

Pre- and Post-Tensioning

- Cable Trusses
- Concrete Beams
- Stressed Membranes



2024 Tower Test

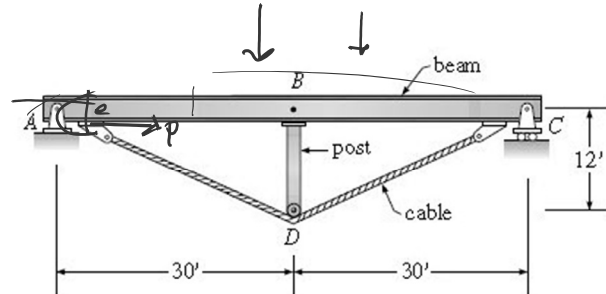


Cable Trusses

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

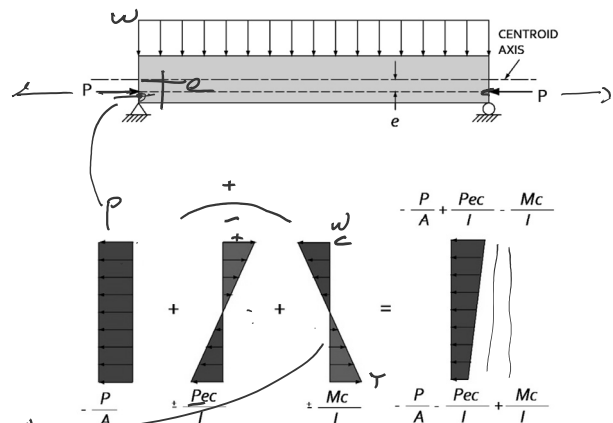


$$f = -\frac{P}{A} \pm \frac{M}{S} \pm \left[\frac{Pe}{S} \right]$$

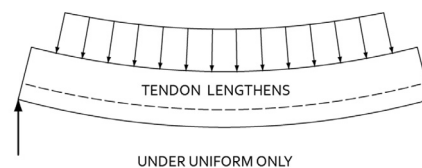
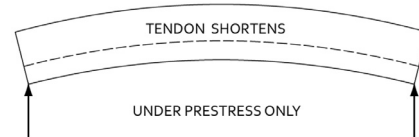


Pre-stressed Concrete

- 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

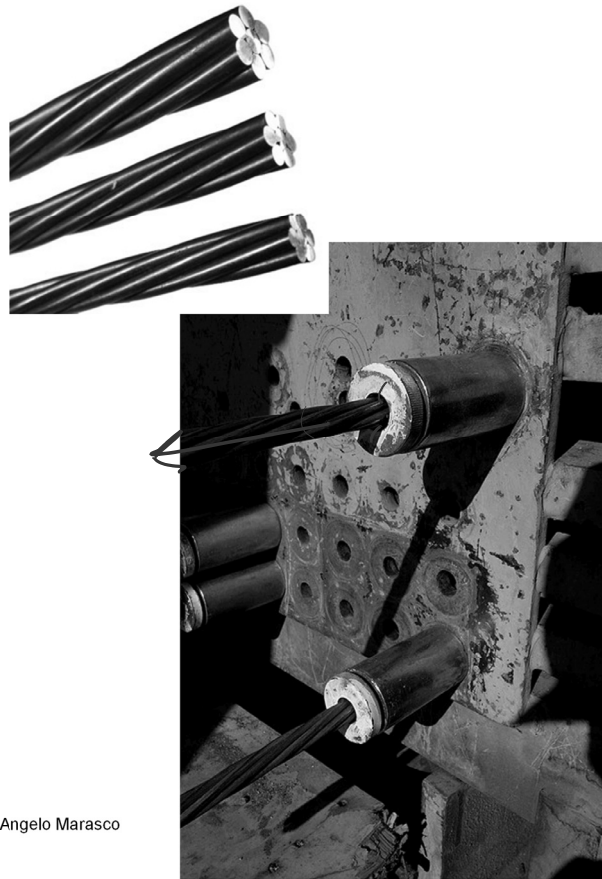
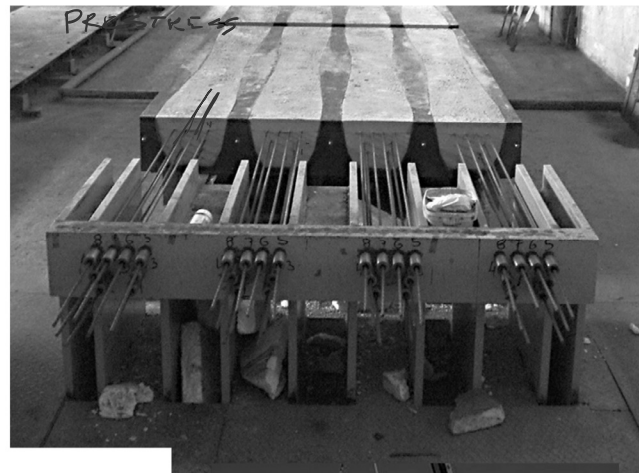


Photo by Angelo Marasco

Concrete:

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

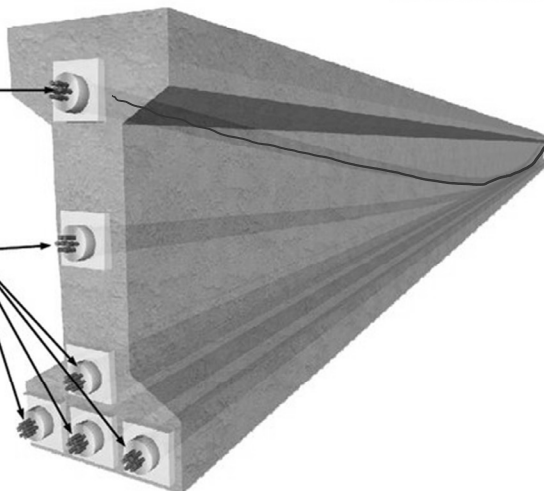
Pre-stressed Concrete



POST TENSION

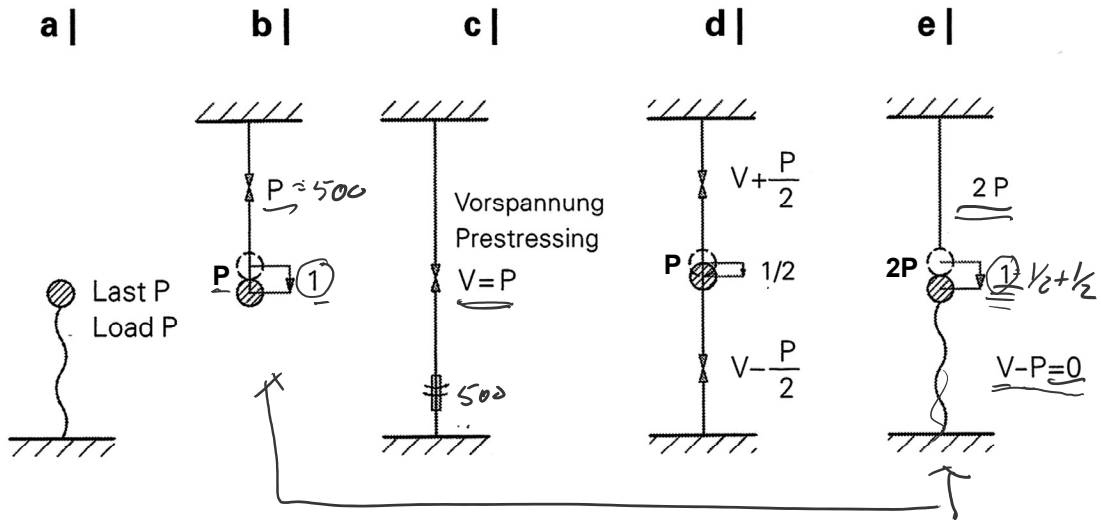
Multi-strand system
with smart strand and
steel strands

Multi-strand system
with steel strands only



Pre-stressing

Reducing deformation



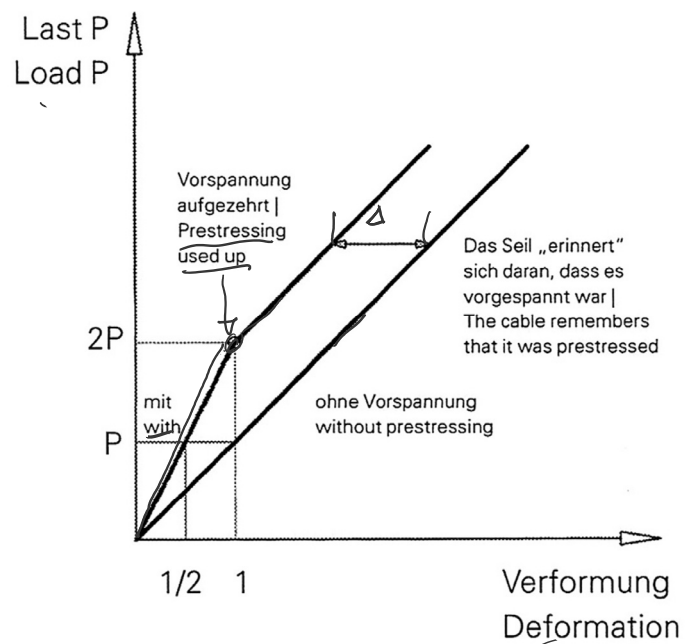
Jörg Schlaich, *Light Structures*

Pre-stressing

increasing stiffness

and

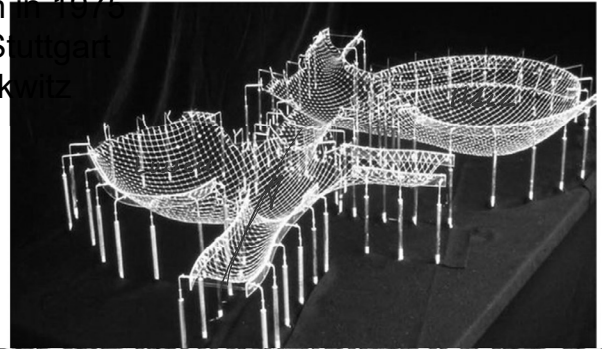
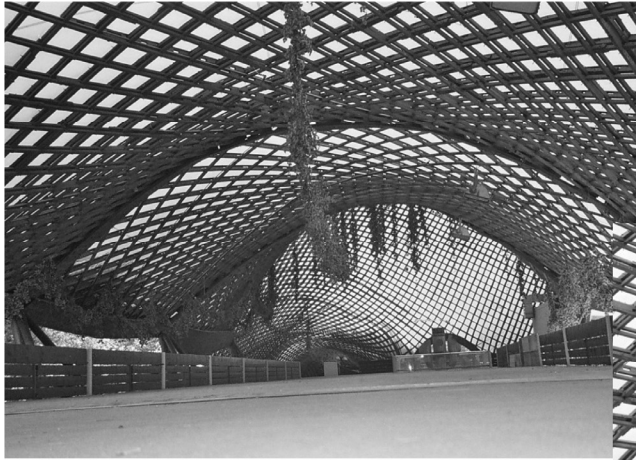
reducing deformation



Jörg Schlaich, *Light Structures*

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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Structures II

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Multihalle Mannheim

erection and load testing

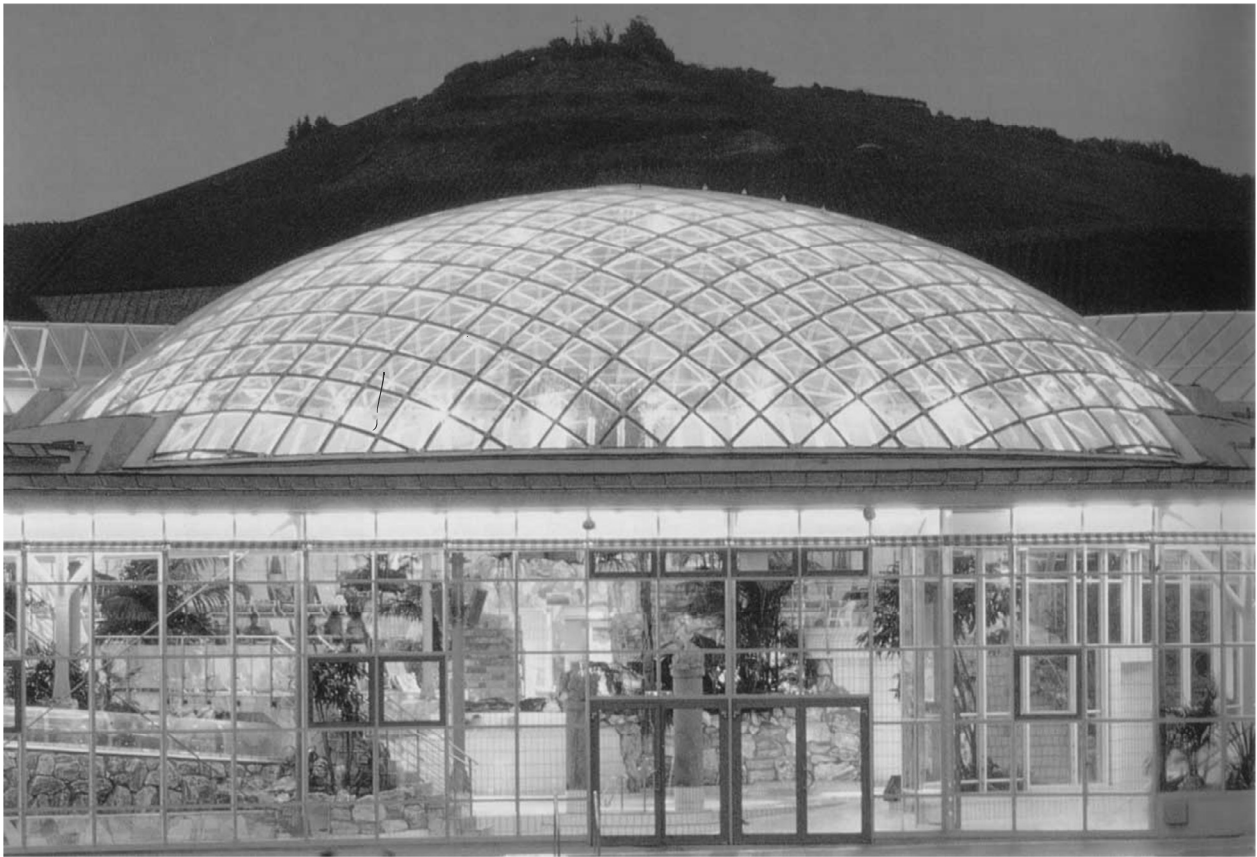


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Structures II

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Schlaich Bergemann & Partners – Neckarsulm Swimming Pool



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Structures II

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Schlaich Bergemann & Partners

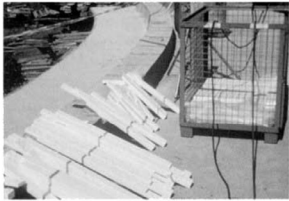
Neckarsulm, 1989



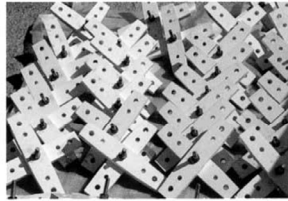
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Structures II

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6.14
The slats



6.15
The rotatable joints



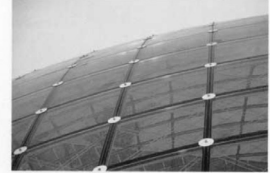
6.16
Assembly of the grid elements



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 Bergemann & Partners

Neckarsulm Pool

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Schlaich Bergemann & Partners

History of Hamburg Museum



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Structures II

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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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Structures II

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Stressed Membrane

Renaissance Center
Entrance Pavilion
Detroit 2004
SOM



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Expo '67, Montreal

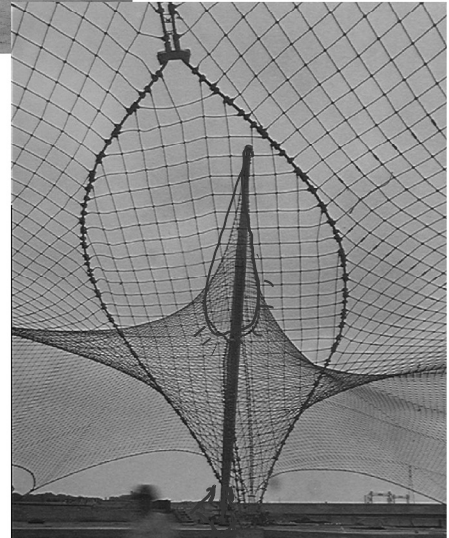
Frei Otto
German Pavilion



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Structures II



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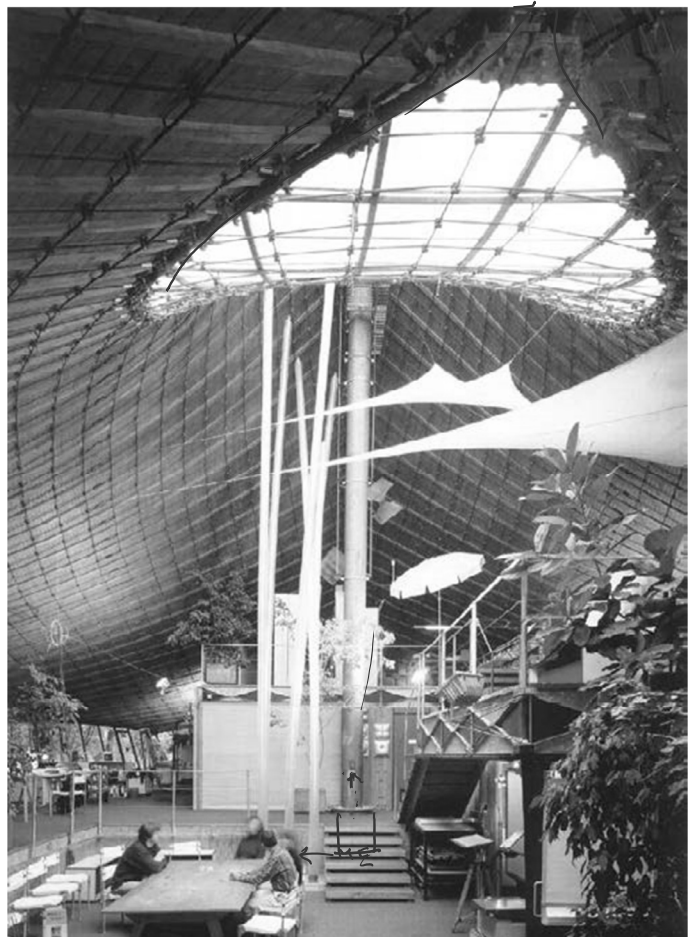
Institute for Lightweight Structures – IL (now ILEK)

University of Stuttgart



Frei Otto, IL building, University of Stuttgart

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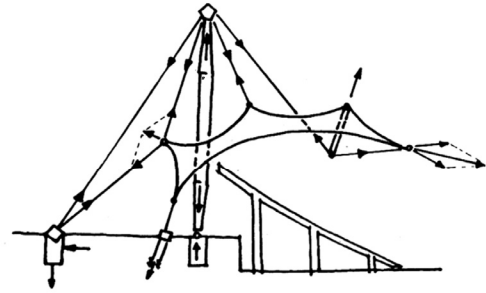
Structures II

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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

