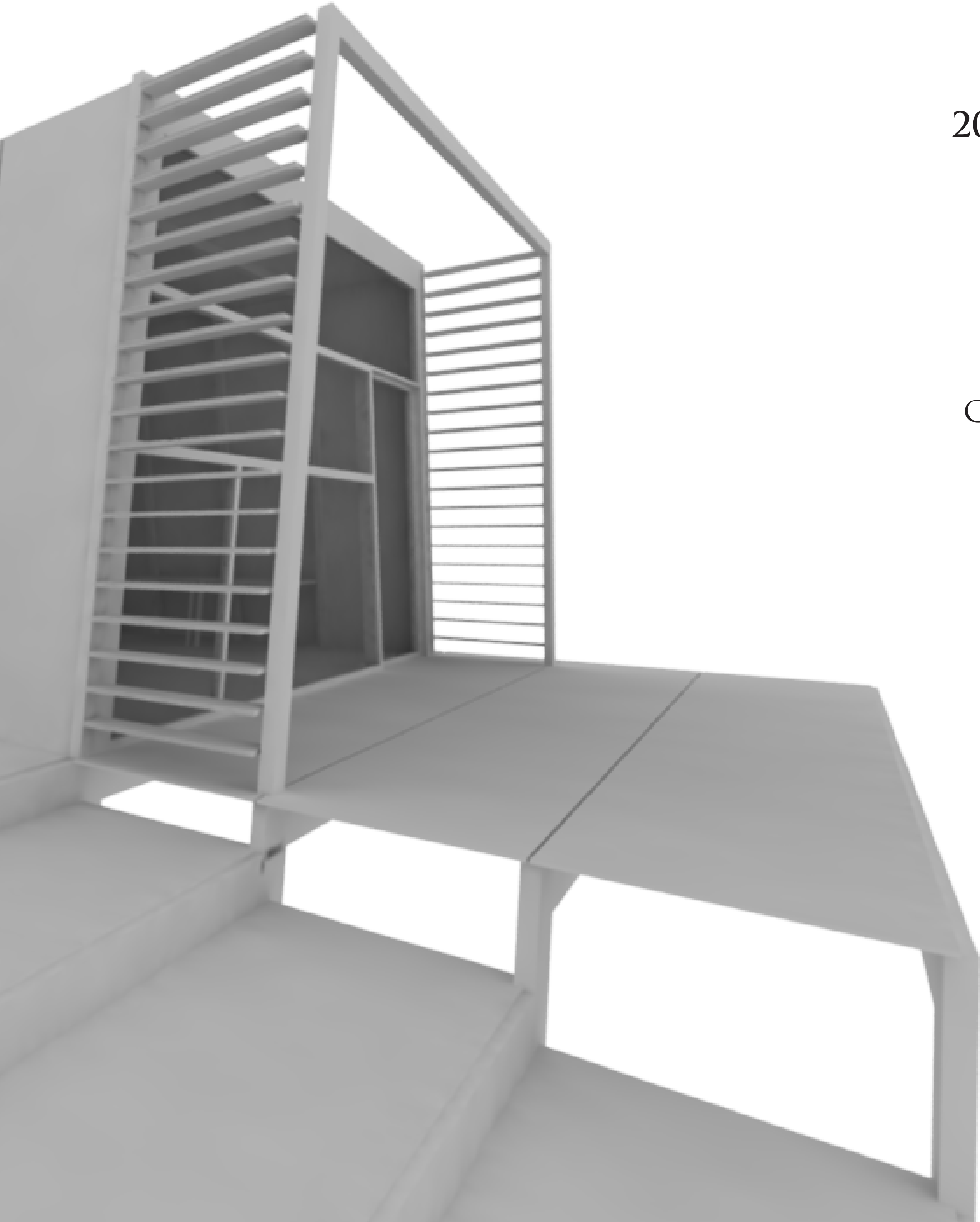
Framed & Sealed Enclosure with southern glazing: View looking north

Sealed, glazed enclosure: View looking west

Installation of finished wood siding and corrugated metal sheathing: View looking south

Project Contributors





2009 RISD DESIGN TEAM

JONATHON KNOWLES R.A.

RAYMOND GABRIELE

NICHOLAS SIMPSON

CASSANDRA D'ALESSANDRO

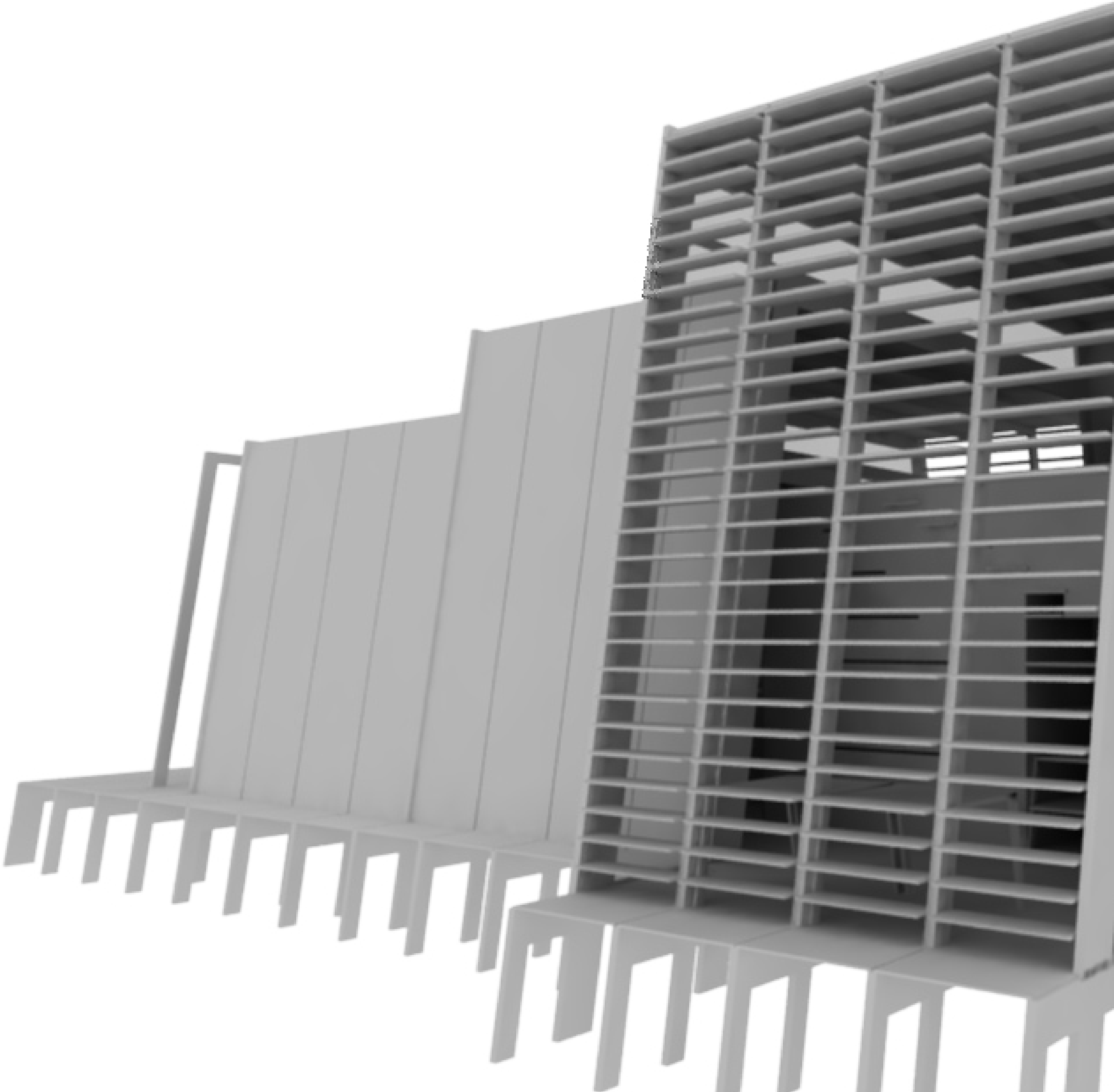
CARLOS ENDRIGA

ALLEN PHILLIPS

NICOLE KIM

JOANNE LEE

ER-TI CHEN



2009 Brown Engineering TEAM

CHRISTOPHER BULL

RUSS STACKHOUSE

HECTOR INIRIO

ERIC RUDASAILIE

AHLAYA NIRMALAN

BRENDAN WARNER

JERRERSON COX

RUSLAN SKOMOROHOV

SARAH BERGLUND

YONATAN DOLGIN

JON CUCCO

JORDAN CHESIN

NICHOLAS STOCKER

The RISD-Brown Solar Pavilion
Rhode Island School of Design
Brown University