Structural Classification Systems

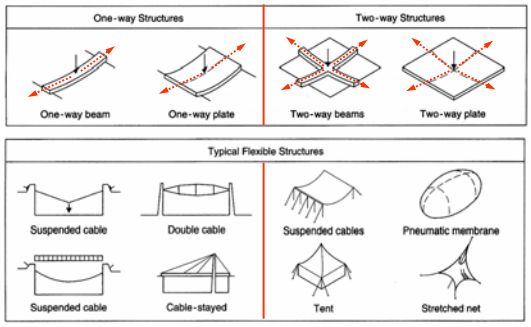
- **Typological by Geometry**
  (planar vs. curvilinear)
- **Typological by Stiffness**
  (rigid vs. flexible)
- **Typological by Span Type**
  (one-way vs. two-way action)

Structural Classification Systems

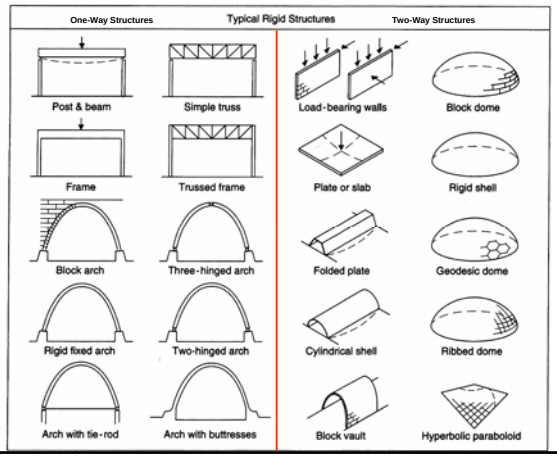
- **Typological by Material**
  (Schodek Chapter 15, Ching Chapters 4-6)
  - Wood (light wood frame, heavy timber)
  - Masonry (quarried stone, formed brick, concrete masonry units)
  - Concrete (cast-in-place, precast)
  - Steel
- **Typological by Load-Carrying Action**
  (funicular vs. bending)

Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004

Typological Structural Classification by Span Type
(Schodek, *Structures*, fig. 1.3)

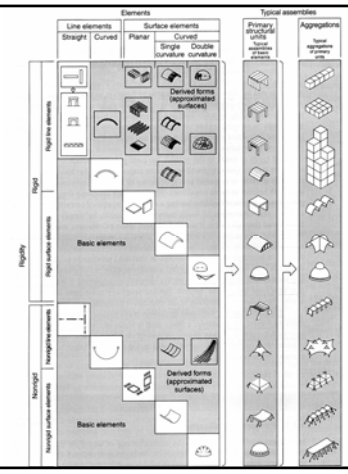


Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004



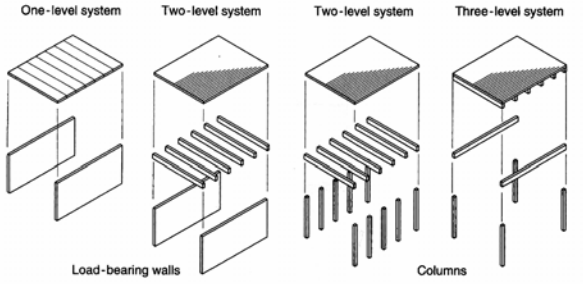
Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004

Typological Structural Classification by Geometry, Rigidity and Span Type
(Schodek fig. 1.1)



Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004

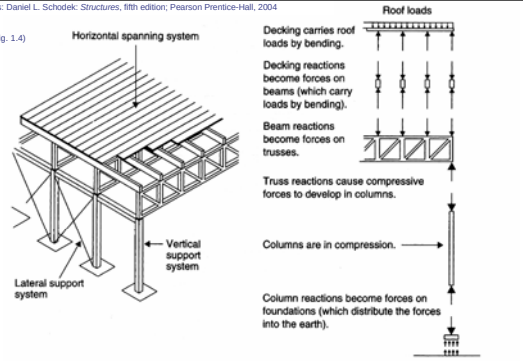
Typical One-Way Structural Assemblies
(Schodek fig. 1.4)



(a) Common types of horizontal spanning systems (one-, two-, and three-level systems) used in relation to different types of load-bearing wall and columnar vertical support systems.

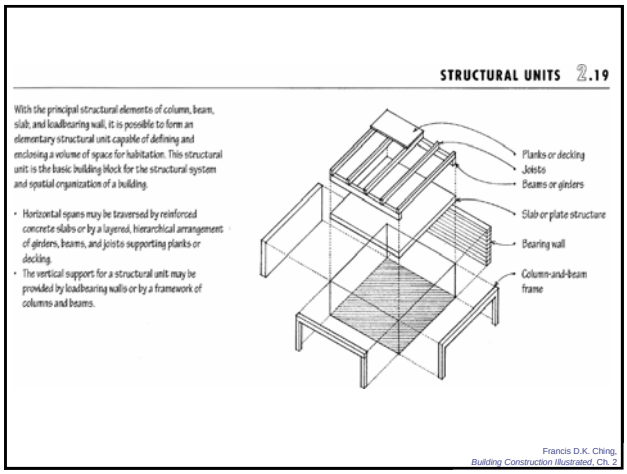
Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004

(Schodek fig. 1.4)

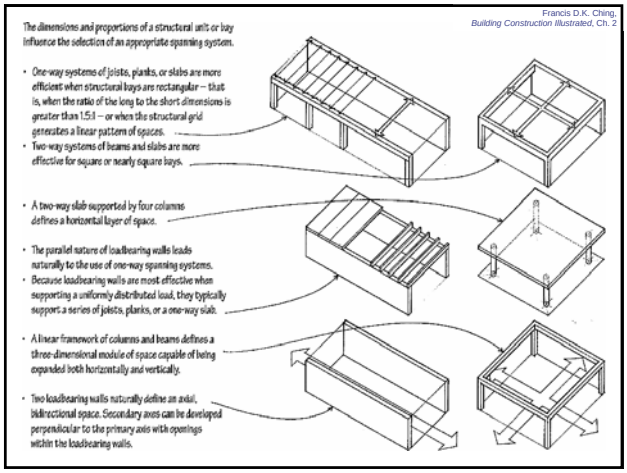


(b) Common assembly of elements. The surface-forming decking is supported by a secondary framing system consisting of closely spaced beams, which is in turn supported by a primary system of more widely spaced trusses. A one-on-one fit exists between the trusses and the supporting columns.

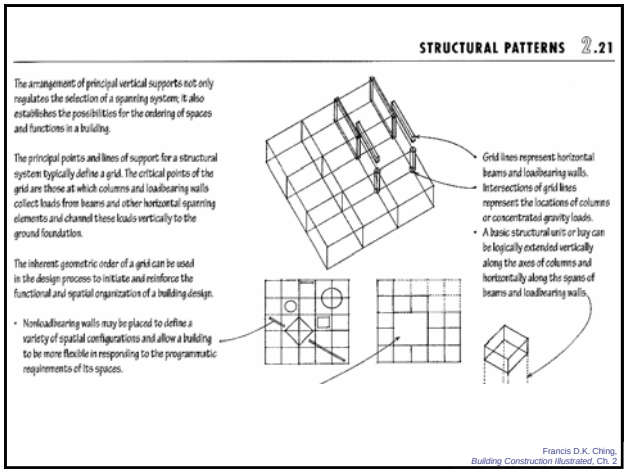
(c) The decking transfers roof loads to the secondary beams. The beams transfer the loads to the trusses, which in turn carry them to the columns. The columns transmit the loads to the foundations. These force transfers occur through the development of reactive forces between members and typically get progressively larger at lower levels.



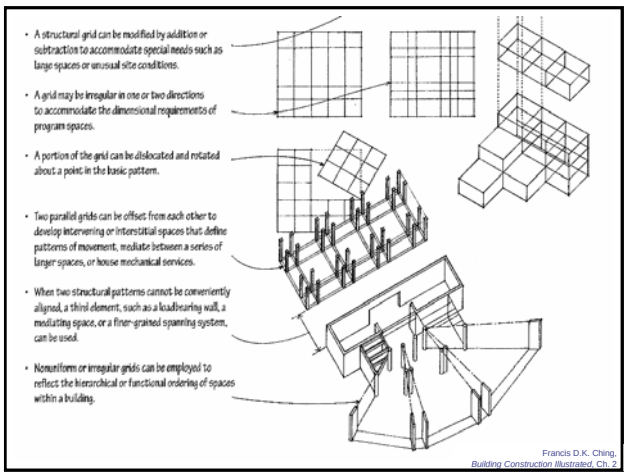
Francis D.K. Ching, *Building Construction Illustrated*, Ch. 2



Francis D.K. Ching, *Building Construction Illustrated*, Ch. 2



Francis D.K. Ching, *Building Construction Illustrated*, Ch. 2

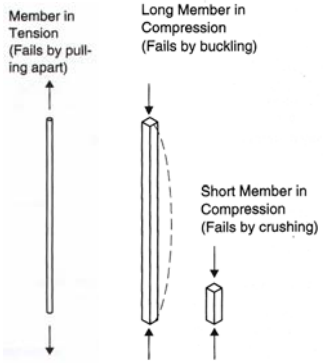


Francis D.K. Ching, *Building Construction Illustrated*, Ch. 2

Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004

Typological Structure Classification by Loading Type

(Schodek fig. 1.8)



Axial Loadings

Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004, Figure 1.8

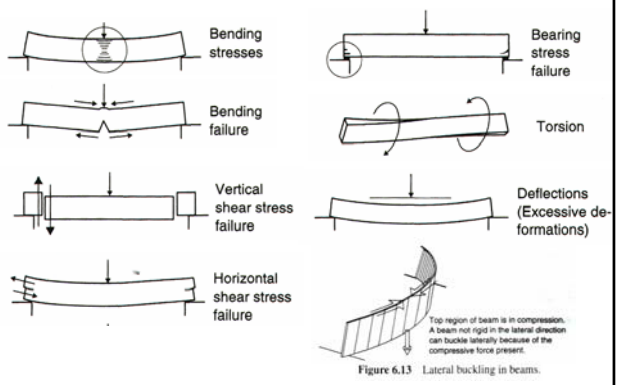


Figure 6.13 Lateral buckling in beams.

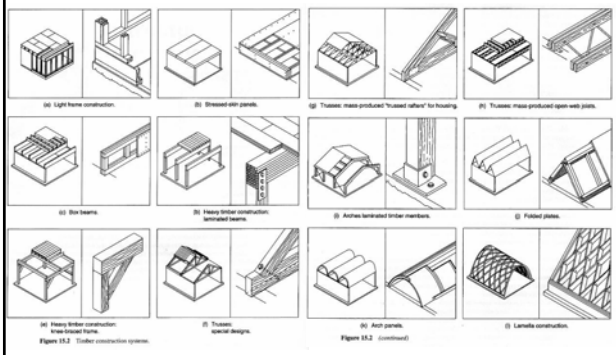
Transverse Loadings

Primary Structural Elements

(Schodek , *Structures*, §1.2.2)

- Beams & Columns
- Frames
- Trusses
- Arches
- Walls & Plates
- Cylindrical Shells & Vaults
- Spherical Shells & Domes
- Cables
- Membranes, Tents & Nets

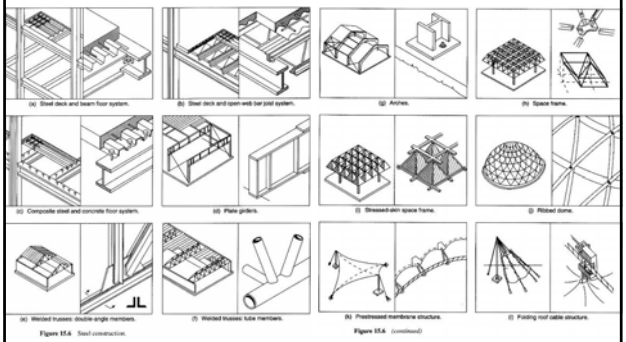
Timber Construction Systems



Typological Structure Classification by Construction Material

Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004, Fig. 15.2

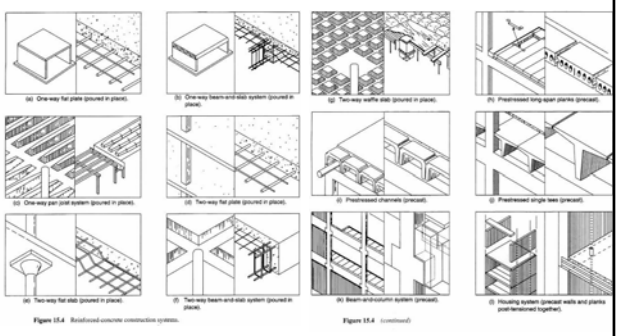
Steel Construction Systems



Typological Structure Classification by Construction Material

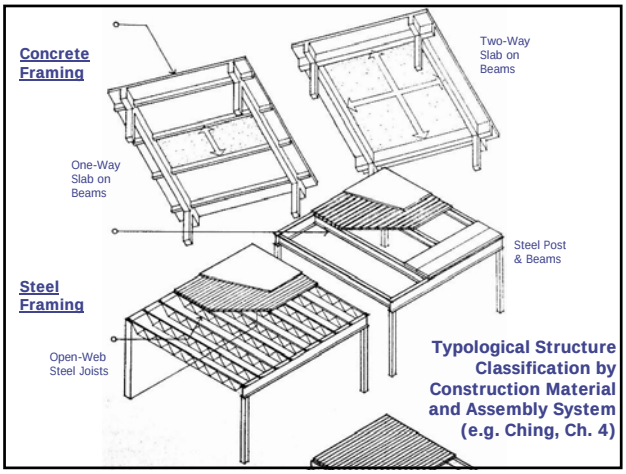
Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004, Fig. 15.6

Reinforced Concrete Construction Systems



Typological Structure Classification by Construction Material

Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004, Fig. 15.6

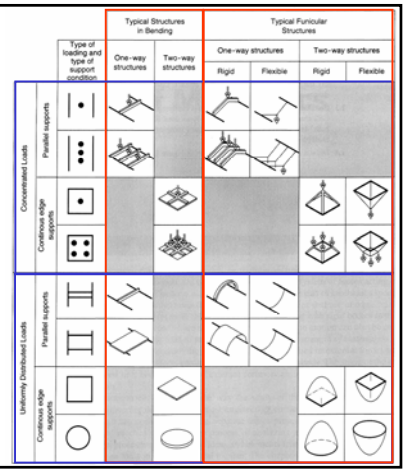


Typological Structure Classification by Construction Material and Assembly System (e.g. Ching, Ch. 4)

Illustrations: Daniel L. Schodek: *Structures*, fifth edition; Pearson Prentice-Hall, 2004

Typological Structural Classification by Load-Carrying Actions

(Schodek fig. 1.15)





Material: Engineered lumber (glued laminated timber)
Pattern: Linear, one way system, two levels
Type: Post & beam system



Project: Pont de l'Alma over the River Seine, Paris
Material: Steel
Pattern: Linear, one way system, two levels
Type: Girder system, shaped to loading & internal stress

Image © University of California, Berkeley, Godden Slide Library: http://nisee.berkeley.edu/jpg/6257_3021_0122/IMG0060.jpg



Project: Gund Hall (Harvard Architecture GSD)
Material: Structural steel
Pattern: Linear, one way system, three levels
Type: Tubular truss system



Project: BWI Airport Terminal
Material: Structural steel
Pattern: Distributed, two way system, two levels
Type: Space truss



Project: Jacob Javits Convention Center — I.M. Pei, Architect
Material: Structural steel
Pattern: Distributed, two way system, two levels
Type: Space truss



Project: Sainsbury Center, Norwich, Enlgand — Foster & Associates, Architect
Material: Structural steel
Pattern: One way structure, two levels, linear pattern
Type: Space truss / rigid frame

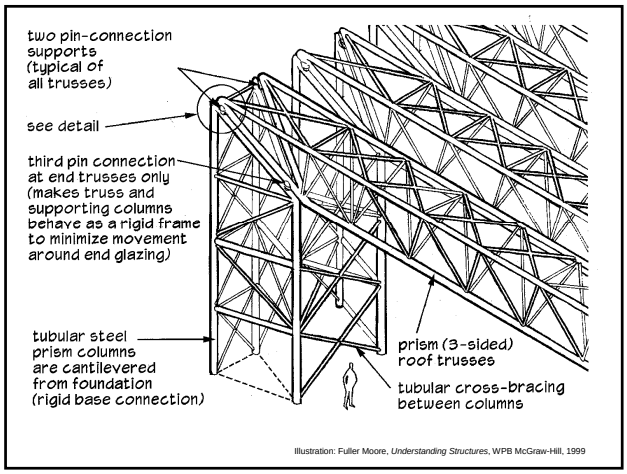


Illustration: Fuller Moore, *Understanding Structures*, WPB McGraw-Hill, 1999



Project: Riola Church, Riola Italy (Alvar Aalto, architect)
Material: Reinforced concrete
Pattern: One-way structure, regular linear grid, three levels
Type: Rigid frame



Project: Daley Center Building, Chicago
Material: Structural Steel
Pattern: Regular grid, one way system, three levels (probably)
Type: Rigid frame, plate girder spandrel members

Image © University of California, Berkely, Godden Slide Library: http://misee.berkeley.edu



Project: Office Building, Palo Alto, CA
Material: Structural Steel
Pattern: Regular grid, one way system, three levels (probably)
Type: Rigid frame

Image © University of California, Berkely, Godden Slide Library: http://misee.berkeley.edu



Project: John Deere World Headquarters, Moline, Illinois (Eero Saarinen, architect)
Material: Structural Steel (Cor-Ten® weathering steel)
Pattern: Regular grid, one way system, three levels
Type: Rigid frame

http://img.photobucket.com/albums/v420/rockvi/Dcp_0901.jpg



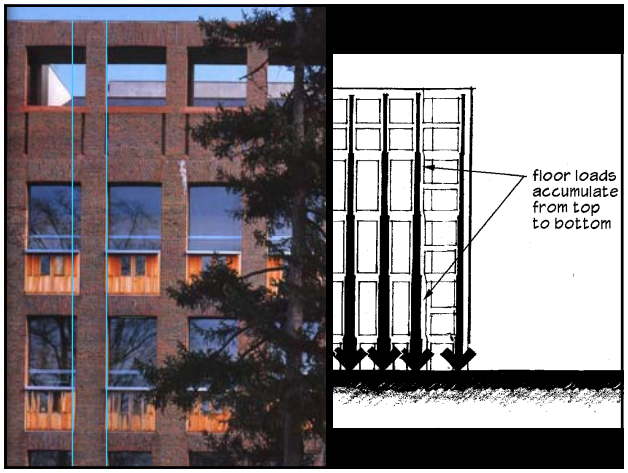
Project: L'Unite d'Habitation (Marseilles, France; Le Corbusier, architect)
Material: Reinforced concrete
Pattern: Regular grid, two level (slab on girders)
Type: Rigid frame

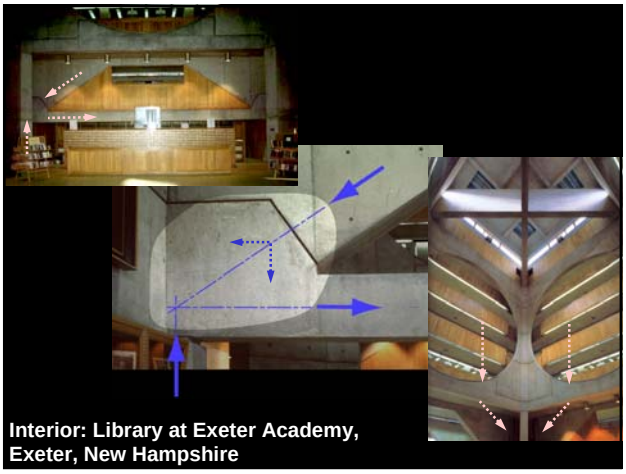


Project: University of Maryland, Center for Physics
Material: Structural Steel
Pattern: Regular grid, one way system, three levels (probably)
Type: Beam and column system, cantilevered spandrel truss (expressed arch'ly.)

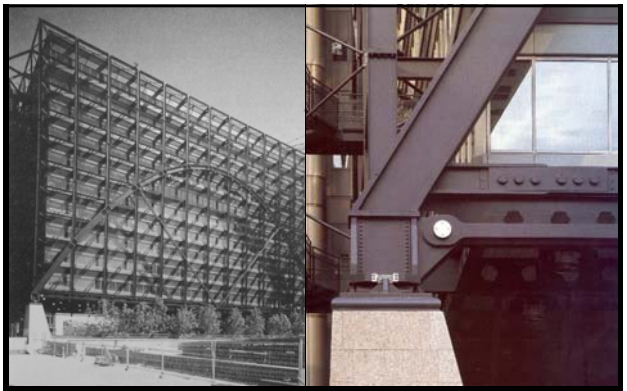


Project: Exeter Academy Library, Exeter, NH (Louis I. Kahn Architect)
Material: Brick Masonry (exterior walls) & Concrete (interior structure)
Pattern: Regular grid, one way system, two level system
Type: Bearing wall structure

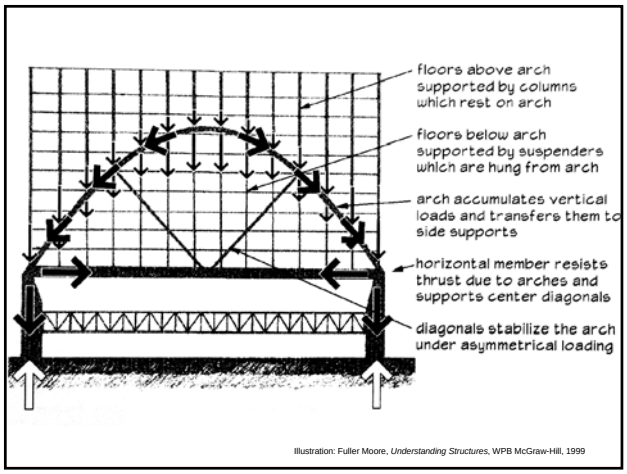


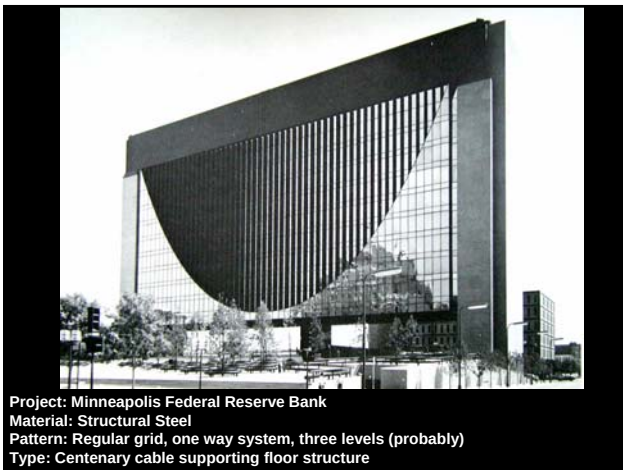


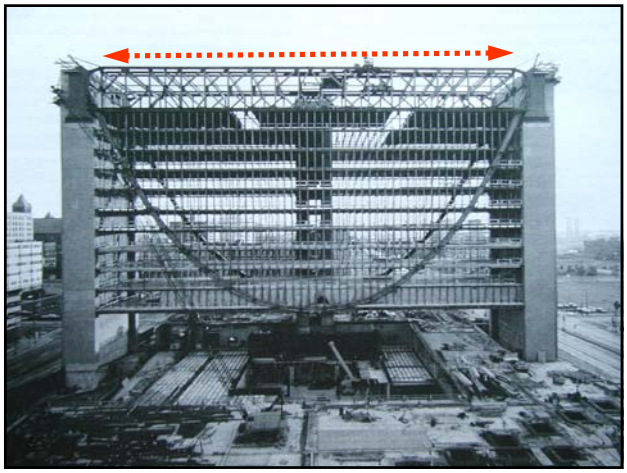
Interior: Library at Exeter Academy,
Exeter, New Hampshire

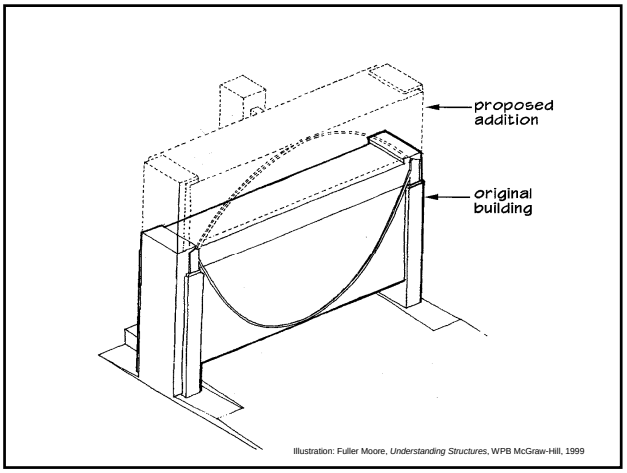


Project: Broadgate Exchange House Office Building, London (SOM Architects)
Material: Structural Steel
Pattern: Regular grid, one way system, three levels (probably)
Type: Unique steel arch structure spanning over railway station below

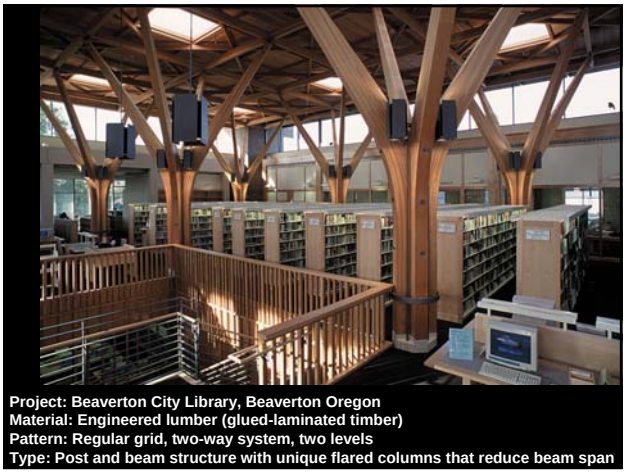

floors above arch supported by columns which rest on arch
floors below arch supported by suspenders which are hung from arch
arch accumulates vertical loads and transfers them to side supports
horizontal member resists thrust due to arches and supports center diagonals
diagonals stabilize the arch under asymmetrical loading
Illustration: Fuller Moore, Understanding Structures, WPB McGraw-Hill, 1999


Project: Minneapolis Federal Reserve Bank
Material: Structural Steel
Pattern: Regular grid, one way system, three levels (probably)
Type: Centenary cable supporting floor structure



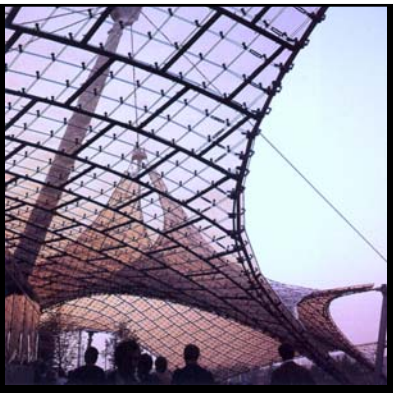

proposed addition
original building
Illustration: Fuller Moore, Understanding Structures, WPB McGraw-Hill, 1999


Project: Kimball Art Museum, Fort Worth, Texas (Louis I. Kahn, architect)
Material: Reinforced concrete
Pattern: Linear, one-way system, one level
Type: Curved post-tensioned beam (not a vault!)


Project: Beaverton City Library, Beaverton Oregon
Material: Engineered lumber (glued-laminated timber)
Pattern: Regular grid, two-way system, two levels
Type: Post and beam structure with unique flared columns that reduce beam span



Project: Lincoln Library
Material: Engineered lumber (glued-laminated timber) & structural steel
Pattern: Radial grid, one-way system, three levels
Type: Post and beam structure with unique flared central steel column



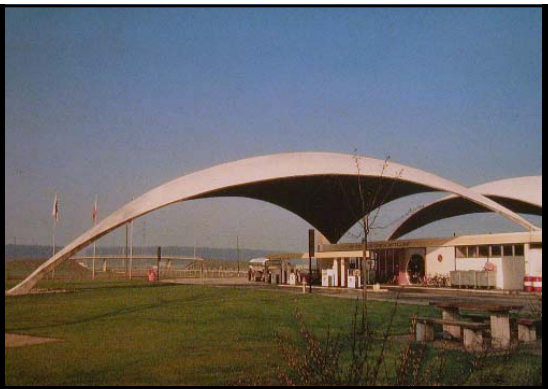
Project: 1972 Munich Olympic Stadium (Frei Otto, Engineer)
Material: Steel cables w/ acrylic panels
Pattern: Radial about track (main stadium), Random (natatorium)
Type: Tensile membrane, two way funicular spanning system



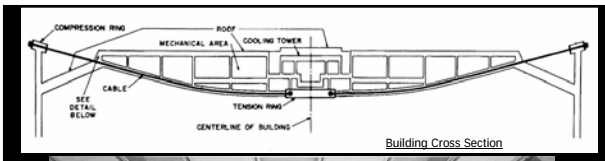




Project: Denver International Airport Terminal
Material: Teflon coated fabric membrane
Pattern: Regular, linear
Type: Tensile membrane, two way funicular spanning system



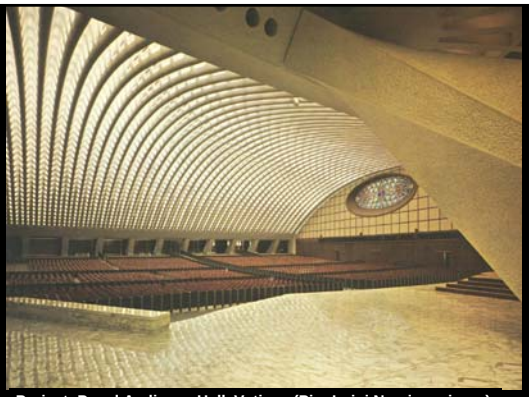
Project: Shell Structure, Switzerland (Heinz Isler, Engineer)
Material: Concrete
Pattern: Regular, parabolic surface
Type: Thin shell funicular surface structure



Building Cross Section



Project: Madison Square Garden, New York City
Material: Steel tension cables Pattern: Radial, two level system
Type: Suspended radial cables w/ central tension ring, exterior compression ring

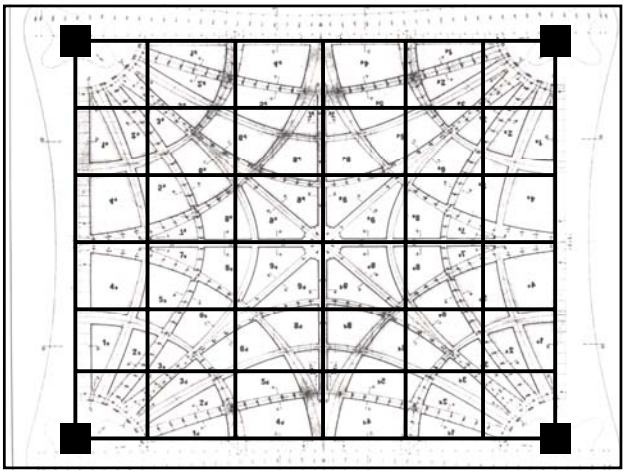


Project: Papal Audience Hall, Vatican (Pier Luigi Nervi, engineer)
Material: Ferro-cement (concrete reinforced with very fine mesh)
Pattern: Linear, one-way system, two levels
Type: Vaulted arch


Pier Luigi Nervi—Papal Audience Hall, Vatican



Project: Papal Audience Hall, Vatican (Pier Luigi Nervi, engineer)
Material: Ferro-cement (concrete reinforced with very fine mesh)
Pattern: Regular Grid, Two-Way System
Type: Isostatic Ribbed Plate





Project: San Diego International Airport
Material: Reinforced concrete
Pattern: Radial, two way system, two levels
Type: Waffle slab

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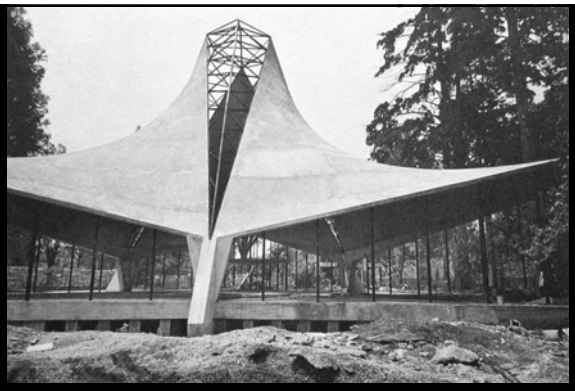
Project: Parking Structure
Material: Reinforced concrete
Pattern: Regular grid, two way system, two levels
Type: Waffle slab

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Project: Renault Distribution Centre, Wilshire, UK (Norman Foster and Partners)
Material: Structural Steel
Pattern: Regular grid, two way system, three levels
Type: Cable-stayed





Project: Chapel, Mexico (Felix Candela, Engineer)
Material: Reinforced Concrete
Pattern: Regular, parabolic surface
Type: Thin shell funicular surface structure (hyperbolic parabolid)





Project: Alamillo Bridge, near Barcelona, Spain (Santiago Calatrava, engineer)
Material: Reinforced concrete, structural steel and steel cable
Pattern: Linear
Type: Cable stayed

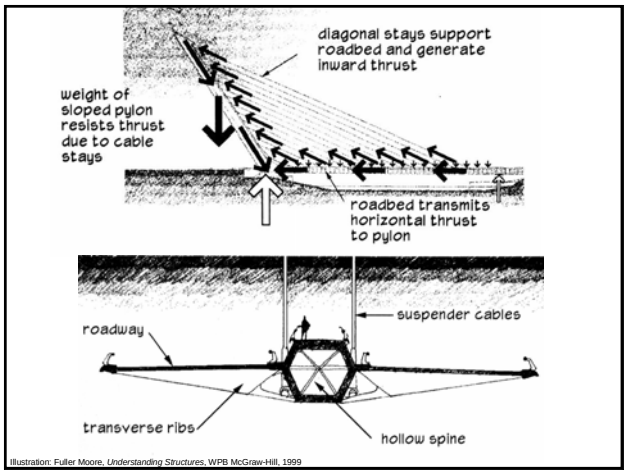
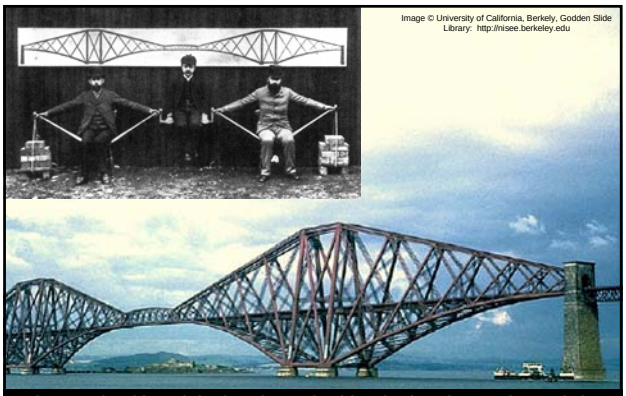
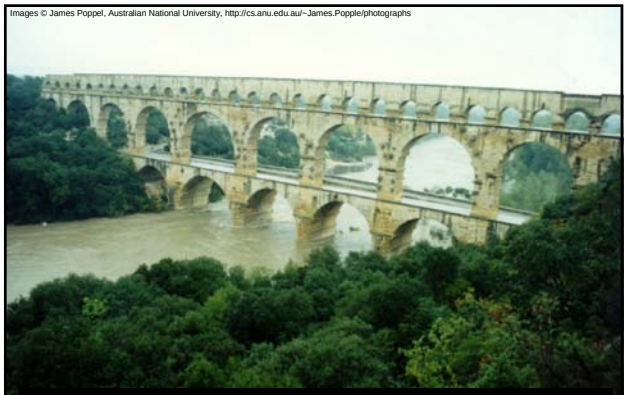


Illustration: Fuller Moore, *Understanding Structures*, WPB McGraw-Hill, 1999


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Project: Forth Bridge, Firth of Forth, Scotland (Benjamin Baker & John Fowler)
Material: Structural Steel
Pattern: Linear
Type: Tubular steel balanced cantilever truss


Images © James Poppel, Australian National University, http://cs.anu.edu.au/~James.Popple/photographs

Project: Pont du Gard, Roman Aqueduct, near Niemes, France
Material: Quarried stone & early form of concrete
Pattern: Linear
Type: Stone arch



Project: Golden Gate Bridge, San Francisco
Material: Structural Steel
Pattern: Linear
Type: Suspension bridge