

Reinforced Concrete Beam Project

Herff College of Engineering
2023 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:

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

- 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** = $\frac{\$1.50}{\text{Cost}}$

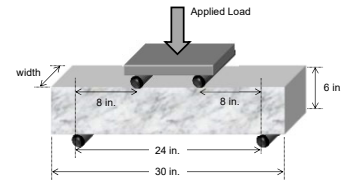
- Using your **Cost Factor**, the cost-adjusted **SWR_{Adjusted}** is computed as:

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

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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 21-23	Introduction; concrete beam #1
February 28 - March 2	Break beam #1; develop concrete beam #2
March 14-16	Break beam #2; develop concrete beam #3
March 21-23	Break beam #3; develop concrete beam #4
March 28-30	Break beam #4; develop final concrete beam
April 4-6	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:

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

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 is placed in the beam the steel cost is estimated as:

Bar #	Diameter (in.)	As (in ²)
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

Cost of steel

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

= \$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:

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

= \$0.71

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

= \$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:

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

= \$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: $Cost\ Factor = \frac{\$1.50}{Cost}$

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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: $Cost\ Factor = \frac{\$1.50}{Cost}$

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

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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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