Andy Hoover

Brick & Mortar | Texas A&M Final Study

TEXAS A&M UNIVERSITY
Architecture

The author is pleased to dedicate this little work to those without whom this would not exist. To his chair, Priya Jain and his committee member Dr. Zachary Stewart. To his parents and sister for their faith and belief. To his companions in studio who have shared in the pain and triumph of creation. To Dr. Deborah Lyons and Dr. Sergio Sanabria. To Nathan and Maggie, constant companions.

Thank you all.

"There flying Elwing came to him, and flame was in the darkness lit,
more bright than light of diamond, the fire upon her carconet.
The Silmaril she bound on him, and crowned him with a living light,
and dauntless then with burning brow, he turned his prow and in the night,"

-Excerpt from the *Lay of Eärendil*, J.R.R. Tolkien

Contents

1 | Introduction

1.02 | Manifesto

In the search for a harmony between art and structure, masonry offered many solutions for centuries. But architects became wiser through the years, and they discovered new structural problems for which the art of masonry was either poorly suited or entirely out of its depth. The industrial revolution hastened the fading of artistic structural masonry. Masonry rejoiced in the display of structural forces, but how could it beat the truss in span, or the wood-stud wall in ability to insulate, or the simplicity of a tilt-up wall? But few of these new ideas could simultaneously display the structure of the building truthfully and achieve pleasing classical or romantic forms. What masonry technology did continue into the 21st century has been slowly relegated to a mere texture on a building's skin, or worse, an ugly structural necessity hidden away in fire stairs and elevator cores.

Many theorists, architects, and engineers have made strong cases for the artistic redeployment of brick and stone masonry since the 19th century. These case studies are of greater value to architects in the 21st century because they coexisted with many of the building materials, architectural systems, and design problems standard today. Because the final study is primarily a design project supplemented by research, the survey of designers was more limited than I would have preferred. My goal was to begin compiling an understanding of specific techniques, letting techniques branch into other areas organically.

The International Masonry Training and Educational Facility in Bowie, MD.

1.03 | Target Program for Phase 1

Student Workshop: center of practical education
Practice Bay – 30,000 ft², unconditioned
. . . . Subdivided into four 7,500 ft² bays
. . . . First Aid station

The Workshop: Research and artisan workshop for revenue
Material Testing Bay – 7,500 ft², unconditioned
. . . . Overhead crane
. . . . Delivery dock
. . . . To be used as artisan workshop during phase 1
Material Testing Lab – 300 ft²
. . . . .Chemical Storage closet
. . . . .Reinforced wall between testing bay and lab
Research Director's Office – 150 ft²
Facilities Coordinator's Office – 150 ft²
Two Additional Offices – 300 ft² (150 ft² each)
Faculty Common Room – 300 ft²
. . . . Kitchenette
. . . . .Restrooms

The Archive: quieter space for lecture-based education, as well as storage of research results, reference materials, and material library. Due to similar interior environmental requirements, it also includes the public exhibition space.
Reading Room – 1,500 ft²
. . . . Material Library
. . . . Document Library
. . . . Digital Archive
Classrooms – 2,400 ft²
. . . . .Four classrooms at 600 ft² each, for 25 adults each.
. . . . .Restrooms
Exhibition Hall – 1,500 ft²
. . . . Models, Displays, Rotating Exhibits

Public Engagement: For local and statewide visitors.
Café – 1,500 ft²
. . . . .Kitchen for 1-3 baristas
. . . . .Seating for students and visitors
Entry Space – 500 ft²
Sculpture Garden – 3,000 ft²
. . . . For Artisans to display sale pieces
. . . . For students to display projects
. . . . For research models to test weathering

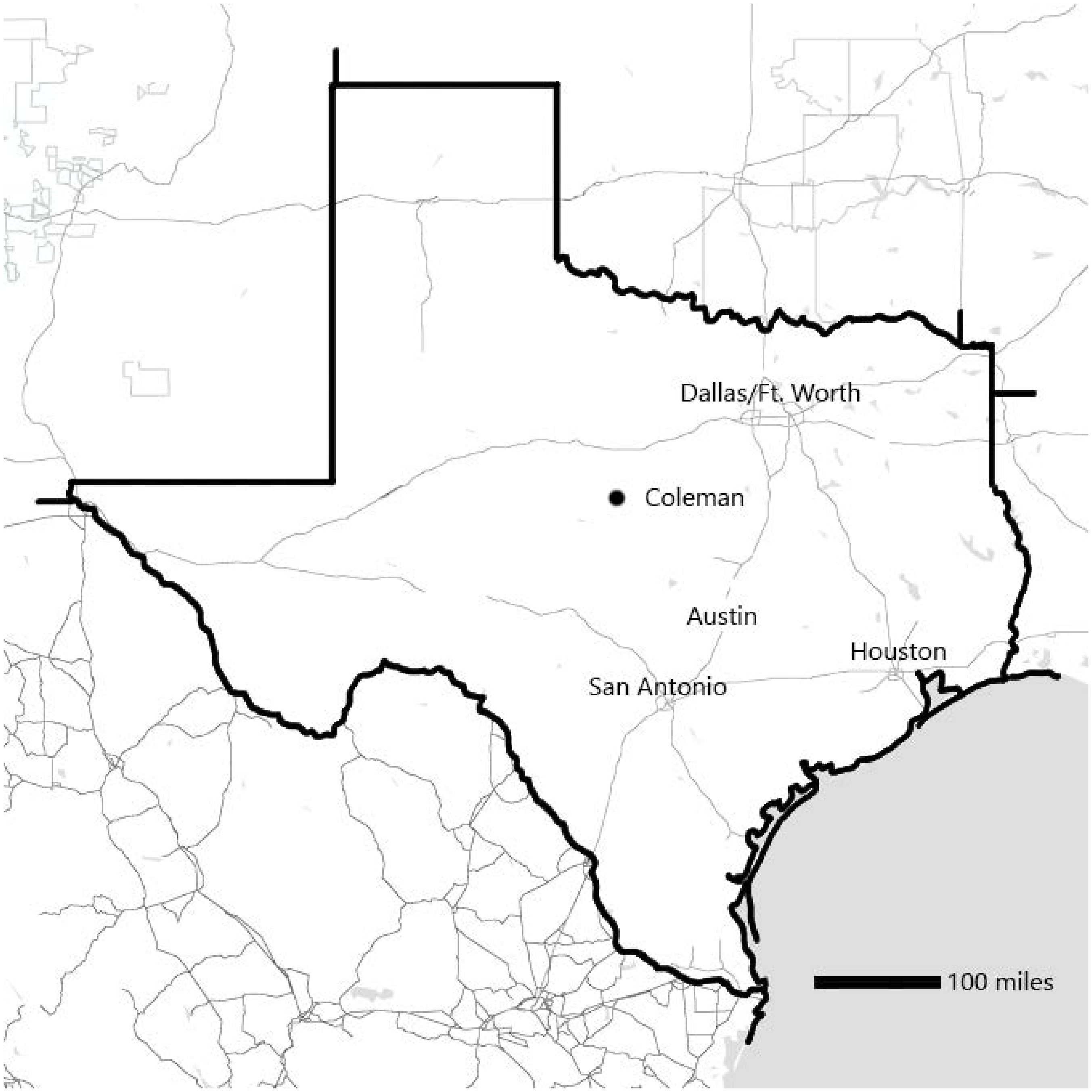
The need to study masonry manifested itself in my program as a facility for training masons. The core of the program is a dedicated workspace for masonry. Three workshops would operate out of this space: a student workshop, an artisan workshop, and a research workshop. For the first phase of the project, only the student and research workshops will be built. The research workshop would be used by the artisans until the artisan workshop would be built in the second phase of development. The artisans are more essential to the early income of the facility, but the research workshop also has the loading dock for the whole facility. Owing to the similar functional requirements of the researchers and artisans, the research space is fully capable of hosting the artisans during the first phase and converting to its full time use in the second phase.

The student workshop generates its income from tuition (likely paid by mason unions or associated craft unions) as well as by having students work on commercial projects. The goal of introducing new structural brick techniques means that this facility would be the only supply of trained labor for these new building components. To be competitive with other structural methods, the techniques would need to produce components that can be fabricated off-site. would be complemented with classrooms for lecture-based instruction, as well as a material and reference library shared by the researchers.

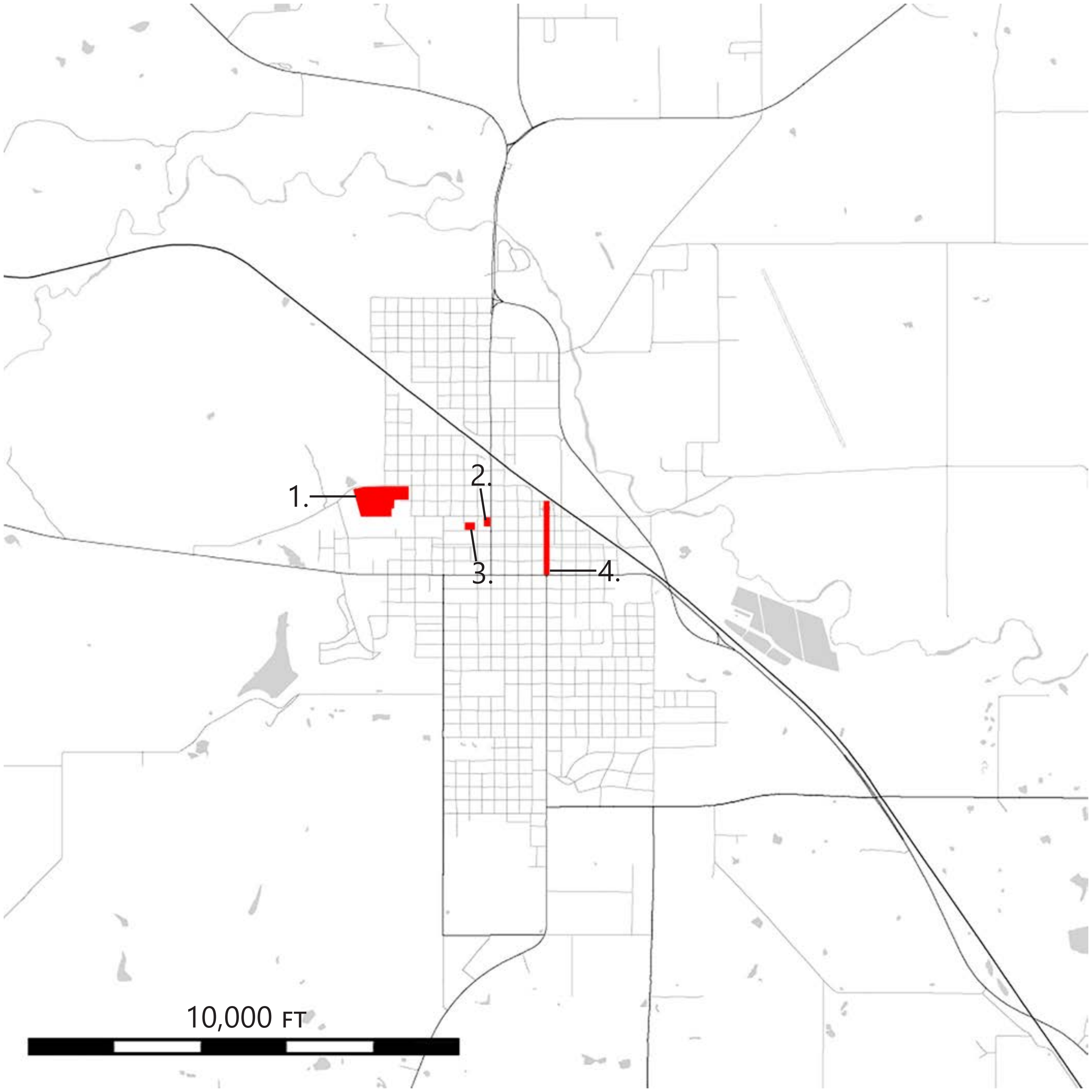
1.04 | Coleman, TX

The ideal city for a facility of this type would be a town with a history of brick manufacturing. Revitalization would add an appealing aspect to the facility. The city presented itself: Coleman, Texas. Coleman was a frontier town in central Texas protected by a nearby US Army camp until the American Civil War. In 1886, a spur of the Santa Fey railroad was built to connect to Coleman, and by 1900, the town's economy was cotton-based. The town shifted away from its agrarian base in the 1920s, when the Great Depression fueled an industry boom, including a fire-brick manufacturer. The brick manufacturer remained until the 1970s, when the supply of clay at the plant began to run dry and the business moved out.

The city itself isn't very large. The site can be reached by a five-minute walk from the courthouse in the center of town. It has a wealth of decorated brick buildings, both on the main street and around the city. Older sections of brickwork are still extent, some of it visible through new pavement on the street and from behind new wall finishes. The main street of town is very well-kept, though the more impressive brick details further out are either on small, old buildings, or are new and understated.



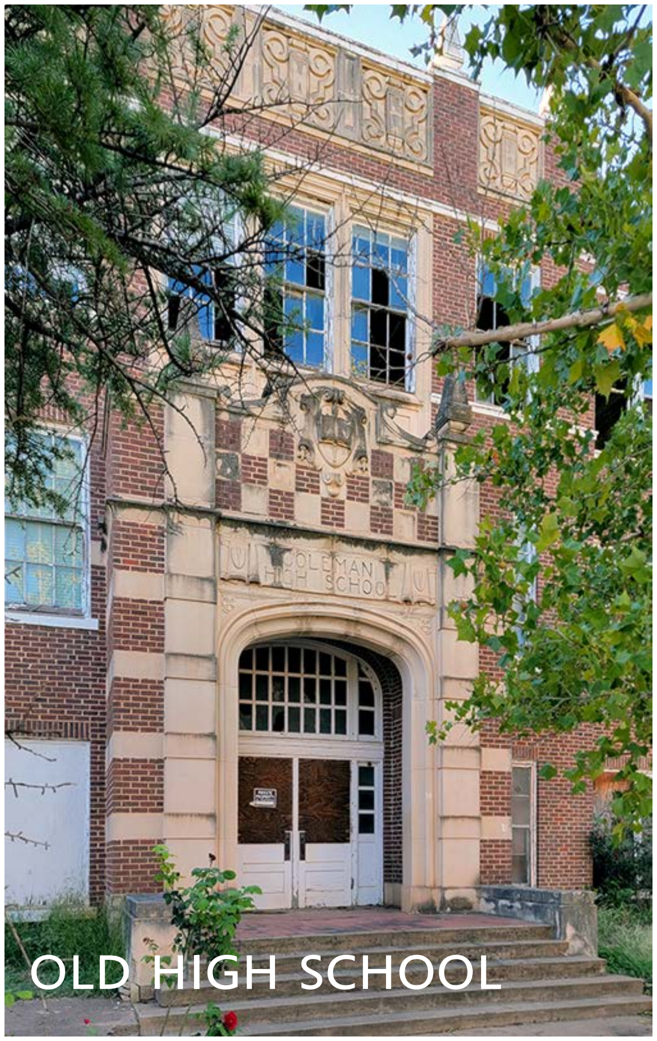
1.05 | Coleman, TX



1. Site Location
2. Old Coleman High School (Abandoned)
3. Old High School Gymnasium (Abandoned)
4. Downtown Main Street

The north end of Coleman is separated from the south by the railroad spur, which passes very close to downtown. The old high school and gymnasium would be relatively simple to convert into a student dormitory and recreation center. However, each of those could be its own final study, and are researved for a later phase of the masonry institute project. It will be both a hands-on training opportunity for the students, and good outreach to the Coleman community to repair derelict buildings with historical value.

Other projects around Coleman include maintenance or replacement of the older brick pavement. The artisan staff will also be able to be contracted for maintaining or replacing historic masonry around the city to supply additional income for the institute.

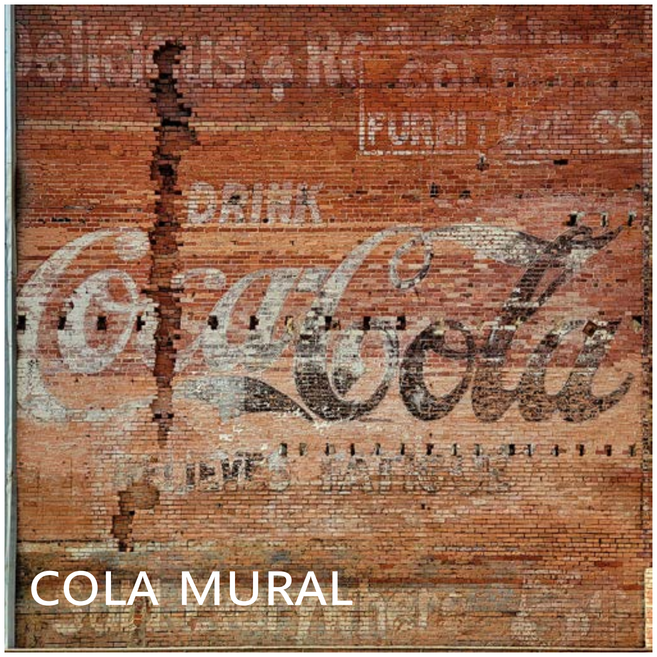


OLD HIGH SCHOOL

AUTO SHOP

MUSEUM

OLD GYMNASIUM

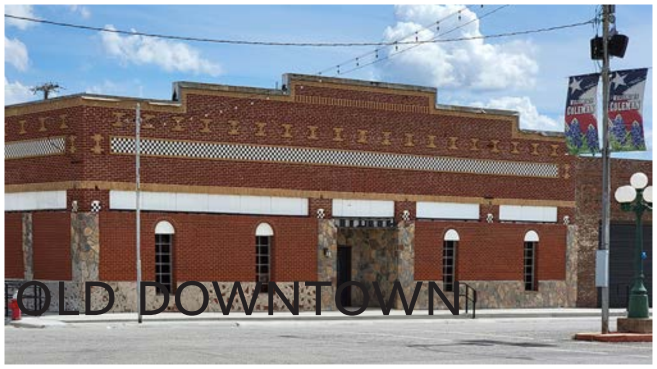


COLA MURAL

OLD DOWNTOWN | BRICK STREET

POST OFFICE

OLD DOWNTOWN



OLD DOWNTOWN

1.07 | Coleman Brick Heritage

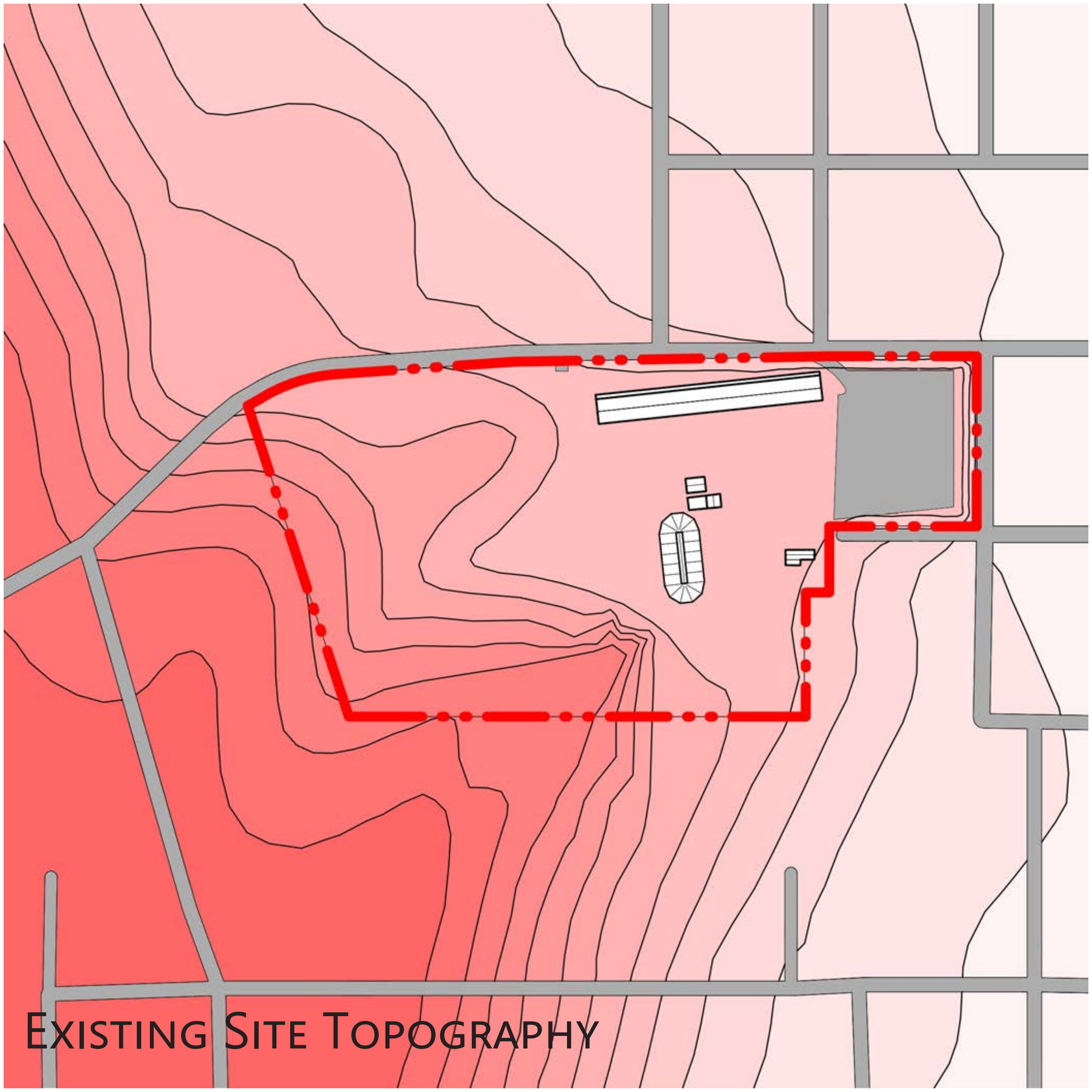
2 | Existing Site

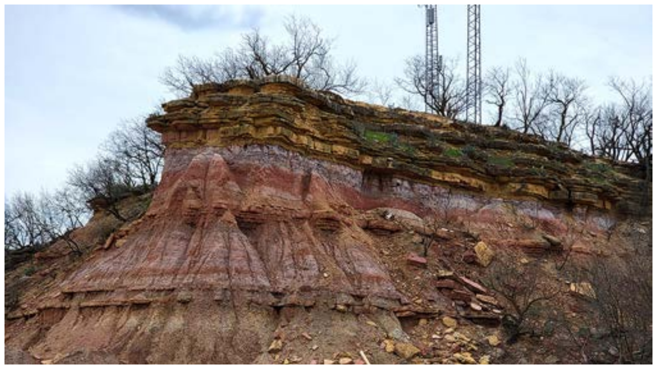
2.02 | The Site

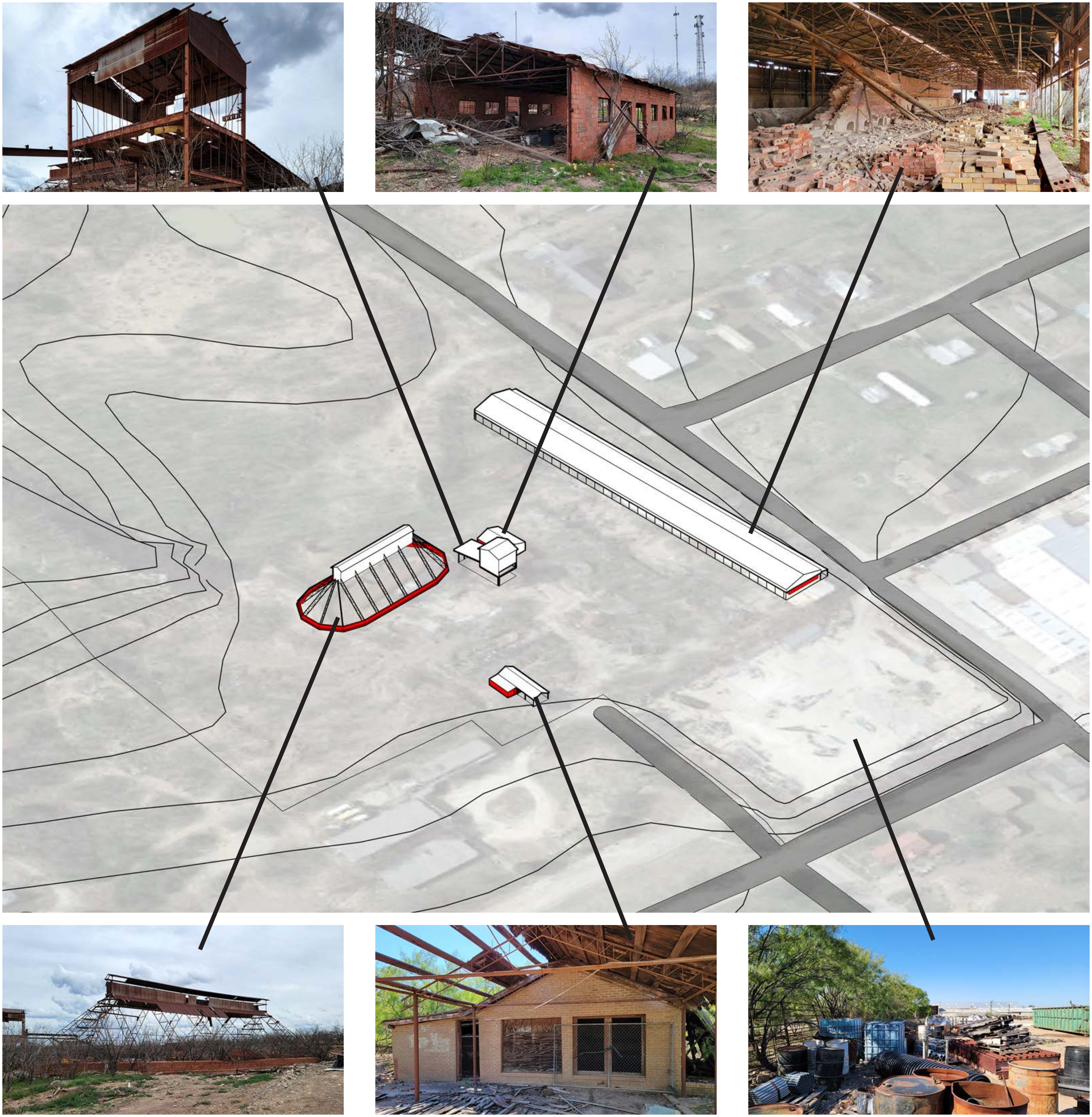
There are five existing buildings on site, all positioned on the east half of the site. The far east side is dominated by a large, paved area with one driveway connecting it to the street on the north side. The main curb appeal on the site is the kiln building, which reveals many of its systems through the trees on the north side (top right). The soil is rusty red, and rich in clay (top center). The site slopes upwards from the east end to the southwest corner, where the hilltop is dominated by mesquite trees (top left).

The south side is dominated by the clay mountain (below left). There are traces of brick-paved roads surrounding the site (below middle), and the edges of the site are strewn with brick rubble (below right) though the central part of the site has various stacked piles of unused brick.

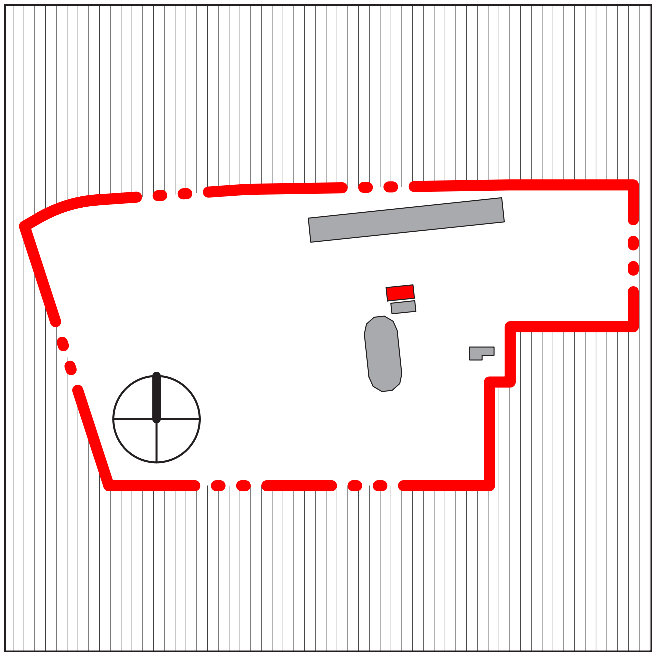
On the topography map, lines represent 10′ elevation increments.

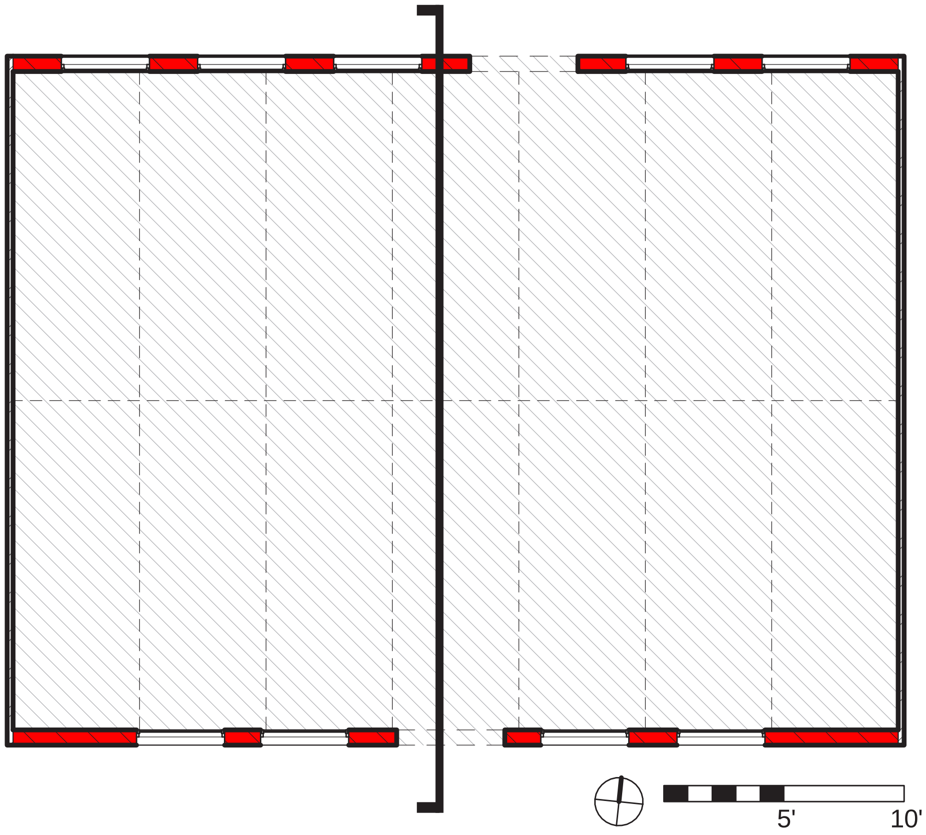


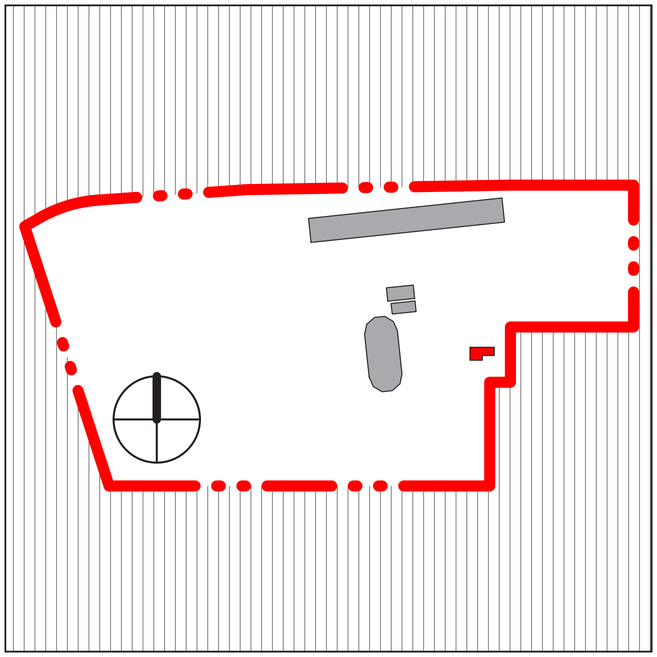


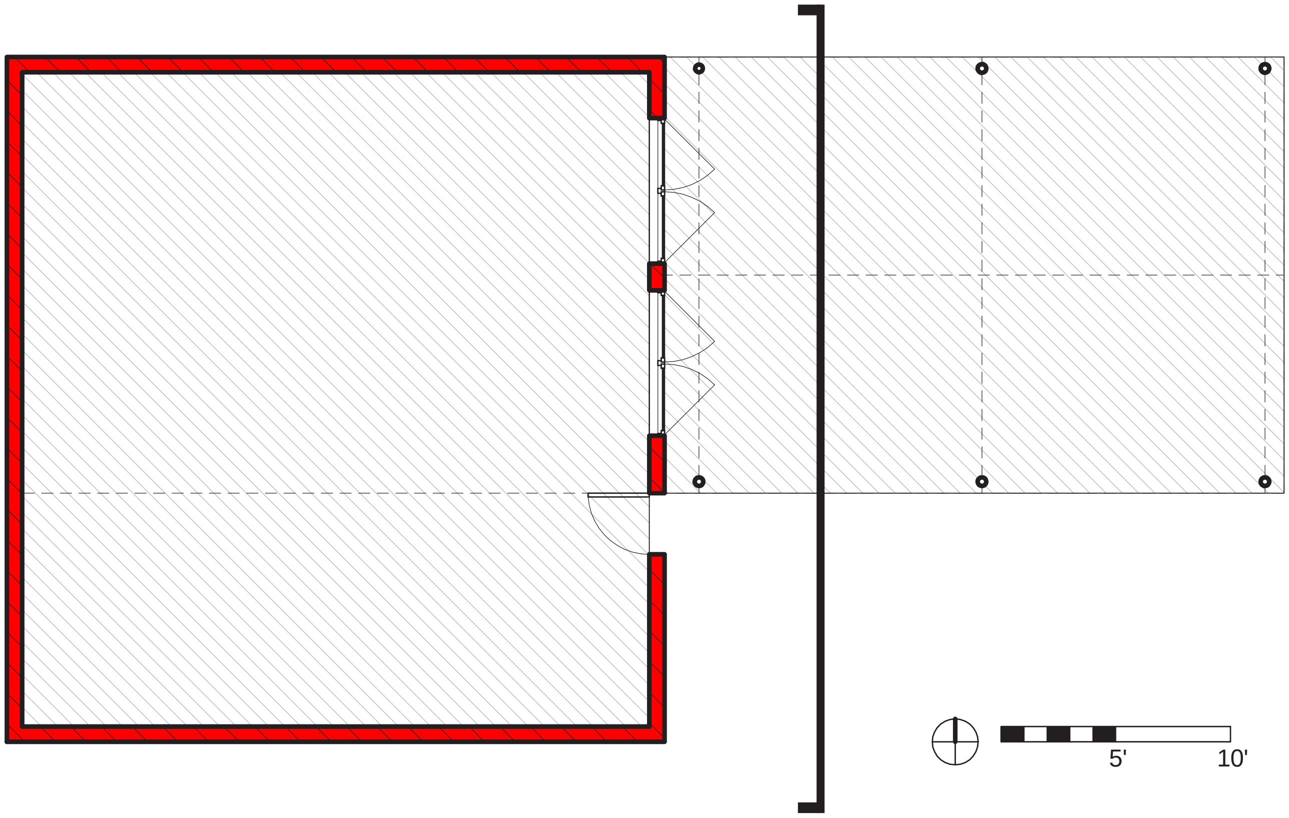


2.04 | "Hollow-Core Brick Building"

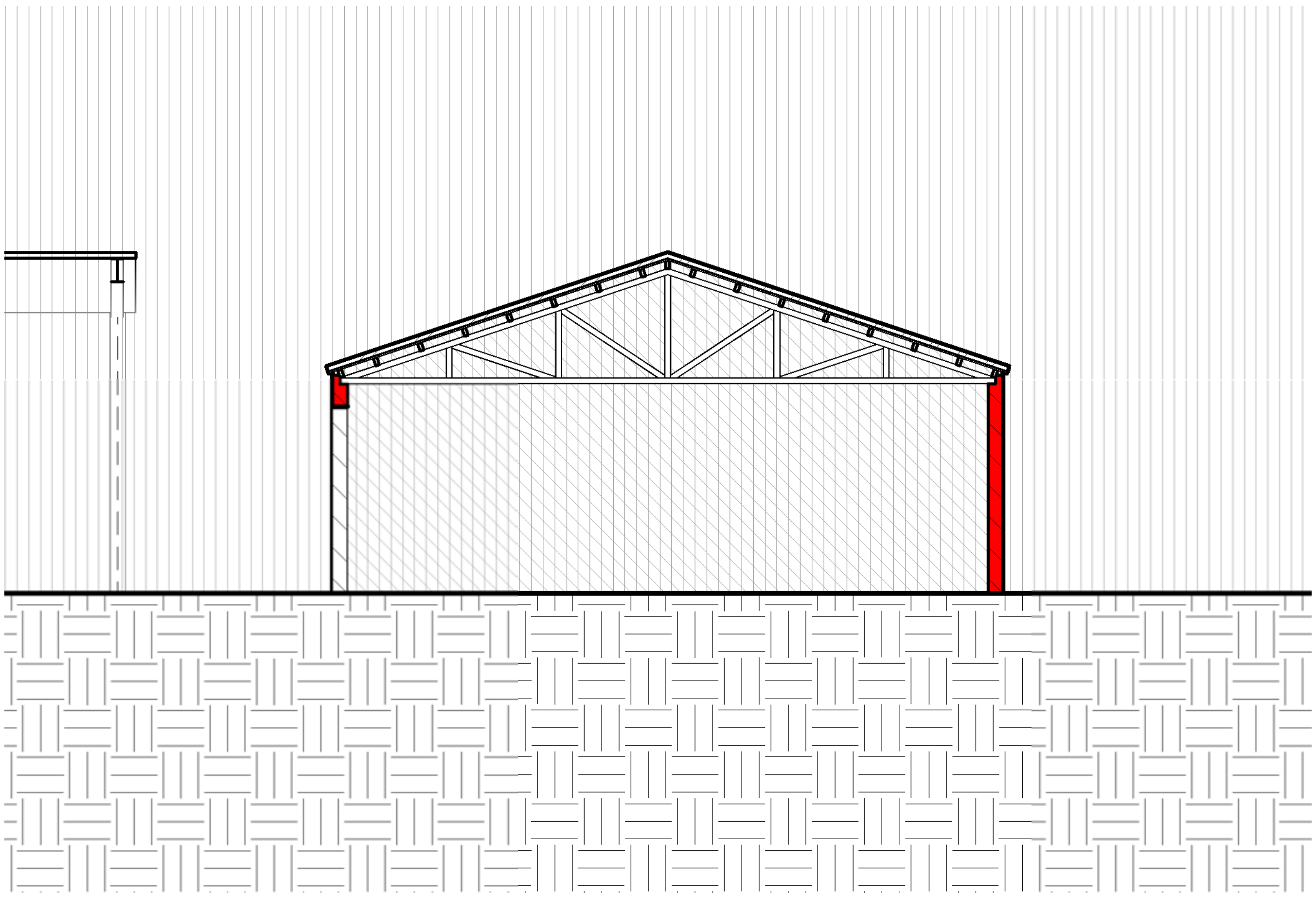






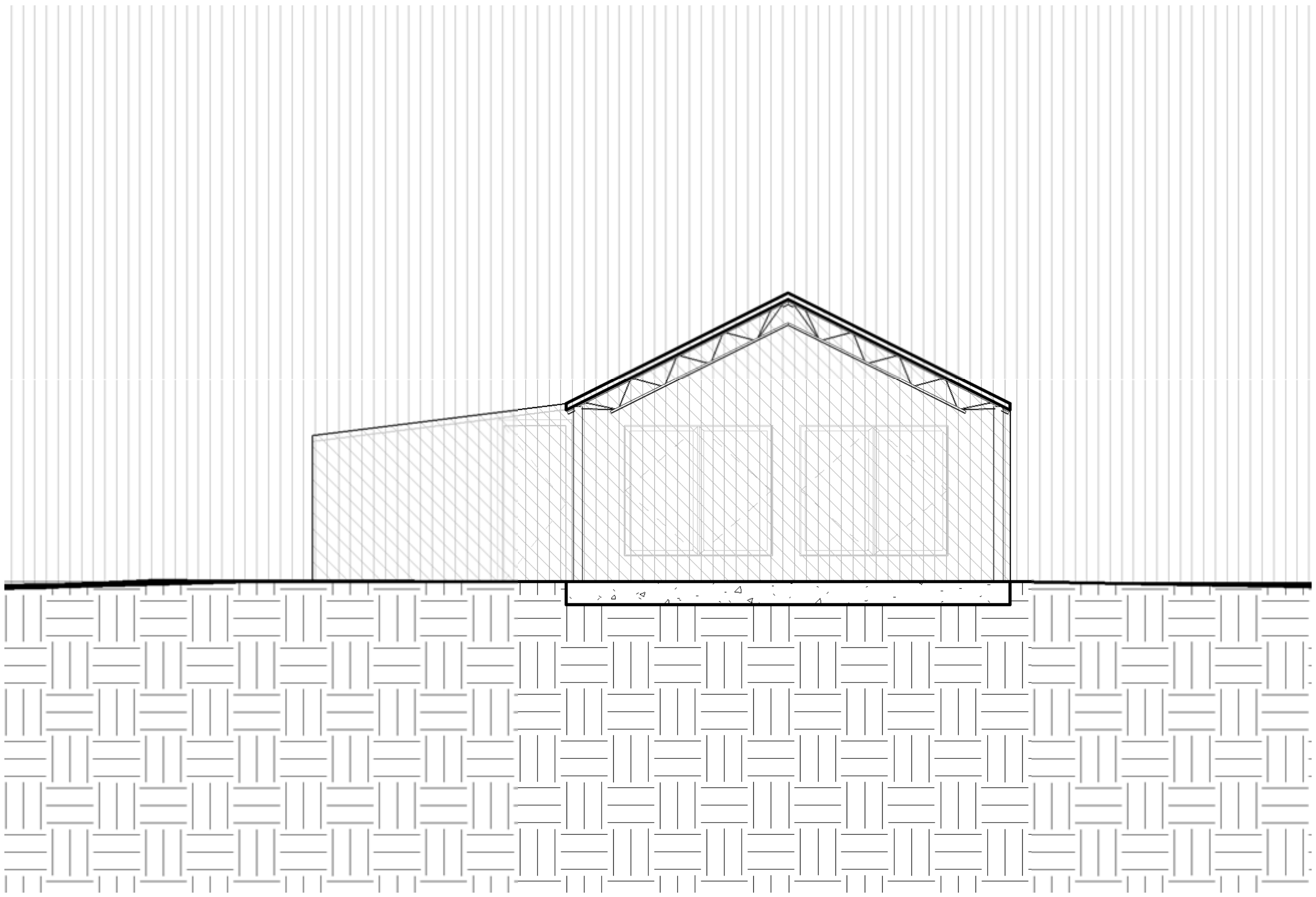


2.04 | "Porch Building"



The “hollow-core brick” building is located towards the center of the site. This building is nick-named for its unique use of oddly-proportioned hollow-core bricks. Two parallel brick walls support a series of trusses, supporting a flimsy roof of 2x4 rafters, plywood, and corrugated metal sheets. Both brick walls have a door rough-in towards their centers, and nine non-operable windows total.

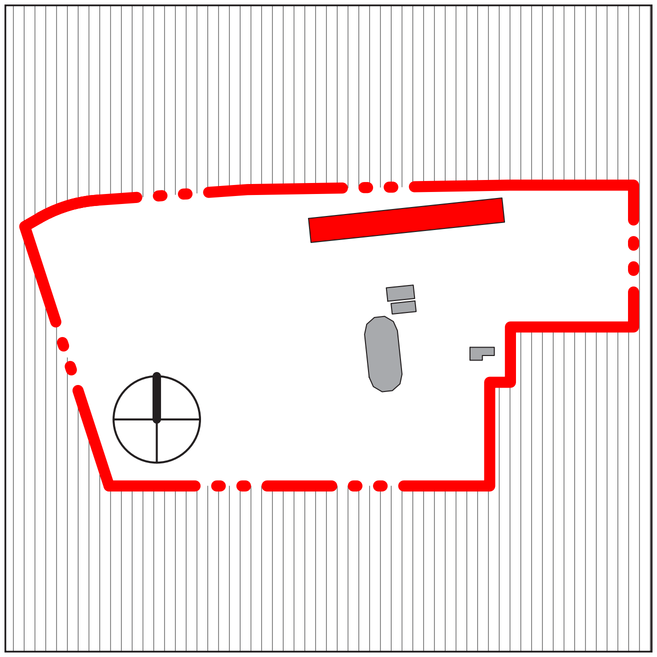
The walls appear to be in good condition, but the entire roof needs to be removed and replaced. The nieghboring building visible in the section is the “steel building” will need to be stripped down to its structure. I have no intention to keep it, since the motive is to preserve historical brickwork, and the “steel building” has none.

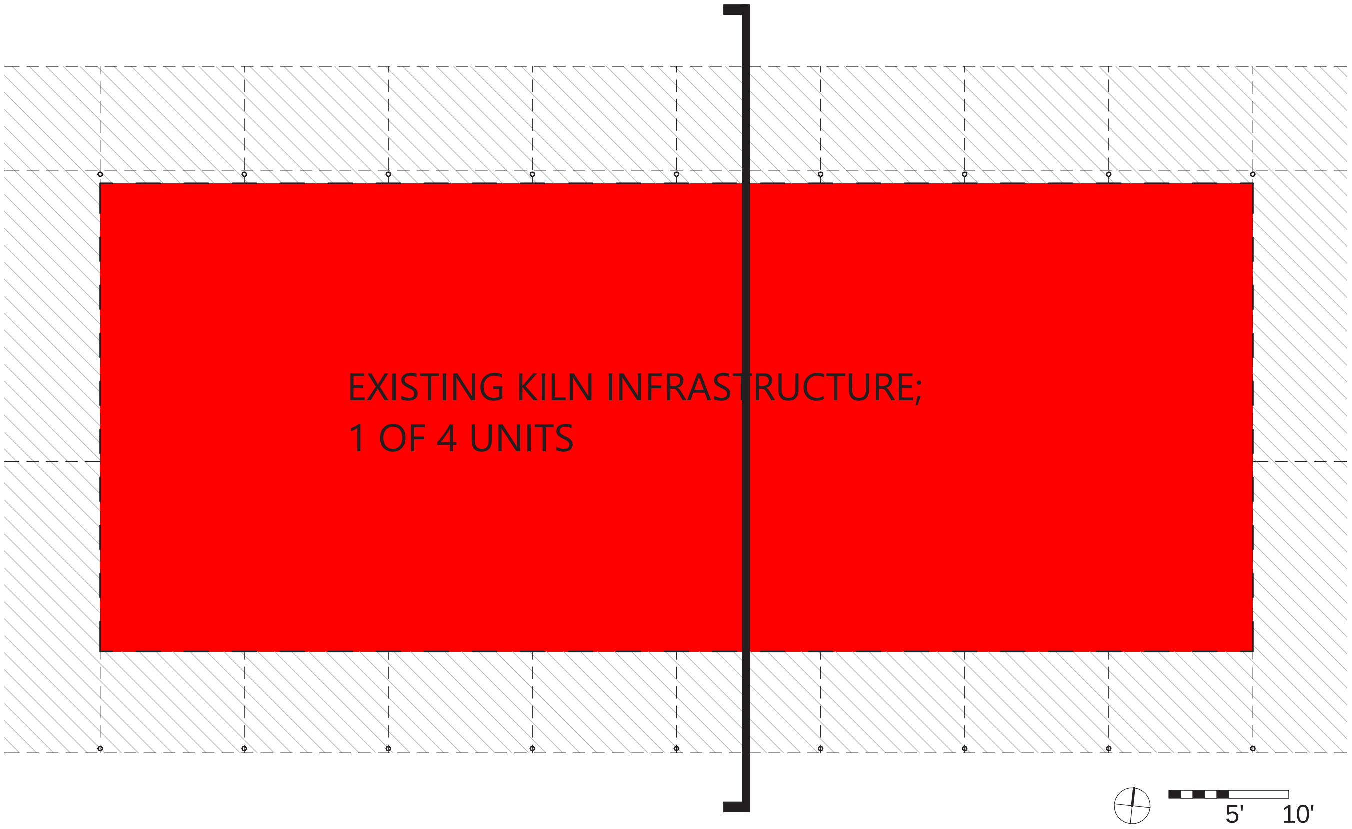


The “porch building” is located at the east side of the site. It gets its nick-name from the overhang facing the street. The walls are all standard brick, but like the “hollow-core brick” building, the roof is woof and metal, and needs to be replaced. It has what appears to be an addition on the south side, where the roof changes pitch and the brick color changes on the side and back of the structure.

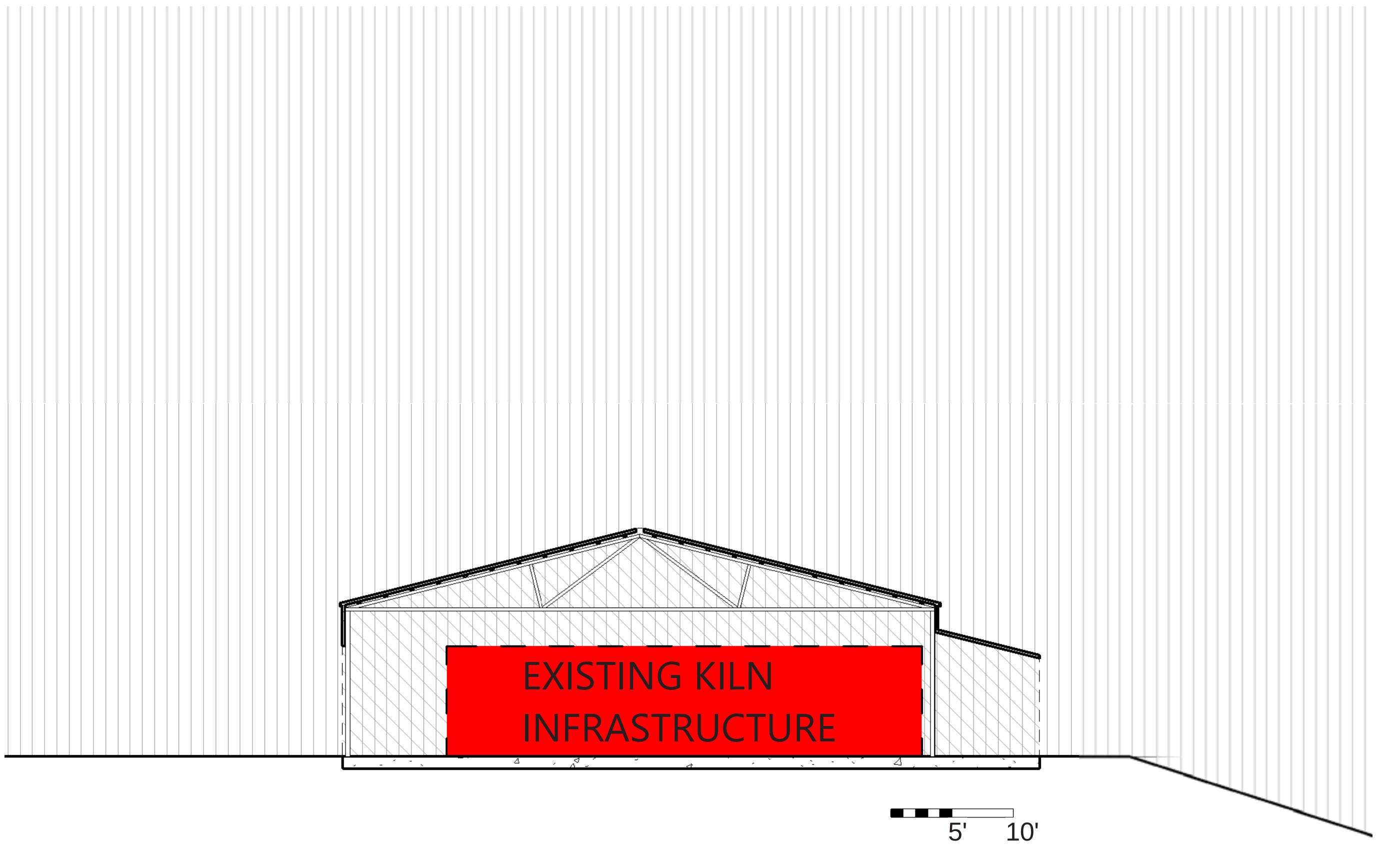
The building is in relatively good shape aside from the roof, so it will remain in place. Since it is removed from the other buildings and has little visual interest, it presents a design opportunity to be redesigned as a welcome center if this is the main entrance to the site, or a convenient storage shed at the back of the site if the entrance is from the north.

2.06 | "Kiln Building"





Standard N/S Section



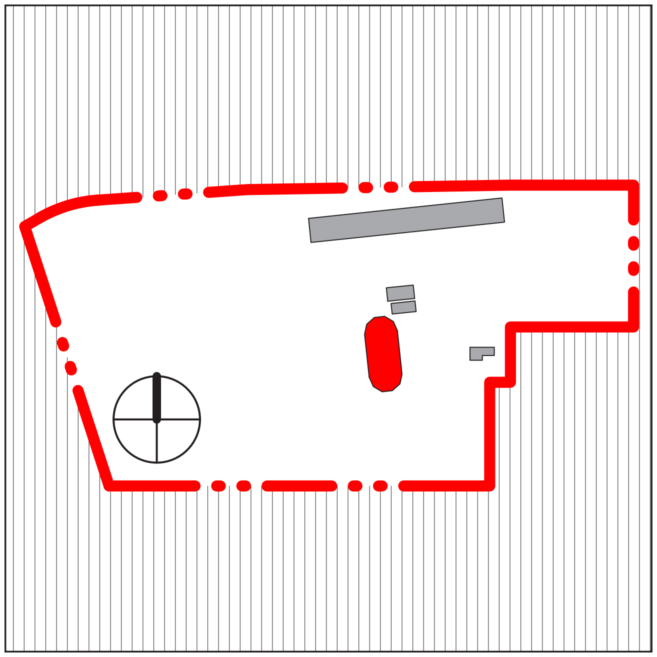
The "kiln building" is the most damaged structure on the site, but it also has the most value for the program. It got its nickname because it housed the kilns that the brick manufacturer used while in operation. I estimate that it once held four kilns, which can still be found on site. It is located along the north edge of the site, and can be seen from the road.

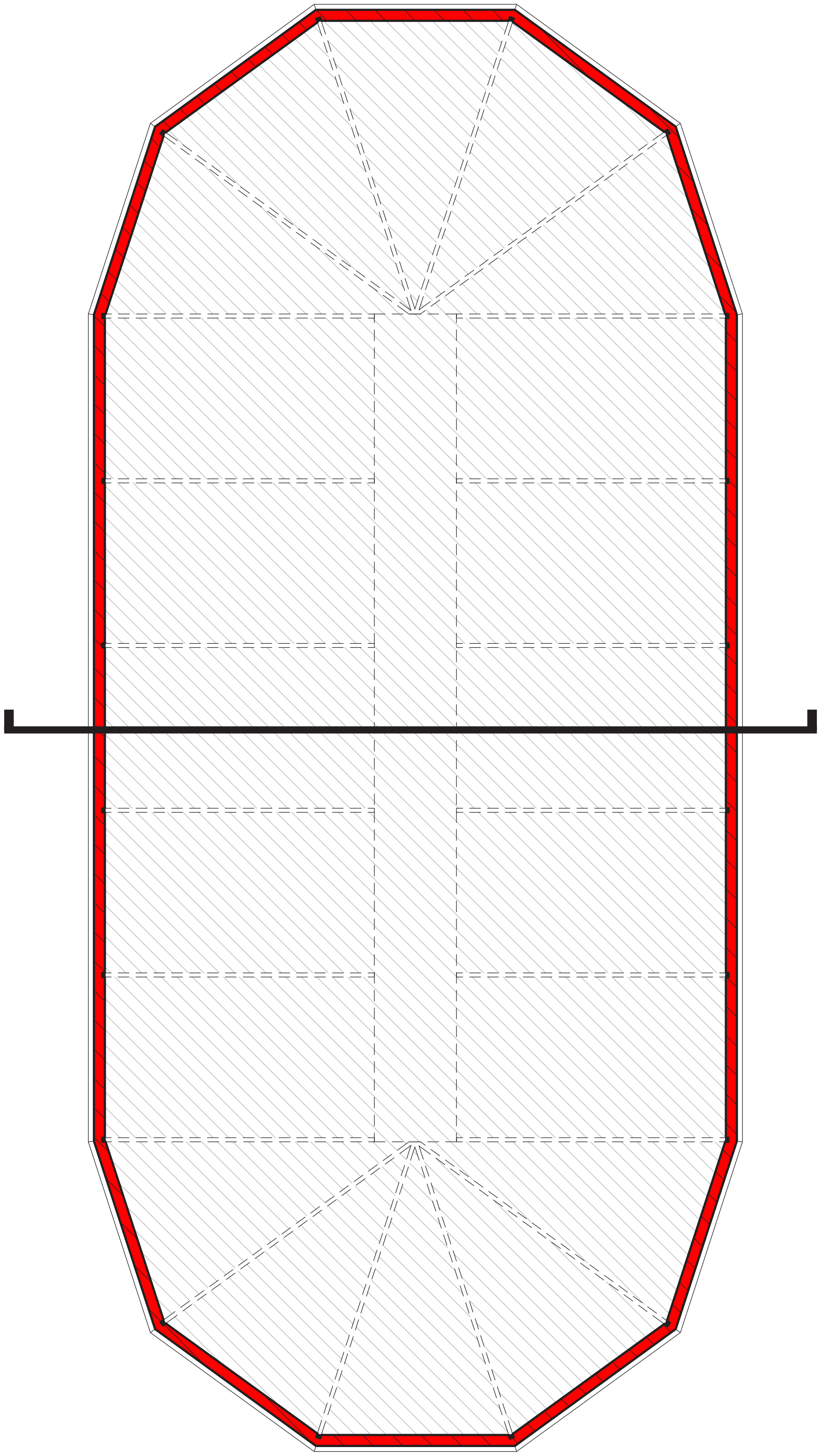
The exterior of the building is a long metal pavilion which has been destroyed completely near the west end. It is largely intact, though somewhat rusted at the east end. I recommend demolishing the entire superstructure and constructing a new pavilion over the historical kilns.

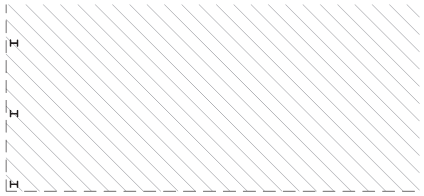
The interior has a labryinth of brick structures, which could be a final study all on its own to document and reconstruct. There are rails embedded in the ground, which I suspect were tracks for a cart that moved bricks throught the kilns. Elsewhere on the site, there are four metal-clad kiln components which have tracks attached to the bottom as if they were removed from the kiln building. Of these, one is completely intact, and another is largely intact. Two are badly damaged, but still recogniazable.

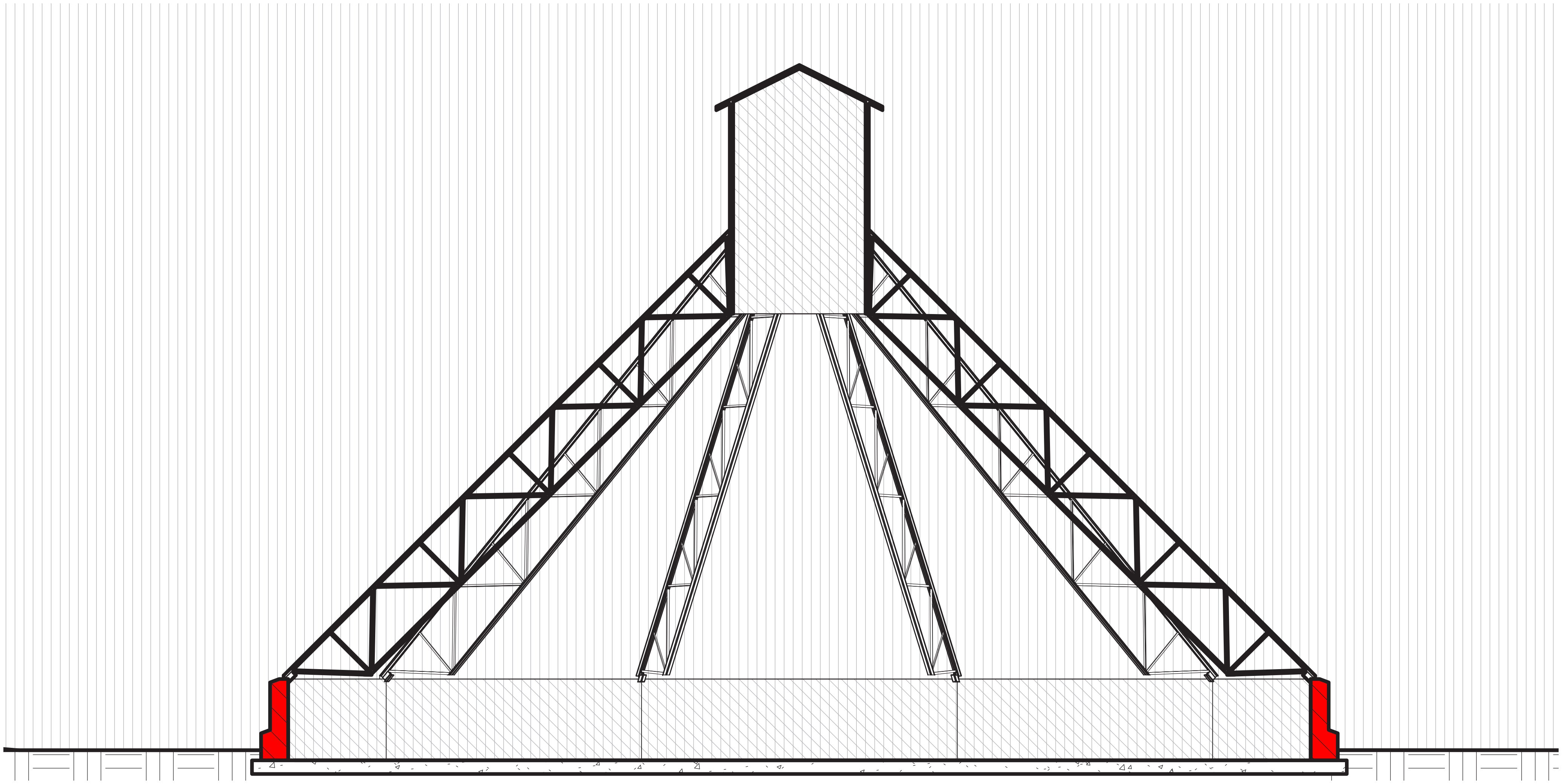
Many brick details are still visible, including a series of arches lining the central chamber. Heavily-insulated pipes run along this chamber, either for supplying or venting the heat using in firing the bricks. It will need to be checked for hazardous materials such as asbestos before construction begins.

2.08 | "Elliptical Building"









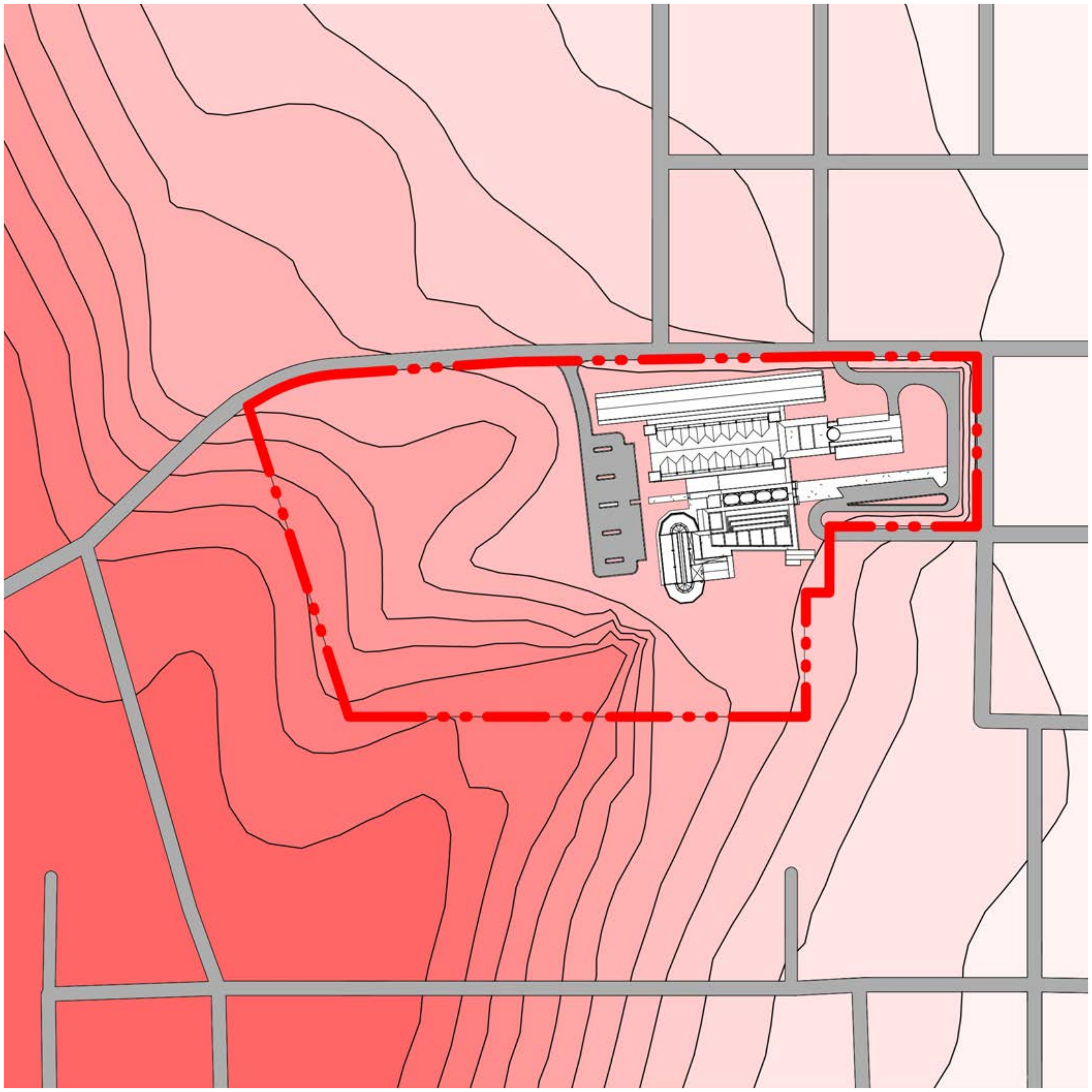
The “elliptical building” consists of a low brick wall forming a 12-sided ring (two halfs of a regular 10-sided polygon joined to a rectangle) around a steel superstructure. There are 20 trusses connecting the wall to a popped out clerestory. The sheets of metal that once formed a roof over the space are now scattered around the site.

This building is the main focal point of the built site, but owing to the terrible condition of the building, the steel should be removed. The foundation around the perimeter and brick wall are still usable, and should be preserved or re-used. The foundation should be checked towards the center however, for flora-related damage.

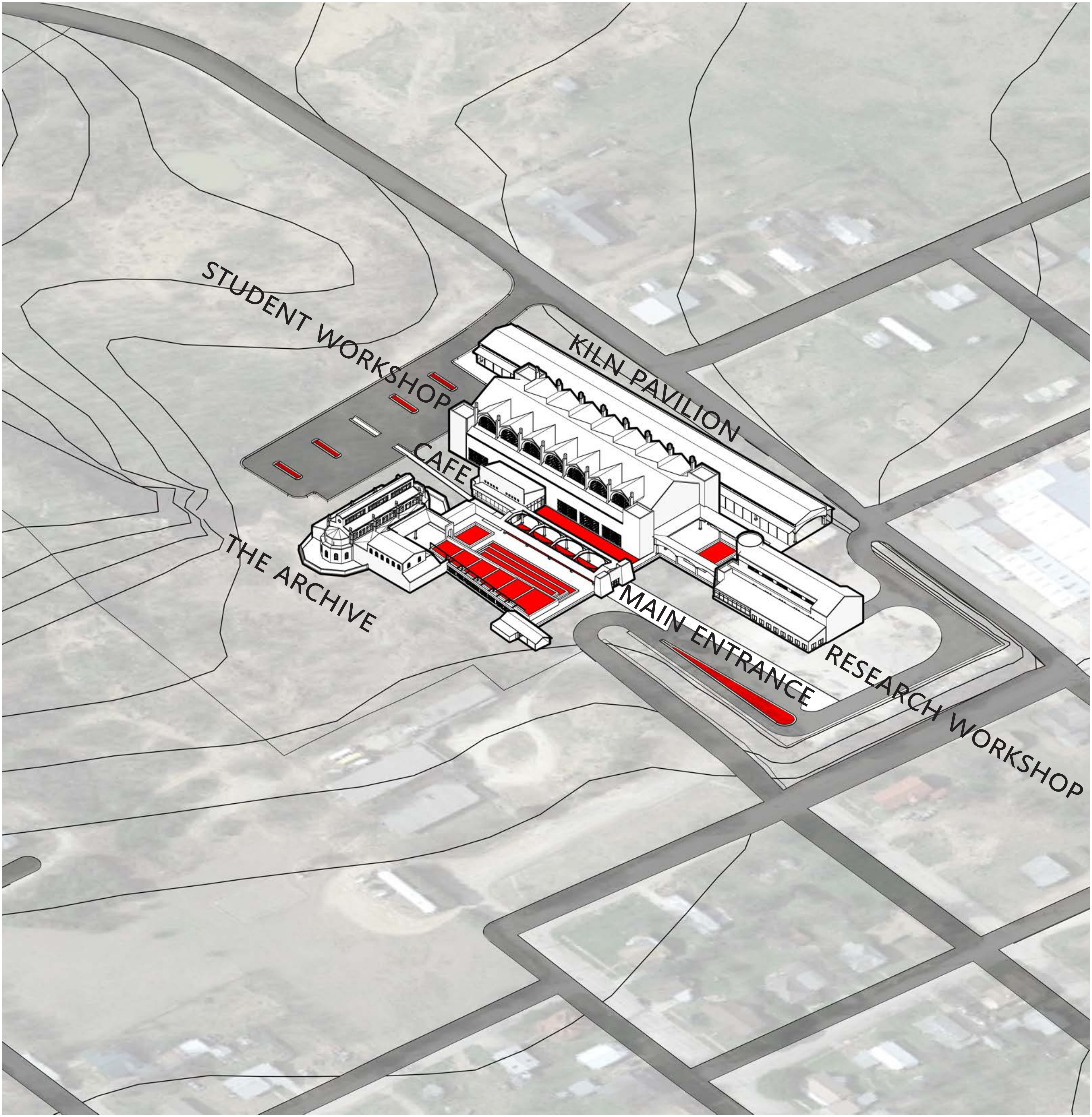
3 | Intervention

3.02 | Campus Layout

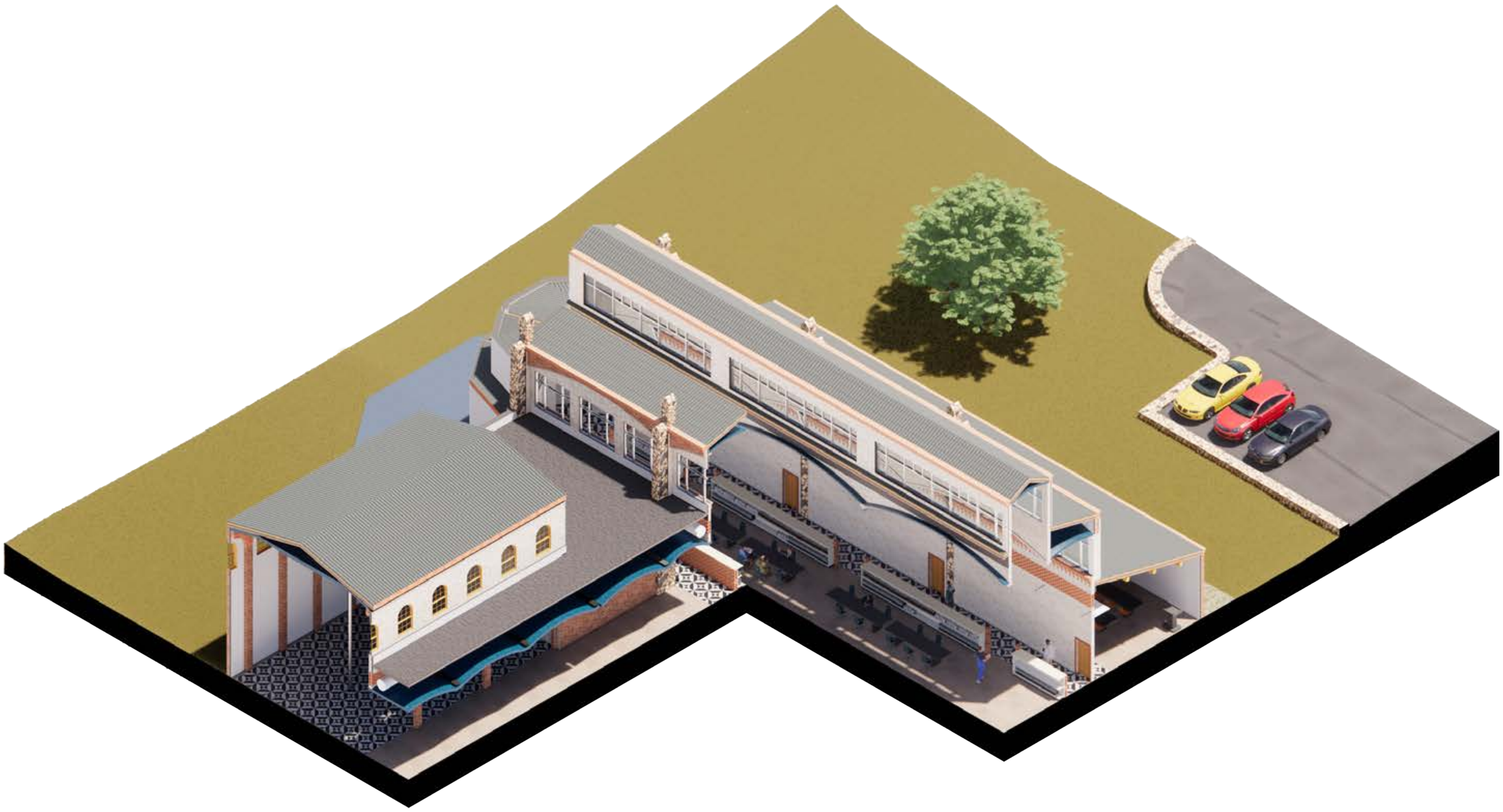
The largest building currently on the site, which I have been calling the "elliptical building" needs to be razed to the foundations due to the dangerous condition of the steel superstructure. This will house the Archive functions detailed in section one. The metal roof over the kilns also needs to be replaced. Because the site was selected for its history of brick manufacturing, as much of the existing site should be preserved as is reasonably possible in order to preserve the memory of the previous site, favoring the more durable masonry components over easily replaceable steel sheets. Access to the site is currently from the east side.



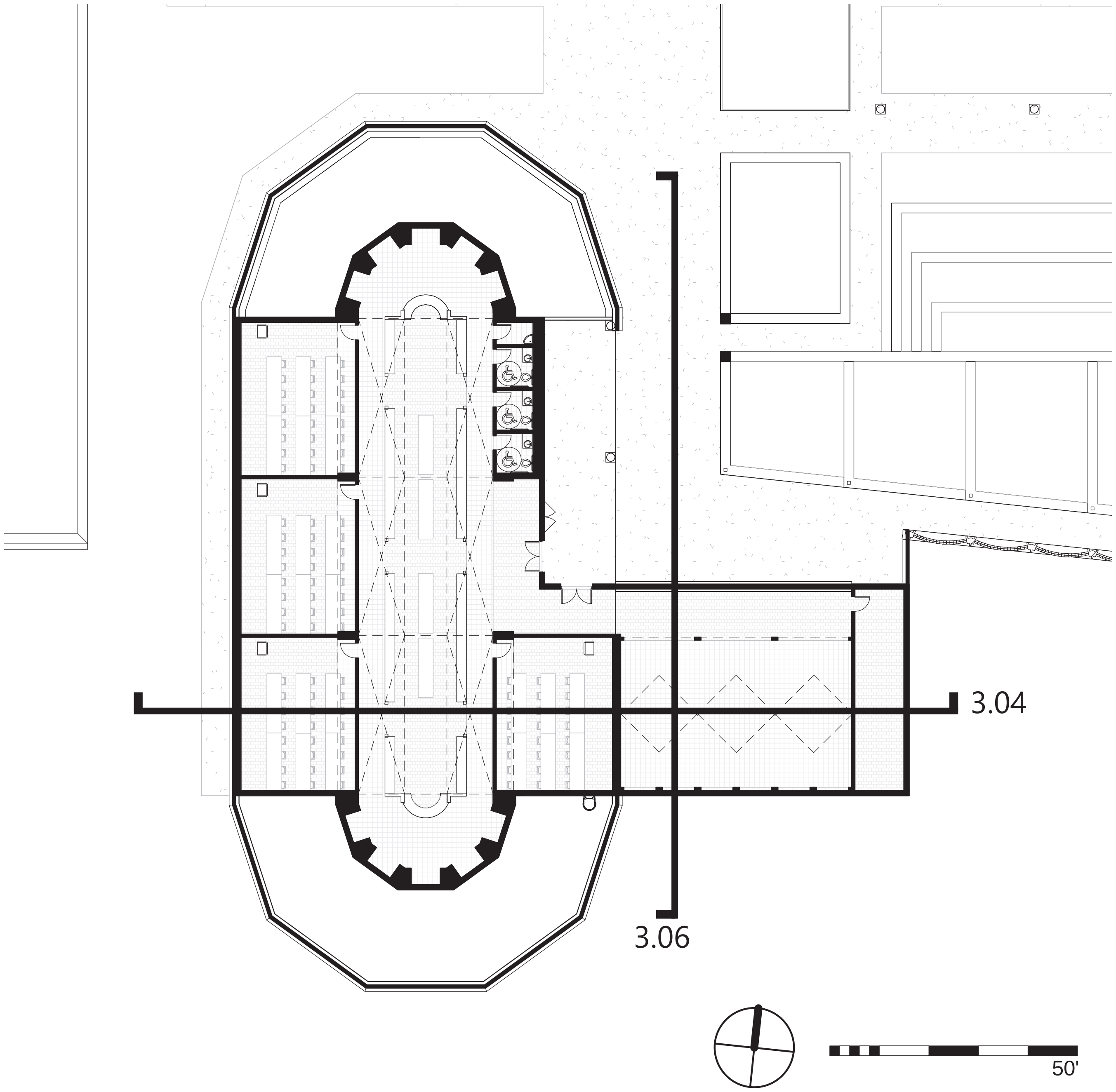
The new workshops will be placed between the kilns and sheds down the center of the site. There will be a new courtyard between them, allowing public access to the historical kilns behind them. There will also be a larger courtyard just south of the entry promenade, which functions as a large social area aside from linking the Archive with the Workshops. Visitor parking will be on the east side by the main entrance to the site, and long-term student parking will be on the west side. It is important not only to build near the existing buildings to integrate them, but they are also on the flattest part of the site, where construction will be easiest and cheapest.


STUDENT WORKSHOP
KILN PAVILION
CAFE
THE ARCHIVE
MAIN ENTRANCE
RESEARCH WORKSHOP

3.04 | The Archive



3.05 | The Archive



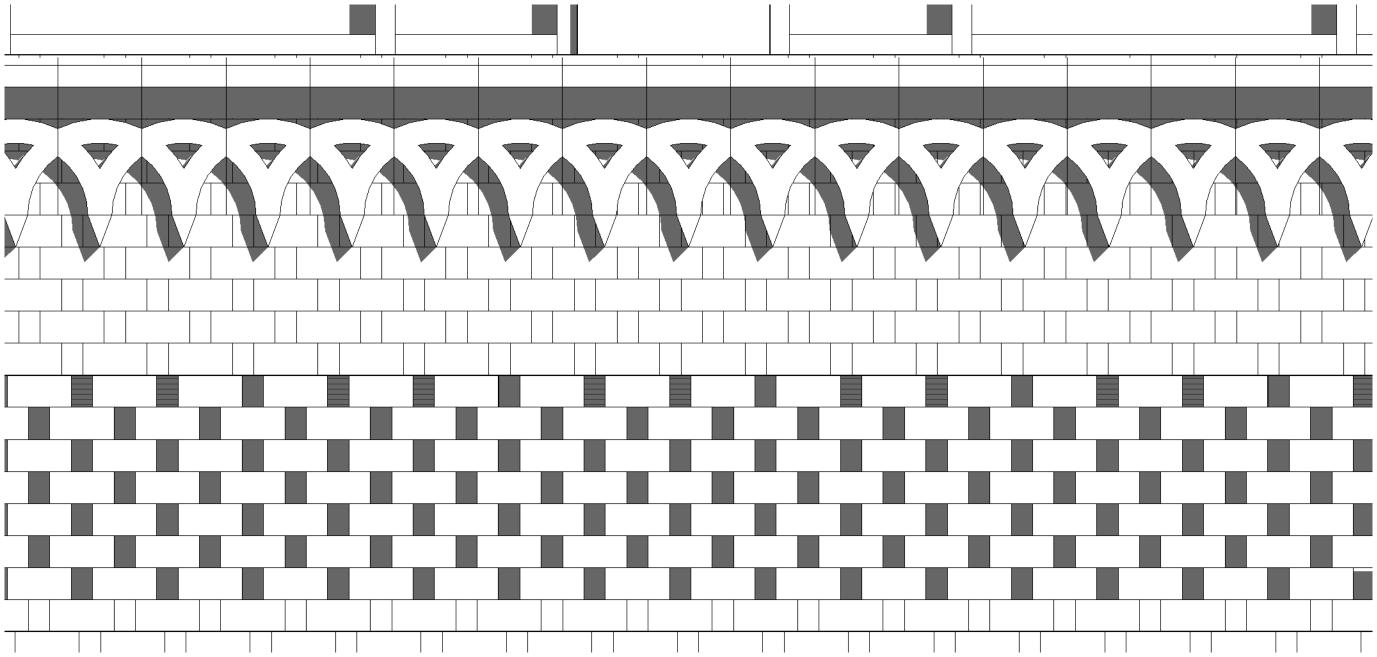
Above Left: EW Section through Reading Room and Exhibition Hall
Below Left: Isometric Rendering through major circulation paths
Above: Archive Plan Drawing

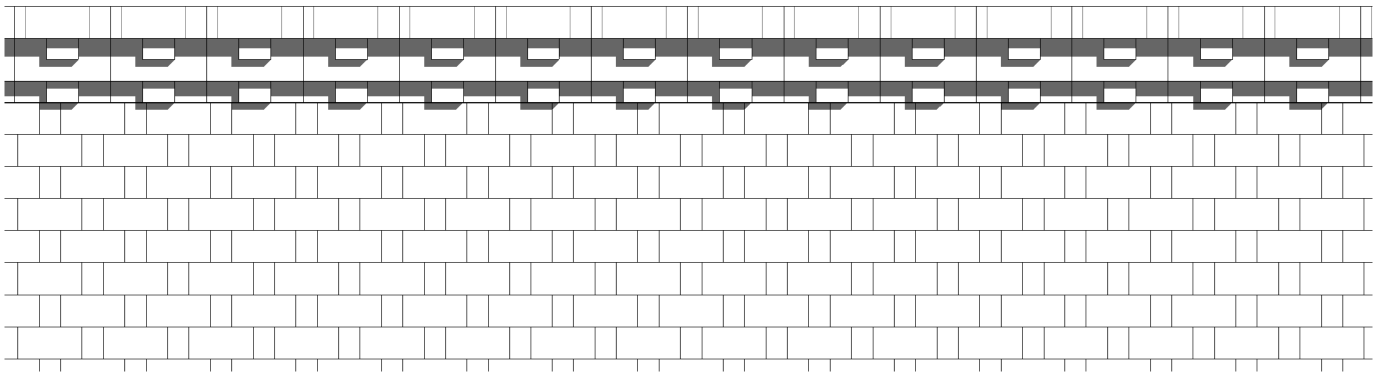
Since December, I have been detailing the “Archive” building, located on the foundations of the former elliptical building, as the main component of my final study. It incorporates the classrooms, material library, and exhibition hall, since they all have a similar need for a thermally and auditorily controlled environment. I focused on this as my principle building because it has the most complex assembly and detailing, since it is the main public point of contact for the site. Since the exhibition hall isn’t on the existing footprint, it will require a new slab foundation with an expansion joint between the structures.

The classrooms are arranged around a central reading room, which contains the material library, reference library, and project archive. The reading room is capped with a polygonal apse at either end. The apses have five alcoves each for a more atmospheric reading experience, as well as using the visual language of older semi-circular lime kilns. The exhibition hall is easily visible and accessible from the entrance.

Since most of the previous building could not be preserved, the new building follows the tent-like form of the existing building, down to the clerestory projecting from the center of the roof-ridge.

3.06 | The Archive



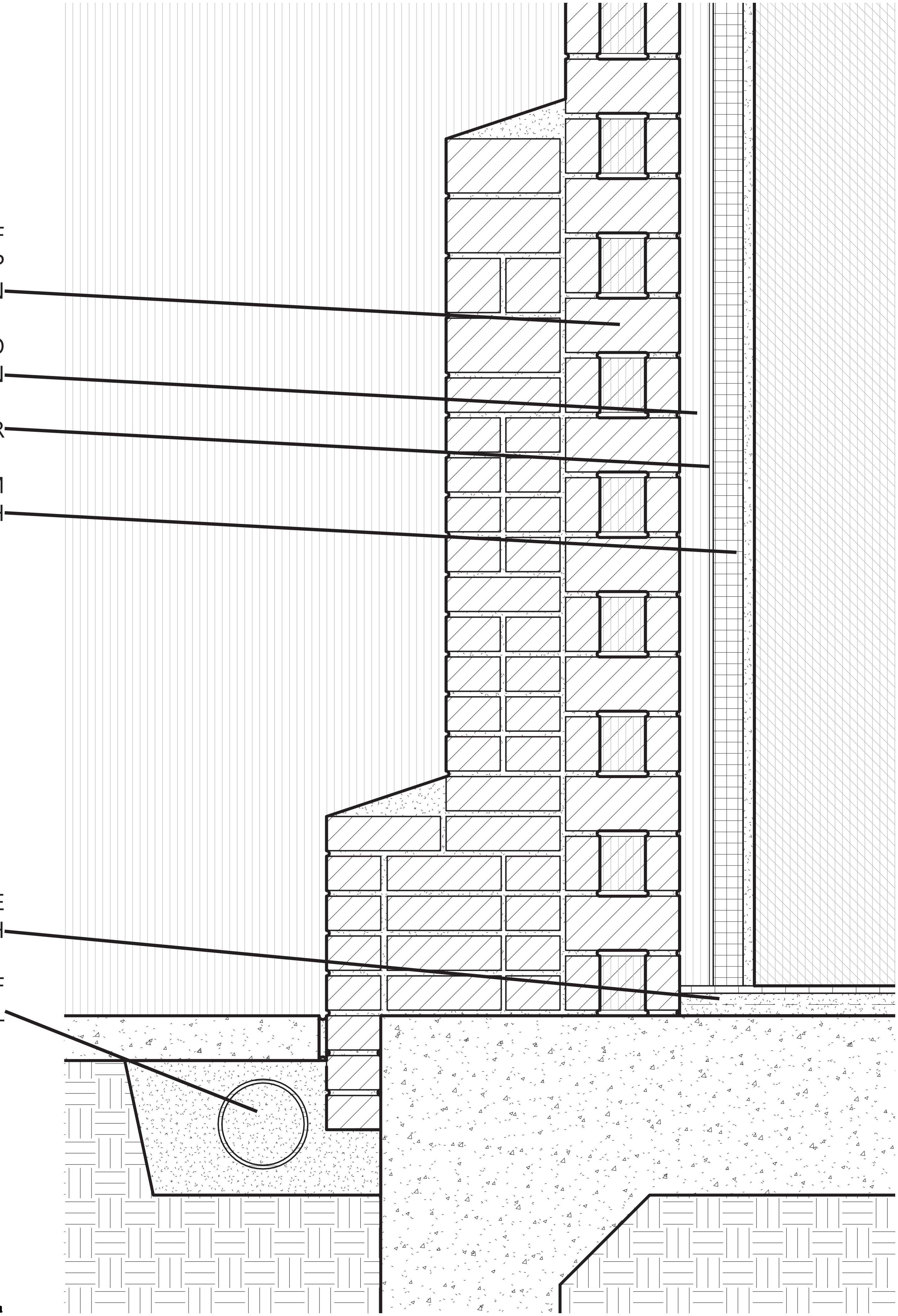


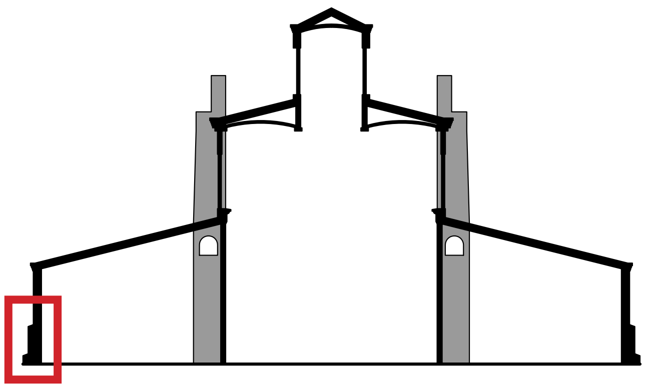
Above Left: NS Section through Exhibition Hall with East Elevation of Archive
Below Left: Interior Perspective of the Reading Room
Above: Interior Terra-cotta Cornice Elevation Detail
Below: Exterior Brick Cornice Elevation Detail

The exhibition hall is for educating visitors about the various activities of the institute, including a permanent exhibit about the unorthodox or innovative techniques used to build the institute. Inpiration for this space came from Rafael Guastavino's reading room at the Boston Public Library, which uses the same basic arrangement. The reading room on the other hand is more visually similar to one of Viollet-le-Duc's theoretical stone and iron buildings.

The reading room displays all of the special masonry techniques that I discovered in my research. The walls are made with rat-trap bond using a light brick, reducing the weight of the structure as well as the materials used. Screen walls show where the mechanical systems are housed within the walls. The timbrel vaults used in the ceiling are supported by geometric steel frames, which are braced on concrete piers made with rubble collected from the site itself. On the non-structural walls, the exterior is clad with terra-cotta panels, so that it is in keeping with the ceramic theme, but visibly non-structural. In the following pages, I will show by various parts of the building section these features in detail.

3.08 | The Archive

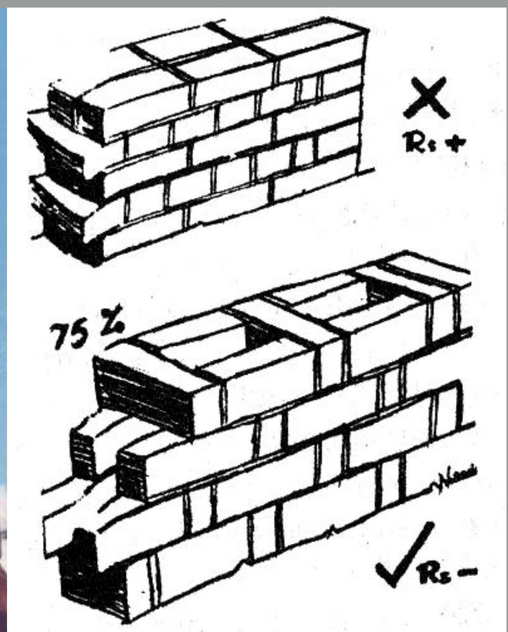


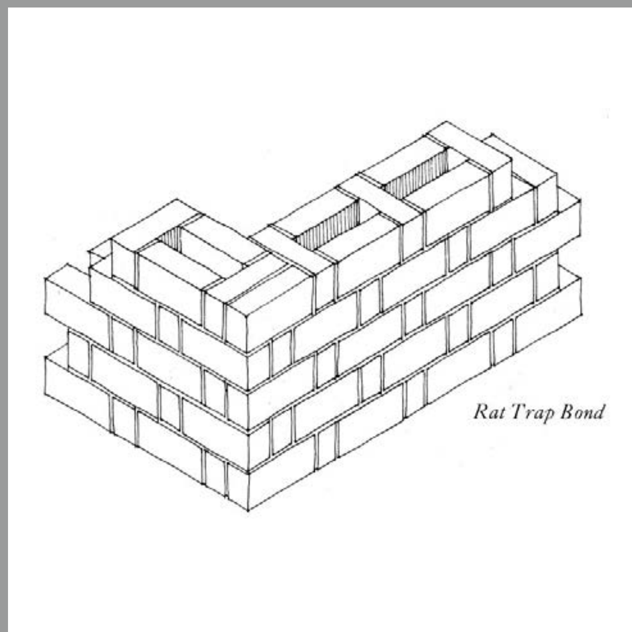


3.09 | Rat-trap Bond

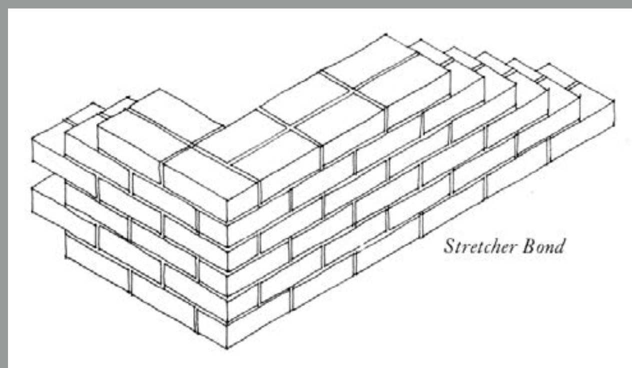
Rat-trap bond is a brick laying technique where bricks are laid on the stretcher face rather than the bed, alternating the bed and header as the face exposed to the exterior, similar to a Flemish bond. Three courses of standard brick are 12” tall, instead of the 8” with stretcher bond. The center of an 8” thick rat-trap wall is mostly hollow, giving the wall additional insulation from the air gap. This technique was widely used by the British-Indian architect Laurie Baker (1917-2007). Baker, seeking the maximize the economy of his building methods, found that laying bricks in this way used 75% of the materials that the same wall built using a solid bond would use.

I used this technique throughout the project, including a double-wythe variant I discovered used in the Pirouette House by Wallmakers. The consistent use will distinguish new construction from existing construction.

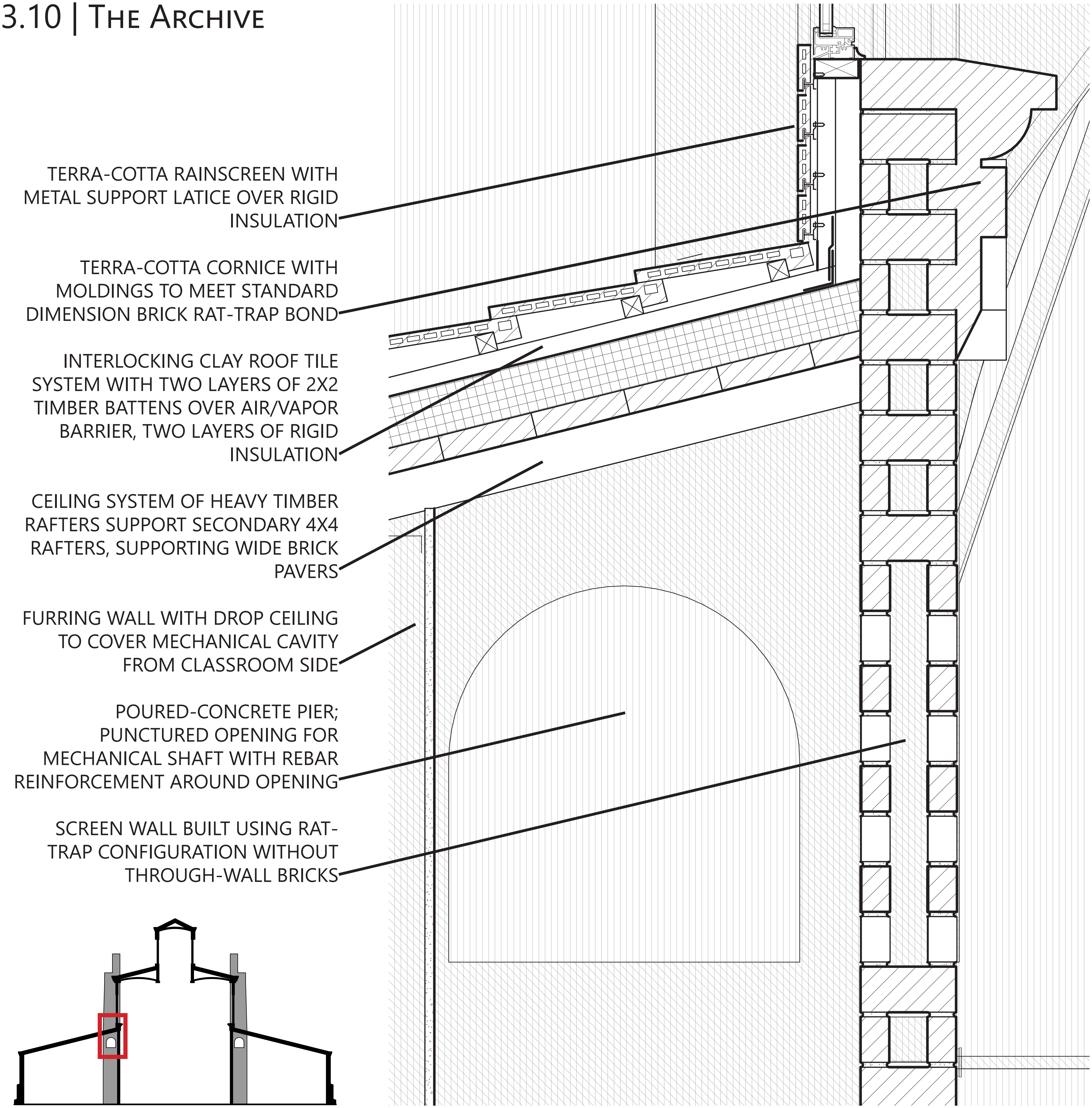




Another cost-saving method Baker used was contributing labor to the construction himself. He is shown here building a rat-trap brick wall on the left. On the right is one of his sketches from a series illustrating his imperical best practices.



3.10 | The Archive



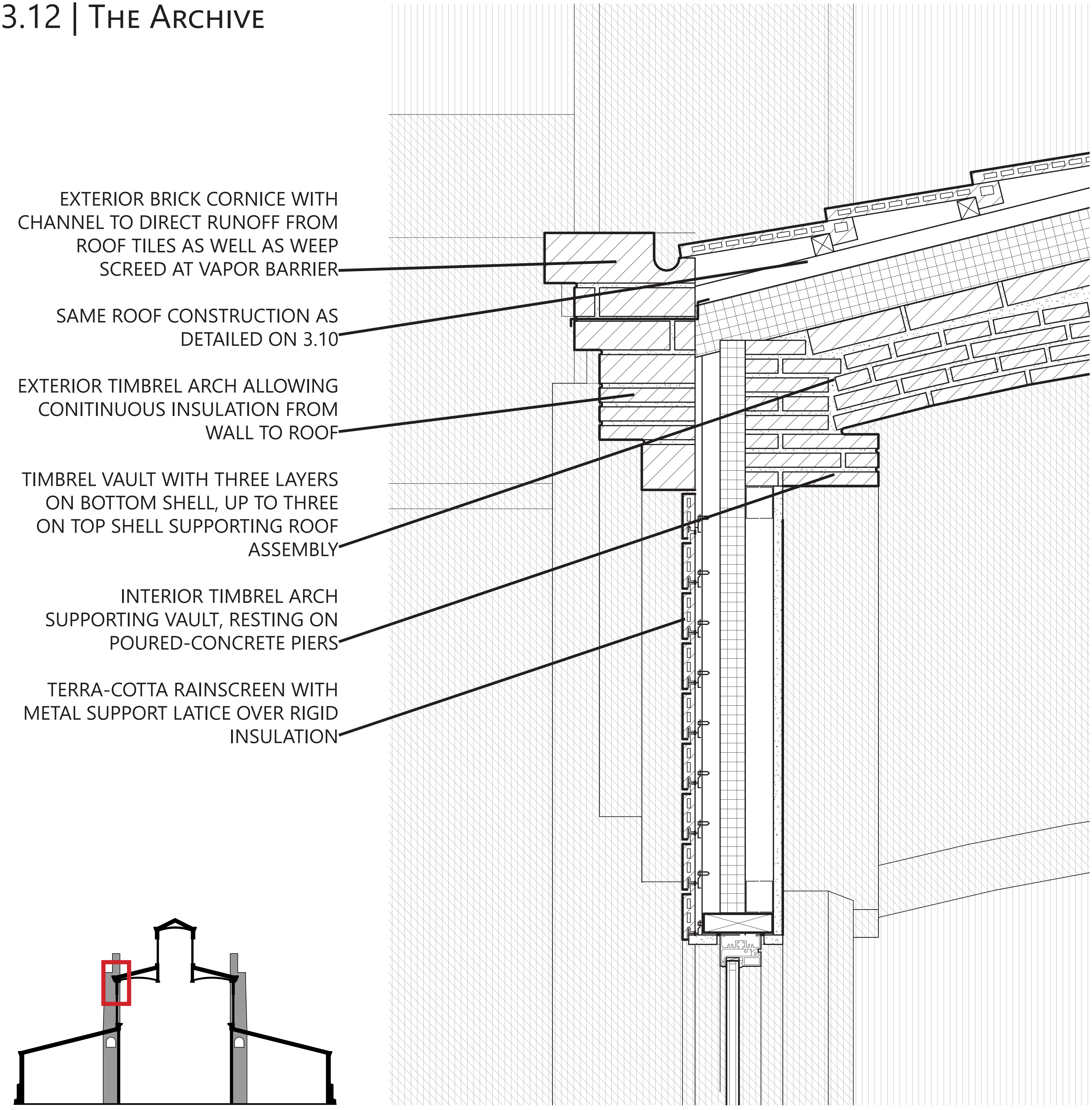
3.11 | Jali & Mechanical Cavities

Another technique Laurie Baker commonly used was the jali wall. Jali is a Malayalam word which means screen wall. Baker used brick screens to replace wooden screens to allow natural ventilation. Air conditioning was not something he had access to in rural India.

Since I was adapting techniques for use in the 21st century North America, meaning that air conditioning is assumed, I combined the idea of the jali with a comment by Rafael Guastavino regarding the placement of mechanical systems in hollow walls. Since massive structural masonry walls were no longer necessary, Guastavino suggested replacing them with wide, hollow walls to allow the building to breathe.

The jali thus solved the problem of how to put the mechanical systems out of sight without outright hiding them. There is a blind jali segment of the wall that runs around the interior of the reading room revealing where the air ducts are kept within the wall. Since the other side of the walls are classrooms, there is a soffit built around the mechanical systems on that side to prevent sound permeation through the jali.

3.12 | The Archive



3.13 | Timbrel Vaulting

Rafael Guastavino, standing on a completed timbrel arch at a worksite.

This technique was not a modern invention, but it was used widely by Rafael Guastavino. Timbrel vaults (also called Catalan vaults, owing to their localized use in Spain) are constructed by alternating layers of thin tiles with layers of hydraulic cement. This differs from a traditional masonry vault because the hydraulic cement gives the vault a certain amount of tensile strength, so it is structurally similar to a shell structure.

Guastavino identified several major advantages to this technique. It is lightweight, fire-resistant, strong, doesn’t require complex scaffolding, and it can support workers the day after it is built. Antoni Gaudí also used this technique extensively in double-curvature surfaces. Gaudí’s use also shows that they can be used to create incredibly flexible, complex forms. By using straight lines to generate these surfaces, he was able to economize their construction.

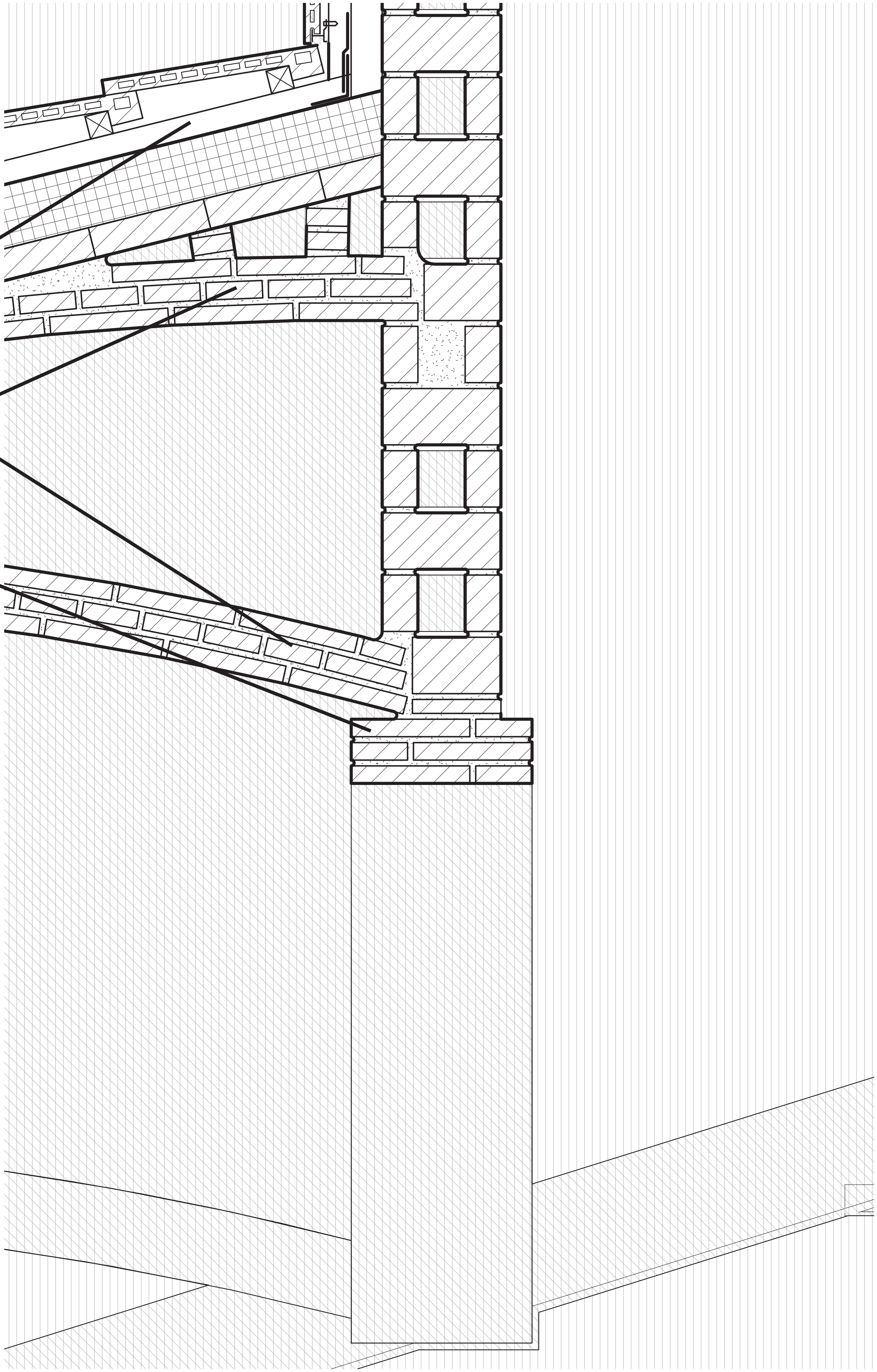
The major disadvantages of this system were labor cost for Guastavino and over-sophistication for Gaudí. Indeed, Gaudí’s Güell Crypt was left unfinished because the design was so complicated that the site couldn’t physically accommodate the number of workers needed to assemble it at one time. Taking note of these shortcomings, I used very simple, repeated double-curve surfaces that can be pre-fabricated on the ground and hoisted into place.

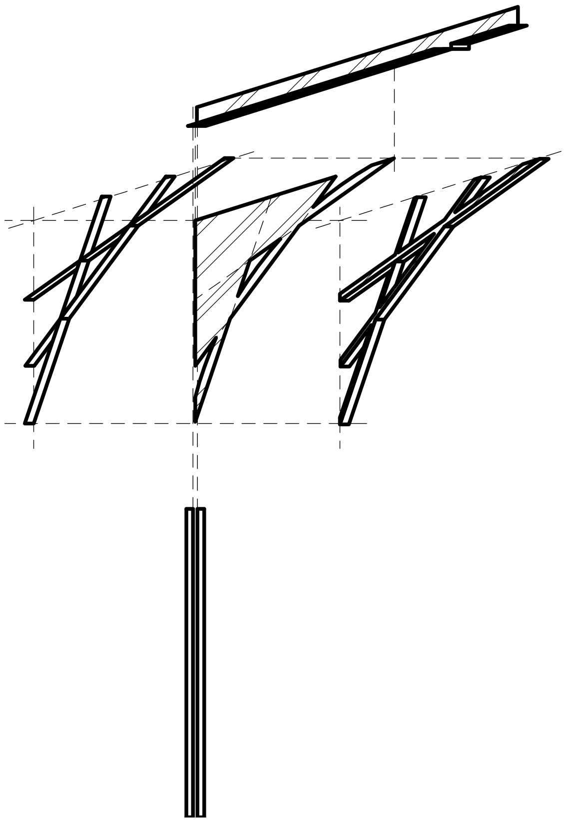
3.14 | The Archive

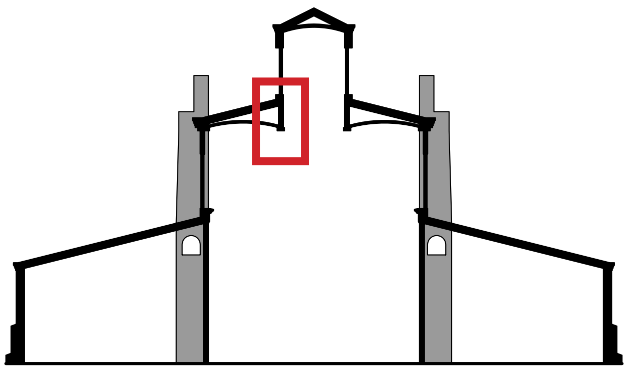
SAME ROOF CONSTRUCTION AS DETAILED ON 3.10

TIMBREL VAULT WITH THREE LAYERS ON BOTTOM SHELL, UP TO THREE ON TOP SHELL SUPPORTING ROOF ASSEMBLY

INTERIOR TIMBREL ARCH SUPPORTING VAULT, RESTING ON STEEL FRAMES BETWEEN POURED-CONCRETE PIERS

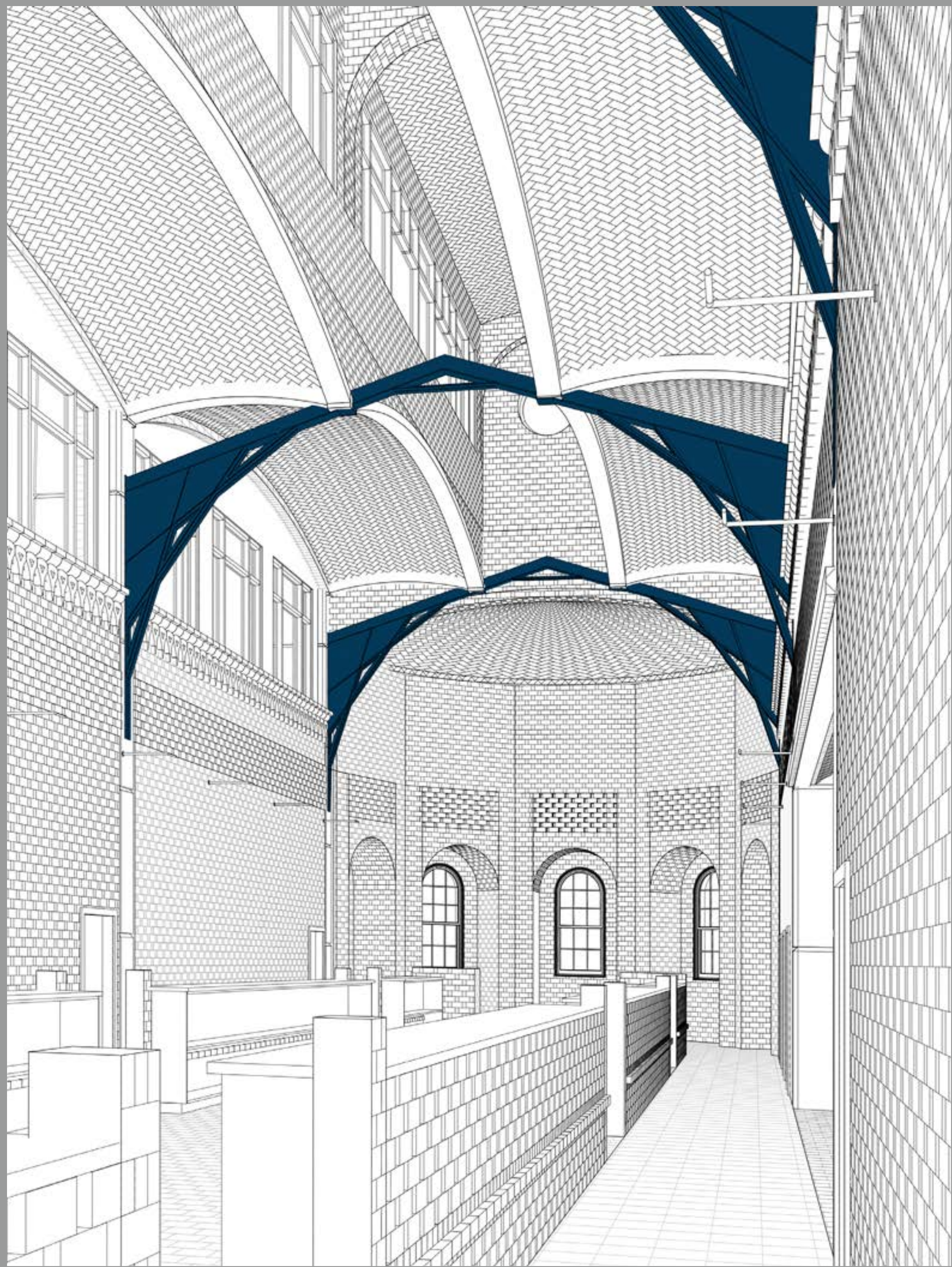






3.15 | Steel Skeleton

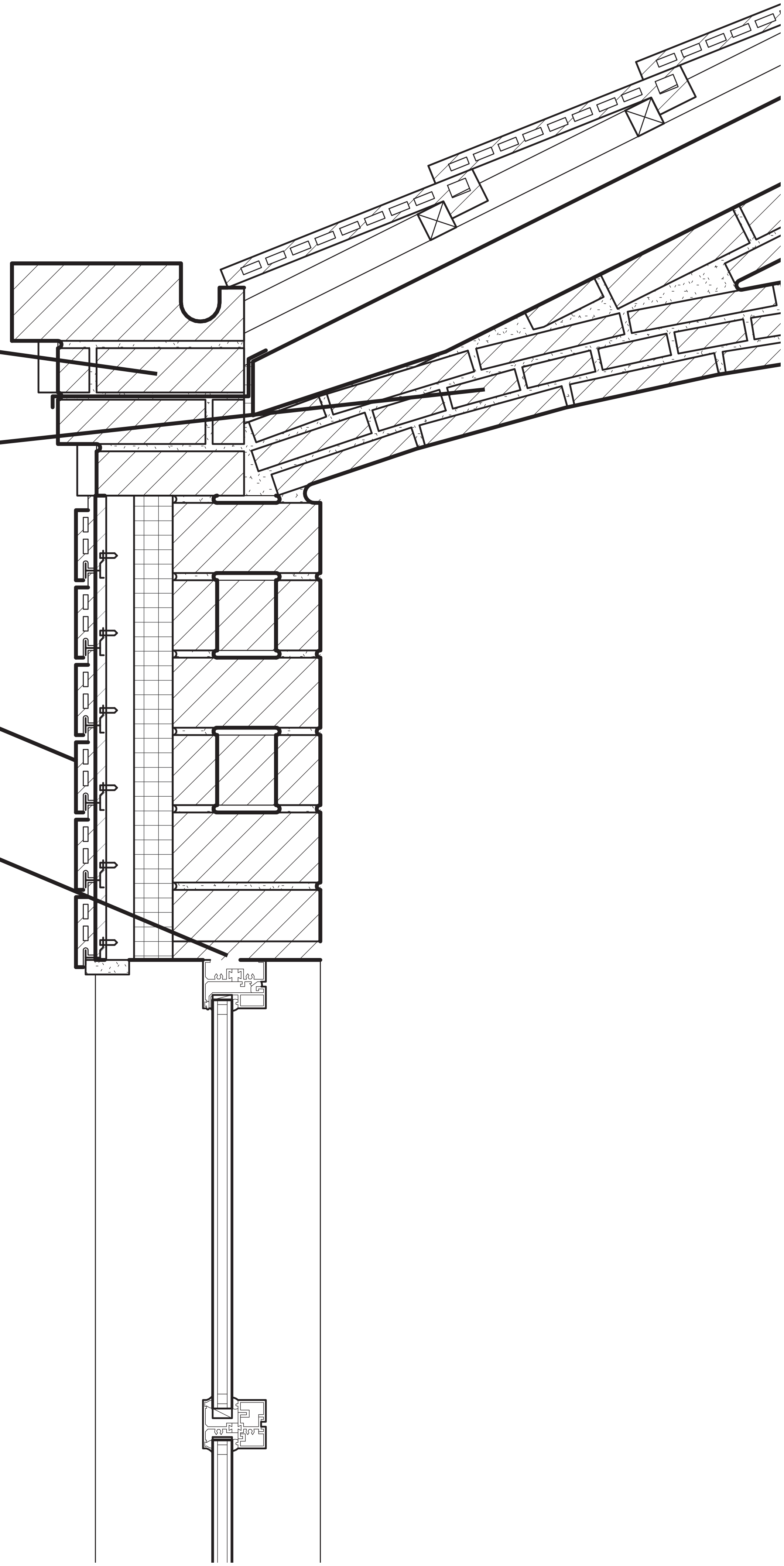
When structural iron was gaining more widespread use in the later 1800s, Viollet-le-Duc proposed combining a steel skeleton with a masonry shell. In his discourses, he showed hypothetical buildings that could extend the range of masonry vaults without creating a forest of columns or relying on massively thick walls to bear the load of such a ceiling. Although his writings influenced many architects, this concept as he envisioned it was never adopted.

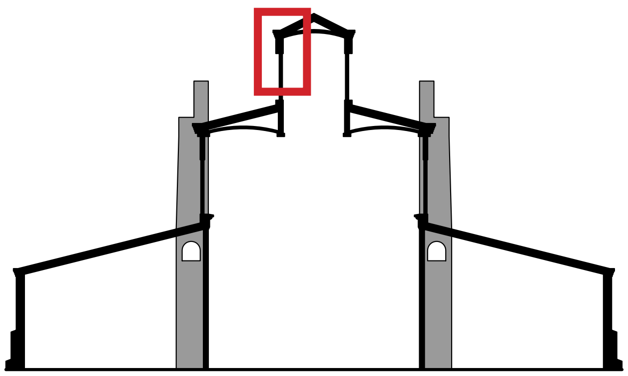


“The method of structure in iron and masonry fulfills the conditions that, in our opinion, should characterize such works. Thus, the iron framework is visible, independent, and free to expand and contract, so that it cannot cause dislocation in the masonry, whether through oxidation or variation in temperature. The masonry, while concrete in parts, yet preserves a certain degree of elasticity, owing to the small arches that carry the whole… it requires a minimum of materials and only thin walls, which (excepting the points of support) may be partly built of rubble stone.” -Viollet-le-Duc, *Discourse XII*

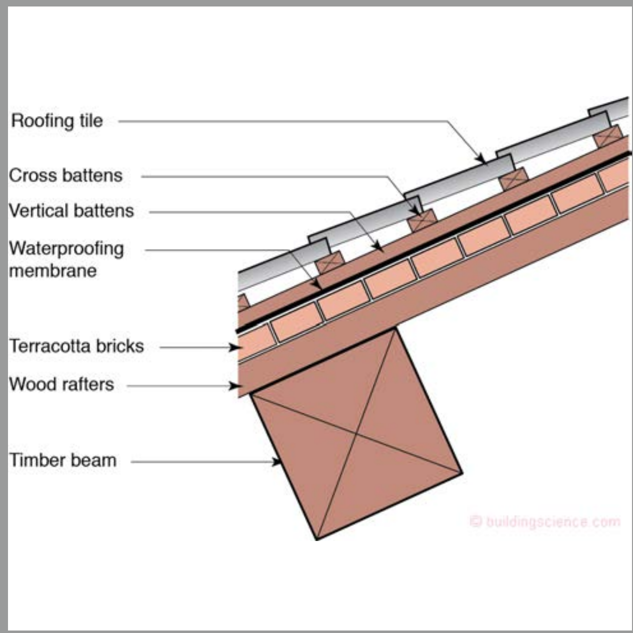
I have modified it according to the writings of Eladio Deiste, who has noted that cost estimators favor planar buildings over organic buildings. I also included a visual allusion to Frank Lloyd Wright, by using the ceramic rubble from the site in tall poured concrete columns, a modification of the desert masonry technique used by Wright at Taliesin West.

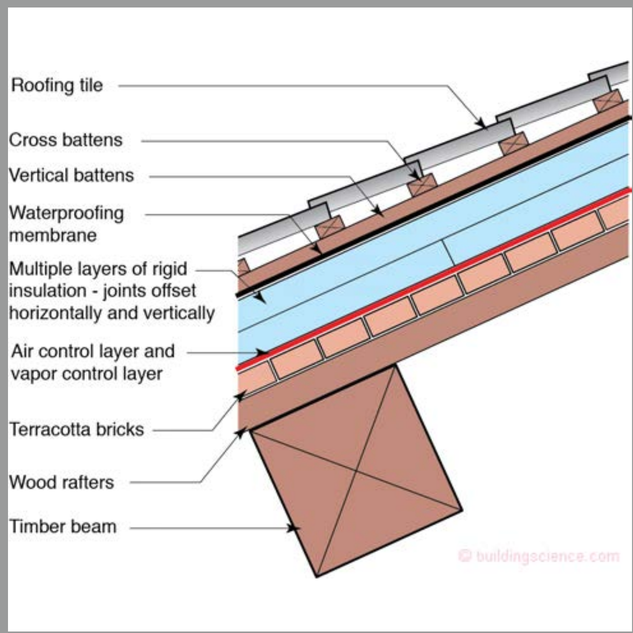
3.16 | The Archive





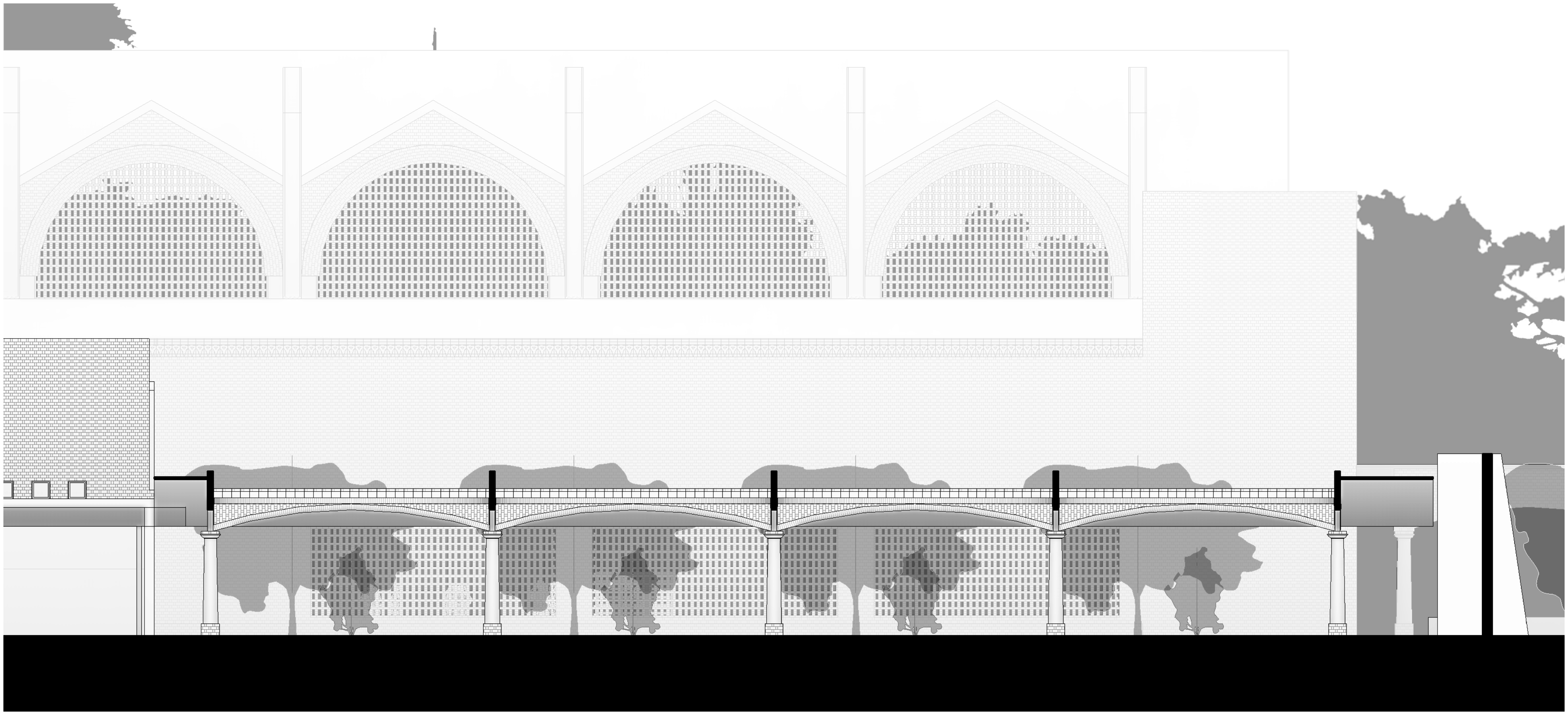
3.17 | Improved Tuscan Roof



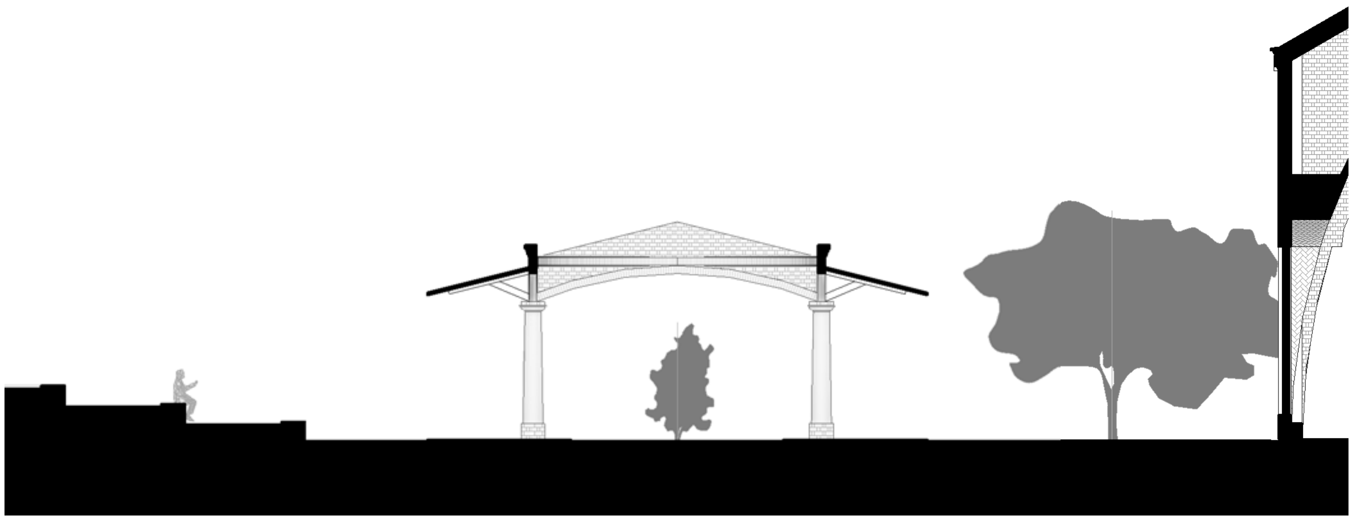


Traditional masonry building in Tuscany is designed for passive environmental control. When such buildings are modernized, the mechanical intervention is still limited. A Tuscan ceiling, while offering a wealth of detail, is relatively simple to construct, and the only additions needed to bring it into the 21st century are rigid insulation on top of the brick pavers and a water barrier between the insulation and tiles.

3.18 | Landscape



3.19 | Landscape



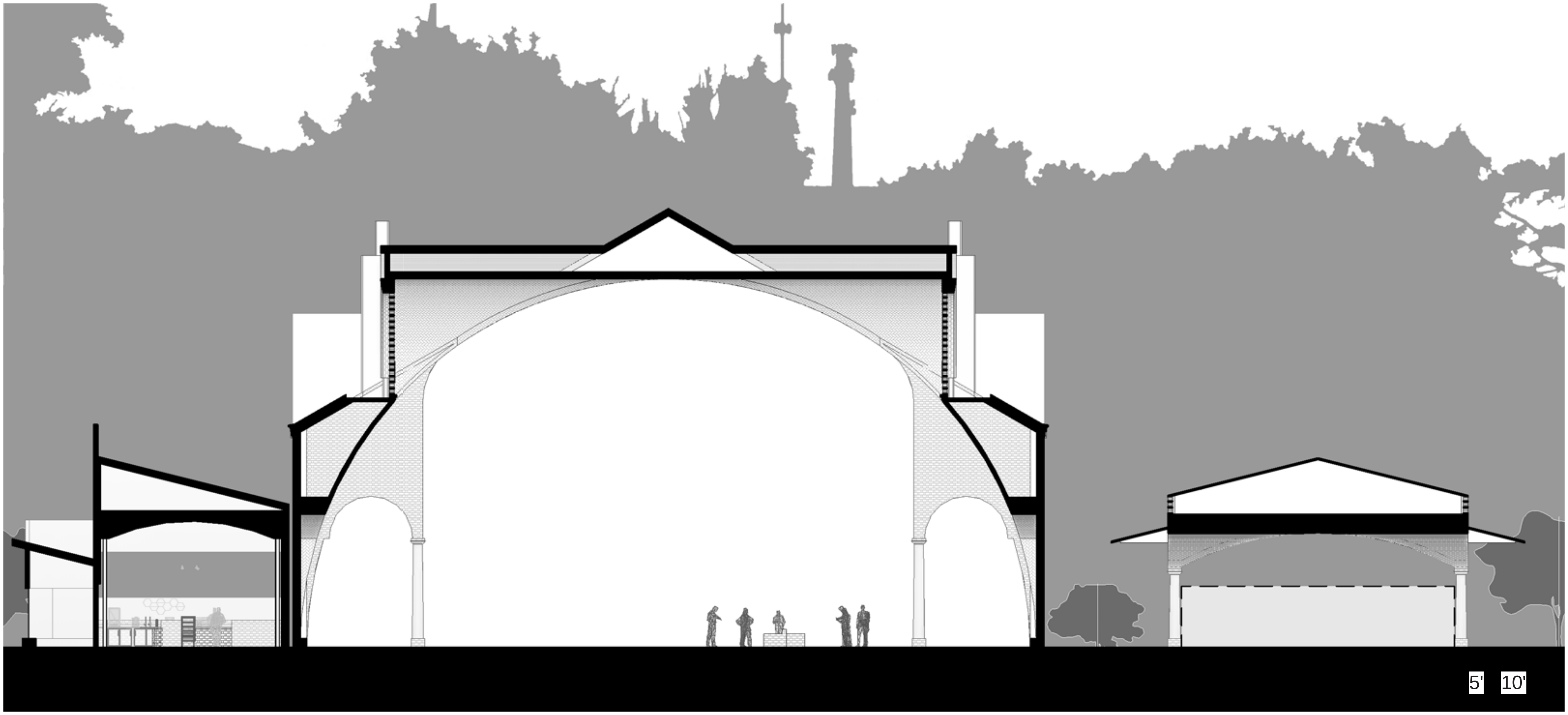
Above Left: EW Section through Entry Promenade
Below Left: Exterior Perspective of Entry Promenade
Above: NS Section through Entry Promenade

The landscaping features were essential to unifying the campus, as well as serving as a prominent social space and point of public contact. Through the main eastern entry, the path splits to form a long promenade leading into the entry space (to be added in phase 2, inessential to basic operation). The entry promenade structure consists of 8 columns, spanned by low-rise timbrel arches, with elliptical brick rings resting on the tops of these arches. Each ring will be held in place by a steel compression ring. The structure is a lightweight structure intended to give an immediate demonstration of how brick can be used imaginatively.

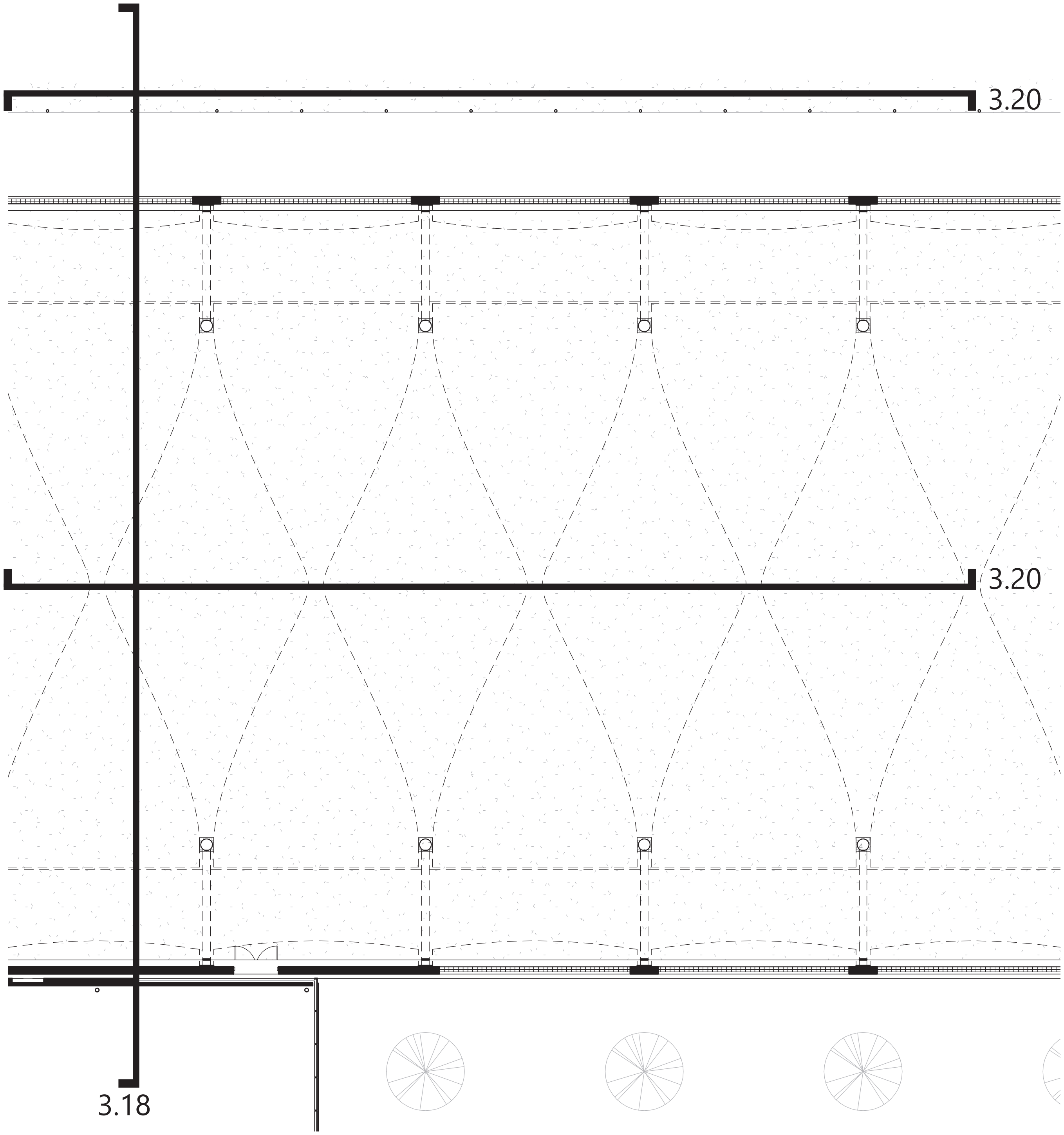
The central aisle is planted with a line of small trees (centered within each ellipse) and is open to the sky, while each of the pathways are covered. The covered paths connect to the entrance to the welcome are and café, and also connect with other covered paths between the workshops and archive, providing a dry path all year.

The southern half of the enclosed landscape is dominated by a raised earth feature, using retaining walls made from the same rubble-faced poured concrete used by the piers in the Archive. The form is made by two sets of stepped earth terraces, one facing north and one west. Both are easily walkable and the steps rise 18”, so they serve as natural seating. The north-facing one can treat the promenade as a stage, as shown by the performers in the rendering.

3.20 | Student Workshop



3.21 | Student Workshop

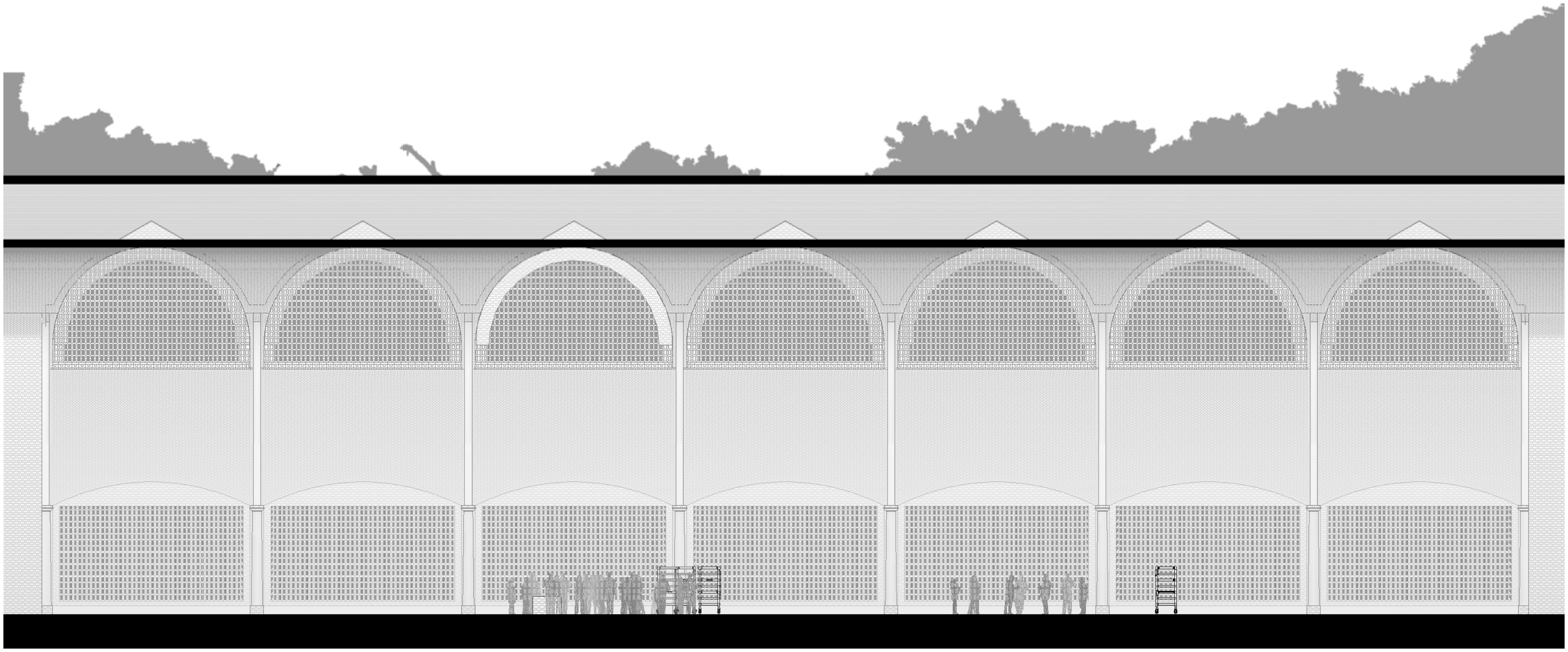


Above Left: NS Section through Cafe, Student Workshop, and Kiln Pavillion
Below Left: Interior Perspective of the Student Workshop
Above: Student Workshop, Plan of Three Bays

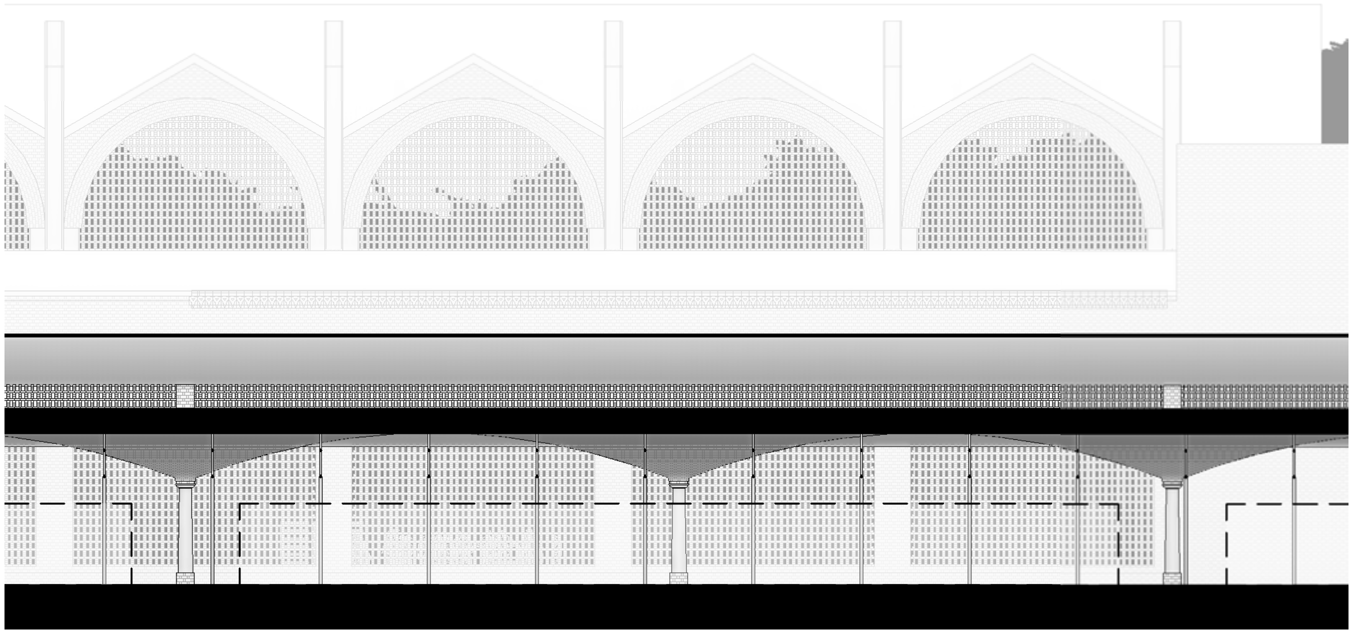
The remaining pages show the student workshop and artisan/ research workshop. Because I was only detailing the Archive for the final study, these were developed at a lower level to demonstrate what could be there. The basic form of the student workshop is a timbrel groin vault, floating high over the workspace. Because this space doesn't have to be conditioned, the openings are only covered with a brick screen to allow cross-ventilation.

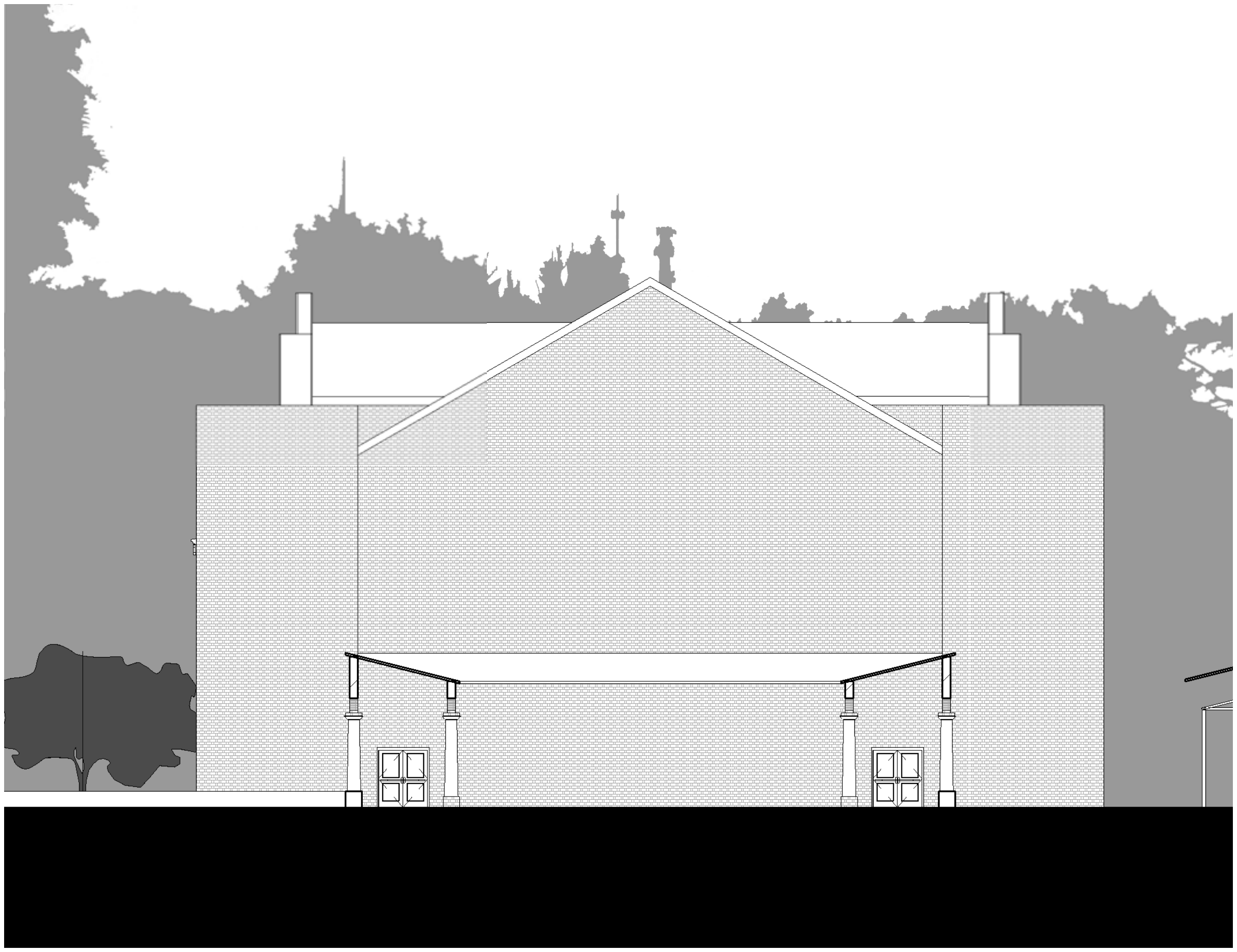
The kiln pavilion, located parallel to the workshops at the northern edge of the site, shows the historical kilns from the former brick plant. They will not be operational in the first phase, since the brick plant closed when they were running low on locally available clay. In a future phase, they may be restarted for experimental batches of clay, or new, up-to-date kilns may be built instead elsewhere on the site. The current kiln pavilion will be covered with a simple timbrel groin vault and covered with a corrugated metal roof similar to what is covering it now.

3.22 | Student Workshop



3.23 | Student Workshop

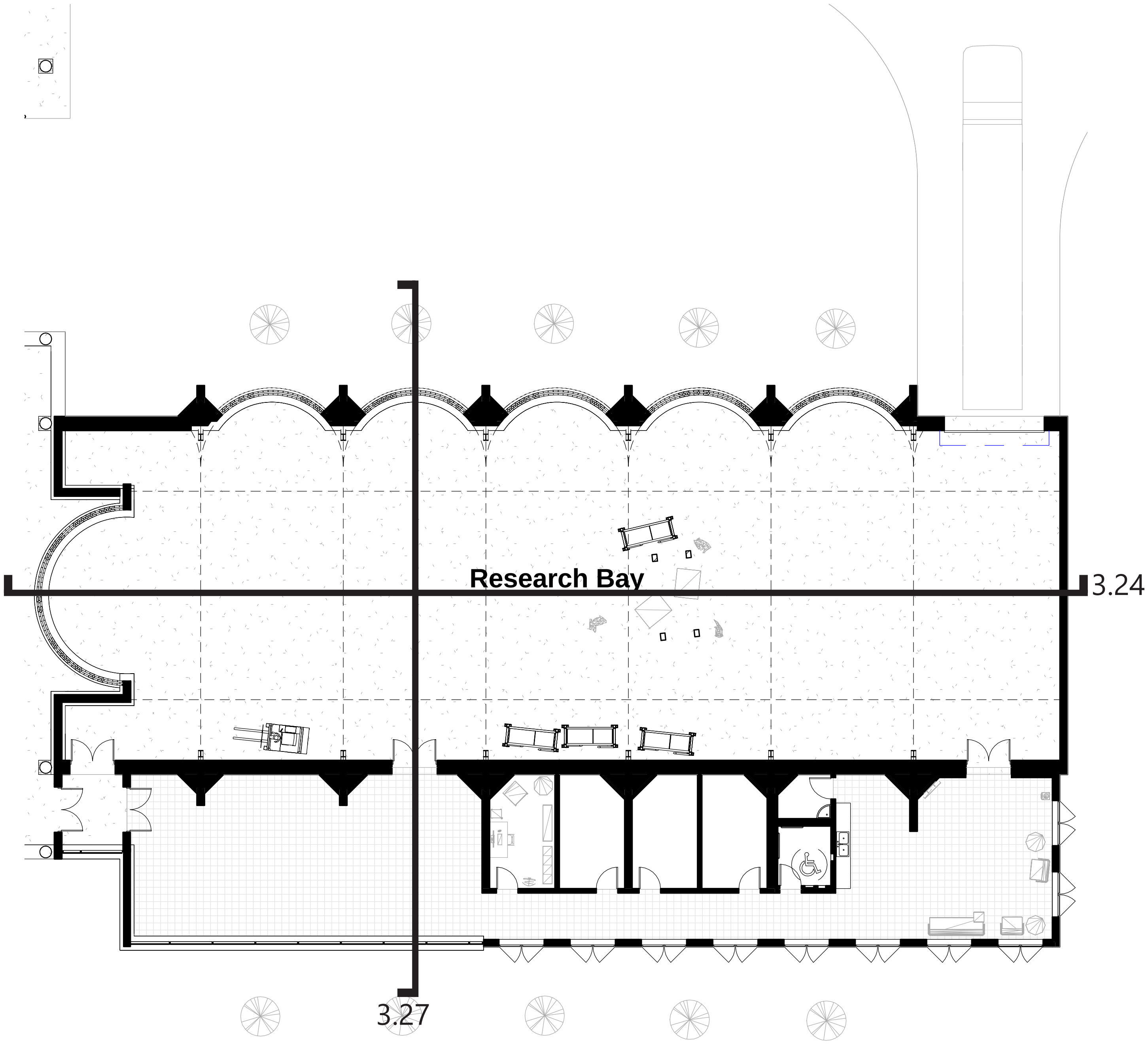




Above Left: EW Section through Student Workshop
Below Left: Exterior Perspective of the Student Workshop
Above: EW Section through Kiln Pavillion facing Student Workshop
Below: East Elevation of Student Workshop

3.24 | Research Workshop

3.25 | Research Workshop



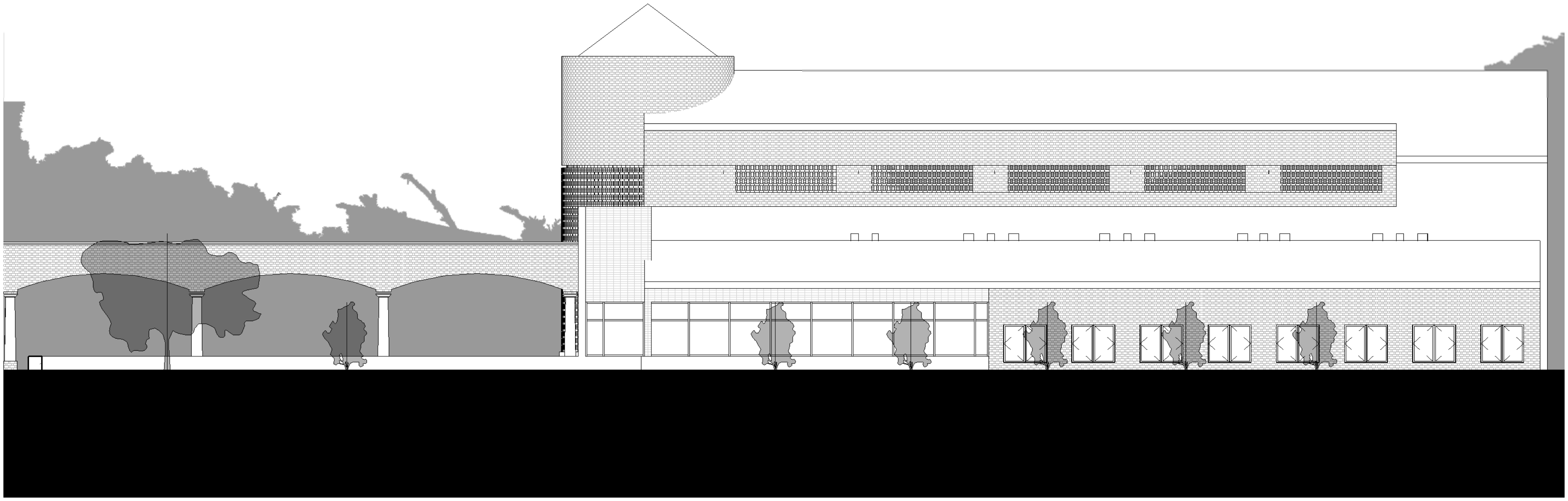
Above Left: EW Section through Research Workshop and North Courtyard
Below Left: Interior Perspective of the Research Workshop
Above: Plan View of Research Workshop

The research workshop, located east of the student workshop, will house the artisans in the first phase, since they have similar needs for the space. The research phase will include an open bay, as a material and structure testing lab. This room will have an overhead crane for moving full-scape testing structures around, as well as to assist in loading and unloading shipments from the delivery dock. A thick concrete wall separates the testing bay from the rest of the building, so that failure testing can be done safely.

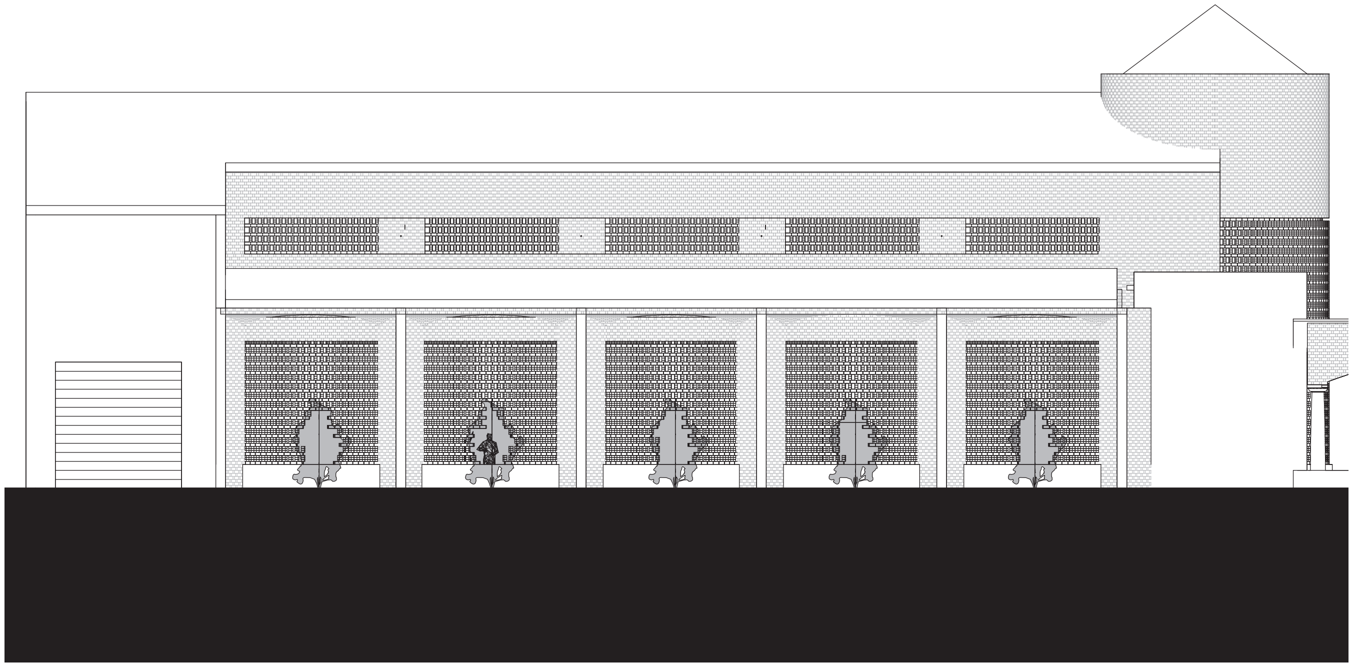
Since this was not going to be the area I concentrated on for the final, I used it to experiment with many of the techniques I had researched over the summer. The steel supports in this room are oblique, a technique suggested by Viollet-le-Duc and favored by Antoni Gaudi. The vaults span the space between steel members, which Guastavino recommended for ceilings.

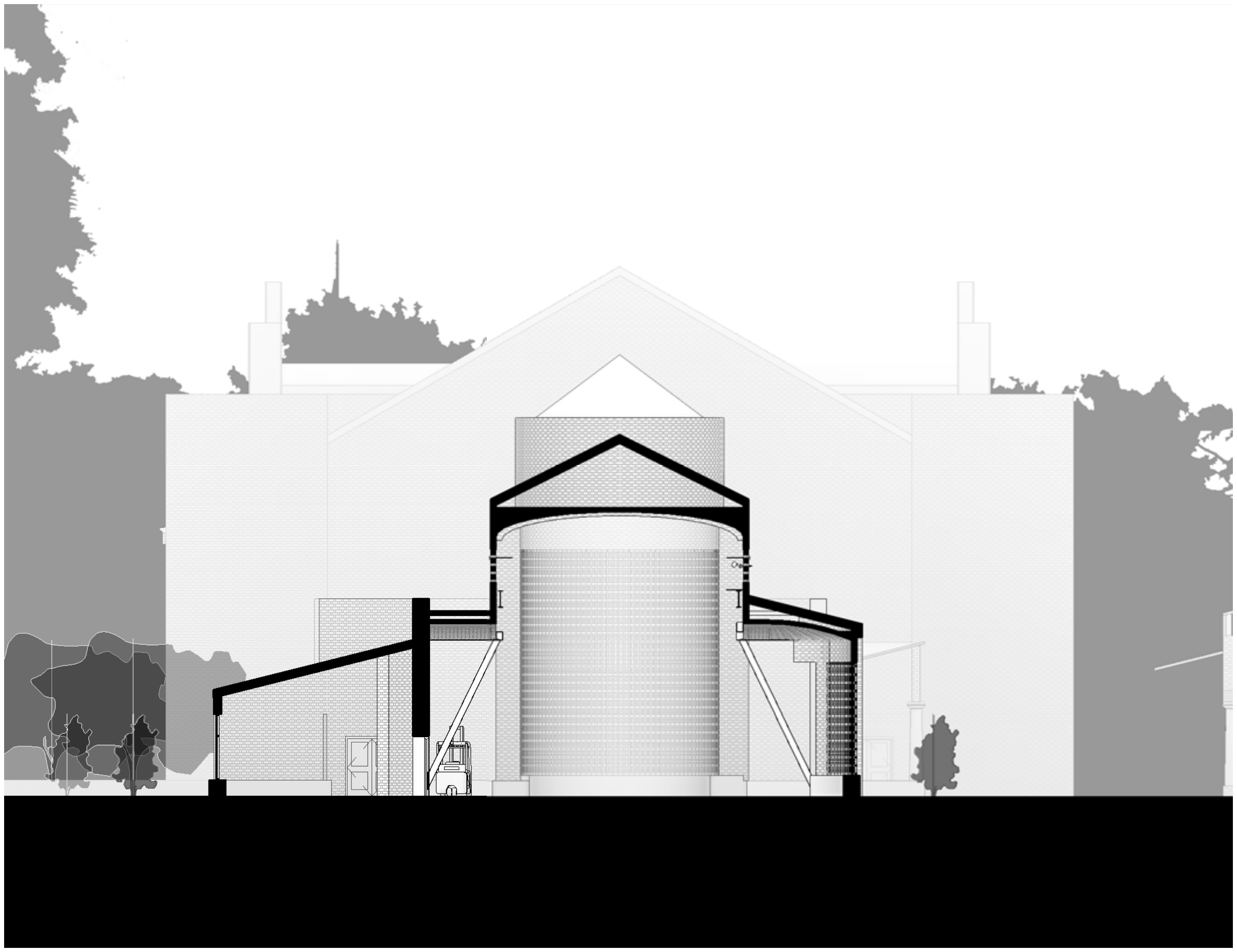
The south side of the building is climate controlled, since it houses the indoor labs and research directors' offices, as well as a break room with kitchenette. The courtyard between the workshops responds to both workshops as well as the kiln pavilion, so that columns are aligned to all three. Though it is presented at less detail than the larger south courtyard, it uses the same idea of interactable low concrete walls. This space has the additional function of housing full-scale masonry experimental structures that are being exposure tested.

3.26 | Research Workshop



3.27 | Research Workshop





Above Left: South Elevation of Research Workshop
Below Left: Exterior Perspective of the Research Workshop
Above: North Elevation of Research Workshop
Below: NS Section through Research Workshop

4 | References

4.02 | Image References

All other graphics, photos, drawings, and renderings were created by the author.

Austin, Peter. “Guastavino, Rafael, Sr. (1842-1908).” *North Carolina Architects and Builders - A Biographical Dictionary*, The NC State University Libraries, 2015, https://ncarchitects.lib.ncsu.edu/people/P000279.

Bhatia, Gautam. *Laurie Baker: Life, Work, Writings*. Penguin Books, 1994.

Burte, Himanshu. “Laurie Baker (1917-2007).” Architectural Review, 26 July 2020, https://www.architectural-review.com/essays/reputations/laurie-baker-1917-2007.

“Coleman, TX.” *TSHA*, https://www.tshaonline.org/handbook/entries/coleman-tx.

Guastavino, Rafael. *Essay on the Theory and History of Cohesive Construction: Applied Especially to Timbrel Vault: Read before the Society of Arts, Massachusetts Institute of Technology, Boston*. Ticknor and Company, 1892.

“International Training Center.” *International Masonry Institute Training Center*, 21 Dec. 2020, https://imtef.org/national-training-center/.

Lstiburek, Joseph. “Tuscan Villas.” *Building Science Corporation*, 15 Nov. 2018, https://buildingscience.com/documents/building-science-insights-newsletters/bsi-107-tuscan-villas. Accessed 21 Apr. 2023.

Molema, Jan. *Gaudí. The Construction of Dreams*. Episode Publishers, 2009.

Mower, David. *Gaudí*. Oresko Books Ltd, 1977.

Plumridge, Andrew, and Wim Meulenkamp. *Brickwork. Architecture and Design*. Seven Dials, 1993.

“Structural and Materials Testing Laboratory.” *Texas A&M Transportation Institute*, https://tti.tamu.edu/facilities/structural-and-materials-testing-laboratory/.

Tolkien, J. R. R. *The Fellowship of the Ring*. Houghton Mifflin Company, 1994.

Viollet-le-Duc Eugène-Emmanuel, and M. F. Hearn. *The Architectural Theory of Viollet-Le-Duc: Readings and Commentary*. MIT, 1990.