Reinforced Concrete Beam Project

Herff College of Engineering
2022 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 < \$3 then: $Cost\ Factor = 1$

If cost > \$ then: $Cost\ Factor = \frac{\$3}{Cost}$

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

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

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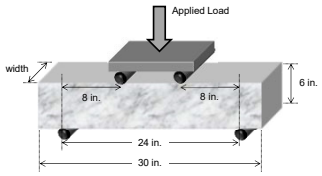
- The concrete beam ***must*** have a length of 30 in., a height of 6 in., and have a prismatic cross-section. Maximum width of the beam is 6 in.



- 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 22-24	Introduction; concrete beam #1
March 1-3	Break beam #1; develop concrete beam #2
March 15-17	Break beam #2; develop concrete beam #3
March 22-24	Break beam #3; develop concrete beam #4
March 29-31	Break beam #4; develop final concrete beam
April 5-7	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	$123/ton
Coarse aggregate	$18/ton
Fine aggregate	$10/ton
Steel reinforcement	$1,500/ton
Admixtures - water reducer	$15/gal.
Admixture - silica fume	$100/ton
Fiber reinforcement	Market value (see Dr. Camp)

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The cost of steel may be estimated as follows:

$$Cost\ of\ steel = \frac{A_s L}{1{,}728\ \text{in.}^3/\text{ft.}^3}\left(490\ \frac{\text{lb.}}{\text{ft.}^3}\right)\left(\frac{\$1{,}500}{\text{ton}}\right)\left(\frac{\text{ton}}{2{,}000\ \text{lb.}}\right)$$

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 in 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

$$= \frac{(0.31\ \text{in.}^2)(30\ \text{in.})}{1{,}728\ \text{in.}^3/\text{ft.}^3}\left(490\ \frac{\text{lb.}}{\text{ft.}^3}\right)\left(\frac{\$1{,}500}{\text{ton}}\right)\left(\frac{\text{ton}}{2{,}000\ \text{lb.}}\right)$$

$$= \$1.98$$

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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:

$$Cost\ of\ cement = \frac{4\ \text{in.}(6\ \text{in.})30\ \text{in.}}{1{,}728\ \text{in.}^3/\text{ft.}^3}\left(\frac{708\ lb.}{27\ ft.^3}\right)\left(\frac{\$123}{\text{ton}}\right)\left(\frac{\text{ton}}{2{,}000\ \text{lb.}}\right)$$

$$= \$0.67$$

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

$$= \$0.24$$

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

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

$$= \$0.09$$

The cost concrete is estimated as: $1.00

The cost reinforced concrete beam is estimated as: $2.98

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The cost adjustment for the reinforced concrete beam is :

If cost < \$3 then: $Cost\ Factor = 1$

If cost > \$3 then: $Cost\ Factor = \frac{\$3}{Cost}$

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For example, if the unadjusted ***SWR*** for a beam is 210 and the cost is \$2.98, then the cost adjusted ***SWR*** is:

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

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

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If the cost were \$3.50, then the cost adjusted ***SWR*** is:

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

$$SWR_{Adjusted} = 210 \times \frac{\$3}{\$3.50} = 180$$

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Any questions?

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