## Reinforced Concrete Beam Project

Herff College of Engineering
2024 Reinforced Concrete Competition



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## Reinforced Concrete Beam Project

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

➢ The strength-to-weight ratio (**SWR**) is:

$$SWR = \frac{Ultimate\ Load(lb.)}{Beam\ Weight(lb.)}$$

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

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➢ A cost factor will be computed as follows:

If cost < \$1.50     then: *Cost Factor* = 1

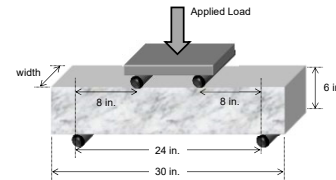If cost > \$1.50     then: $Cost\ Factor = \dfrac{\$1.50}{Cost}$

➢ Using your *Cost Factor*, the cost-adjusted **SWR**$_{Adjusted}$ is computed as:

$$SWR_{Adjusted} = SWR \times Cost\ Factor$$

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➢ 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 6 in.



➢ 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.

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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.

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The reinforced concrete beam project schedule:

| Date | Activity |
|---|---|
| February 20-22 | Introduction; concrete beam #1 |
| February 27-27 | Break beam #1; develop concrete beam #2 |
| March 12-14 | Break beam #2; develop concrete beam #3 |
| March 19-21 | Break beam #3; develop concrete beam #4 |
| March 26-28 | Break beam #4; develop final concrete beam |
| April 2-4 | Break final concrete beam |

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The cost of each beam will be estimated using the following data:

| Material | Cost |
|----------|------|
| Portland Type I cement | $130/ton |
| Coarse aggregate | $18/ton |
| Fine aggregate | $10/ton |
| Steel reinforcement | $530/ton |
| Admixtures - water reducer | $15/gal. |
| Admixture - silica fume | $500/ton |
| Fiber reinforcement | Market value (see Dr. Camp) |

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The cost of steel may be estimated as follows:

$$\textit{Cost of steel} = \frac{A_s L}{1,728 \, ^{in.^3}/_{ft.^3}} \left( 490 \, \frac{lb.}{ft.^3} \right) \left( \frac{\$530}{ton} \right) \left( \frac{ton}{2,000 \, lb.} \right)$$

where $A_s$ 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 in placed in the beam the steel cost is estimated as:

| Bar # | Diameter (in) | As (in²) |
|-------|---------------|----------|
| 2 | 0.125 | 0.0245 |
| 3 | 0.375 | 0.11 |
| 4 | 0.500 | 0.20 |
| 5 | 0.625 | 0.31 |
| 6 | 0.750 | 0.44 |
| 7 | 0.875 | 0.60 |
| 8 | 1.000 | 0.79 |
| 9 | 1.128 | 1.00 |
| 10 | 1.270 | 1.27 |
| 11 | 1.410 | 1.56 |

$\textit{Cost of steel}$

$$= \frac{(0.31 \, in.^2)(30 \, in.)}{1,728 \, ^{in.^3}/_{ft.^3}} \left( 490 \, \frac{lb.}{ft.^3} \right) \left( \frac{\$530}{ton} \right) \left( \frac{ton}{2,000 \, lb.} \right)$$

$$= \$0.70$$

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

| Component | Amount (lb.) |
|-----------|--------------|
| Water | 304 |
| Cement | 708 |
| Coarse aggregate | 1,824 |
| Fine aggregate | 1,131 |

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The cost of the concrete required for a 4 in. by 6 in. by 30 in. beam is estimated as:

$$\textit{Cost of cement} = \frac{4 \, in.(6 \, in.)30 \, in.}{1,728 \, ^{in.^3}/_{ft.^3}} \left( \frac{708 \, lb.}{27 \, ft.^3} \right) \left( \frac{\$130}{ton} \right) \left( \frac{ton}{2,000 \, lb.} \right)$$

$$= \$0.71$$

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

$$= \$0.25$$

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The cost of the concrete required for a 4 in. by 6 in. by 30 in. beam is estimated as:

$$\textit{Cost of fine aggregate} = \frac{4 \, in.(6 \, in.)30 \, in.}{1,728 \, ^{in.^3}/_{ft.^3}} \left( \frac{1,131 \, lb.}{27 \, ft.^3} \right) \left( \frac{\$10}{ton} \right) \left( \frac{ton}{2,000 \, lb.} \right)$$

$$= \$0.09$$

The cost concrete is estimated as: $1.05

The cost reinforced concrete beam is estimated as: $1.75

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The cost adjustment for the reinforced concrete beam is :

If cost < \$1.50    then:   $Cost\ Factor = 1$

If cost > \$1.50    then:   $Cost\ Factor = \dfrac{\$1.50}{Cost}$

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For example, if the unadjusted **SWR** for a beam is 210 and the cost is \$1.75, then the cost adjusted **SWR** is:

If cost > \$1.50    then:   $Cost\ Factor = \dfrac{\$1.50}{Cost}$

$$SWR_{Adjusted} = 210 \times \dfrac{\$1.50}{\$1.75} = 180$$

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If the cost were \$1.35, then the cost adjusted **SWR** is:

If cost < \$1.50    then:   $Cost\ Factor = 1$

$$SWR_{Adjusted} = SWR \times Cost\ Factor$$

$$SWR_{Adjusted} = 210 \times 1 = 210$$

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## Any questions?



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