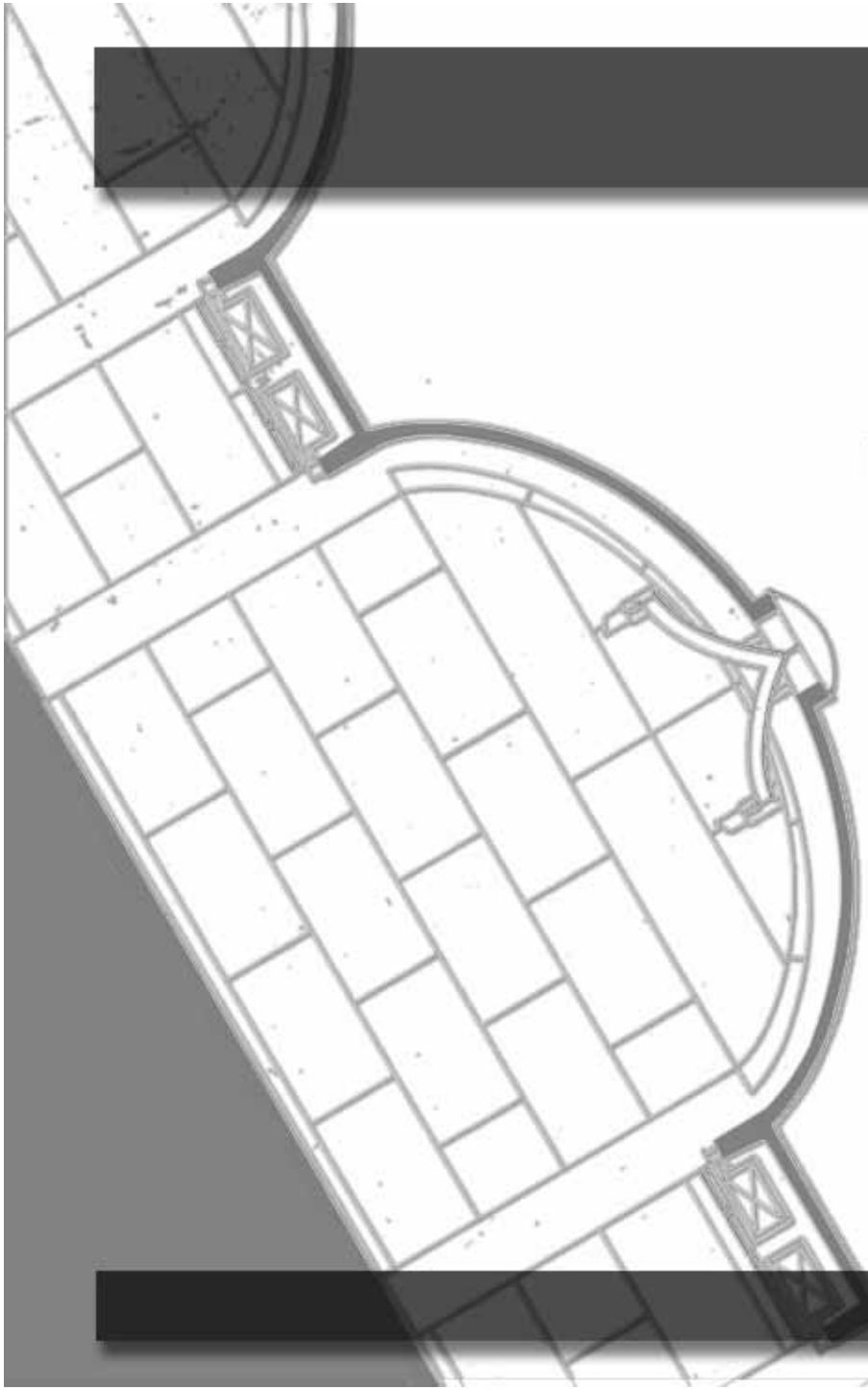
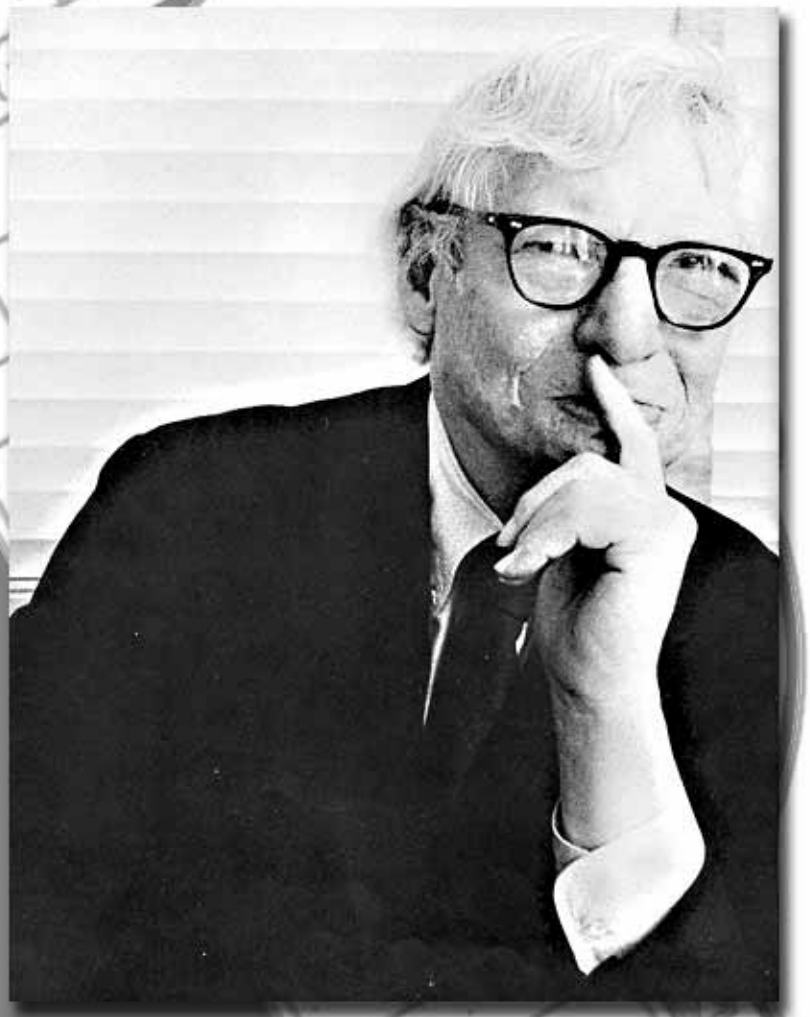
Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



"The vault is a kind of surface that could receive light. The measure of an interior space is its sense of position to light, and in what way the light confirms the chosen shape of the room. I put glass between the structure members and the members which are not of structure because the joint is the beginning of ornament. And that must be distinguished from decoration which is simply applied. Ornament is the adoration of the joint."

-Louis I. Kahn

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



Architect: Louis Kahn

Born in Estonia 1901

Family immigrated to the United States in 1906 and settled in Philadelphia where he died in 1974

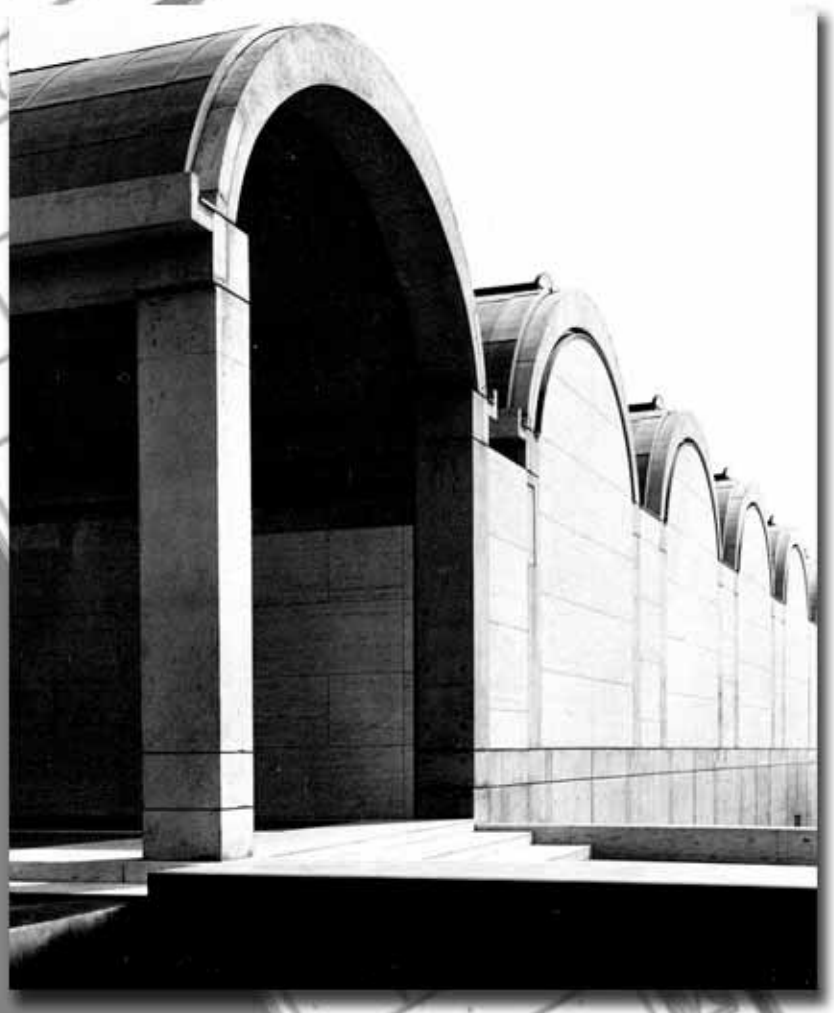
Kahn studied architecture in the Beaux-Arts tradition at the University of Pennsylvania. He graduated in 1924

Focused on differentiating between served spaces and servant spaces

Used contrasting textures in his material selections

Worked closely with engineers to find unique design solutions

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



Project information

Architect – Louis I. Kahn

Structural Engineer – August E. Komendant

Mechanical / Electrical Engineer – Cowan, Love & Jackson, Inc.

Landscape Architect – George E. Patton, Inc.

Project Architect – Marshall Meyers

Project Completion – October 1972

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

Program & Function

A museum conceptualized by Kay Kimbell and Velma Fuller Kimbell to be "'an art institute' for the people of Texas" (www.kimbellart.org/MuseumInfo/Architecture.aspx)

Political / Funding Background

Kay Kimbell, "a successful miller, industrialist, and art collector," passed away in April 1964. The creation of his conceptualized "art institute" was mandated in Kimbell's will and "his widow decided that the entire Kimbell estate should be used to implement this institution. Within a week of his death, she contributed her share to the Foundation."(www.kimbellart.org/MuseumInfo/Architecture.aspx)

1966 – Kahn commissioned by museum director Richard Fargo Brown to design a museum for the Kimbell Art Foundation (www.kimbellart.org/MuseumInfo/Architecture.aspx & Komendant)

The museum trustees insisted that Kahn's studio work as associates with a local firm: Preston M. Geren, Architect and Engineer.

The disagreements developed between Geren and Kahn about the museum structure and design caused great adversity and almost lead to several lawsuits. (Komendant)

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

The Building

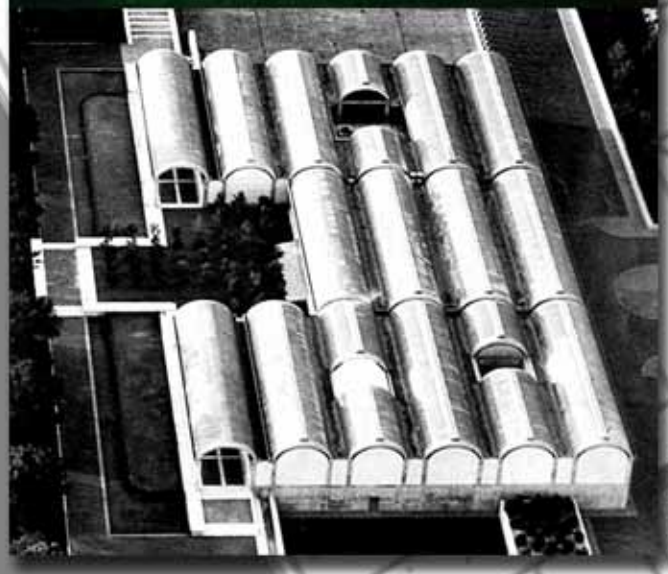
The **preliminary design** had a museum and an auditorium connected with an arcade

The **semi-circular shell roofs** made their first appearance in this design. **Geren did not like the roof design and subsequently could not get it to work structurally. Komendant, who designed the cycloid vaults, had no problem making them structurally sound.**

Important **design concept** used by Kahn for the final design was to focus on **"'silence and the quality of light.'"** (Komendant)

The Kimbell Art Museum is considered to be Kahn's masterpiece

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



Building Program

Upper Level:
gallery space, auditorium, library, book store, refreshment area

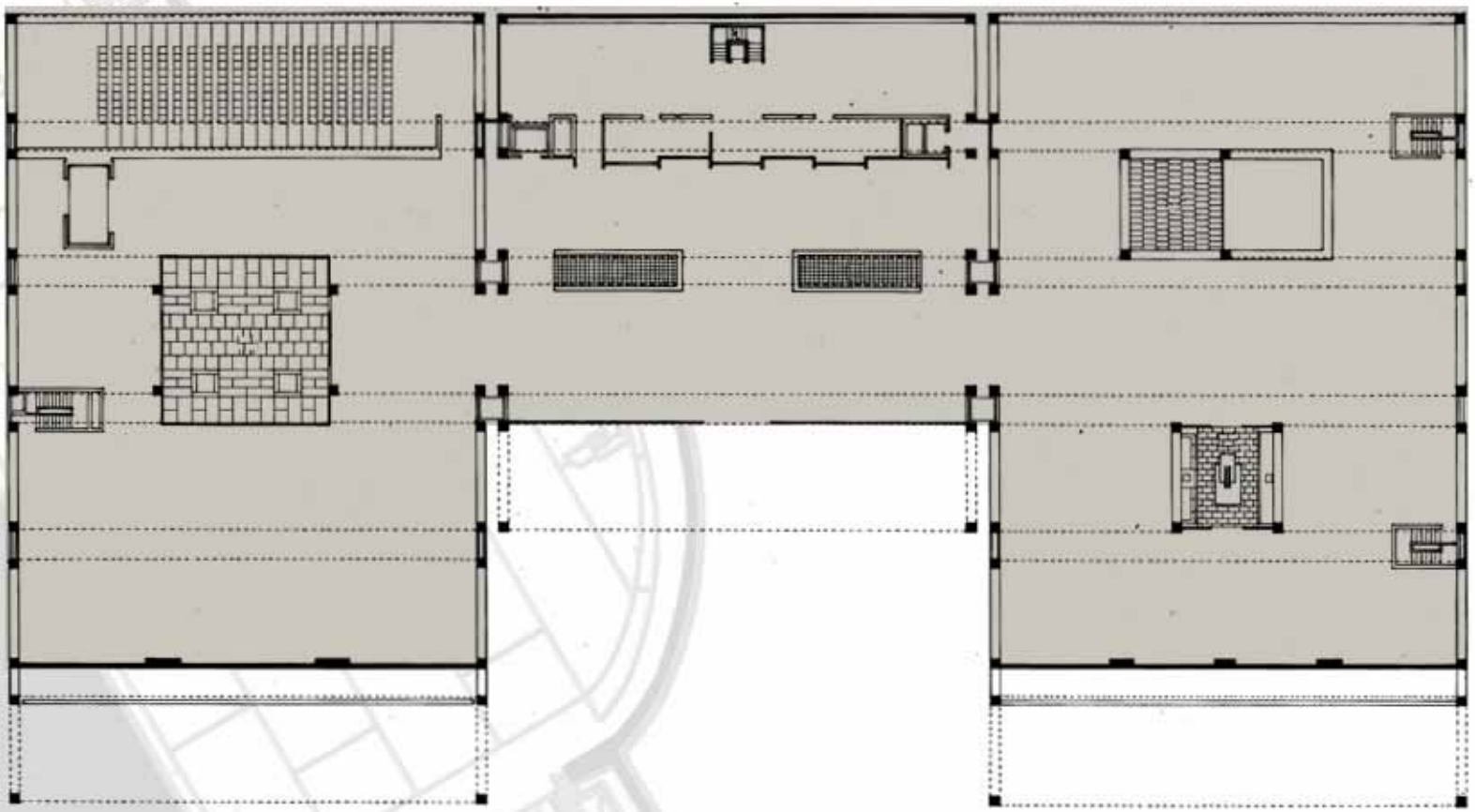
Lower Level:
laboratories, shops, shipping and receiving

Basement Level:
mechanical and electrical distribution systems

Entrance:
main public access on west side of upper level and an east side entrance on the lower level from the parking lots

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

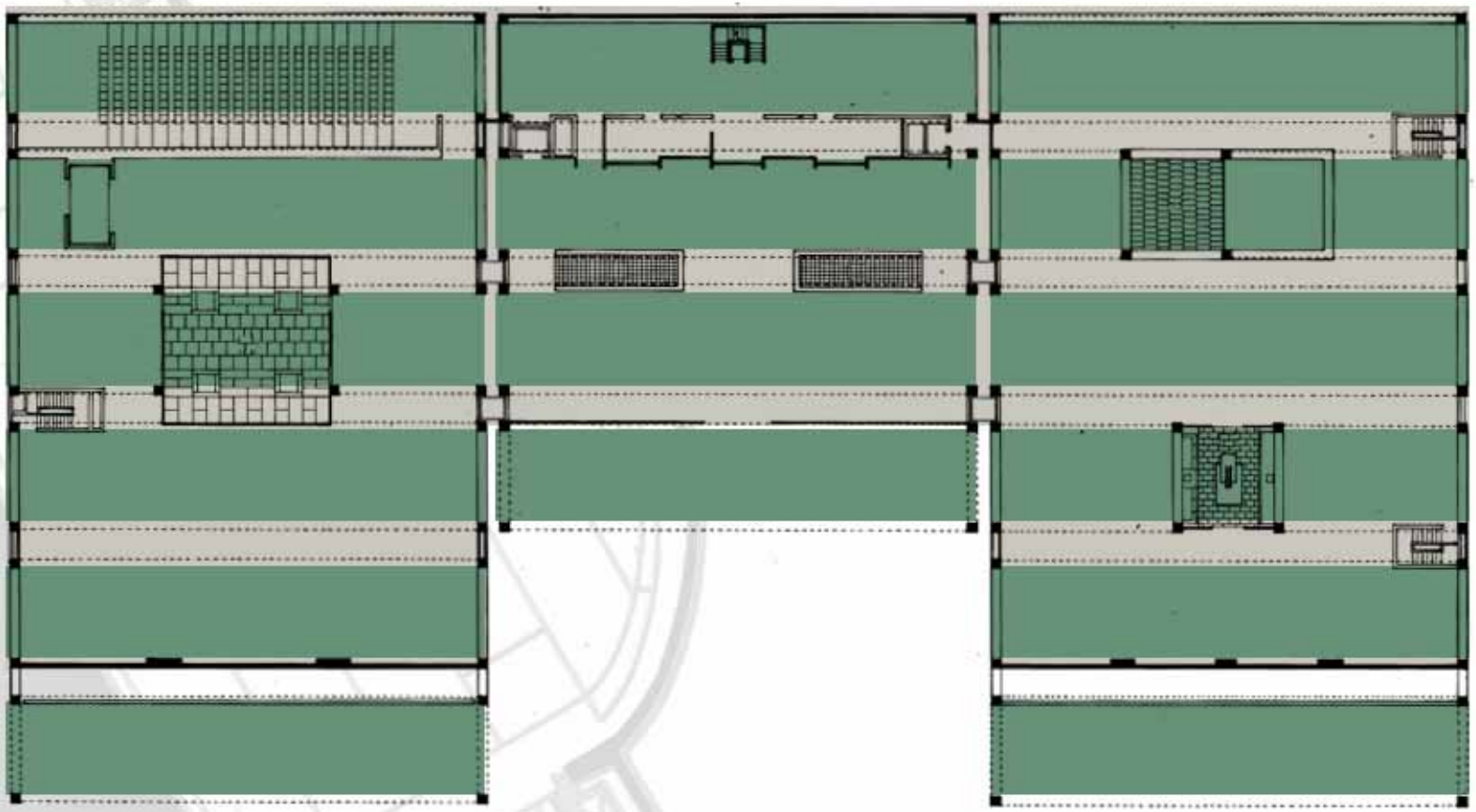
Basic Structural Plan



Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

16 Vaults

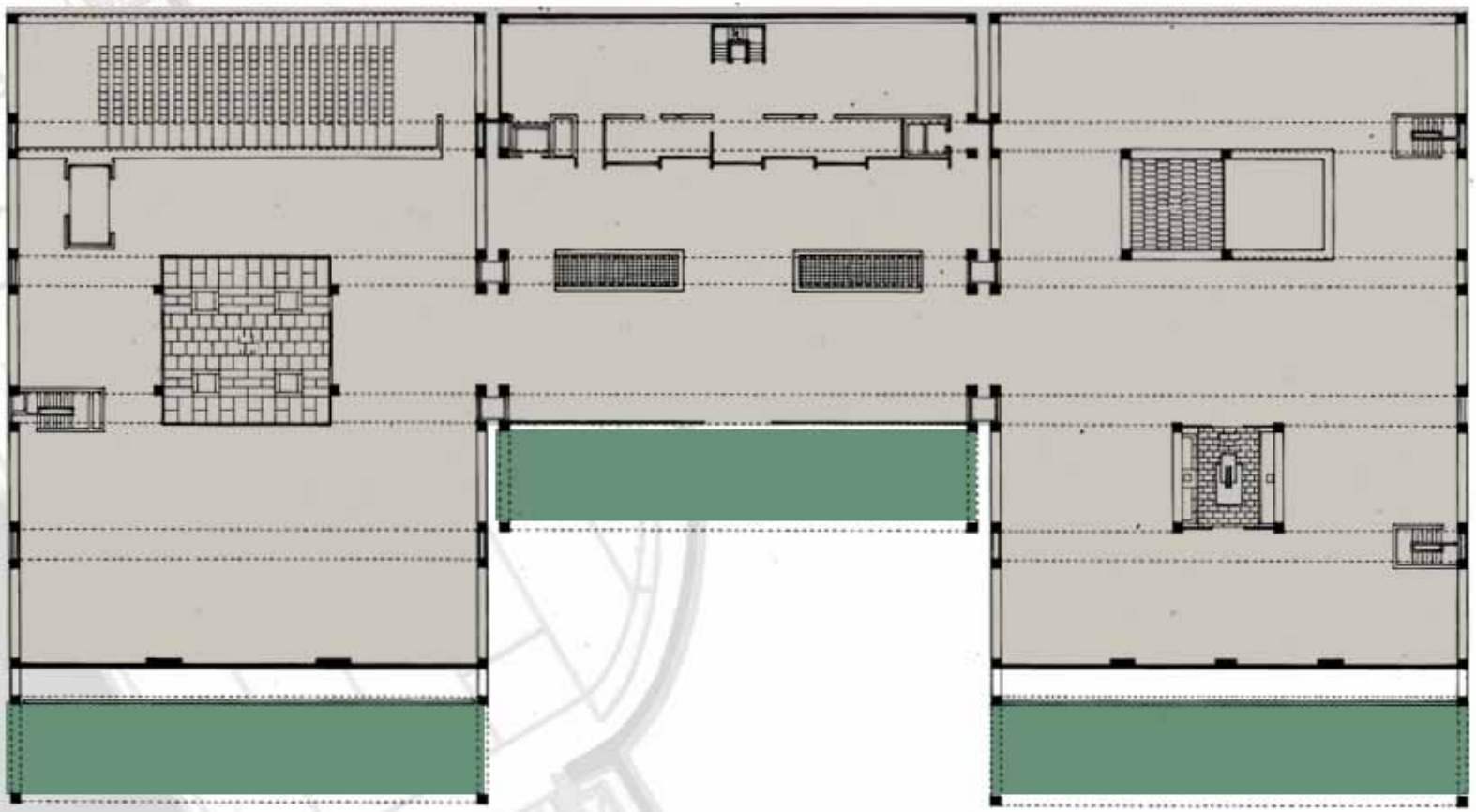
Basic Structural Plan



Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

East vaults are porticos

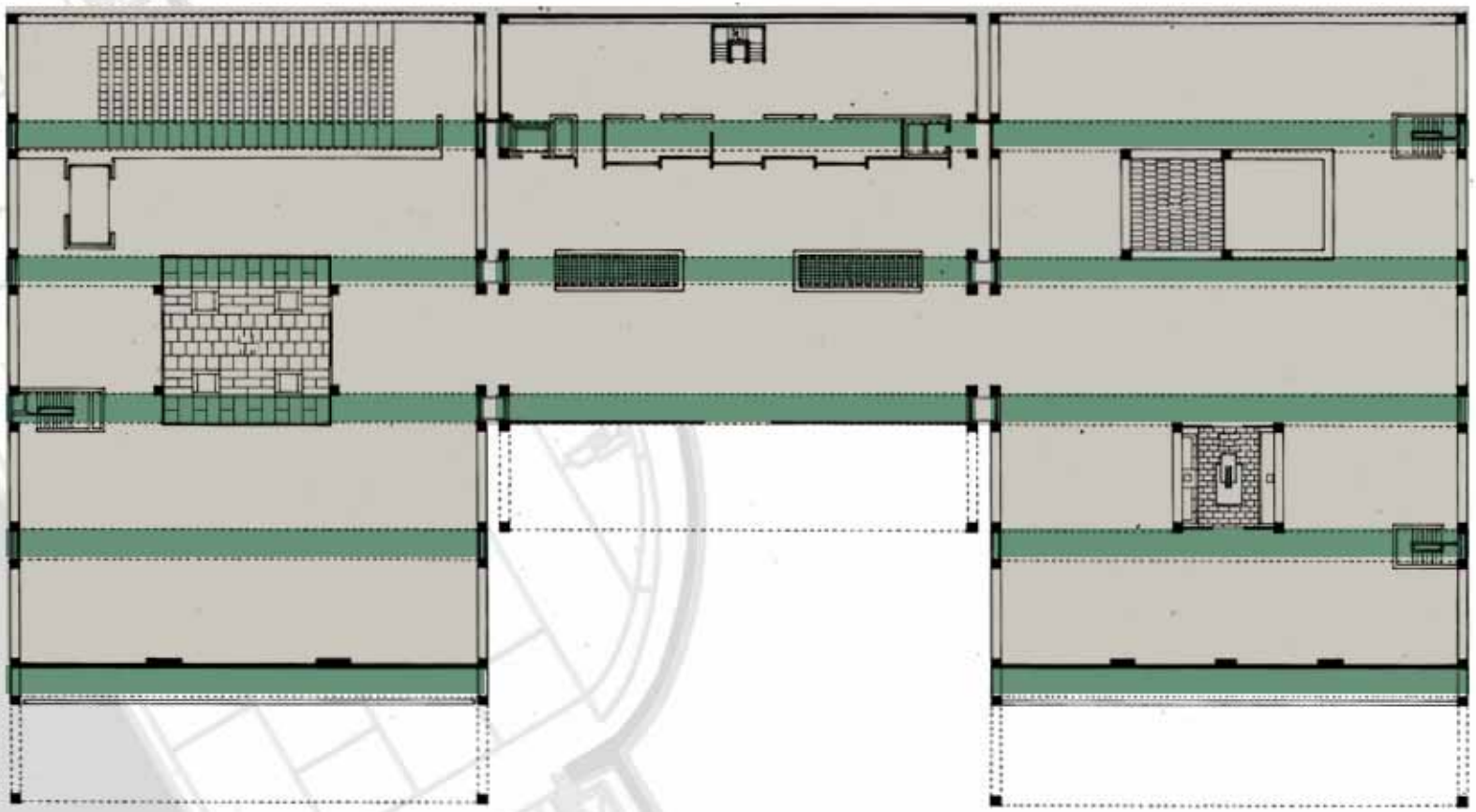
Basic Structural Plan



Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

6‘ wide channels between vaults for mechanical and air handling systems

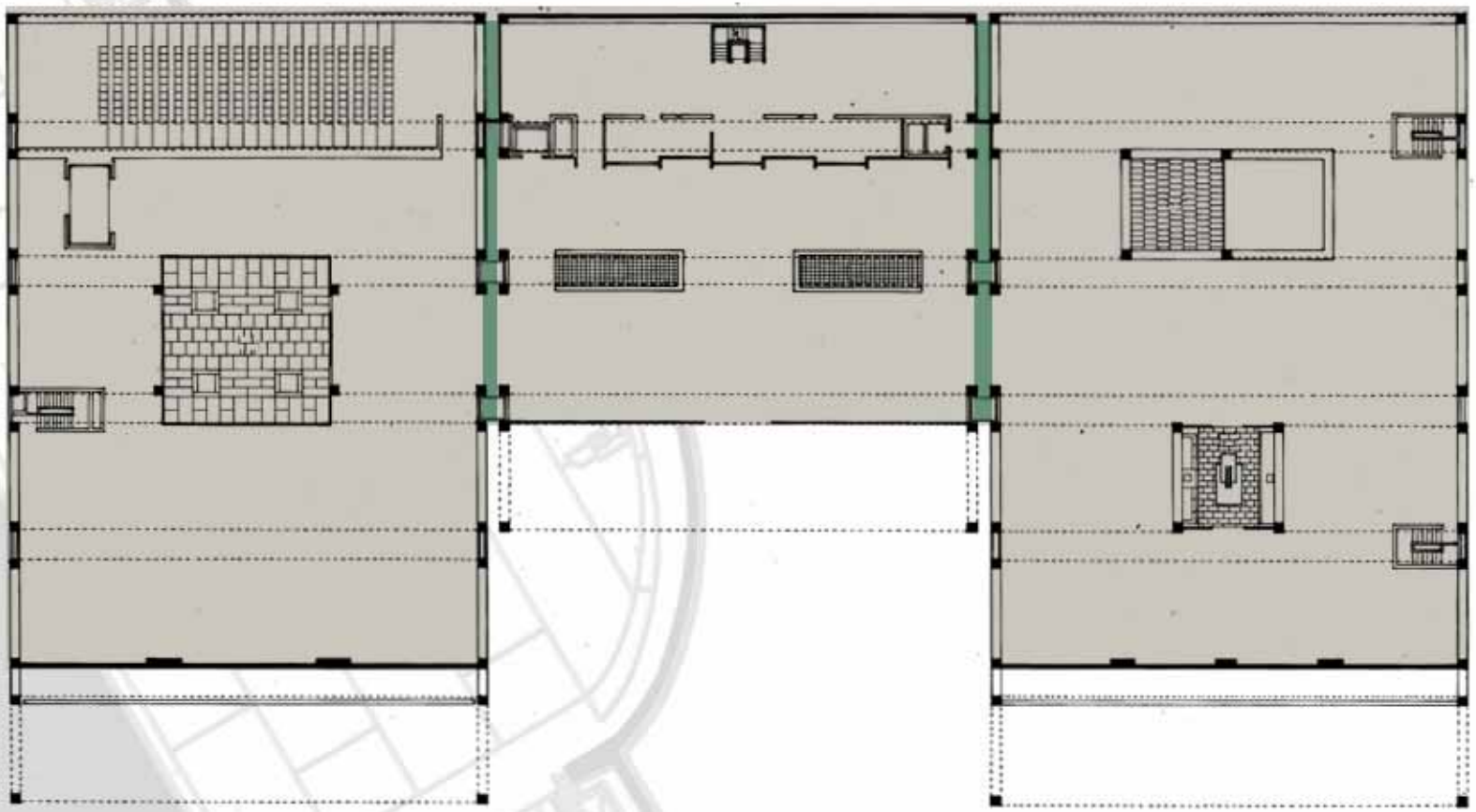
Basic Structural Plan



Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

Mirrored glass slits

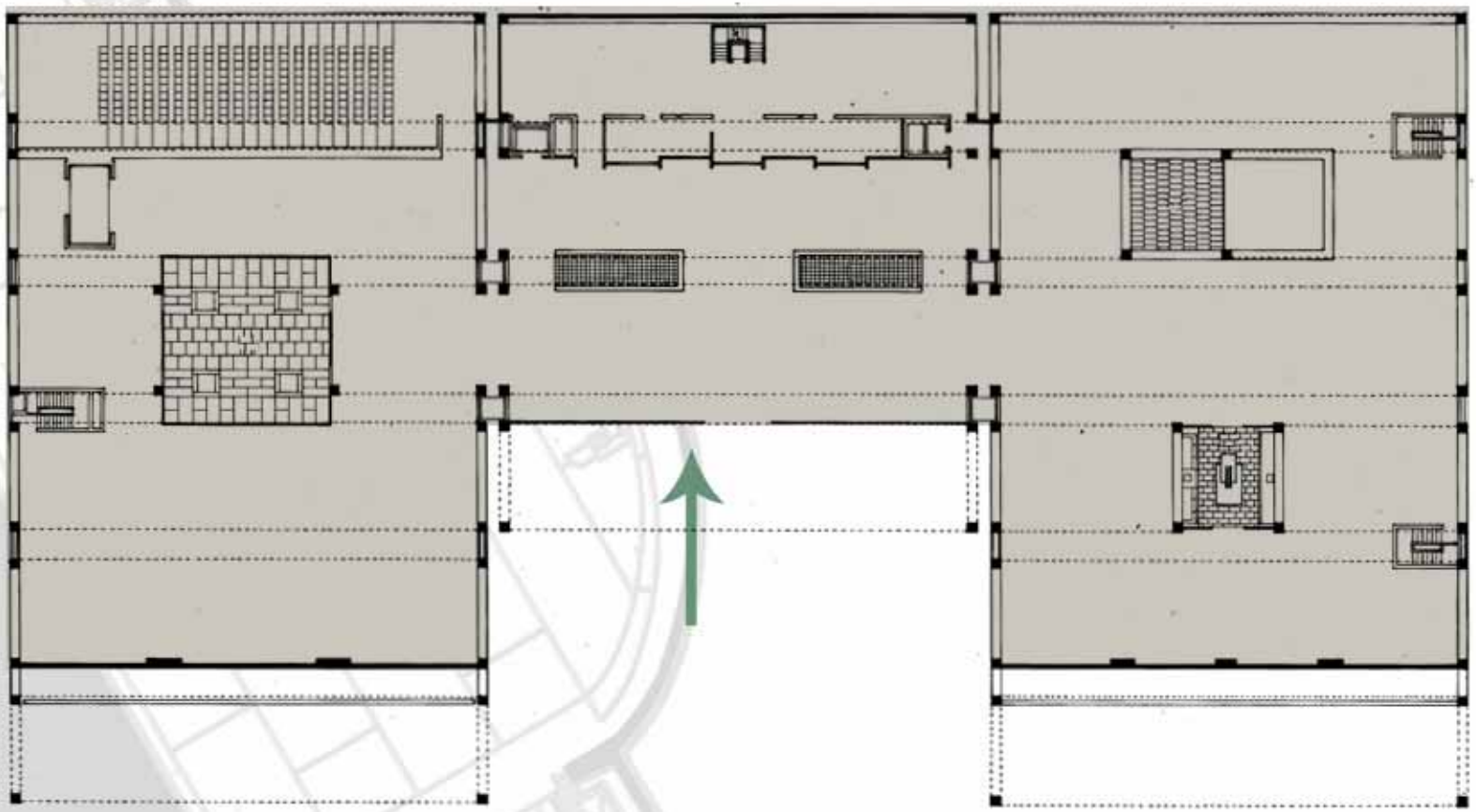
Basic Structural Plan



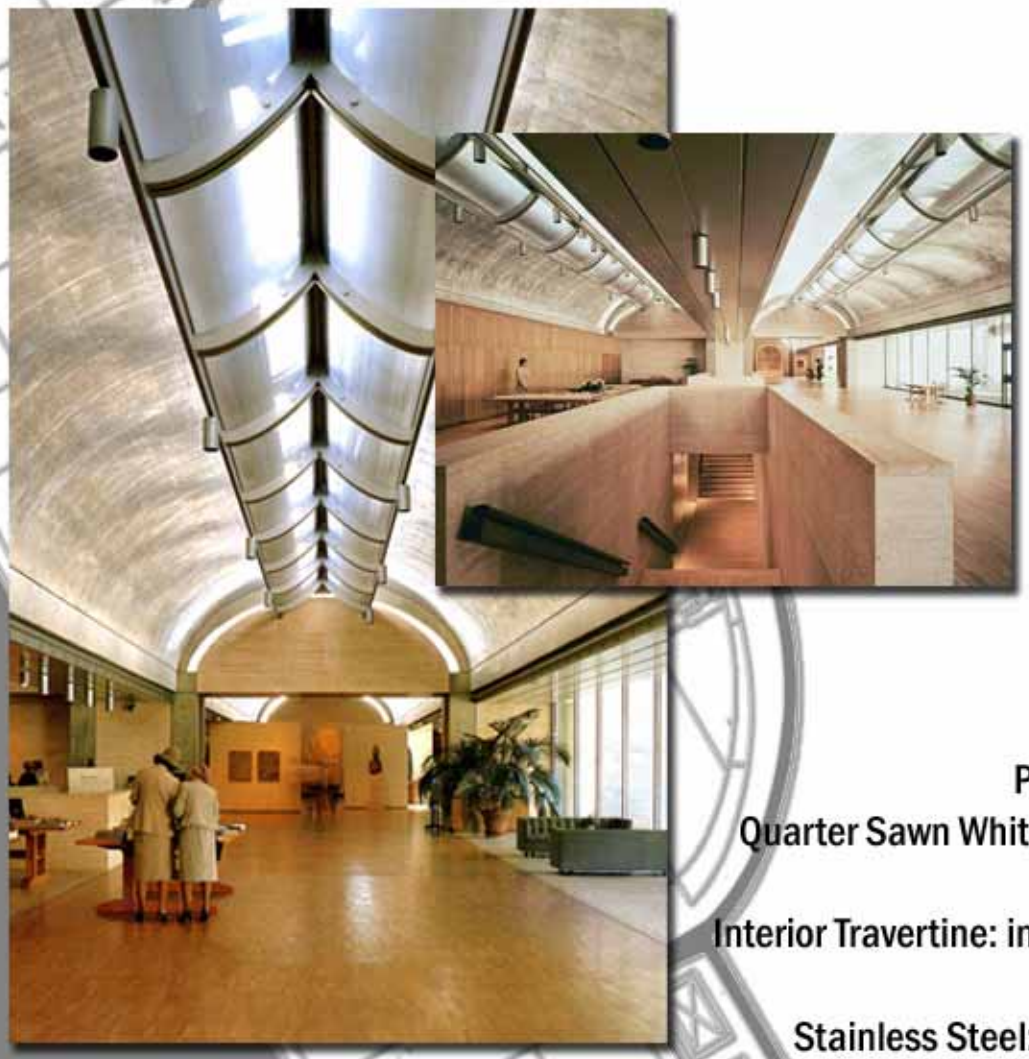
Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

Main Entrance

Basic Structural Plan



Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



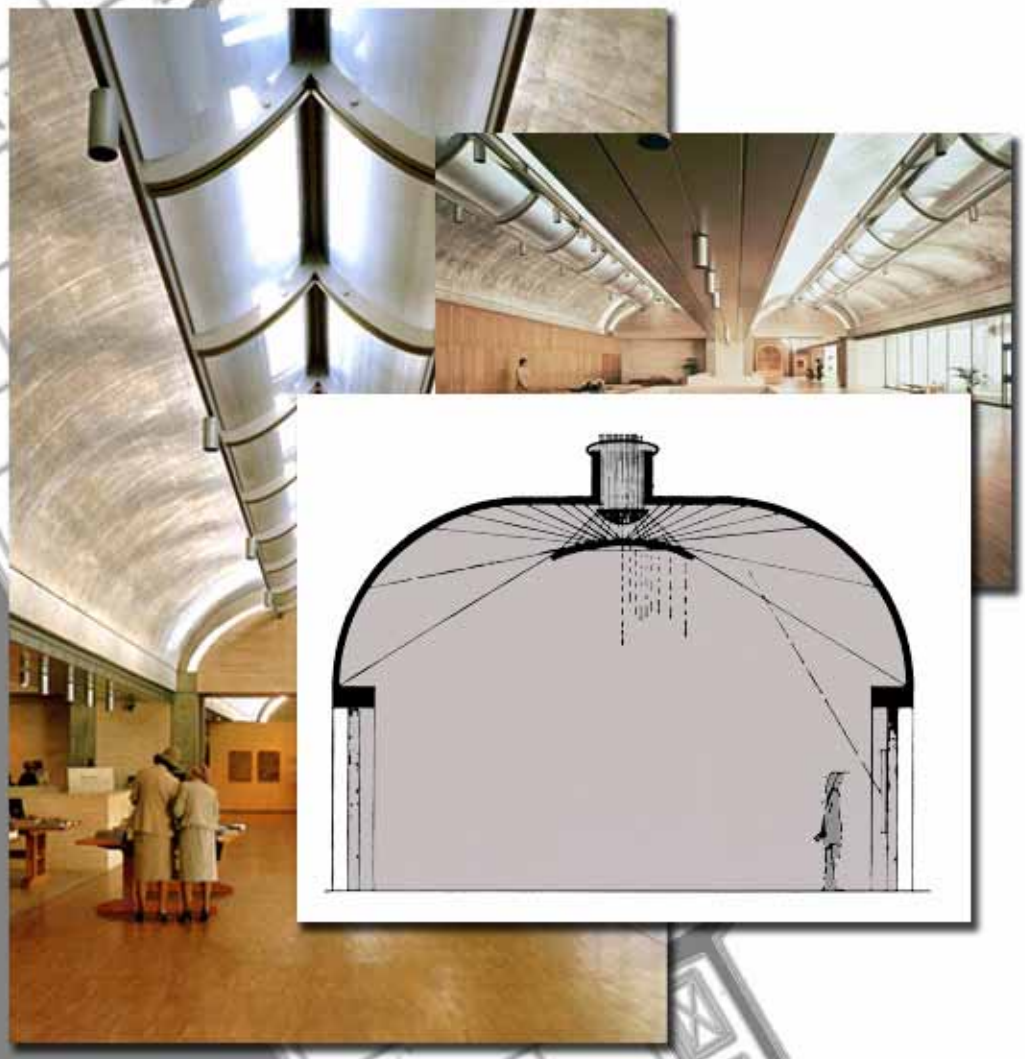
Materials

Roof:
concrete cycloid shells separated by a longitudinal skylight

Walls:
exterior walls - nonbearing and surfaced
travertine marble on the exterior
travertine marble and wood on the interior

Details:
Double Insulating Glass: gallery level
Plexiglas: skylights that run down the barrel vaults
Quarter Sawn White Oak: gallery flooring, cabinet work, and interior doors and frames
Interior Travertine: infill walls, stairs, balustrades, and portions of the floor
Stainless Steel: doors, frames, windows, elevator, and handrails

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



Natural Light Concepts

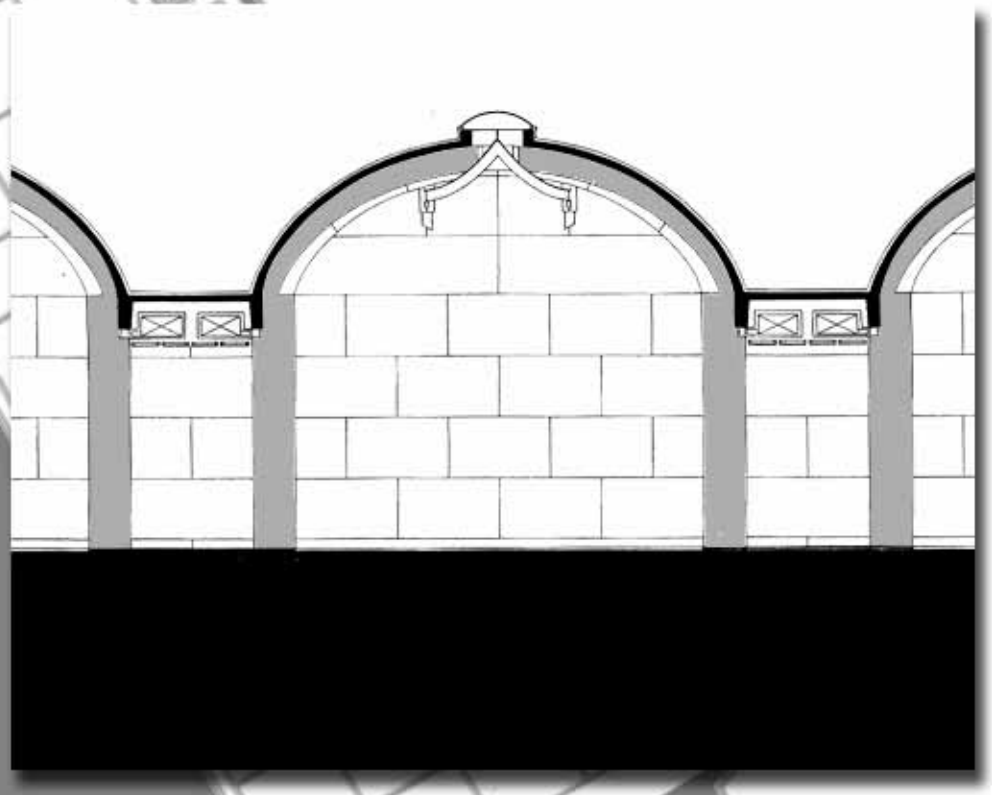
"Nothing static, nothing static as an electric bulb, which can only give you one iota of character of light. So the museum has as many moods as there are moments in time, and never, as long as the museum remains as a building, will there be a single day like the other."

Each vault has a longitudinal 3' slit at the apex:

works as a natural light fixture
filters light through reflection
gives room a silver glow

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

Barrel Vault Description



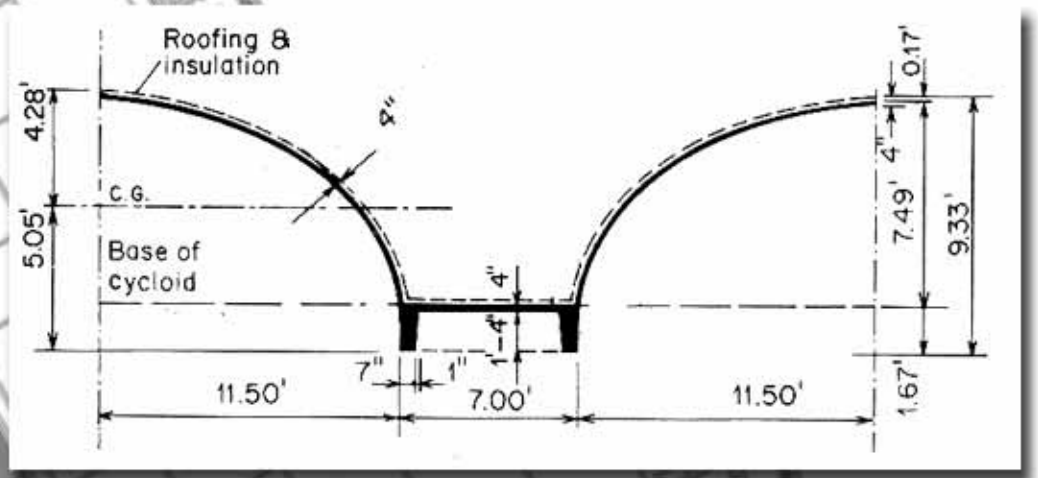
Each vault a 23 X 100 foot clear span of 2 cycloid concrete shells

Vaults are supported by 2 X 2 foot corner concrete columns

Each vault is structurally independent and is separated by the concrete channels

Each vault has its own column supports

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



Barrel Vault Structural Details

"Neither pure vault nor pure shell."

Vaults are formed by two cycloid concrete shells that are separated by longitudinal skylight

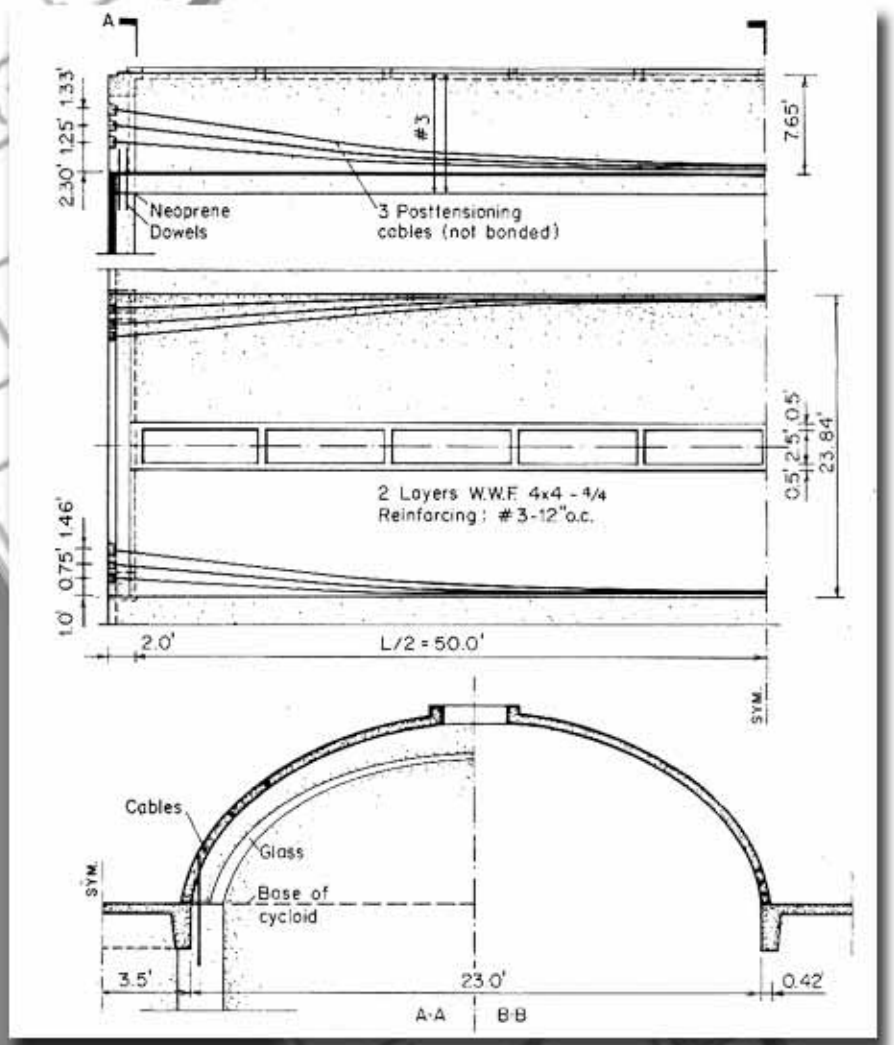
Cycloid: similar to a semi-ellipse with the bottom of the curve being a vertical line

Shells have a uniform thickness of 4 in. as required by codes and the space needed for steel reinforcement

Roof insulation and a lead-coated copper roof are applied above

Vaults are solely supported on the corners by four square concrete columns

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



Reinforcement of Cycloid Shells

Reinforced by three catenary steel post-tensioning cables within each side of the lower part of the shells, along with conventional steel reinforcing

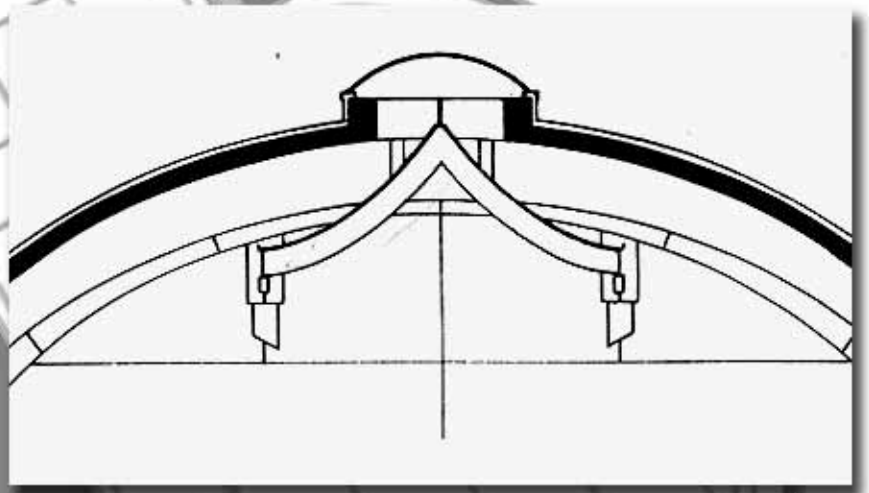
Vaults are formed by two cycloid concrete shells that are separated by longitudinal skylight

Shells are thickened at the ends to form stiffening arches

Arches are separated from the end walls by a thin glass strip, which emphasizes that the walls are nonbearing. All loads are transferred from the arches to the columns.

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

Skylight Structural Details



3 ft. wide skylight runs down the center of most vaults

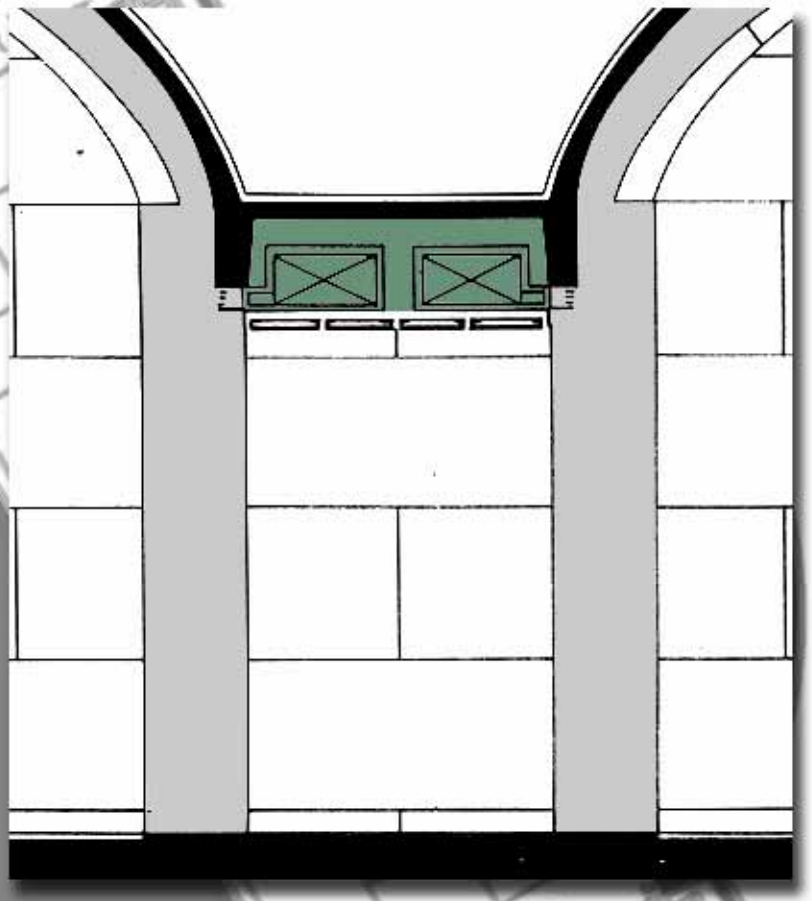
11 concrete spacers hold the two shells apart to counter the compressive forces that occur along their sides at the apex

The upper part of the shells functions as a diaphragm, serving as a horizontal beam that spans the distance between the spacers. For more stability, the shell is thickened at this opening

.

The skylight admits light through the use of a curved reflector (perforated stainless steel), which reflects most of the light onto the underside of the shell and downward to the floor.

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



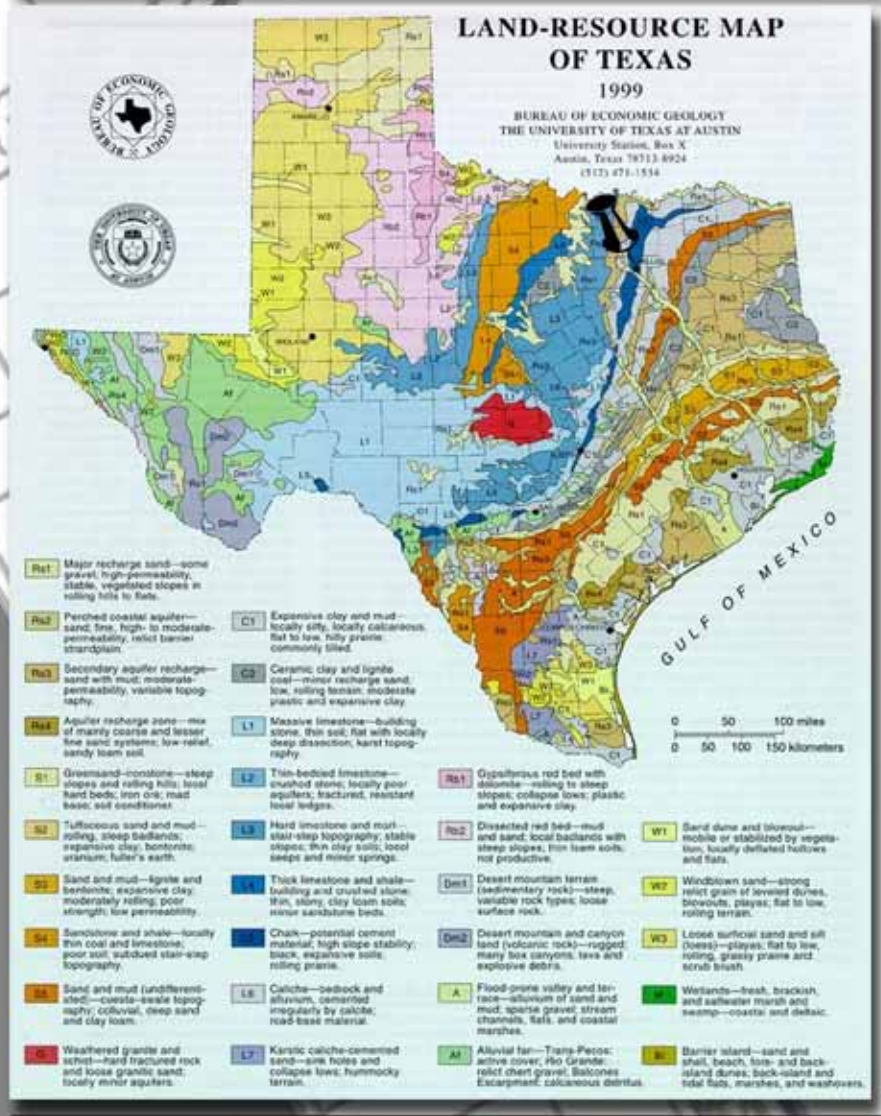
Concrete Channels

Six foot reinforced concrete channels between each vault house mechanical and electrical systems.

Serves to stiffen the lower edges of the cycloid shells against buckling.

The shells provide the primary structure and support the channels.

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



Floor Systems and Foundation

Upper level floor slabs are two way post-tensioned concrete

Ground floor is post-tensioned concrete slab supported by short piles

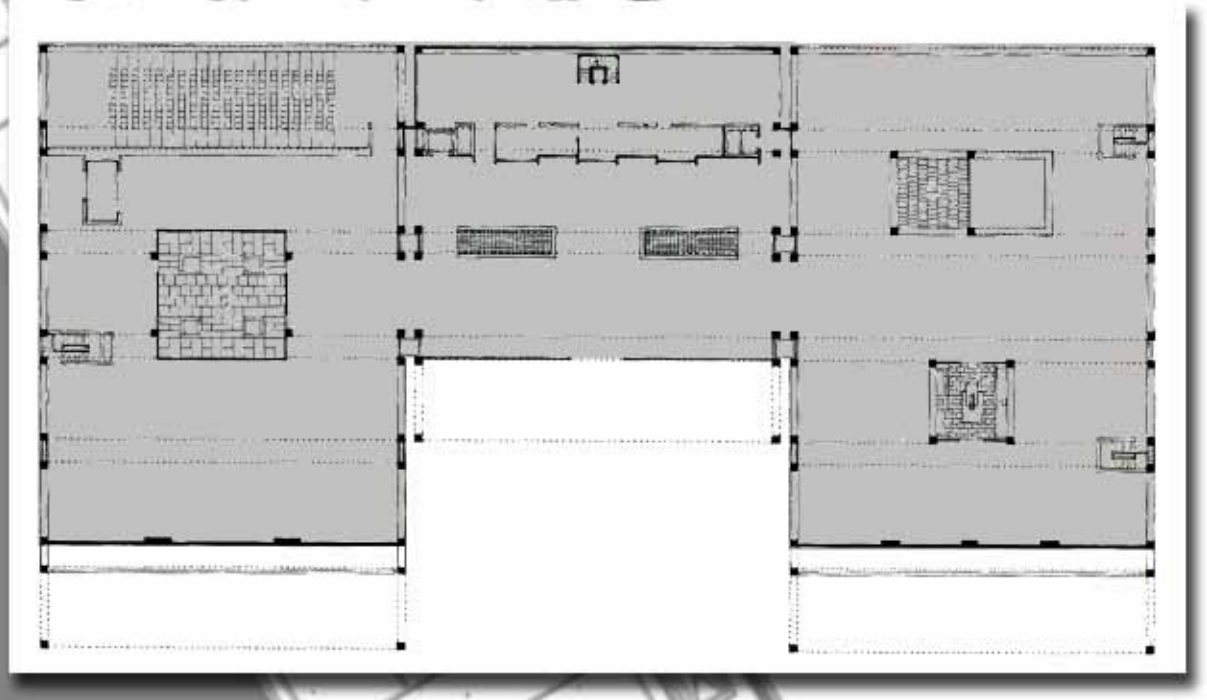
Soil is highly expansive clay soil typical of Dallas

Soil Description from Map: Chalk-Potential cement material; high slope stability; black, expansive soils; rolling prairie

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

Load Transfer

Load at apex of roof transferred along vault longitudinally and vertically to reach the four lower corners. Each barrel vault can function independently as a diaphragm to transfer the loads.



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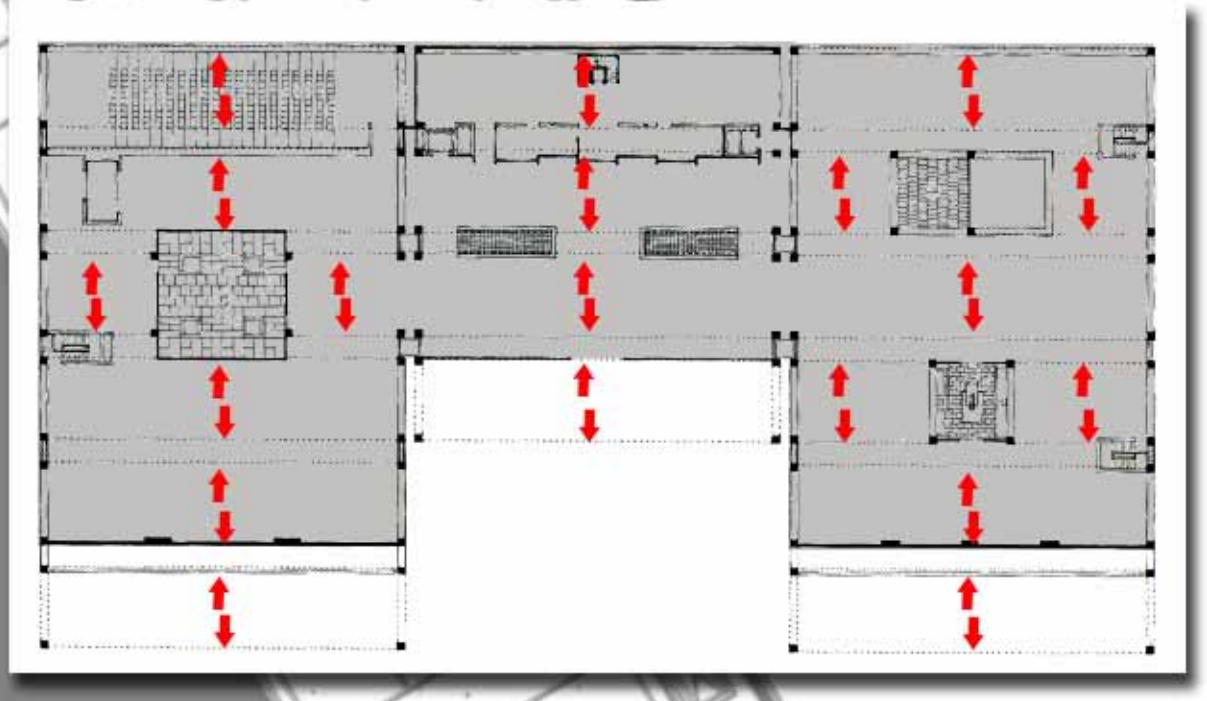

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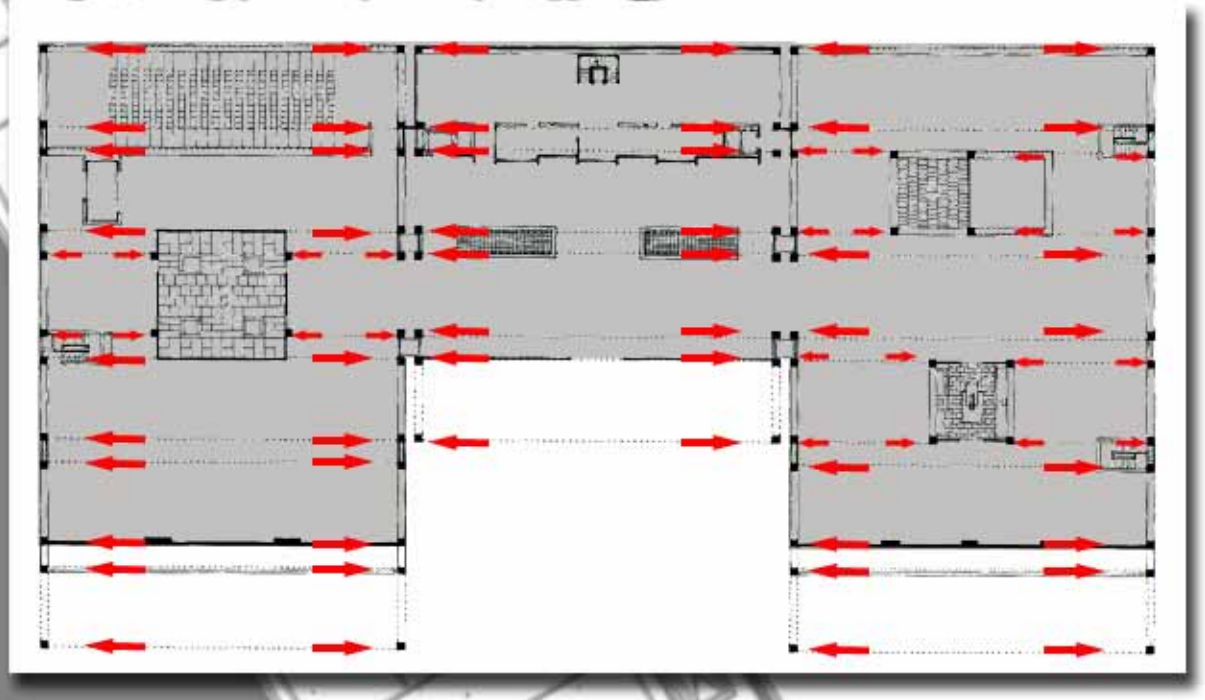
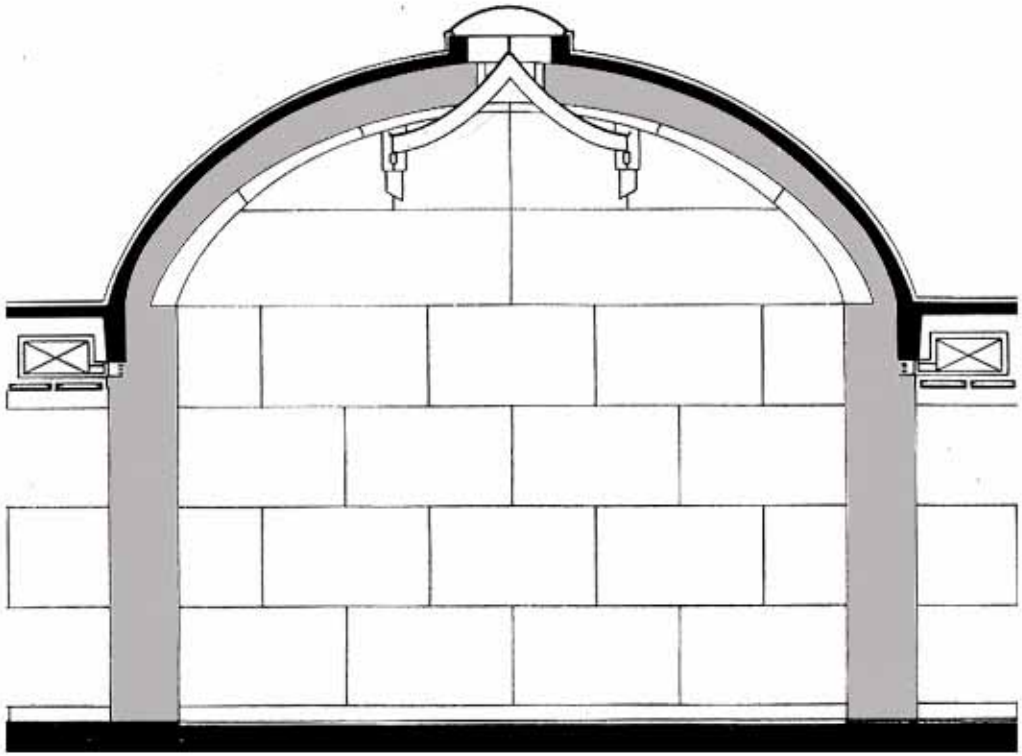


Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

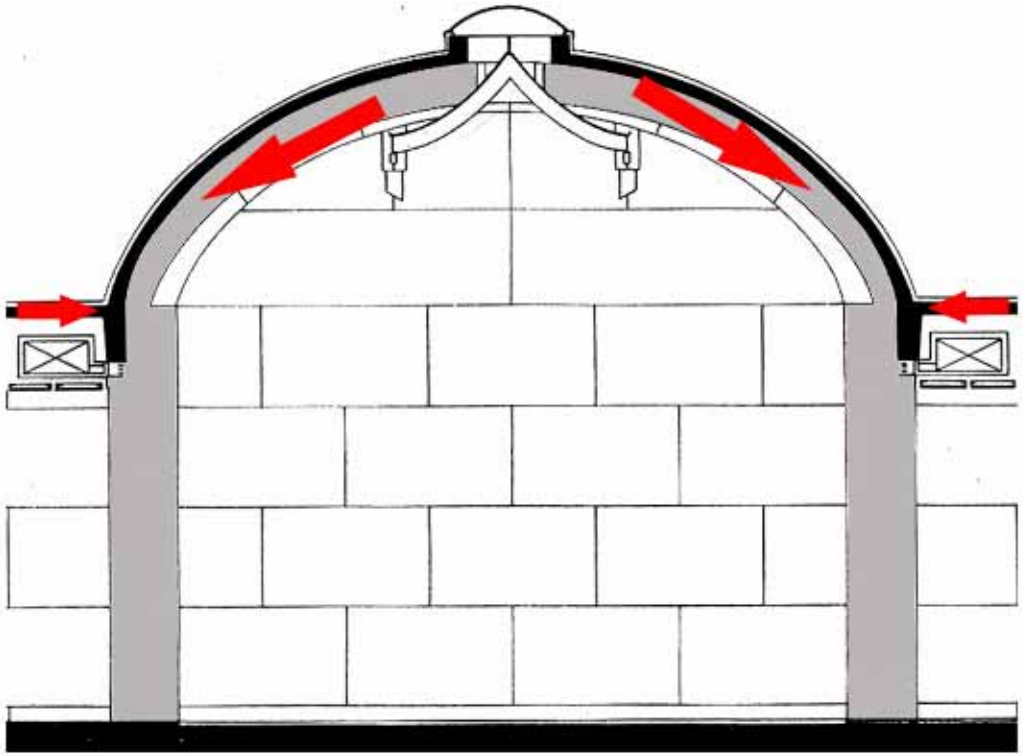


Load Transfer

This load, combined with the load from the concrete channels, is directed down to the concrete columns. Walls are non-bearing.

Loads directed down the columns to the ground floor slab where they are dispersed into the foundation.

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



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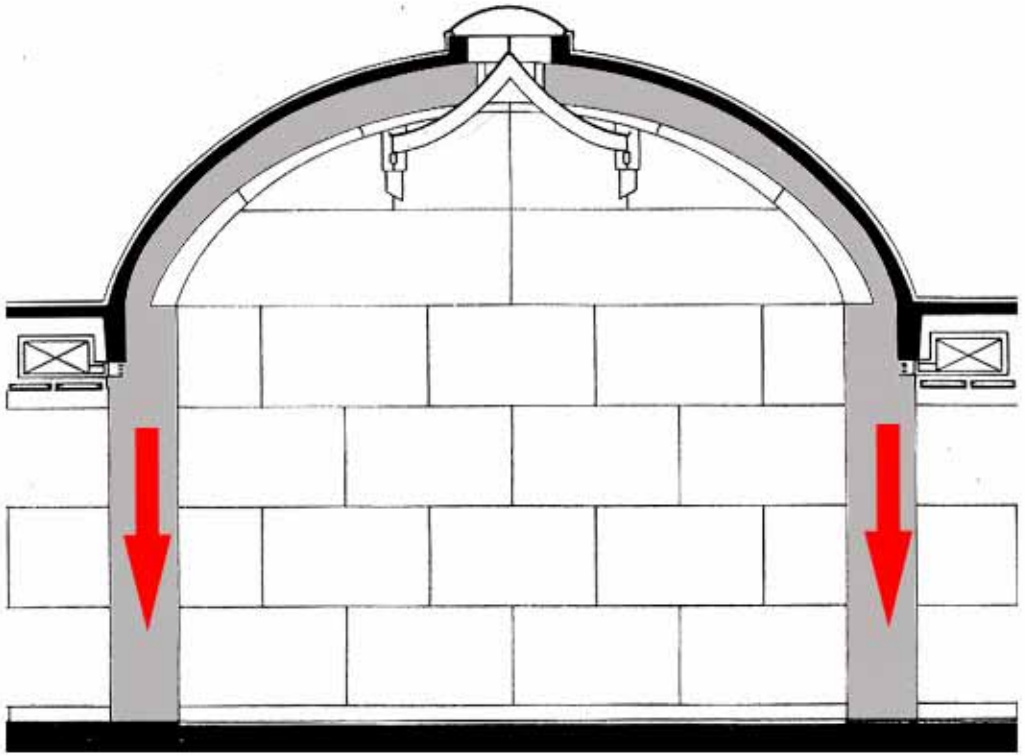

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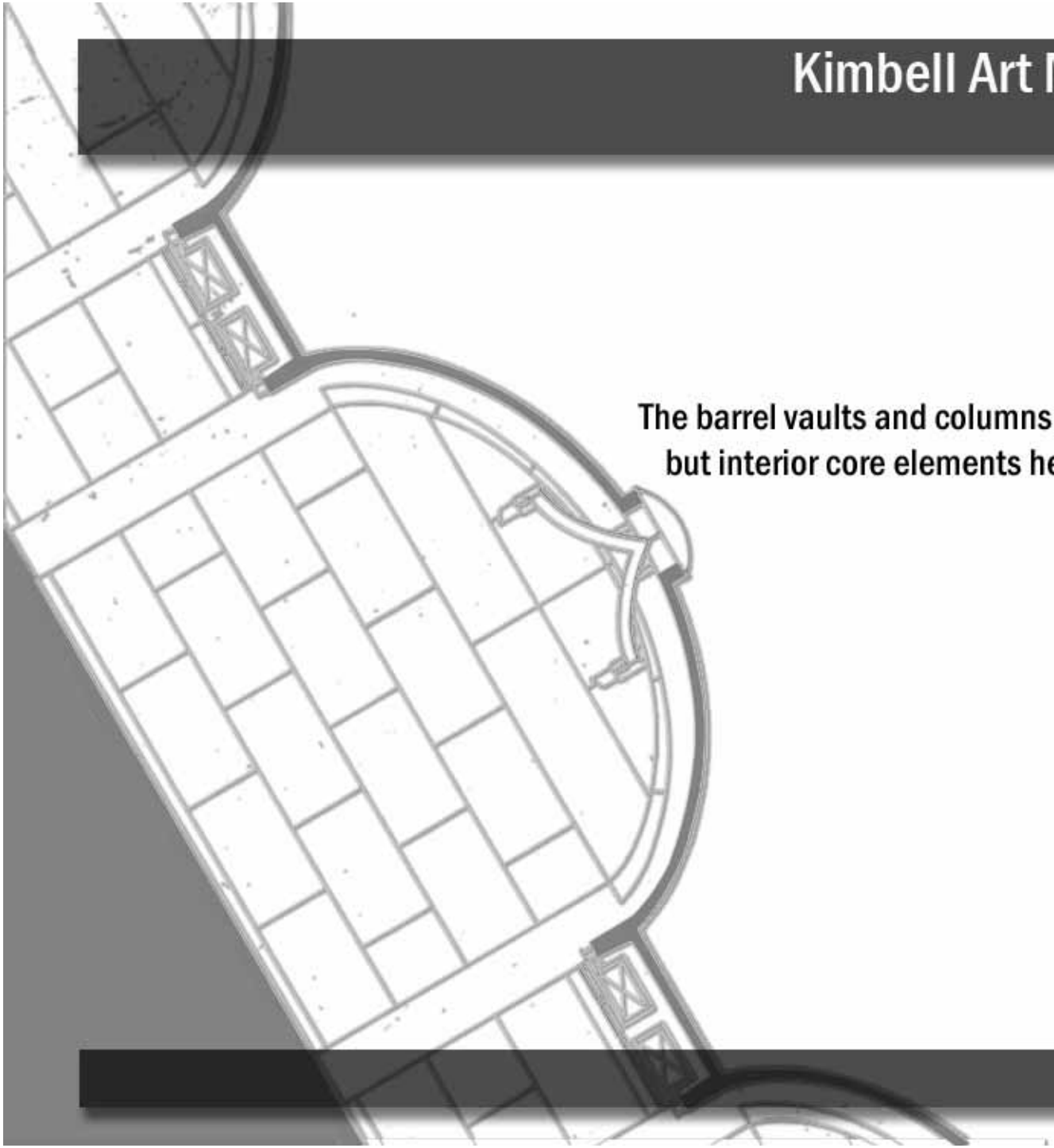
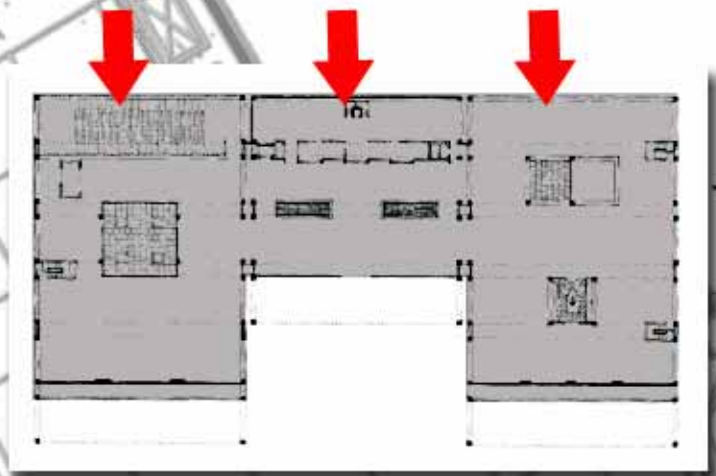


Lateral Loads

Wind loads are minimal

The barrel vaults and columns provide the primary resistance, but interior core elements help to strengthen against lateral loads

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



Lateral Loads

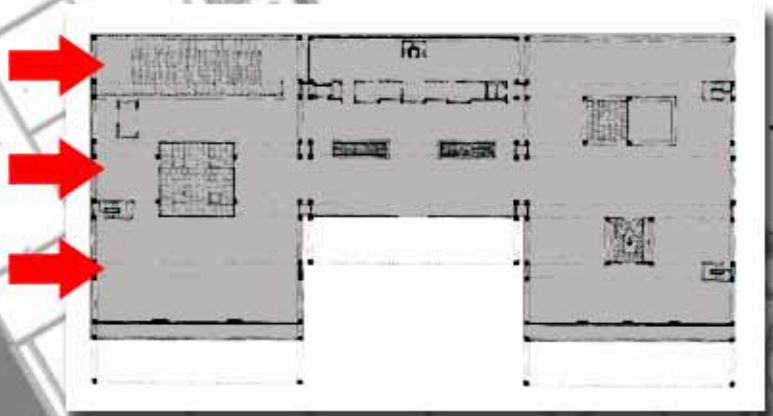
Wind loads are minimal

The barrel vaults and columns provide the primary resistance, but interior core elements help to strengthen against lateral loads

Loads in East-West Direction

Load hits the long side of the barrel vault, which functions as a diaphragm to carry the load down through the columns to the foundation
Remaining forces are transferred to the next bay and process of transferring loads to the foundation is repeated until all forces are resolved.

Kimbell Art Museum: Fort Worth, Texas
Louis Kahn



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Wind loads are minimal

The barrel vaults and columns provide the primary resistance, but interior core elements help to strengthen against lateral loads

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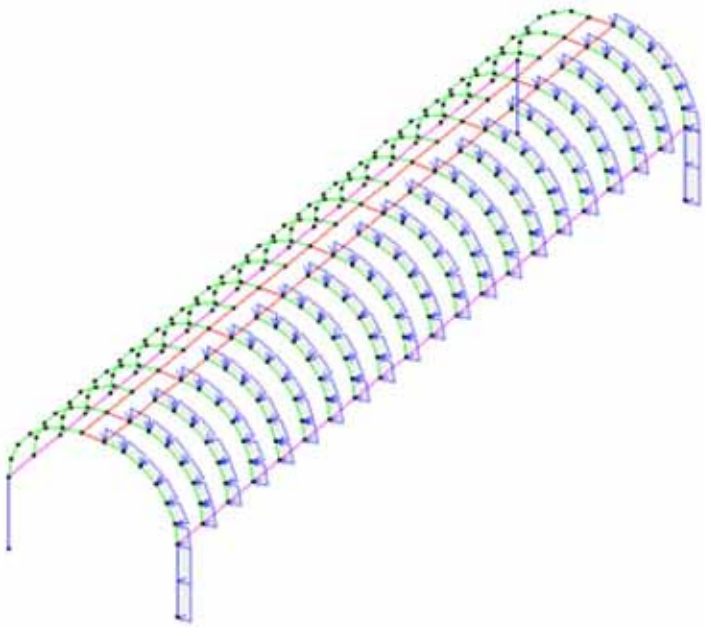
Load hits the long side of the barrel vault, which functions as a diaphragm to carry the load down through the columns to the foundation
Remaining forces are transferred to the next bay and process of transferring loads to the foundation is repeated until all forces are resolved.

Loads in North-South Direction

Loads run parallel to the long side of the vaults and are transferred along it and down the columns into the foundation
This is the longer (stronger) dimension so it is better capable of resisting lateral loads than the east-west direction

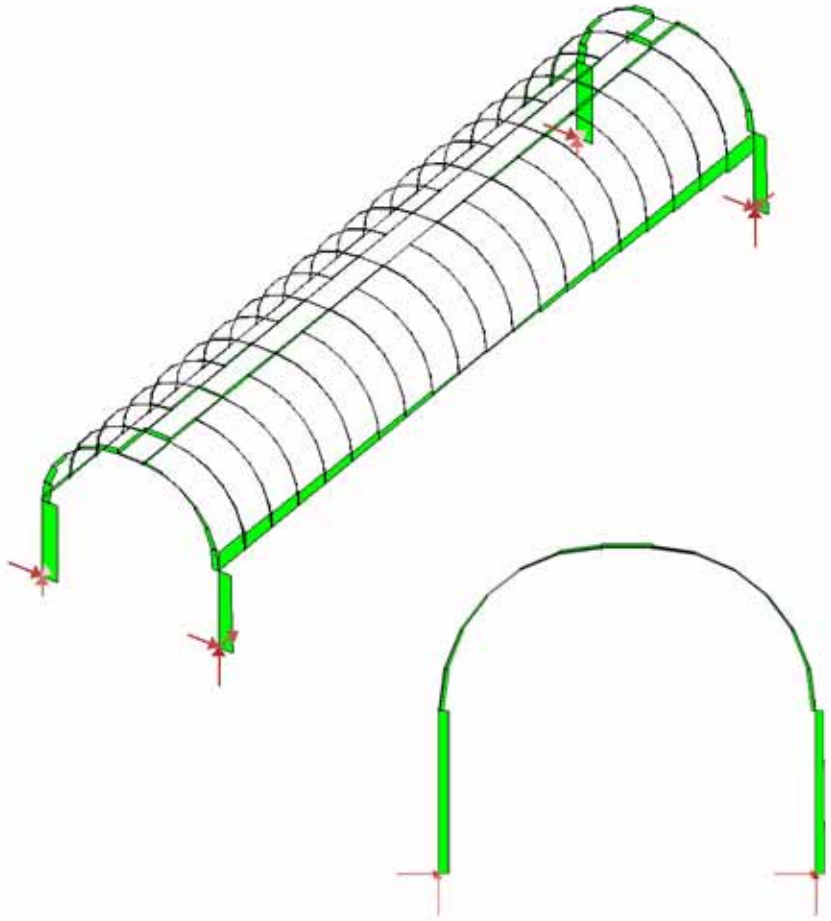
Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

MultiFrame Diagram



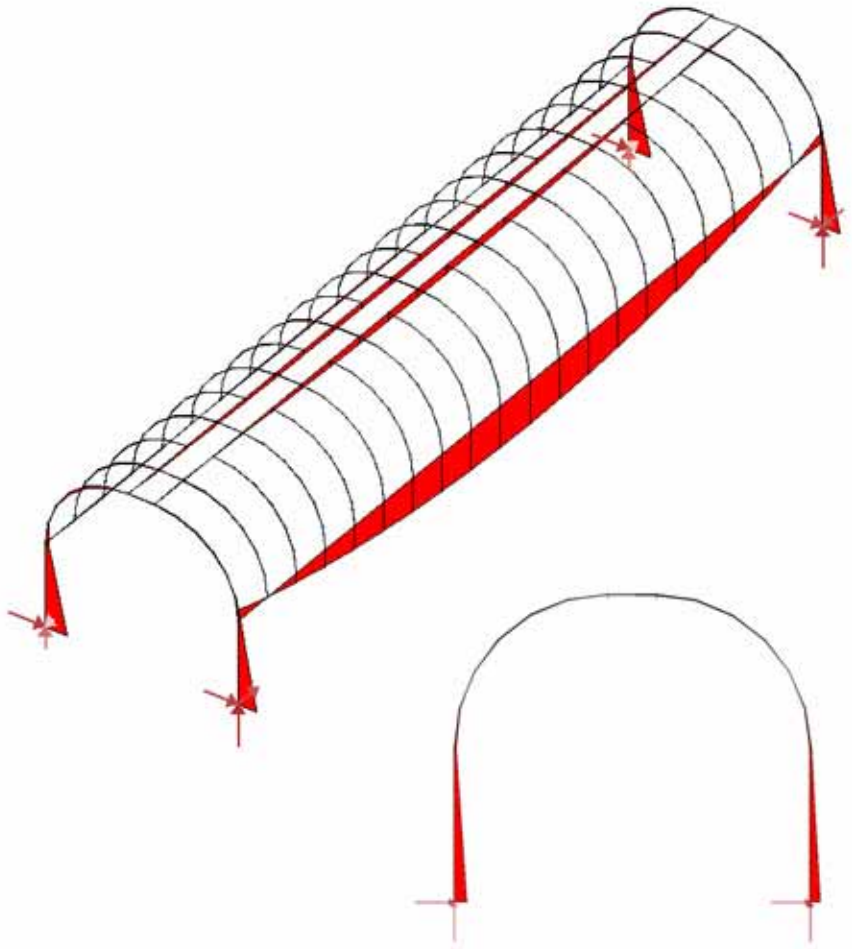
Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

MultiFrame Shear Diagram



Kimbell Art Museum: Fort Worth, Texas
Louis Kahn

MultiFrame Moment Diagram



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