Freyssinet, Finsterwalder and Fallingwater
Origins and Solutions in Prestressed Concrete

Lecture themes
Freyssinet’s story and the origins of prestressed concrete (PC)
   Aside: how does construction elegance map into structural art?
Finsterwalder’s advancements in PC bridges
   Aside: Magnel’s ground breaking work popularizing PC
Precast PC and America’s Walnut Lane Bridge
   Aside: Challenges with expressing form in PC
Fallingwater, historic preservation enabled through PC
moment
Le Veurdre
Freyssinet
1879-1962
“an official letter put me in charge of supervising...the execution of these bridges whose designer I was, for which I was to be the contractor and the plans of which had never been submitted for anyone’s approval...[My superior granted] me unlimited credit out of his funds but without giving me a single man, tool, or piece of advice. Never was a builder given such freedom, I was absolute master receiving orders and advice from no one.”

Freyssinet’s recollection of the Le Veurdre commission
apply load and hold
what happens?
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Industry has created its tools.
Business has modified its habits and customs.
Construction has found new means.
Architecture finds itself confronted with new laws.
Industry has created new tools: the illustrations in this book provide a telling proof of this. Such tools are capable of

ARCHITECTURE OR REVOLUTION

A FACTORY (FRÉSSINET & LIMOUSIN)
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A HANGAR (FREYSSINET & LIMOUSIN)

Width 250 feet, height 150 feet, length over 900 feet. The Nave of Notre Dame is 40 feet wide and about 107 feet in height.
Q: Does elegance in construction matter?
Q: How does construction fit into the concept of structural art?
COMPRESSION

TENSION

REINFORCED CONCRETE BEAM
Consider a single pre-stressed concrete T-beam as shown under load test to the right.

Loss of stress in the pre-stressing steel:
- Friction: 6,800 psi (47 MPa)
- Creep: 17,400 psi (120 MPa)
- Shrinkage: 12,100 psi (83 MPa)
- Relaxation: 3,800 psi (26 MPa)
- Total: fill in total here!

*numerical values inspired from Nilson, Design of Presstressed Concrete, Ch. 6
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- Total: 40,100 psi (276 MPa)

If I use standard 50,000 psi steel, what is the loss in effectiveness? % loss??

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Loss of stress in the pre-stressing steel

<table>
<thead>
<tr>
<th>Loss Type</th>
<th>Stress Value (psi, MPa)</th>
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<tr>
<td>Friction</td>
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If I use standard 50,000 psi steel what is the loss in effectiveness?

\[
\frac{40,100}{50,000} = 0.8 \rightarrow 80\%
\]

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% loss??

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$$\frac{40,100}{250,000} = 0.16 \Rightarrow 16\%$$

*numerical values inspired from Nilson, Design of Presstressed Concrete, Ch. 6*
Luzancy Br. (1946)
Similar to DC’s 2006 Woodrow Wilson Bridge?
Gustave Magnel
No. 3c.

Projet: Strasbourg

No. 4.

Projet: Bartholomé et David.

No. 5.

Projet: Alexandre Giroud.

No. 6.

Projet: PRECO (3 chaînes)
Ulrich Finsterwalder
Hilfsstützen

Bestehende Pfeiler

Hilfsstützen
Power of prestressing:

\[ Z_b = \frac{M_{TL} - \alpha M_D}{\sigma_b} \]

- beam size
- material strength
www.structurae.de
Maldonado Bridge
Date taken: 8 March 2003
Photo by Jose Bellido de Luna
Pre-stressing is an enabling technology.

Does it always enable innovation in structures that leads to structural art?
Pre-stressing is an enabling technology.

Does it always enable innovation in structures that leads to structural art?

Let us learn the story of how pre-stressed concrete came to America. (and what aspects of pre-stressing became popular the world over)
shape the pre-stressing tendon instead of shaping the beam...
SCULPTURED P/C FRAME
Pre-stressing is an enabling technology.

Does it always enable innovation in structures that leads to structural art?

Discuss..
Pre-stressing is an enabling technology.

Does it always enable innovation in structures that leads to structural art?

What are other potentials of such technology?
“It is every homeowner’s nightmare. The architect got into a fight with the engineer over whether the design skimped on structural materials. The engineer wanted to make the floors stronger, but the architect said extra steel would make them unsupportably heavy. Now, both are dead, and it turns out that the engineer was right.”

–New York Times
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Multi-Faceted Investigation – Preservation Approach

Structural Analysis

Temporary Shoring / Stabilization
ed his design. Once again he forced Kaufmann, Sr., to choose between him and Metzger-Richardson. Kaufmann, Sr., decided to go ahead with the house as originally planned.

Still, the house's owner remained concerned about the tilting of the terraces, so he commissioned a surveyor to measure the deflections on a regular basis by recording the elevations of the tops of the parapet walls. This was done from 1941 until 1955, when Kaufmann, Sr., died. In 1963 Kaufmann, Sr., presented the house to the Western Pennsylvania Conservancy. Between 1953 and the time our first was retained in 1964, only one or two random measurements of the terraces' deflections were recorded.

low, because the two floors are structurally interdependent.

Our first question was, "Have the deflections stopped, or are they still growing?" Using an instrument called a water level, we took height readings at more than 30 locations and attempted to relate them to the survey readings done earlier. Our measurements showed that the edge of the west terrace had sagged by as much as 146 millimeters and the edge of the east terrace by as much as 144 millimeters. The deflection of the south end of the master bedroom terrace was about 114 millimeters. We then installed electronic monitors to measure very small movements of the terraces and changes in the width of the cracks in the terrace's parapet.
PLANNED REPAIRS involve relieving the stresses in the cantilever beams through the creative use of post-tensioning. Steel cables will be rigged on both sides of each beam, anchored in concrete blocks attached to the beam's ends (left). The cables will then be tightened from the outside using a hydraulic jack. The tension in the cables will exert a positive bending moment on the beam, counteracting the negative moment caused by cantilever action. A section of one cantilever beam beneath the living room floor (below) has already been exposed to allow engineers to inspect it.
Construction / Renovation
Finished Work

- Sustainability of Resources
- Sustainability of Culture