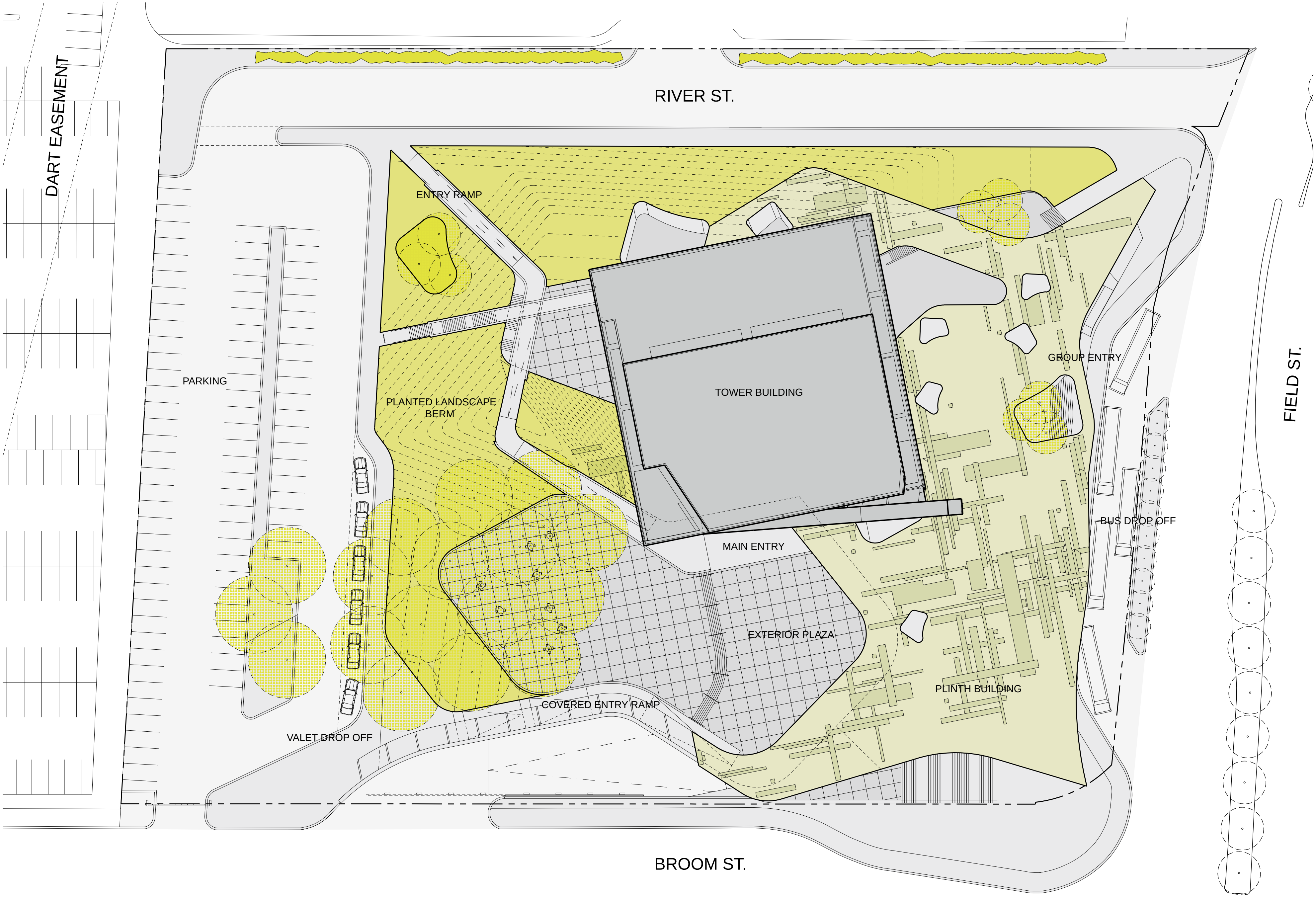
PEROT MUSEUM OF NATURE & SCIENCE
AIA TAP AWARDS 2014

"The extensive use of BIM in the early design phases by the architect, engineers, and contractor resulted in a more thorough coordination between all building systems as well as more precise control of material quantities and pricing. This integrated team work continued throughout the fabrication and construction phases. BIM was not only used for clash detection but also as an integral part of the shop drawing process to reduce the review time and increase quality control. The use of BIM also assisted in the development of several innovative construction techniques for the geometrically complex areas of the project; the precast concrete façade, main lobby ceiling and the theater ceiling and walls.

This integrated approach to design and project delivery increased efficiency and maximized value throughout the project lifecycle."

- Client Statement

OVERVIEW



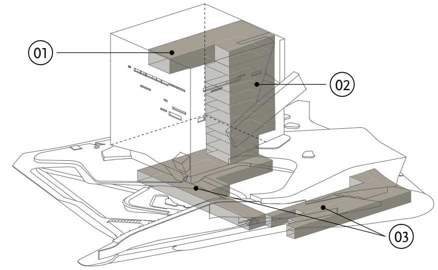
SITEPLAN

OVERVIEW

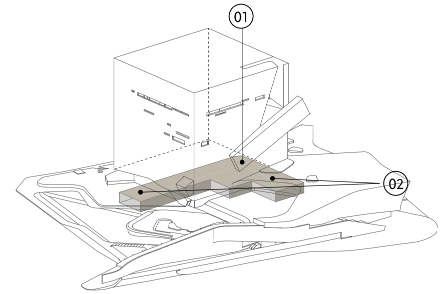
The new Perot Museum of Nature & Science in Victory Park will create a distinct identity for the Museum, enhance the institution's prominence in Dallas and enrich the city's evolving cultural fabric. Designed to engage a broad audience, invigorate young minds, and inspire wonder and curiosity in the daily lives of its visitors, the Museum will cultivate a memorable experience that will persist in the minds of its visitors and that will ultimately broaden individuals' and society's understanding of nature and science.

The Museum will strive to achieve the highest standards of sustainability possible for a building of its type. High performance design and incorporation of state of the art technologies will yield a new building that will minimize its impact on the environment. This world class facility will inspire awareness of science through an immersive and interactive environment that actively engages visitors. Rejecting the notion of museum architecture as neutral background for exhibits, the new building itself becomes an active tool for science education. By integrating architecture, nature, and technology, the building demonstrates scientific principles and stimulates curiosity in our natural surroundings.

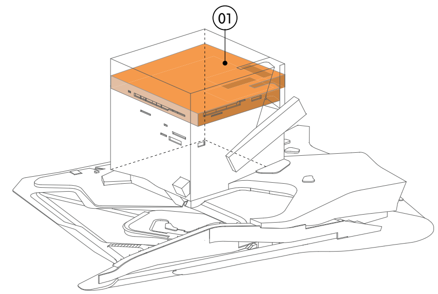
The new 180,000 square-foot facility is a center for education, exploration, and discovery. It features lively exhibits, vivid contextual displays of the museum's



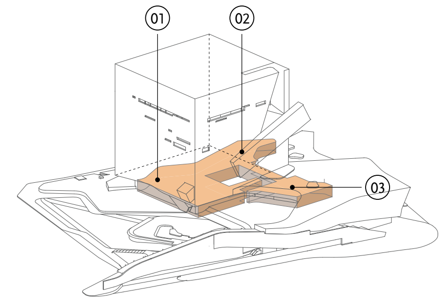
SERVICE
01 MECHANICAL/PENTHOUSE
02 BUILDING CORE
03 BACK OF HOUSE



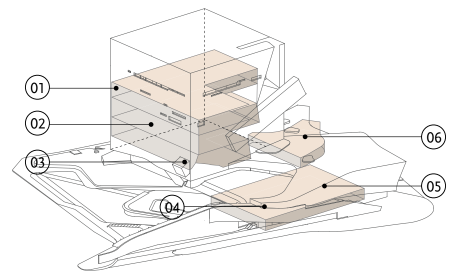
EDUCATION
01 CLASSROOMS
02 FORUM



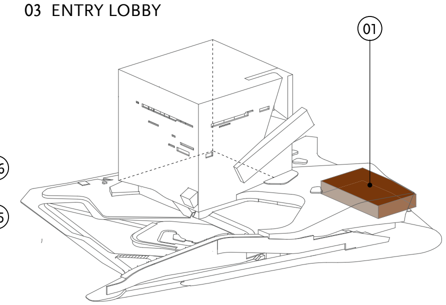
OFFICE
01 OPEN OFFICE



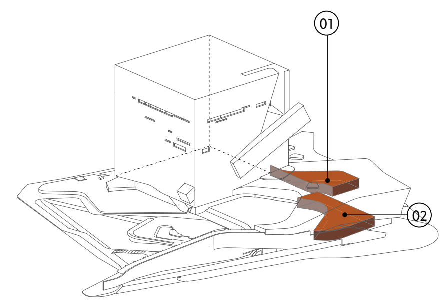
LOBBY
01 MAIN LOBBY
02 ROOF TERRACE
03 ENTRY LOBBY



GALLERY
01 ANIMALS THROUGH TIME GALLERY
UNIVERSE GALLERY
02 ENERGY GALLERY
GEM GALLERY
EARTH GALLERY
03 ENGINEERING GALLERY
BEING HUMAN GALLERY
LIFE GALLERY
04 SPORTS GALLERY
05 TEMPORARY GALLERY
06 CHILDREN'S MUSEUM



THEATER
01 THEATER



CAFE/ SHOP
01 MUSEUM SHOP
02 CAFE

collections, state-of-the-art technology, multimedia presentations and hands-on activities. Standing 14 stories tall, the museum features ten permanent exhibition halls including a children's museum, an outdoor playspace/courtyard, a traveling gallery that will host world-class exhibitions, and a ground level workshop exhibit surrounded by large windows, allowing the public to view activities. The facility includes an expansive, glass enclosed lobby connected to an outdoor terrace, a multi-media digital cinema with seating for 300, a retail store and offices for museum staff.

Attached to the facility is an acre of roofscape comprised of native, drought-resistant grasses that reflect Texas' indigenous landscape, a large shady grove of East Texas native canopy trees, and an assortment of native flowering plants surrounding the roof deck terrace and museum lobby. The skin of the museum, designed to emulate a geologic formation, includes 700 pre-cast, custom-molded concrete sections. The building features a 54-foot continuous-flow escalator contained in a 150-foot glass-enclosed tube. This glass-enclosed escalator extends outside the building and provides unobstructed views of the museum and the city skyline. A large, urban plaza wrapped around the side of the facility accommodates cafe tables, seating, and three water features available for gatherings and public events.

"It became natural for the team to solve each issue within the 3D model, which saved the project time and money and delivered a high quality project."

- Contractor Statement

PROCESS

The colocation of design and construction teams was the foundation to the Integrated Project delivery enabling and creating opportunities to collaborate—at any point in the day, on any subject—without having to schedule specific meetings around busy calendars at off-site locations. Colocating key stakeholders at the Perot Museum of Nature and Science job site integrated people, systems, business structures and practices into a process that collaboratively harnessed the talents and insights of all participants which optimized efficiency through all phases of design, fabrication and construction, eliminating waste and maximizing value throughout the project life cycle.

PROCESS

INTEGRATED PROJECT TEAM

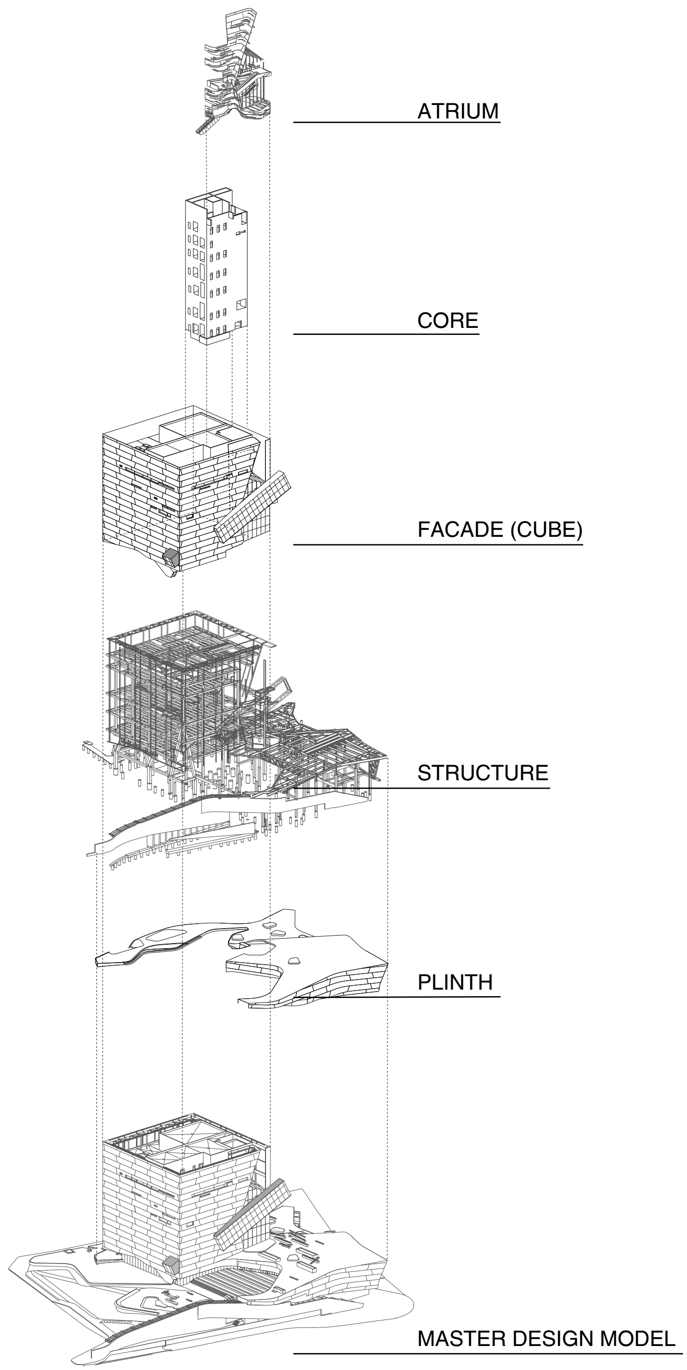
A comprehensive BIM model was maintained throughout the design and construction process. The model was used for visualization and validation, trade coordination, virtual prototyping, quantitiy take-offs and cost estimating, 4d construction sequencing and fabrication.

Model Authoring

- Architect
- Structural Engineer
- MEP Engineer
- Facade Consultant
- General Contractor
- Steel Contractor
- MP Contractor
- Architectural Precast Contractor
- Exterior Glazing Contractor
- Framing and Drywall Contractor

Model Review and Coordination

- Architect
- Structural Engineer
- MEP Engineer
- General Contractor
- Owner



The success of the Perot Museum of Nature and Science relied on an integrated BIM process that allowed for the simultaneous exploration of complex architectural spaces and the coordination of intricate building systems through 3D modeling, rapid prototyping of details and extraction of 2-D documentation from a comprehensive BIM model. The process depended upon a collective investment in the comprehensive BIM. Cross-platform interoperability was accommodated through industry standards and proprietary processes allowing for a seamless workflow between the architect, project consultants, and subcontractors. The accuracy of the design BIM allowed the team to share the detailed 3-D models with the client, consultants, and eventually subcontractors. Subsequently, these models were used for 3-D coordination of shop drawings, CNC fabrication, and frameworks for installation of complex building components. The reliability of the design model built trust among the project stakeholders allowing for an open and integrated approach to the delivery of the project. This integrated BIM approach, allowed the project team to deliver a state-of-the-art, world-class museum on budget and ahead of schedule.

Quality Control began with Preconstruction, all subcontractors were short-listed based on a series of pre-established criteria. The short-listed subcontractors were then interviewed jointly by the design team, owner and general contractor and a joint decision was made regarding which subcontractors to bring on to assist with the design process. Early subcontractor involvement allowed the design team to utilize subcontractor experience and capabilities while developing the design details.

PROCESS
PRECONSTRUCTION

The project team utilized full scale construction mock-ups to establish a baseline expectation for a variety of components of the project, including the concrete core walls, polished concrete flooring, ornamental stairs, fourth floor mezzanine guardrails, concrete “V” columns and the double curved concrete light well walls. Co-location provided the opportunity for the construction team to receive direct feedback from the architect and client on the mock-ups allowing for all necessary adjustments to be made immediately.

PROCESS
MOCK-UPS

By providing a shared project server and employing tablets, construction technology quickly moved from the office trailer to the field. The project team used these technologies to review construction progress, monitor quality, ensure design intent and transmit information to the entire design team. All team members, including subcontractors, were given access to the system providing a single environment for documenting and tracking construction progress. This combination of technologies was used exclusively during the punch list phase of the project allowing for all comments and notifications to be communicated to the proper trades in real-time eliminating the time typically lost waiting for the team to issue formal documentation.

PROCESS

IMPLEMENTATING THROUGH TECHNOLOGY

Tracking the total project schedule allowed the entire team to understand the expectations surrounding project deliverables. This process was so successful on the Perot Museum of Nature and Science project that the design team never missed a design package delivery date and the General Contractor never missed an estimate delivery date.

The team used the holistic project schedule as a guide and continued to refine the schedule as the team moved into different phases of the project. These procurement activities included items such as:

- Scopes of work
- Subcontractor negotiations
- Materials submittal and review
- Material fabrication
- Material delivery

The urban location of the project and the expansive footprint provided logistically challenges to the site limiting lay down areas. To resolve the site and logistic constraints just-in-time deliveries were implemented for all trades; materials were brought to the site and installed on the same day.

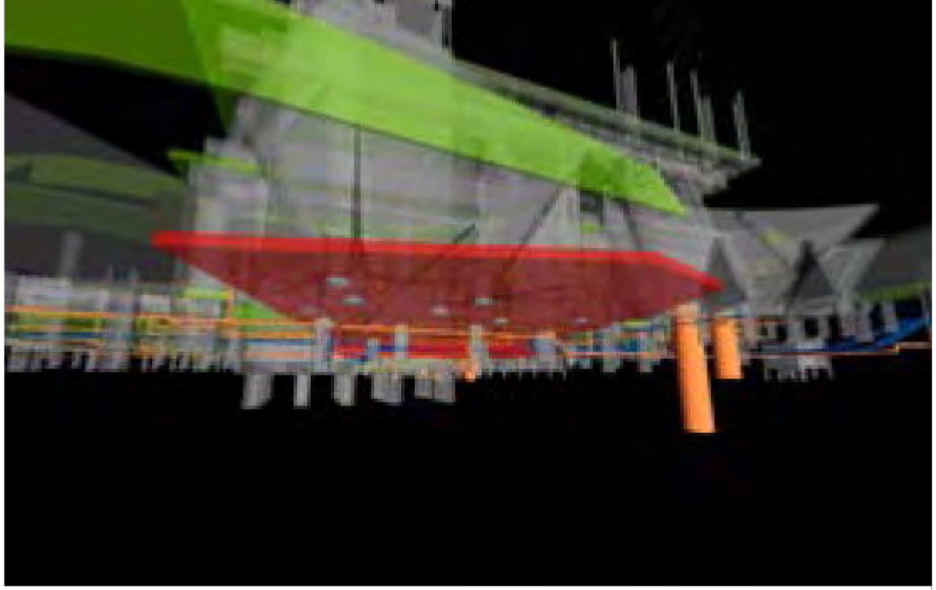
PROCESS

COLLABORATIVE SHCEDULING

"The Perot Museum of Nature of Science provided our office with the opportunity to advance the use of technology through an integrated BIM approach. Collective investment in an integrated approach to design and delivery allowed the project team to work collaboratively and collectively throughout the project lifecycle. The shared investment in BIM by all stakeholders provided the open platform necessary to delivery this state-of-the-art museum on budget and ahead of schedule."

- Architect Statement

INNOVATION

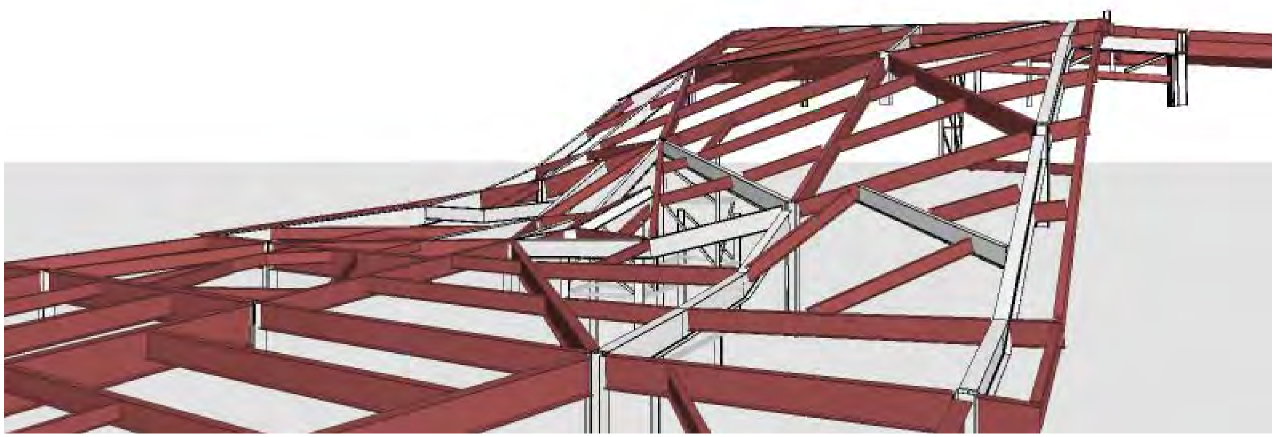


During excavation, an abandoned structure, dated to 1926, was discovered. The structures location conflicted with the museum's foundation and the main electrical feeds for the building. The traditional solution would have been to remove the structure, and complete the foundation as designed. Instead, the team used GPS to survey the location of the bridge. By modeling the existing structure, the engineers were able to develop a structure that "fit" around the existing bridge. The team laid out six piers, piercing through the structure as necessary, providing support for a structural platform above. The team's innovative use of technology averted what would have been a six-to-eight week delay to the project schedule.

ROI: AVOIDED 8 WEEK DELAY IN CONSTRUCTION SCHEDULE

INNOVATION
ABANDONED STRUCTURE

The complexities of the plinth design were overcome by utilizing BIM technology to coordinate and produce the shop drawings. The architect required the model be sent, along with the shop drawings, in order to verify that the design geometry was maintained. The coordinated model information was then used for shops and CNC fabrication. The coordination process using the 3D model prior to fabrication of this complex structural steel frame with few 90-degree connections allowed for 860 tons of steel with 8,400 connections to be installed without a single RFI. In addition almost all connections were bolted and not one required modification allowing structural steel erection to end a week ahead of schedule.



ROI:

- AVOIDED ALL POTENTIAL DELAYS IN CONSTRUCTION SCHEDULE.
- AVOIDED ANY IN-FIELD ADJUSTMENTS TO ALL PREFABRICATED STEEL MEMBERS.
- STEEL ERECTION FINISHED 1 WEEK AHEAD OF SCHEDULE

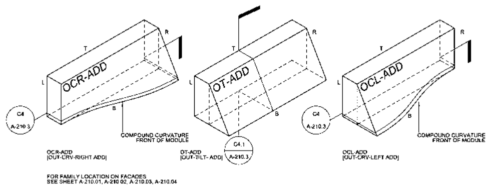
INNOVATION

PLINTH STEEL FRAMING

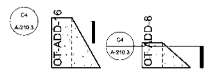
The museum was designed to emulate a geologic formation rising from the Earth. Each panel consists of a series of striations that project from the panel and/or recess into the panel, creating a dynamically textured façade. The facade includes 700 precast panels that maintain continuity of all geometries across panels. To keep the project within budget, the design team developed a component based mold system with 39 geometry families (recessed components and protruding components), that were arrange on 4 panel shapes in 12 patterns. The component families were assembled into a panel mold; after the precast panel was poured and cured it was removed and the component families could then be disassembled and then reassembled into a new panel type. The systematic use of component molds allowed the design team to deliver a custom 3-dimensional façade that appears to be random and natural.

ROI: CUSTOM FACADE SYSTEM DESIGN AND DELIVERED ON BUDGET AND SCHEDULE.

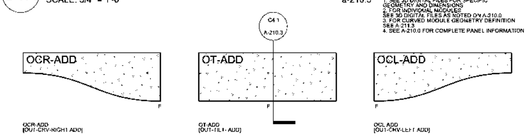
INNOVATION
PRE-CAST CONCRETE FACADE



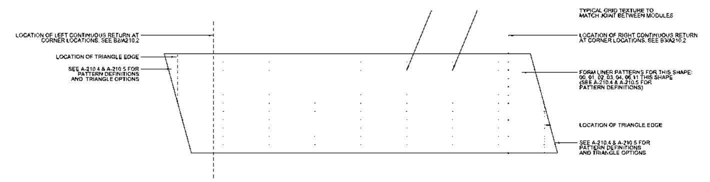
E4 POSITIVE PROTRUSION GEOMETRY FAMILY - ADD
SCALE: NTS a-210.3



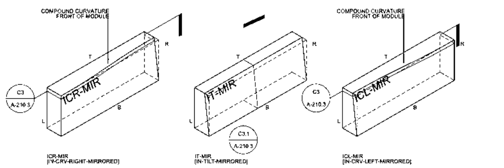
C4.1 POSITIVE PROTRUSION ADD SECTION
SCALE: 3/4" = 1'-0" a-210.3



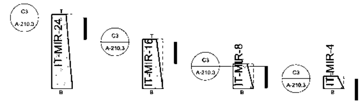
C4 POSITIVE PROTRUSION FAMILY - ADD
SCALE: 3/4" = 1'-0" a-210.3



B4 SHAPE D
SCALE: 1/4" = 1'-0" a-210.3



E3 NEGATIVE RECESS GEOMETRY FAMILY - MIRRORED
SCALE: NTS a-210.3



C3.1 NEGATIVE RECESS MIRRORED SECTION
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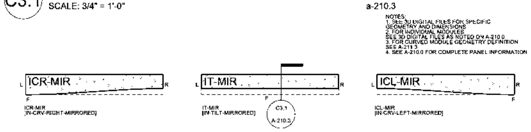
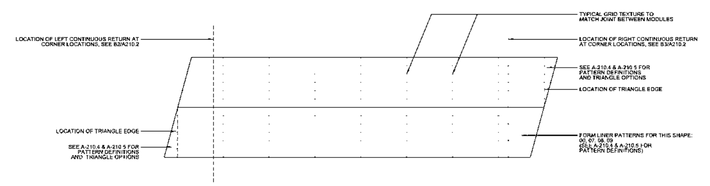
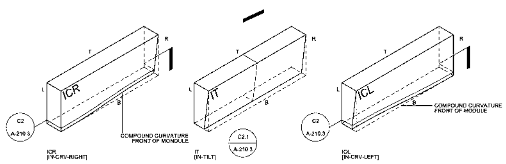


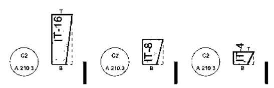
C3 NEGATIVE RECESS GEOMETRY FAMILY - MIRRORED
SCALE: 3/4" = 1'-0" a-210.3



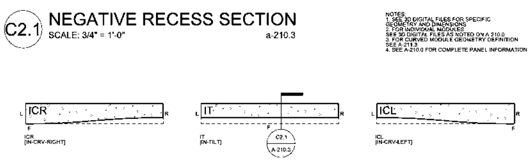
B3 SHAPE C
SCALE: 1/4" = 1'-0" a-210.3



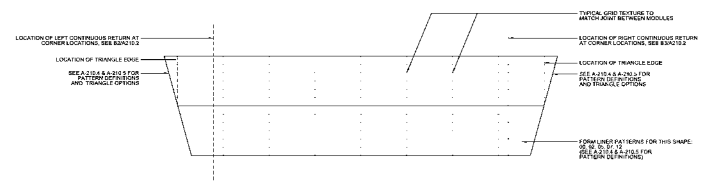
E2 NEGATIVE RECESS GEOMETRY FAMILY
SCALE: NTS a-210.3



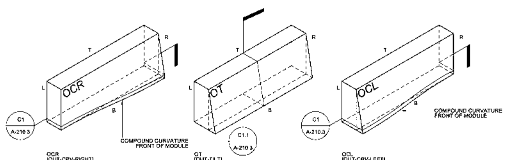
C2.1 NEGATIVE RECESS SECTION
SCALE: 3/4" = 1'-0" a-210.3



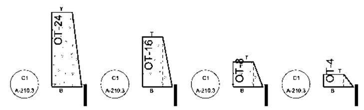
C2 NEGATIVE RECESS GEOMETRY FAMILY
SCALE: 3/4" = 1'-0" a-210.3



B2 SHAPE B
SCALE: 1/4" = 1'-0" a-210.3



E1 POSITIVE PROTRUSION GEOMETRY FAMILY
SCALE: NTS a-210.3



C1.1 POSITIVE PROTRUSION SECTION
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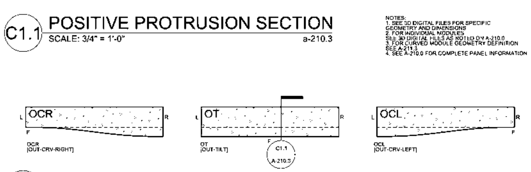
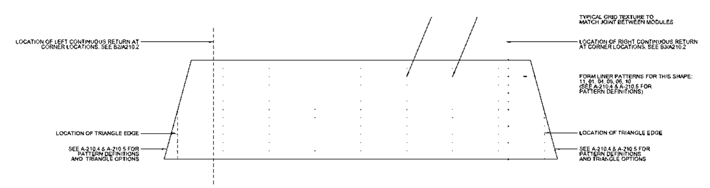
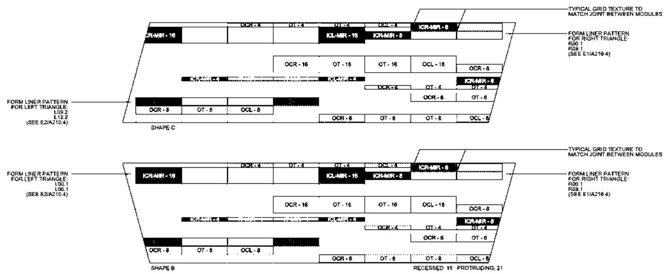


C1 POSITIVE PROTRUSION GEOMETRY FAMILY
SCALE: 3/4" = 1'-0" a-210.3

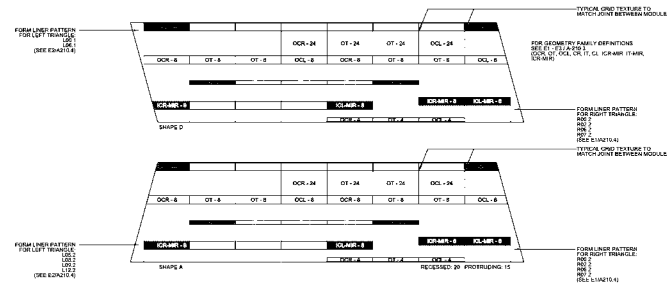


B1 SHAPE A
SCALE: 1/4" = 1'-0" a-210.3

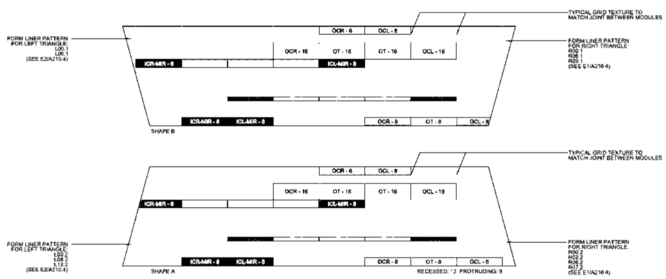
PRE-CAST CONCRETE FACADE



D4 PANEL PATTERN 07
SCALE: 1/4" = 1'-0" a-210.4



B4 PANEL PATTERN 06
SCALE: 1/4" = 1'-0" a-210.4



D3 PANEL PATTERN 05
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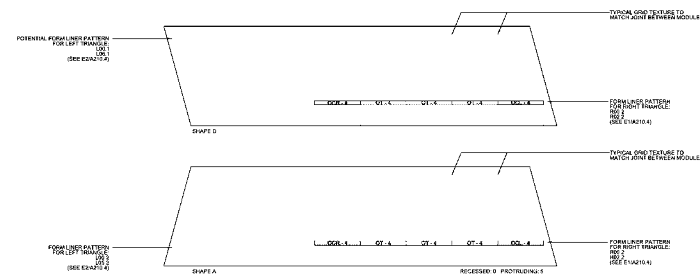

B3 PANEL PATTERN 04
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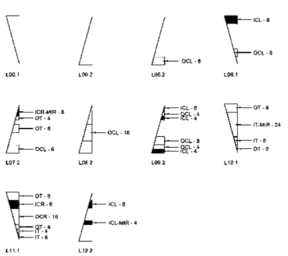
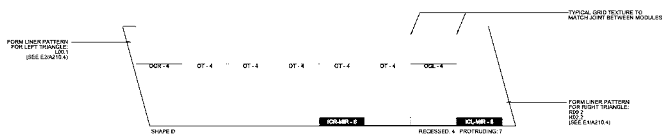


E2 LEFT TRIANGLE PATTERNS
SCALE: 1/4" = 1'-0" a-210.4



D2 PANEL PATTERN 03
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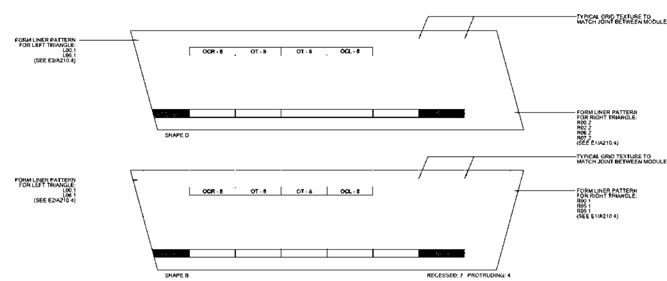

B2 PANEL PATTERN 02
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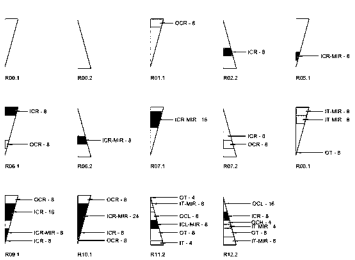
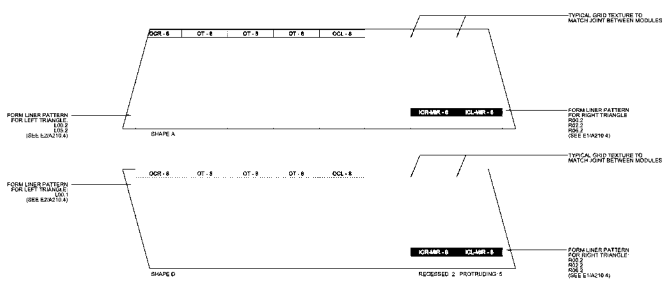
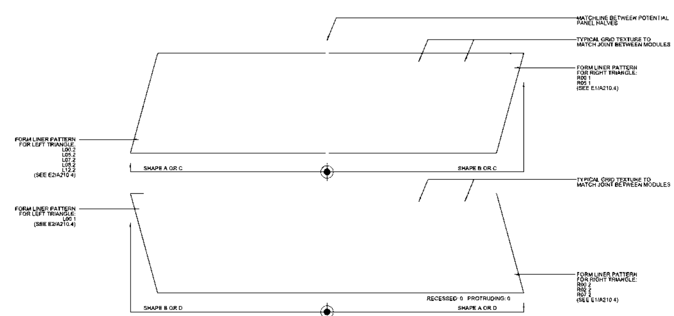


E1 RIGHT TRIANGLE PATTERNS
SCALE: 1/4" = 1'-0" a-210.4



D1 PANEL PATTERN 01
SCALE: 1/4" = 1'-0" a-210.4



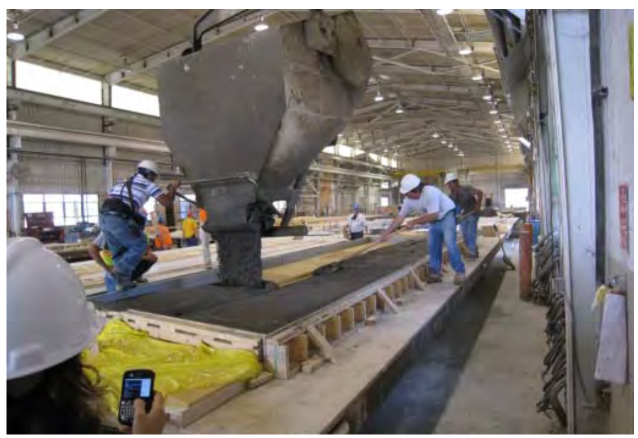
B1 PANEL PATTERN 00
SCALE: 1/4" = 1'-0" a-210.4

PRE-CAST CONCRETE FACADE

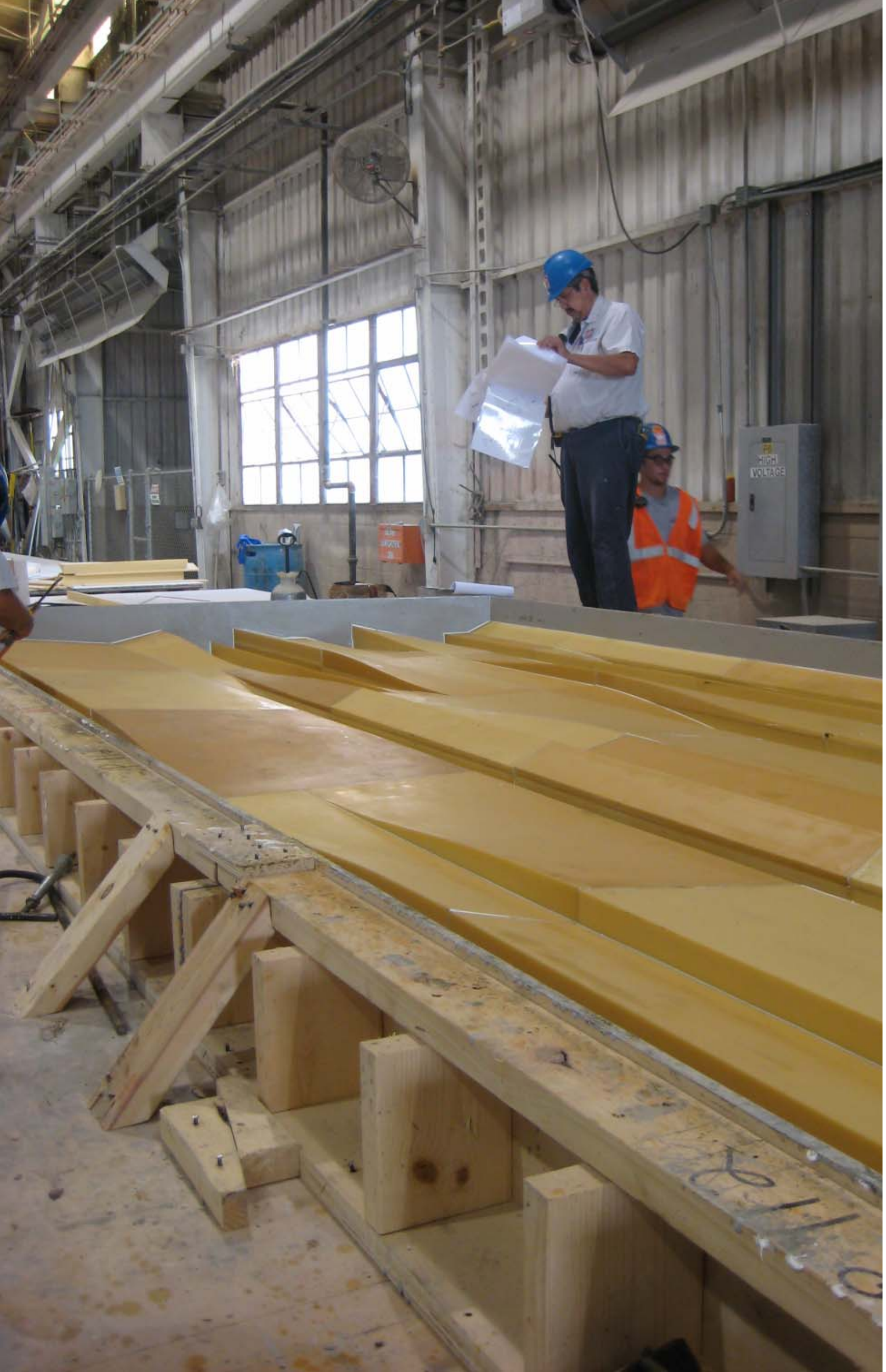






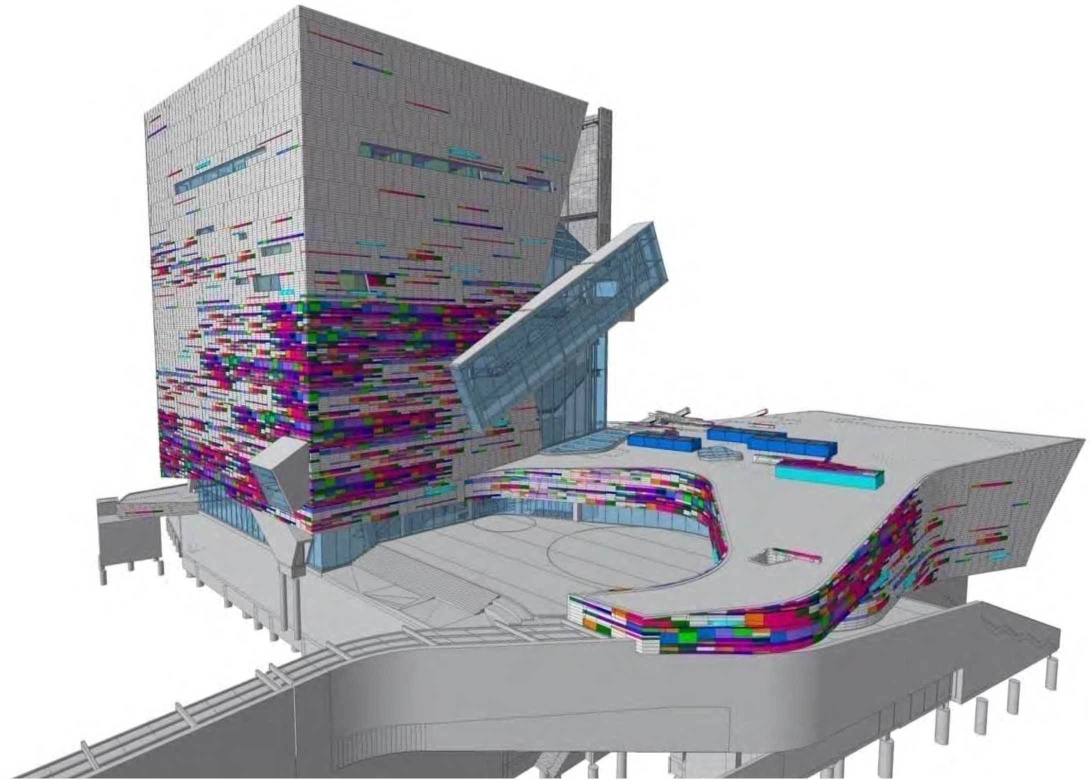



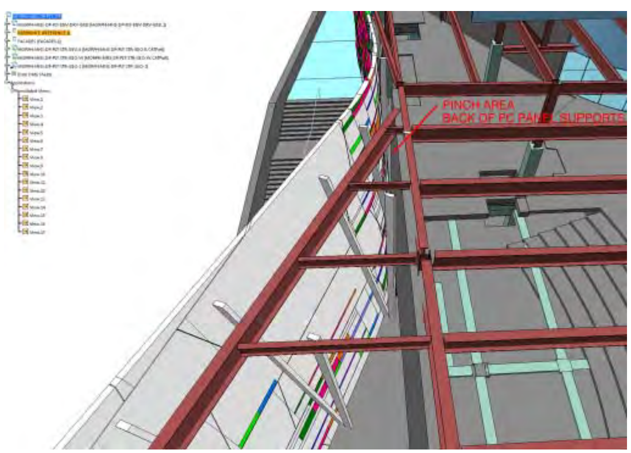

PRE-CAST CONCRETE FACADE

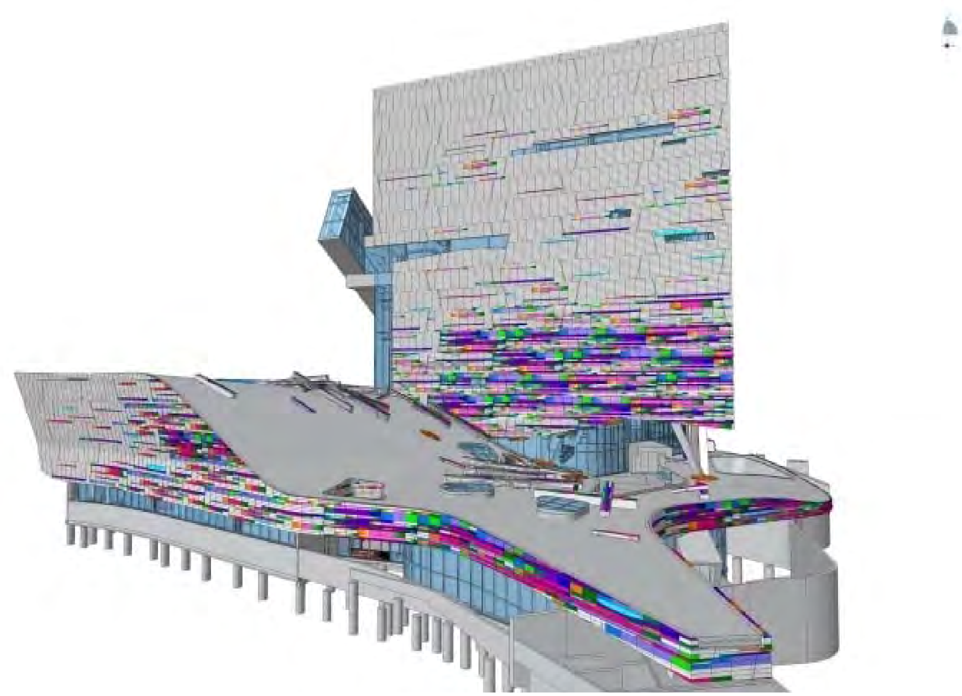


PRE-CAST CONCRETE FACADE

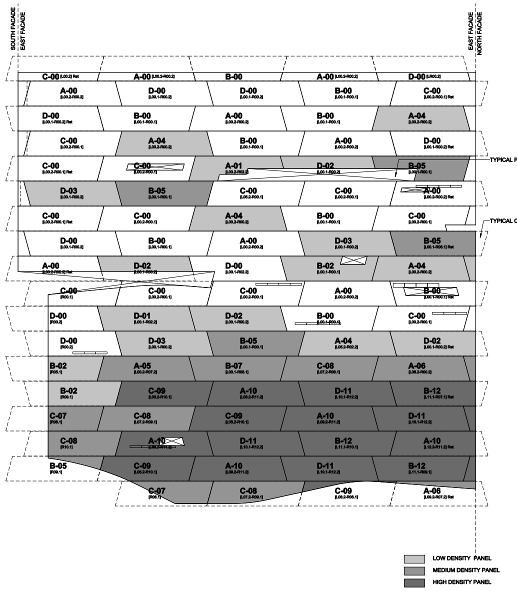
The precast concrete façade was engineered and fabricated based on a 1 to 1 BIM model developed by the design team. As part of the design process the architect develop a systematic approach to organizing the façade. The parametric model provided an environment for the development of individual panels and helped establish the adjacency rules for the overall facades.



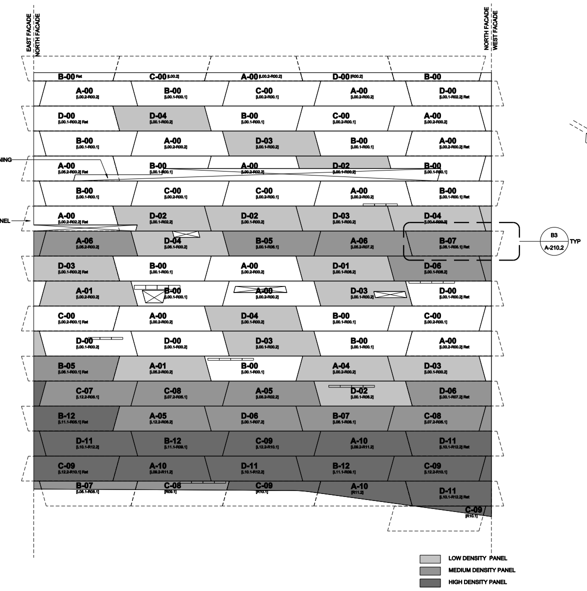




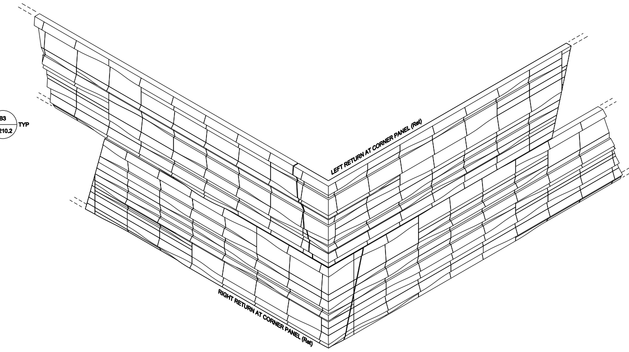
PRE-CAST CONCRETE FACADE



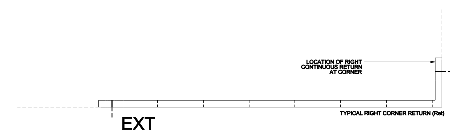
E3 EAST FACADE - PRECAST CONCRETE PANEL LAYOUT
SCALE: 1/16"=1'-0" a-210.2



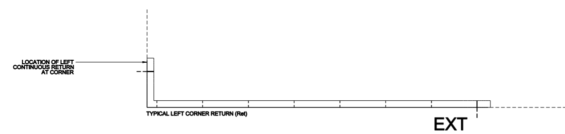
C3 NORTH FACADE - PRECAST CONCRETE PANEL LAYOUT
SCALE: 1/16"=1'-0" a-210.2



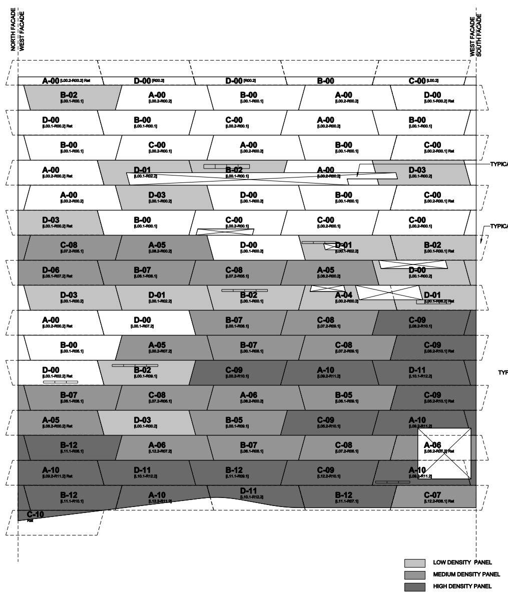
B4 CORNER PANEL AXONOMETRIC DIAGRAM
SCALE: 1/4"=1'-0" a-210.2



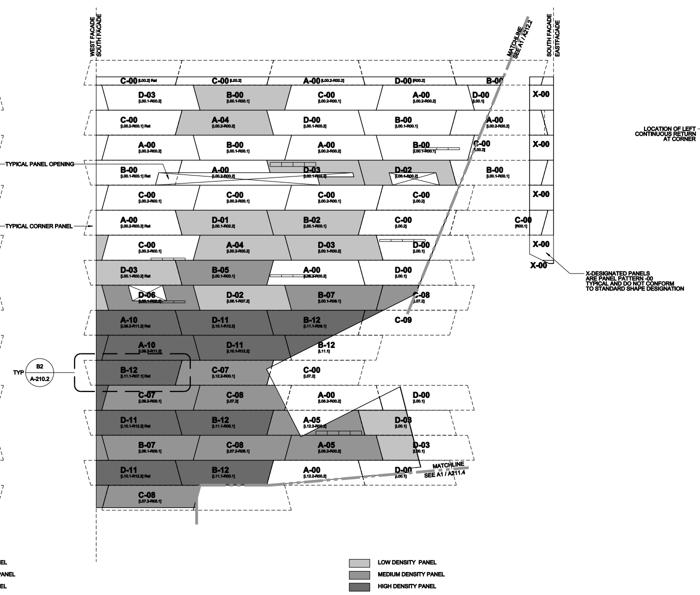
B3 CORNER PANEL PLAN DIAGRAM
SCALE: 1/4"=1'-0" a-210.2



B2 CORNER PANEL PLAN DIAGRAM
SCALE: 1/4"=1'-0" a-210.2

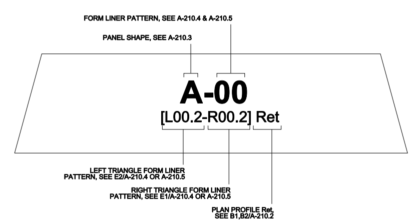


E1 WEST FACADE - PRECAST CONCRETE PANEL LAYOUT
SCALE: 1/16"=1'-0" a-210.2



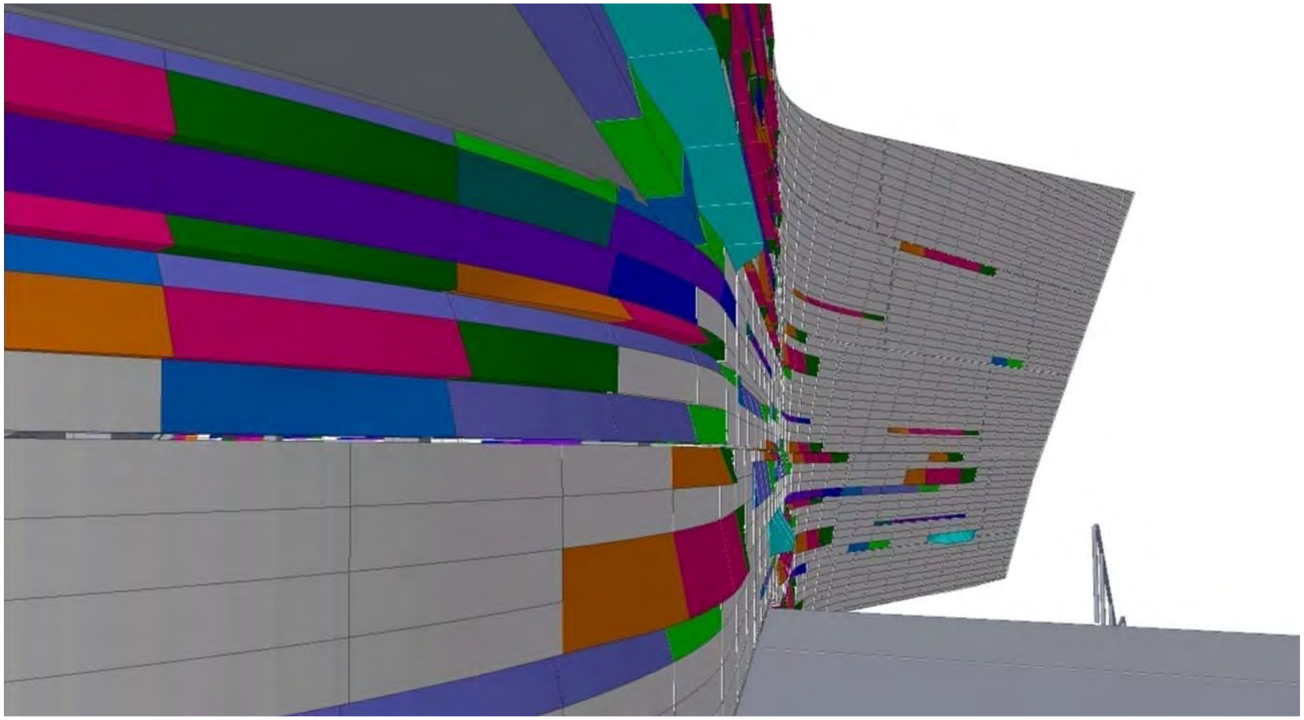
NOTES:
1. SEE A-210.0 FOR COMPLETE TOWER PRECAST INFORMATION AND ADDITIONAL REFERENCES.
2. SEE A-210.4 THROUGH A-210.5 FOR INDIVIDUAL PANEL PATTERNS.

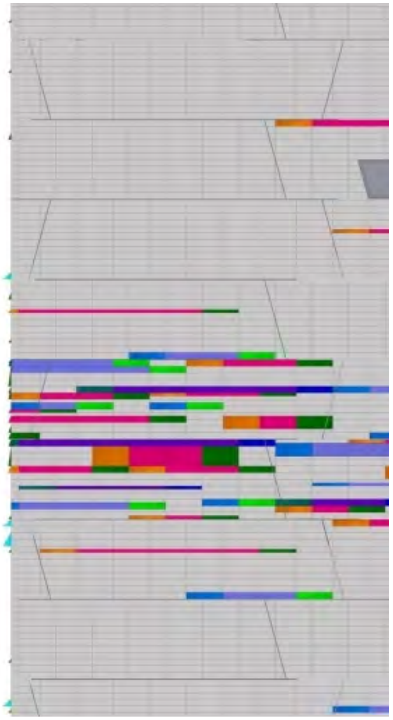
C1 SOUTH FACADE - PRECAST CONCRETE PANEL LAYOUT
SCALE: 1/16"=1'-0" a-210.2

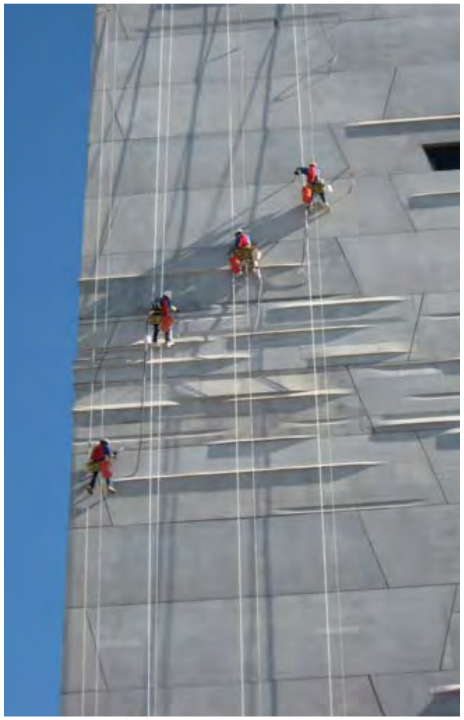


B1 TOWER PRECAST FACADE PANEL ANNOTATION
SCALE: 1/4"=1'-0" a-210.2

PRE-CAST CONCRETE FACADE







PRE-CAST CONCRETE FACADE

PRE-CAST CONCRETE FACADE

PRE-CAST CONCRETE FACADE

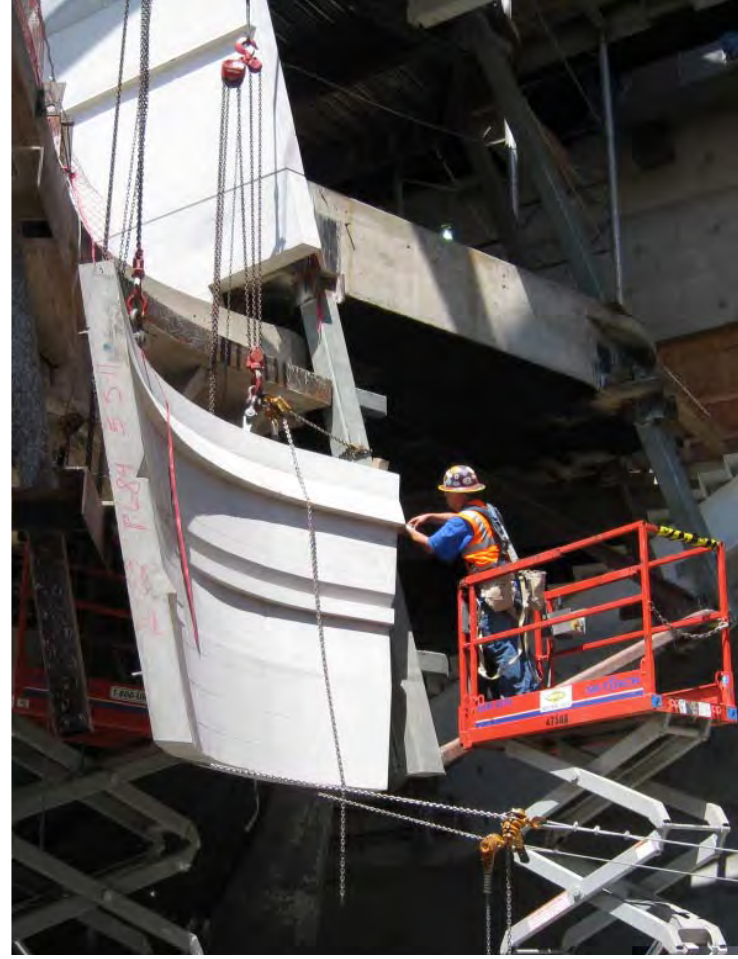
Installation of the precast concrete in the atrium presented its own set of challenges. The first challenge was how to get the panels into the building. The space was too small to allow the tower crane block to fit through the opening at roof level. To resolve this issue, 150' chokers (a rigging for the precast panels) were provided, which allowed the block to remain outside of the building structure. After the panel was lowered into the building, the steel erector used a chain fall hoist to pull the panel into the space and a separate chain fall hoist to pull it into position to be welded to the structure. While the process seems simple, the concrete panels weighed in excess of 17,000 pounds which was a major obstacle with mechanical chain fall hoists. In addition, this task was performed without any safety incidents.

ROI:

- PROCESS PLANNING ALLOWED FOR PANEL INSTALLATION WITHOUT ANY SAFETY INCIDENTS.

INNOVATION

PRE-CAST CONCRETE ATRIUM



PRE-CAST CONCRETE ATRIUM

PRE-CAST CONCRETE ATRIUM

The organic geometry of the lobby ceiling is created by a series welded wire mesh panels precisely shaped and located in space. Measurements obtained from design BIM, which was the contractual deliverable, allowed the construction team to create a custom system that gives the ceiling the appearance of a continuous panel.

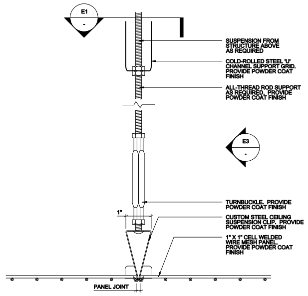
Paramount to this design is a custom fastening system that ties the corners of each panel together while accommodating the unique geometries of the ceiling. This meant that all panels had to be individually fit during installation. To construct the ceiling's complex geometry, the team used the BIM model and robotic total stations to establish precise elevation points of the ceiling's form. The crew established approximately 9,000 elevation points extracted from the design BIM to determine the pitch and slope of the ceiling and height of the ceiling hangers.

ROI:

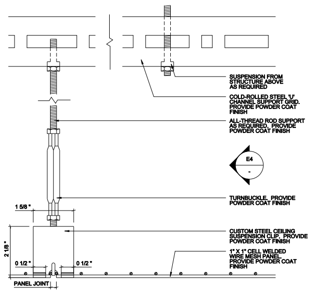
- AVOIDED 3 MONTH INCREASE IN CONSTRUCTION SCHEDULE
- AVOIDED ALL MAN HOURS AND COSTS ASSOCIATED WITH ENGINEERING AND REVIEW OF SHOP DRAWINGS.

INNOVATION

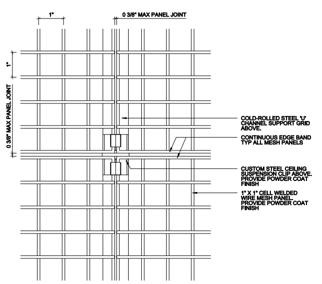
LOBBY CEILING



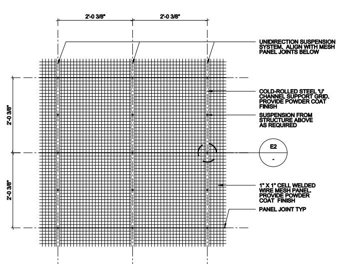
E4 MESH CEILING SUSPENSION SYSTEM - ELEVATION
HALF SCALE
MNS-a-dtC3030-01



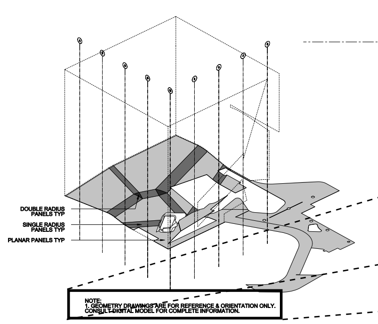
E3 MESH CEILING SUSPENSION SYSTEM - ELEVATION
HALF SCALE
MNS-a-dtC3030-02



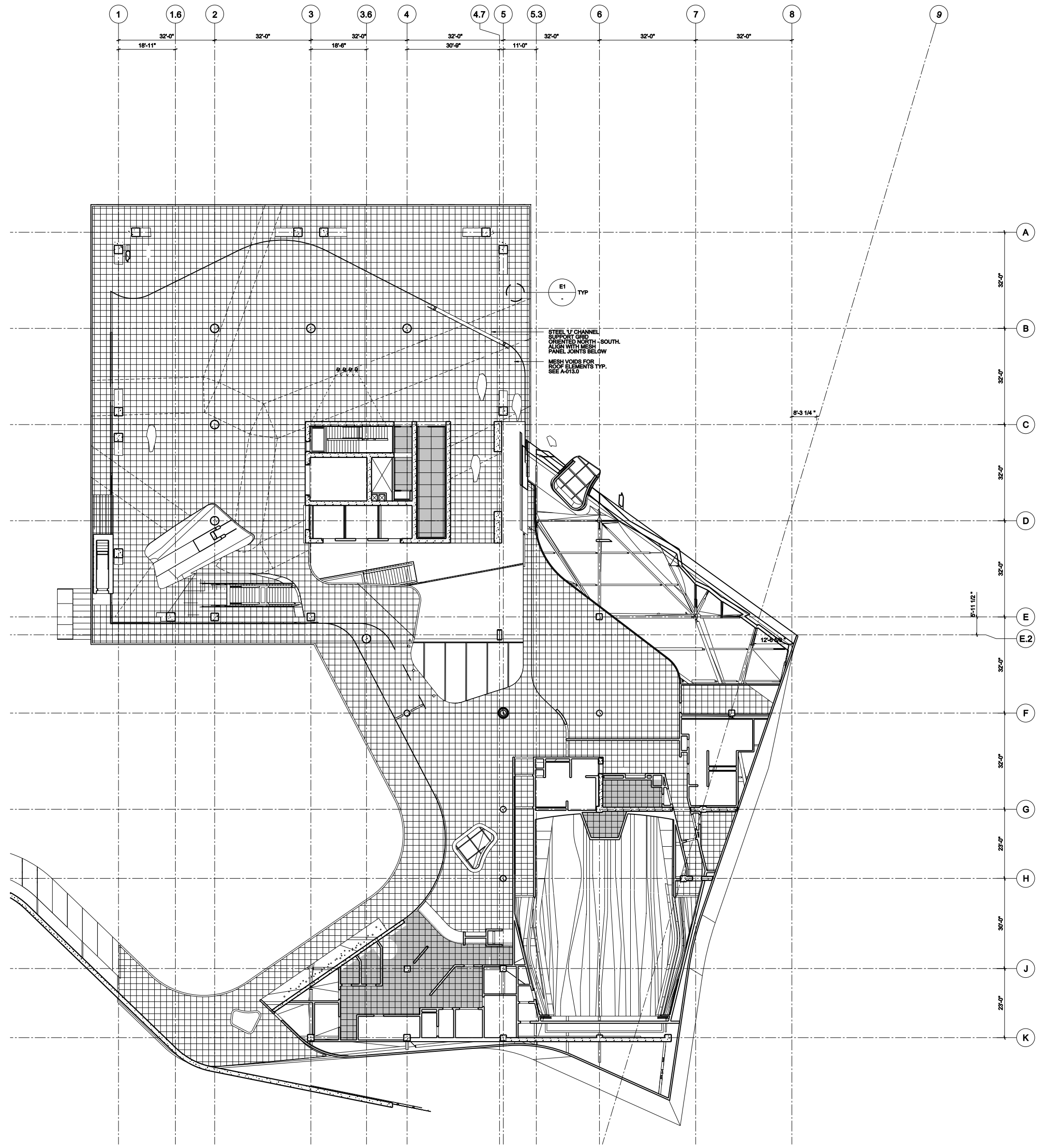
E2 MESH CEILING SUSPENSION SYSTEM - RCP VIEW
HALF SCALE
MNS-a-dtC3030-03



E1 MESH CEILING SUSPENSION SYSTEM - PLAN VIEW
SCALE: 3/4"=1'-0"
MNS-a-dtC3030-04



D1 TOWER LOBBY CEILING DIAGRAM
SCALE: 1/16" = 1'-0"
a-160.0

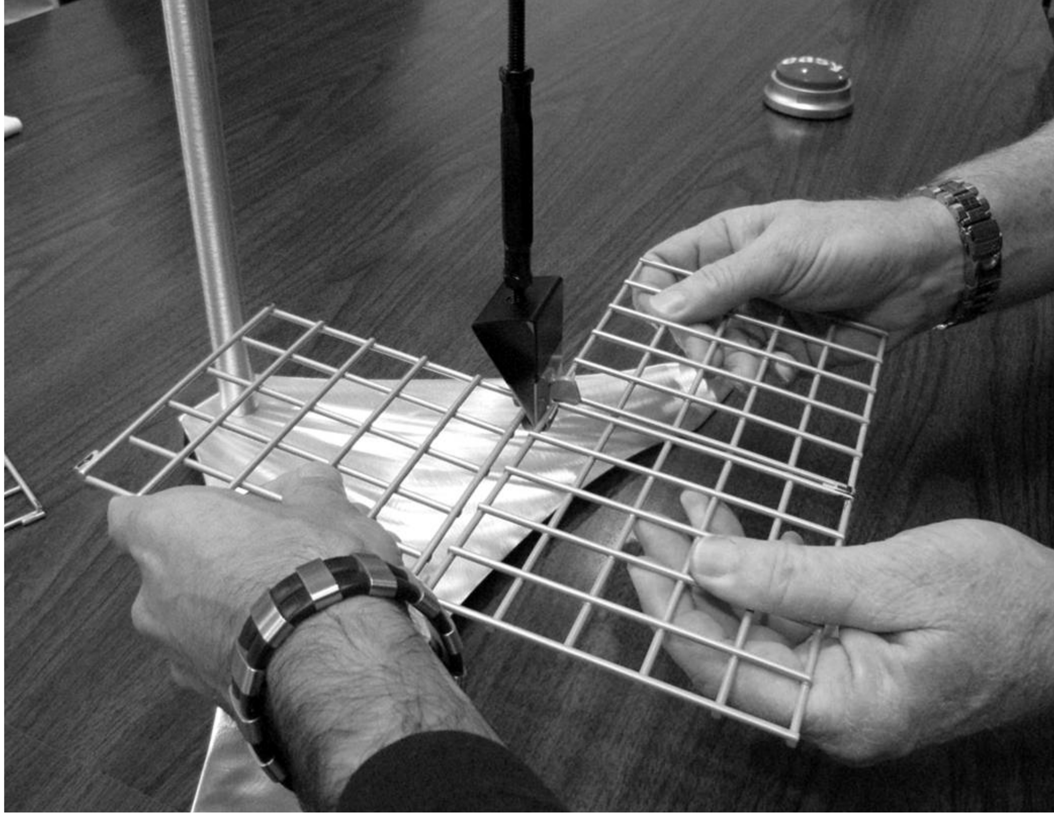


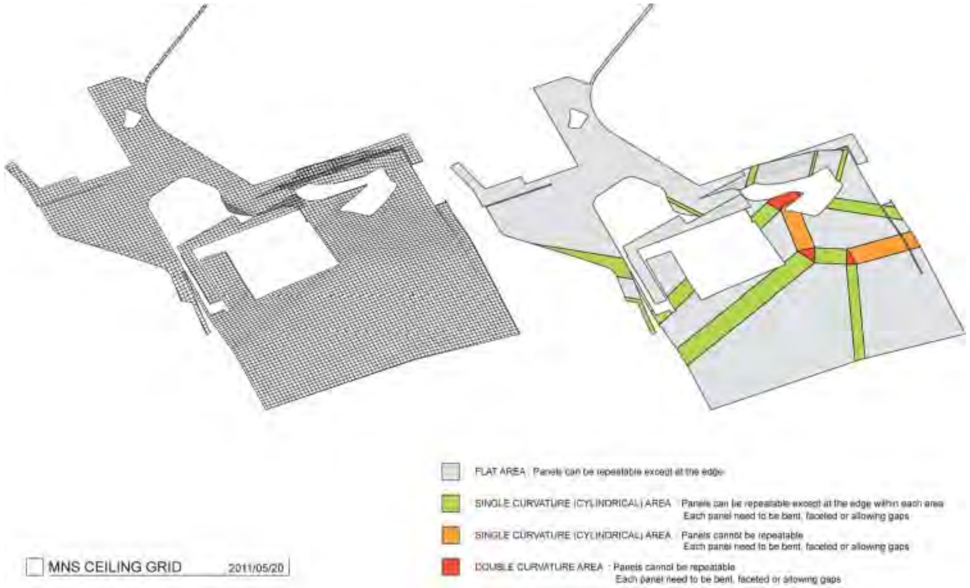
NOTE:
1. GEOMETRY DRAWINGS ARE FOR REFERENCE AND ORIENTATION ONLY. CONSULT DIGITAL MODEL FOR COMPLETE INFORMATION

NOTE:
ALL SINGLE AND DOUBLE CURVED CEILING PANELS TO BE FORMED (NOT FACETED)
ALL FINAL CEILING GEOMETRIES TO BE PER DIGITAL MODEL

A1 LOBBY REFLECTED CEILING PLAN DIAGRAM AND DETAILS
SCALE: 1/16" = 1'-0"
a-160.0

LOBBY CEILING





LOBBY CEILING

LOBBY CEILING

The theater design, a set of compound curves covered by stretched fabric, was created by extracting a series of cross sectional profiles from the design BIM. The profiles are made up of 4-foot by 12-foot sheet metal sections (to fit the mechanical contractors requirements). Each unique section was fabricated using a CNC plasma cutter. The sheet metal is suspended from the ceiling with conventional hangers and the walls are fastened directly to the substrate. The sections were then covered with a drywall substrate and 1 inch rigid-board acoustical insulation to provide a smooth surface for the fabric which was stretched over the ceiling and walls and fastened to a fabric rail at the corners. The final installation was supported by a 12'x12' mock-up, which took approximately five weeks to design and develop. The resulting process allowed, the ceiling and walls of the 60-foot by 80- foot theater to be framed in two weeks. The job would have taken five to six times longer, and required more manpower.

ROI: 12 WEEK REDUCTION IN CONSTRUCTION SCHEDULE

INNOVATION

THEATER CONSTRUCTION

THEATER CONSTRUCTION

THEATER CONSTRUCTION

The prefabricated distribution shaft is a steel structure that stands 170 feet tall and contains all of the vertical mechanical/ plumbing systems. As prefabrication was something the City of Dallas was not accustomed to, the team had to develop a specific and detailed plan to allow inspections to take place as required to meet the city's codes. Once the structural concrete core topped out, the shaft was delivered to the site where each section of the shaft was carefully rigged and hoisted into the core. All five sections were set in a one day period. At each floor level, connections were made between each section to create one continuous piping and duct system through the height of the building.

ROI:

-70 DAY ACTIVITY REDUCED TO A SINGLE DAY.

- ENGINEERED OUT ALL SAFETY HAZARDS FOR ALL STAFF WHO WOULD HAVE ENTERED SHAFT.

-PROVIDED PERMANENT MAINTANENCE ACCESS FOR END USER.

INNOVATION

PREFABRICATED VERTICAL MEP

The structural engineering for the facade required erecting precast panels in a continuous spiral around the building, loading all sides of the building uniformly. Since the façade needed to be assembled sequentially, it was impossible to leave out a single panel. To resolve this challenge, the team developed a plan to place the hoist on the inside of the passenger elevator shaft.

ROI:

- Precast was installed as designed.
- Building envelope was dried in the desired sequence, allowing downstream trades to proceed.
- Interior work proceed as scheduled.
- Exhibitor work was started ahead of schedule.
- Contributed to project achieving early completion and early opening.

INNOVATION
HOIST IN ELEVATOR CORE

The Perot Museum of Nature and Science is currently on track to receive a LEED Gold rating from the United States Green Building Council and was awarded a level four Green Globe rating, the highest sustainable Green Globe certification possible. In the United States, this facility is one of only five projects to receive four Green Globes and is the only Green Globe-certified museum.

INNOVATION
SUSTAINABILITY

HIGH REPLACEMENT CONTENT CONCRETE MIIXES

High-replacement content concrete mix designs were utilized as part of their sustainability strategy for recycled content towards achieving LEED points. One of these mix designs used 50% fly ash in lieu of cement, which is a fairly common practice, however, the second mix utilized 50% slag replacement for the cement. This had never been used in the Dallas market or by any of the project's ready-mix providers. To overcome this challenge the design team worked with the concrete suppliers to develop a strength analysis of the new proposed mixed design utilizing the slag mix. By working with the contractor and concrete suppliers we were able to achieve the LEED requirements by utilizing the new slag mix design and introduction of a new product type to the Dallas market.

WATER COLLECTION AND REUSE

A gravity-fed waterfall and ‘raintubes’ that reveal the journey of water from roof to cistern, a building dashboard that displays data about water capture and reuse, and an integrated system that diverts 100% of site runoff for toilets and landscape irrigation; these features are part of a systems design that both integrates and celebrates water conservation at the new Perot Museum of Nature and Science

DOZERS AND DONUTS

Local elementary school children were brought to the construction site to discuss current construction process and potential careers in construction. To keep the event interesting, we viewed the building features in the BIM model and then pointed out these same building features being constructed real-time.

PHILANTROPIC AND EDUCATIONAL TOURS

The museum was funded solely from donations and key to this process was the availability for visitors to tour the museum while it was under construction, getting perspective donors excited about the project. The design team was instrumental in assisting the museum with the tours and ensuring safety on an active construction site. This iconic museum drew interest from peers in the A/E/C industry curious about the new and innovative construction techniques taking place on the project. The design team provided tours for design firms and architectural students from around the country.

IMAGES


OF NATURE AND SCIENCE


AND ROSS
PEROT
BUILDING


MARGOT AND ROSS PEROT BUILDING


THE PAST COMES ALIVE
Putting the Pieces Together

PEROT MUSEUM OF NATURE & SCIENCE

AIA TAP AWARDS 2014