Thoughts on Museum Design

By Thomas Taylor, Jeffrey Koke, and Robert Fry

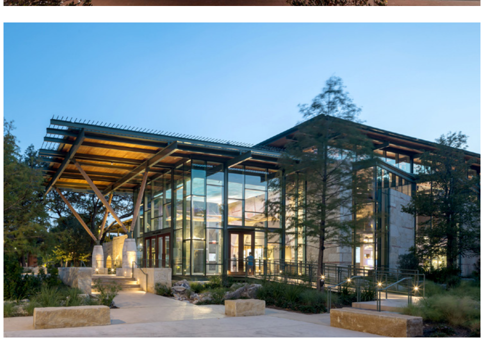

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Table of Contents

Museum Experience 1

Museum Projects

Dallas Museum of Art
Expansion & Renovation
Dallas, Texas
Design Architect: Nieto Sobejano Arquitectos
Architect of Record: Perkins&Will
New gallery on the existing roof, a new roof terrace and various renovations
2027

Alamo Museum and Visitor's Center
San Antonio, Texas
Design Architect: Gensler
New visitor center and museum will combine footprint of the three buildings totaling 70,000 sq. ft. over three floors with rooftop addition of one level. 15,000 sq. ft. of additional indoor and outdoor space.
$130 Million
2024

UTD Phase I of the O'Donnell Athenaeum
Richardson, Texas
Design Architect: Morphosis
Local Architect: GFF
The new 57,000 sq. ft. building includes offices, classrooms, art library, art storage and gallery space
$42 Million
2023

Alamo Exhibit Hall & Collections Building
San Antonio, Texas
Design Architect: Gensler
2 stories, 24,000 sq. ft.
Includes a 10,000 sq. ft. exhibit space to display the $15.5 million Phil Collins Collection.
$15 Million
2022

Dallas Arboretum
Dallas, Texas
Design Architect: Marlon Blackwell Architects
9,500 sq. ft. building overlooking White Rock Lake
2019

Texas Tech Universiteum
Lubbock, Texas
Design Architect: Morphosis
Architect of Record: GFF
40,000 sq. ft. of gallery space, a community engagement center, laboratories, work areas, and storage facilities.
$100 Million

Dallas Holocaust and Human Rights Museum
Dallas, Texas
Design Architects: Omniplan
The 52,300 sq. ft. building includes two 50-seat classrooms, exhibit spaces, lobby, common areas, and an auditorium on the first floor.
2019

Rockport Center for the Arts
Rockport, Texas
Design Architect: Lake|Flato
2020

Cattle Raisers Museum Renovation
Ft. Worth, Texas
Design Architect: BBP Architects
8,000 sq. ft. of renovations
2016

Witte Museum
San Antonio, Texas
Design Architect: Lake Flato
40,000 sq. ft. addition, 37,000 sq. ft. renovation
LEED Gold
$19 Million
2016

The DoSeum
San Antonio, Texas
Design Architect: Lake|Flato
70,000 sq. ft.
LEED Gold
$45 Million
2015

Perot Museum of Nature & Science
Dallas, Texas
Design Architect: Morphosis
Consulting Architect: GFF
Joint Engineer: John A. Martin & Associates
7 stories, 180,000 sq. ft.
Four Green Globes
LEED Gold
2013

Marine Education Center at the Gulf Coast Research Laboratory
Ocean Springs, Mississippi
Design Architect: Lake|Flato
$10 Million
32,000 sq. ft.
2014

Museum Projects

Naples Botanical Garden Visitor Center
Naples, Florida
Design Architect: Lake|Flato
Visitors center and cafe
LEED Gold
$6.8 Million
2014

The Witte Museum
Research & Collections Center Building
San Antonio, Texas
Design Architect: Lake|Flato
25,000 sq. ft. renovation
2013

Rory Meyers Children's Adventure Garden
The Dallas Arboretum
Dallas, Texas
Design Architect: Dattner Architects
Civil Engineer: Pacheco Koch
Discovery Center 8,000 sq. ft. building.
Texas Skywalk 290-foot long architecturally-exposed structural steel bridge that connects the Discovery Center roof to the exposed concrete-and-steel elevator tower platform in the center of the garden space.
2013

Briscoe Western Art Museum
San Antonio, Texas
Design Architect: Lake|Flato
Renovation of a 1930's 4 story, 32,000 sq. ft. library to convert to an art museum.
Located on the Riverwalk.
2012

Sixth Floor Museum
Visitors Center Expansion
Dallas, Texas
Design Architect: Booziotis
2012

Fort Worth Museum of Science & History
Fort Worth, Texas
Design Architect: Legorreta & Legorreta
Architect of Record: Bennett Benner Partners
166,000 sq. ft.
$40 Million
2009

The Chickasaw Cultural Center
Sulphur, Oklahoma
Design Architect: Overland Partners
The cultural center is a 105,000 sq. ft. building that helps to represent the story and history of the Chickasaw Nation. The building is open with wide spaces and two central courtyards. There are permanent and rotating art, historical and educational exhibits.
2008

Old Red Museum
Clock Tower Reconstruction
Dallas, Texas
Design Architect: James Pratt
$8 Million
2007

Dallas Garden Center at Fair Park
Dallas, Texas
Design Architect: James Pratt

Dallas Museum of Art Renovation
Dallas, Texas
Design Architect: Gluckman Mayner
Renovated gallery, ramp & stairs, theater, office, classroom 1 & 2, horchow auditorium, focus vestibule & gallery
2007

UT Blanton Museum of Art
Austin, Texas
Design Architect: Kallmann McKinnell & Wood
Architect of Record: Booziotis
120,000 sq. ft. gallery building connected by a tunnel to a 60,000 sq. ft. building with cafeteria, bookstore and administration.
2006 (Phase 1)
2008 (Phase 2)

Nasher Sculpture Center
Dallas, Texas
Design Architect: Renzo Piano
Architect of Record: Beck
Client: Nasher Foundation
(Joint Venture with Arup London)
2003

Museum Projects

Amon Carter Museum
Fort Worth, Texas
Design Architect: Philip Johnson
Architect of Record: Jacobs
Project Manager: Linbeck Construction Company
Partial demolition, reconstruction and expansion of existing building creates a 110,000 sf, 3 story museum. Existing basement walls, floors and foundations were strengthened to accept new floors.
$28 Million
2001

National Cowgirl Museum & Hall of Fame
Fort Worth, Texas
Design Architect: David Schwarz
Architect of Record: Bennett Benner Partners
Client: Sundance Development Group
2001

The Women's Museum
Dallas, Texas
Design Architect: Wendy Evans Joseph
Architect of Record: SmithGroupJJR *(F&S Partners)*
(Designed in conjunction with Charles Gojer)
2000

Trammel Crow Asian Art Museum
Dallas, Texas
Design Architect: Booziotis
1998

Chapel of St. Ignatius, Seattle University
Seattle, Washington
Design Architect: Steven Holl
1996

Lower Colorado River Authority Museum
Kingsland, Texas
Design Architect: STG Design
1994

American Museum of Miniature Arts Renovation
Dallas, Texas

Texas Discovery Garden
Dallas, Texas
Design Architect: Oglesby Greene

Sixth Floor Museum
Texas School Book Depository
Dallas, Texas
Design Architect: Burson & Williams
1987

Thanks-Giving Square Chapel & Museum
Dallas, Texas
Design Architect: Philip Johnson and Burgee
1976

Texas State History Museum
Construction Management Services
Austin, Texas
Client: Thomas S. Byrne

UTD Crow Museum at O'Donnell Athenæum
Richardson, Texas

Design Architect: Morphosis

Local Architect: GFF

56,600 sq. ft.

The new 56,600 sq. ft. project includes the Crow Museum, a 600 seat performance hall and the Traditional Arts of the Americas Museum all connected by an art plaza. The project also includes a 1100 car parking garage. The building will include interior and exterior event spaces, galleries, library and reading room, seminar rooms, conservation lab, art storage, offices and loading dock. This modern building will enrich the student experience by fostering art on the campus and enhance the campus environment, and will bring new visitors to the campus to come and see the latest in artistic and cultural innovation.

Dallas Holocaust and Human Rights Museum
Dallas, Texas

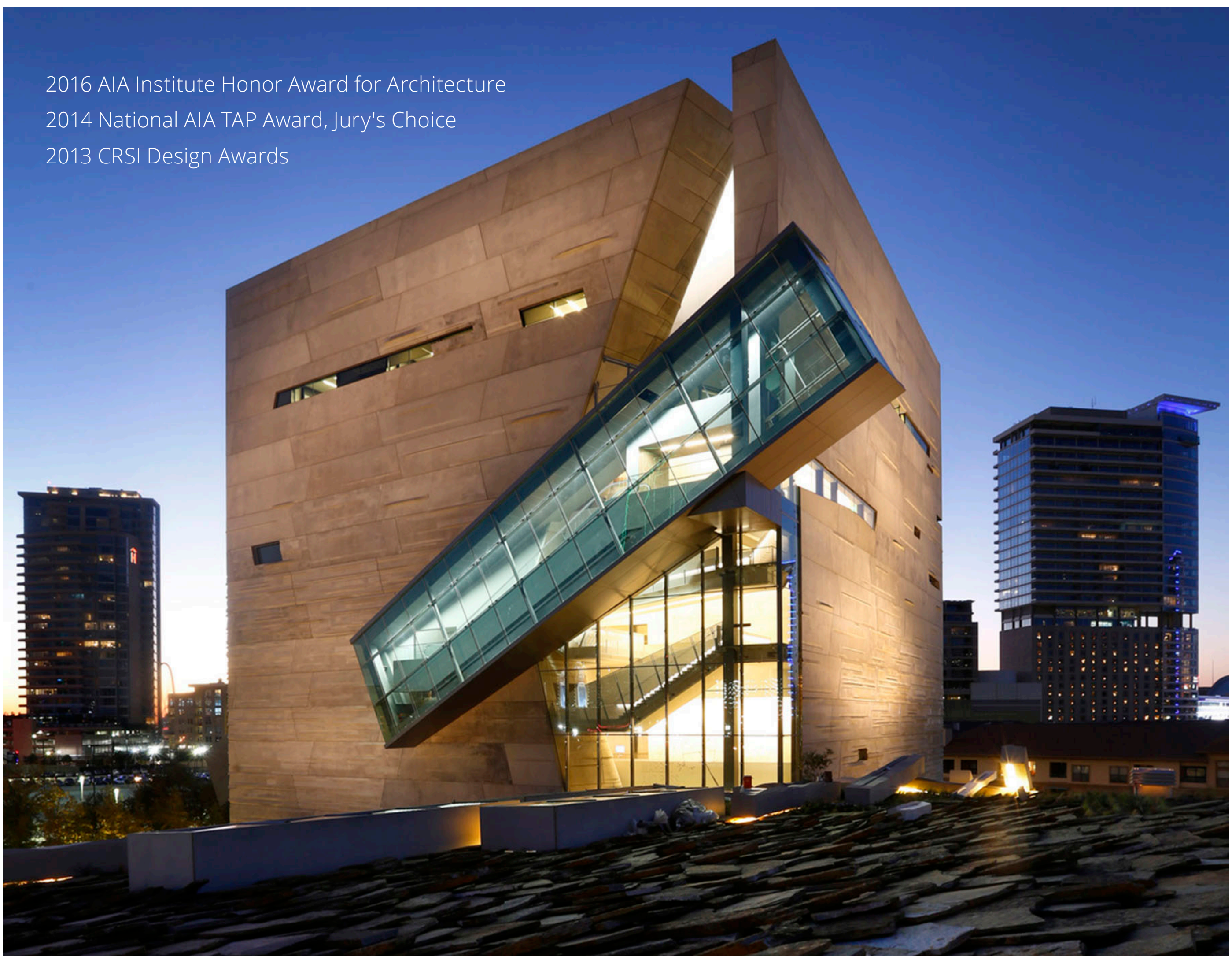
Design Architect: Omniplan

52,300 sq. ft. exhibition space, performing arts auditorium, community lobby, reflection space, education spaces, library archives, administration offices, and a public plaza.

Perot Museum of Nature & Science
Dallas, Texas

Design Architect: Morphosis
Consulting Architect: Good Fulton & Farrell
Joint Engineer: John A. Martin & Associates
Four Green Globes
LEED Gold

The museum is a center for education, exploration, and discovery. The approximately 150,000 sq. ft. facility features lively exhibits, vivid contextual displays of the Museum's collections, the latest technology, multimedia presentations, and hands-on activities. The facility offers dynamic exhibits on topics ranging from dinosaurs to DNA. The Museum introduces new public programming for adults and families that will complement and enhance exhibitions and other museum activities as well as specialty programming that encourages school-aged children to pursue careers as scientists, educators, researchers, and engineers. Programming includes hands-on exploration areas, discovery stations, ongoing workshops, demonstrations, lectures and symposia, field trips, labs, ArtsReach programming, a teacher development center, a mobile learning lab, after-school classes, special interest clubs, summer study, and travel programs. Technology-based programming includes web site activities, interactive media in exhibits, and distance and online education programs.


2016 AIA Institute Honor Award for Architecture
2014 National AIA TAP Award, Jury's Choice
2013 CRSI Design Awards

Fort Worth Museum of Science and History

Fort Worth, Texas

Design Architect: Legorreta & Legorreta

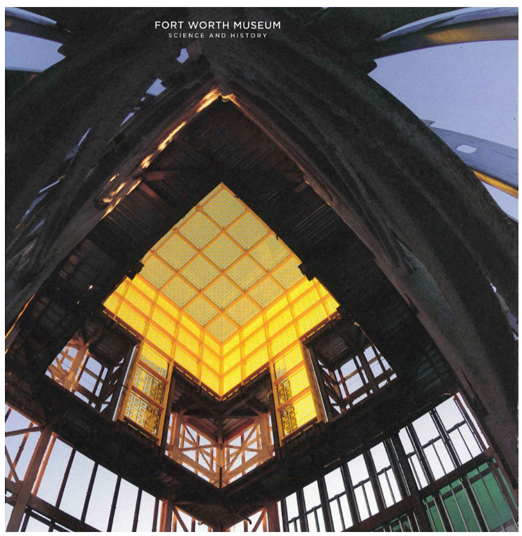
Architect of Record: Bennett Benner Partners

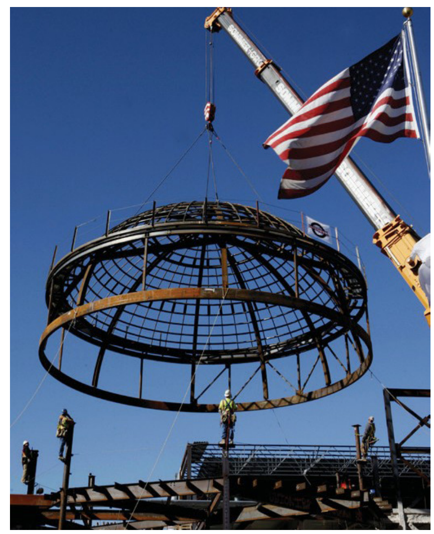
166,000 Sq. Ft.

$65 Million

2009

The 166,000 SF museum has many exhibit spaces, classrooms and dining areas. Three unique structures are incorporated into the design. The new domed Noble Planetarium is a state of the art facility to view the stars. The Energy Gallery roof is a huge cantilever over a ribbon window that “appears” to be supported by glass. And, the main entrance is an 80 foot tower we call the “Urban Lantern”. This will be an icon for the complex. The top of the tower consists of a glowing glass box that can be seen for miles around. The Fort Worth Museum is a World Class Facility and will be a source of pride for the city, museum staff and the designers for years to come.





Old Red Museum

Dallas, Texas

Design Architect: James Pratt Architecture/Urban Design

We have performed structural modifications to this 1892 building since the 1980's. It has been through many occupants during that time. The last renovation converted the building into the Museum of Dallas County History & Culture.

There were many clay tiles that fell out of the flat arch masonry floor over a period of about 20 years. We ultimately found that the contractor had left out, of the flat arch, the required horizontal reinforcing steel. We developed techniques to work around this omission and load tested the floors and ceilings to confirm the strength of the floor was appropriate for a museum. The old original bell tower was removed in the 1920's due to "structural defects". We took old photographs of the bell tower and blew them up to scale so we could determine the actual physical properties of the tower. We found it was indeed undersized. In 2005, we replaced the bell tower to its original appearance with added structural steel strengthening on the inside. Most people had never seen the bell tower since it had been down for over 85 years. It is an exact replica of the original bell tower that we could make, even though it was structurally undersized.

There was considerable steel rust and wood damage on the roof that we inspected and had repaired. We added stairs and elevators to bring it up to code which required considerable structural modifications.

Nasher Sculpture Center

Dallas, Texas

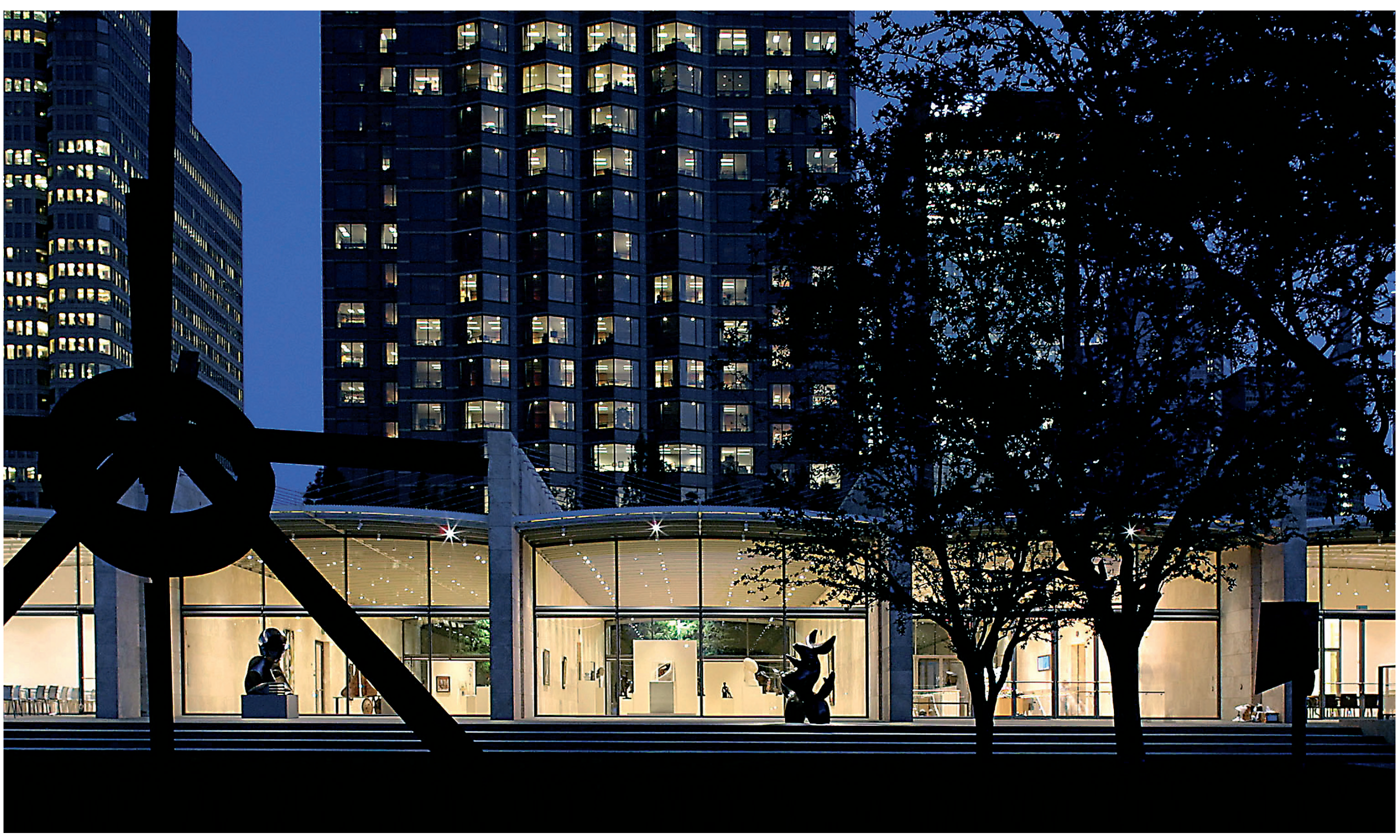
Design Architect: Renzo Piano

Architect of Record: Beck

(Joint Venture with Arup London)

The Nasher Sculpture Center, Ray Nasher's $80 Million gift to the city of Dallas, rests at the southwest end of downtown and the Arts District, providing a green haven in the city's urban core.

Architect Renzo Piano of Italy was commissioned to design the facility, along with local architect Beck and the international engineering firm Arup. Datum provided local structural consulting services throughout the design process, working closely with Arup's engineers and the architects. We also designed foundation elements and much of the site structures, as well as the James Turrell space at one end of the garden.



The DoSeum

San Antonio, Texas

Design Architect: Lake|Flato

70,000 Sq. Ft.

$45 Million

2015

LEED Gold

The DoSeum is a children's museum in San Antonio. The exposed structural steel, bar joist, and tilt wall panels--inside and out--are a part of the museum experience. The tilt wall is the "bones" of the building and many tilt wall panels were left exposed to view on the inside as well. The combination of exposed steel and tilt wall concrete was selected for economics and architectural expression. The project includes 104,000 sq. ft., including the exterior spaces. The building produces 30% of its energy and 98% of its construction waste was recycled.

The Witte Museum

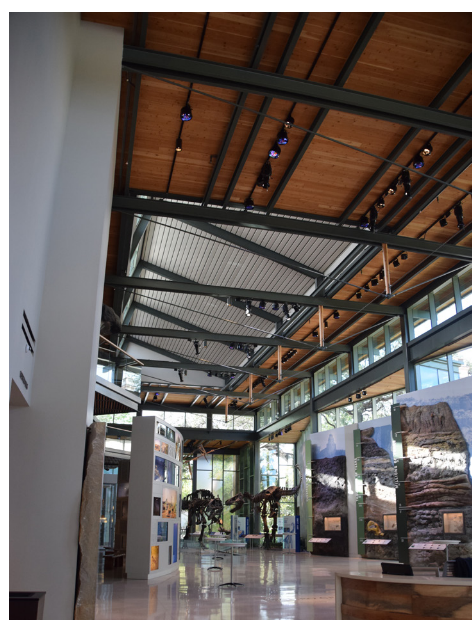
San Antonio, Texas

Design Architect: Lake|Flato

40,000 sq. ft. addition, 37,000 sq. ft. renovation

2016

LEED Gold



Briscoe Western Art Museum
San Antonio, Texas

Design Architect: Lake|Flato

This project consisted of a new 3 story addition adjacent to an existing historic building. The existing building was renovated for museum space. The primary structural design work in the existing building consisted of adding two floors and a grand stair within the large atrium. We added a freight elevator and major mechanical equipment on the existing roof. We constructed an electrical room in the basement for the power company.

The new addition is a steel structure with an architectural exposed steel roof structure and overhangs the low roofs. We worked closely with the Architect to develop the details of the exposed steel roof trusses. The concept includes a bridge visually separating the additions from the existing building.

Naples Botanical Garden Visitor Center
Naples, Florida

Design Architect: Lake|Flato

160-acre botanical garden visitor center, cafe, and birdwatch tower

$6.8 Million

2014

LEED Gold

The Chickasaw Cultural Center

Sulphur, Oklahoma

Design Architect: Overland Partners

The cultural center is a 105,000 sq. ft. building that helps to represent the story and history of the Chickasaw Nation. The building is open with wide spaces and two central courtyards. There are permanent and rotating art, historical and educational exhibits.

WoodWORKS – Wood Design Engineering Award 2012

UT Blanton Museum of Art

Austin, Texas

Design Architect: Kallmann, McKinnell & Wood

Architect of Record: Booziotis & Company

2 Buildings, 150,000 Sq. Ft.

$55 Million

2005

The long-awaited Blanton Museum project broke ground in 2003 with a monumental design by designer Kallmann McKinnell & Wood. The two buildings form a new gateway to the south face of the UT Austin campus, bookending Congress Avenue opposite the State Capitol 5 blocks away, and standing diagonally across from the new State History Museum.

The design features a grand scale building clad in native shell limestone with granite accents, and the requisite red-tile pitched roof. It houses masterworks from the Suida-Manning collection of Baroque and Renaissance art, along with world-class collections of prints and drawings, a Latin American collection, and a contemporary/American gallery.

Natural light is an important design element, which challenged Datum's engineers to innovate a complex system of non-parallel alternating sawtooth steel trusses that allow light into the trapezoidal atrium. Thorough coordination was required to marry the structure with the complex system of reflectors that diffuse light into the galleries.

A 25'-deep basement under the entire footprint houses the extensive mechanical systems. A structural grid of 25' was selected for economy and regularity after an exhaustive framing selection process that investigated numerous systems with spans up to 80'. Cast-in-place columns and wide pan joists frame the structure, which has 22' tall stories. The floors were designed for a live load of 250 psf to accommodate forklifts and heavy artwork moving around the building.

Amon Carter Museum

Fort Worth, Texas

Design Architect: Philip Johnson/Alan Ritchie Architects

Architect of Record: Jacobs

2001

Renowned architect Philip Johnson designed the original exhibit space for the Amon Carter art collection in 1961 on a wedge-shaped piece of land in what has become the Fort Worth Arts District. Subsequent additions behind the original building filled the wedge-shaped piece of property with a series of 2-story building segments and courtyards, but eventually left the collection without adequate space for exhibits and curatorial support, and little opportunity for expansion.

In the mid-1990's, the Carter family insisted that only Philip Johnson could be trusted to fulfill the promise this site held for their collection. The new scheme called for the demolition of all but the original masterpiece "jewel box" building, and the construction of a new 4-story structure that would fill the wedge-shaped property, tripling the space for exhibits, and creating adequate support space for a modern museum.

The new design would create a solemn dark granite monolith behind the jewel box, with a single central "beacon," or light monitor over a central atrium, as the lone adornment.

To maximize the value of the new building, we analyzed the existing structure on the site to determine how much of it could be re-used within the expansion program. We were able to salvage much of the 2-story basement and the basement floor, as well as walls and some of the below-grade mechanical spaces in the process.

This is a complete museum with galleries, auditorium, office space, art storage, vaults, cold storage, freight docks, photo studio, art restoration and processing, reading room, museum store and library. As a result, almost every type of structural loading that could occur in a museum can be found in the Amon Carter. Concerns for vibration and sound transmission to the auditorium were addressed. Cold storage insulation, concerns for moisture protection of art storage vaults in case of plumbing leaks or worse, and compact file areas impacted the structural design.

Chapel of St. Ignatius

Seattle, Washington

Design Architect: Steven Holl

This project, constructed of standard tilt-wall construction was **awarded one of the 8 National AIA Design Awards in 1998** and was awarded the **AIA 25-Year Award for Design Excellence in 2022**.

Although not a museum, the construction and finishes are museum-quality. The budget was extremely tight but the desired quality was extremely high. Working closely together, the Steven Holl and Datum team conceived the use of stained tilt-wall concrete panels to build the shell of the structure, which allowed the architect to focus on the interior space and finishes. The result is an incredibly inspiring spiritual space.

At the exterior, the design team paid close attention to the joints of the concrete panels and used unconventional shapes to create a magnificent building shell. Lifting inserts for the panels were highlighted with brass buttons in the finished product.

Datum's knowledge of precast detailing and our spirit of collaboration in the design process allowed Steven Holl to create a beautiful building with a simple construction concept.

Thanks-Giving Square
Dallas, Texas

Design Architect: Philip Johnson

Thanks-Giving Square Chapel is truly a unique structure. The structural shell consists of a 176'- long, coiled cantilever concrete wall, which creates a dramatic and beautiful space for the stained glass ceiling.

The use of bush-hammered white cement concrete with a specially selected quartz aggregate allowed the structure to be exposed as the finished exterior surface of the building. This made it critical that we address the design and structural stresses to prevent cracking. We also worked hard to eliminate reinforcing congestion, which can lead to honeycombing in the exposed structural finish.

Datum worked closely with designers John Burgee and Bob Kirk to create the desired geometry, look, and feel of this complex structure, and used our knowledge of structural design and construction practices to help create a timeless building.

The Women's Museum
Dallas, Texas

Design Wendy Evans Joseph

Architect of Record: SmithGroupJJR

(Designed in Conjunction with Charles Gojer)

2000

The Women's museum at the State Fair of Texas was one of the original fair grounds building that was constructed in 1907. This building had severely decayed due to the lack of occupancy for several years. Large gaping holes existed in the wood roof deck. Steel was rusted, large areas of the exterior masonry wall had collapsed and the rest of the masonry was cracked. The foundation had a differential settlement of 7".

This required a survey of the building's condition and to make recommendations on how to repair the damage and stabilize the foundations. There was only a small budget available for repairing the building as the funds were allocated to the displays and functional improvements of the interior.

We ultimately recommended a solution to stabilize the foundations and prevent future movement. We surveyed and repaired the wood deck, rusted steel and masonry walls as required. We cut control joints into the remaining masonry walls.

The end result was a beautiful new museum with no signs of its previous deteriorated condition.

National Cowgirl Museum and Hall of Fame

Fort Worth, Texas

Design Architect: David Schwarz

Architect of Record: Bennett Benner Partners

2001

The National Cowgirl Museum and Hall of Fame occupies a site adjacent to the famed Will Rogers Memorial Center in Fort Worth, near the museum district.

Designed with David M. Schwarz and local associate Bennett Benner Pettit, the Building encompasses 40,000 square feet over two levels.

Trammel Crow Asian Art Museum

Dallas, Texas

Design Booziotis

1998

This might have appeared to be a simple structural project, at first, since it was to be built in an existing building. But, the program required the addition of a gallery mezzanine on a floor that was not designed to support extra framing. We had to strengthen the floor in another area to support the 22,000 pound stone facade of an ancient Asian home without being able to access the floor from below. Another challenge was to build a 50'-0" long bridge connecting the two spaces within a 1'-3" depth limitation.

Sixth Floor Museum at Dealey Plaza

Dallas, Texas

Design Architect: Burson & Williams

The sixth floor museum was constructed on the 6th floor of the 1920's School Book Depository building. This historic venue was the location of Lee Harvey Oswald when he shot President Kennedy from the window on the 6th floor. The building is a wood structure with a load bearing masonry perimeter wall. The building had been empty for a number of years and had deteriorated. A large sign on the roof had caused serious structural wind damage before being removed. The arched masonry window lintels were inadequate for today's codes. The County Commissioners wanted to build the Commissioners Court on the ground floor by removing 4 columns that supported 6 floors and a roof. We found solid structural and economical solutions to all the structural issues of the building and contributed to creating the space for the museum.

In addition, we renovated the 6th floor for a visitor's center and constructed an elevator to the 6th floor.
We later expanded the visitor's center and extended the elevator to the 7th floor. We are presently in the master planning stage for a new expansion of the visitor's center.

Rory Meyers Children's Adventure Garden
The Dallas Arboretum

Dallas, Texas

Design Architect: Dattner

Civil Engineer: Pacheco Koch Consulting Engineers

The primary exhibit building at the Dallas Arboretum Children's Garden is the Discovery Center building, housing 9,500 square feet of exhibit space, offices, and guest services and constructed of architecturally-exposed concrete. The roof of the building is an occupied space with greenscape and pavers. Extending from the upper floor is a 290-foot long architecturally-exposed structural steel Texas Skywalk that connects the Discovery Center roof to the exposed concrete-and-steel Elevator Tower platform in the center of the Garden space.

In addition to designing the primary building structures on this site, we consulted with the landscape architect to produce numerous structures to enhance the outdoor experience. These included:

- An entry plaza with seating in the round covered by an open framework steel canopy. The plaza slab cantilevered over grotto niche below with glass waterfall structure.
- A tree house structure with an internal spiral stair case inside of a manufactured "tree" shell. The stair provides access to a platform in the tree canopy with netting extending out from the platform to allow children a climbing adventure up in the trees.
- Two lamella truss structures provide shade over platforms in a lagoon. The lagoon is also home to a weir and waterwheel.

Datum also assisted in the design of wood frame shade structures and pavilions, steel pavilions and provided supports for trellises arbors and exhibit bases.

Photo courtesy of Dallas Arboretum

Structural Design Criteria 2

D

Structural Design Criteria

Structural Loading

The most obvious and first thought that comes to mind when you think of criteria for structural engineering is the loading requirements of the space. In a museum this deserves a much more in-depth review than simply applying the provisions of the code. We generate a question list at an early stage in schematic design to begin to identify where special loading requirements will be required.

For example:

Gallery Space: The code states that areas of public occupancy shall be designed to support 100 pounds per square foot superimposed live load without taking advantage of the code-provided reduction formulas. This should be and is usually adequate, but in a general way. A heavy sculpture and the forklift required to transport the sculpture or art can create concentrated wheel loads on a small area considerably larger than 100 psf. So, in addition to the overall design criteria, a concentrated load criteria must be established and thin slabs and short span structural elements need to be checked for this criteria.

Many museums are designed for 150 psf to 250 psf live load, with slabs and individual joists designed to support concentrated loads from sculptures, fork lifts, etc.

It is important to understand how the Museum intends to transport art, sculptures, and exhibits within the museum and create a design criteria to accommodate this added loading. Concentrated wheel loads need to be addressed and could influence the type of structural system selected. Individual slabs and beams supporting a small tributary area may be designed for loading in excess of 150 psf to 200 psf to account for concentrated wheel loads. If specific information of fork lifts and weight of sculptures is not available during design, then a sound engineering judgment must be made based on prior experience.

The museum might also need to take the floor loading criteria into consideration when they select equipment to drive across the floor to move sculptures and to change light bulbs. This should be discussed in the early design stages and design the structure to be compatible with equipment required to properly operate the facility.

Special elevated floor coverings such as concrete toppings, tile and stone may have restrictive deflection criteria. Code deflection minimums may not be good enough for some floor coverings. These materials must be investigated on a case by case basis.

Requirements for recessed slabs for flooring, in-slab cable trays, or embedded conduit can be easily overlooked until very late in the design process, but can significantly impact the structure. Exhibitors need to know this is an important item to identify early. Planetariums and theatres tend to have specific requirements for in slab cable trays and embedded conduit.

Exhibitors must state their floor vibration expectations. For example, if there is a planetarium, vibration for the projector can be of concern and can be detrimental to the presentation.

Exhibit information will be difficult to get early due to the design process, but if they can think about these structural items up front, our coordination efforts will be easier and more flexible for them.

Structural Design Criteria

In addition, some sculptures or other objects may need to be displayed by being hung from the ceiling. The code-minimum live load of 20 pounds per square foot will not be adequate for this, so the topic of hanging loads in the gallery spaces must be addressed during design. Isolated concentrated loads need to be addressed on individual members.

Storage Vaults: The building code establishes live loading for storage areas in the 125 psf to 250 psf range. But, to conserve space, many museums are utilizing compact files which can produce live loading in the area of 300 psf and above. It is extremely important to identify the need for, and the location of, compact files (maybe even if for future expansion) in order to have the strength designed into the structure.

Some museums are using hanging racks to store art. Although the floor of the vault area may be designed for 125 psf live load or greater, all of the storage load on a hanging rack is going to the ceiling. Therefore the floor of the space above has to be designed to support the live load intended for that floor, and also has to be designed to support the hanging load from below. Although it might be unusual to hang a 100 psf load from a hanging rack, the rack manufacturer usually designs these systems to support this load. So, in effect, the floor above, if it is a gallery for example, would have to be designed for 100 psf public occupancy live load plus 100 psf hanging load from below or a total of 200 psf.

CLEAN AIR

One problem for museum quality art can be particles of spray fireproofing on a steel structure circulating in the air conditioning system. Steel construction, particularly for roof construction, may be a practical solution if fireproofing is not required. If fireproofing is required and steel construction still appears to be the desired economical choice, then a troweled-on cementious fireproofing or other currently available system may be worth considering. The design team should receive guidance from the museum on this issue.

WATER DAMAGE

Depending on the organization of the spaces and the location of water lines in the building, it may be necessary to recess the structure over storage vault areas and add a waterproof membrane and topping to protect artwork. Obviously the desired solution is to avoid this condition, but if required this solution can be implemented.

VIBRATION SEPARATION

Depending on the proximity of the mechanical room to the theatre and the type of usage of the auditorium, there may be a requirement for a structural separation to prevent transmission of vibrations through the structure. This can impact structural framing systems and should be addressed during the early planning phases.

COLD STORAGE

Cold storage areas require recessing and strengthening the floor for insulation and a topping slab. Above the cold storage unit, the design team must consider how to support the insulated ceiling.

CURATORIAL & BACKSTAGE SPACES

These areas often have concrete block walls instead of drywall. This adds considerable loading to the structure in the area where the walls occur. We need to account for this weight, if it occurs, in our calculations and provide extra framing stiffness to prevent cracking the walls.

Structural Design Criteria

D

SLAB-ON-GRADE CONSTRUCTION

Slab-on-grade construction is economical, but we often recommend that this be considered as a value engineering option to bring the project back in budget, if necessary, while recognizing the risks. The risk of some slab movement and associated damage to partitions, doors, etc. is normally identified in the soil report. This risk can be minimized with the recommended soil preparation, but it still exists.

A major potential problem with slab-on-grade construction in a museum is the difficulty of repairing broken water lines that occur below the slab. Putting the lines in the ceiling above the floor to avoid this possible problem can create an even worse problem.

Also, since museums tend to have long useful lives, they are often renovated over time. A suspended ground floor over a crawl space allows for the utilities and MEP infrastructure to be re-routed without tearing up the slab. This can be critical to keeping portions of the museum operational during renovation work.

If a slab-on-grade is used, a specialty consultant should address the possible increased humidity in the building due to potential vapor transmission and if it is at a level that could be a concern.

STRUCTURED GROUND FLOOR

A structural ground floor with a crawl space is often a good choice for long term performance and underfloor flexibility for repairing broken lines or relocating lines, if the following steps are taken:

- Construct the bottom of the crawl space above outside grade or create proper provisions to drain the crawl space in case it gets wet.
- Construct a vapor barrier and mud slab in the crawl space.
- Provide cross ventilation, using forced ventilation or air-conditioning the crawl space.
- Add insulation to the underside of the floor.
- Seal all penetrations in the floor around ducts and pipes.

Use of slab on void boxes is not recommended, due to the inability to access and repair broken water lines below the slab.

The slab-on-grade versus structured floor over crawl space is an important quality decision that will require serious discussion during schematic design.

COLUMNS IN WALLS

Columns are typically larger than the thickness of interior walls and most exterior walls. This creates pilasters on the wall that project out on both sides or one side of the wall. In most exhibit spaces, a column projection into the space is very objectionable. It limits display space flexibility on the walls. Early in the design process we discuss with the architect:

- How to locate columns to miss display walls.
- When column is in display wall would it be possible to project the column to the other side of the wall leaving a smooth face on the exhibit side?

Structural Design Criteria

- Should you make the column a little smaller and the wall a little thicker to encase the column totally in the wall? It takes up a little extra space but may make the remaining space more usable.

- Look for ways to create this structural relationship to the functional use of the facility.

FUTURE EXPANSION

Historically, museums tend to grow over time, often beyond the scope envisioned at the time of the current design. It may be appropriate for planning purposes to design the structure and to at least consider the details that would make future expansion possible.

In addition to expansion by new construction, expansion is often accomplished by expanding compact storage areas and other heavily loaded storage. Some effort needs to be made to identify the possible locations of these potential expansion areas for the future.

Hopefully there will be enough information about future expansion plans to be able to design the structure to support future expansions, without having to construct new foundations up against Phase I when Phase II is built. Future foundation construction directly adjacent to the existing structure can be a vibration issue, and must be addressed.

A balance needs to be struck so that the additional dollars spent to provide future flexibility are used judiciously without running up the cost over large areas.

Appendix 3

Schizophrenic Agora

Mission, Market, and the Multi-tasking Museum

Joseph Cornell,
Untitled [Mona Lisa], c. 1940-42.
Collection Marguerite and
Robert Hoffman.

By
Marjorie
Schwarzer

You have to understand that all through the 1950s . . . a museum was empty rooms with knights in armor where you had one sleepy guard for every seven centuries.—Don DeLillo, Underworld

At the close of the 20th century, a radical shift with significant consequences has occurred in museums in the United States. Traditional sources of funding—such as deeply pocketed patrons and government agencies—have become more tenuous. Operating costs have risen. Most important, the museum profession has become passionately populist. Control of the museum, formerly the exclusive domain of patron and scholar, is now shared by marketer and visitor. Today's museums are schizophrenic agoras; they seek to retain their lofty status (at least implying a kind of cultural elitism) and at the same time engage more diverse, larger, and novice audiences. Less isolated, museums are part of a vital and growing cultural tourism and entertainment industry. Institutions now find themselves forced to reconcile the competing functions of marketing and mission. One result has been a transformation of the museum's functional design, its physical presence—a transformation of museum architecture itself.

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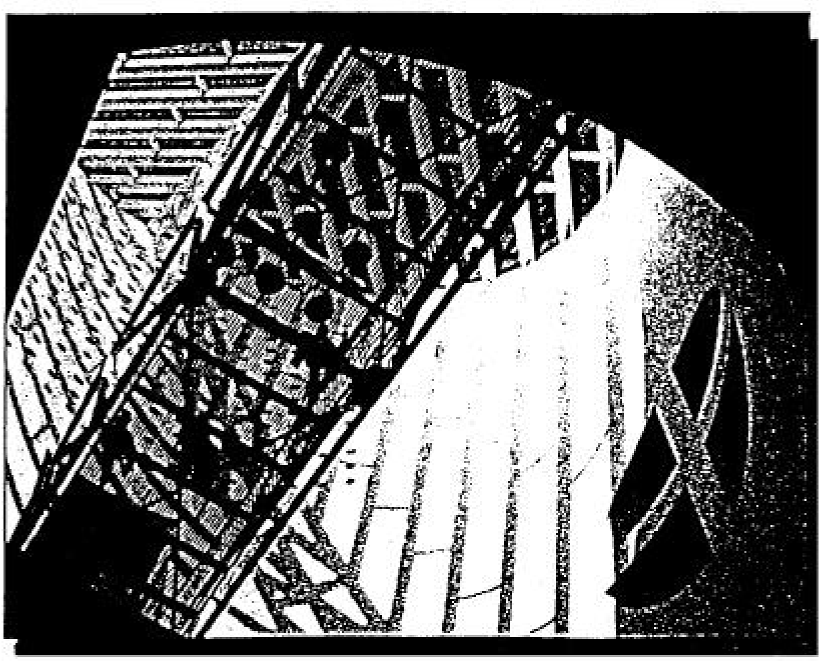
The museum is now routinely pitched as an enjoyable leisure-time outing, well suited to the general public's use of its precious free time in today's frenetic world. Michael J. Wolf, author of "The Pleasure Binge," in *Wired* magazine (March 1999), argues that the consumer's use of free time has altered dramatically in the past few decades. Despite the common perception, the average 30 hours of "unallocated time" that Americans are said to have per week remains unchanged since the 1950s. Rather, the way Americans use their free time has changed. We are a nation of multi-taskers who expect to be simultaneously productive and entertained. According to Wolf's research, while the rate of personal savings in the United States has declined to a 63-year low of 2.1 percent, entertainment spending is at a high of 8.4 percent of total consumer spending. Furthermore, we spend our leisure dollars and time carefully, parceled out in bite-sized blocks to maximize both fun and usefulness. Wolf cites the themed mega-mall and packaged weekend getaway vacations, where entertainment and shopping are pitched to the time-starved consumer as commercial enterprises that understand leisure-time trends.[1] But he could have pointed to the new museum. As architectural historian Victoria Newhouse recently proclaimed: "Shopping, eating, performances, along with fund-raising and urban renewal now vie with preservation and exhibition as museum mandates."[2]

The demands of leisure-time mass audiences have transformed museum architecture. In the 1930s, architect Philip Johnson envisioned the museum as "the most beautiful and useless building in the world, small galleries, dark, cool and gorgeous . . . I mean a lot of wasted space. One should enter a museum up steps and . . . be impressed and rather afraid to enter."[3] If in the past the architect could approach museum design as a chance to make monumental statements, market forces now contest this activity. Postmodern leisure-time museums are multi-functional, multi-tasking spaces accommodating varied consumer needs. With the exception of once-in-a-century, billion-dollar commissions such as Richard Meier's Getty Center for the Arts (1998) in Los Angeles, architects can ill afford to continue designing museums based on past models of glory. Rather, the architect is called on to develop a new architecture that assimilates and composes the museum's multiplying personalities.

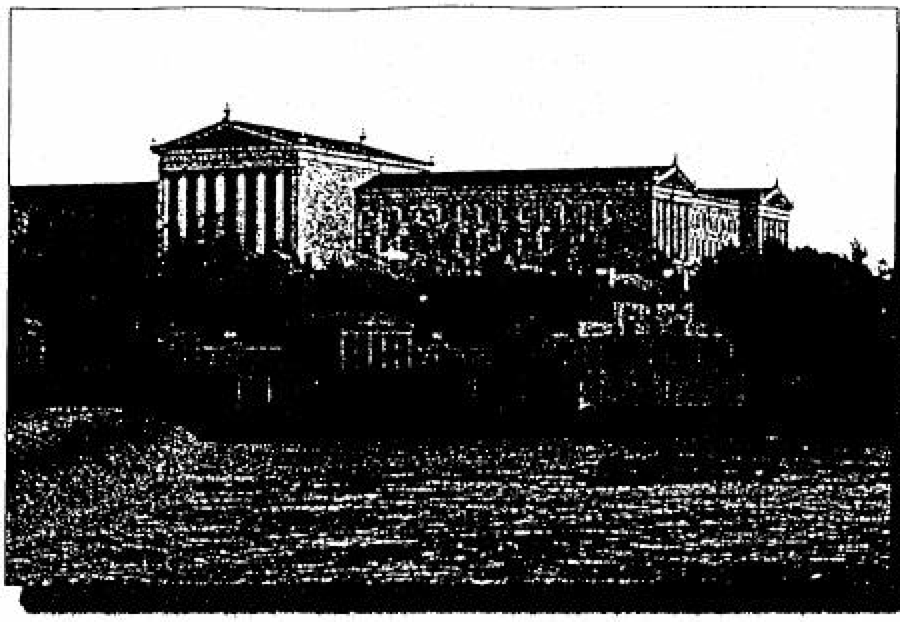
From Aesthetic Monument to Leisure-Time Destination

I introduce the multi-tasking museum by comparing visitor experiences in two museums, German architect Karl Friedrich Schinkel's Altesmuseum in Berlin (1829) and Swiss architect Mario Botta's San Francisco Museum of Modern Art (SFMOMA) (1995). Schinkel's museum embodies 19th-century debates on how to display objects in order to uplift the viewer.[4] His was the model for great 19th-century American buildings like the Museum of Fine Arts, Boston and the Philadelphia Museum of Art. In contrast, Botta's building exemplifies the late 20th-century struggle to define museums amidst an urban consumer culture.

The Altesmuseum is ceremonial. The visitor encounters it from afar, approaching the horizontal and palatial building from a great plaza. An impressive staircase leads the visitor into the building through 18 Ionic columns. Once inside, the visitor moves toward a central circular rotunda framed by sculptures and culminating skyward in a pantheon-type dome. In Schinkel's words: "The sight of this beautiful and exalted space must create the mood for and make one susceptible to the pleasure and judgement that the building holds in store throughout."[5] Upon entering the galleries, one experiences works of art by proceeding through an ordered and subdued series of rooms. The museum-goer's experience



Mario Botta's design for SFMOMA incorporates a bridge that traverses the skylit tower at the center of the building. Photo by Richard Barnes.



The Philadelphia Museum of Art, inspired by the classic formalism of Friedrich Schinkel's 1829 Altesmuseum in Berlin.

is an often solitary, unhurried pilgrimage with the goal of quiet reflection and inspiration.

SFMOMA provides a markedly different experience. The building's site is on San Francisco's Third Street, making it a part of the hustle and bustle of the surrounding city. There are three sidewalk entry points: store, café, and lobby. The store generates more revenue per square foot than any other retail space in San Francisco. The café is usually crowded and, like the store, is open more hours than the museum galleries. The lobby entry, less than one-fifth of the total street frontage, opens immediately onto walls bearing names of donors and booths selling memberships and admissions tickets.

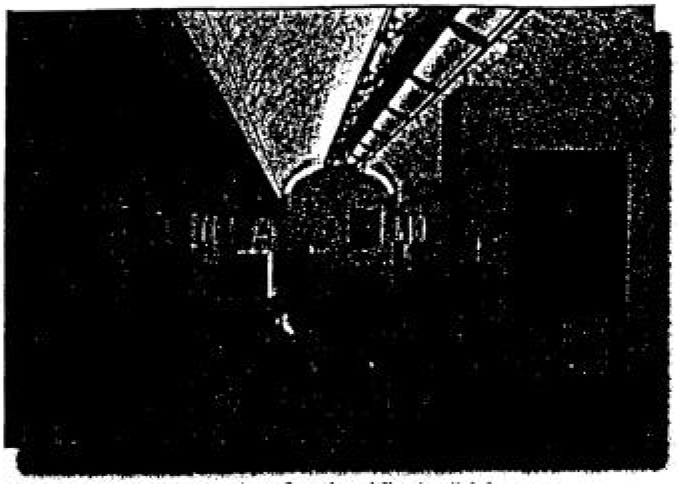
Beyond the ticket booths in the multi-story lobby, there is still no art; unlike the Altesmuseum's sculptures, no objects at SFMOMA's entrance suggest what awaits the visitor. After ascending via elevator or cramped central staircase to the gallery floors above, the visitor views the art in vertically stacked, well-lit galleries of various sizes and shapes. Although Botta modeled SFMOMA on his prior church designs, the experience inside is hardly sacral.[6] People mill about: talking, flirting, playing on computer terminals. The experience is bright, social, and urbane. Jeff Newcomb, a marketing professor at John F. Kennedy University, Orinda, Calif., suggests that SFMOMA's exterior is also its logo, which establishes the museum as a branded product.

This contrast illustrates the dramatic changes museums have undergone and suggests what the contemporary marketplace demands from architects. Like the modern consumer desiring to use her free time effectively, the museum is multi-tasking. Current museum priorities include access and comfort, eating and shopping, flexible exhibiting, and engaging the visitor. These priorities not only challenge museum architects, they challenge the core identity of the museum itself.

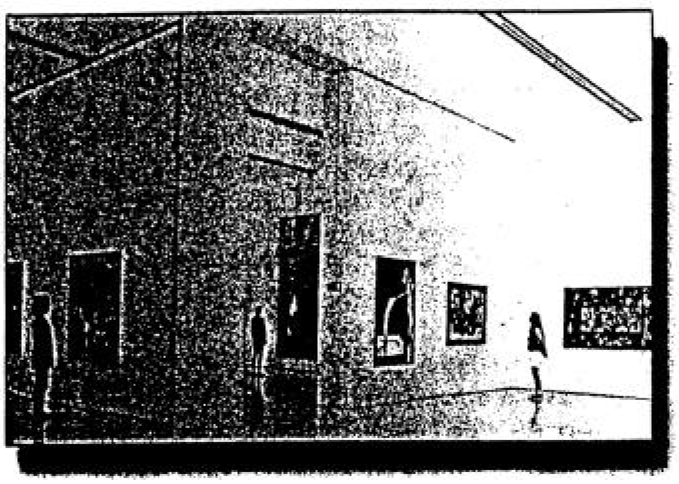
Access and Comfort

As museums reach out, access and comfort are essential to entice members of the public not only to visit, but to feel they have spent their time so wisely that they want to return and join as members or donors. The focus on convenience begins at the visitor's arrival. Grand landscaped setbacks (such as the dramatic fountains and ponds leading to the Cleveland Museum of Art) and palatial stairways (such as those iconic steps leading up to the Philadelphia Museum of Art), which Johnson hoped would inspire reverence, have given way to urban buildings without setbacks and with ordinary street entrances. For example, one now enters the Cleveland Museum of Art from behind, via a hotel lobby-like driveway with easy vehicular access. When Robert Venturi designed the new downtown Seattle Art Museum (1994), he placed the grand staircase inside the building. One enters the museum through glass doors directly from the street. The parking garage entrance into the Oakland Museum of California, which occupies its entire city block and places its garden atop the building, provides all the ceremony of entering an airport terminal through a parking lot, yet it is familiar and easy. Likewise, according to Katherine Hough, director of exhibitions and collections at the Palm Springs Desert Museum in California, a priority of a recent renovation creating a ground-level entry was to relieve the visitor's burden of having to ascend the grand entry staircase.

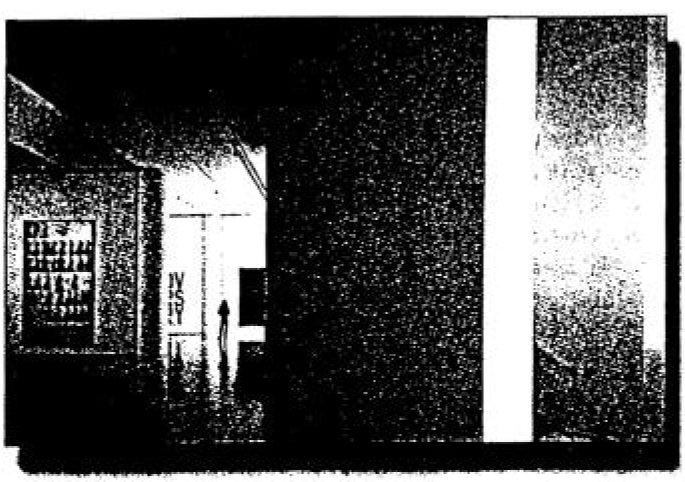
To attract mass audiences, museums mount blockbuster exhibitions—such as the recent van Gogh show at the National Gallery of Art in Washington, D.C., and the Los Angeles County Museum of Art—with large publicity campaigns. These shows draw huge crowds, sometimes up to 12,000 visitors a day, in spaces designed to accommodate 2,000 at most. Yet, Americans tolerate waiting in line less



Louis I. Kahn's design for the Kimbell Museum made innovative use of natural light to create calm, inviting galleries. Photo by M. Bodycomb.



Stacked galleries of different shapes and sizes accomodate SFMOMA's exhibitions and programs (above and below). Photos by Richard Barnes.



and less. Quick entry into the museum, like fast checkout in a supermarket, is tantamount to excellent customer service. The leisure-time museum demands from architects crowd-control solutions that move visitors waiting in long lines through museum spaces happily and efficiently. It also requires a balance between enough seats and benches for comfortable gallery viewing and sufficient space for maximum visitor capacity.

Restrooms take on added urgency. Finding a restroom in the Louvre was, as recently as 1994, an exercise in patience and self-control. In the multi-tasking museum, restrooms on every floor need to be visible, clean, bright, and wheelchair accessible, as well as have space for diaper changes to accommodate increasing numbers of family audiences. Some museums even use this space for additional programming. The Chicago Children's Museum's restrooms have educational labels explaining how toilets, toilet paper, and other accoutrements were invented. The Chabot Observatory and Science Center's new facility in Oakland, Calif., will have restrooms with educational information on how astronauts relieve themselves in outer space.

Eating and Shopping

The trend toward effortless entrances, short waits, and restrooms aplenty joins other amenities offered by the leisure-time museum. The phenomenon of museum fatigue—that dizzying feeling one can experience after hours of intense viewing—is now broken up by opportunities for sustenance and consumption, exemplified by the museum restaurant and store.[7] These retail functions are so essential to a museum's survival that museums undergoing building projects are increasingly hiring independent facilities experts and consultants to help them articulate the program of retail spaces to architects.

Museum eating and shopping are relatively recent phenomena. Surprisingly, New York's Metropolitan Museum of Art did not install a large public restaurant until its 1954 renovation, and even then the restaurant was viewed more as mission-related; a Greek column was placed in front of the food service to draw people into the classical antiquities galleries. My 1960s childhood visits to the museums on the Washington, D.C., Mall often ended in a whiny, hungry departure; there simply was no place for a family to sit down and eat inside one of those institutions. Today, the Mall's National Gallery of Art's west and east wings are connected by a huge underground indoor cafeteria adjacent to a retail space that attracts a variety of visitors.

According to the *Manask Report*, a newsletter covering food service issues for museums, aquariums, and zoos, the most popular (and profitable) brand-name restaurants found in today's museums include McDonald's, Taco Bell, Pizza Hut, Wendy's, Burger King, and Starbucks: "Nationally branded concepts work particularly well in institutions that attract families and children. Art museums . . . tend to be good partners for well-known local or regional restaurant operators who are interested in lending their names, talent, creativity, and resources to the museum environment."[8]

Indeed, food options in today's museums cater to a diverse clientele: from the McDonald's located next to the Boston Children's Museum to a cappuccino bar at San Francisco's Exploratorium to the Brooklyn Museum of Art's gourmet Café Monet, which was developed in tandem with last year's "Monet and the Mediterranean" exhibition.[9] Museums often offer themed cuisine to match exhibition themes. For example, Chicago's Museum of Science and Industry's cafeteria serves African-American cuisine during its annual February exhibitions featuring black scientists and inventors. Museums have even followed the model of Borders and similar café/bookstores, interlacing retail food areas right into galleries. A "real" Viennese café was part of the "Vienna 1900" exhibition at New York's Museum of Modern Art (MOMA) in 1986. Eating is such a part of the museum experience that it overtakes conservators' very real fears of potential damage to artifacts and calls on museum architects to consider the needs of kitchens, such as ventilation, cooking equipment, and food storage.

Gift shops in museums are also ubiquitous. They, too, were originally an afterthought, relegated, according to marketing experts Neil Kotler and Philip Kotler, to "out-of-the-way locations as if the shops somehow defiled the educational and research aims of the museum."[10] In the late 1960s, American museum professionals argued to sell merchandise. They contended that museum store wares enhanced the museum's educational mission by providing people with opportunities to bring home a souvenir of their visit.[11]

This thinking has evolved dramatically, from educational justification to aggressive retailing. Museum shop merchandise currently generates between $785 million and $1 billion annually, and the stores are so successful that museums walk a fine line between for-profit retailing and their legal nonprofit status. For example, the most popular 1998 gift shop item at the Fort Worth Museum of Science and History in Texas was beanie babies.[12]

With the drive to increase retail profits, museum capital renovations call for prominently placed stores and restaurants, such as SFMOMA's street-level store and café. The museum shop, like the restaurant, is a destination in and of itself. In fact, *Museum Store* magazine recommends that museum stores build a distinct visual identity that emulates such prototypes as Niketown, FAO Schwarz, and Pottery Barn. These savvy merchants blame architects for stores' failings: "Some museum stores are lucky enough to be positioned on the main floor, near the entrance to the museum or exhibition space. . . . And then there are the other shops. Unfortunately, since architects and not merchants create space plans, these shops are buried in the least-desirable core of the museum's floor plan and hidden from view."[13]

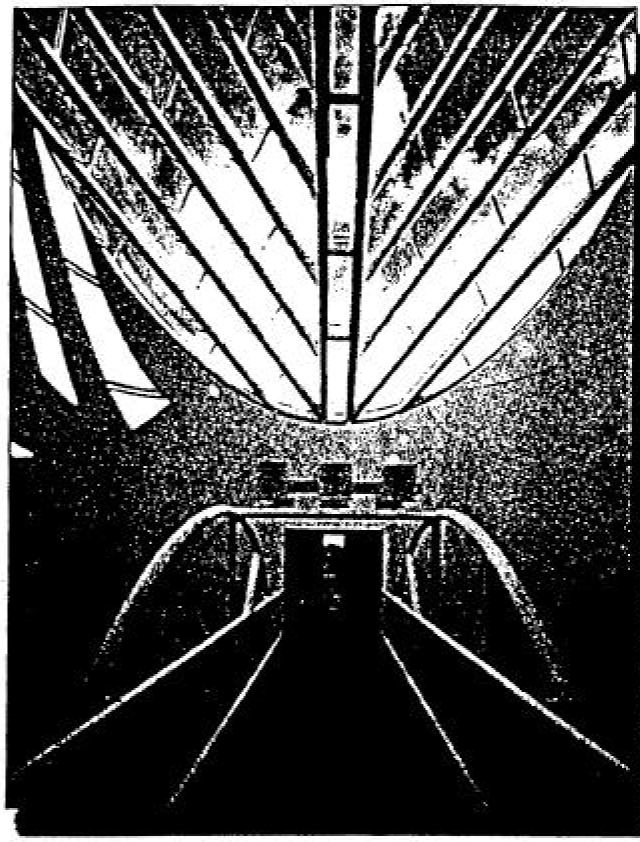
In addition to stores at the museum's entrance, retail spaces are commonly found within the museum, at exhibition exits, and even in exhibitions themselves. After visiting the Jackson Pollock show at the Museum of Modern Art last year, I could buy a poster, catalogue, or notecards as I exited the exhibit on the third floor. The 1998 traveling Keith Haring show contained a "Pop Shop" as part of the exhibition.

Shopping and exhibition in the museum are intertwined in a way that goes beyond the wildest dreams of the 1960s museum professionals who advocated for mission-driven merchandise. At the new museum, one can enter with comfort and feed and shop for an entire family. Blending seamlessly into this leisure museum are exhibitions and programs. These activities also respond to the marketplace philosophy of the multi-tasking museum, challenging conventional spaces that house them and the architects who design them. What, architects would argue, will distinguish future museums from the new specialty and themed shopping experiences springing up everywhere?

Flexible Exhibiting and Engaging the Visitor

Throughout the history of museums, architects have played a pivotal role in determining the exhibition program of the museum and have responded to changing cultural demands. Ceiling height, room size, sequencing, and spacing determined what kinds of objects could be shown and how they would be perceived. Architects experimented with different building forms to address specific circumstances related to exhibiting objects. Schinkel and his contemporaries, for example, wrestled with how to build museums in response to 19th-century debates in Germany on aesthetics and nationalism. Palaces and salons were models for establishing a noble presence for the treasures in the new public museum. Museum architects in late 19th-century France addressed the relationship between the museum object and its value as commodity. They looked to emerging department store floor plans and methods of display as inspiration for how to present items to the public.[14] Modern urban museums, beginning with Edward Durrell Stone's 1939 MOMA, needed to fit into tight urban spaces with high real estate values. Architects designed stacked galleries modeled after office buildings.

In post-war America, the continuing desire of communities to erect museums as visible symbols of civic pride and urban renewal led to an outburst of bold modern museum designs. At their best, as in Louis Kahn's Kimbell Art Museum (1972) in Fort Worth, Tex., modern architects created spaces of extraordinary warmth and intimacy. At their worst, architects designed extravagant buildings that constrained and competed with the museum's collections and exhibitions. A notoriously inflexible space, for example, is Frank Lloyd Wright's Guggenheim Museum (1959) in New York. Wright's single-room, spiral-ramped museum sets in concrete the spatial arrangement of the art with canvases hung on curved and sloping walls. Even more extreme is Houston's airplane hangar-like Museum of Contemporary Art (Gunnar Birkerts, 1972). There, according to economist Karl Meyer, artists once were asked to paint on larger canvases so their work would be more sympathetic to the building.[15] Meyer conjectures that museum building projects such as these were really about creating opportunities to raise capital funds through highly ambitious financial schemes and publicity sensations. He uses the example of the Guggen-



A view from the bridge in SFMOMA's light-filled atrium. Photo by Richard Barnes.

heim to argue that modern architects were unresponsive to functional needs of the museums.[16]

Such unresponsiveness has created a backlash toward architects among many museum professionals.[17] Now they demand flexible spaces for the varied needs of the marketplace. Museums no longer rely on their permanent collections to build new and repeat audiences. Changing shows and traveling blockbusters are far more effective. But they require spaces that are easily and quickly altered by in-house designers to the specifics of each show. In addition to a parade of exhibits, changing programs with a variety of space needs occur in museums. These can range from educational family days, large community festivals, and performances to singles events, like the San Francisco Asian Art Museum's recent "Sushi, Sake and Sex."

In addition to creating their own programs to attract new audiences, museums typically earn revenue by renting out space for functions. Like shops and restaurants, function rental is also relatively new; the oldest program began at the Art Institute of Chicago in 1974. Function rental is so profitable that many museums employ full-time facilities-use staff to manage these events. Museum spaces need to adapt to caterers and dance bands and at the same time be special enough to attract rentals in the first place.[18]

Whether for museum-originated or outsider events, the demand for public space is so great that other museum operations, most notably storage and office space, are sometimes moved off-site to make room for more exhibitions and revenue-generating spaces. In fact, because collections are so costly to acquire and preserve, some new museums forgo them altogether and devote their space to exhibitions, programs, and functions. Older museums quietly deaccession works, sometimes with the unspoken goal of freeing available storage space.

The developments discussed thus far redefine the museum as a leisure-time entertainment center targeted far beyond the traditional audience of the educated elite seeking to quietly contemplate treasures. In addition to comfort, access, amenities, and flexibility, the market demands that the museum's core feature—its exhibits—become more exciting. Static, scholar-focused displays do not engage or satisfy today's impatient consumer.

Witness the revolution taking place in natural history museums. Previously characterized by rows of cases filled with specimens, neatly ordered dioramas viewed from behind glass, and roped-off dinosaurs scientifically arranged in grand halls, newer exhibits are exciting, interactive environments with multiple entrances and exits. These multi-sensory environments send the visitor on a kinetic journey: up and down ramps, through caves and primeval forests, over moats, inside giant replicas of germs and beating human hearts, underneath glass-bottomed aquaria. Pulleys, mirrors, lights, moving objects, videos, buttons, blocks, acoustics, and computers further animate the experience. This interactive exhibiting approach of involving the visitor in creating the museum experience radically challenges the architect. He can no longer determine the museum's programmatic needs from a solitary vision about the meaning of exhibited objects. Instead, the architect, like the visitor, participates in a complex, public process that calls into question the very ownership and meaning of the museum.

The Future Museum

Not discounting the joys of access, comfort, eating, shopping, engaging exhibitions, and, of course, free time, there is an inherent danger in this market-driven museum. The museum, of course, has always been tied to the marketplace, whether to the wealth of a patron or to the symbiotic relationship between the objects housed and the financial worth of those objects. Yet, the multi-tasking museum stretches this relationship into a new realm, reaching to the consumer marketplace by emulating malls, theme parks, chain stores, and franchised restaurants. Will the market-led leisure approach result in homogeneous, formulaic museums? Or can the museum survive as an institution with the power to lift the public above the everyday, everyday?

People are drawn to museums because they offer a singular experience, an experience that connects them to humanity, history, and a sense of place. We delight in both the eccentric and elevating museum: stumbling upon an exhibition of antique fire engines in the basement of the Haggin Museum in Stockton, Calif.; flipping through shuttered Renaissance drawings in the Isabella Stewart Gardner Museum in Boston; turning a corner in London's National Gallery of Art and seeing Jan van Eyck's magisterial painting, *Giovanni Arnolfini and His Wife*, beckoning at the end of a sequence of enfiladed rooms. We find something in a museum that we cannot find in Niketown, Pottery Barn, McDonald's, or even on the Internet. Museums, unlike franchised or virtual experiences, are rooted to their unique communities, geography, and architecture.

Zaha Hadid, one of today's most innovative architects, suggests a role for the museum that bridges its aesthetic past with its populist and market-oriented present. Her plan for the Cincinnati Contemporary Arts Center (2001)—a non-collecting exhibition space—combines aspects of Schinkel's Altesmuseum and Botta's SFMOMA. Hadid envisions a museum with a large public lobby that opens with "an urban carpet" onto the street.[19] Her design cleverly reveals layers of both art and commerce through "a cluster of tubes dynamically cantilevered toward the street." In Hadid's words, "Multiple perceptions and distant views should create a richer, more perplexing experience, taking your body through a journey of compression, release and reflection."[20] Her building tackles the dynamic tension facing the new museum's architect, pleasing many constituents while making an original gesture to the cultural legacy of the museum.

Jacques Herzog and Pierre de Meuron's design for the new M. H. de Young Museum in San Francisco's Golden Gate Park (2005) also demonstrates how public visibility and accessibility can be spatial architectural experiments of the highest aesthetic dimension. They have created four entrances (one on each side of the building) where visitors pass by clear glass vistas of displayed art. A publicly accessible glass tower will provide dramatic views of the park, linking the museum's collections to their setting and community.

Like the museum store, balancing between mission and market, and the exhibit, perching between education and entertainment, the museum architect walks a fine line. The responsible architect cannot ignore needs for access, comfort, revenue-generation, and flexibility, crucial to the museum's survival. The astute architect cannot ignore trends in ways people use their free time. Yet, the multi-tasking museum also calls for visionary architects who understand why—in this age of online, frenetic consumerism—people value museum experiences so intensely. The challenge is how to fulfill this need for a special place apart amidst financial pressures and the demands of today's crowds.

All this said, can today's best architects focus the museum's blurred vision on the demarcation between mission and market? Probably not. In the 19th and early 20th centuries, patrons, museum directors, and architects worked closely together to forge a shared vision for the architecture of the public museum. Design complemented the museum's goal to elevate humanity by exhibiting treasures, innovations, and oddities. Since the 1970s, however, this alliance has dissolved amid the complexities of the postmodern condition. A less unified cast of players now engages in a delicate dance to realize new museum buildings. Each project breeds its own unique debates and inter-relationships among community representatives, special interest groups, the media, government agencies, trustees, funders, administrators, staff, marketers, and, of course, architects. The mission of the museum, with its new multi-tasking personality, and its architecture cannot possibly share the focus they once did, unless the museum is willing to sacrifice gains in public access, comfort, amenities, and, most important, visitor-focused, pluralistic viewpoints in exhibits and flexible spaces to respond to new ideas and opportunities.

Still, striking and innovative architecture can elevate the museum's disparate constituencies into shared delight, if not quiet reflection. The challenge of architecture is to coordinate physical forms and spaces with human aspirations and experiences. Similarly, the museum faces the challenge of shaping places that are flexible yet meaningful, useable yet exciting—wonderful places that can educate, inspire, and reach the broad audience of the 21st century.

References

1. Michael J. Wolf, "The Pleasure Binge," *Wired*, March 1999, 86-93.
2. Victoria Newhouse, *Towards a New Museum* (New York: Monacelli Press, 1998), 11.
3. Alice Goldfarb Marquis, *Alfred Barr, Jr.: Missionary for the Modern* (Chicago: Contemporary Books, 1989), 169, quoting Philip Johnson.
4. Douglas Crimp, *On the Museum's Ruins* (Cambridge, Mass.: MIT Press, 1993), 285-318.
5. Ibid., 301, quoting Schinkel.
6. Newhouse, 61-65.
7. Joseph Rykwert, "Temples of Today: The Multiplication and Santification of the Museum," *The Times Literary Supplement*, Nov. 6, 1998, 3-4.
8. *The Manask Report: Food Service News and Views for Museums, Aquariums and Zoos* (Burbank), Spring 1999, 5.
9. Ibid.
10. Neil G. Kotler and Philip Kotler, *Museum Strategy and Marketing: Designing Missions, Building Audiences, Generating Revenue and Resources* (San Francisco: Jossey-Bass, Inc., 1998), 279.
11. Ibid.
12. *Museum Store* 26, no. 4 (Winter 1998), 94.
13. Jerry Gelsomino, "Your Store's Not Just a Store—It's a Marketing Tool for Your Museum," *Museum Store* 26, no. 3 (Fall 1998), 15.
14. Chantal Georgel, "The Museum as Metaphor in Nineteenth Century France," in *Museum Culture*, ed. Daniel J. Sherman and Irit Rogoff (Minneapolis: University of Minnesota Press, 1995), 113-121.
15. Karl E. Meyer, *The Art Museum: Power, Money, Ethics* (New York: William Morrow and Company, 1979), 131.
16. Ibid. For a more sympathetic view of Wright's Guggenheim, see Joseph Giovanni's "Hadid's Midwest Coup," in *Art in America*, February 1999, page 41. Giovanni argues that Wright's building makes a "potentially confusing multistory visit continuous, intelligible and poetic."
17. "Mental Sets and Museum Architecture" (editorial), *Museum Management and Curatorship* 16, no. 4 (December 1997), 329-336.
18. Kehaulani J. Proctor, "Facility Use Programs in Art Museums: Money and Mission" (master's thesis, John F. Kennedy University, Orinda, Calif., 1994).
19. Aaron Betsky, *Zaha Hadid: The Complete Buildings and Projects* (New York: Rizzoli, 1998), 168.
20. Giovanni, 43, quoting Hadid.

MSC

MODERN **STEEL** CONSTRUCTION

October 2010

Building the Night Sky

IN THIS ISSUE

Curved Steel Front and Center

A Structure That Teaches

Bridge Trades Up to Steel

A Texan *Extreme* Makeover

BY JEFFREY S. KOKE, P.E.

Three stunning structures combine to anchor the new Fort Worth Museum of Science and History.

THE FORT WORTH Museum of Science and History has been operating for many years, enlightening and inspiring multiple generations. People speak fondly of memories they have of exploring the museum when they were children. However, decades of wear and tear, plus ever-expanding exhibits and growing attendance, made the 1954 museum building inadequate for the new century. Although a difficult decision, it was time for a new museum.

The new Fort Worth Museum of Science and History replaced the existing museum building on the same site in November 2009. The museum has 166,000 gross sq. ft composed of one-story and two-story spaces. The building consists mostly of exhibit spaces, classrooms, support areas, public spaces and dining areas. Three unique steel structures are the main massing of the building design: the new domed Noble Planetarium, the Energy Gallery roof, and the main entrance, called the "Urban Lantern."

Domed Noble Planetarium

The new Noble Planetarium is a state-of-the-art facility that sports a 50-ft-diameter steel-framed "ribbed dome," which was completely fabricated on the ground and lifted into place. That operation was featured prominently in the *Dallas Morning News* and was the symbol of construction progress for some time.

The dome is constructed of arched ribs, joined together with a compression ring at the top and tension ring at the bottom. It has 8-in. wide-flange column ribs with 2-in.-diameter transverse pipes encircling the dome in concentric rings. The rings serve as lateral bracing for the vertical arched members, add rigidity for the dome, and provide support for the dome cladding.

The dome members were delivered as individual pieces ready to be assembled like a kit of parts. A staging area next to the final location was set up for the erection process where the steel erector welded the elements together on the ground.

All vertical wide-flange ribs were welded to the tension ring at the bottom and converged to a compression ring at the top of the dome. Once the ribs were in place and the transverse pipes were installed, the resulting configuration was a semi-rigid grid

Photos by Datum Engineers except as noted.

that resisted racking and was stiff enough to be lifted into its final location.

Additionally, smaller tubes and angles were connected to the main frame to accept the dome cladding. This additional framing enhanced the smoothness of the dome to prevent ridges or offsets from occurring between cladding panels.

Months earlier, additional analysis and careful coordination among the structural engineer, erector and contractor had been performed to allow the nearly flawless installation to occur. Hanging locations were determined and analyzed for performance during the 60,000-lb lift. The erector performed an in-depth study of shoring and the hoisting procedure that ended in an evolution that appeared to spectators as a quick and easy solution.

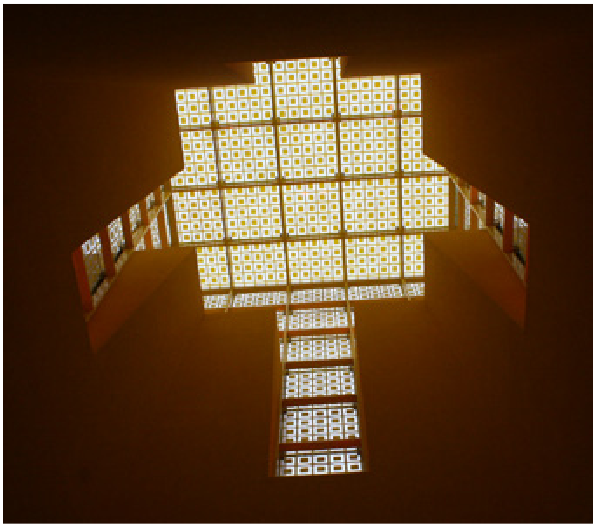
◄ ▲ The new museum facility is anchored by the Noble Planetarium Dome, the Urban Lantern, and the Energy Gallery.

▼ Arriving on site as individual pieces, the Noble Planetarium Dome was assembled on the ground, then lifted into place.

The Dallas Morning News

Jeff Koke, P. E., is a structural engineer and studio leader in the Dallas office of Datum Engineers and has served as project manager on a variety of projects since he joined the firm in 2003. He has developed a niche for cultural projects such as museums and sculpture gardens. His work currently in progress includes the $185 million Perot Museum of Nature and Science. Jeff holds a bachelor's degree in Architectural Engineering from The University of Texas at Austin, and spent 20 years in the Navy.

To help control gravity load deflections in the Energy Gallery roof's 55-ft cantilever, engineers provided 6-in.-diameter pipe columns tucked behind mullions.



The planetarium's second floor framing was carefully analyzed and designed to minimize vibration interference from exterior distractions to ensure successful operation of the projector. Locating a column directly below the mechanism and increasing the concrete slab thickness provides the required platform stability and helps mitigate vibration interference with the projector.

The Energy Gallery Roof

The Energy Gallery roof was designed with 7-ft-deep steel trusses, supporting an 8-ft-tall ribbon of brick. The visual expression of the structure is a 50-ft cantilever with a 15-ft backup span and support. To control gravity load deflections and high stresses, the "cantilever" is supported by small intermediate columns consisting of 6-in. pipe located behind window mullions. This configuration contributed to significant calculated wind sways at the end of the cantilever in the transverse direction, because the only wind bracing in the transverse direction is at far end of the space. The high roof uses horizontal X-bracing to maximize the rigidity of the diaphragm to transfer the lateral loads to the rear bracing system. The low roof diaphragm minimizes the sway of the structure and helps distribute the lateral loads.

Close coordination with the glazing manufacturer's engineer was required to accommodate the anticipated structural movements. The connections for the tall windows were designed to accommodate larger than usual horizontal and vertical movements. Attention to these details of the design by the structural engineer and the glazing manufacturer's engineer was critical to its success.

The Urban Lantern

The Urban Lantern is the pride of the museum. Its proportions and interior volume create a space that is tall, open and impressive. The Lantern is 76-ft tall and topped with a glass box made of 97 yellow-fritted glass panels, each measuring 5-ft 7-in. square and weighing 500 lb.

The exterior brick on the Urban Lantern is supported by a system specifically designed not to have visible horizontal kickers, leaving interior space open.

The 76-ft Urban Lantern, topped with a yellow glass box, provides an impressive main entryway to the new Fort Worth Museum of Science and History.

The Lantern is a critically important element because it is the gateway to the museum. Design architect Ricardo Legorreta expressed this by saying, "Light symbolizes knowledge, creativity, imagination and spirituality. Color, on the other hand, for us means passion for life, humanism and happiness."

Careful computer modeling and structural analysis were conducted using RISA to ensure the framing system and brick supports would perform as expected. The basic approach was to create a braced tower with an open interior. Usually a tower would have horizontal cross-bracing or floors to prevent racking and distribute lateral loads, but this was not an option. Instead, engineers used the building's adjacent low roof diaphragm and a 5-ft 10-in.-wide reinforced concrete slab on composite deck at the tower's second level to provide racking strength. This essentially created a rigid floor slab with a big hole in the middle of it. Additionally, the roof corners at higher levels have similar concrete slabs to enhance stiffness.

Full-height cross-braces were provided at the corners of the tower for stability. Horizontal HSS12×6 girts at 10-ft vertical spacing tie the tower together and provide connection points for the brick support system.

The exterior brick is supported by a system specifically designed not to have visible horizontal kickers so as not to obstruct the interior open space. Vertical HSS5×5 members spaced at 4-ft centers provide support for the brick shelf angles at each level. The horizontal HSS girts are designed to resist the moments and reactions from the vertical tubes induced by wind and the eccentric brick loads at each level.

The unique idea of Legorreta's Urban Lantern incorporates a glass box to the top that glows at night, guiding its patrons to the museum's front door. The structural engineer conceived the structural concept and design of the glass box at the top of the tower. Then Menomonee Falls, Wis.-based manufacturer Novum Structures LLC implemented the design and built the glass box. The loads calculated by Novum's engineers were provided to the structural engineer to include in the overall building model.

This state-of-the-art glass system includes unique proprietary glass connections and expansion joints designed specifically for the Fort Worth area. The end result accomplished the architect's vision.

The Fort Worth Museum's "extreme make-over" resulted in a facility that is world class and will be a source of pride for the city, museum and the designers for years to come. MSC

Structural Engineer
Datum Engineers, Dallas, Texas (AISC Member)

Project Manager
The Projects Group, Fort Worth, Texas

Design Architect
Legorreta & Legorreta, Mexico

Architect of Record
Gideon Toal, Fort Worth, Texas

General Contractor
Linbeck, Fort Worth, Texas

Steel Fabricator
CMC Alamo Steel, Waco, Texas (AISC Member)

Steel Erector
Bosworth Steel Erectors, Dallas, Texas (AISC, IMPACT and SEAA Member)

Structural Software
RISA

Full-height cross-braces at the corners provide stability to the Urban Lantern tower.

The Art of Deference

by Mark Oberholzer, AIA

PROJECT Jack S. Blanton Museum of Art, Phase I & II, Austin

CLIENT University of Texas at Austin

ARCHITECT Kallman, McKinnell & Wood Architects in association with Booziotis & Company Architects

DESIGN TEAM (Kallman, McKinnell & Wood Architects) Michael McKinnell, FAIA; Don Eurich, AIA; (Booziotis & Company Architects) Jess Galloway, AIA; Lois McGinnis, AIA; Maria Nadeau, AIA; Yi Yu

CONTRACTOR Skanska USA Building

CONSULTANTS Datum Gojer Engineering (structural); Arup (MEP, daylighting, IT/AV/acoustic); Fisher Marantz Stone (lighting); Charles Gojer & Assoc. (civil/site); Peter Walker & Partners (landscape architecture); Schirmer Engineering Corp. (code/fire sprinkler and alarm/life safety); DVS Security (security); Davis Langdon (cost); Jose I. Guerra (electrical)

PHOTOGRAPHERS Emory Photography; Scott Melcer

A GLIMPSE THROUGH THE FRONT DOORS OF THE BLANTON MUSEUM OF ART reveals a soft blue light—it's the new piece, *Stacked Waters*, a cast acrylic site-specific installation by artist Teresita Fernández. Wrapping around the walls of the atrium, *Stacked Waters* suffuses the space with unexpected and atmospheric light against the backdrop of the main stair hall. The effect illustrates how the Blanton is, in many ways, a deferential building—a backdrop not just to art on the inside but to the campus on the outside as well.

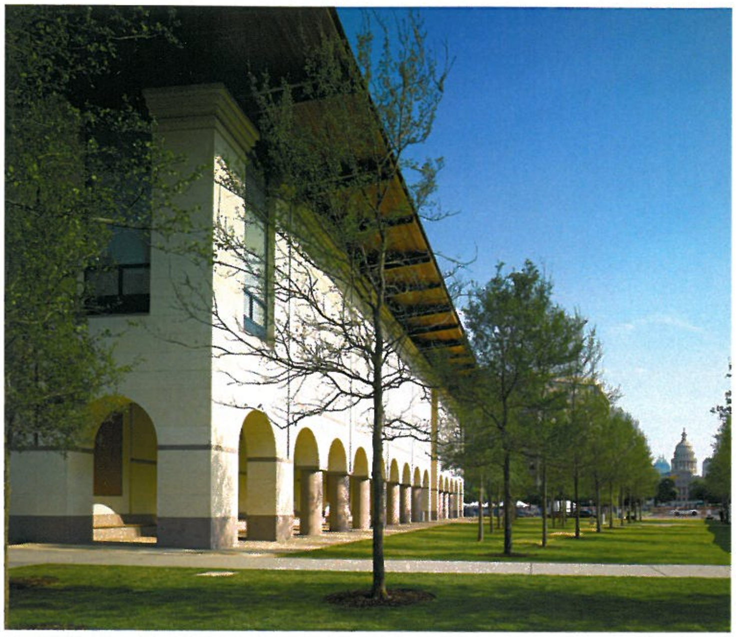
With the opening last November of its second wing, the 56,000-sq. ft. Edgar A. Smith Building, the Blanton is complete nearly 10 years after its design was initially considered. The first wing, the 124,000-sq. ft. Mari and James A. Michener Gallery Building, opened in 2006. Kallman, McKinnell & Wood Architects was the second firm to tackle the design of the museum, following the departure of Herzog and de Meuron in 1999. The well-documented drama of how the architectural commission changed course is now legend to architects in Texas, still managing to provoke strong feelings from all sides. Fred Clarke, FAIA, principal of Pelli Clarke Pelli, who was instrumental in developing the university's master plan at the time, succinctly comments on the debate: "Exceptional and innovative buildings must be built but the essential qualities of the campus must also be protected. It is imperative that the approach to the future of this extraordinary place be measured and thoughtful and not simply a reaction to a moment in time that is long past."

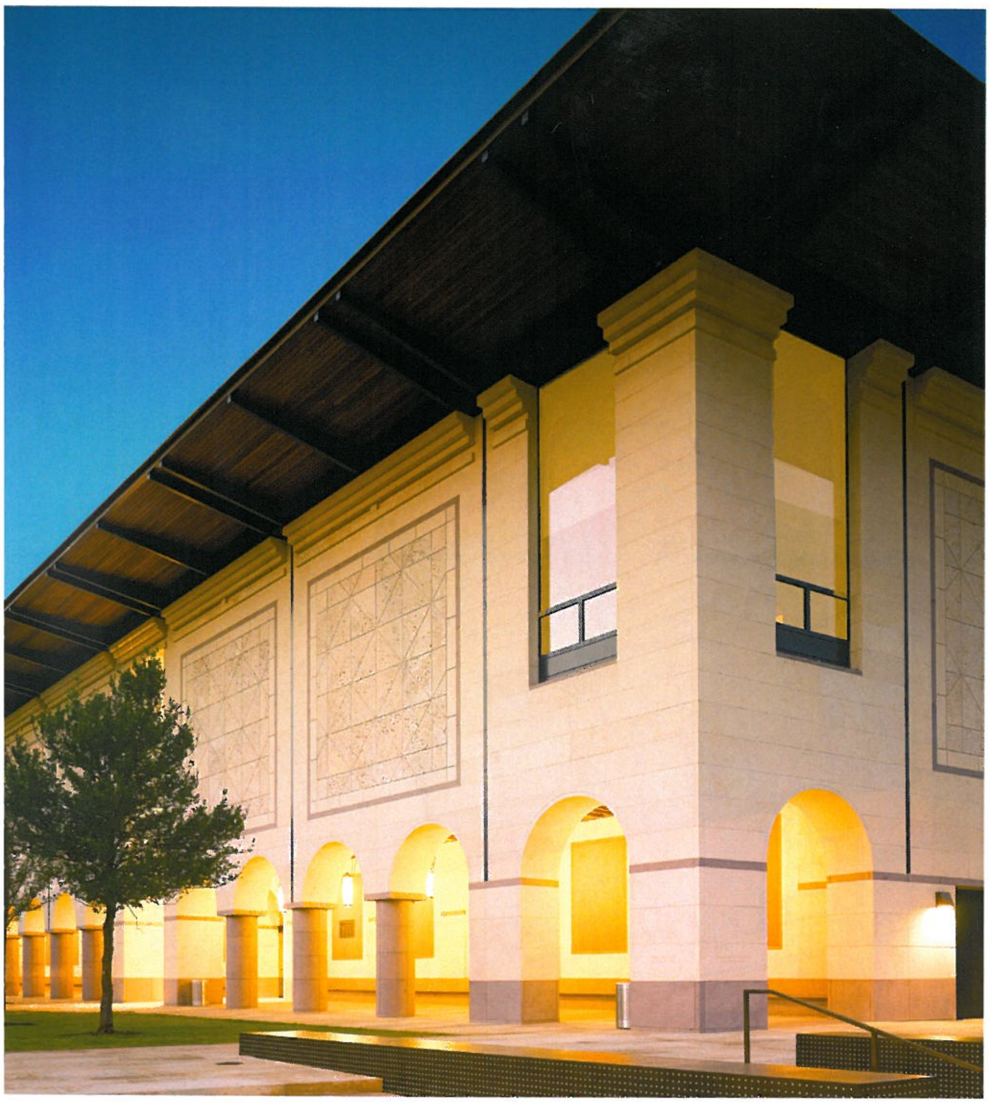
In the Pelli master plan, the Blanton's site was originally identified as a site for student housing, with separate wings flanking an open space intended to form a secondary gateway from Austin's urban grid to the campus. In the design of the museum, Michael McKinnell, FAIA, kept this open space intact, dividing the museum's program into two separate buildings. Bounded on two sides by the wings of the museum, the space between the buildings, designed by landscape architects Peter Walker & Partners, eschews any attempt of a traditional plaza for a linear design that emphasizes the transition from campus to city, graduating from a linear grove of cedar elms to low, perforated bronze lanterns. The design allows the landscape to link the museum firmly into a campus pathway and direct views out toward the dominant dome of the State Capitol five blocks to the south.

The smaller of the Blanton's two buildings is the recently completed Edgar Smith Building that houses the museum store, café, and educational spaces. (A university gallery as well as a major museum, the Blanton has more than its share of classroom and meeting spaces.) The two-building design of the museum allows the café and store to be located on the external face of the Smith Building adjacent to the open space instead of buried within the bulk of the museum, making these functions open to the public. An open arcade runs along the entire length of the building, fronting the grove of trees and mirroring the arcade of the museum's larger component, the 124,000-sf Michener Gallery Building.

The entrances to both museum buildings directly face each other, interrupting their respective arcades with double-height glazing. Entering the Michener building, visitors pass through a perfunctory lobby, drawn instead to the center of the building by the light-filled atrium, where *Stacked Waters* now encircles the lower half of the double-height space. The atrium is trapezoidal in plan, reflecting the overall geometry of the museum. In addition to a gallery for temporary exhibits, the first floor houses public spaces, work areas, and an administrative suite. A monumental limestone stairway leads visitors to the second floor, which is effectively the main floor of the building, similar to the piano nobile of many traditional museums.

The second floor houses the permanent collection of the museum, which ranges from small-scale, antique prints to full-size facsimiles of Classical Greek and Roman sculpture to very large contemporary paintings. The largest university art museum in the nation, the Blanton contains 17,000 works. The museum galleries follow a traditional enfilade sequence





(cover, front and back) The Michener Gallery Building, completed in 2006, features exhibit space on two levels. Stairs lead to displays from the permanent collection. (The gift shop has been relocated to the newly completed second building.)

(this spread, top row left to right) Sunshine filtered through a central plenum augments the galleries' track lighting. Slightly more than 36,000 sq. ft. is dedicated to displaying art. The Michener building's bottom level houses traveling exhibitions. The Edgar A. Smith Building, completed in November, consolidates administrative offices, educational facilities, the museum store, and café under one red tile roof.

(this page, left) While working within the recommended design guidelines for campus buildings, the architects exaggerated the exterior corbel detail and embellished otherwise smooth limestone walls.

Art at the Blanton

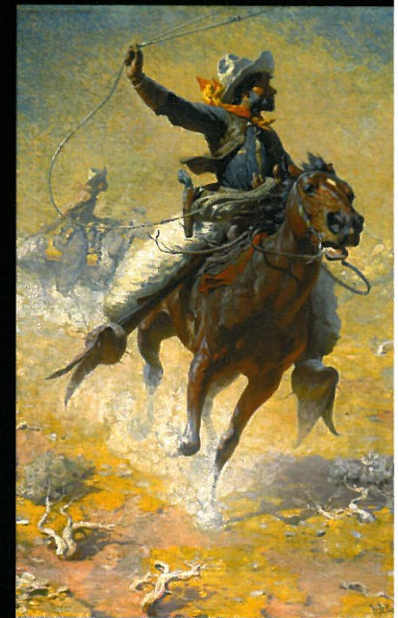
Saint Cecilia by Simon Vouet

The Blanton Museum of Art is predominately strong in modern and contemporary art from the United States and Latin America, and European art ranging from fifteenth-century paintings to contemporary prints and drawings.

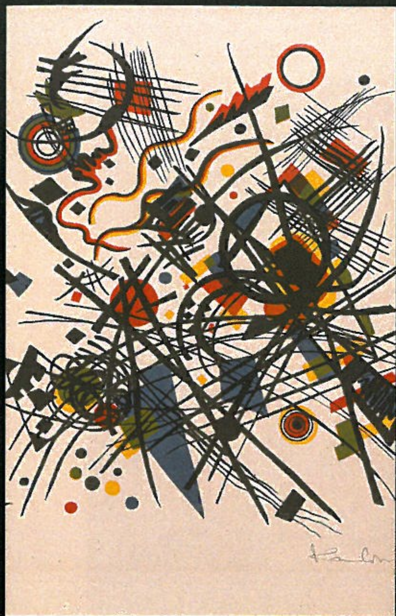
The institution was originally established in 1963 as the University Art Museum through a large donation by Archer M. Huntington. During the 1960s and 1970s a number of important collecting areas developed, including twentieth-century American paintings (approximately 400 from novelist James Michener and his wife, Mari) and Latin American art (200 paintings and 1,200 drawings from John and Barbara Duncan). Other notable early gifts included the C. R. Smith Collection of Paintings of the American West, given over a period of years between 1965 and 1985, and a donation in 1968 by Charles Clark of McAllen of nearly 1,000 contemporary prints.

The growth and character of the collections took a dramatic turn in 1998 with the important acquisition of the Suida-Manning Collection, which was made possible through the generosity of numerous individuals. Assembled by two generations of art historians, the collection is one of the nation's preeminent collections of Renaissance and Baroque art. It features 230 paintings and 400 drawings by many significant painters and draftsmen.

ALL IMAGES COURTESY THE BLANTON MUSEUM OF ART: *SAINT CECILIA* (1626) BY SIMON VOUET, OIL ON CANVAS, THE SUIDA-MANNING COLLECTION, 1999; *THE ROPING* (1914) BY WILLIAM ROBINSON LEIGH, OIL ON CANVAS, GIFT OF C.R. SMITH, 1984; *LITHOGRAPHIE FUR DIE FIERTE BAUHAU* (1922) BY VASILY KANDINSKY, LITHOGRAPH, GIFT OF MR. AND MRS. RICHARD GONZALEZ, 1989; *OIL FIELD GIRLS* (1940) BY JERRY BYWATERS, OIL ON BOARD, 30 X 24 IN., MICHENER ACQUISITIONS FUND, 1984; *STACKED WATERS* (2009) BY TERESITA FERNANDEZ, CAST ACRYLIC, COMMISSIONED BY THE BLANTON MUSEUM OF ART, GIFT OF JEANNE AND MICHAEL KLEIN



The Roping **by William Robinson Leigh**



Lithographie fur die Fierte Bauhau by Vasily Kandinsky

Oil Field Girls by Jerry Bywaters

Stacked Waters by Teresita Fernandez

of spaces, including small rooms that wind around the stairway atrium and larger rooms located along the perimeter. Natural light is permitted or excluded as needed in each room, which is provided with a central lantern that channels light from a common skylit plenum. Continuous passage through the sequence of galleries is relieved periodically by rooms with windows, allowing views out as well as back to the central atrium.

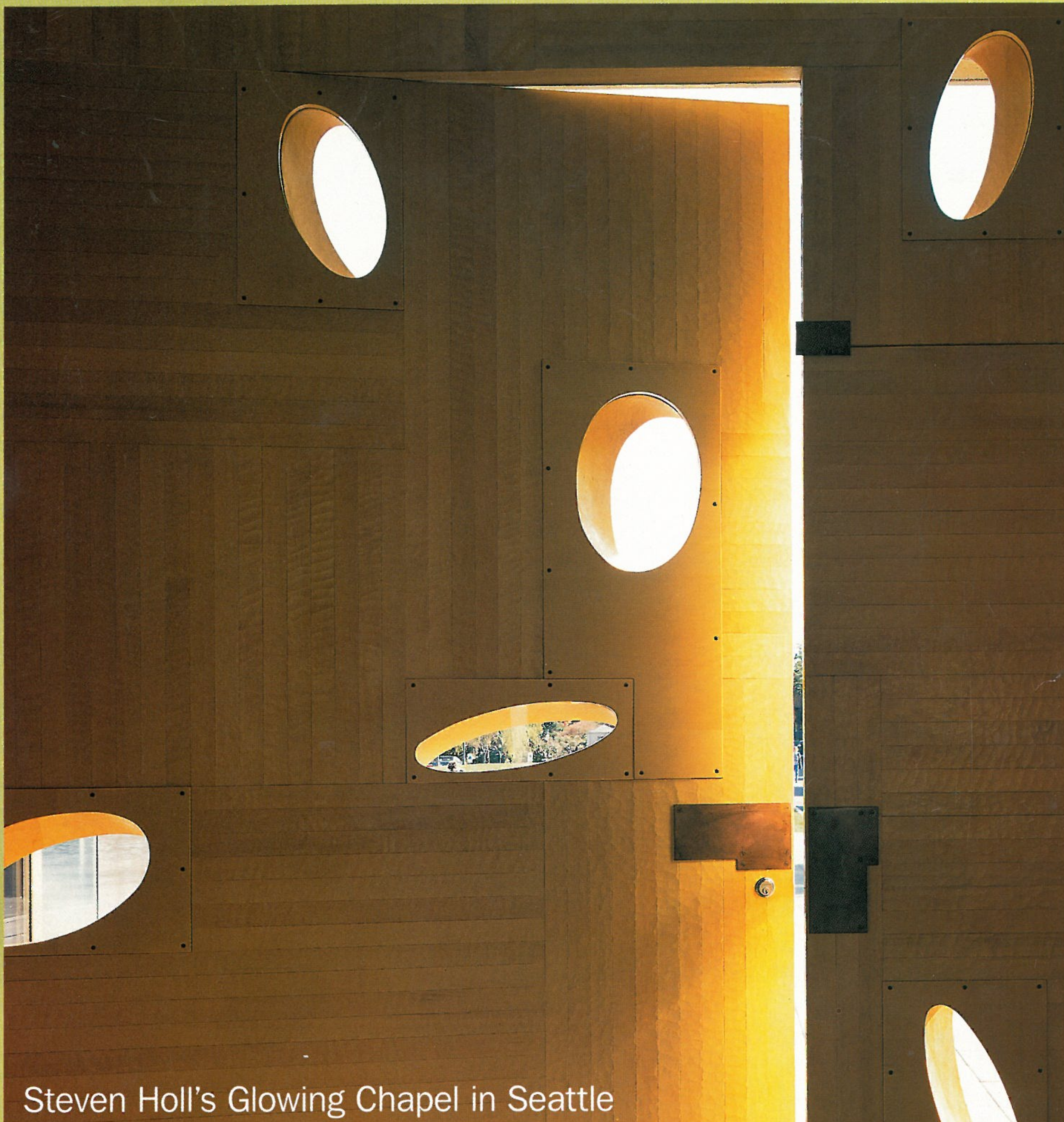
Although the exterior of the museum buildings adopts the recommended campus standard of limestone walls and a red tile roof, these same materials on the Blanton are used to a markedly different effect. Very large overhangs lend visual dominance to the Blanton's roofs, further accentuated by an emphatic limestone corbel detail where wall and roof meet. Aside from the corbel detail, the exterior – though patterned – is a predominately smooth, flush surface. Every architect working on the Texas campus since the completion of the earliest buildings in the 1930s has had the opportunity to riff on – or reject – the original architectural language, and the Blanton is no exception.

Many of the University of Texas' campus buildings fall into two successful types. The first is exemplified by most of the older buildings, which have been designed to frame and balance an outdoor space. The second type includes most of the newer, postwar buildings that stand as objects within a field of landscape. On a campus with substantial changes in elevation, these two types of buildings add an intriguing variety not found on many college campuses. The Blanton Museum of Art has characteristics of both of these types without committing to either: while the basic planning of the building creates an exterior space, the buildings themselves seem more recessive than integral to this newly created landscape. As a prototype of a building attempting to follow its own demands as well as those of the campus plan, the Blanton offers a window into what the future might hold for the next generation of buildings on the University of Texas at Austin campus.

A frequent contributor to *TA*, Mark Oberholzer, AIA, works with Rhode Partners in Austin.

RESOURCES MASONRY UNITS: Acme; **UNIT MASONRY WALL ASSEMBLIES:** Headwaters Construction Materials (Materials Products International); **STONE:** Texas Quarries, Cold Spring Granite (Materials Products International); **ARCHITECTURAL METAL:** Berger Iron Works; **RAILINGS:** Metalrite; **ARCHITECTURAL WOODWORK:** Buda Woodworks (Phase I), Howard McKinney (Phase II); **WATERPROOFING:** W.R. Grace; **ROOF TILES:** Ludowici Roof Tile; **METAL ROOFING:** AEP-Span; **SPECIALTY DOORS:** Cookson Rolling Doors; **METAL WINDOWS:** Hope's Windows; **SKYLIGHTS, GLAZED CURTAINWALL:** Kawneer; **ACOUSTICAL CEILINGS:** Armstrong; **SPECIAL CEILING SURFACES:** Decoustics

ARCHITECTURAL RECORD


Steven Holl's Glowing Chapel in Seattle

Hyper Growth: Michael Sorkin in China

Pacific Rim Roundup: Reports from Thirteen Countries

Affordable Family Housing in Context

A reflecting pool at the chapel's south is a "thinking field," says Holl. New campus quads are planned to the east and north.

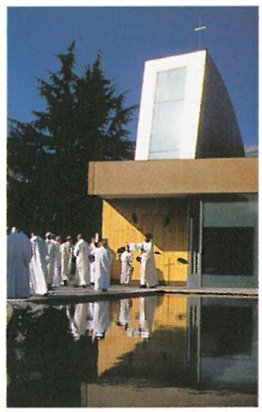
What is sacred space? Steven Holl's **CHAPEL OF ST. IGNATIUS** answers with texture, light, and color.

by Sheri Olson, AIA

When clouds pass over, the light pulses," says Steven Holl, AIA, of the interior of the Chapel of St. Ignatius at Seattle University (SU). The scheme is deceptively simple: Holl refers to it as "a stone box, containing seven bottles of light." What makes the interior so arresting and enigmatic are the halos of softly pigmented light sliced through by shocking patches of otherworldly color. The effect, mysterious itself and made more so by the constant variations of light as clouds move across the sky, requires several visits to the chapel to grasp its permutations. "One professor told me, 'I'm not a believer, but this is my third visit to the chapel in two days,'" reports the Reverend Jerry Cobb, chair of the university chapel committee. "People of all faiths, or no faith, experience it as a compelling spiritual space."

"The chapel is the fusion of a spiritual and an architectural notion," says the Reverend William J. Sullivan, president emeritus of SU and the project's driving force. St. Ignatius of Loyola, the Jesuit founder, saw spiritual life as internal lights and darknesses—what he called consolations and desolations. "St. Ignatius's biographical writings inspired me," says Holl. "He uses the metaphor of a light that comes from above."

Holl translated St. Ignatius's imagery into a dramatic roofscape of light scoops that emerge from an inscrutable concrete box. "By designing a building without a lot of openings, relying instead on light scoops to bring in the outside world, Holl created a reverential space for an urban setting," says Sullivan. The chapel is the first building to interrupt the existing street grid that rules the surrounding campus. This places it—practically and metaphorically—in the center of what will become a large new quadrangle (see site plan) and creates the potential for an esplanade anchoring a new lower mall.



It's surprising that the Manhattan-based Holl's first major completed public building in the United States is for a small university in the Pacific Northwest. "This is directly attributable to the vision of Father Sullivan," says Cobb. "He wanted to make a significant architectural gift to the city." The chapel is the culmination of the president emeritus' 20 years at SU, which in its 105-year history had never had a freestanding place of worship. Sullivan envisioned a provocative project that would put the school on the map. As part of the selection process, Holl, a Seattle native, along with Moshe Safdie, Bohlin Cywinski Jackson/James Cutler Architects, and Dagit Saylor, was invited to lecture on creating sacred spaces. "The large crowds that turned out when Steven spoke told us that this is someone people are paying attention to," recalls Sullivan of the decision process.

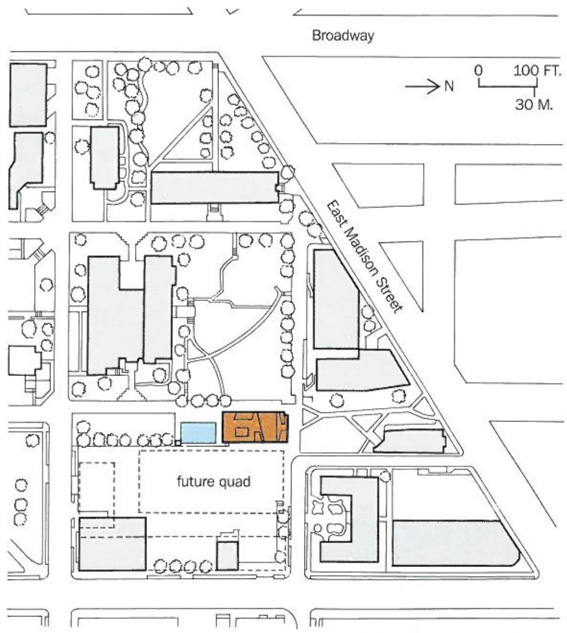
Church building committees are notoriously contentious, and

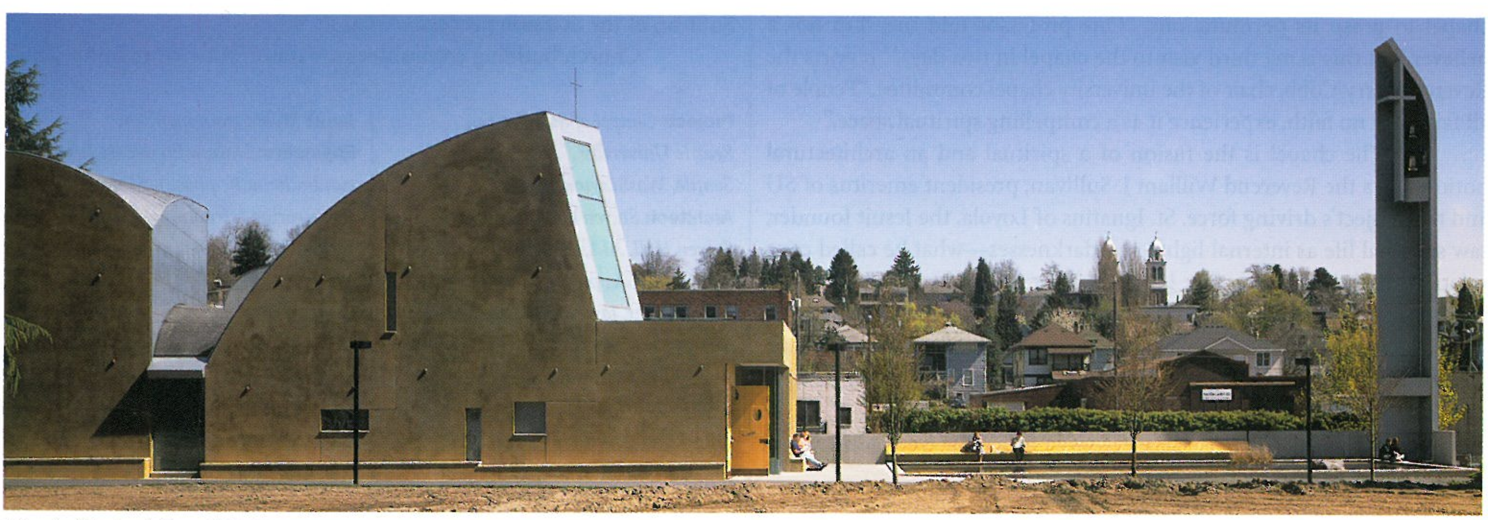
Sheri Olson, AIA, is a writer and architect based in Seattle. She is a regular contributor to RECORD on design and technology.

Project: *Chapel of St. Ignatius, Seattle University Seattle, Washington*
Architect: *Steven Holl Architects—Steven Holl, AIA, principal-in-charge; Timothy Bade, project architect; Justin Korhammer, Jan Kinsbergen, Audra Tuskers, project team*
Associate Architect: *Olson Sundberg Architects—Rick Sundberg, FAIA, Tom Kundig, principals-in-charge; James Graham, project manager; Janice Webb, team member*
Engineers: *Datum Engineers (structural/schematic phase); Monte Clark Engineering (structural); Abacus Engineered Systems (mechanical/electrical/plumbing)*
Consultants: *Bill Brown, AIA (liturgical); L'Observatoire International (lighting); Peter George and Associates (acoustical)*
General Contractor: *Baugh Construction*

PHOTOGRAPHY: © PAUL WARCHOL, EXCEPT AS NOTED; SOLANGE FABIÃO FAR RIGHT

Anchored by a slender 52-ft-high bell tower clad in a preweathered zinc (bottom), the chapel's processional route is extended into the campus by a subtly sloped ramp that runs along the 6-in.-deep reflecting pool. The tower's two bronze bells were cast in Anney-le-Vieux, France.





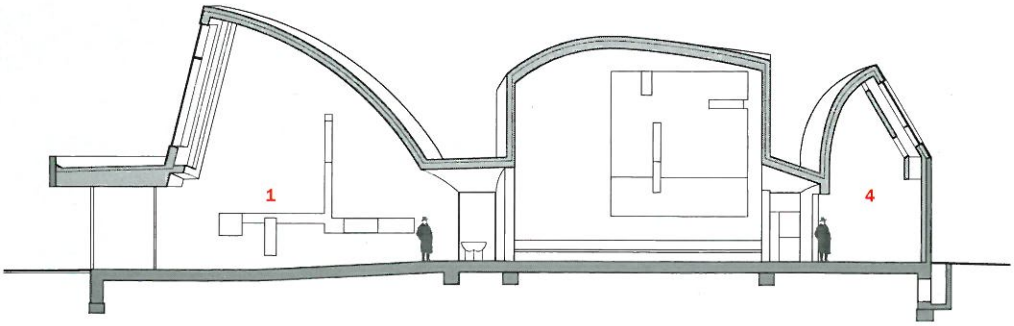
Windows occur where the tilt-up concrete panels come together. The walls are stained "Roman ochre" to resemble ancient stone churches. Bronze covers the hook points.

this one experienced its share of differences regarding liturgical interpretation and the resulting architectural implications. Holl found the input from students, gathered over five meetings, to be helpful in resolving issues. "At a time when the campus ministry was moving toward worship-in-the-round, the students were instrumental in helping to make the procession a major aspect of the plan," recalls Holl. The students "also wanted real pews [whereas] the campus ministry wanted chairs, like a lounge."

A slender metal-clad bell tower marks the approach to the chapel. The processional route begins with a rectangular green to the chapel's south and continues up a subtly sloped ramp alongside a shallow reflecting pool. The route "symbolizes the transition from the outside world to the spiritual world," says Sullivan. Set into the pool is a box of wild grasses and a black basalt rock from that venerable State of Washington symbol, Mt. Rainier, which is barely visible from the site. The poolside wooden bench is already a favorite spot for outdoor studying, while the patch of lawn is overrun by Frisbee-throwing students.

The chapel's tautly planar profile and ochre concrete stain recall early Roman churches. Holl's original design used yellow Kasota stone, which proved too expensive and now is limited to window ledges and a bench at the chapel's west side. The $3.25 million construction budget—90 percent of which came through private donation—wasn't sufficient for the initial program of 10,000 sq ft, so the project was reduced to 6,100 sq ft. "Before, the 'bottles of light' were loose inside the frame, and this [reduction] helped to tighten up the scheme," says Holl of the plan's present incarnation, which was literally shrunk to fit. The light scoop volumes shear off when they intersect the perimeter wall, creating an irregularly scalloped edge along the roofline, intensified because of their compression into a staccato rhythm that alternates between swooping and soaring.

But the sense of transcendent space does not stop at the door. "The exterior does not fully prepare you for the interior," says Cobb. Holl explains: "Like a novel, the cover does not reveal everything." The monochromatic exterior is a foil for an explosion of color inside. Light passes through small, intensely colored glass lenses set within *(text continues)*



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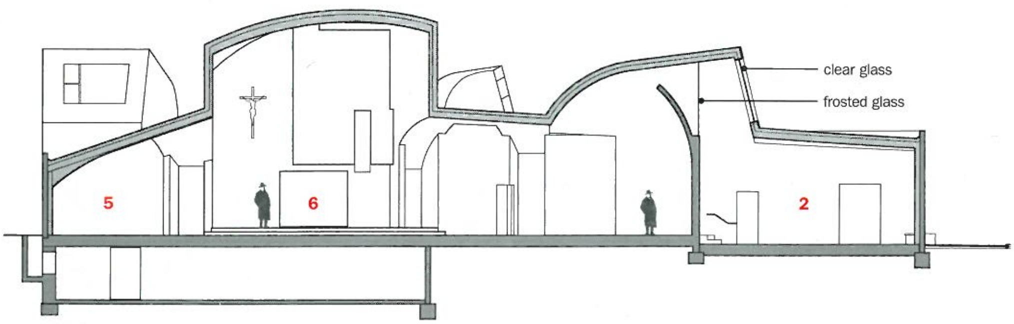

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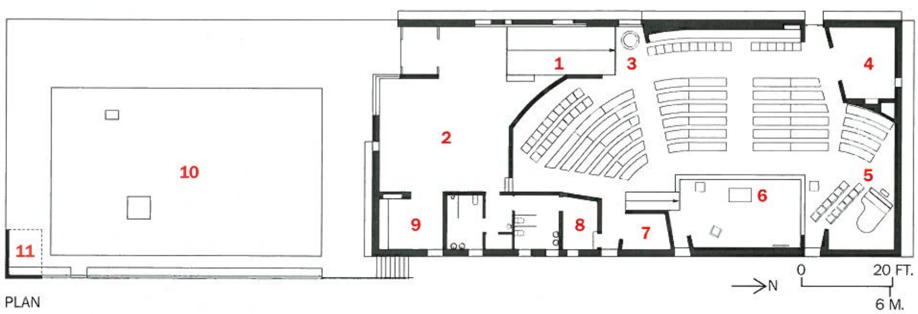
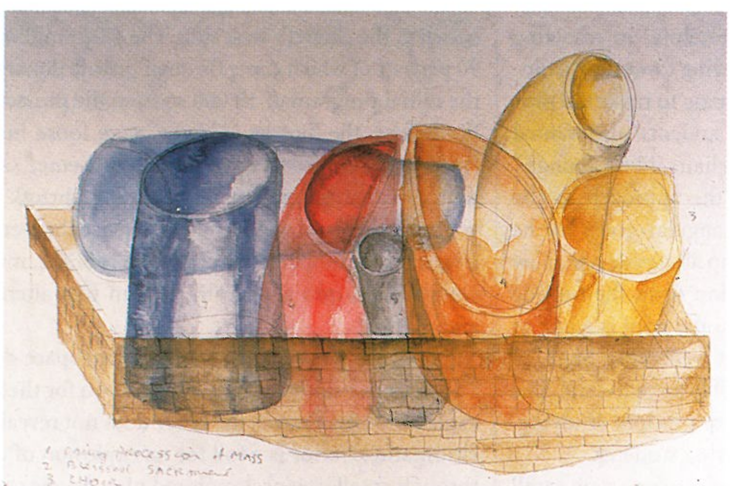
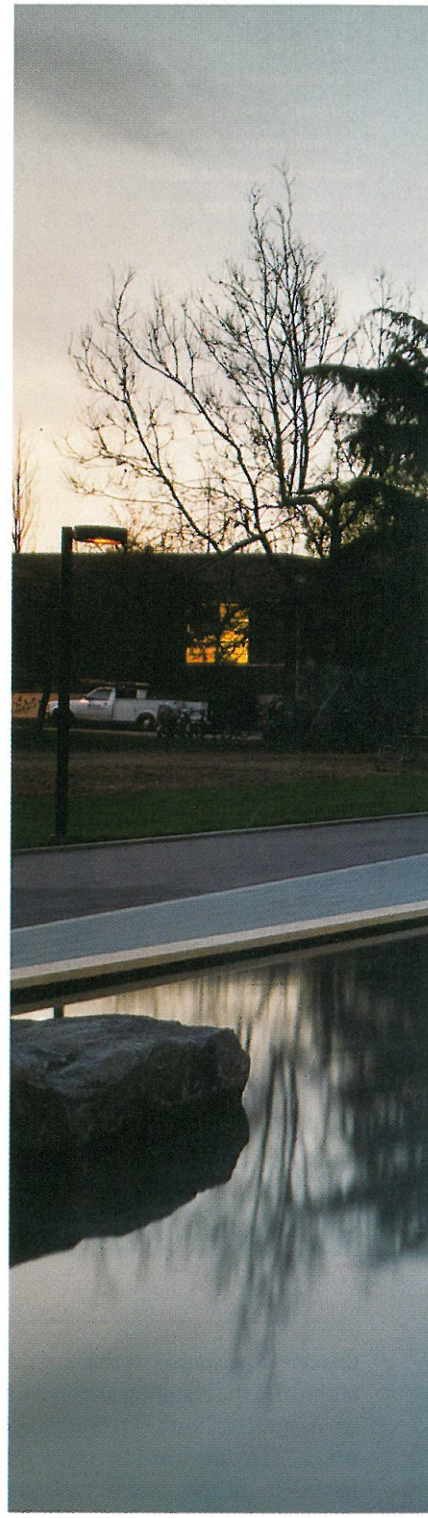


PLAN

1. *Procession*
2. *Narthex*
3. *Baptistry*
4. *Blessed Sacrament Chapel*
5. *Choir*
6. *Altar*
7. *Reconciliation Chapel*
8. *Bride's room*
9. *Vesting sacristy*
10. *Reflecting pool*
11. *Bell tower*





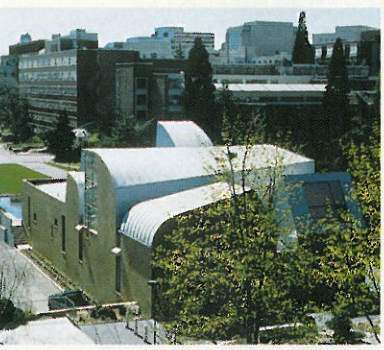
DRAWING: © STEVEN HOLL ARCHITECTS

Holl's early concept sketch of the "seven bottles of light" (opposite) resembles the final result (above). At dusk, the chapel comes to life—important in a region where thick clouds are common. Lights on the interior of the scoops duplicate the effect of sunlight on the inside and dramatically reverse the daytime effect outside as colored light is projected into the darkening sky.

"The whole building was horizontal, then 24 hours later, like an apparition, it rose," says Steven Holl of the construction of the Chapel of St. Ignatius. Using tilt-up concrete panels, the process, akin to a modern-day barn raising, was such an event that Holl's office captured it on videotape.

The project's unique conditions required creative rethinking of this typically down-and-dirty construction technique. "We thought of this as job-site precast rather than tilt-up construction due to the level of finish required," says Chris Toher, project manager of Baugh Construction, the general contractor. The chapel's 21 concrete panels interlock like pieces of a giant Chinese puzzle box, adding another layer of complexity.

"The material realization of a project is crucial," maintains Holl.



The roofscape looking south (above) and the west elevation of some of the 21 concrete tilt-up panels (below).

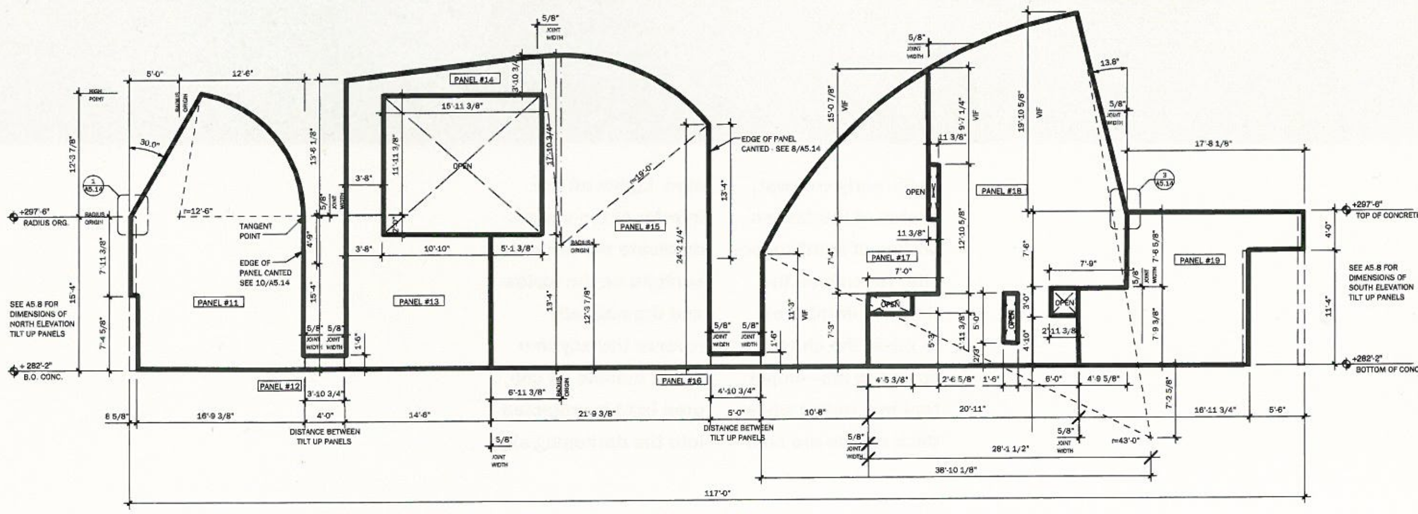
Although Kasota stone was originally intended for the chapel's "stone box," he was intrigued by the possibilities of tilt-up, which is less expensive. He was inspired by R. M. Schindler's use of site-cast concrete for his 1922 Kings Road house in Hollywood, Calif. In that project, the spaces between wall panels are glazed, allowing light to filter inside. "The chapel is based on a similar idea; the windows are formed in the interlock of the tilt-up slabs," explains Holl. "It's a pure tectonic expression."

Unlike typical tilt-up construction, which is usually cast on a slab on grade, the chapel's panels were formed on top of precast hollow-core planks over the basement. Since the casting surface deflected slightly, the panels were cast face-up so that any unevenness would be located on their back side and therefore would not be visible. The surface of the wet concrete was smoothed with a steel trowel and finished with an acid-based ochre-colored stain.

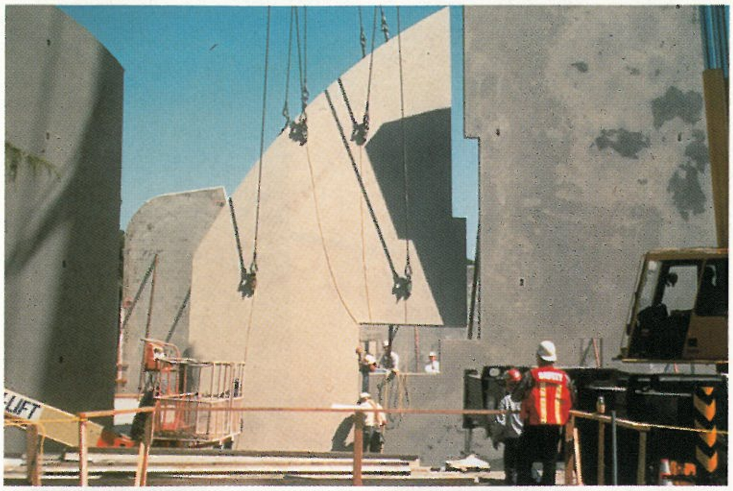
Because of the limited area available for casting, the panels were carefully laid out puzzlelike on the chapel floor. The bottom of the unfilled reflecting pool was also used as a casting area. Since the panels were cast wherever they fit, they couldn't simply be jacked up into place. Instead, the 8- and 10-in.-thick panels—some weighing as much as 78,000 lbs—were picked up, rotated, and positioned by hydraulic crane.

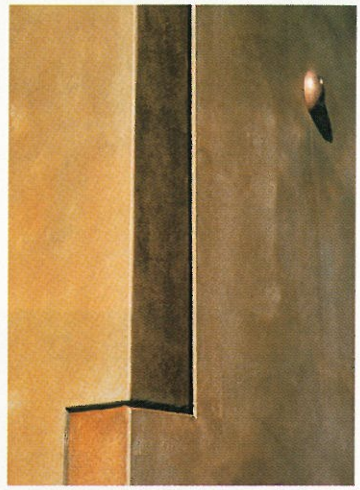
Panels were picked up flat by cables attached to at least four support points on the upper and lower portions of their face. Two cables were then attached to the top edge of the panel before the cables on the bottom portion were released, allowing the panel to go vertical. Since the panels interlock, proper sequencing was essential. The process also demanded precision with the crane so that edges were not chipped or cracked. "We handled those panels with kid gloves," says Toher.

To cover the holes left on the front of the panels by the pick-up points, Holl's office designed cast-



WEST ELEVATION – TILT-UP PANELS





bronze point-plugs. After the first designs were rejected as "too potatolike," artisan David Gulassa cut a fishing line float in half to create a mold. A close look at the completed project reveals the wood grain of the float. "The plugs serve as traces of the construction method," says Holl, "and cast changing shadows on the walls."

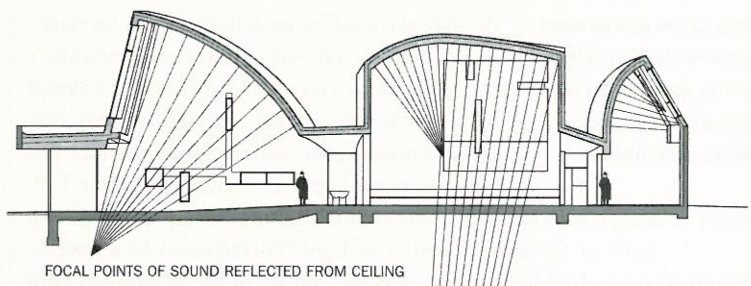
"The most complex aspect of the chapel is the geometry of the structural steel roof framing," says Toher. "It involves 38 tons of steel, and the shop drawings took over four months to draw." The light scoops are formed using a curved steel-tube framing system Holl previously employed on the Stretto House in Dallas. The rolled pipe and tube sections allow elements to attach in multiple directions.

Timothy Bade, project architect at Holl's office, translated the roof form from a cardboard study model into an accurate computer model by plotting points in space. "What made this project particularly tricky is that the steel [roof] members are rarely horizontal or straight," says Bade. "This resulted in calculating the intersections of angled curved pieces . . . without an orthogonal structural grid while maintaining an accuracy of 1/16 of an inch."

The roof is supported at bearing pockets cast into the backs of the concrete panels. "It's a critical juncture where the two systems come together," says James Graham of Olson Sundberg. "Out of 256 'embeds,' only six were located incorrectly or missing," he says of Baugh's accuracy. For stability, the precast walls were braced until all of the roof's structural steel was in place, constricting work space.

The light scoops and bell tower are clad in Rheinzink, a preweathered solid zinc roofing material. "We wanted materials that aren't slick or new looking, but show signs of age and history," says Bade. Because of the venting required to keep zinc from corroding, a 10-in.-thick roof assembly was necessary to fit layers of metal decking, rigid insulation, waterproofing, channels, plywood, and felt.

The chapel's curved ceilings were carefully checked during design to ensure that reflected sound would not focus at ear level. "Most of the focal points for sound reflected off of the ceiling fall below the floor level or well above head height," explains Bade. "This allows the reflected sound to be more evenly distributed throughout the space without areas of amplification or dead spots." Complete acoustic isolation of the distinct liturgical zones, however, is not possible without walls. For Mass, voices trained to project don't need to rely on the sound system that was installed just in case. "During hymns the space sounds wonderfully full even when the chapel is not," reports Father John Baldovin.



Interlocking panels form window openings. Bronze plugs cover crane pick-up points (above). A diagram shows the architect's acoustic analysis for the chapel's curved ceiling (right).

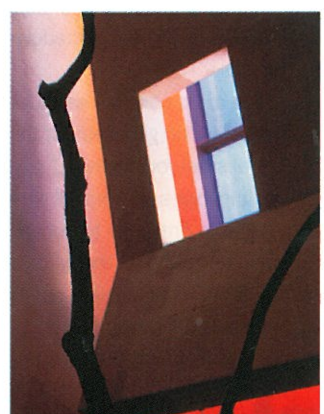
One of the pair of hand-carved Alaskan yellow cedar doors is oversized for ceremonial entrances (above).

the glazed mouth of each light scoop. Drywall-faced baffles coated with complementary Day-Glo colors retract and diffuse the colored light across the curved, stippled interior surfaces, concealing the source of illumination. The effect is reminiscent of Holl's offices for D.E. Shaw & Company in New York City [RECORD, June 1992, pages 114–19].

Each of the seven "bottles of light" corresponds to a specific liturgical space, highlighting the episodic nature of the prescribed path through the chapel. In the narthex, where people gather before and after each liturgy, for example, the light is bright and uncolored. On axis with the entry doors, the processional route, another "bottle," is defined by a high arch overhead and a shallow ramp leading to the baptismal font and the Blessed Sacrament Chapel beyond. The font acts as a hinge between the two modes of worship—communal gathering in the main sanctuary and private meditation in the smaller chapel. It also helps to resolve the conflict between worship-in-the-round and a processional of discrete liturgical spaces. "This plan fuses the two," explains Holl.

Just beyond the baptismal font, a vista opens into the main sanctuary. Overhead, the ceiling reaches its maximum height of 30 ft and is framed by lower arched areas on either side. The tension between the orthogonal baffles and the sensuous curves of the ceiling creates a feeling of buoyancy as if the chapel is about to float upward. Colors bounce off the highly polished concrete floor in unpredictable ways. Holl had the plaster finishers alternate the tooth of the veneer-plaster trowel for a visibly rough texture that catches light in irregular patches.

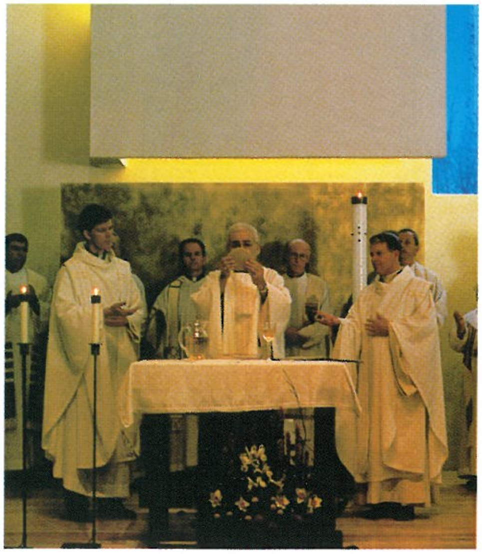
In the Blessed Sacrament Chapel, Seattle artist Linda Beaumont embedded gold-leaf prayer texts in the walls beneath ghostly layers of dripped beeswax; its sweet smell permeates the air. Making furnishings for the chapel within a chapel, Beaumont went beyond SU's original request, creating an artistic installation of the space itself. In the muted red light (the lens is purple and the baffle is painted orange), the onyx tabernacle containing the Eucharist bread softly glows. A twisted branch of a Madrona tree holds a lantern whose light is visible from busy Madison Street through a Holl-designed fused-glass window.



Similar attention to detail carries through the chapel, beginning with the cast-bronze handles of the cedar doors, which resemble the billowing folds of a priest's stole. Inside, liturgical furnishings—from wood pews to glass bottles of holy oils—are by Holl's office and were made by mostly local artisans. "Seattle has an incredible craft *(text continues)*

PHOTOGRAPHY: © SOLANGE FABIÃO,BOTTOM LEFT

Beeswax walls of the Blessed Sacrament Chapel are by artist Linda Beaumont. Holl's window has the Seal of the Society of Jesus. A Madrona tree symbolizes life's struggles.



"We wanted the chapel to be a tactile and multisensory experience," says the Reverend Jerry Cobb of the scratch-coat plaster walls, cedar baptismal font (left), pews (below), and altar framed by gold leaf (opposite and above at the consecration).

The dialectic of colors—one projected through a stained-glass lens and its complement reflected off Day-Glo paint on the back of a baffle—in the Reconciliation Chapel echoes the back-and-forth between priest and student in St. Ignatius's spiritual exercises.

Holl designed the narthex carpet. Fused glass windows along the processional route are Holl's abstractions of St. Ignatius's four spiritual exercises.

capacity," notes Holl, who tapped local expertise for the blown-glass pendant lights in the main sanctuary and wall sconces throughout the project. To communicate the chapel's complexities to the building committee—and to potential donors—Holl built a model with a mirror hung underneath for a worm's-eye view of interior spaces. The model was purchased by New York City's Museum of Modern Art for its permanent collection.

Bridging the gap between design artistry and constructability was the focus of the collaboration between Holl and his associate architect, the Seattle firm of Olson Sundberg. Holl wanted his office to produce the construction documents and perform construction administration, but SU wanted a more fully involved local firm. In the end, Holl's office produced an unusually complete set of design-development drawings. The collaboration often revealed differences in the two firms' attitudes toward construction expression. "At times we would generate a detail that would not be in the spirit of their vision," says Tom Kundig, an Olson Sundberg principal. "For instance, we would show a reveal where the plaster meets the window frame, but Steven preferred them to butt right up to each other." Certain details proved particularly challenging for all, especially the butt-glazed corner in the narthex and the knife-edge along the top of the precast-concrete panels.

The chapel marks a critical moment in Holl's career as a series of high-profile projects—a major addition to the Cranbrook Institute of Science in Michigan and the Kiasma Museum of Contemporary Art in Helsinki—reach completion. Although traces of past projects are found in the chapel, it is a departure for Holl. For the first time, the meditative quality of light and space that characterizes his work is not just architectural expression but also program. Holl develops the sensory, perceptual, and emotional intentions of a project—what he calls phenomenology—through watercolors that he paints religiously every morning, part of a sketching practice begun as a student at the University of Washington in Seattle.

Holl's return home is causing a lot of excitement in a city that has a large number of architects if not significant new buildings. "The chapel raises the standard for Seattle architecture," claims Douglas Kelbaugh, a local practitioner and a University of Washington professor of architecture. "It should give some of the [area's] Microsoft millionaires something to think about." Just as the Reverend William Sullivan dreamed, the Chapel of St. Ignatius is generating heat as well as light. ■

Manufacturers' Sources

Structural steel roof, tubes: *United Iron Works, MKE Detailing*
Concrete pigment: *L.M. Scofield Co.*
EPDM roof: *Carlisle Syntec Systems*
Zinc "roof bottles": *Rheinzink*
Sloped glazing: *EverGreenHouse*
Windows: *Kawneer, Fleetwood Aluminum Products*
Glass laminating: *Northwest Industries*
Cast-glass lenses: *Doug Hansen*
Colored art glass: *Spectrum Art Glass*
Hand-carved entry doors, baptistry, altar furnishings: *Salmon Bay Millwork*
Vestibule doors, cabinetwork: *W.W. Wells*
Door pulls, metal finishes, metal work: *David Gullassa & Co.*
Integral-color concrete floor: *Emil's Concrete Construction Co.*
Scratch-coat plaster: *O'Malley Brothers' Plastering Co.*
Pews, presider's chair, cantor's stand: *Solid Visions, Inc.*
Exterior lighting: *Bega, McPhilben, Norbert Belfer*
Interior lighting, controls: *Halo, Leviton*
Custom glass sconces, pendant fixtures: *Preston Singletary, Norman Courtney*
Narthex carpet: *V'Soske*

TILT-UPTODAY

SPRING 16

TILT-UPTODAY

A publication of the Tilt-Up Concrete Association

20 Years of a Tilt-Up Icon

20 Años de un Ícono de Tilt-Up

THE CHAPEL OF ST. IGNATIUS
STEVEN HOLL

LA CAPILLA DE SAN IGNACIO
STEVEN HOLL

WORDS: MITCH BLOOMQUIST
IMAGES: PAUL WARCHOL

Two decades ago, construction began on a small chapel on the campus of Seattle University in Seattle, Washington. Designed by Steven Holl, the Chapel of St. Ignatius serves as one of the greatest examples of the architectural potential of tilt-up construction. The project is highly regarded by architectural critics, students, and professionals and widely publicized. In a *Time* article entitled "To the Lighthouse," Richard Lacayo wrote, "One of the most widely studied churches of the past few years has been Steven Holl's Chapel of St. Ignatius."[1] Noted authors Kenneth Frampton[2], Robert McCarter and Holl himself have specifically called out the construction method as a major contributor to the success of the project, yet the project did not immediately spark a wider interest in the use of tilt-up by other significant architects.

Holl's introduction and approach to the application of tilt-up technology lends great insight to the success of the project. His understanding of the method's potential led him to utilize tilt-up on several other projects including the Planar House in Arizona and the Avi Telyas residence on Long Island. "I am inspired by the potential that architecture can tell you how it is made and that structure can be a core part of the meaning of a project," said Holl. "The Chapel concept 'seven bottles of light in a stone box' became possible when we envisioned the tilt-up as 'giant stone fragments,' which could interlock in a sculptural way. I see many opportunities to explore these ideas further."

THE STONE BOX

Holl's concept for the Chapel of St. Ignatius, "seven bottles of light in a stone box," is expressed through the tilt-up method of construction, though it did not start out that way. Initially, Holl envisioned the use of stone, a material traditionally employed for religious construction, as the primary material for the structure's exterior. "However, in a demonstration of [Frank Lloyd] Wright's aphorism 'limits have always been the best friends of the architect,' budgetary limitations resulted in the decision to construct the outer walls as tilt-up concrete" (McCarter, 2015, p. 106).[3]

Holl and Frampton too point to both the practical project savings provided by the method and the benefits afforded by the material, agreeing that the integral-color site-cast concrete panels "define a tectonic more direct and far more economical than stone veneer" (Holl, 1999, p. 42).[4]

Thomas Taylor, P.E., Managing Principal for Datum Engineers, Inc., who worked closely with the design team on the transition from masonry to tilt-up, said Holl was open to the idea from the beginning. "I was inspired by tilt-up construction years before when I visited the Kings Road House by Rudolf Schindler," said Holl.

The poetry of Steven Holl's application of the tilt-up method resides in the interaction between desired effect and its inherent manifestation in the construction method. McCarter (2015) writes "When seen from the outside, the integrally colored tilt-up concrete walls together form flat vertical surfaces precisely revealing the shape of the interior section, and emphasizing through their monolithic

Hace dos décadas, la construcción de una pequeña capilla comenzó en el campus de la Universidad de Seattle en Seattle, Washington. Diseñada por Steven Holl, la Capilla de San Ignacio sirve como uno de los grandes ejemplos del potencial arquitectónico de la construcción tilt-up. El proyecto es altamente estimado por críticos, estudiantes y profesionales de arquitectura y ampliamente publicitado. En un artículo de *Time* titulado "To the Lighthouse", Richard Lacayo escribió, "Una de las iglesias más estudiadas de los últimos años ha sido la Capilla de San Ignacio de Steven Holl…"[1] Notables autores Kenneth Frampton, Robert McCarter y Holl en sí han llamado específicamente el método de construcción como un contribuidor importante del éxito del proyecto, pero aún así el proyecto no provocó un interés mayor en el uso de tilt-up por otros arquitectos importantes.[2]

La introducción y alcance de Holl a la aplicación de la tecnología de tilt-up presta mucha comprensión al éxito del proyecto. Su entendimiento del método lo llevó a utilizar el tilt-up en otros varios proyectos incluyendo la Casa Planar en Arizona y la residencia de Avi Telyas en Long Island. "Estoy inspirado por el potencial que la arquitectura puede decirle cómo se realiza y que la estructura puede ser una parte intrínseca del significado de un proyecto", dijo Holl. "El concepto de la Capilla de siete botellas de luz en un caja de piedra pudo ser posible cuando visualizamos a tilt-up como 'fragmentos gigantes' de piedra, que podían conectarse de manera escultural. Veo muchas oportunidades para explorar aún más estas ideas".

LA CAJA DE PIEDRA

El concepto de Holl para La Capilla de San Ignacio, "siete botellas de luz en una caja de piedra", es expresado por medio del método de construcción tilt-up, aunque no comenzó de esa manera. Inicialmente, Holl visualizó el uso de piedra, un material tradicionalmente empleado para la construcción religiosa, como el material principal para la estructura exterior. "Sin embargo, en una demostración del aforismo de Wright [Frank Lloyd] 'los límites siempre han sido los mejores amigos del arquitecto', las limitaciones de presupuesto resultaron en la decisión de construir las paredes exteriores como concreto tilt-up" (McCarter, 2015, p. 106).[3]

Thomas Taylor, P.E., directivo de Datum Engineers, Inc., quien trabajó muy de cerca con el equipo de diseño en la transición de mampostería a tilt-up, dijo que Holl estaba abierto a la idea desde el principio. "He estado inspirado por la construcción tilt-up desde hace muchos años antes cuando visité la Casa Kings Road por Rudolf Schindler", dijo Holl.

Holl y Frampton también señalaron tanto los ahorros prácticos del proyecto provistos por el método como los beneficios permitidos por el material acordando que los paneles de concreto de color integral vaciados en el sitio "definen un tectónico más directamente y más económicamente que un revestimiento de piedra" (Holl, 1999, p. 42).[4]

La poesía de la aplicación de Steven Holl del método tilt-up reside en la interacción entre el efecto deseado y su manifestación inherente en el método de construcción. McCarter (2015) escribe "Cuando es materiality the way in which the inner space presses out against the rectangular limits of the volume" (p. 106).[3]

Openings occur strategically within the joint between two panels and at the edges of panels, interacting with the roof, building corner, and ground. The opportunistic placement of the openings accentuates the joints and dissolves the appearance of a panelized façade.

"The complexly interlocking tilt-up concrete walls, each a different size and shape, are like the pieces of a puzzle in the way they reveal the process of assembly, and in their combination of massive panels and intimate apertures they have an ambiguous sense of scale," writes to McCarter (2015). "Quite different from that which would have been imparted by the repetitive pieces of stone cladding that were initially considered" (pg. 106).[3]

At the corners of the building, the concrete panels interlock to reveal the load-bearing thickness of the panels.

A MASTER CLASS EVERYONE ATTENDS BUT FEW COMPREHEND

The Chapel of St. Ignatius is like a master class in tilt-up that everyone took but few put have put the lessons learned into action. Holl's masterful demonstration of the potential for tilt-up to produce canonical architecture has been, for many architects, their first and often only exposure to tilt-up construction. The application of the technology was extraordinarily creative as the method had, at the time, a reputation for use primarily on industrial structures.

Low cost, low technology movements in architecture are nothing new though. The ideas of reusing shipping containers as building blocks or inflatable balloons covered in concrete as shelter continue to be studied by architectural students and professionals and are continuously covered in-depth by serious architectural publications. Many of these ideas lack broad-based support from developers and contractors, something tilt-up construction has enjoyed for decades. One has to wonder, is there something inherent in architecture that is attracted to the acrobatics of these approaches over the innovative application of a preexisting method for delivering low-cost, low-technology architecture?

One answer may be the stigma of big box technology is too much to overcome for architects. Perhaps a more plausible reason, one that Jeffrey Brown (Powers Brown Architecture) points to in his research, is that its acceptance by the development and construction industries has made it too mainstream and architects have been trained by decades of media coverage to worship the avant-garde.

WHILE NOT AVANT-GARDE, TILT-UP OFFERS A DIFFERENT SORT OF ACROBATICS

At a time when designers are infatuated with the 3d printing of buildings and constructing skyscrapers in just days, another look at a technology offering similar drama seems fitting. Holl described the tilt-up process as inspiring. "Father Sullivan and I watched the tilt-up

visto desde afuera, las paredes de concreto coloreadas integralmente forman superficies verticales planas precisamente revelando la forma de la sección interior, y enfatizando por medio de materialidad monolítica la manera en la cual el espacio interno presiona hacia afuera contra los límites rectangulares del volumen" (p. 106).[3]

Las aperturas ocurren estratégicamente dentro de la unión de dos paneles y a los bordes de los paneles, interactuando con el techo, la esquina del edificio y el piso. La colocación oportunista de las aperturas acentúa las uniones y disuelve la apariencia de una fachada de paneles.

Según McCarter (2015) "Las paredes de tilt-up de conexión compleja, cada una de tamaño y forma diferente, son como piezas de un rompecabezas de manera que muestran el proceso de armado, y en su combinación de paneles masivos y aperturas íntimas tienen un sentido ambiguo de escala. Muy diferente de lo que hubiera sido impartido por piezas repetitivas de revestimiento de piedra consideradas inicialmente" (pg. 106).[3]

En las esquinas del edificio, los paneles de concreto se conectan para revelar el grosor de los paneles de soporte.

UNA CLASE DE MAESTRÍA A LA QUE TODOS ASISTEN PERO POCOS COMPRENDEN

La Capilla de San Ignacio, es como una clase de maestría en tilt-up que todos tomaron pero pocos pusieron las lecciones aprendidas en acción. La demostración magistral de Holl del potencial de tilt-up para producir arquitectura canónica ha sido para muchos arquitectos, su primera exposición a la construcción tilt-up y con frecuencia su única exposición al método. La aplicación de tecnología fue extraordinariamente creativa ya que el método, en el momento, tenía una reputación de uso primario en estructuras industriales.

El bajo costo, los pocos movimientos tecnológicos en arquitectura no son para nada nuevos. Las ideas de reusar recipientes de envío como bloques de edificación, o globos inflables cubiertos en concreto como un refugio, continúan siendo estudiadas por estudiantes y profesionales de arquitectura y son continuamente cubiertos en profundidad por publicaciones serias de arquitectura. Muchas de estas ideas carecen un apoyo amplio de desarrolladores y contratistas; algo que la construcción tilt-up ha disfrutado por décadas. Uno se tiene que preguntar, ¿hay algo inherente en arquitectura que siente atracción por las acrobacias de estos alcances durante la aplicación innovadora de un método preexistente para brindar arquitectura de bajo costo y tecnología?

Una respuesta podría ser el estigma de la tecnología de caja grande es demasiado para que los arquitectos la superen. Quizás una razón más probable, una que Jeffrey Brown (Powers Brown Architecture) señala en su investigación, es que su aceptación por compañías de desarrollo y construcción lo han hecho muy común, y los arquitectos han sido entrenados por décadas por la cobertura de los medios a adorar lo de vanguardia.

operation together with a certain joy," writes Holl. "The structural body of the chapel rose up suddenly from the campus ground like an apparition!" (Holl, 1999, p. 42)[4].

Best of all, tilt-up technology is ready for the type of research and exploration architects are good at. The economics are there, the material technology is there and the buy-in from clients is there. What's missing is adequate design creativity and innovation.

AN EVOCATIVE AND TIME-HONORED MATERIAL

Concrete is an evocative and time-honored material. It is both historic and cutting-edge. The ancient materials of water, sand, stone, and cement combine with high-tech admixtures to form a material so relevant that, after water, it is the most widely used material in the world.

World renowned architect Le Corbusier is said to have had a love affair with the material, fascinated "...with the remarkable adaptability of concrete, and with its sculptural and structural potential."[5] While Corbusier favored 'beton brute' [bare concrete], Japanese architect, Tadao Ando's architecture could never be

MIENTRAS QUE NO ES DE VANGUARDIA, TILT-UP OFRECE UNA MANERA DIFERENTE DE ACROBACIA

En la época en que los diseñadores están enamorados de la impresión 3D de edificios y la construcción de rascacielos en solo días, otra mirada a una tecnología que ofrece un drama similar parece ser adecuado. La erección de un edificio tilt-up es inspiradora. "El padre Sullivan y yo miramos juntos la operación de tilt-up con cierta alegría. ¡El cuerpo estructural de la capilla se elevó de repente del suelo del campus como una aparición!"(Holl, 1999, p. 42)[4]

Lo mejor es que la tecnología tilt-up está lista para este tipo de investigación y exploración para las cuales los arquitectos son buenos. Los factores económicos están ahí, la tecnología de material está ahí y el apoyo de clientes está ahí. Lo que falta es la creatividad de diseño y la innovación adecuadas.

UN MATERIAL EVOCATIVO Y HONRADO POR EL TIEMPO

El concreto es un material evocativo y honrado por el tiempo. Es histórico y de avanzada. Los materiales antiguos de agua, arena, piedra y cemento combinados con mezclas de alta tecnología forman

described as brutal. In a recent interview with Spencer Bailey for *Surface Magazine*, Ando described how the application of a "ubiquitous, ordinary material" can be innovative, all the while contributing to the "preservation of the country's architectural DNA."[6]

In the case of the Chapel of St. Ignatius, the 'stone box' is aging gracefully. "I was just in Seattle last weekend for the Vitra Kahn exhibit at Holl's Bellevue Art Museum," said McCarter. "Steven and I spent an hour in the St. Ignatius Chapel that evening, with choirs rehearsing for a concert. It is in terrific shape for the 20-year celebration. The tilt-up slabs look terrific, aged and ageless, like Unity Temple."

[1] Lacayo, R. (2002, August 25). Into the lighthouse. Time. Retrieved from http://content.time.com/time/magazine/article/0,9171,344060-2,00.html
[2] Frampton, K. (2003). Steven Holl architecture. Electra Architecture.
[3] McCarter, R. (2015). Steven Holl. New York, NY: Phaidon Press Inc.
[4] Holl, S. (1999). The Chapel of St. Ignatius. New York, NY: Princeton Architectural Press.
[5] Quddus, S. (2014, December 4). Material Masters: Le Corbusier's Love for Concrete. Arch Daily. Retrieved from http://www.archdaily.com/574981/material-masters-le-corbusier-s-love-for-concrete
[6] Bailey, S. (2015, February). Tadao Ando. Surface. Retrieved from http://www.surfacemag.com/tadao-ando/

un material tan relevante que, después del agua, es el material más usado en el mundo.

Se dice que el arquitecto de renombre mundial Le Corbusier ha sentido pasión por el material, ha estado fascinado "...con la adaptabilidad notable del concreto, y su potencial escultural y estructural".5 Mientras que Corbusier favoreció el 'beton brute' [concreto simple], la arquitectura del arquitecto japonés Tadao Ando nunca podría ser descrita como brutal. En una entrevista reciente con Bailey para Surface Magazine, Ando describió cómo la aplicación de un "material ordinario y ubicuo" puede ser innovador, y al mismo tiempo contribuir a la "preservación del ADN arquitectónico del país".

En el caso de La Capilla de San Ignacio, la 'caja de piedra' está envejeciendo con gracia. "Recién estuve en Seattle el fin de semana pasado para la exhibición de Vitra Kahn en el Museo de Arte Bellevue de Holl", dijo McCarter. "Steven y yo pasamos una hora en la Capilla San Ignacio esa noche, con los coros ensayando para un concierto. Está en forma estupenda para la celebración de sus 20 años. Los paneles tilt-up se ven estupendos, envejecidos y siempre jóvenes como Unity Temple".

Tilt Wall and the Creative Process

Paredes Tilt y el Proceso Creativo

WORDS: THOMAS W. TAYLOR P.E., DATUM ENGINEERS
IMAGES: STEVEN HOLL ARCHITECTS

Much has been written about this beautiful architectural vision of Steven Holl Architects inspired by St. Ignatius that would be well beyond my ability to expand upon. I did have the amazing experience of watching and participating in Steven Holl's creative process that led to such a successful spiritual space that embraced the spirit of Ignatius. But I would like to address, through the eyes of an engineer, how Steven Holl guided the creative process which led to the use of tilt wall construction for the construction of the "stone box" from which the bottles of light emerged as he envisioned.

In our engineering practice 20 years ago, tilt wall construction was mostly prevalent in warehouse and industrial buildings. This construction technique was not initially considered for the exterior walls of the chapel, mainly for this reason. Tilt wall just wasn't the type of construction one would consider, 20 years ago, for a jewel box like the Chapel of St. Ignatius. We began with the assumption that load-bearing walls would be the most economical solution. We first considered load-bearing reinforced masonry walls clad with stone and plastered on the interior face. As pricing of the structure began, it was clear that the large volume of the small space generated a large amount of exterior wall area, which was a major contributor to the budget overruns. It was clear that it would be impossible to accomplish the vision, in budget, with this wall system. The goal continued to be to retain the vision and find another way to accomplish the "stone box" without damaging the form of the space.

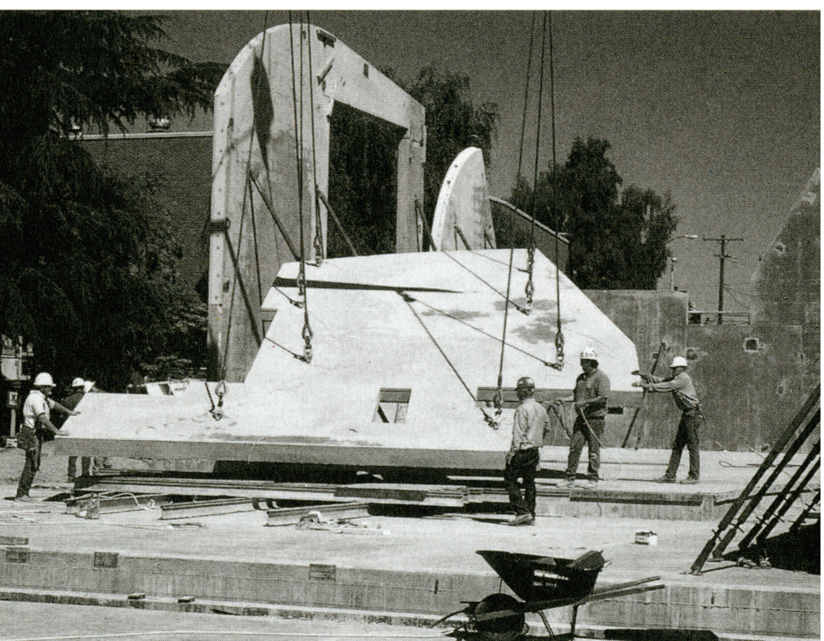
As I recall, the general contractor proposed we consider tilt wall construction. I was convinced that Steven would not want to consider such an industrial construction process. However, this was one of my first insights into Steven Holl's innovative abilities that extended to

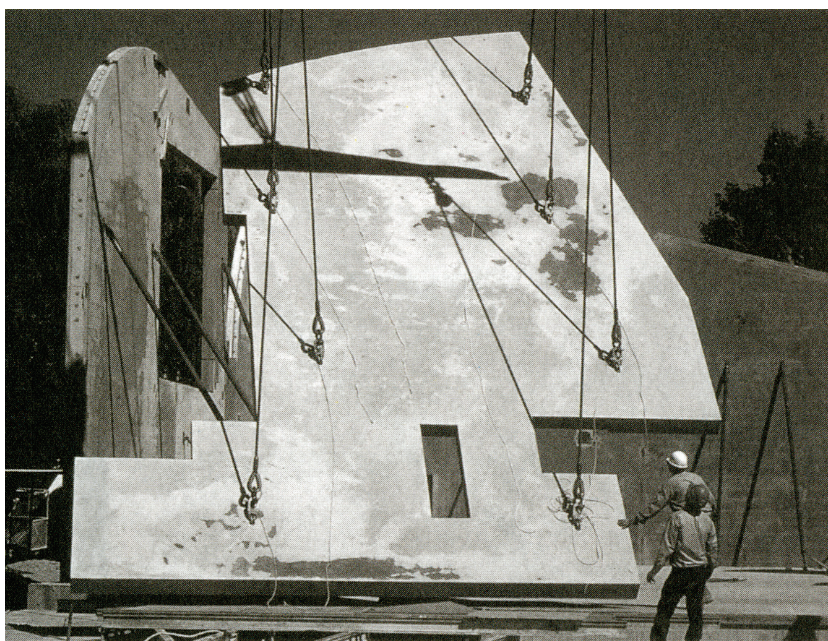
Mucho se ha escrito sobre la hermosa visión arquitectónica de Steven Holl Architects inspirada para San Ignacio que podría estar más allá de mi habilidad de explicarla. Sí, tuve la experiencia maravillosa de mirar y participar en el proceso creativo de Steven Holl que llevó a tal espacio espiritual exitoso que adoptaba el espíritu de Ignacio. Pero me gustaría tratar por medio de los ojos de un ingeniero, cómo Steven Holl guió el proceso creativo que llevó al uso de la construcción de paredes tilt para la construcción de la "caja de piedra" de la cual las botellas de luz emergieron como fueron concebidas.

Por lo menos, hace 20 años en nuestro despacho de ingeniería, la construcción de paredes tilt era mayormente predominante en edificios de almacenes e industriales. Esta técnica de construcción no fue considerada inicialmente para las paredes exteriores de la capilla, principalmente por esta razón. Las paredes tilt no eran el tipo de construcción que uno consideraría, hace 20 años, para una joya como la Capilla de San Ignacio. Comenzamos con la suposición que las paredes de soporte serían la solución más económica. Sin embargo, primero consideramos paredes reforzadas de soporte de mampostería revestidas con piedra y enyesadas en la cara interior. Al comenzar la tarificación de la estructura, fue claro que el volumen grande del espacio pequeño generaba una gran cantidad de área de pared exterior, lo cual era un contribuidor principal a los excesos de presupuesto. Era claro que sería imposible lograr la visión, en el presupuesto, con este sistema de paredes. El objetivo continuaba siendo mantener la visión y encontrar otra manera de lograr una "caja de piedra" sin dañar la forma del espacio.

Según recuerdo, el contratista general propuso que consideráramos la construcción de paredes tilt. Yo estaba convencido que Steven no desearía considerar dicho proceso de construcción industrial. Sin embargo, este fue uno de mis primeros conocimientos de las capacidades innovadoras de Steven Holl que se extienden a la apreciación para la constructibilidad, además de su visión arquitectónica y espiritual. Rápidamente abrazó el desafío. Siento que esta sencilla directiva en una capilla pequeña en Seattle cambió el curso de la construcción tilt-up para toda la industria.

El contratista deseaba que limitáramos el peso de los paneles a 80,000 libras para permanecer dentro del proceso económico de





the appreciation for constructability, in addition to his architectural and spiritual vision. He quickly embraced the challenge. I feel this one simple directive on a small chapel in Seattle changed the course and direction of tilt wall construction for the entire industry.

The contractor wanted us to limit the weight of the panels to 80,000 pounds to stay within economical tilt wall construction process on this site 20 years ago. Based on this guidance from the general contractor, together with Steven Holl's office, we drew possible tilt wall joints on the architectural elevations that met the weight limits requested by the general contractor and also retained the architectural form and location of window openings. This exercise identified 21 different unusual shapes of tilt wall panels. I was concerned the general contractor would object to the unusual shapes, the tight interlocking panel tolerances and the large number of different panels created for such a small project.

I knew all of the panels weighed less than 80,000 pounds, but worried that the unique panel shapes would change his budget estimates. I don't remember all of the cost information, but the general contractor was on board with the concept and this was the beginning of the process of using tilt wall construction for this special chapel.

Details of all of the joints became an important part of the architectural expression. We created an attractive interlocking detail at the corners that expressed the thickness of the panels from each elevation and contributed to the connection strength of the corners.

Casting the tilt wall panels on the floor structure led to the desire to cast the panels "face up". My next concern was the fact that all of the lifting inserts to attach the lifting cables to the panels would be exposed on the exterior architectural exposed face of the panel. My inquiry to Steven Holl regarding this issue created the next insight into Steven Holl's innovative abilities that extended to an appreciation for constructability. The answer I got back from Steven Holl was to locate the lifting inserts where it was most advantageous to the contractor and they would deal with it. Steven didn't tell me how he would deal with it, but that he would. So we proceeded with this directive and I continued to wonder how Steven Holl was going to address the issue.

Steven Holl's solution of capping the lifting inserts with cast bronze covers became an important element of the architectural expression of the Chapel. The interesting aspect of this detail is that the locations of the inserts were set by constructability, with maybe some minor tweaking and not by some artificial architectural location.

This small project had so many unique issues to address and proved that tilt wall construction can play a major role in this type of high design architectural projects we see in today's tilt wall market. Tilt wall construction brought the project in the budget. The flexibility of this system allowed us to create unique shapes and forms, as well as locate joints in architecturally creative ways that opened up tilt wall construction as an exciting structural/architectural system to be expanded upon by architects over the last 20 years.

la construcción de paredes tilt en este sitio hace 20 años. Basados en la guía del contratista general, junto con el despacho de Steven Holl, diseñamos las uniones de paredes tilt en las elevaciones arquitectónicas que cumplían con los límites de peso solicitados por el contratista general y además mantenían la forma arquitectónica y ubicación de las aperturas de las ventanas. Este ejercicio identificó 21 formas inusuales diferentes de paneles de paredes tilt. Estaba preocupado que el contratista general objetaría las formas inusuales, las ajustadas tolerancias de paneles conectados y el gran número de paneles diferentes creados para tan pequeño proyecto. ¿Permanecería este alcance particular dentro de las estimaciones del presupuesto?

Sabía que todos los paneles pesaban menos de 80,000, pero me preocupaba que las formas únicas de los paneles cambiaran sus estimaciones de presupuesto. No recuerdo toda la información de costo, pero el contratista general estaba a bordo con el concepto y este fue el comienzo del proceso de usar la construcción de paredes tilt para esta capilla especial.

Detalles de todas las uniones se convirtieron en una parte importante de la expresión arquitectónica. Creamos un detalle de conexión atractivo en las esquinas que expresa el grosor de los paneles desde cada elevación y que contribuyó a la fuerza de conexión de las esquinas.

El formado de los paneles de paredes tilt en la estructura del piso llevó al deseo de vaciar los paneles "cara hacia arriba". Mi próxima inquietud era el hecho que todos los insertos de elevación para unir los cables de elevación a los paneles estarían expuestos en la cara arquitectónica exterior del panel. Mi pregunta a Steven Holl sobre este asunto creó el siguiente conocimiento de las habilidades innovadoras de Steven Holl que se extendía a una apreciación de la constructibilidad. La respuesta que recibí de Steven Holl fue colocar los insertos de elevación donde fuera más ventajoso para el contratista y ellos se encargarían del resto. Steven no me dijo cómo se encargarían de esto, pero que él lo haría. Entonces procedimos con esta directiva y continuamos preguntándonos cómo Steve Holl solucionaría este asunto.

La solución de Steven Holl de tapar los insertos de elevación con cubiertas de bronce fundido se convirtió en un elemento importante de la expresión arquitectónica de la Capilla. El aspecto interesante de este detalle es que las ubicaciones de los insertos fueron establecidas por la constructibilidad, con quizás retoques menores y no por algún lugar arquitectónico artificial.

Este proyecto pequeño ha tenido muchos asuntos particulares para solucionar y probó que la construcción con paredes tilt puede jugar un rol importante en este tipo de proyectos de alto diseño arquitectónico que vemos en el mercado actual de paredes tilt. La construcción de paredes tilt mantuvo el proyecto bajo presupuesto. La flexibilidad de este sistema nos permitió crear formas y figuras únicas, y ubicar las conexiones de manera arquitectónicamente creativa, lo que abrió a la construcción tilt-up como un sistema estructural/arquitectónico excitante para que fuera expandido por arquitectos durante los últimos 20 años.

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