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)
Efficiency
Safety
gravity
Permanence
three ideals of structural engineering

• efficiency
• safety
• permanence
Efficiency

Delaware Water Gap rail bridge
Safety
Permanence
What should be the order of importance efficiency, safety, and permanence in structural design and construction?
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?
<table>
<thead>
<tr>
<th>Structural Engineering</th>
<th>Structural Art</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Efficiency</td>
</tr>
<tr>
<td>Safety</td>
<td>(Scientific)</td>
</tr>
<tr>
<td>Permanence</td>
<td>Economy</td>
</tr>
<tr>
<td></td>
<td>(Social)</td>
</tr>
<tr>
<td></td>
<td>Elegance</td>
</tr>
<tr>
<td></td>
<td>(Symbolic)</td>
</tr>
</tbody>
</table>
some statics..

examine solution on the board
\[ M(x) \propto x^2 \]
Epure de résistance au vent

1er Cas : Vent de 300 à 400 de la base au sommet.
2e Cas : Vent provenant de 200 à la base jusqu'à 400 du sommet.

Surfaces et effets correspondants.

<table>
<thead>
<tr>
<th>Serre</th>
<th>Basique</th>
<th>Surface de base</th>
<th>Zone de surcharge</th>
<th>Caractère de base</th>
<th>Zone de surcharge</th>
<th>Indice de base</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>70°</td>
<td>950</td>
<td>300</td>
<td>250</td>
<td>650</td>
<td>500</td>
</tr>
<tr>
<td>2</td>
<td>60°</td>
<td>1000</td>
<td>300</td>
<td>232</td>
<td>650</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>50°</td>
<td>535</td>
<td>300</td>
<td>151</td>
<td>650</td>
<td>500</td>
</tr>
<tr>
<td>4</td>
<td>40°</td>
<td>1234</td>
<td>300</td>
<td>113</td>
<td>650</td>
<td>500</td>
</tr>
<tr>
<td>5</td>
<td>30°</td>
<td>1234</td>
<td>300</td>
<td>113</td>
<td>650</td>
<td>500</td>
</tr>
<tr>
<td>6</td>
<td>20°</td>
<td>1234</td>
<td>300</td>
<td>113</td>
<td>650</td>
<td>500</td>
</tr>
<tr>
<td>7</td>
<td>10°</td>
<td>1234</td>
<td>300</td>
<td>113</td>
<td>650</td>
<td>500</td>
</tr>
<tr>
<td>8</td>
<td>0°</td>
<td>1234</td>
<td>300</td>
<td>113</td>
<td>650</td>
<td>500</td>
</tr>
<tr>
<td>---</td>
<td>500°</td>
<td>1234</td>
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<td>113</td>
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</table>

Détermination des efforts dans les arbalétriers.

Le problème que nous avons propre à la section AB renvoie chaque au point O où est la réduction des forces 1.2.3.4.5. On peut donc en ce point O décomposer cette force de 1.234.50° suivant la direction des montants.

En ce qui concerne le calcul de la surface d'un montant d'une base:

- Poids total de la construction au niveau de l'ouvrage : 650 000
- Moment de renversement à la base : 300 350 170
- Charge à la base d'un montant de la poussée propre : 1 550 000
- Charge à la base d'un montant due à l'effort de vent : 500 000
- Charge totale : 3 150 700

Section d'une membrane d'une base : 2.240 = m²
Section d'une membrane : 2.240 = m²
Longueur de la base : 2.240 = m

Polygone des forces du 1er cas de surcharge due au vent

Polygone des forces du 2e cas de surcharge due au vent.
<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
Guillaume Apollinaire

LA TOUR EIFFEL

S
A
LUT
M
ON
DE
dont
je suis
LA LAN
GUE É
LOQUEN
TEQUETA
BOUCHE
O PARIS
TIRE ET TIRERA
T OU JOURS
AUX A L
LEM ANDS
Guillaume Apollinaire

LA TOUR EIFFEL

SALUT MONDE dont je suis
LA LAN GUE É LOQUEN TEQUÉTA BOUCHE O PARIS TIRE ET TIRERA T OU JOURS AUX A L L E M ANDS
Can you think of another structure that has inspired works of fine art?
Eiffel Tower

**Efficiency**: Efficient form of an iron cantilever (9400 tons to go 984 ft - $1/10^{th}$ 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
Pruitt Igoe
Housing Project

A fascinating topic in its own right, and full of big names of 20th century architecture and politics...
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..
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(Scientific) (Social) (Symbolic)
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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>Structural Engineering</th>
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<td>Strength (Firmitas)</td>
<td>Efficiency (Scientific)</td>
</tr>
<tr>
<td>Safety</td>
<td>Usefulness (Utilitas)</td>
<td>Economy (Social)</td>
</tr>
<tr>
<td>Permanence</td>
<td>Beauty (Venustas)</td>
<td>Elegance (Symbolic)</td>
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Q: What do you think Vitruvius meant by his 3 ideals?

Q: How are Vitruvius’ ideas reflected (or not) in structural art?
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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
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](http://www.ce.jhu.edu/perspectives)
  select assignments, writing 1