The Eiffel Tower and the Gateway Arch

Lecture Themes (Write these down each class!)

- The ideals of structural engineering
- The ideals of structural art
- Sculptural form vs. structural form: issues of scale
- Form as a response to forces
three ideals of structural engineering

• efficiency
• safety
• permanence

(good structural engineering does not necessarily create structural art)
three ideals of structural engineering

• efficiency
• safety
• permanence
Safety
Permanence
What should be the order of importance efficiency, safety, and permanence in structural design and construction?

Can you think of examples where this order of importance was followed? Was not followed?
The diagram illustrates the concept of moments, denoted as $M(x)$, which are proportional to the square of the distance $x$. The relationship is given by $M(x) \propto x^2$. The figure on the left represents the Paris Eiffel Tower with dimensions labeled, while the right side shows the graphical representation of the moment function.
<table>
<thead>
<tr>
<th>Tower Leg Force (k)</th>
<th>Force if Legs not splayed (k)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2230</td>
<td>2230</td>
</tr>
<tr>
<td>2925</td>
<td>8994</td>
</tr>
<tr>
<td>3120</td>
<td>16848</td>
</tr>
<tr>
<td>3253</td>
<td>26677</td>
</tr>
</tbody>
</table>
...symbolic
Can you think of another structure that has inspired works of fine art?

Scientific  
Social  
Symbolic

Efficiency  
Economy  
Elegance
Eiffel Tower

**Efficiency**: Efficient form of an iron cantilever (9400 tons to go 984 ft - 1/10th Wash Monument, 1/3 StL Arch)

**Economy**: Small cost to the people of Paris (Eiffel built with grant + 20 years of attendance concessions)

**Elegance**: A pure form which is appropriate to its loads and has inspired artists
St. Louis Gateway Arch - Eero Saarinen - 1965

Garabit Viaduct - Eiffel
Gateway Arch

Scientific: Inefficient catenary for resisting wind, structure must be hidden and complex to provide safety

Social: A popular trip which does not let the visitor experience the structure (100 at a time vs. 10,000 at a time in Eiffel’s Tower)

Symbolic: A monument (to the Louisiana Purchase and the opening of the West) impressive for its scale, not its novel form

Gateway Arch

**Efficiency**: 20,000 tons for 600 feet (vs. 9400 tons for 984 ft with Eiffel’s Tower)

**Economy**: $11 million to people of St. Louis and the U.S.

**Elegance**: An oversized sculpture to be viewed rather than experienced – it is daring – is it elegant?

structure or sculpture?
In-class exercise

- Break into groups of 4 or less.
- To select a recorder/speaker for your group determine which person has the most musical talent in the group – that’s your recorder for this time.
<table>
<thead>
<tr>
<th>Structural Engineering</th>
<th>Structural Art</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Efficiency (Scientific)</td>
</tr>
<tr>
<td>Safety</td>
<td>Economy (Social)</td>
</tr>
<tr>
<td>Permanence</td>
<td>Elegance (Symbolic)</td>
</tr>
</tbody>
</table>

Q: How are the ideals of structural engineering reflected, or not reflected, in the ideals of structural art?

(Discuss in your groups, record your names and key thoughts on paper, be prepared to share those thoughts with the class)

<table>
<thead>
<tr>
<th>Architecture (Vitruvius)</th>
<th>Structural Engineering</th>
<th>Structural Art</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength (Firmitas)</td>
<td>Efficiency</td>
<td>Efficiency (Scientific)</td>
</tr>
<tr>
<td>Usefulness (Utilitas)</td>
<td>Safety</td>
<td>Strong (Firmitas)</td>
</tr>
<tr>
<td>Beauty (Venustas)</td>
<td>Permanence</td>
<td>Useful (Utilitas)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beautiful (Venustas)</td>
</tr>
</tbody>
</table>

Q: What do you think Vitruvius meant by his 3 ideals?

Q: What ideals does the Arch meet? Which ones does it fail to meet?
Tower and the Bridge Ch. 1

Subsections

- A New Tradition Art in Engineering
- A New Art Form
- The Ideals of Structural Art
- The History of Structural Art
- Engineering and Science
- Structures and Machines
- Structures and Architecture
- The Three Dimensions of Structure
- Structural Art and Society

Tower and the Bridge Ch. 1

Subsections

- A New Tradition Art in Engineering
  - Can a structure be A New Art Form?
  - The Ideals of Structural Art are? (hint: E’s)
  - The History of Structural Art (shall be taught)
  - Engineering and Science what is the difference?
  - Structures and Machines what is the difference?
  - Structures and Architecture differ how?
  - The Three Dimensions of Structure are? (hint: S’s)
  - Structural Art and Society relate how?

writing assignment

- writing assignment is posted online
- assignment asks you to select a structure
- and gather information in a style consistent with the critiquing of structural art
- full details at www.ce.jhu.edu/perspectives
- select assignments, writing 1