

Pre- and Post-Tensioning

- Cable Trusses
- Concrete Beams
- Stressed Membranes

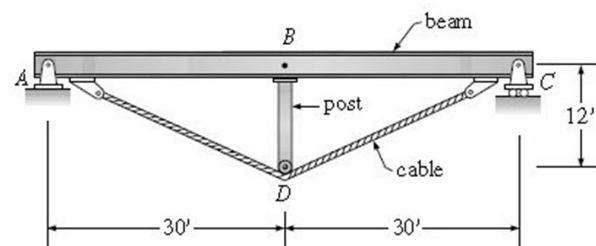


Cable Trusses

- Reduce flexure stress
- Reduce deflection
- Produces stiffer section with less material
- Lighter weight
- Longer spans possible
- Analysis by combined stress



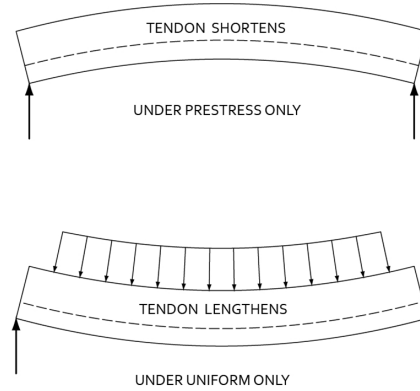
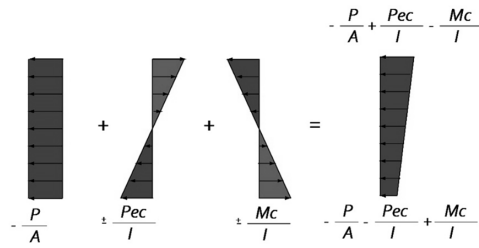
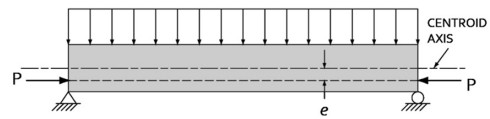
$$f = -\frac{P}{A} \pm \frac{M}{S} \pm \left[\frac{Pe}{S} \right]$$



Pre-stressed Concrete

- More concrete active in resisting moment
- Produces stiffer section with less material
- Lighter weight
- Longer spans possible
- Analysis by combined stress

$$f = -\frac{P}{A} \pm \frac{Pec}{I} \pm \frac{Mc}{I}$$



Pre-stressed Concrete

Steel:

high strength wires 250 or 270 ksi
 wire diameter 0.105 – 0.276
 used in strands of bundled wire
 most common is 7 wire strand



Concrete:

higher strength 5 – 10 ksi
 to reduce creep and strain
 reduced cracking
 stiffer sections

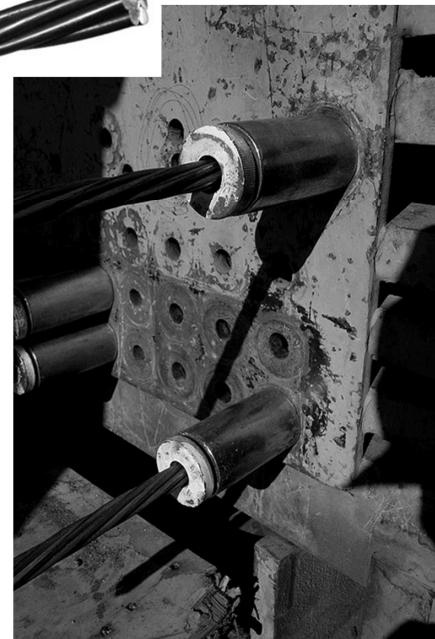
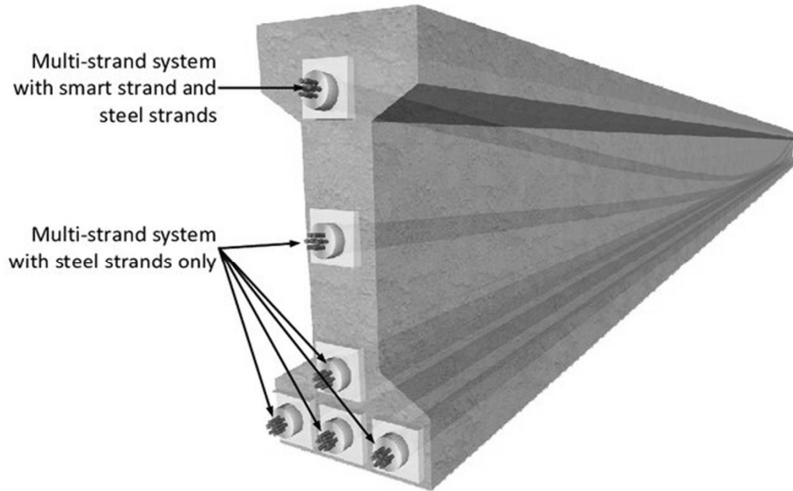
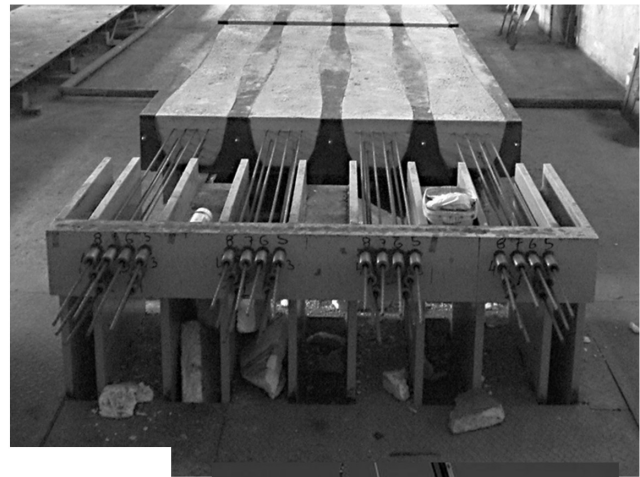


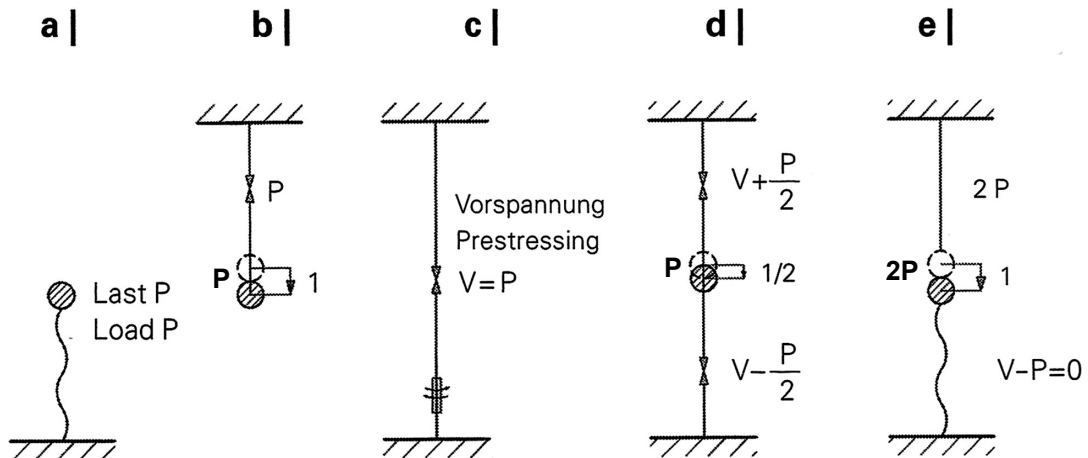
Photo by Angelo Marasco

Pre-stressed Concrete



Pre-stressing

Reducing deformation

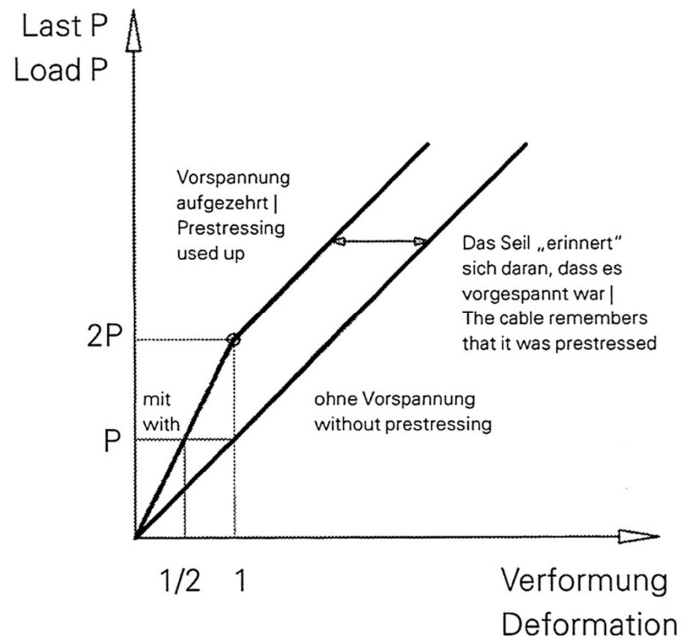


Pre-stressing

increasing stiffness

and

reducing deformation



Jörg Schlaich, *Light Structures*

University of Michigan, TCAUP

Structures II

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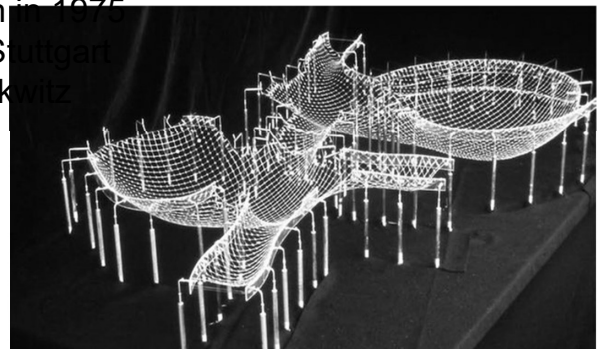
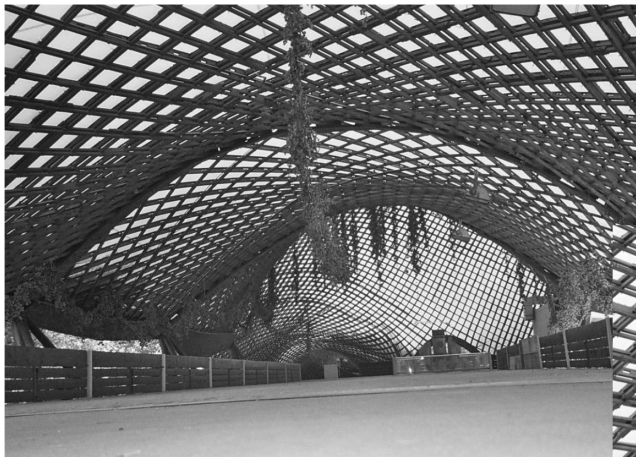
Multihalle Mannheim

Designed and engineered by Frei Otto and Buro Happold

Built for the Bundesgartenschau in Mannheim in 1975

Design and initial analysis with models at IL Stuttgart

Computer force density analysis by Klaus Link



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Multihalle Mannheim

erection and load testing

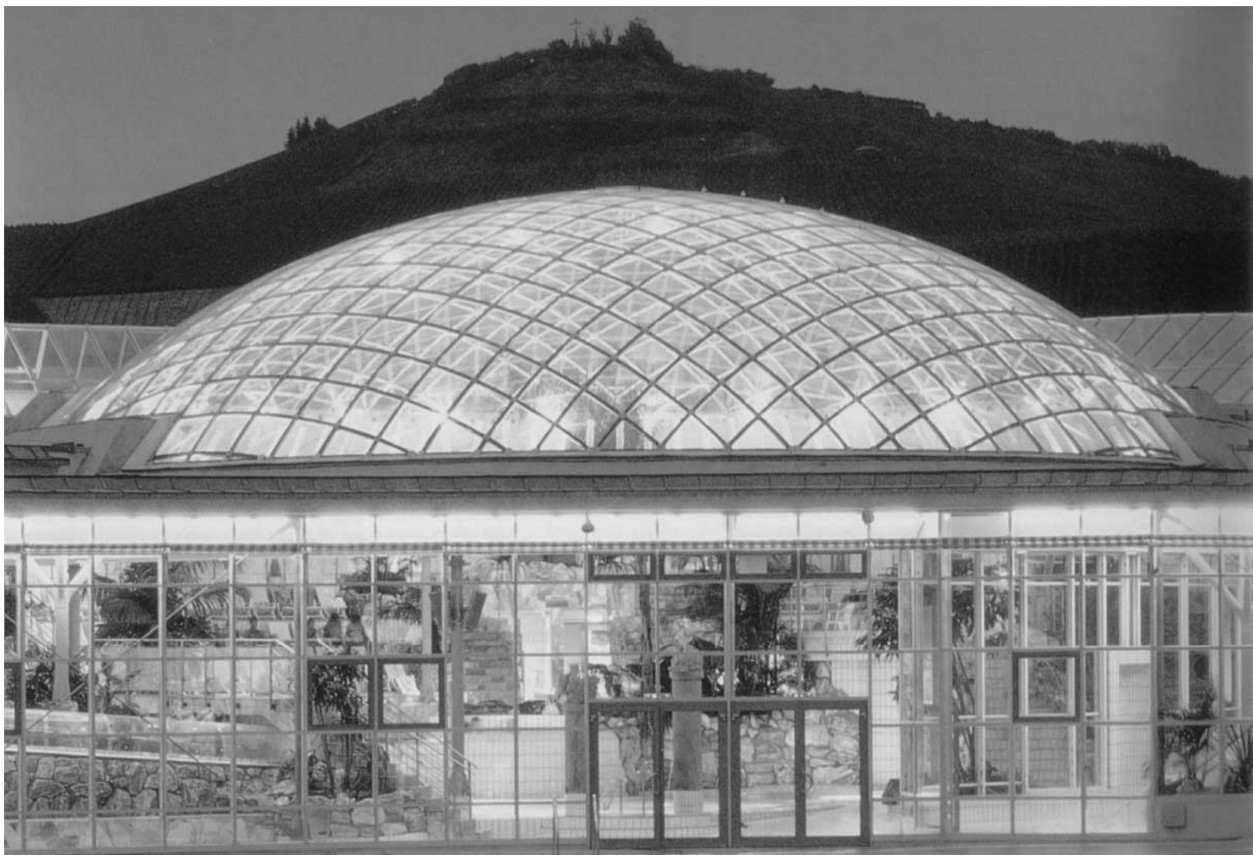


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Schlaich Bergemann & Partners – Neckarsulm Swimming Pool



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Schlaich Bergermann & Partners

Neckarsulm, 1989



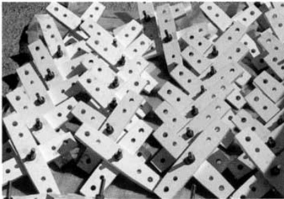
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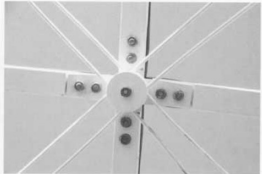
6.14
The slats



6.15
The rotatable joints



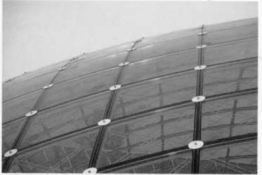
6.16
Assembly of the grid elements



6.17
Close-up of the joint assembly
with diagonal cables installed



6.18
A segment of the grid showing the double
pattern formed by the slats and cables



6.19
A segment of the completed roof
with the spherically-curved glass panes



6.20
Water barrels representing
partial snow load

Schlaich Bergermann & Partners

Neckarsulm Pool

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Schlaich Bergermann & Partners

History of Hamburg Museum



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Stressed Membrane

Renaissance Center
Entrance Pavilion
Detroit 2004
SOM

- Point supported glass
- “fish belly” cable truss bacing



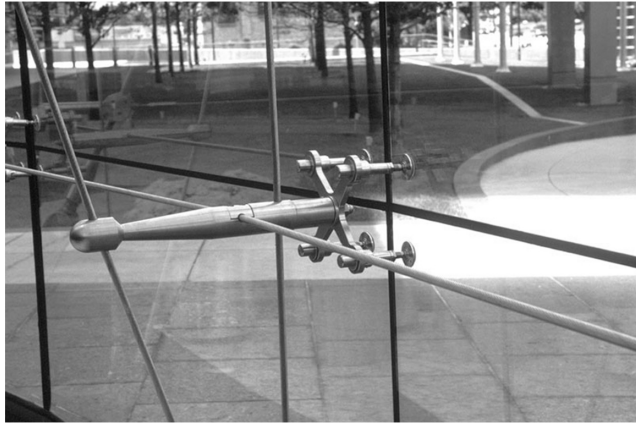
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Stressed Membrane

Renaissance Center
Entrance Pavilion
Detroit 2004
SOM



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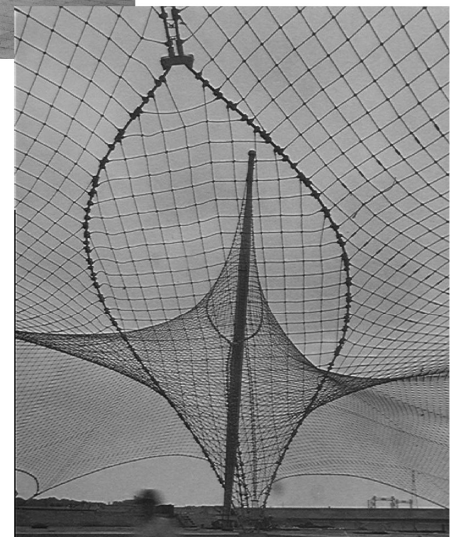
Expo '67, Montreal

Frei Otto
German Pavilion



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Institute for Lightweight Structures – IL (now ILEK)

University of Stuttgart



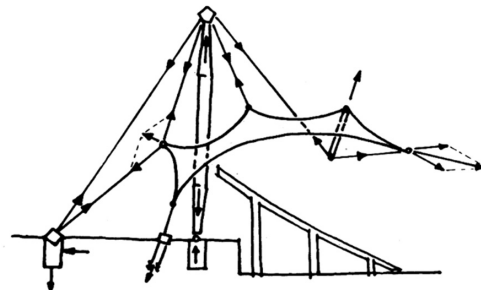
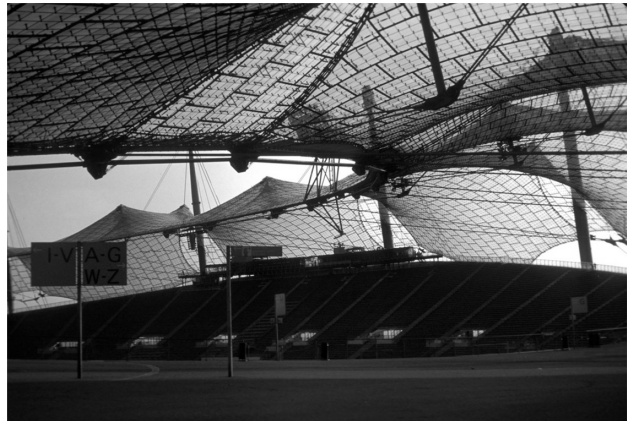
Frei Otto, IL building, University of Stuttgart



Stressed Membrane

Olympic Buildings, Munich 1972
Eng. Otto, Leonhardt, Schlaich
Arch: Behnisch

- Opposing curvature
- Stressed by anchors and masts





Frei Otto, Munich Soccer Stadium (from back)

Stressed Membrane Olympic Stadium, Munich 1972

