Roof Vaults and National Styles

Early 20\textsuperscript{th} 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 Dychcrhoff and Widmann
F. Dischinger (1887-1953)
U. Finsterwalder (1897-1988)
A. Tedesko (1903-1994)
<table>
<thead>
<tr>
<th>Date</th>
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<th>Span (m)</th>
<th>Rise (m)</th>
<th>Weight (metric ton)</th>
</tr>
</thead>
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<td>42</td>
<td>21</td>
<td>10,000</td>
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<tr>
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### Longest Spanning Domes in the World

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

\[
\frac{du}{dy} = -a_y \frac{\pi}{L} v + a_y \frac{2}{Eh} N_{xy}
\]

\[
\frac{dv}{dy} = a_y \frac{W}{R_y} + a_y \frac{N_y}{Eh}
\]

\[
\frac{dw}{dy} = a_y \theta
\]

\[
\frac{d\theta}{dy} = -a_y \frac{12}{Eh^3} M_y
\]

\[
\frac{dM_y}{dy} = -a_y \frac{\pi^2}{L^2} \frac{Eh^3}{6} \theta + a_y S_y
\]

\[
\frac{dN_y}{dy} = a_y \frac{\pi}{L} N_{xy} + a_y p_y
\]

\[
\frac{dN_{xy}}{dy} = a_y \frac{\pi^2}{L^2} Eh v + a_y p_x
\]

\[
\frac{dS_y}{dy} = -a_y \frac{N_y}{R_y} + a_y p_z
\]
Ribbed barrels by
Anton Tedesko

1948
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)
Sagrada Familia School
Church of the Sagrada Familia
Gaudi, 1882 - present
Church of the Colonia Guell
Zarzuella Hippodrome (1935), Eduardo Torroja
Torroja  

Nervi
double curvature = stiffness
Algeciras market hall
Locate the double curvature in this shell
Comment on the aesthetics
Xochimilco restaurant

Felix Candela

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

Italian tradition

Spanish tradition
• Which of the forms is most complex?
• Which is the most expressive/readable?
• How is each of the forms stiffened?
• In which form is the economy of material most evident?
Announcements

– Meet Thursday in the lobby of the Fine Arts Center

– Print out the hw assignment and bring it with you, be prepared to sketch