Roof Vaults and National Styles

Early 20th Century

The German approach: analysis and geometry
The Italian approach: ribs, coffers, and buttresses
The "Spanish" approach: double curvature and thinness
Concrete shells and stiffness
Economy of labor vs. efficiency of materials
Complexity of analysis vs. complexity of form
German Tradition

*Firm of Dycherhoff and Widmann*

F. Dischinger (1887-1953)
U. Finsterwalder (1897-1988)
A. Tedesko (1903-1994)
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<th>Span (m)</th>
<th>Rise (m)</th>
<th>Weight (metric ton)</th>
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<td>42</td>
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<tr>
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**Longest Spanning Domes in the World**

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\[ R_y \left( \frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{R_y \partial \phi^2} \right)^4 w + \frac{12}{h^2} \frac{\partial^4 w}{\partial x^4} = f(p_x, p_y, p_z) \]

\[
\frac{du}{dy} = -a_y \frac{\pi}{L} v + a_y \frac{2}{Eh} N_{xy} \\
\frac{dv}{dy} = a_y \frac{W}{R_y} + a_y \frac{N_y}{Eh} \\
\frac{dw}{dy} = a_y \theta \\
\frac{d\theta}{dy} = -a_y \frac{12}{Eh^3} M_y
\]

\[
\frac{dM_y}{dy} = -a_y \frac{\pi^2}{L^2} \frac{Eh^3}{6} \theta + a_y S_y \\
\frac{dN_y}{dy} = a_y \frac{\pi}{L} N_{xy} + a_y p_y \\
\frac{dN_{xy}}{dy} = a_y \frac{\pi^2}{L^2} Eh u + a_y p_x \\
\frac{dS_y}{dy} = -a_y \frac{N_y}{R_y} + a_y p_z
\]
Ribbed barrels by Anton Tedesko
1D ribs = Stiffness
Describe the method used by the German school for finding forms for roof structures.

Why would such an approach be justified for structural engineering?

Why might it be limiting for structural art?
Italian Tradition

P.L. Nervi (1891-1979)
2D ribs = Stiffness

1D rib = Strength
Little Sports Palace
1957
Describe the differences in the ribbing in these two Nervi structures. What are the differences in the way domes and barrels carry loads?
failures in translation
structure, not structural art
What makes Nervi’s solution so much more elegant?
What are the scientific reasons, if any, for his aesthetic choices?
Spanish Tradition

Catalan influence

A. Gaudi (1852-1926)

E. Torroja (1899-1961)

F. Candela (1910-1997)

E. Dieste (1917-2000)
Church of the Sagrada Familia
Gaudi, 1882 - present
Church of the Colonia Guell
Zarzuella Hippodrome (1935), Eduardo Torroja
double curvature = stiffness
Algeciras market hall
Locate the double curvature in this shell
Comment on the aesthetics
Xochimilco restaurant

www.structurae.de

Felix Candela
\[ z = \frac{y^2}{b^2} - \frac{x^2}{a^2} \]
Describe the different approaches Gaudí (left) and Candela (right) took to form-finding? Did material choice have any effect on their choices?
Church of Christ Worker
photo credit: Samuel Smith
who needs tradition?
Kresge Auditorium (MIT)
German tradition

Italian tradition

Spanish tradition
Exam 1 Next Tuesday

1. Study IDs from online index website > exam review (can be printed)
2. Study Tower and the Bridge. This is the core material for questions
3. Study each lecture theme. Practice writing and answering questions based on them
4. No calculation, but quantitative questions and axial force / moment diagrams are fair game

Format: IDs; multiple choice/matching/blanks