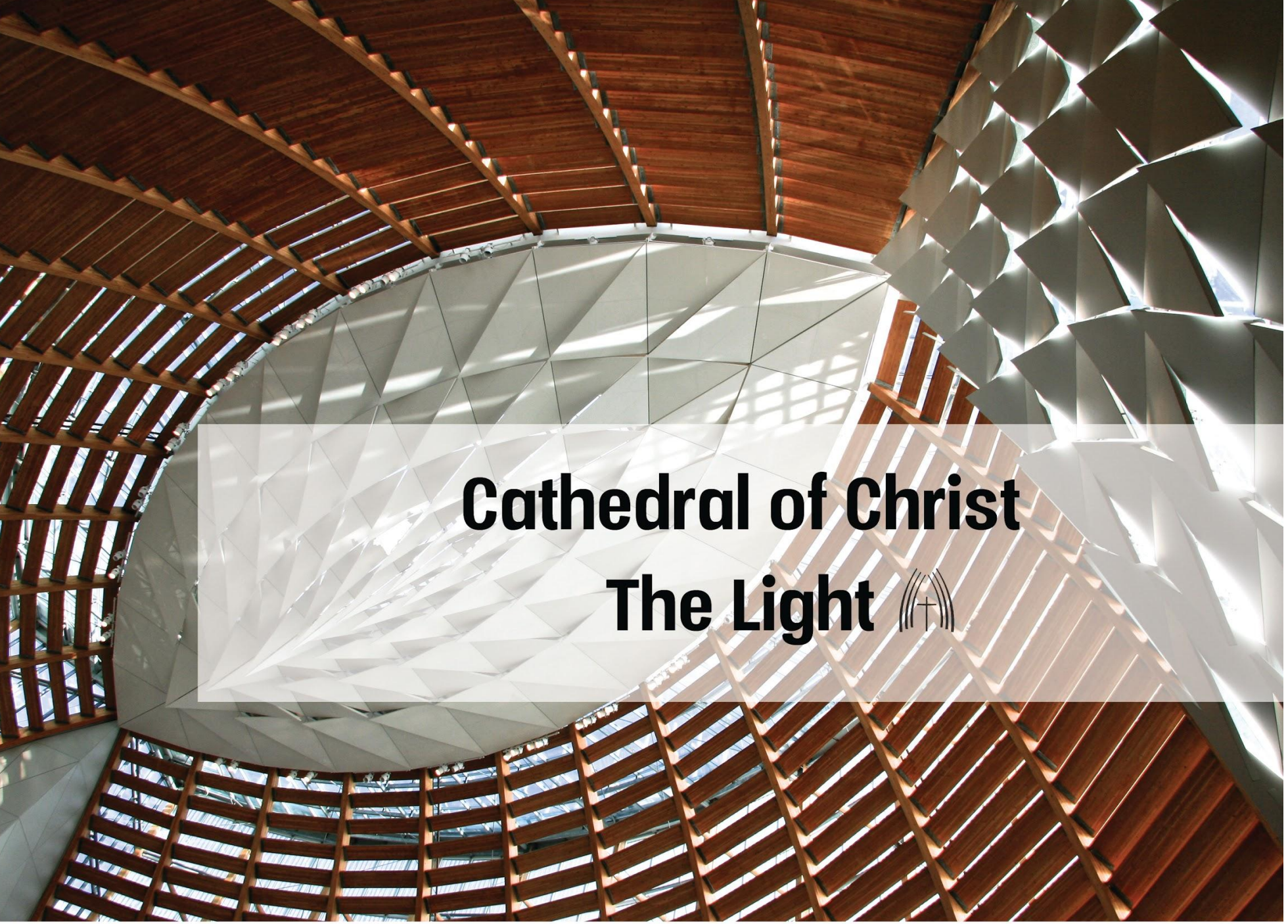

Cathedral of Christ
The Light

Architectural Structures- ARCH 631
oup Project - Structural Analysis

ADITHYA DEVDAS
SANDRA HERNANDEZ
DEEKSHA JOSHI
YUE HAO
XUAN LIU

ARCHITECTURE
TEXAS A&M UNIVERSITY

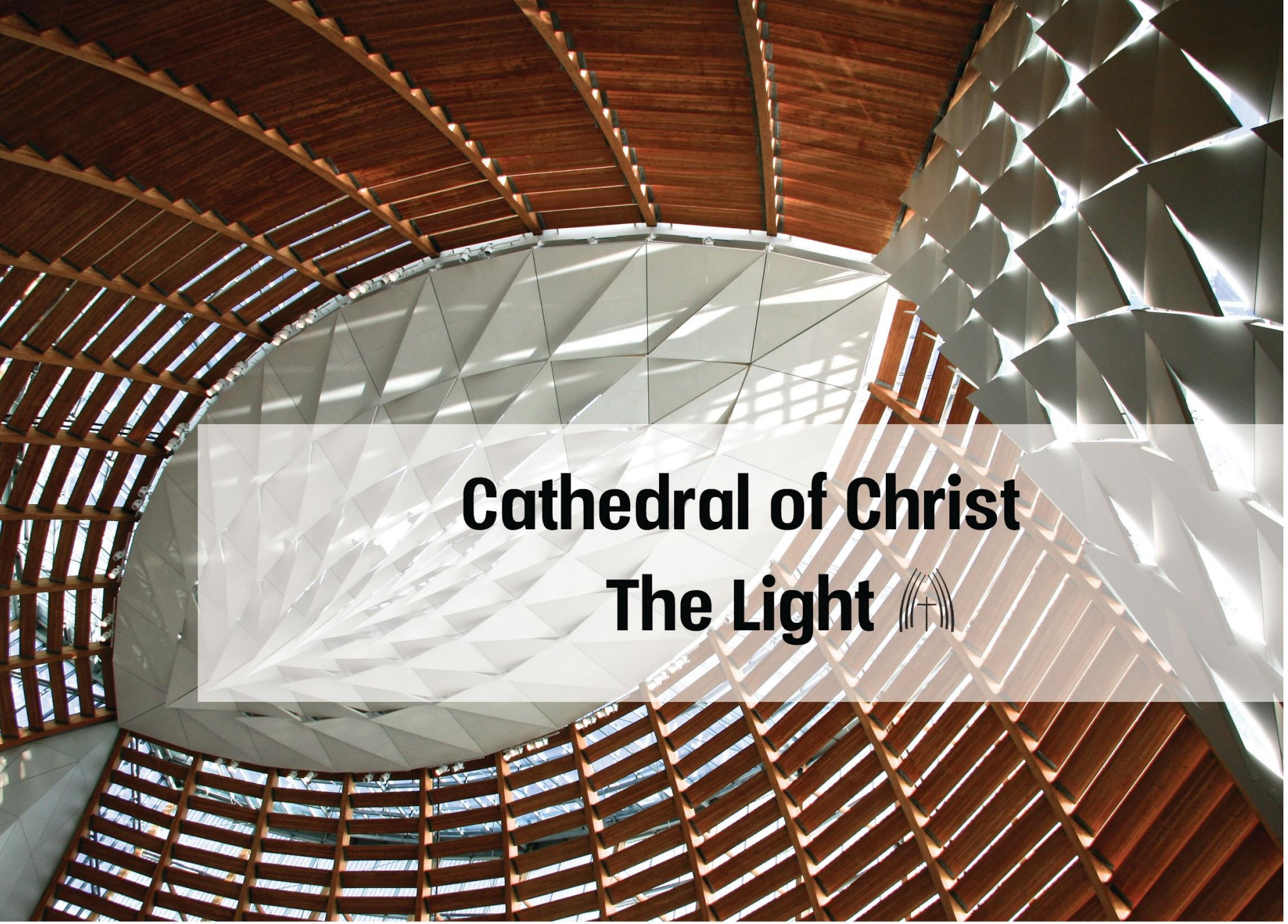

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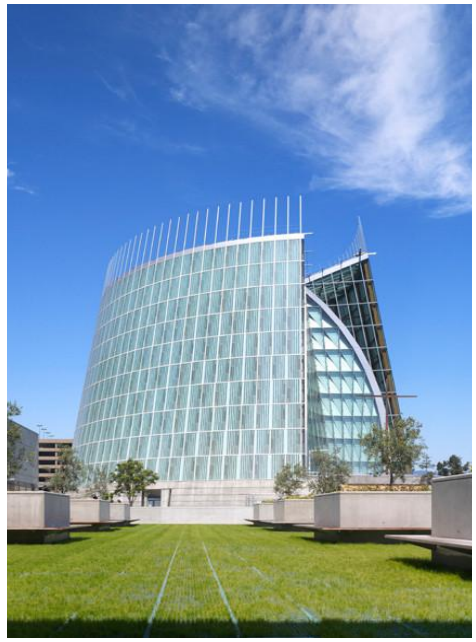
TABLE OF CONTENTS

INTRODUCTION

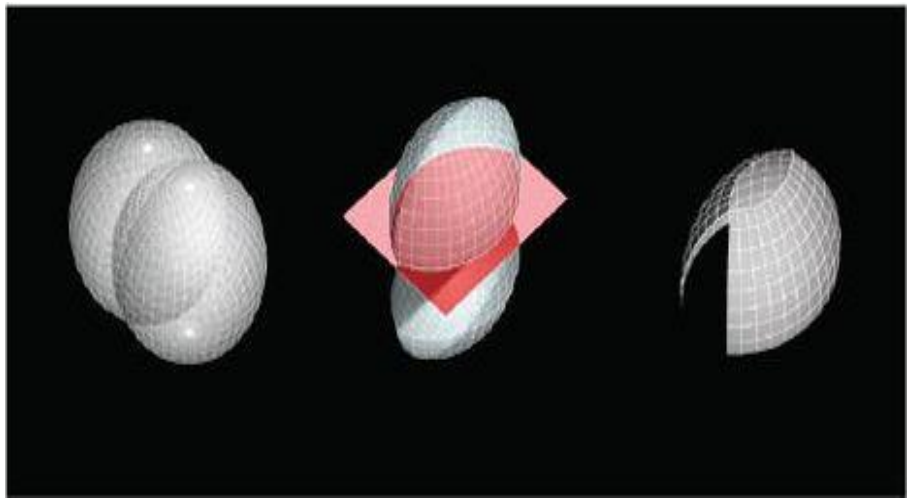
HISTORY

- Pope XXIII established the Diocese in Oakland in the year 1962. St. Francis De Sales was then designated as the first Cathedral. It was initially built with major funding from an Irish immigrant.
- It already served as a lively hub in Oakland. It became a center of ethnic richness with settlers from World war II and after that it started to attract people from the phillipines and other places across the globe.
- This gave it a global face and started to become an icon.
- The music of this Cathedral rose to new levels of excellence and it came to be known as the "Cathedral Oakland Sound".
- In october 1989, the Loma Prieta earthquake damaged the Cathedral rendering the building unusable.

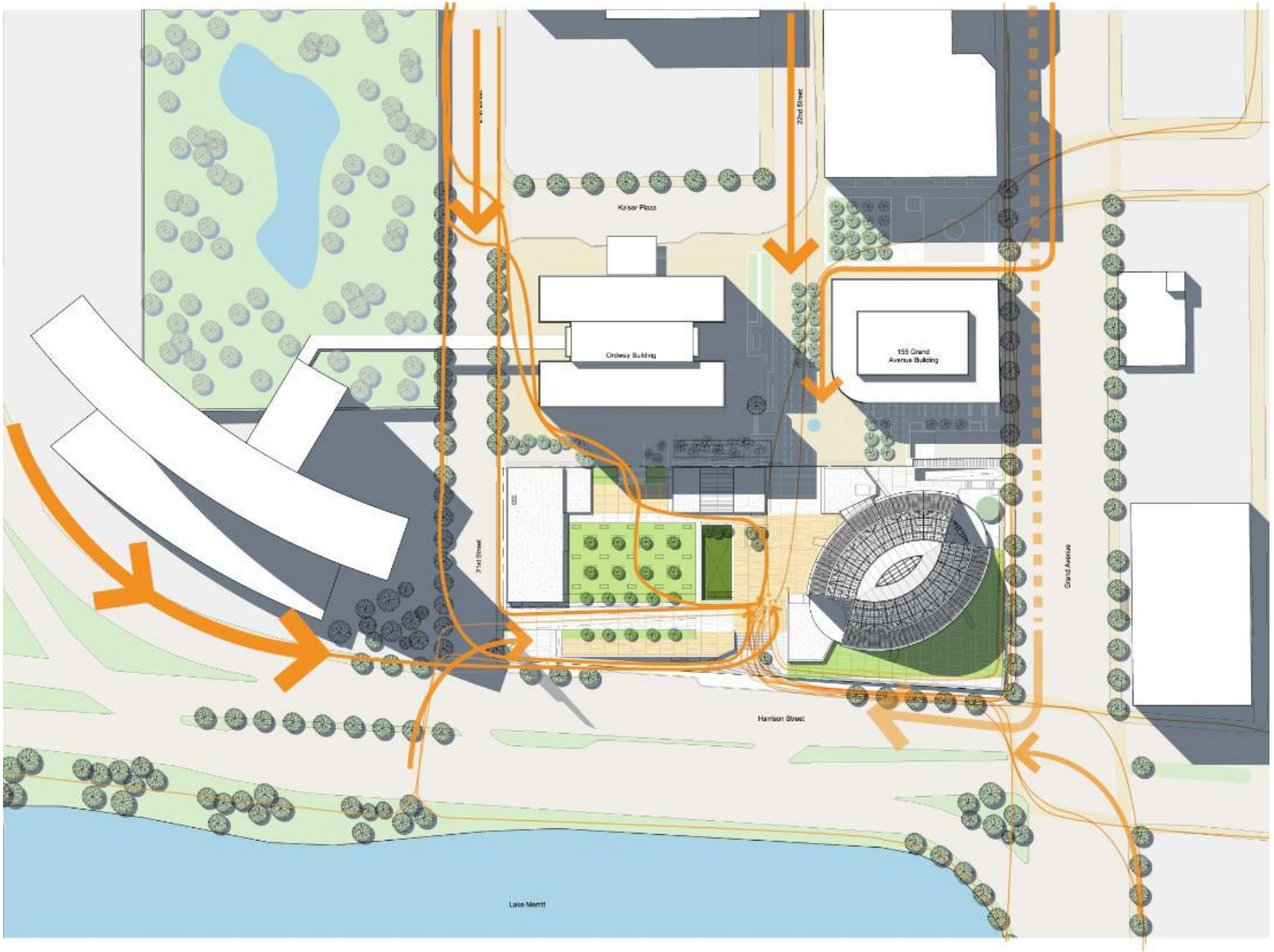


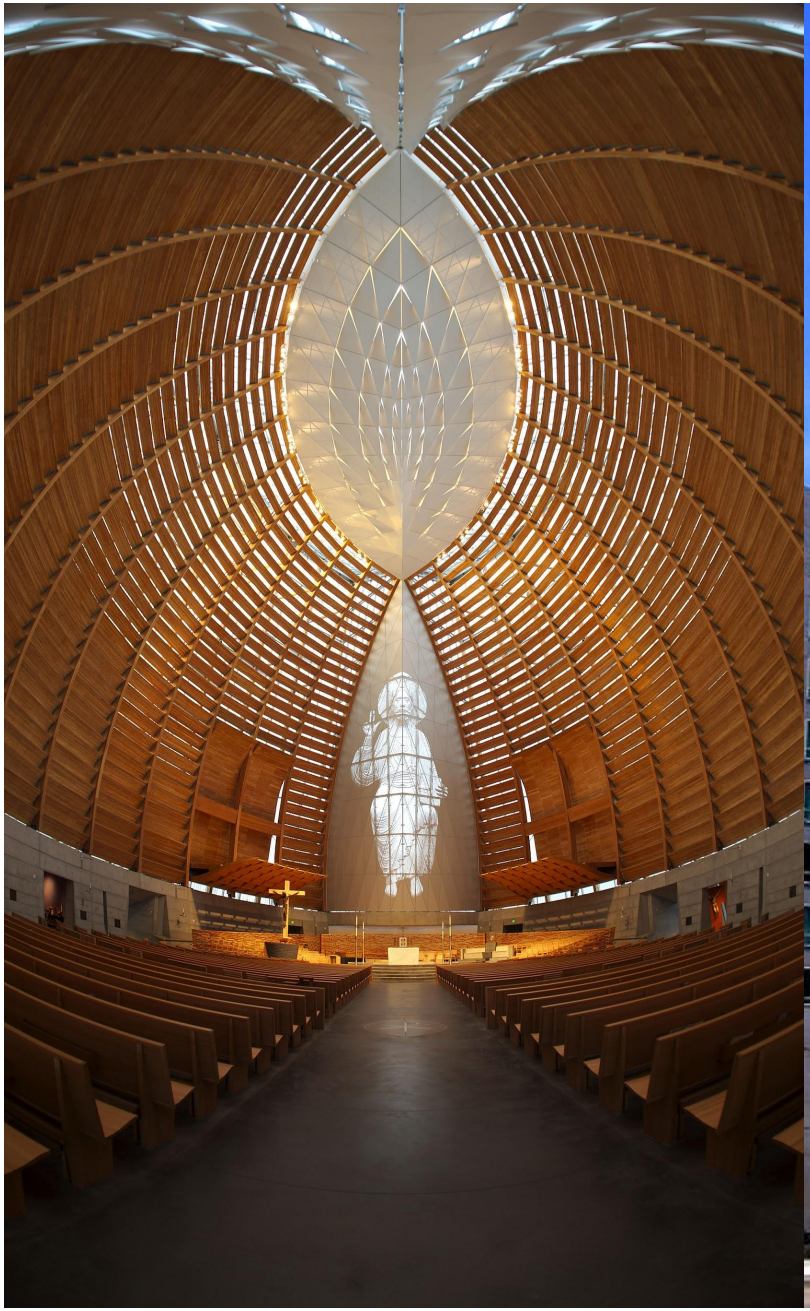
NEW BUILDING

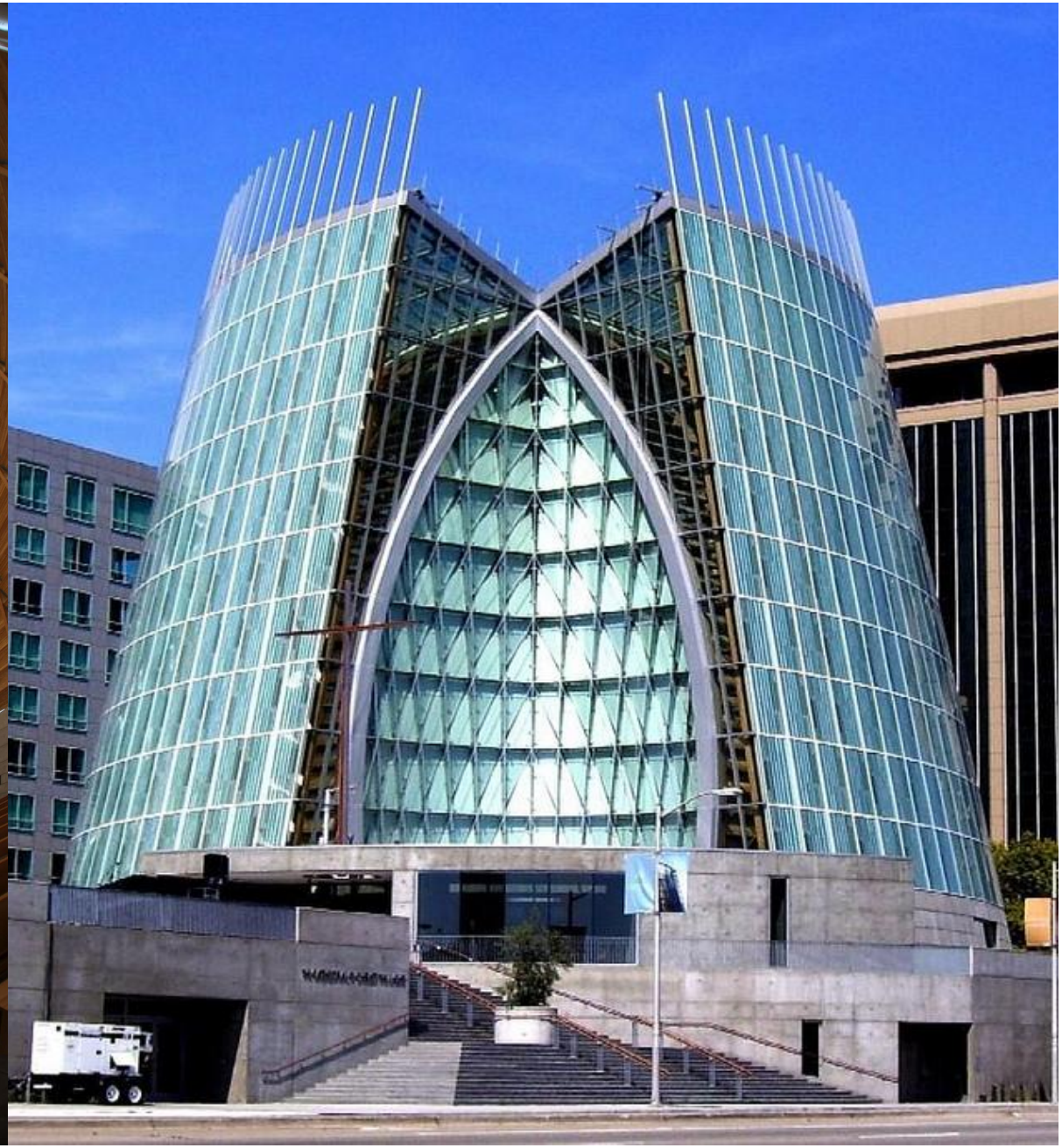
- The project leaders of the new building thought that it is essential for a building located to a major fault line to have a life of at least 300 years. With proper time to time maintenance it is said to have a life 1000 years.
- The structure is a glue laminated timber structure with a skeleton of steel rods with glass over it.
- The central theme of this structure is light.
- IT can seat up to 1500 people.
- The Vesica pisces is the biggest inspiration for this project and the floor plan is designed to resemble this. Vesica Pisces has great religious significance. When two circles are placed such that the center of each of them is on the circumference of the other. It forms the shape that in ancient texts is a sign of a congregation space.
- It is also the symbol of the miracle of loaves and fishes among Catholics.



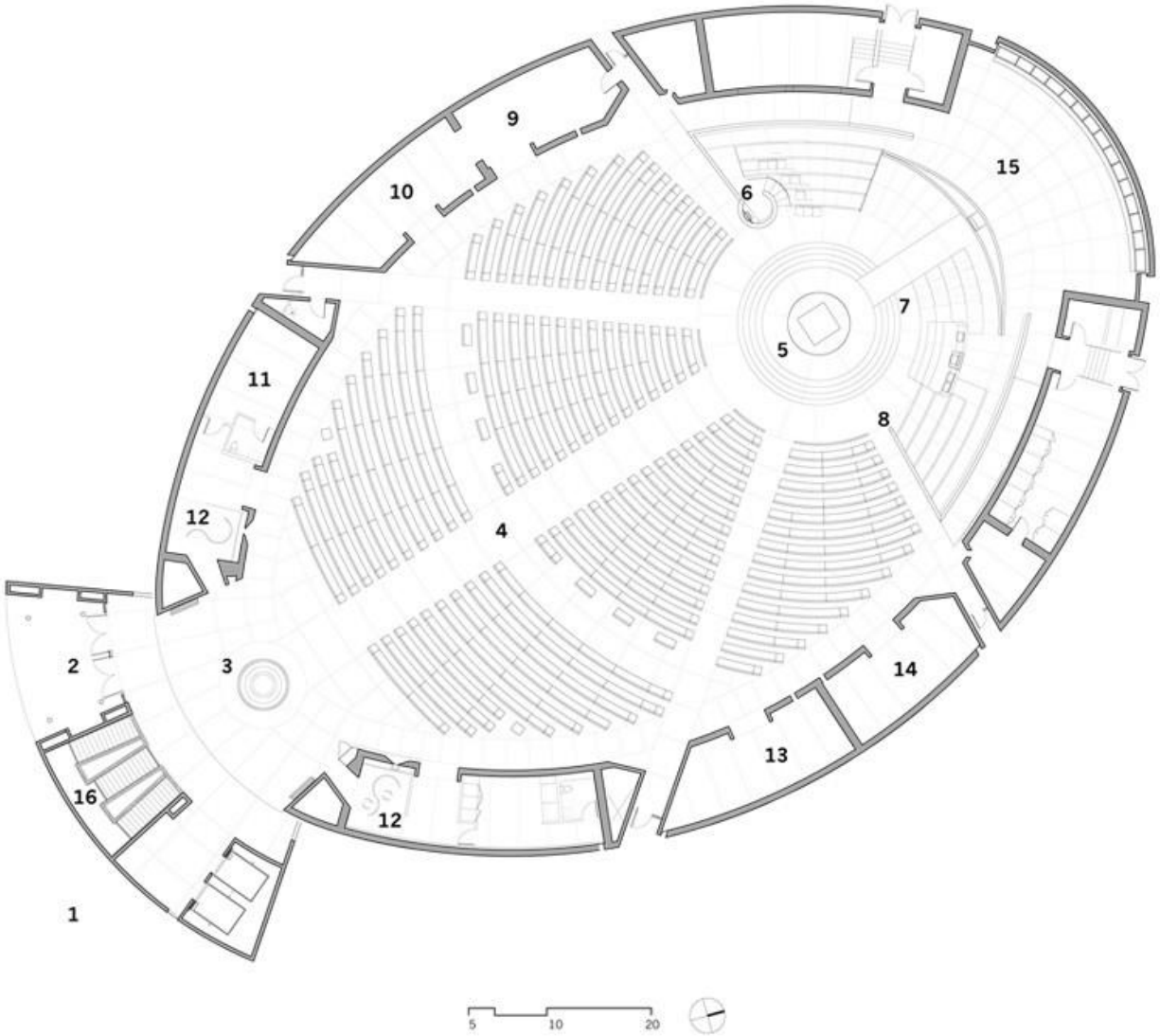
LOCATION


Kaiser Plaza
Ordway Building
155 Grand Avenue Building
22nd Street
21st Street
Grand Avenue
Harrison Street
Lake Merritt





PLAN



1 PLAZA
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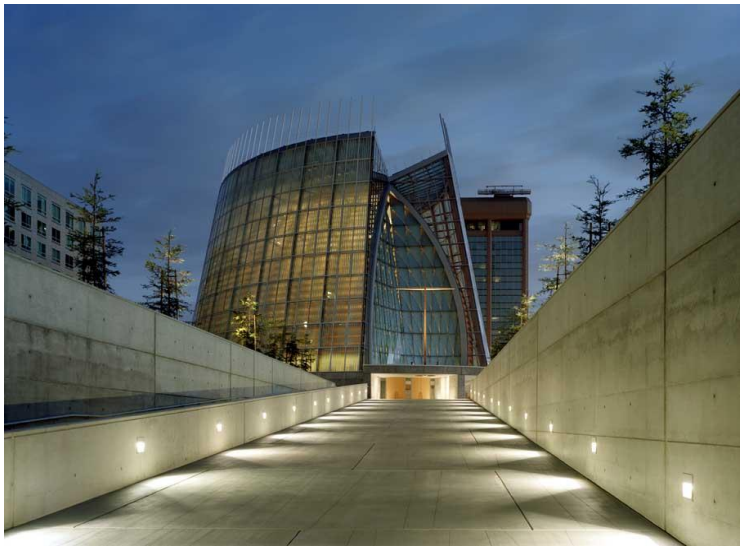
15 BLESSED SACRAMENT CHAPEL
16 STAIRS TO MAUSOLEUM

CATHEDRAL OF CHRIST THE LIGHT
SKIDMORE, OWINGS & MERRILL LLP

BUILDING DATA



Location: Oakland, California

Owner: Catholic Diocese of Oakland

Project Start: 2002

Project Completion: 2008

Site Area: 2.50 acres

Project Net Area: 250,000 Sq.ft

Number of Stories: 1

Building Height: 136 ft

Target User Group: Cultural

Service: Architecture, Interior Design, Structural & Civil Engineering, Branding & Graphics.

Architects: Skidmore, Owings & Merrill LLP

Architect Of Record: Kendall/Heaton Associates, Inc., Houston

Interior Design: Tamara Dinsmore, Chanda Capelli, Susanne LeBlanc, Carmen Carrasco, David Lou

Landscape Architect: Peter Walker and Partners

Technical Coordinator: David Diamond, AIA

Electrical Engineering: The Engineering Enterprise

Mechanical Engineering: Taylor Engineering, LLC

Civil Engineering: Korve Engineering

General Contractor: Webcor Builders

Exterior Wall Systems: Glass, Precast Concrete

Projects Representatives: Bishop Allen H. Vigneron, Provost Father Paul Minnihan, Project Director John L. McDonnell Jr.

Environmental Graphics: Lonny Israel, Alan Sinclair

Digital Design Coordinator: Douglas Smith, Associate AIA

Mausoleum Contractor: Oliver + Co.

Construction And Program Management: Conversion Management Associates, Inc. (CMA, Inc.)

AWARDS & HONORS

2015 - 50 Significant Structures in 50 Years Structural Engineers Association of Illinois

2010 - National Honor Award for Interior Architecture American Institute of Architects (AIA)

2009 - California Wood Design Award: Landmark Category Wood Works

2009 - Award of Excellence: Large Project, Landmark Structures Category Structural Engineers Association of Northern California

2009 - Jurors' Favorite Honor Award Structural Engineers Association of Illinois

2009 - Award of Excellence: Landmark Structures Structural Engineers Association of California

2009 - Jurors' Favorite Honor Award Structural Engineers Association of Illinois.

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2009 - Award of Excellence: Landmark Structures Structural Engineers Association of California

2009 - Architecture & Interiors Category: Gold Award Spark Awards

2009 - Honor Award Society for Environmental Graphic Design

2009 - Best East Bay Public or Cultural Space San Francisco Business Times

2009 - Best Community Impact - Inner East Bay San Francisco Business Times

2009 - Pro AV Spotlight Award (led by Shen Milsom Wilke, Inc.)Pro AV Magazine

2009 - Outstanding Project, New Buildings Under $10 million National Council of Structural Engineers Association.

2009 - Interior Design Award International Interior Design Association

AWARDS & HONORS

2009 - Best in Show International Interior Design Association - Northern California Chapter

2009 - Honor Award International Interior Design Association - Northern California Chapter

2009 - Best of Year: Institutional Merit Award Interior Design

2009 - Award for Community or Residential Structures Institution of Structural Engineers

2009 - Wood Engineering Innovation Award Forest Products Society

2009 - Design Award for Religious Architecture: Liturgical/Interior Design Faith and Form magazine and the Interfaith Forum on Religion, Art and Architecture (IFRAA)

2009 - Design Award for Religious Architecture: New Facilities Faith and Form magazine and the Interfaith Forum on Religion, Art and Architecture (IFRAA)

2009 - Annual National Award D&AD British Design and Art Direction

2009 - American Architecture Award Chicago Athenaeum

2009 - Annual Design Review Architect Magazine

2009 - Outstanding Architectural Engineering Project of the Year American Society of Civil Engineers - San Francisco Section

2009 - Annual National Award American Institute of Graphic Arts

2009 - National Honor Award for Architecture American Institute of Architects (AIA)

2009 - Excellence in Architecture: Honor Award AIA - San Francisco Chapter

2009 - Honor Award AIA - East Bay Chapter

2009 - Honor Award AIA - California Council

2008 - Ten of the World's Most Beautiful Green Buildingstreehugger.com

2008 - Wood Design Awards: Honor Award Wood Design & Building Magazine

2008 - Best Building Site of the Year Wallpaper Magazine

2008 - Best of the Best Award McGraw-Hill Construction

2008 - Overall Top Project California Construction Magazine

2008 - Outstanding Architectural Design California Construction Magazine

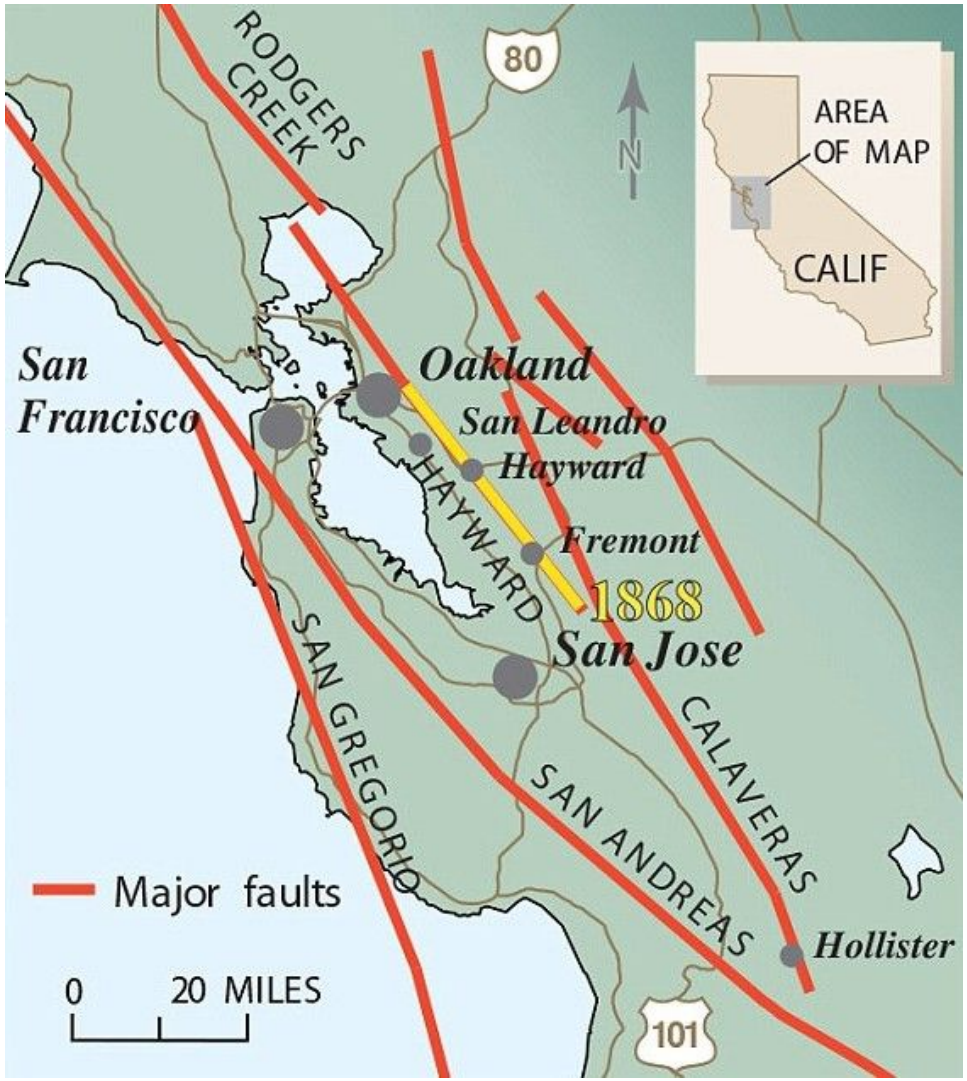
2007 - Regional Architecture Award for Use of Concrete American Concrete Institute - Northern California and Western Nevada Chapter

2003 - Unbuilt Design Award AIA - San Francisco Chapter

GEOGRAPHY

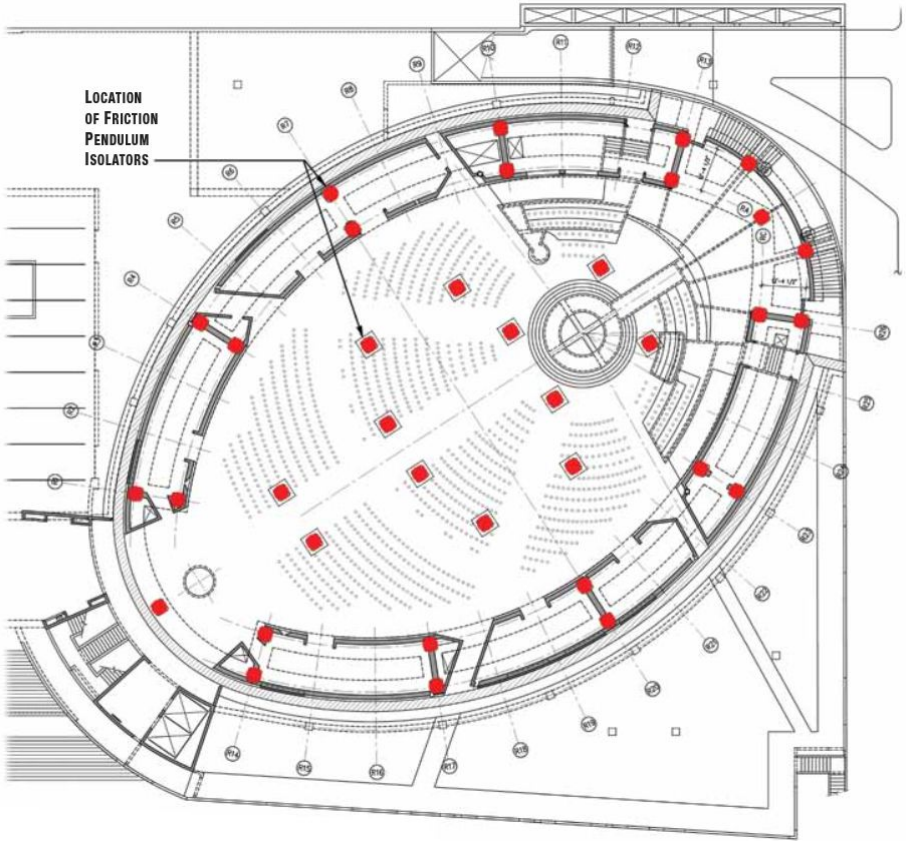
STRUCTURAL DESIGN GOALS

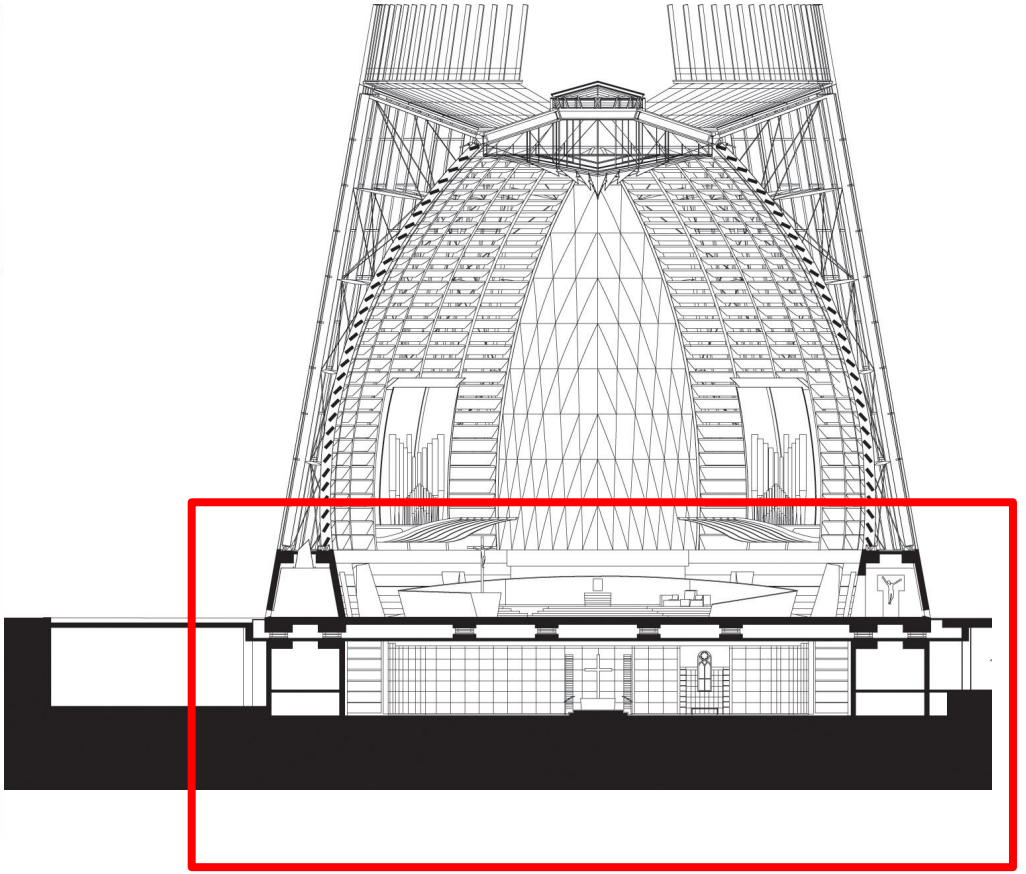
- Building life of 300 years
- Withstand a 1000 year earthquake event
- Site located 9 miles from the Hayward Fault



FOUNDATION

BASE ISOLATION FOUNDATION SYSTEM





Concrete base floats on 36 insulators: situated beneath its thick concrete floor slab,, each with a four-foot-diameter steel bearing.

At same time, the superstructure is supported atop an eighteen-foot-high mausoleum substructure of reinforced concrete extending to a reinforced concrete mat foundation.

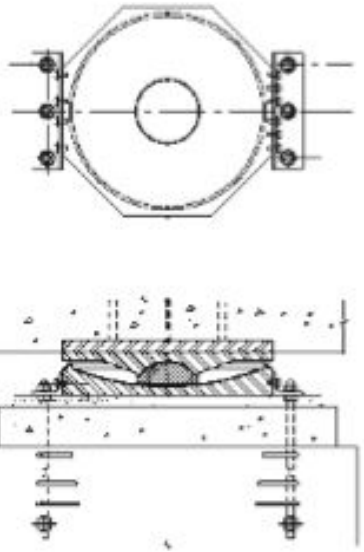
FOUNDATION

Seismic base isolation, along with cast in place reinforced concrete on the base due to California's earthquake prompt location.

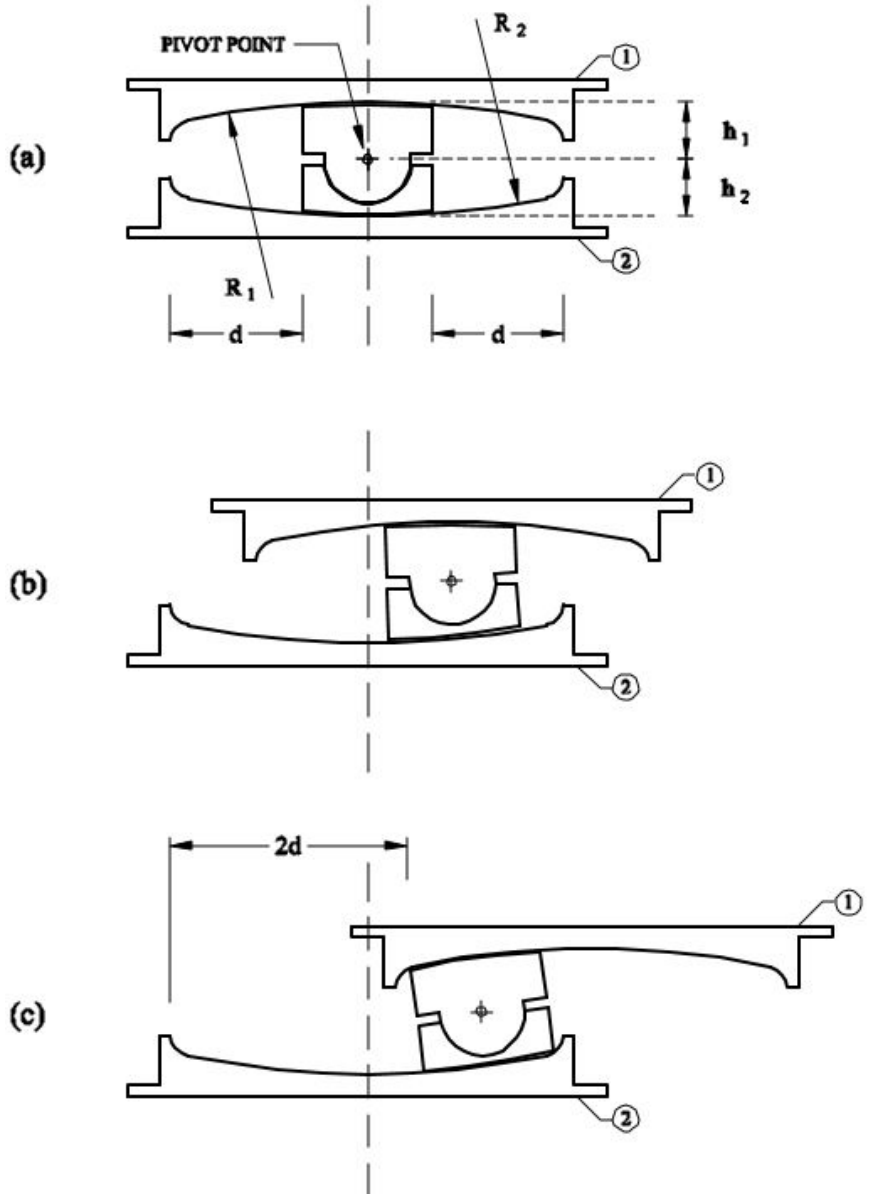
Base isolation was typically applied for one of the following reasons:

1. Providing immediate post-earthquake operability for disaster response.
2. Providing higher-than-normal levels of seismic performance as desired by the owner, because of the building's function or contents.
3. Enhancing the seismic performance of an existing historic building with minimal architectural disruption.

BASE ISOLATION SYSTEM

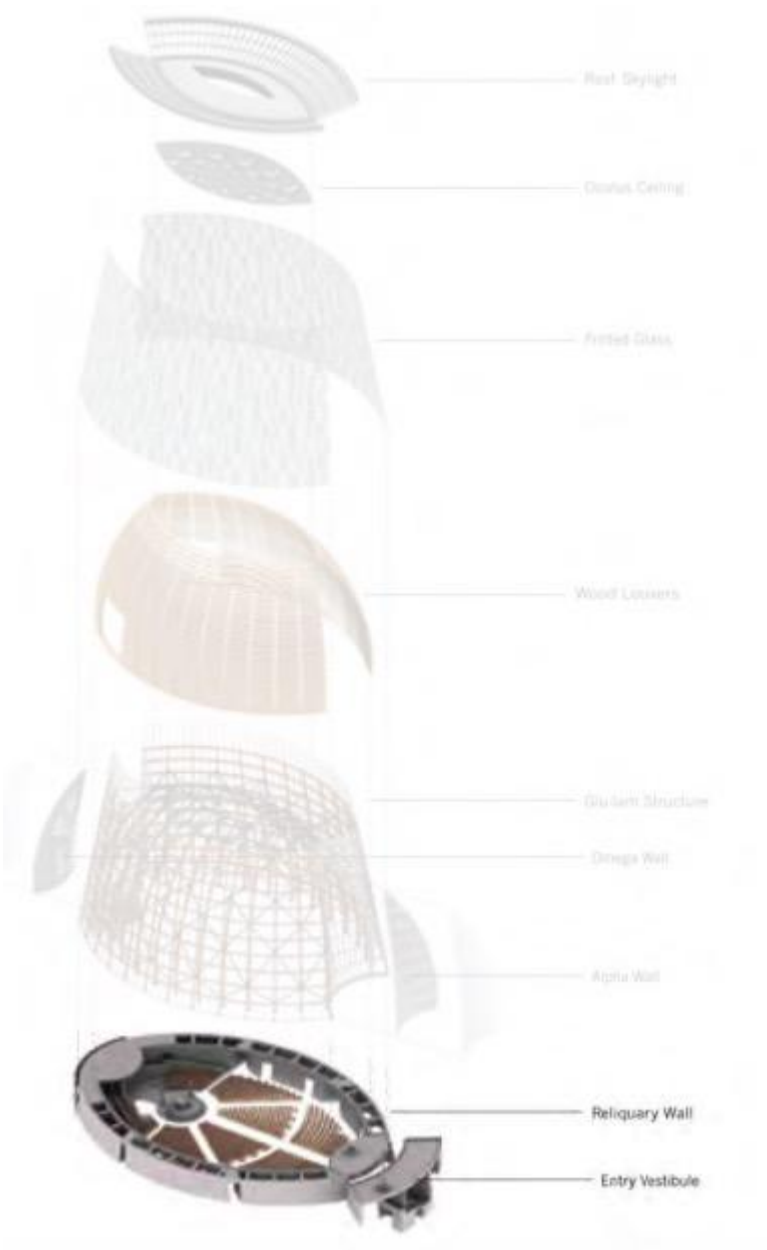


DOUBLE CONCAVE STEEL FRICTION PENDULUM SYSTEM

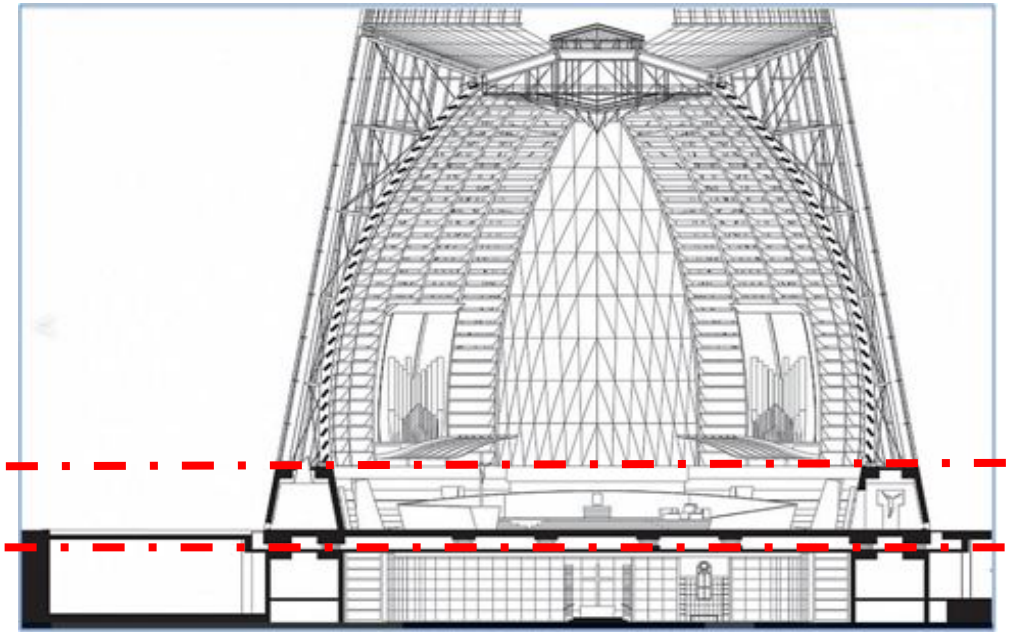


Cross section of DCFP bearing at various stages of lateral movement

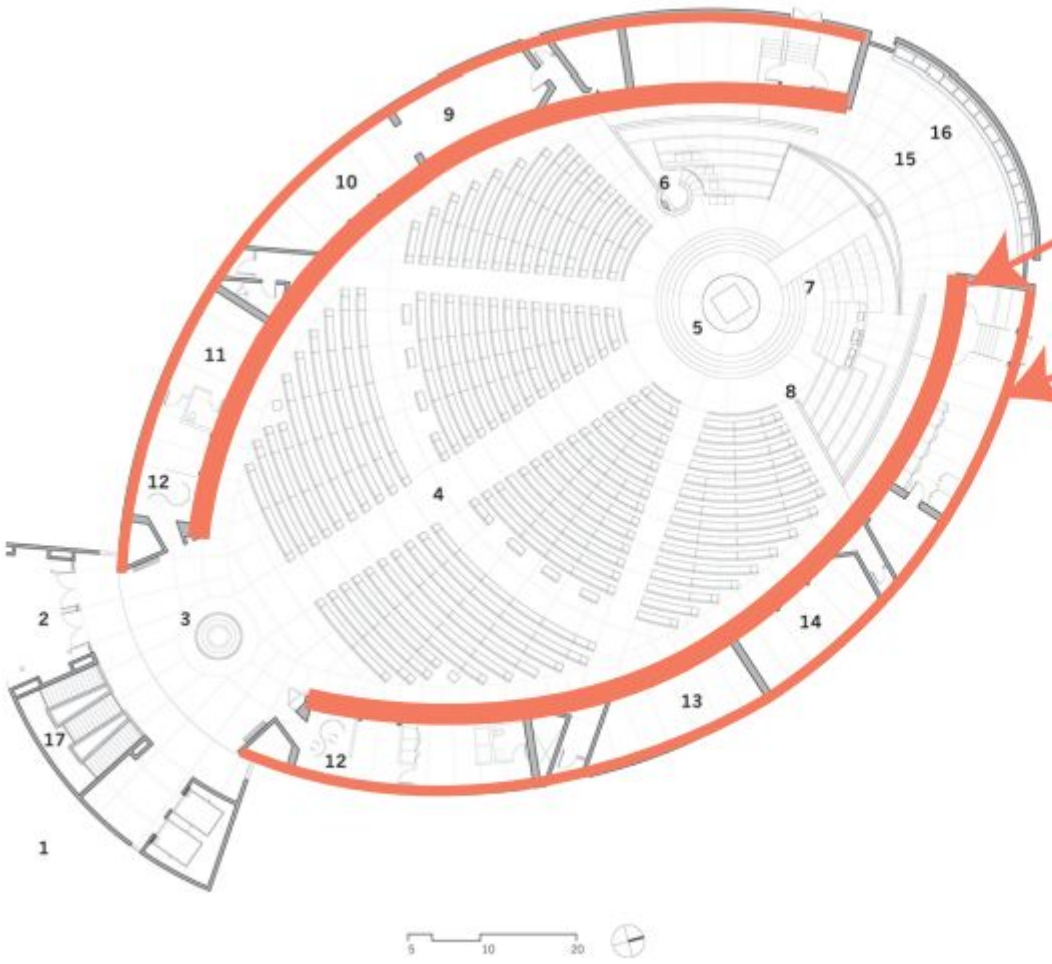
RELIQUARY WALL



The superstructure system of timber and structural steel is supported by 14 in. (356 mm) thick cast-in-place ductile reliquary walls of reinforced concrete. The architecturally exposed concrete reliquary walls extend 15 ft (4.6 m) above the sanctuary floor and provide both gravity and lateral load support for the superstructure above. The walls are curved in plan and slope in section. The bases of the reliquary walls are interconnected by a horizontal two-way 12 in. (305 mm) thick concrete diaphragm slab reinforced in two directions at the sanctuary floor. The tops of the walls are interconnected by reinforced-concrete framing beams and slabs that also provide support for the pinned connections to the glulam timber ribs above.



SHEAR WALL PLAN



Primary Structure on Interior Circumference

Secondary Structure on Exterior Circumference

1 PLAZA
2 ENTRYWAY
3 BAPTISTRY
4 CENTER AISLE
5 ALTAR
6 AMBO
7 CATHEDRA
8 MARY–MOTHER OF THE CHURCH OF OAKLAND
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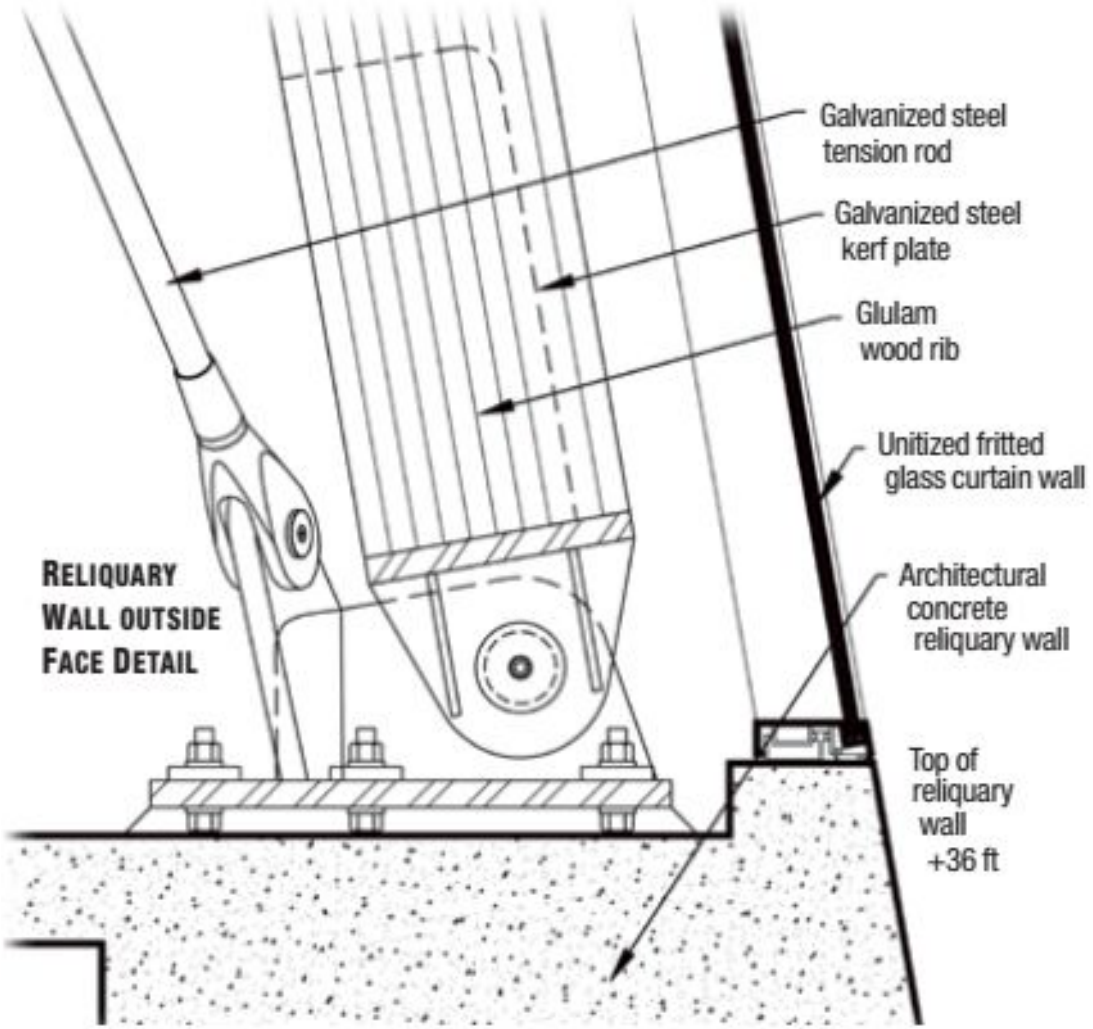
16 BLESSED SACRAMENT CHAPEL
17 STAIRS TO MAUSOLEUM

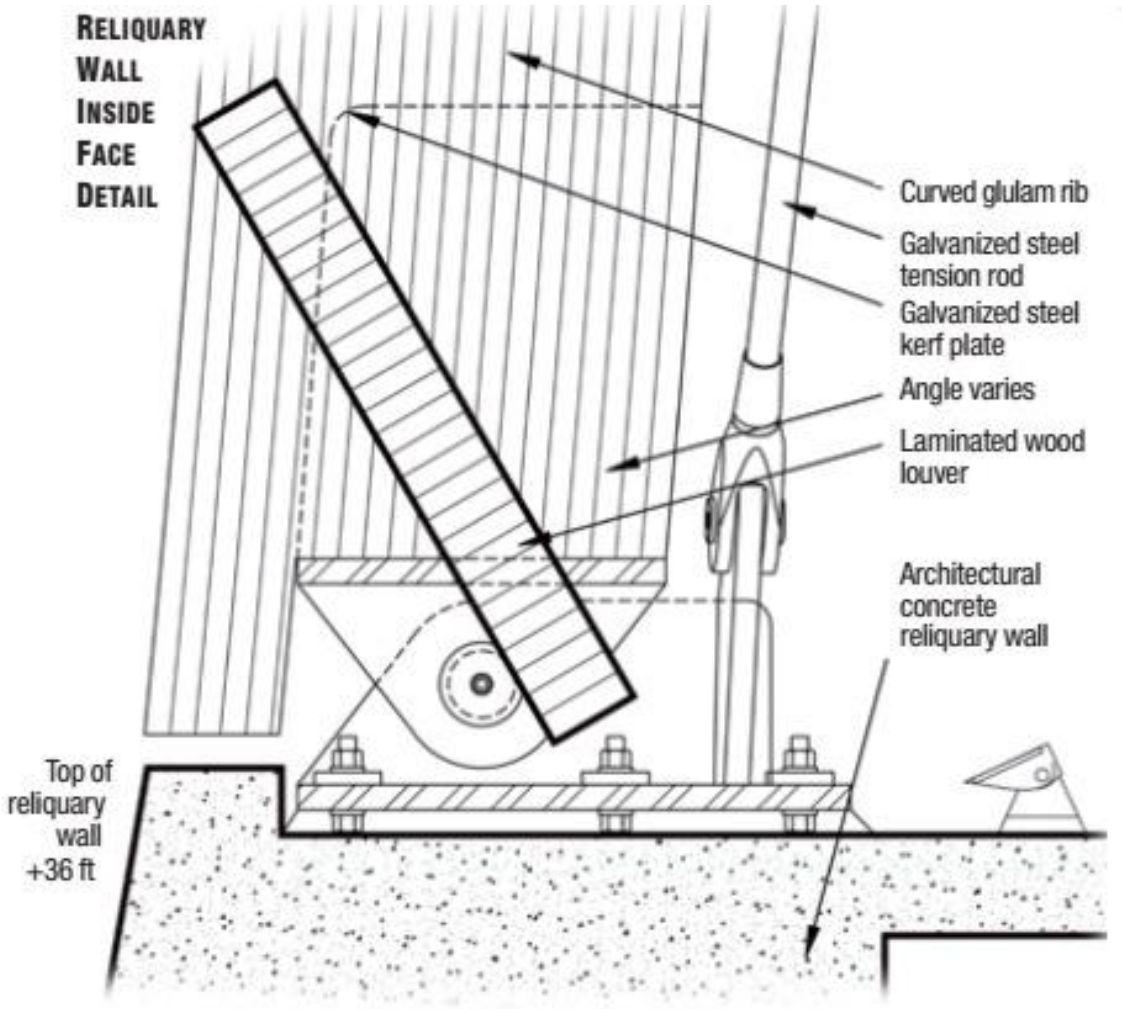
REINFORCED CONCRETE

REINFORCED CONCRETE

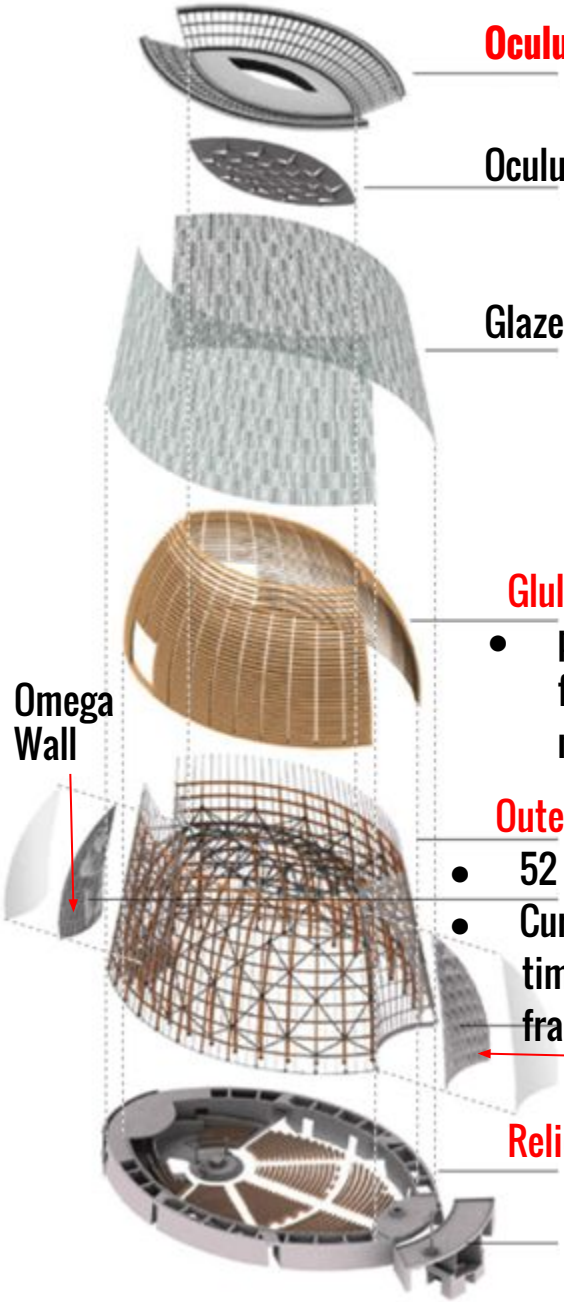
Outside Joint Details



Inside Joint Details



SUPERSTRUCTURE - COMPONENTS



Oculus steel roof framing

Oculus Ceiling

Glazed Exterior Wall

Glulam Louvers

- provide **lateral bracing** for the inner curved rib members

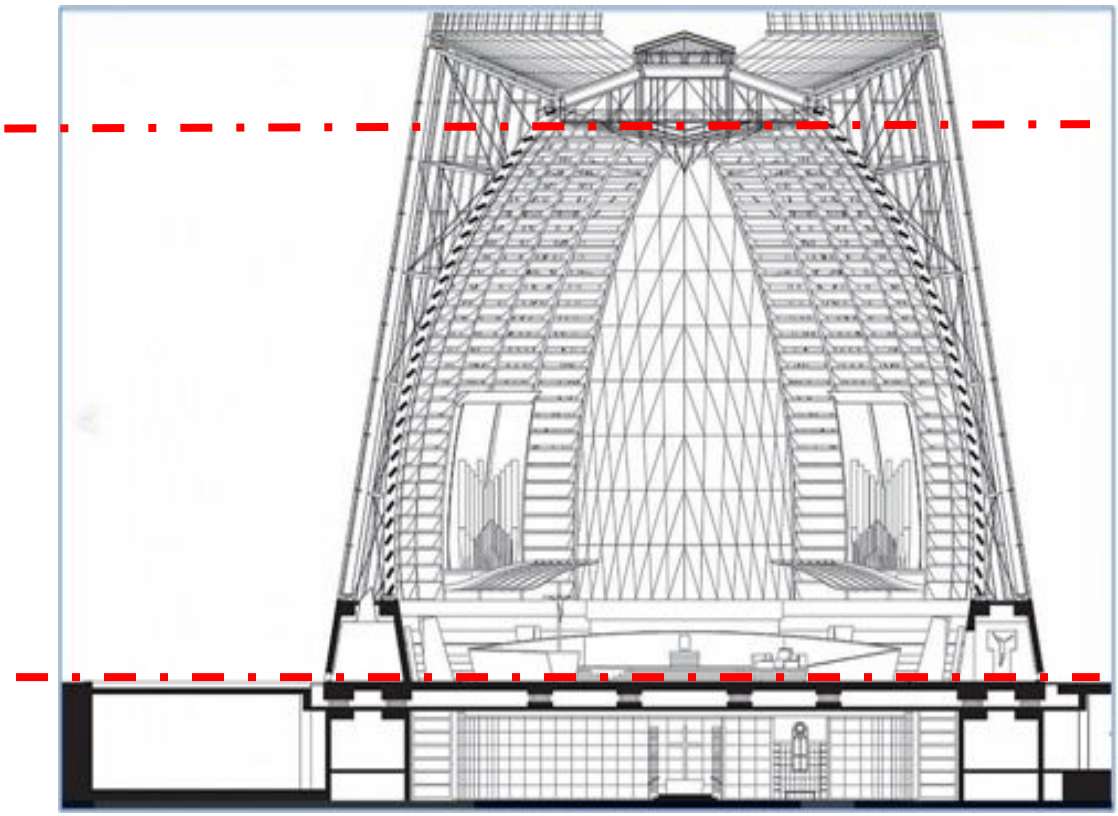
Omega Wall

Outer and Inner timber Ribs

- 52 members **resist Gravity Loads**
- Curved and Tapered glulam wood timber rib members form the framework

Alpha Wall

Reliquary Wall



SECTION

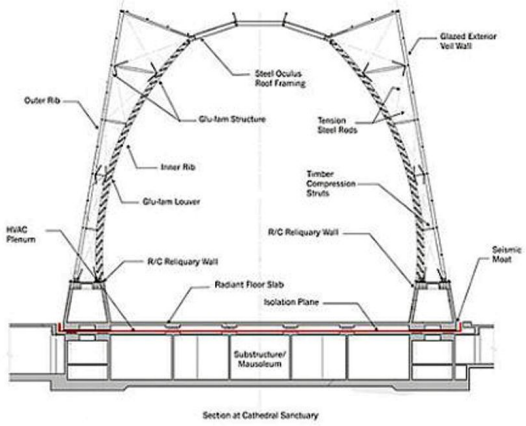
The superstructure is supported atop an 18 ft high mausoleum substructure of reinforced concrete that extends to a reinforced-concrete mat foundation.

WOOD IN CATHEDRAL

- Unifying Architectural, structural and spiritual design element
- Design team examined glulam timber use-historical development, current standards and codes, durability and exposure to ultraviolet light, effect of temperature, relative humidity, structural redundancy, protective treatment and long term maintenance
- The wood timbers natural cellulose structure of lignin and cellulose fiber makes it excellent insulating material highly resistant to acids, alkalis, salts, and other chemical substances.
- **Douglas fir** selected because of its availability on West Coast and offered economic benefits, strength, stability, consistency and natural architecture appearance

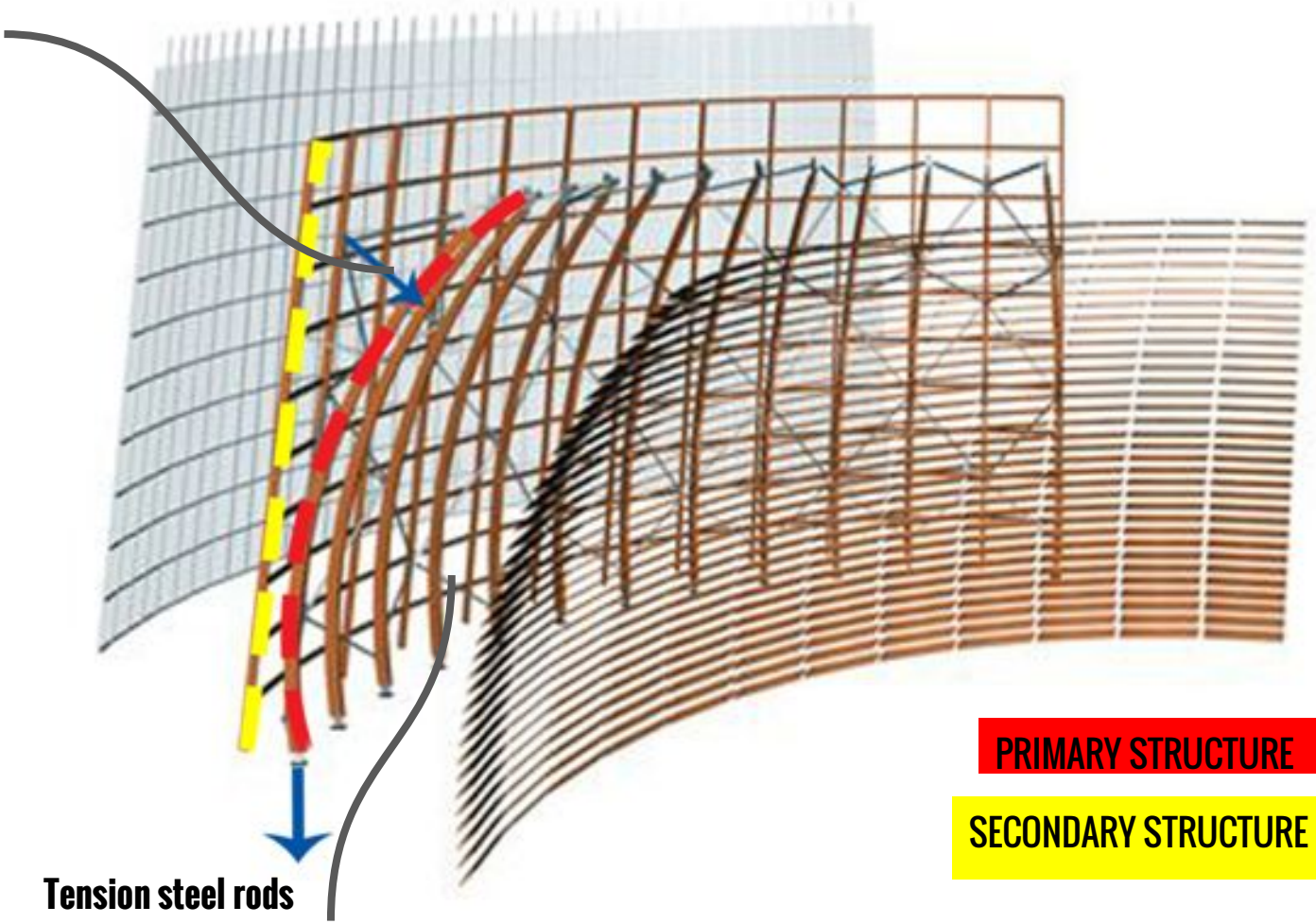
HYBRID STRUCTURAL SYSTEM

- Reinforced concrete
- Prefabricated glue laminated timber
- High strength structural steel rods paired with glued laminated wood compression struts
- Steel friction pendulum seismic base isolation system



Section at Cathedral Sanctuary

Timber Compression Struts



Tension steel rods

PRIMARY STRUCTURE

SECONDARY STRUCTURE

224 steel tension rods and 104 glulam timber compression struts

- Provide redundancy and reserve **ductile capacity** in the **lateral-load-resisting system**.
- The steel rods **resist both wind and seismic forces.**
- Typical rods are 1 in. diameter, while the critical load path rods range in diameter from 1.25 to 2 in.
- .Force amplification was calculated to be approximately 10 percent greater than the anticipated static load.
- 104 turned glulam compression struts are located between the inner curved rib and the outer vertical rib at 20.5 ft intervals to coincide with the connection points of the high-strength steel rods.
- **Axial compression struts** feature **pinned connections** to the inner curved rib and the outer vertical rib

OCULUS CEILING

- Made of structural steel wide-flange framing and a metal roof deck
- Behaves as **compression ring and diaphragm** interconnecting the hybrid steel and timber braced-frame elements from all sides of the cathedral at the roof elevation

GLULAM TIMBER LOUVERS

- 51/8 in.wide and vary in depth from 39 in.at the base to 22 in.at the top.
- Mounting angle from horizontal varies from 60 degrees at the base to 16 degrees at the top.
- 724 closely spaced glulam timber louver members interconnect and **provide lateral bracing** for the inner curved rib members.

STEEL MULLION

Horizontal tubular Steel mullions

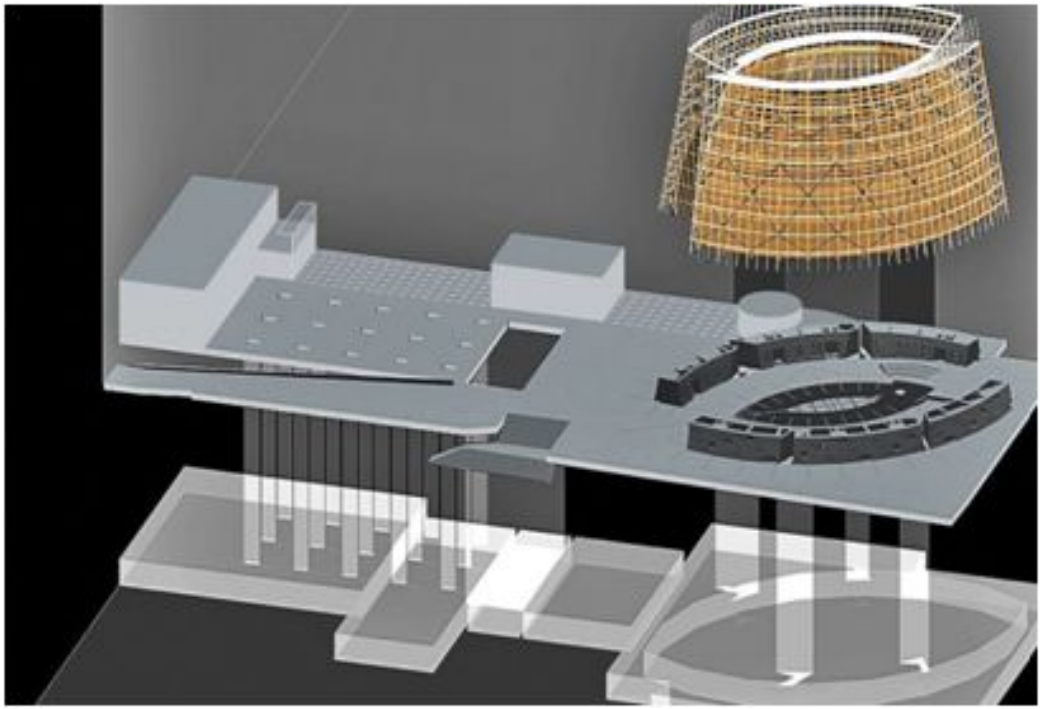
- Located between outer vertical rib members spaced at 10.25 ft intervals.
- The mullions are 6 in. wide and 3 in. deep and provide **lateral bracing** for the outer vertical ribs and support the exterior wall.
- Structural steel bolted connections are used to connect the primary structural members.
- All hybrid frame timber and steel elements and connections- shop-welded and subjected to hot-dip galvanization.

Seismic performance-SUPERSTRUCTURE

Components of the super structure -exterior wall, roof enclosure, interior components were designed for DBE (Design Basis earthquake) MCE (Maximum Considered Earthquake) force levels including peak vertical and horizontal accelerations

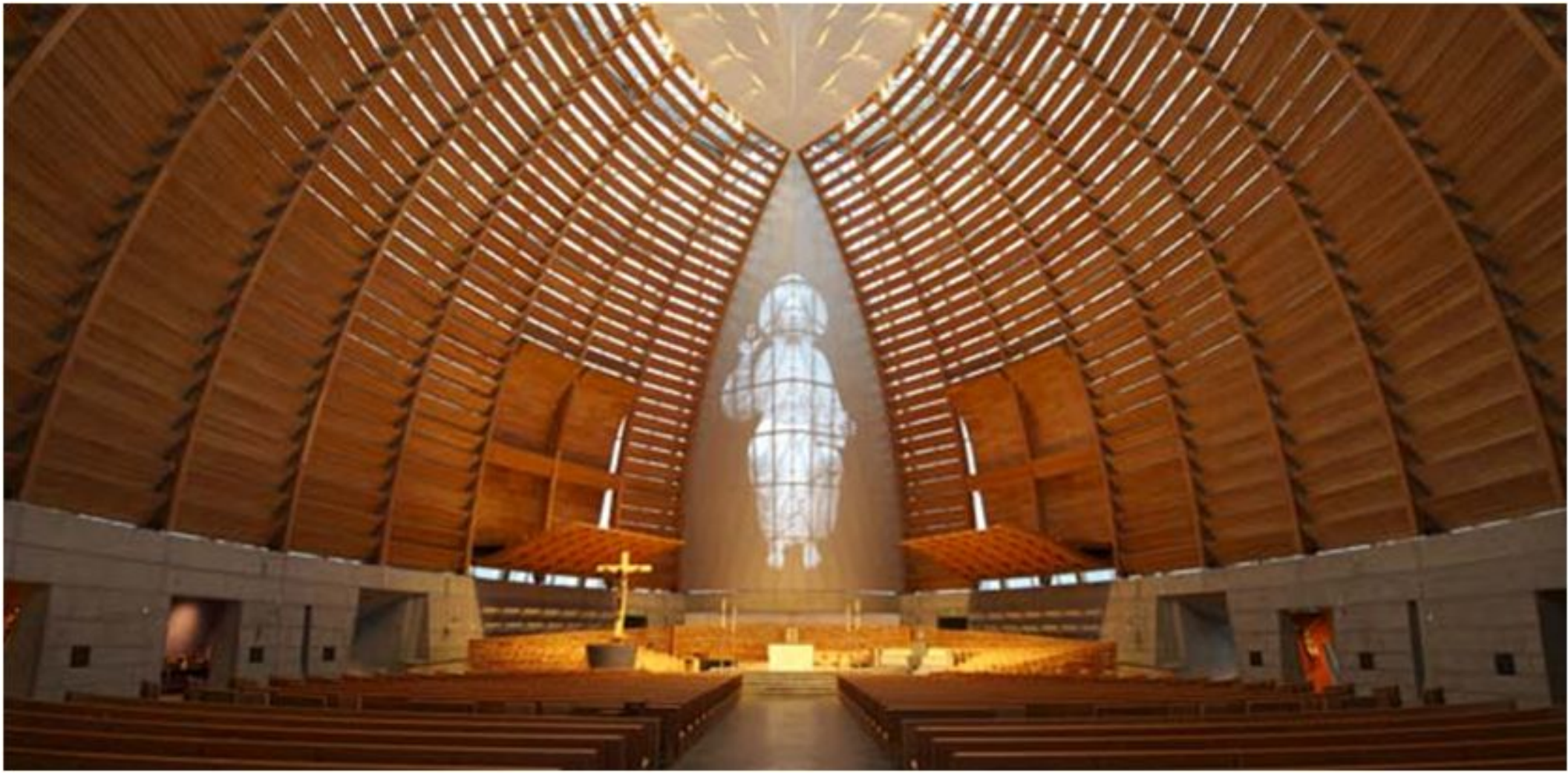
- DBE (Design Basis earthquake)- peak horizontal accelerations with 10% probability of exceedance in 50 years
- MCE (Maximum Considered Earthquake)- the peak horizontal accelerations with 2% probability of exceedance in 50 years

Pedestrian level wind tunnel studies were also conducted along with **estimation of base shears, overturning moments, base torque, load case combinations and dynamic effect of wind gusts**.



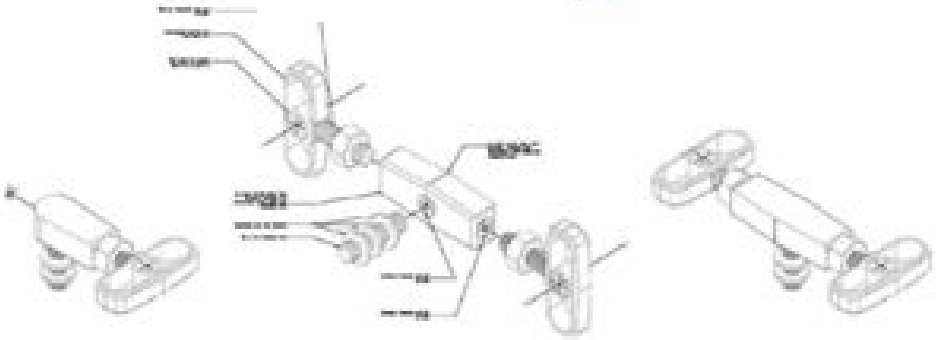
OMEGA WALL

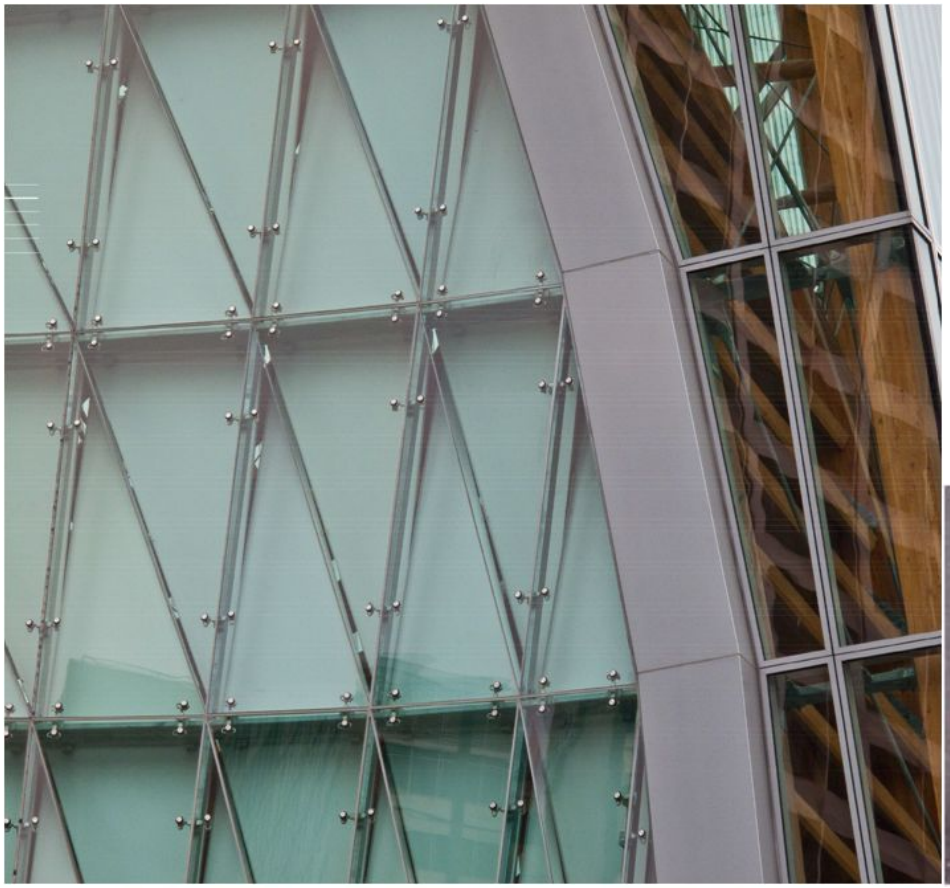
- Located at Sanctuary's Northern end
- Bounded by roof compression ring, end glulam timber ribs, reliquary wall elements
- 58 ft high tall image of Jesus Christ created from series of perforated triangulated aluminum panels

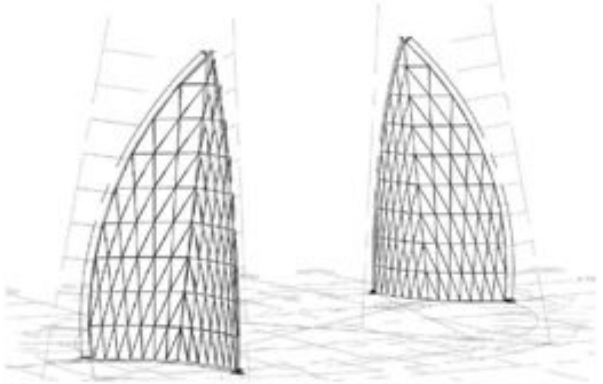


GLASS IN ALPHA AND OMEGA WALLS

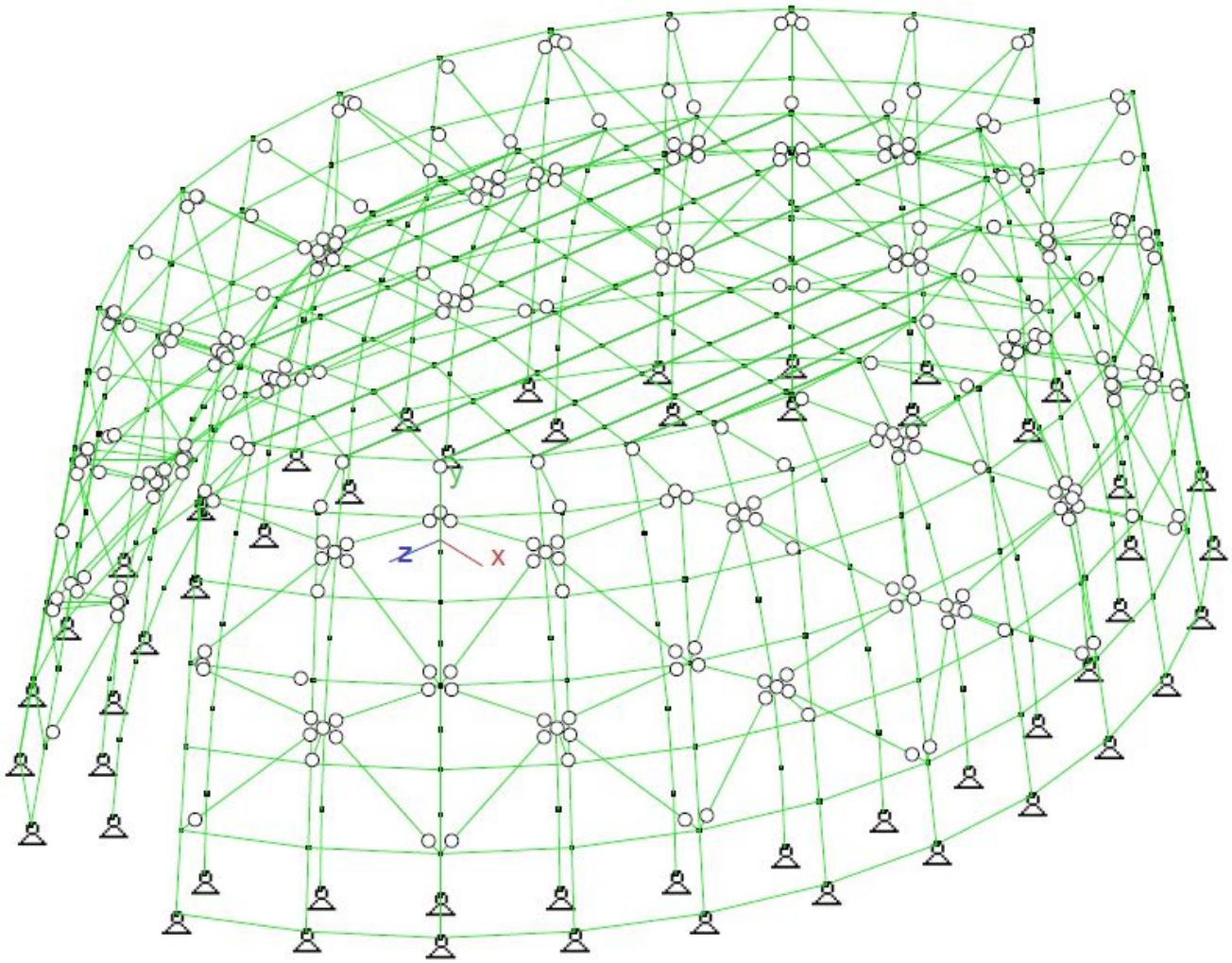
- Two 88 ft point supported glass walls -600 sqft of sloped glazing
- 308 triangulated glass panels create double curvature surface supported by glass bolts at four drilled hole location offset from each panel corner along two out of three edges.
- The offset from vertex of six unique panels reduces nodal coordination



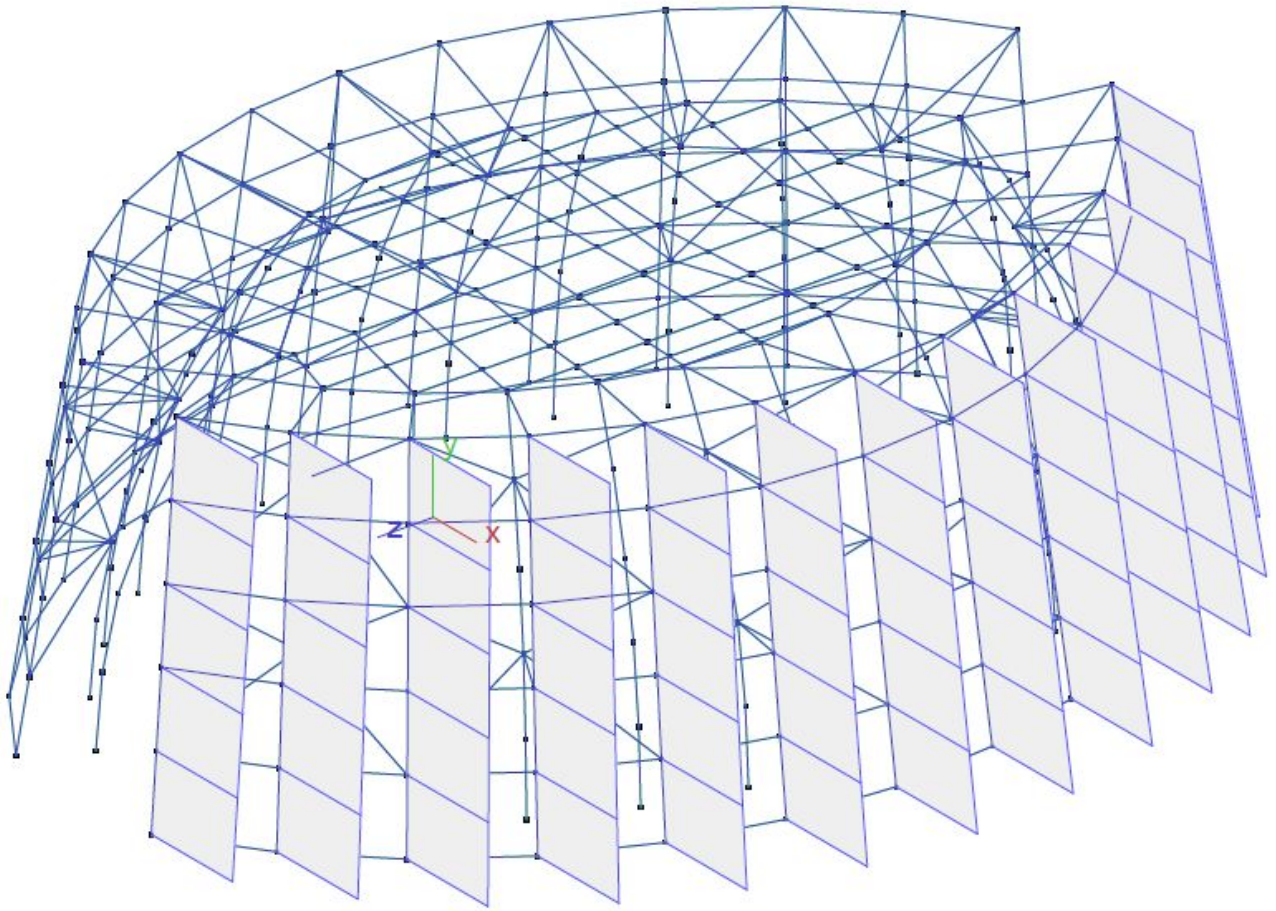




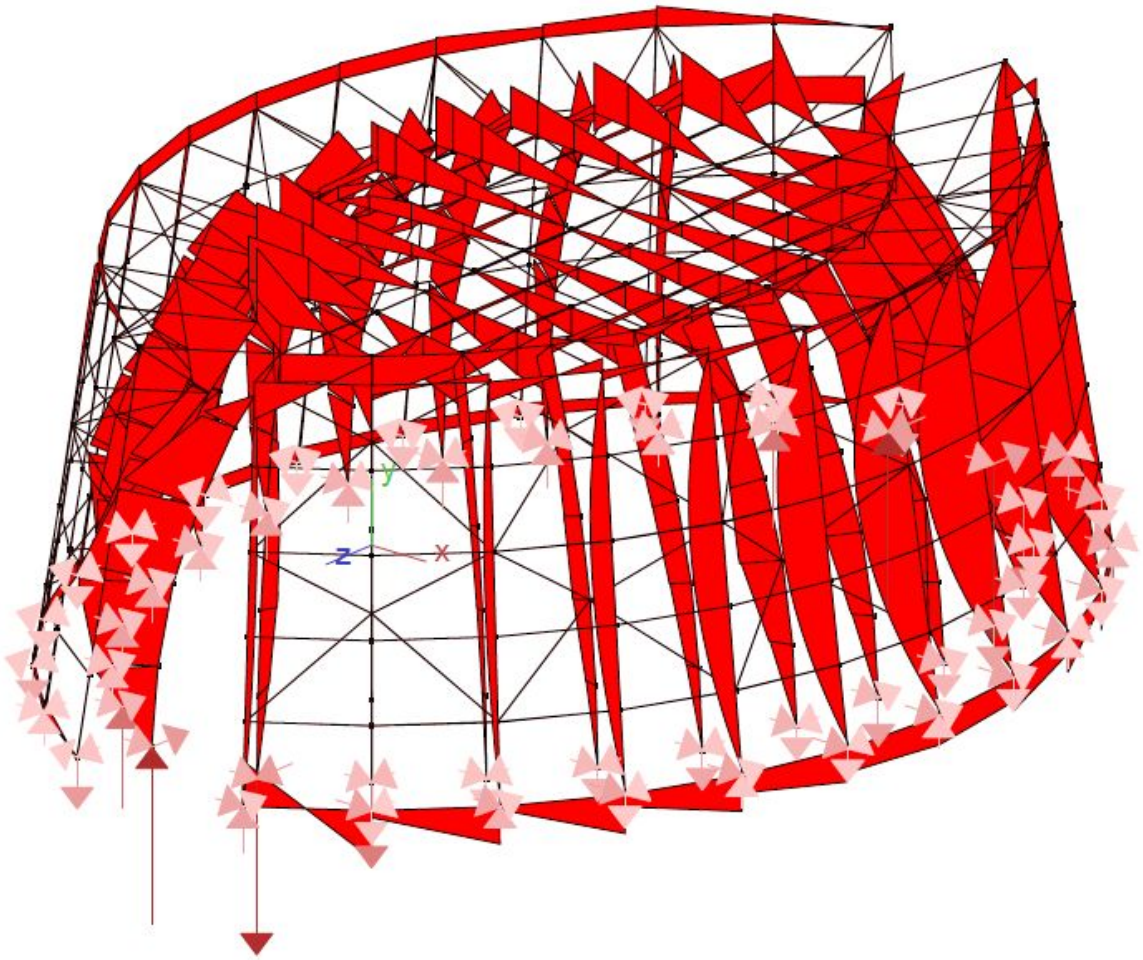
LOAD ANALYSIS - Joints Type

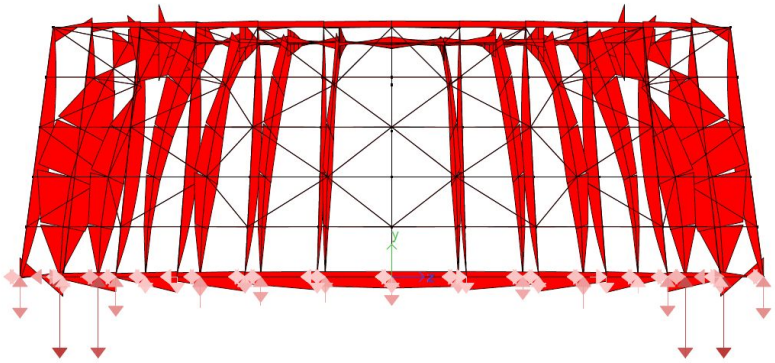


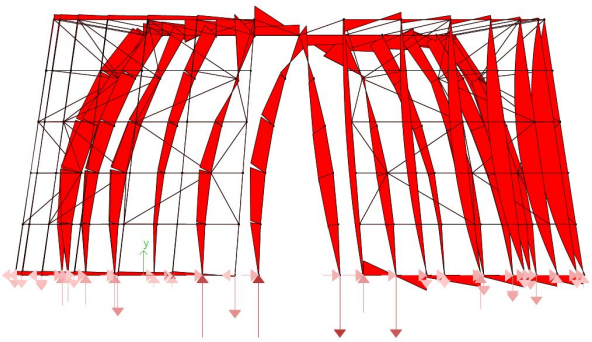
LOAD ANALYSIS - Lateral Load



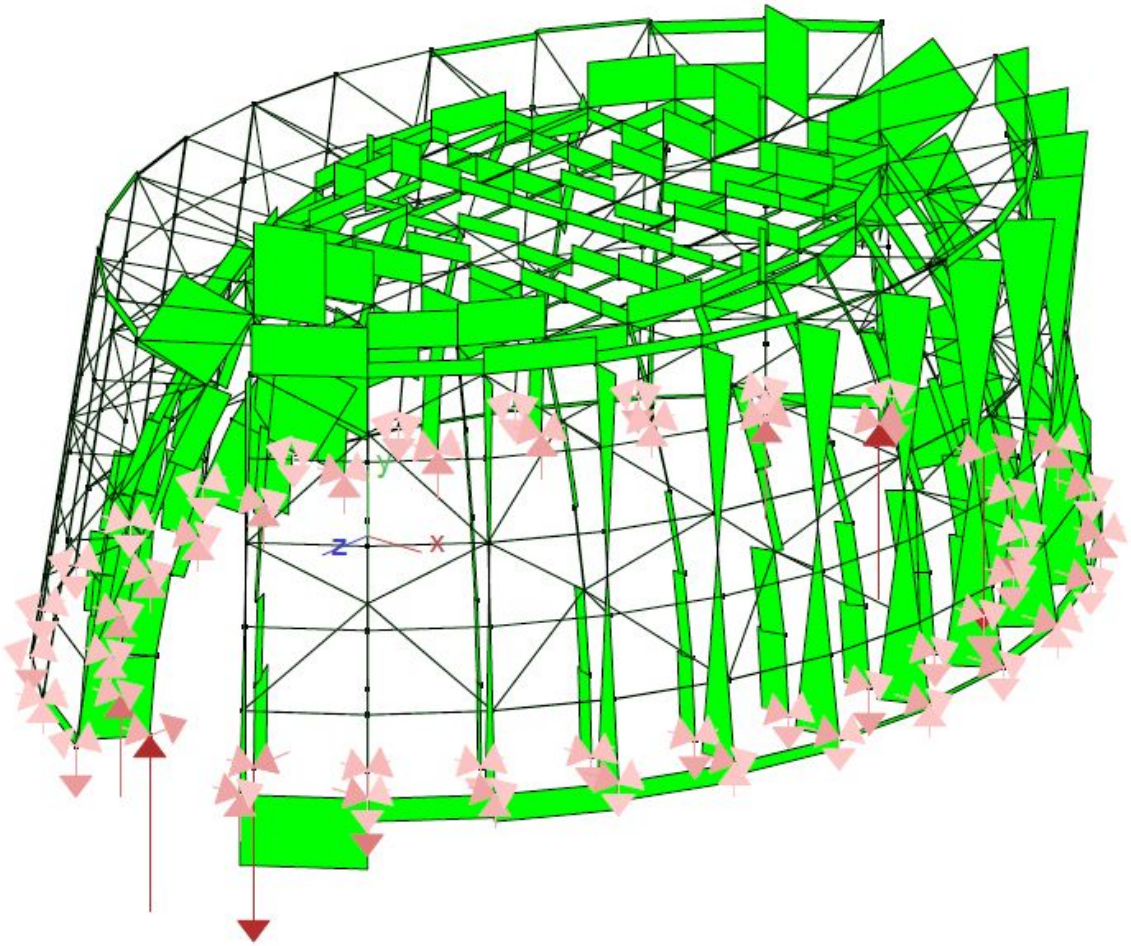
LOAD ANALYSIS - Bending Moment

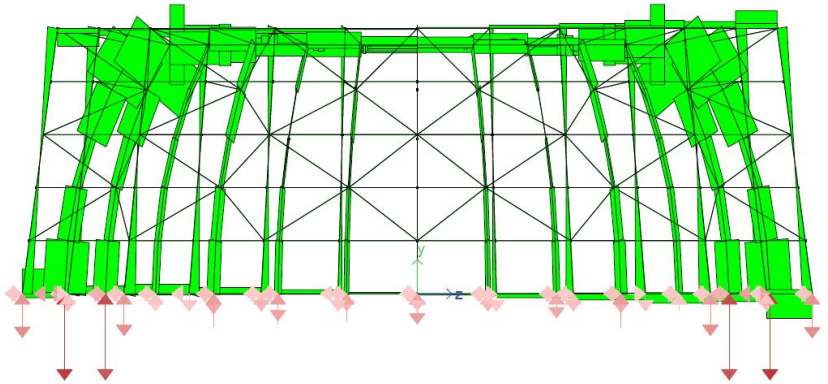


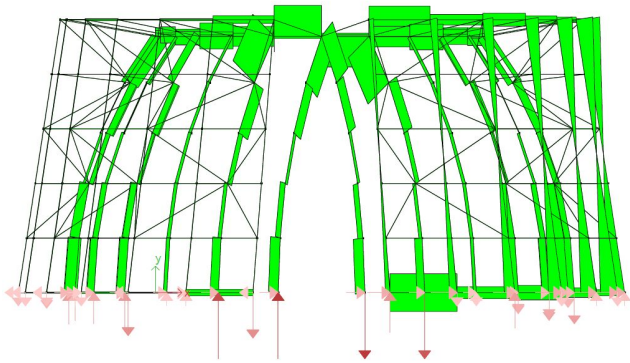




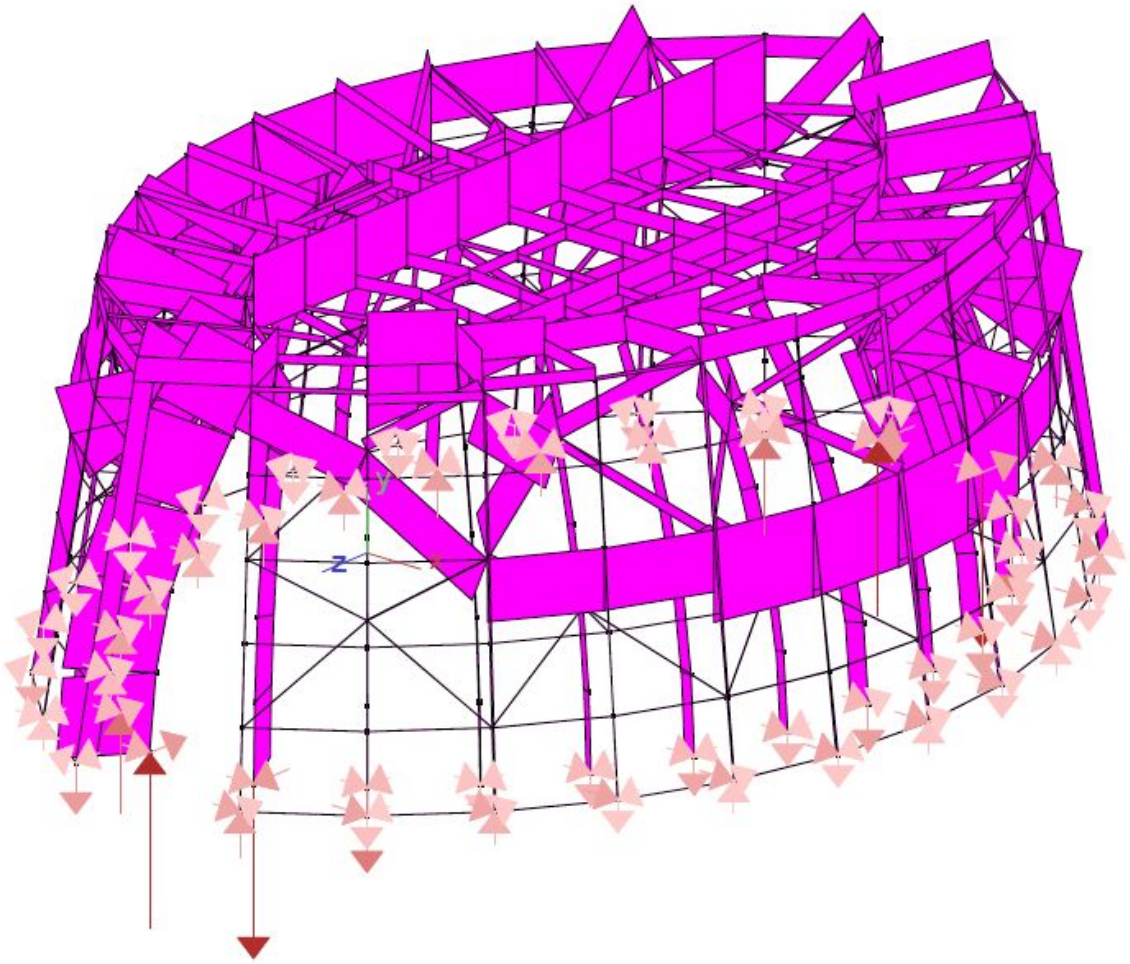
LOAD ANALYSIS - Shear







LOAD ANALYSIS - Axial Force



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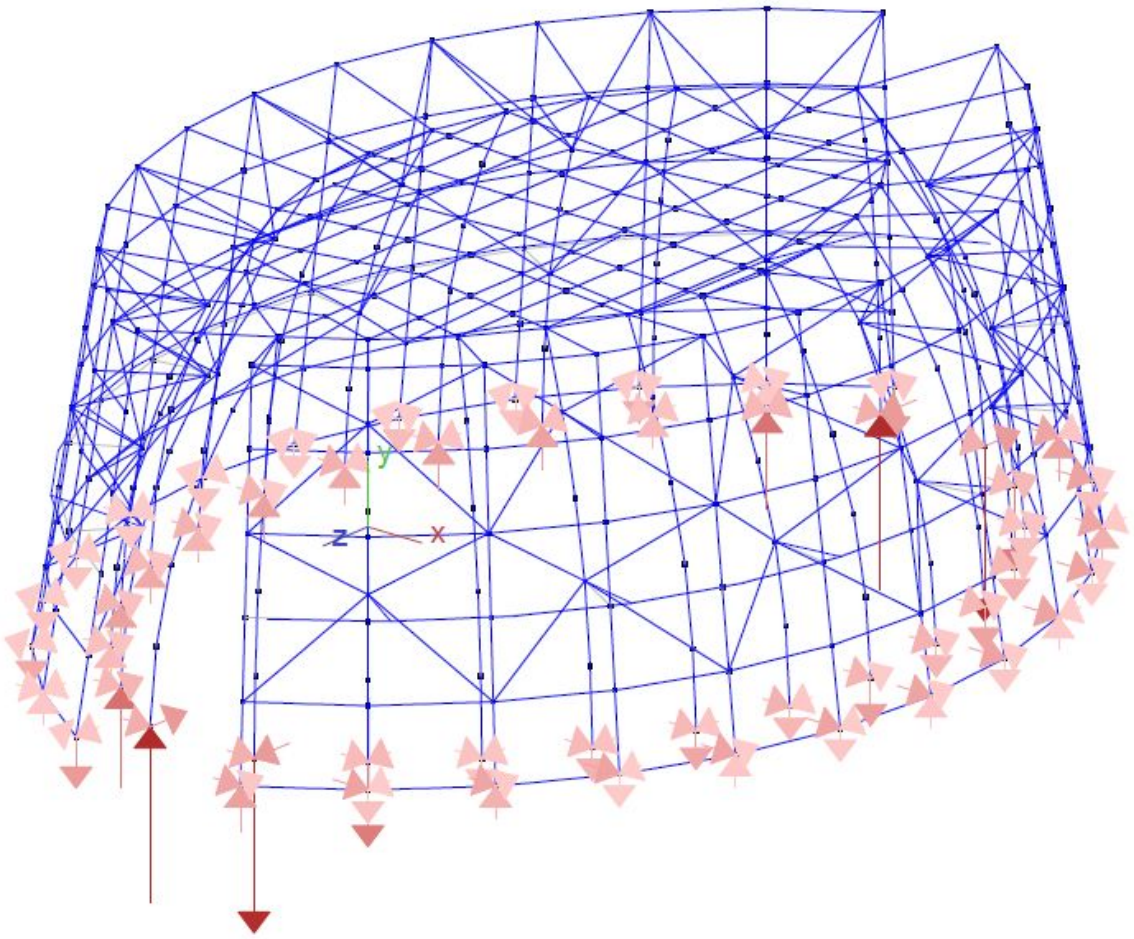

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ima photography

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GLULAM TIMBER LOUVER IMAGE SOM-Skidmore, Owings & Merrill LLP. www.som.com/projects/cathedral_of_christ_the_light-structural engineering

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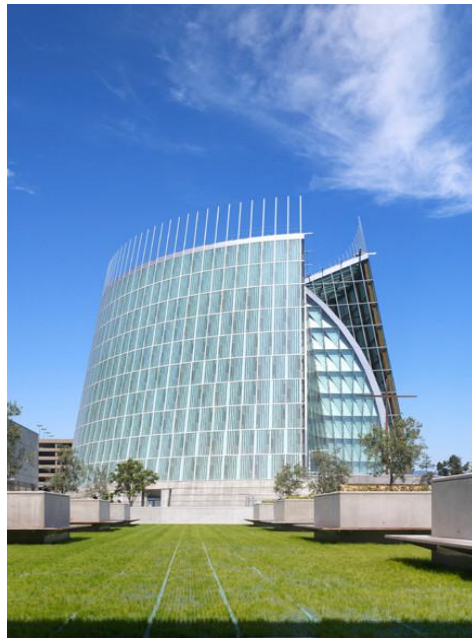
“An Aggie does not lie, cheat or steal or tolerate those who do”

TABLE OF CONTENTS

INTRODUCTION

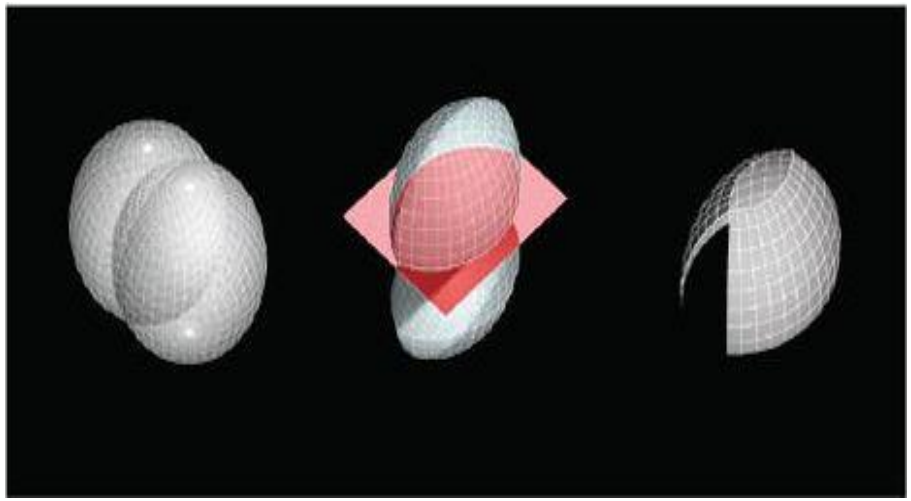
HISTORY

- Pope XXIII established the Diocese in Oakland in the vear 1962. St. Francis De Sales was then designated as the first Cathedral. It was initially built with major funding from an Irish immigrant.
- It already served as a lively hub in Oakland. It became a center of ethnic richness with settlers from World war II and after that it started to attract people from the phillipines and other places across the globe.
- This gave it a global face and started to become an icon.
- The music of this Cathedral rose to new levels of excellence and it came to be known as the "Cathedral Oakland Sound".
- In october 1989, the Loma Prieta earthquake damaged the Cathedral rendering the building unusable.

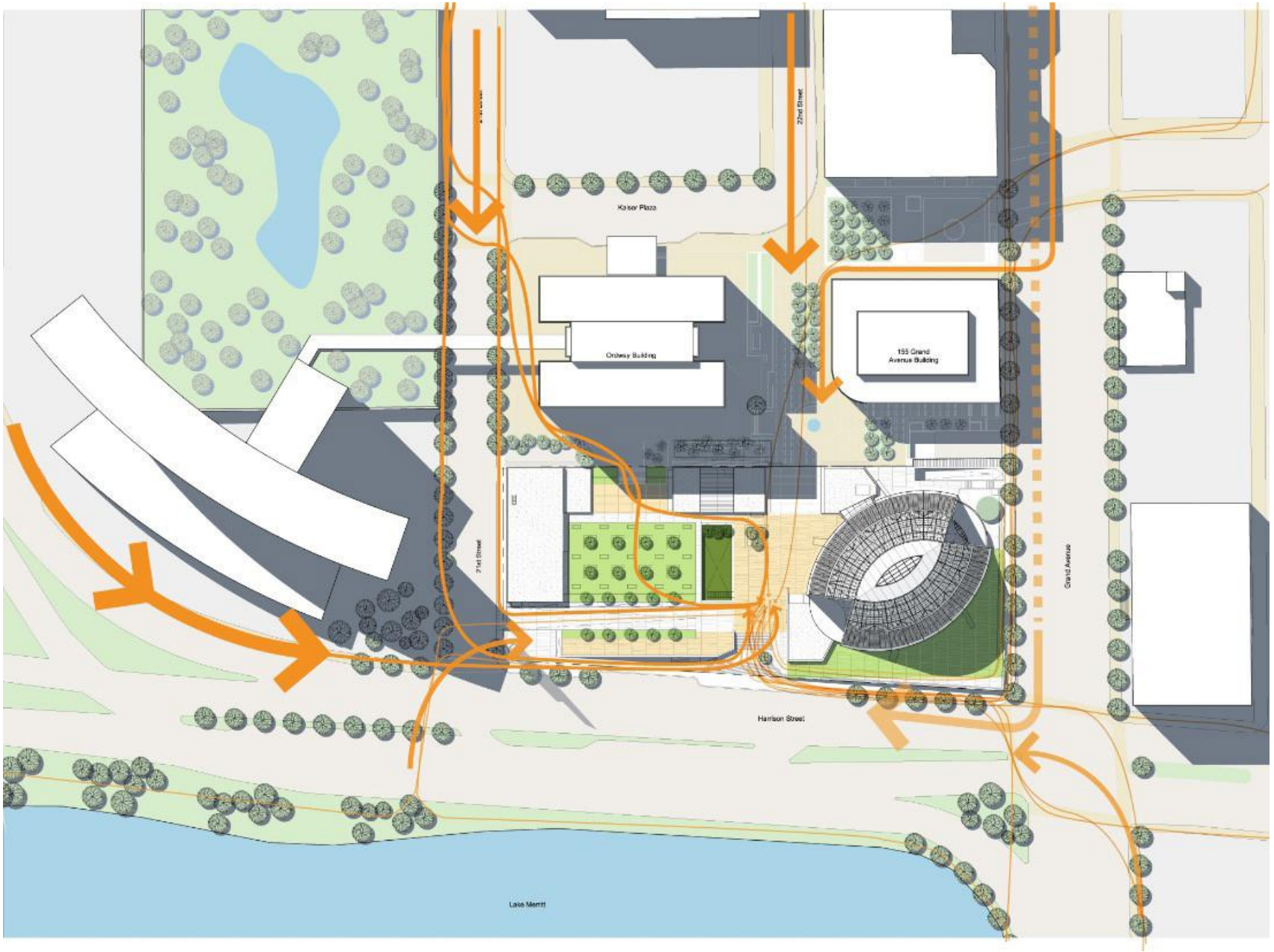


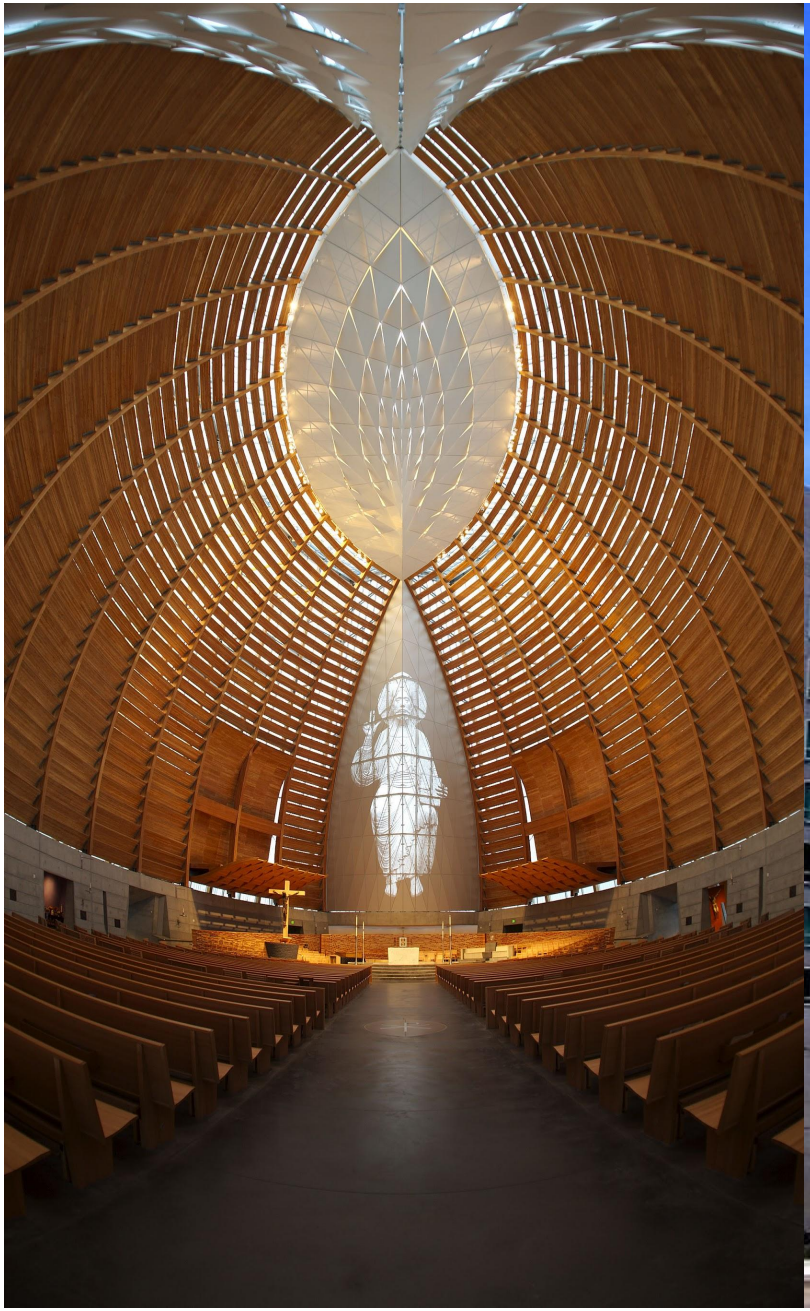
NEW BUILDING

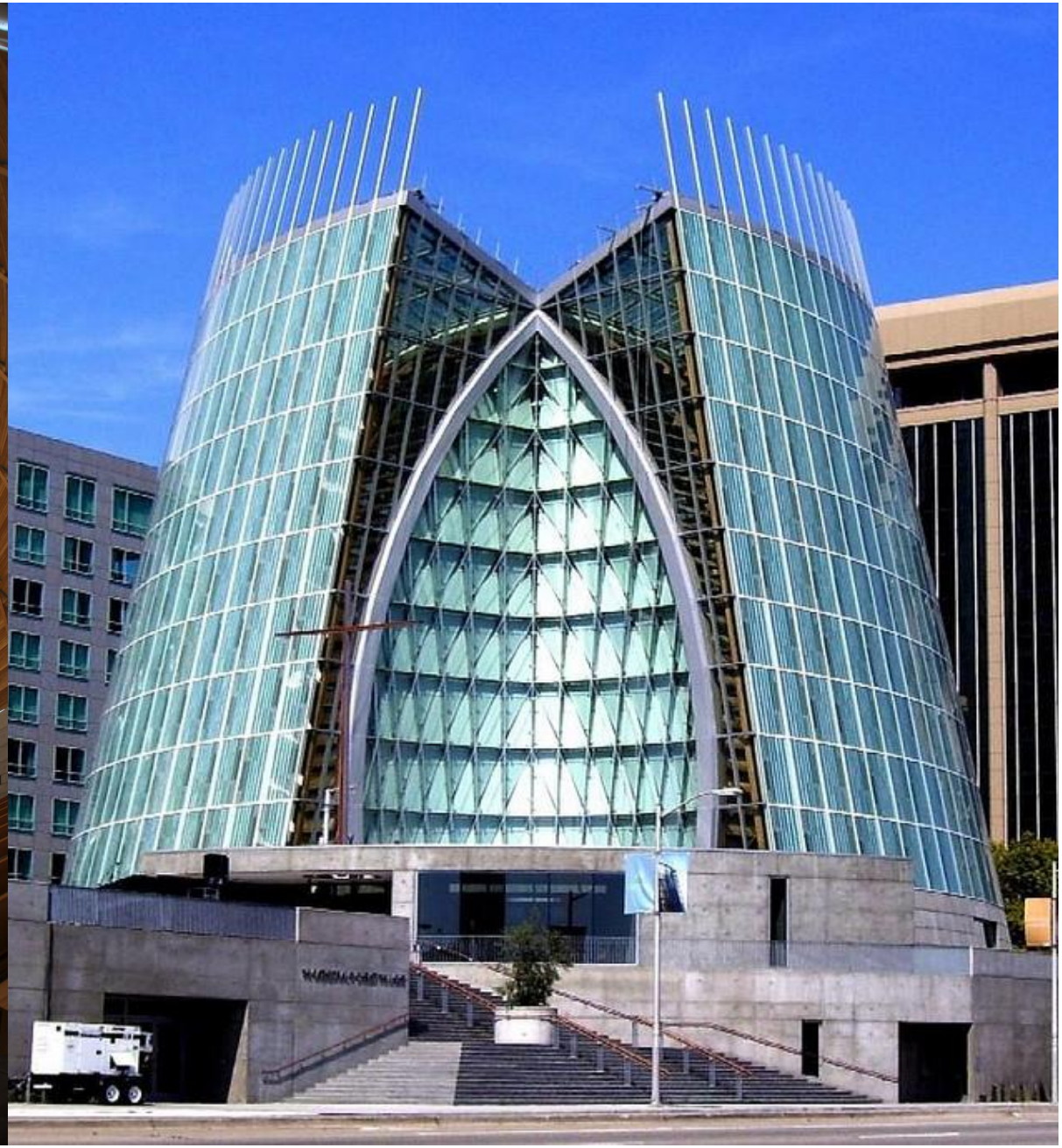
- The project leaders of the new building thought that it is essential for a building located to a major fault line to have a life of at least 300 years. With proper time to time maintenance it is said to have a life 1000 years.
- The structure is a glue laminated timber structure with a skeleton of steel rods with glass over it.
- The central theme of this structure is light.
- IT can seat up to 1500 people.
- The Vesica pisces is the biggest inspiration for this project and the floor plan is designed to resemble this. Vesica Pisces has great religious significance. When two circles are placed such that the center of each of them is on the circumference of the other. It forms the shape that in ancient texts is a sign of a congregation space.
- It is also the symbol of the miracle of loaves and fishes among Catholics.



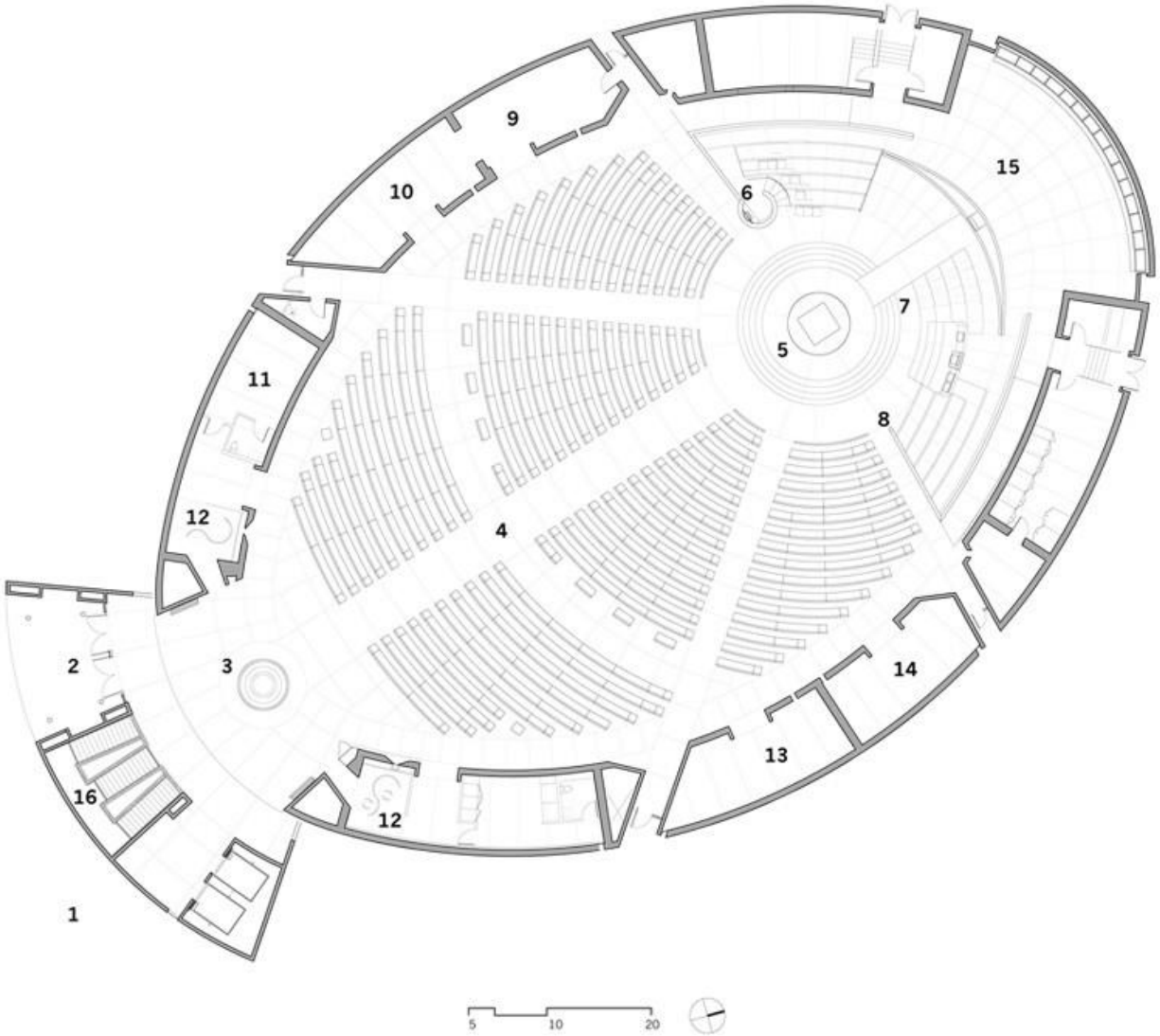
LOCATION


Kaiser Plaza
Ordway Building
155 Grand Avenue Building
22nd Street
21st Street
Grand Avenue
Harrison Street
Lake Merritt





PLAN



1 PLAZA
2 ENTRYWAY
3 BAPTISTRY
4 CENTER AISLE
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6 AMBO
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10 CHAPEL OF ALL SAINTS
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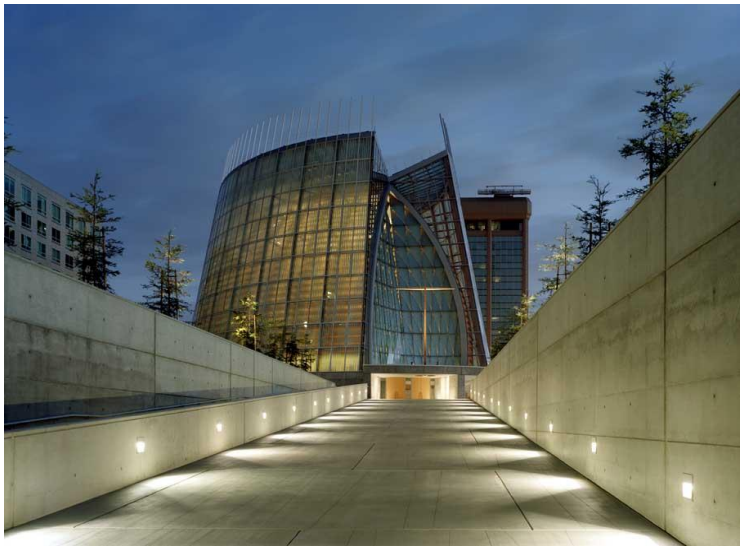
12 RECONCILIATION CHAPELS
13 CHAPEL OF THE HOLY FAMILY
14 CHAPEL OF THE SUFFERING CHRIST
15 BLESSED SACRAMENT CHAPEL
16 STAIRS TO MAUSOLEUM

CATHEDRAL OF CHRIST THE LIGHT
SKIDMORE, OWINGS & MERRILL LLP

BUILDING DATA



Location: Oakland, California

Owner: Catholic Diocese of Oakland

Project Start: 2002

Project Completion: 2008

Site Area: 2.50 acres

Project Net Area: 250,000 Sq.ft

Number of Stories: 1

Building Height: 136 ft

Target User Group: Cultural

Service: Architecture, Interior Design, Structural & Civil Engineering, Branding & Graphics.

Architects: Skidmore, Owings & Merrill LLP

Architect Of Record: Kendall/Heaton Associates, Inc., Houston

Interior Design: Tamara Dinsmore, Chanda Capelli, Susanne LeBlanc, Carmen Carrasco, David Lou

Landscape Architect: Peter Walker and Partners

Technical Coordinator: David Diamond, AIA

Electrical Engineering: The Engineering Enterprise

Mechanical Engineering: Taylor Engineering, LLC

Civil Engineering: Korve Engineering

General Contractor: Webcor Builders

Exterior Wall Systems: Glass, Precast Concrete

Projects Representatives: Bishop Allen H. Vigneron, Provost Father Paul Minnihan, Project Director John L. McDonnell Jr.

Environmental Graphics: Lonny Israel, Alan Sinclair

Digital Design Coordinator: Douglas Smith, Associate AIA

Mausoleum Contractor: Oliver + Co.

Construction And Program Management: Conversion Management Associates, Inc. (CMA, Inc.)

AWARDS & HONORS

2015 - 50 Significant Structures in 50 Years Structural Engineers Association of Illinois

2010 - National Honor Award for Interior Architecture American Institute of Architects (AIA)

2009 - California Wood Design Award: Landmark Category Wood Works

2009 - Award of Excellence: Large Project, Landmark Structures Category Structural Engineers Association of Northern California

2009 - Jurors' Favorite Honor Award Structural Engineers Association of Illinois

2009 - Award of Excellence: Landmark Structures Structural Engineers Association of California

2009 - Jurors' Favorite Honor Award Structural Engineers Association of Illinois.

2009 - Jurors' Favorite Honor Award Structural Engineers Association of Illinois

2009 - Jurors' Favorite Honor Award Structural Engineers Association of Illinois

2009 - Award of Excellence: Landmark Structures Structural Engineers Association of California

2009 - Architecture & Interiors Category: Gold Award Spark Awards

2009 - Honor Award Society for Environmental Graphic Design

2009 - Best East Bay Public or Cultural Space San Francisco Business Times

2009 - Best Community Impact - Inner East Bay San Francisco Business Times

2009 - Pro AV Spotlight Award (led by Shen Milsom Wilke, Inc.)Pro AV Magazine

2009 - Outstanding Project, New Buildings Under $10 million National Council of Structural Engineers Association.

2009 - Interior Design Award International Interior Design Association

AWARDS & HONORS

2009 - Best in Show International Interior Design Association - Northern California Chapter

2009 - Honor Award International Interior Design Association - Northern California Chapter

2009 - Best of Year: Institutional Merit Award Interior Design

2009 - Award for Community or Residential Structures Institution of Structural Engineers

2009 - Wood Engineering Innovation Award Forest Products Society

2009 - Design Award for Religious Architecture: Liturgical/Interior Design Faith and Form magazine and the Interfaith Forum on Religion, Art and Architecture (IFRAA)

2009 - Design Award for Religious Architecture: New Facilities Faith and Form magazine and the Interfaith Forum on Religion, Art and Architecture (IFRAA)

2009 - Annual National Award D&AD British Design and Art Direction

2009 - American Architecture Award Chicago Athenaeum

2009 - Annual Design Review Architect Magazine

2009 - Outstanding Architectural Engineering Project of the Year American Society of Civil Engineers - San Francisco Section

2009 - Annual National Award American Institute of Graphic Arts

2009 - National Honor Award for Architecture American Institute of Architects (AIA)

2009 - Excellence in Architecture: Honor Award AIA - San Francisco Chapter

2009 - Honor Award AIA - East Bay Chapter

2009 - Honor Award AIA - California Council

2008 - Ten of the World's Most Beautiful Green Buildingstreehugger.com

2008 - Wood Design Awards: Honor Award Wood Design & Building Magazine

2008 - Best Building Site of the Year Wallpaper Magazine

2008 - Best of the Best Award McGraw-Hill Construction

2008 - Overall Top Project California Construction Magazine

2008 - Outstanding Architectural Design California Construction Magazine

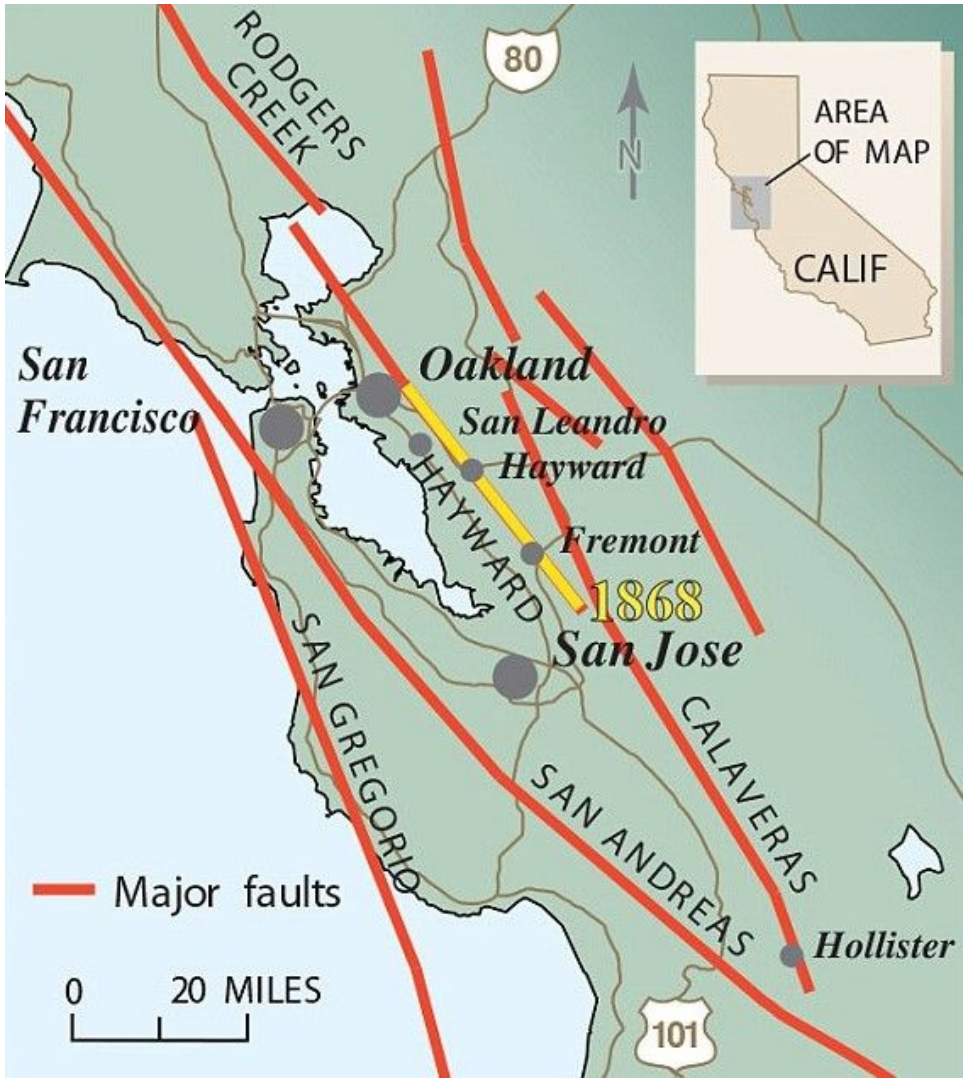
2007 - Regional Architecture Award for Use of Concrete American Concrete Institute - Northern California and Western Nevada Chapter

2003 - Unbuilt Design Award AIA - San Francisco Chapter

GEOGRAPHY

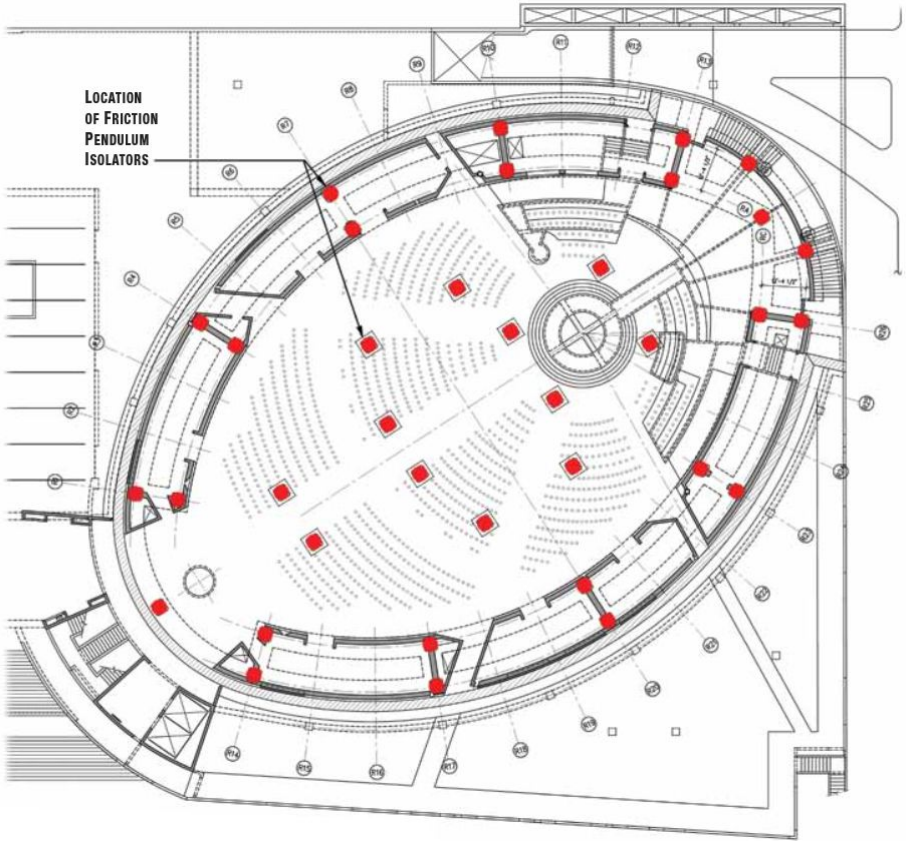
STRUCTURAL DESIGN GOALS

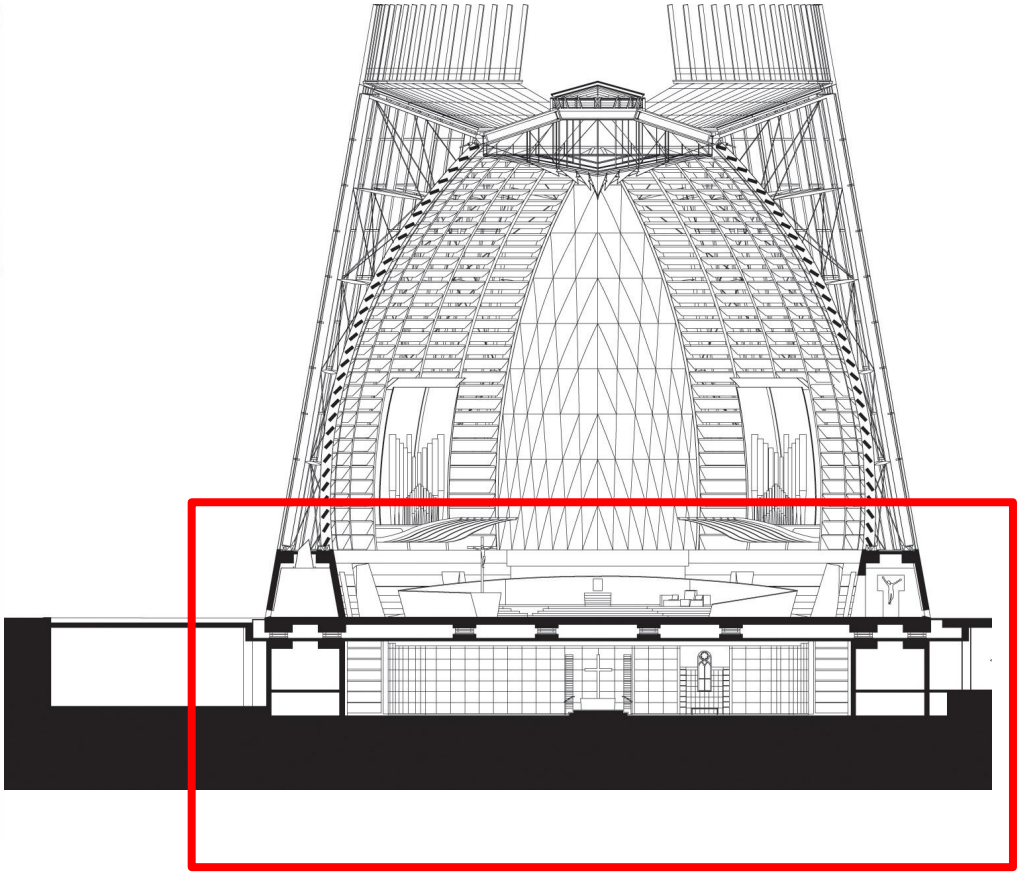
- Building life of 300 years
- Withstand a 1000 year earthquake event
- Site located 9 miles from the Hayward Fault



FOUNDATION

BASE ISOLATION FOUNDATION SYSTEM





Concrete base floats on 36 insulators: situated beneath its thick concrete floor slab,, each with a four-foot-diameter steel bearing.

At same time, the superstructure is supported atop an eighteen-foot-high mausoleum substructure of reinforced concrete extending to a reinforced concrete mat foundation.

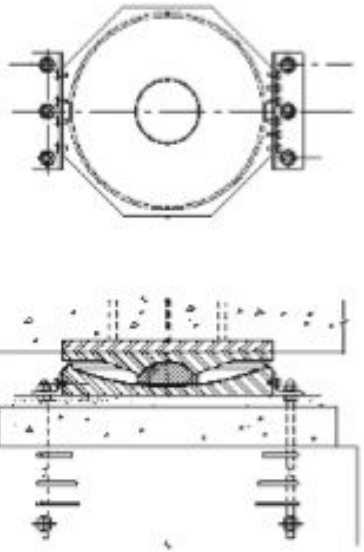
FOUNDATION

Seismic base isolation, along with cast in place reinforced concrete on the base due to California's earthquake prompt location.

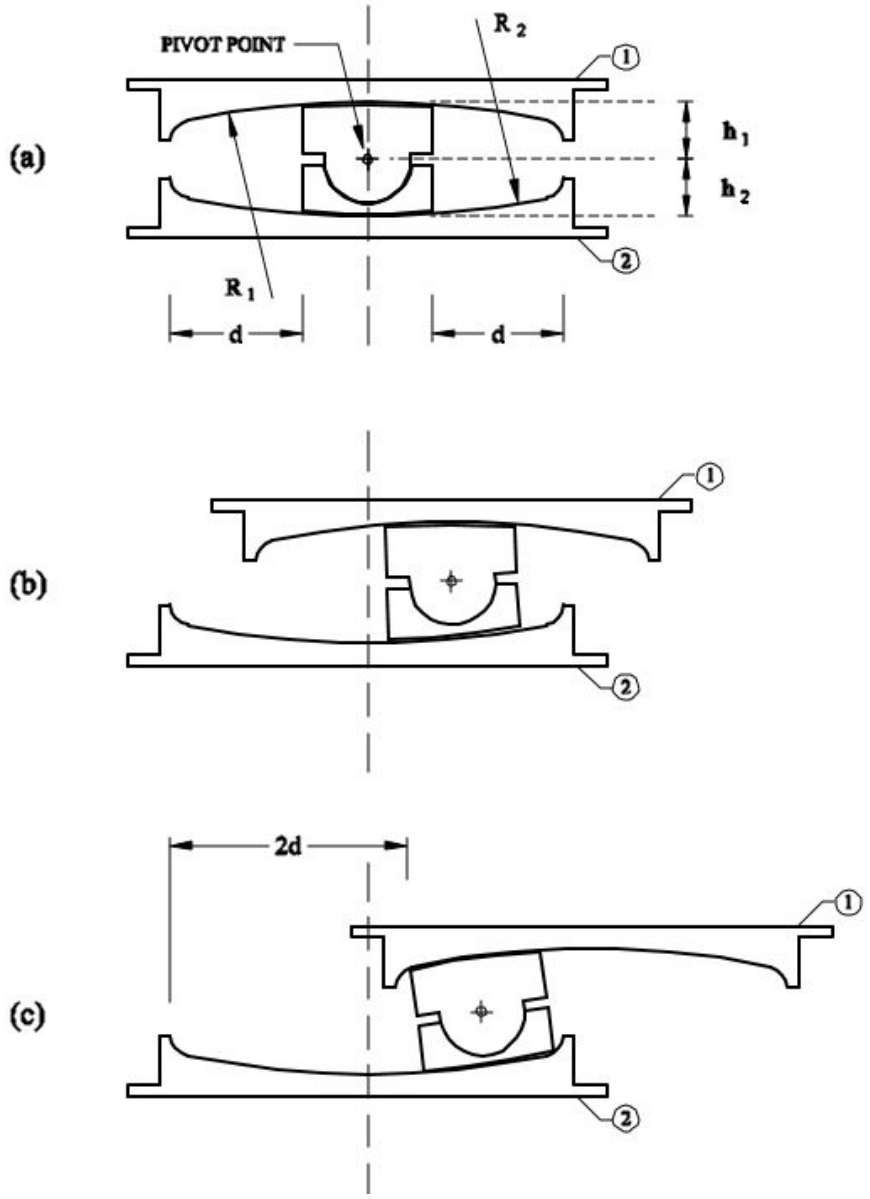
Base isolation was typically applied for one of the following reasons:

1. Providing immediate post-earthquake operability for disaster response.
2. Providing higher-than-normal levels of seismic performance as desired by the owner, because of the building's function or contents.
3. Enhancing the seismic performance of an existing historic building with minimal architectural disruption.

BASE ISOLATION SYSTEM

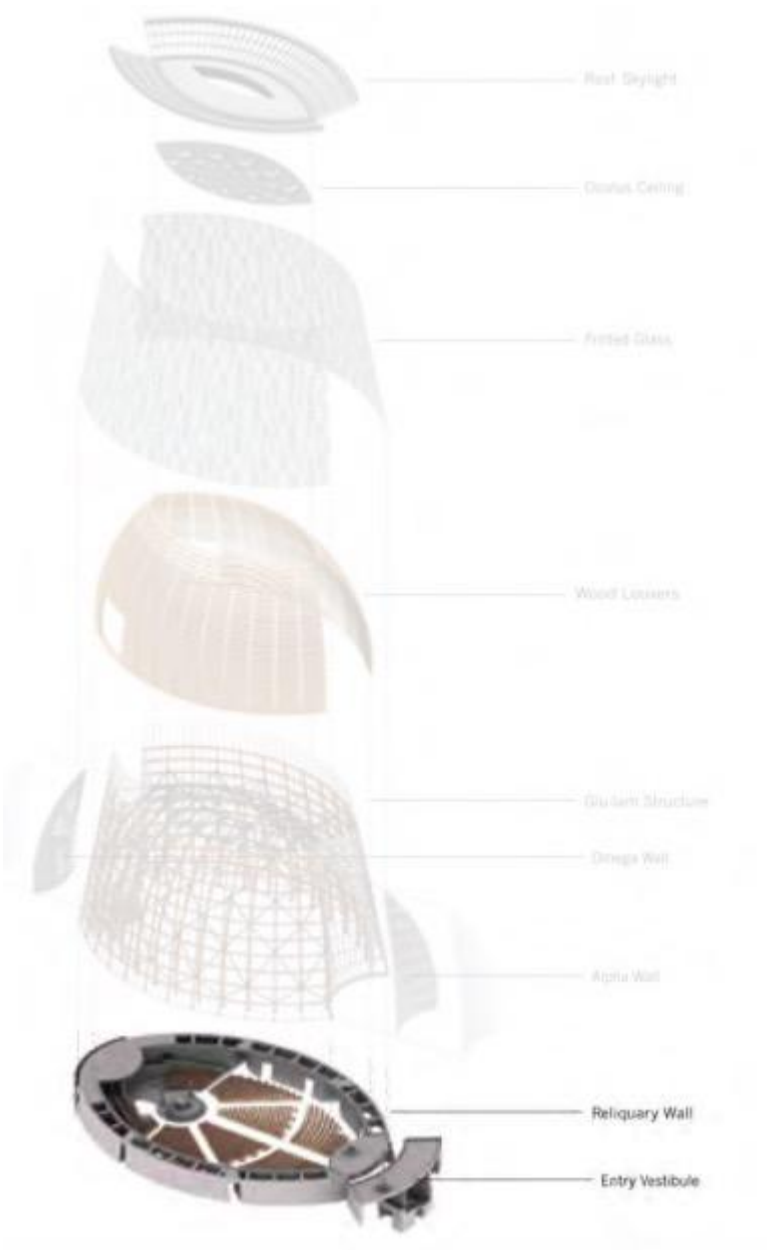


DOUBLE CONCAVE STEEL FRICTION PENDULUM SYSTEM

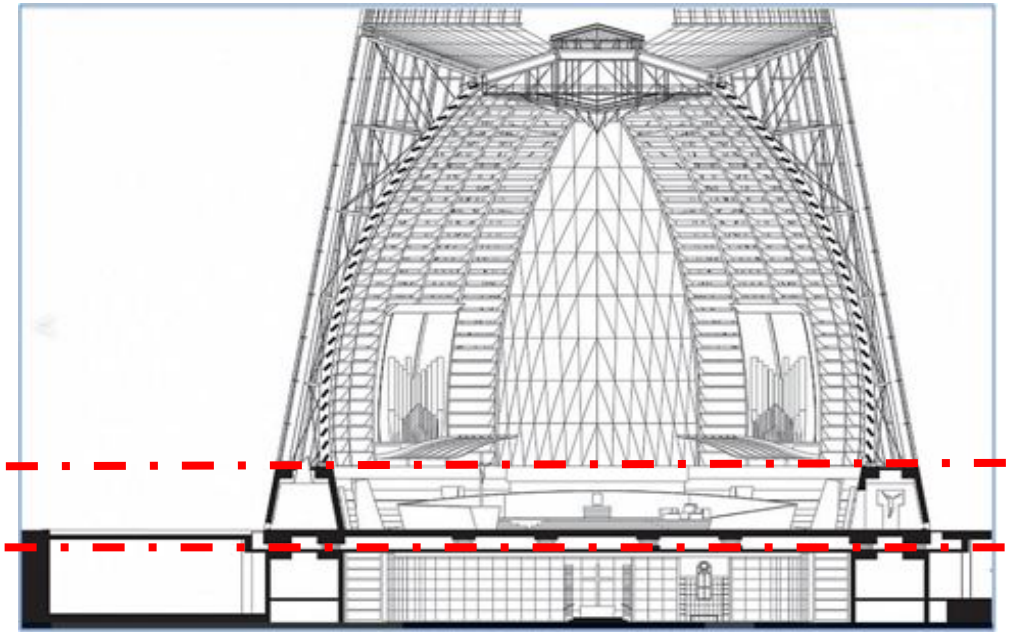


Cross section of DCFP bearing at various stages of lateral movement

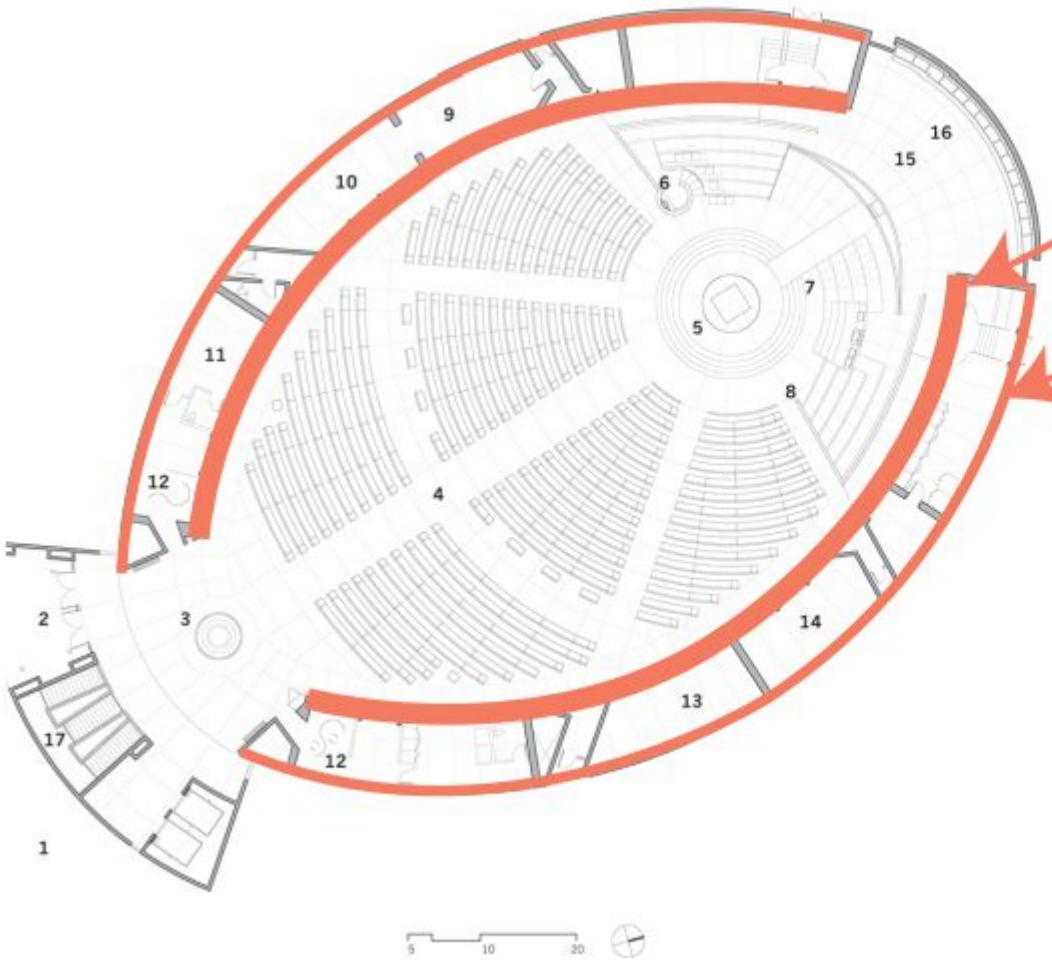
RELIQUARY WALL



The superstructure system of timber and structural steel is supported by 14 in. (356 mm) thick cast-in-place ductile reliquary walls of reinforced concrete. The architecturally exposed concrete reliquary walls extend 15 ft (4.6 m) above the sanctuary floor and provide both gravity and lateral load support for the superstructure above. The walls are curved in plan and slope in section. The bases of the reliquary walls are interconnected by a horizontal two-way 12 in. (305 mm) thick concrete diaphragm slab reinforced in two directions at the sanctuary floor. The tops of the walls are interconnected by reinforced-concrete framing beams and slabs that also provide support for the pinned connections to the glulam timber ribs above.



SHEAR WALL PLAN



Primary Structure on Interior Circumference

Secondary Structure on Exterior Circumference

1 PLAZA
2 ENTRYWAY
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6 AMBO
7 CATHEDRA
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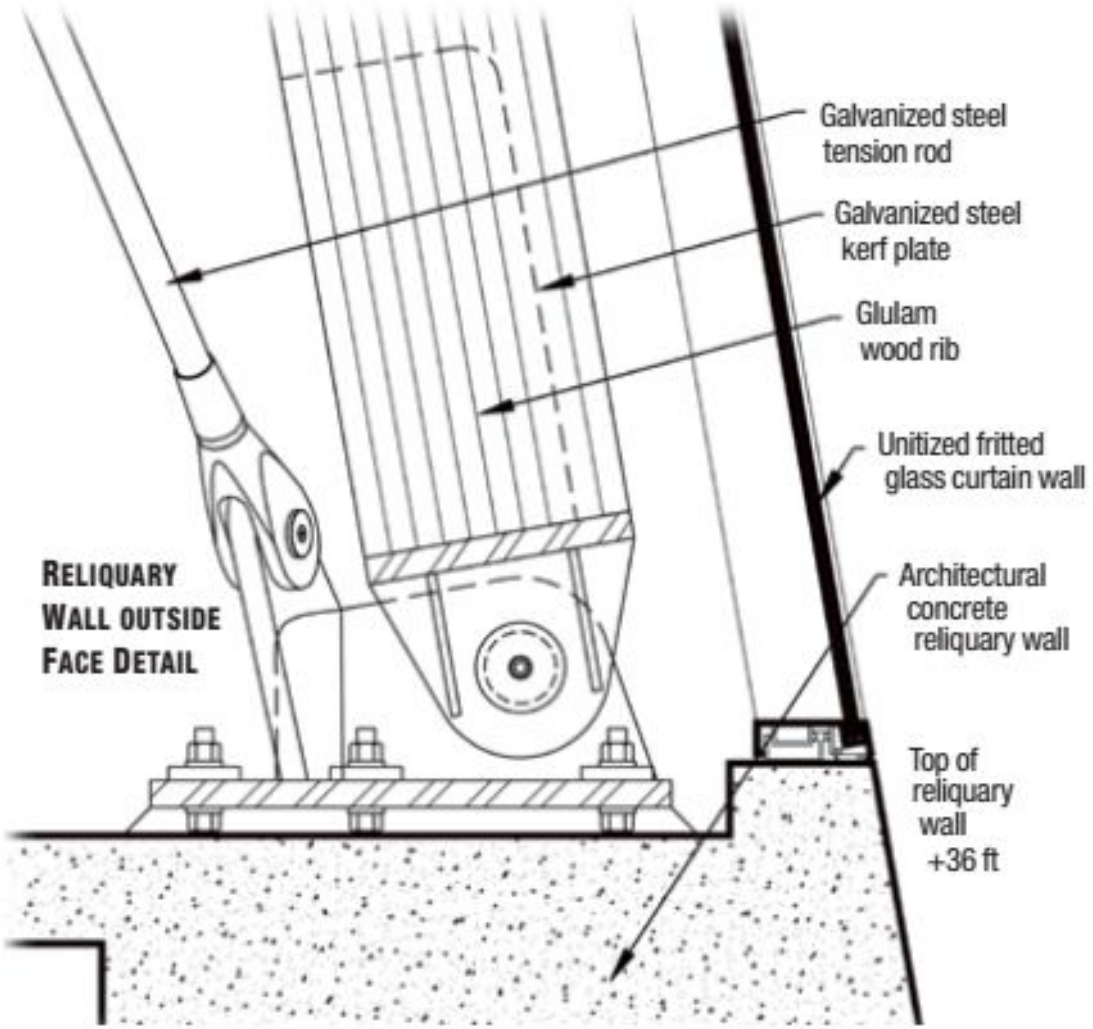
15 OMEGA WINDOW
16 BLESSED SACRAMENT CHAPEL
17 STAIRS TO MAUSOLEUM

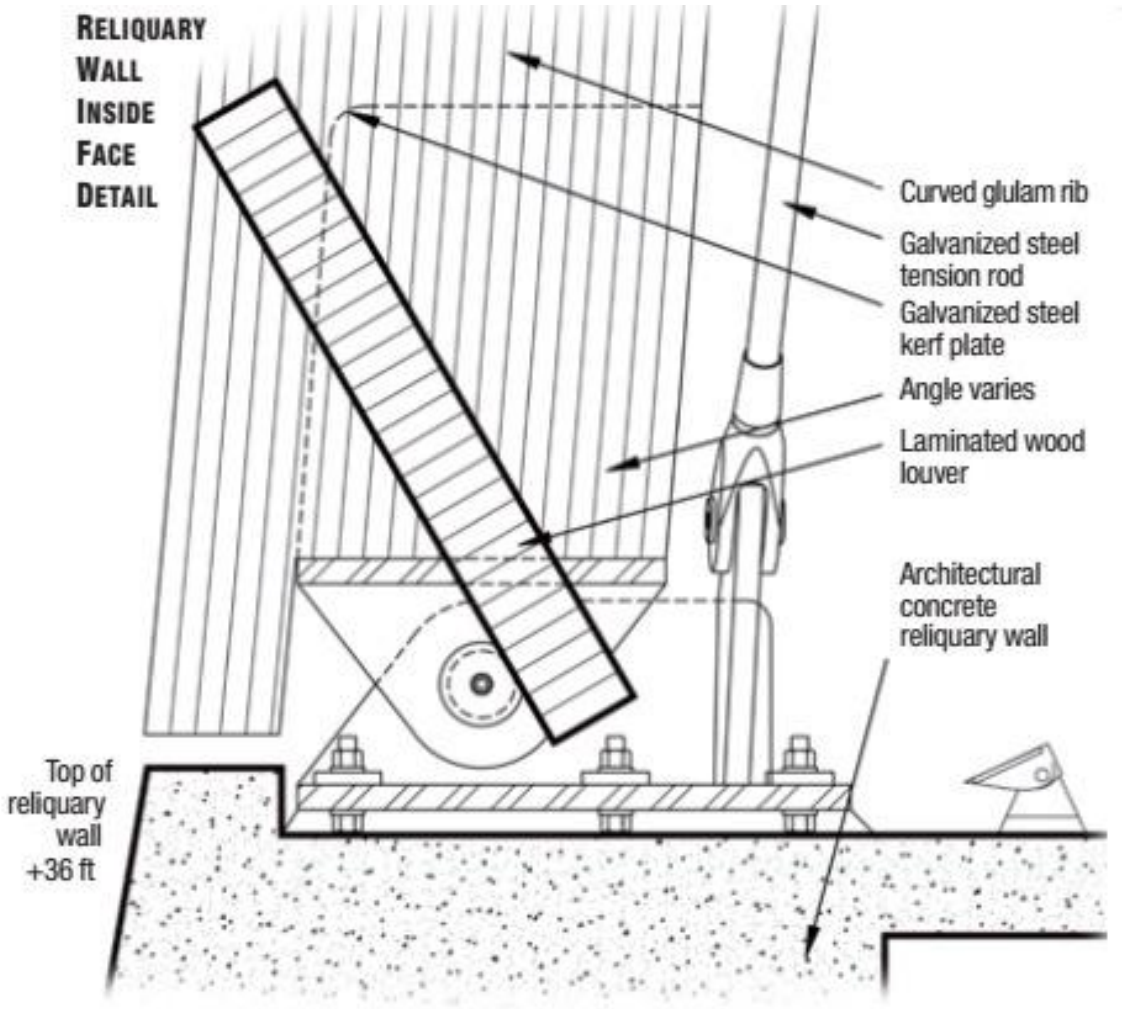
REINFORCED CONCRETE

REINFORCED CONCRETE

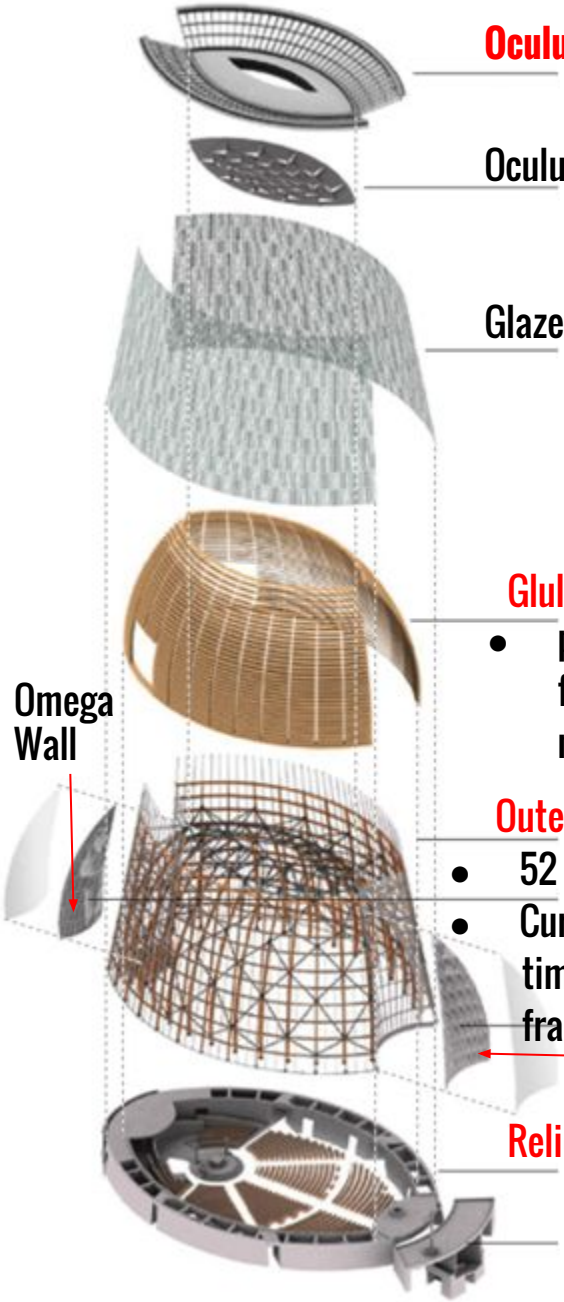
Outside Joint Details



Inside Joint Details



SUPERSTRUCTURE - COMPONENTS



Oculus steel roof framing

Oculus Ceiling

Glazed Exterior Wall

Glulam Louvers

- provide **lateral bracing** for the inner curved rib members

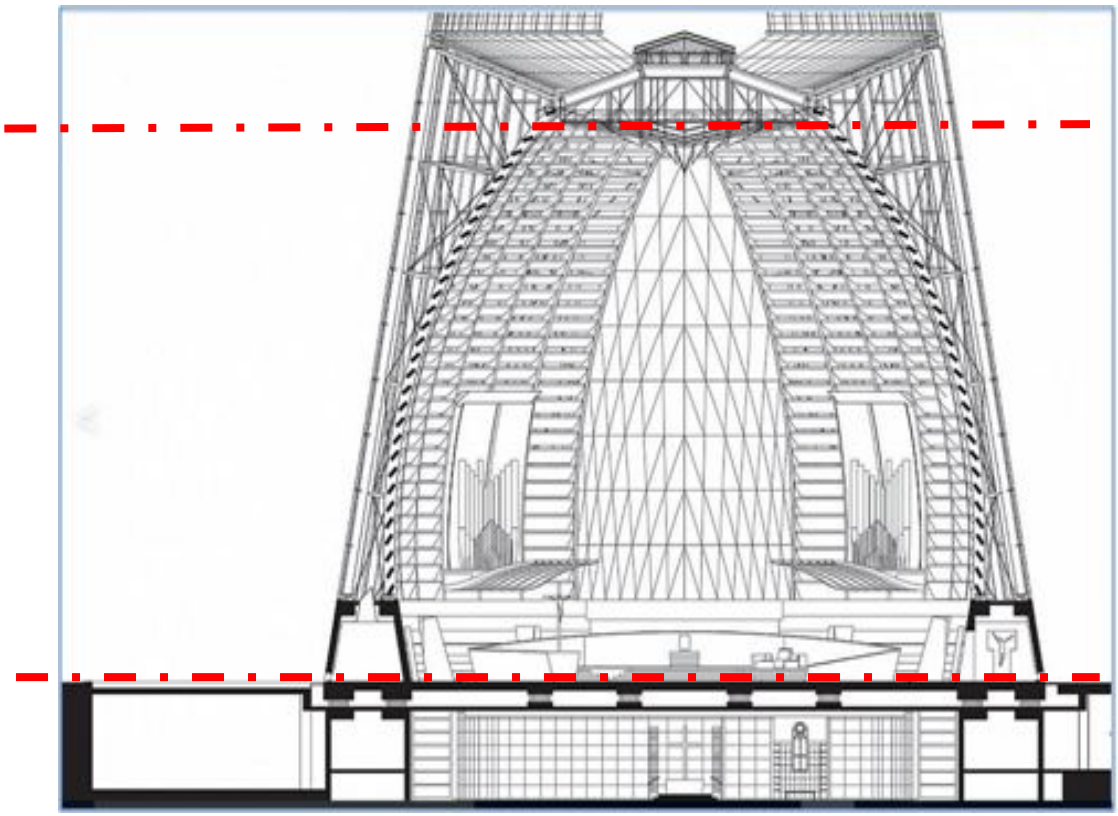
Omega Wall

Outer and Inner timber Ribs

- 52 members **resist Gravity Loads**
- Curved and Tapered glulam wood timber rib members form the framework

Alpha Wall

Reliquary Wall



SECTION

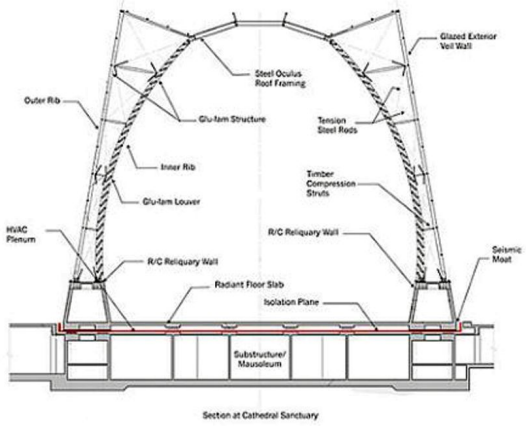
The superstructure is supported atop an 18 ft high mausoleum substructure of reinforced concrete that extends to a reinforced-concrete mat foundation.

WOOD IN CATHEDRAL

- Unifying Architectural, structural and spiritual design element
- Design team examined glulam timber use-historical development, current standards and codes, durability and exposure to ultraviolet light, effect of temperature, relative humidity, structural redundancy, protective treatment and long term maintenance
- The wood timbers natural cellulose structure of lignin and cellulose fiber makes it excellent insulating material highly resistant to acids, alkalis, salts, and other chemical substances.
- **Douglas fir** selected because of its availability on West Coast and offered economic benefits, strength, stability, consistency and natural architecture appearance

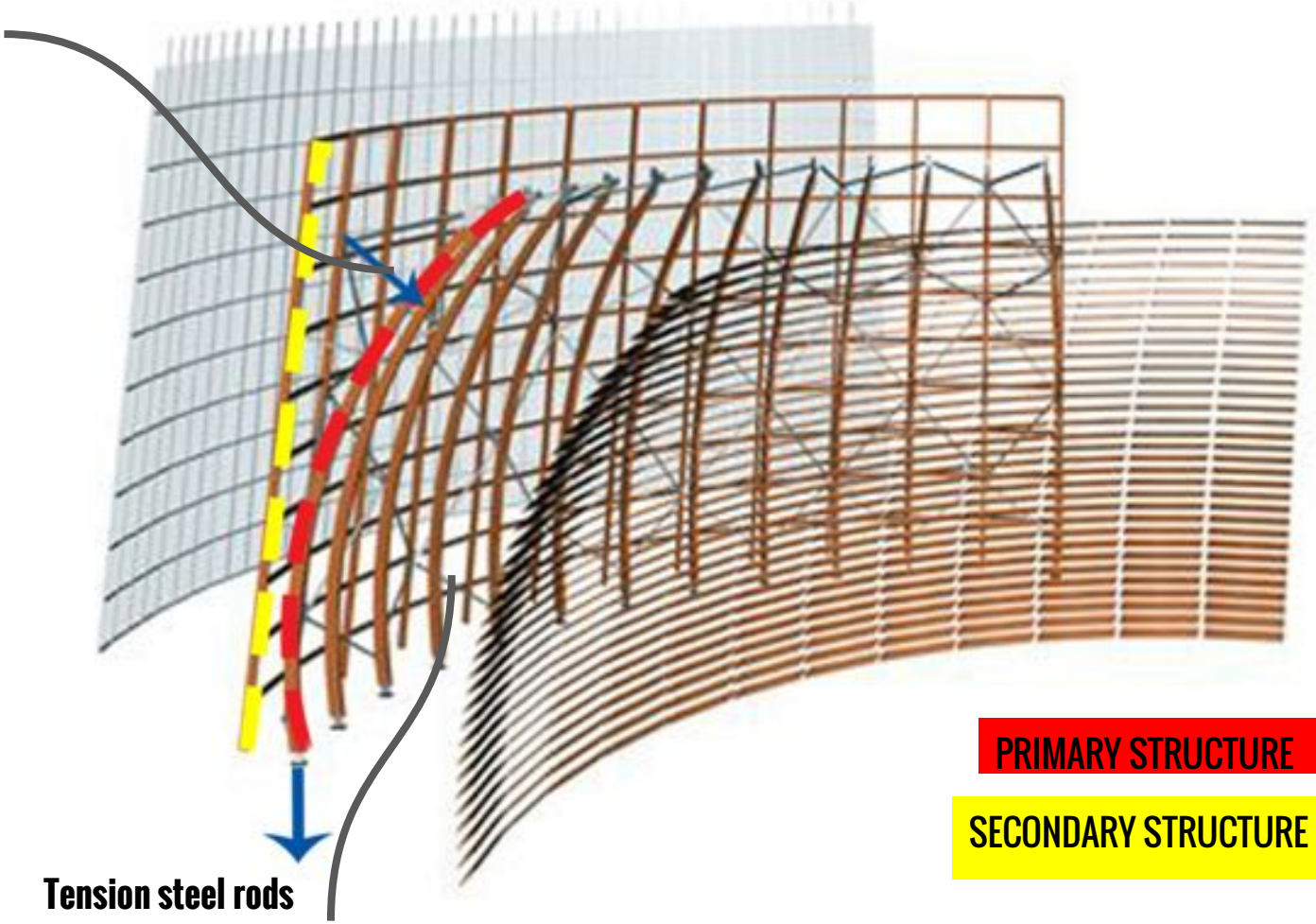
HYBRID STRUCTURAL SYSTEM

- Reinforced concrete
- Prefabricated glue laminated timber
- High strength structural steel rods paired with glued laminated wood compression struts
- Steel friction pendulum seismic base isolation system



Section at Cathedral Sanctuary

Timber Compression Struts



Tension steel rods

PRIMARY STRUCTURE

SECONDARY STRUCTURE

224 steel tension rods and 104 glulam timber compression struts

- Provide redundancy and reserve **ductile capacity** in the **lateral-load-resisting system**.
- The steel rods **resist both wind and seismic forces.**
- Typical rods are 1 in. diameter, while the critical load path rods range in diameter from 1.25 to 2 in.
- .Force amplification was calculated to be approximately 10 percent greater than the anticipated static load.
- 104 turned glulam compression struts are located between the inner curved rib and the outer vertical rib at 20.5 ft intervals to coincide with the connection points of the high-strength steel rods.
- **Axial compression struts** feature **pinned connections** to the inner curved rib and the outer vertical rib

OCULUS CEILING

- Made of structural steel wide-flange framing and a metal roof deck
- Behaves as **compression ring and diaphragm** interconnecting the hybrid steel and timber braced-frame elements from all sides of the cathedral at the roof elevation

GLULAM TIMBER LOUVERS

- 51/8 in.wide and vary in depth from 39 in.at the base to 22 in.at the top.
- Mounting angle from horizontal varies from 60 degrees at the base to 16 degrees at the top.
- 724 closely spaced glulam timber louver members interconnect and **provide lateral bracing** for the inner curved rib members.

STEEL MULLION

Horizontal tubular Steel mullions

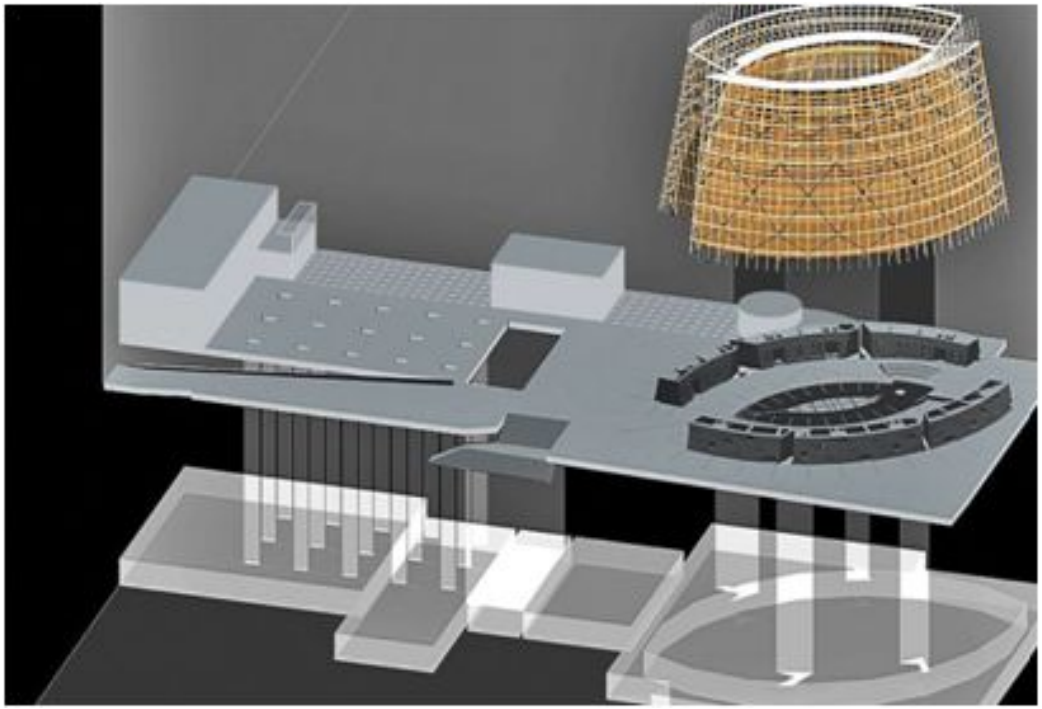
- Located between outer vertical rib members spaced at 10.25 ft intervals.
- The mullions are 6 in. wide and 3 in. deep and provide **lateral bracing** for the outer vertical ribs and support the exterior wall.
- Structural steel bolted connections are used to connect the primary structural members.
- All hybrid frame timber and steel elements and connections- shop-welded and subjected to hot-dip galvanization.

Seismic performance-SUPERSTRUCTURE

Components of the super structure -exterior wall, roof enclosure, interior components were designed for DBE (Design Basis earthquake) MCE (Maximum Considered Earthquake) force levels including peak vertical and horizontal accelerations

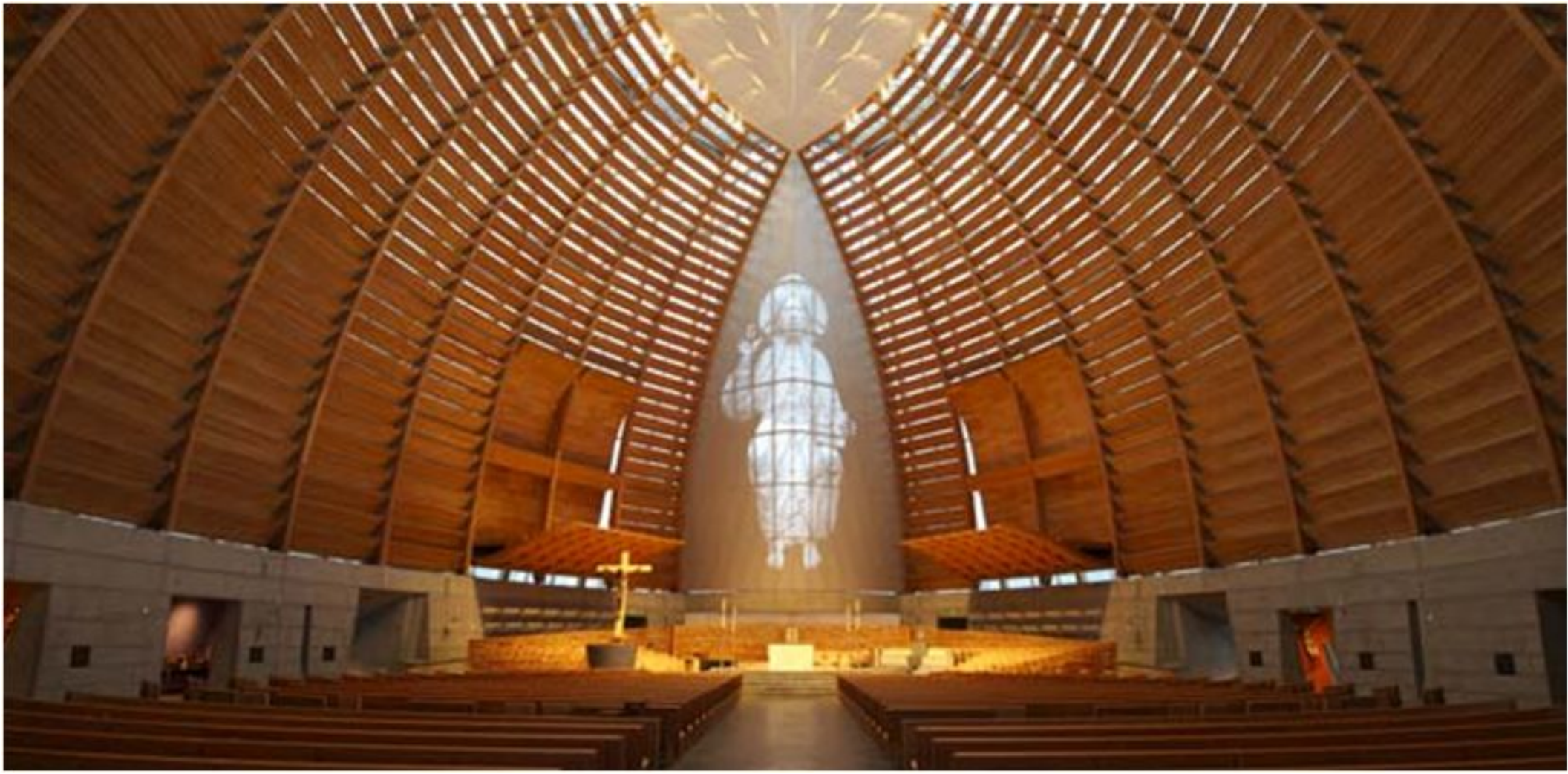
- DBE (Design Basis earthquake)- peak horizontal accelerations with 10% probability of exceedance in 50 years
- MCE (Maximum Considered Earthquake)- the peak horizontal accelerations with 2% probability of exceedance in 50 years

Pedestrian level wind tunnel studies were also conducted along with **estimation of base shears, overturning moments, base torque, load case combinations and dynamic effect of wind gusts**.



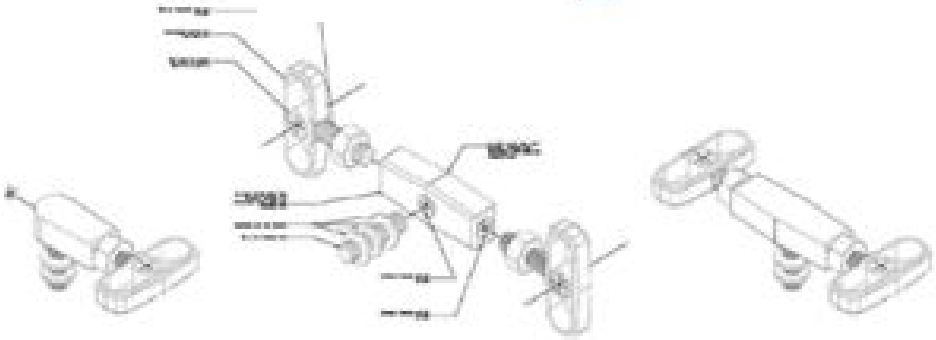
OMEGA WALL

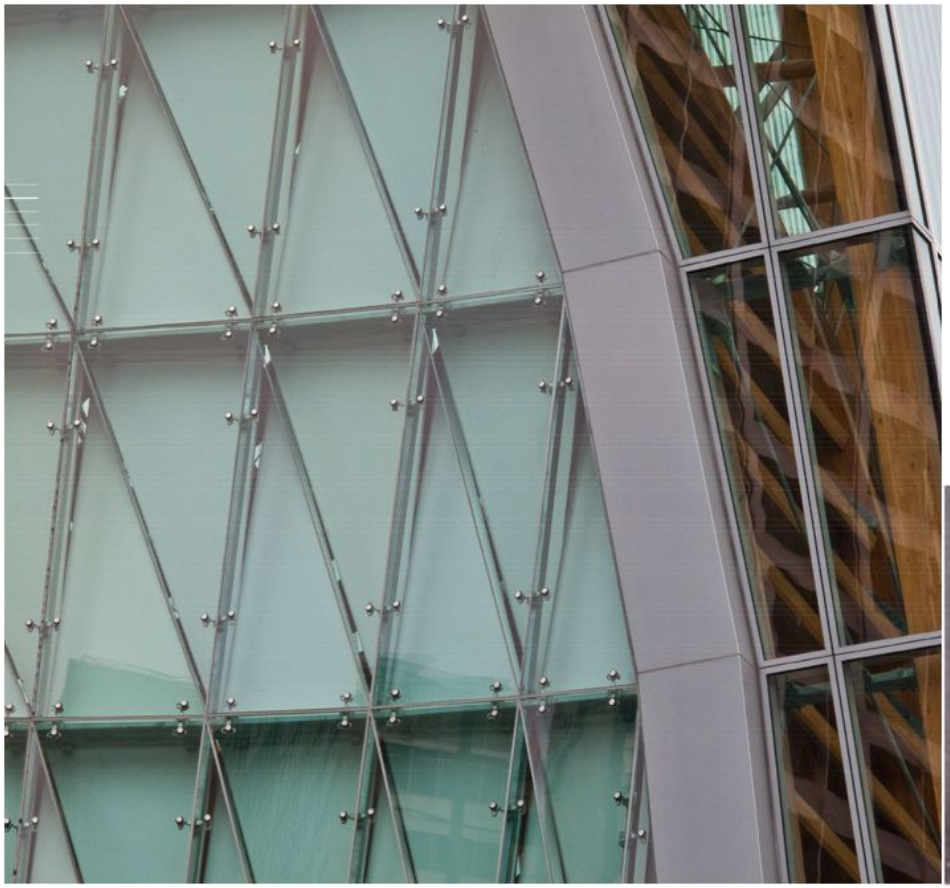
- Located at Sanctuary's Northern end
- Bounded by roof compression ring, end glulam timber ribs, reliquary wall elements
- 58 ft high tall image of Jesus Christ created from series of perforated triangulated aluminum panels

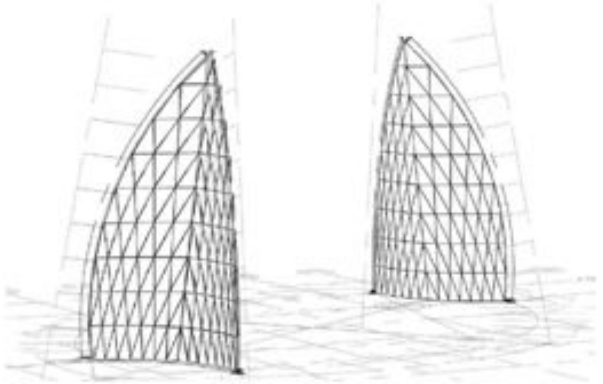


GLASS IN ALPHA AND OMEGA WALLS

- Two 88 ft point supported glass walls -600 sqft of sloped glazing
- 308 triangulated glass panels create double curvature surface supported by glass bolts at four drilled hole location offset from each panel corner along two out of three edges.
- The offset from vertex of six unique panels reduces nodal coordination







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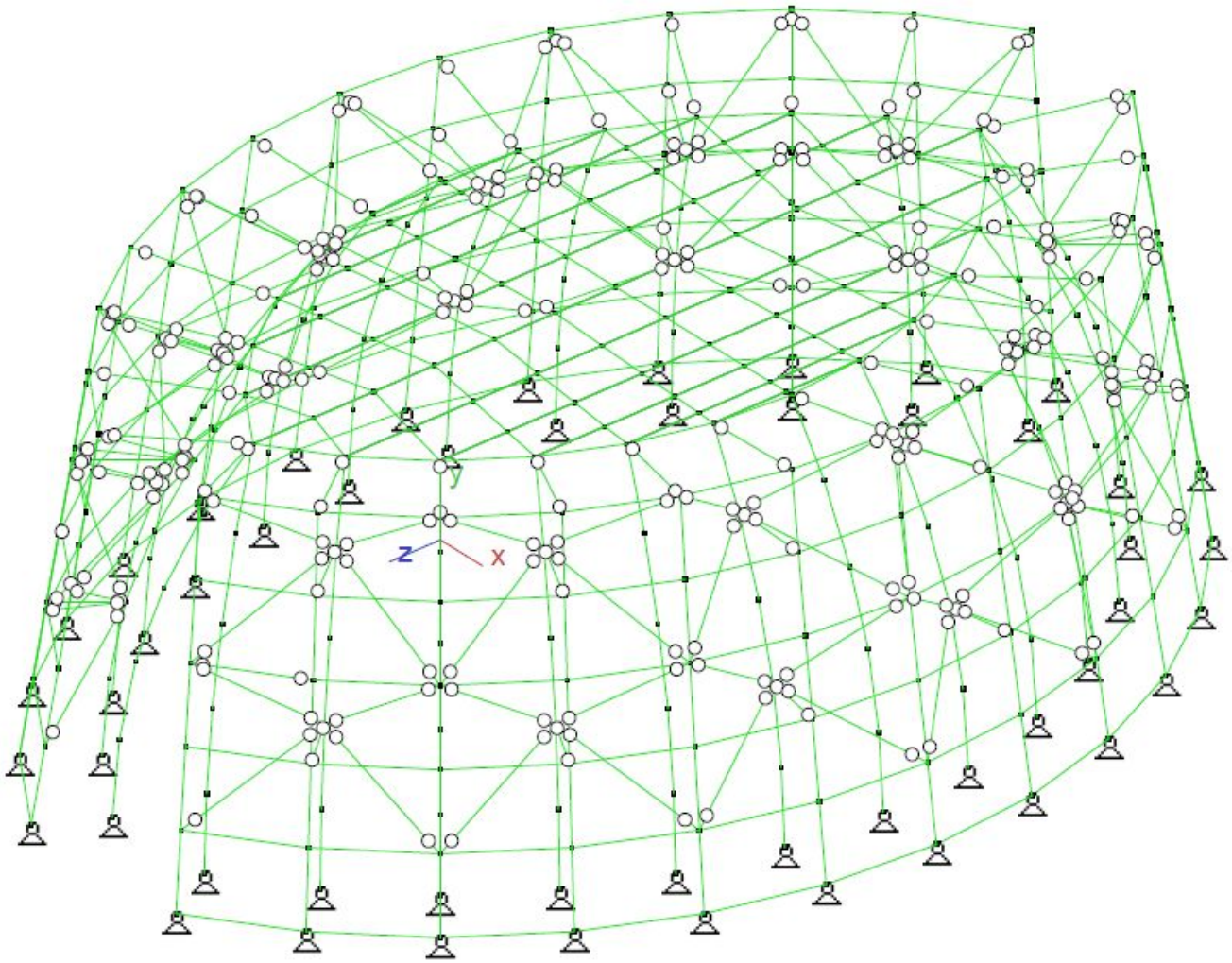

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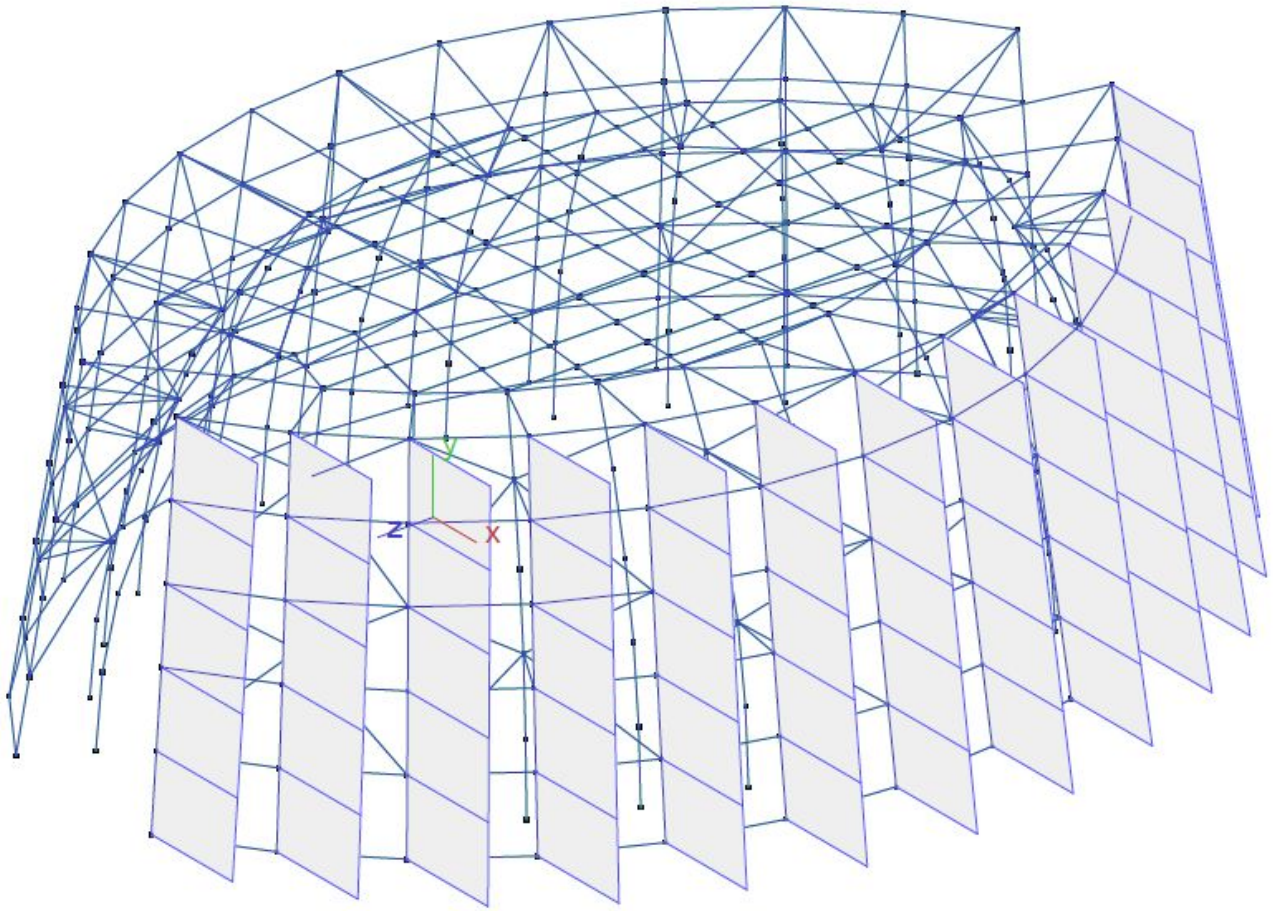

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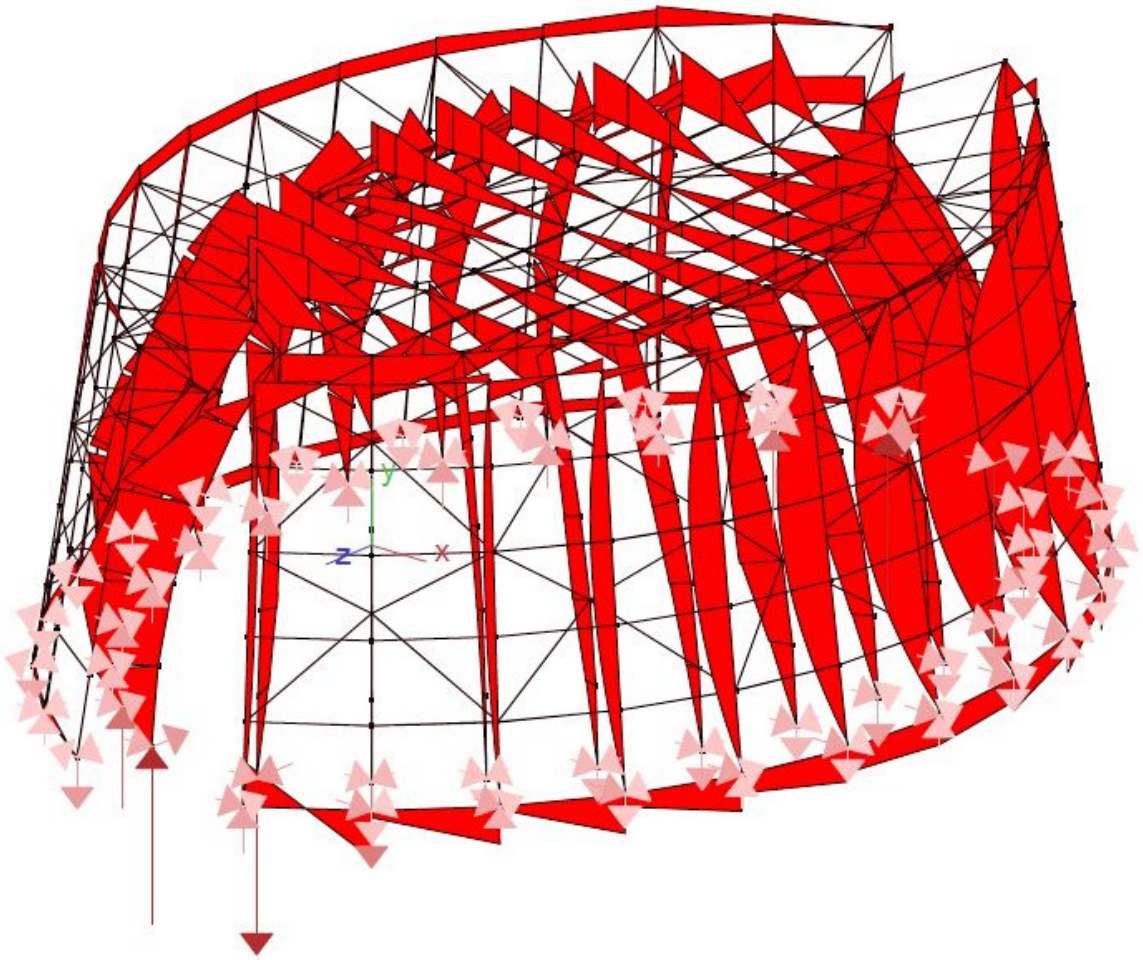

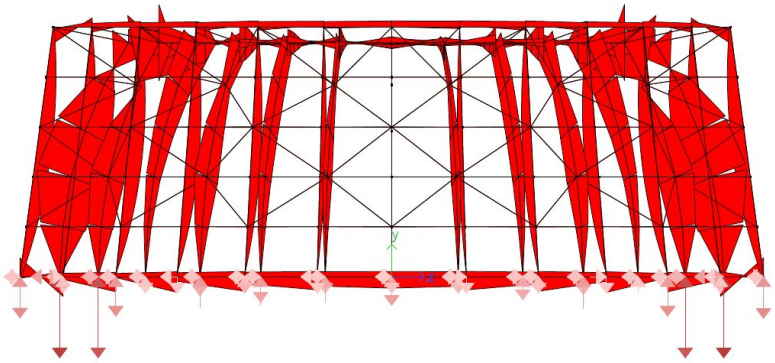

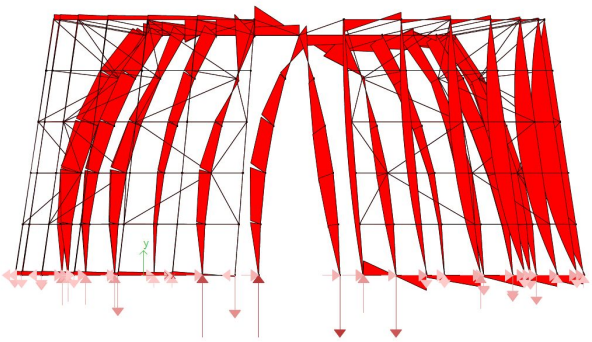

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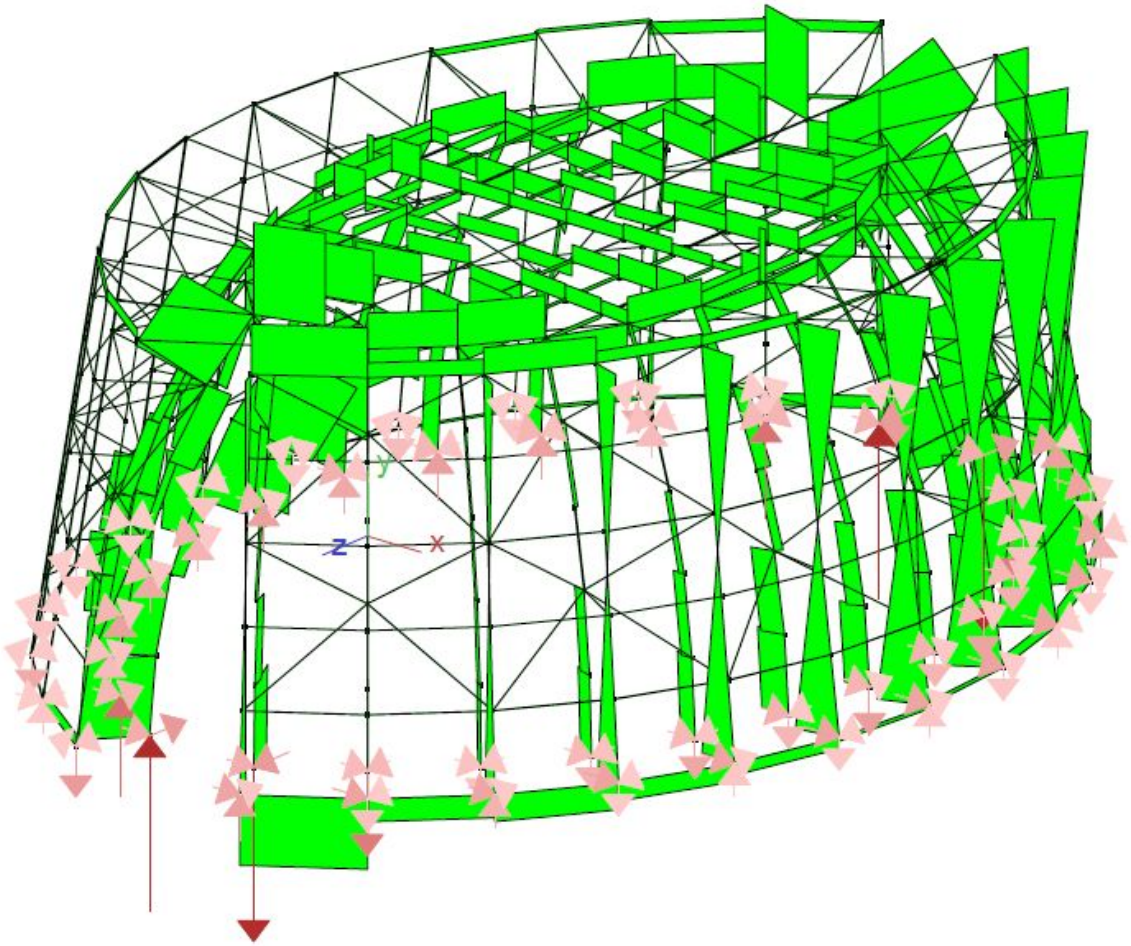

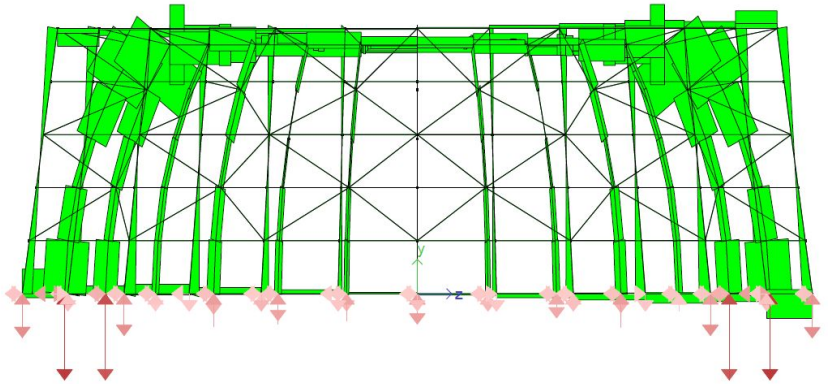

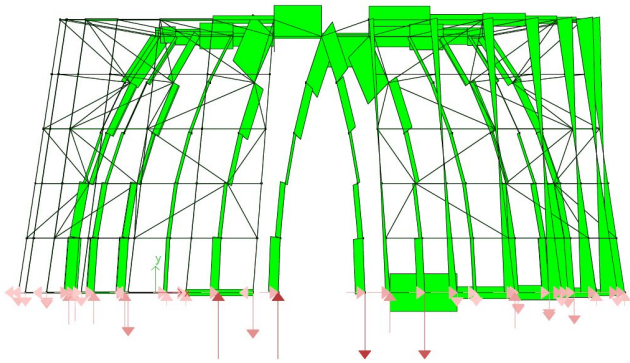

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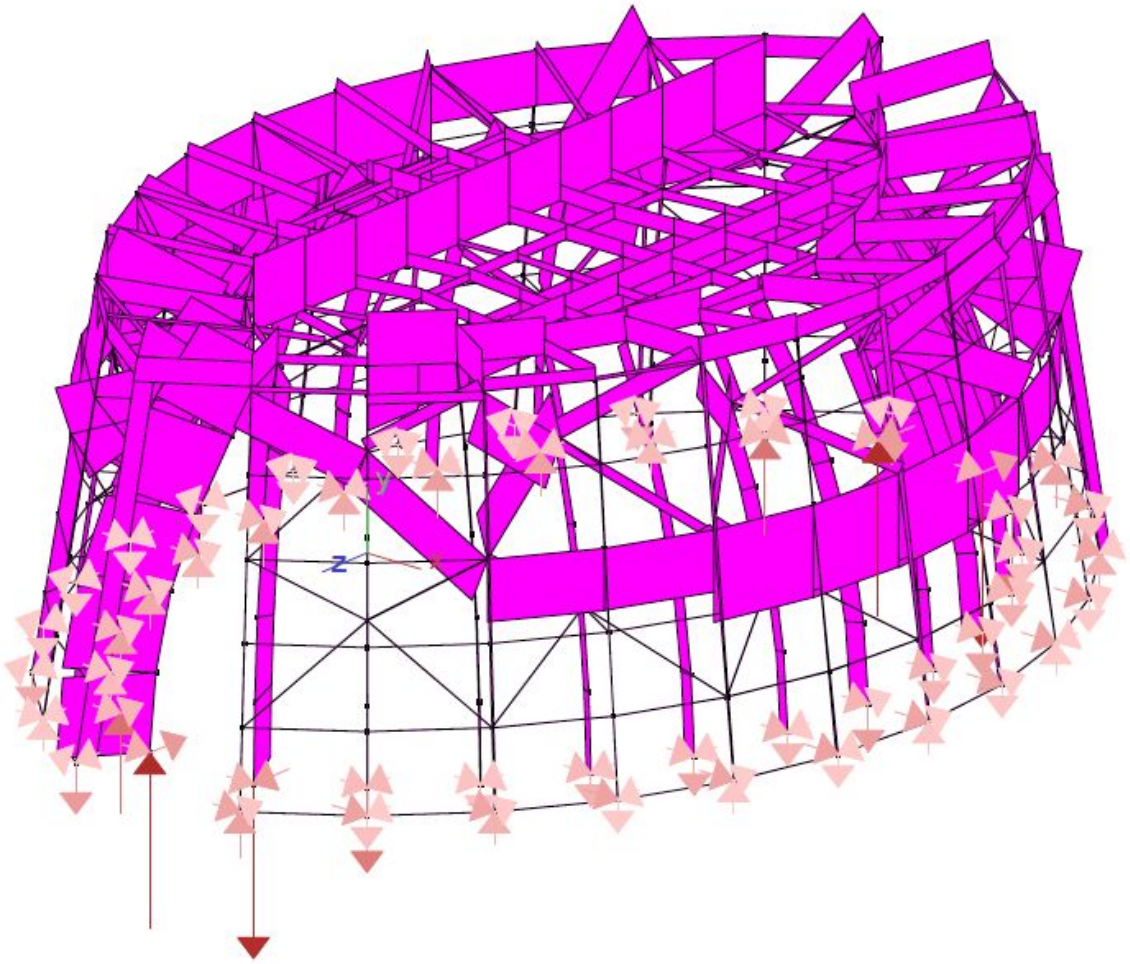

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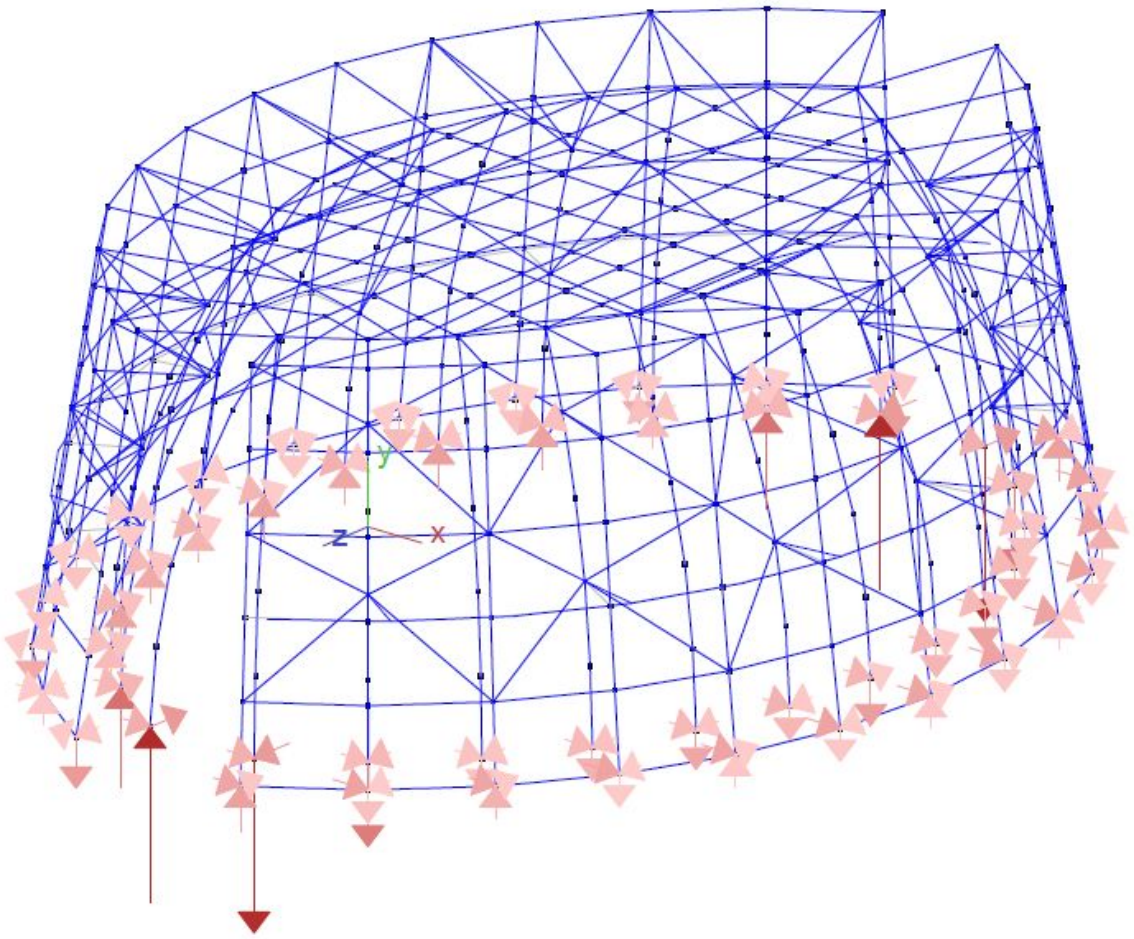

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