Reinforced Concrete Beam Project

Herff College of Engineering
2014 Reinforced Concrete Competition

The objective of this project is to develop the strongest reinforced concrete beam as measured by the cost-adjusted strength-to-weight ratio.

The strength-to-weight ratio \((SWR)\) is:

\[
SWR = \frac{\text{Ultimate Load (lb.)}}{\text{Beam Weight (lb.)}}
\]

The strength of the beam is the ultimate load recorded during testing.

A cost factor will be computed as follows:

If cost < $4.00 then: \(Cost Factor = 1\)
If cost > $4.00 then: \(Cost Factor = \frac{$4.00}{\text{Cost}}\)

Using your cost factor, the cost-adjusted \(SWR_{Adjusted}\) is computed as:

\[
SWR_{Adjusted} = SWR \times \text{Cost Factor}
\]

Each team should prepare a full formal technical report with a 6-minute presentation supported by recent and relevant research.

Final presentation and reports are due Sunday, April 13, 2014 – 6:00 p.m. Engineering Auditorium.

In designing the reinforced concrete beam groups may consider the use of admixtures, various types of reinforcement, various types of cements and aggregates, and non-rectangular cross-sections.

The concrete beam must have a length of 30 in., a height of 6 in., and have a prismatic cross-section. Maximum width of the beam is 8 in.
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- The reinforced concrete beam problem poses several challenges to the student:
  1. selection of the shape and size of the cross-section of the beam;
  2. design of a concrete mix based on strength and workability;
  3. design of the reinforcement (type of reinforcement, amount, and position in the beam), and
  4. the prediction of the SWR of the beam.

Reinforced Concrete Beam Project

- The reinforced concrete beam project schedule:

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 25-27</td>
<td>Introduction; concrete beam #1</td>
</tr>
<tr>
<td>March 4-6</td>
<td>Break beam #1; develop concrete beam #2</td>
</tr>
<tr>
<td>March 10-14</td>
<td>Spring Break</td>
</tr>
<tr>
<td>March 18-20</td>
<td>Break beam #2; develop concrete beam #3</td>
</tr>
<tr>
<td>March 25-27</td>
<td>Break beam #3; develop concrete beam #4</td>
</tr>
<tr>
<td>April 1-3</td>
<td>Break beam #4; develop final beam</td>
</tr>
<tr>
<td>April 8-10</td>
<td>Break final concrete beam</td>
</tr>
<tr>
<td>April 13</td>
<td>Reinforced concrete beam presentations - 6:00 p.m.</td>
</tr>
</tbody>
</table>

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- The cost of steel may be estimated as follows:

\[
\text{Cost of steel} = \frac{A_L}{1,728 \text{in}^3/\text{ft}^3} \left( \frac{490 \text{ lb.}}{\text{ton}} \right) \left( \frac{989 \text{ ton}}{2,000 \text{ lb.}} \right)
\]

where \( A_L \) is the cross-sectional area of steel rebars, \( L \) is the length of the steel rebars, and 490 lb./ft.\(^3\) is the unit weight of steel.

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- For example, if one #5 rebar is placed in the beam the steel cost is estimated as:

\[
\text{Cost of steel} = \frac{(0.31 \text{ in.}^2 \times 30 \text{ in.)}}{1,728 \text{in}^3/\text{ft}^3} \left( \frac{490 \text{ lb.}}{\text{ton}} \right) \left( \frac{989 \text{ ton}}{2,000 \text{ lb.}} \right) = 1.30
\]

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- Consider the following mix for a cubic yard of concrete developed using the ACI mix design procedure.

<table>
<thead>
<tr>
<th>Material</th>
<th>Amount (lb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>304</td>
</tr>
<tr>
<td>Cement</td>
<td>708</td>
</tr>
<tr>
<td>Coarse aggregate</td>
<td>1,624</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>1,151</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland Type I cement</td>
<td>$111/ton</td>
</tr>
<tr>
<td>Coarse aggregate</td>
<td>$18/ton</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>$10/ton</td>
</tr>
<tr>
<td>Steel reinforcement</td>
<td>$599/ton</td>
</tr>
<tr>
<td>Admixtures - water reducer</td>
<td>$15/gal.</td>
</tr>
<tr>
<td>Admixtures - silica fume</td>
<td>$500/ton</td>
</tr>
<tr>
<td>Fiber reinforcement</td>
<td>Market value (see Dr. Camp)</td>
</tr>
</tbody>
</table>
The cost of the concrete required for a 4 in. by 6 in. by 30 in. beam is estimated as:

\[
\text{Cost of cement} = \frac{4\text{in.}(6\text{in.})30\text{in.}}{1,728\text{in.}^3/\text{ft}^3} \times \left(\frac{708\text{ lb.}}{27\text{ ft.}^2} \times \frac{\$111}{\text{ton}} \times \frac{\text{ton}}{2,000\text{ lb.}}\right) = \$0.61
\]

\[
\text{Cost of coarse aggregate} = \frac{4\text{in.}(6\text{in.})30\text{in.}}{1,728\text{in.}^3/\text{ft}^3} \times \left(\frac{1,824\text{ lb.}}{27\text{ ft.}^2} \times \frac{\$18}{\text{ton}} \times \frac{\text{ton}}{2,000\text{ lb.}}\right) = \$0.24
\]

The cost concrete is estimated as: $0.94

The cost reinforced concrete beam is estimated as: $2.24

For example, if the unadjusted \( SWR \) for a beam is 510 and the cost is $2.24, then the cost adjusted \( SWR \) is:

\[
SWR_{\text{Adjusted}} = SWR \times \text{Cost Factor}
\]

\[
SWR_{\text{Adjusted}} = 510 \times 1 = 510
\]

For example, if the unadjusted \( SWR \) for a beam is 510 and the cost is $4.31, then the cost adjusted \( SWR \) is:

\[
SWR_{\text{Adjusted}} = 510 \times \frac{\$4.00}{4.31} = 473
\]

The cost adjustment for the reinforced concrete beam is:

If cost < $4.00 then: \( \text{Cost Factor} = 1 \)

If cost > $4.00 then: \( \text{Cost Factor} = \frac{\$4.00}{\text{Cost}} \)
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Any questions?