Cut / Fill and Bridge Abutment / Span Computations

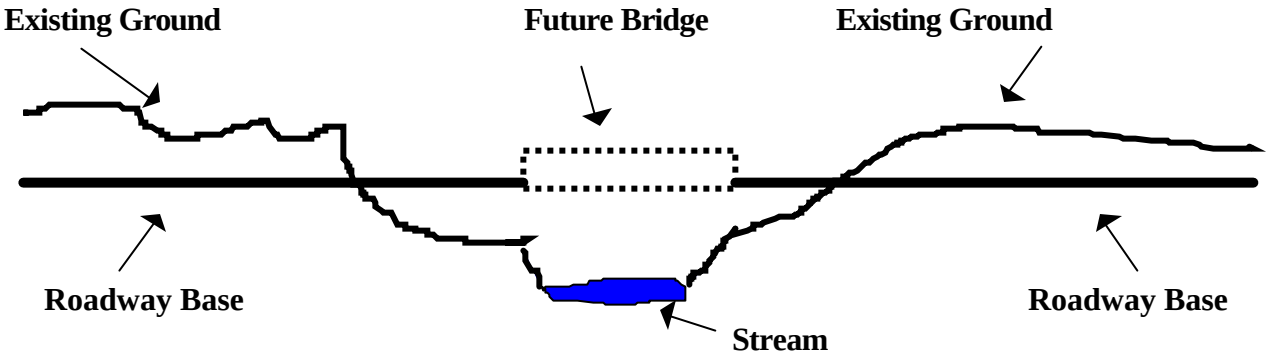
SITUATION: The 62d Engineer Battalion is still gearing up for deployment to the country of Igotit. Three new missions are:

1. Construct a two-lane road from the mine site to the local seaport,
2. Construct two concrete abutments to support a simply supported bridge over a stream, and
3. Verify the bridge span design for the bridge across the river.

The battalion (BN) operations officer (S3) received additional information about the construction requirements around the town of Igotitville and tasked your company to develop some estimates. Your company commander chose you to assist the BN S3 based on your previous good performance.

Reporting to the BN S3, you receive the three missions you must complete.

MISSION #1: The surveying team conducted a detailed survey of the proposed roadway bed for a two-lane heavy traffic highway that will also include the construction of a simply supported bridge over a seasonal stream in the near future. The sketch below relates existing ground elevation with the base of the roadway which will have a maximum width of 50 feet. If earthmovers, on average, can remove soil at the rate of __**6**___ (**e1**) cubic yards per hour per earthmover, how many earthmovers will it take to do the cutting operations in a two-week period if we work ten-hour days? Given that the battalion only has eight earthmovers, can this be done? If not, what could we do? The battalion only has seven twenty-ton dump trucks that can, on average, haul material to the road site at the rate of ___**4.25**__ (**h1**) cubic yards per hour per truck. Calculate the time to complete fill operations. Can we complete the fill operations in one week, working ten-hour days? If not, what can we do?



The surveying crew has provided their survey results along the roadway centerline at 25 yard intervals. Elevation heights (feet) using the roadway base as the reference point and working left to right can be seen in the attached chart. Provide an estimate of how much soil we must remove to lower the existing ground to the level of the roadway base and also an estimate of how much material we will need to raise the existing ground to the roadway base. Do not include the location of the future bridge site (between benchmarks 20 and 23)

in your cut and fill computations. The soil characteristics do not allow us to use the existing soil we cut for any fill operations.

MISSION #2: Develop an equation to model the amount of concrete, $c(t)$, measured in cubic yards, placed for the designed bridge abutments shown below. The rate in which concrete is placed depends upon the number of soldiers and concrete trucks available to support the operation. Historical documentation indicates the concrete emplacement rate can be modeled using the below differential equation

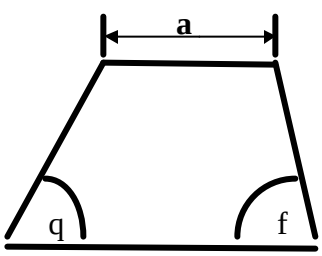
$$\frac{dc}{dt} = \frac{0.75\,(t+m)^2}{t+s},$$

where the amount of concrete initially placed is zero and the time t is in hours. The BN S3 wants you to investigate and determine if the concrete abutments can be completed within __**3**___ (**d1**) ten-hour workdays if __**3**__ (**m**) concrete mixers and __**27**__ (**s**) soldiers are available to work the mission. Investigate to see what happens if we increase or decrease the number of mixers for the project. What impact will changing the number of available mixers have on the project completion time? Support your answer mathematically. Is this a good model?

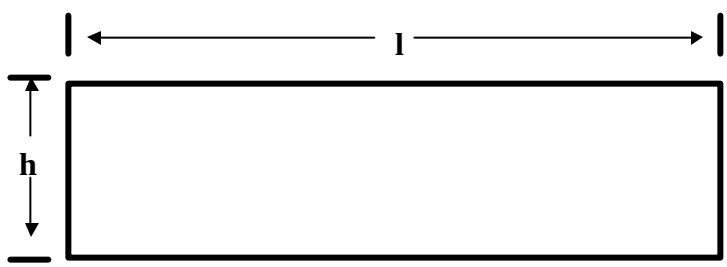
Sketch of Bridge Abutment

(Not To Scale)

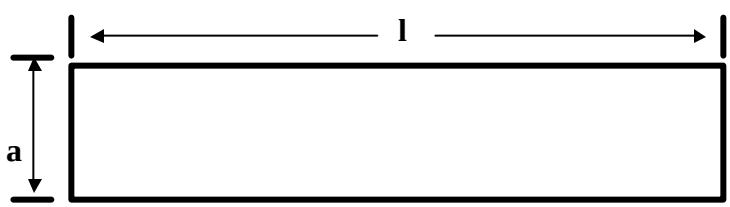
End View



Front View



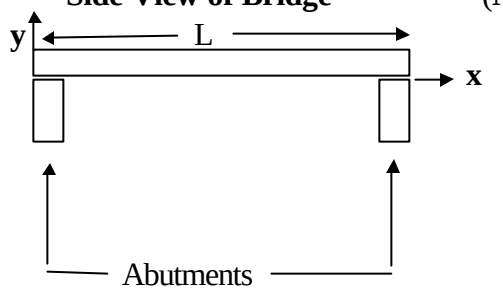
Top View



q = __**75**_ degrees f = __**75**_ degrees **a** = __**6**__ feet **h** = __**5**__ feet **l** = _**45**__ feet

MISSION #3: The BN S3 wants you to verify that the I-beams designed (see sketch) for the __**90**_ (**L**) foot bridge span is sufficient to prevent a __**20**_ (**tn**) ton load, positioned at the midpoint of the bridge span, from deflecting vertically more than __**0.9**_ (**df**) inches. You can assume that the load is distributed uniformly across the beams at the midpoint of the span and that the greatest deflection will occur at this point.

Side View of Bridge (**Not to Scale**) **End Cross-Section View of a Span**



I-beams

The differential equation that models the vertical deflection, from the "Handbook of Engineering Fundamentals," is given by

$$E\,I\,\frac{d^2y}{dx^2} = M(x)$$

where

E ≡ The modulus of elasticity of the material = 29,000,000 lbs/ in^2 ,

I ≡ Moment of inertia = __**11,000**_ in^4 ,

y(x) ≡ Vertical deflection of the beam in inches,

M(x) ≡ Bending moment = $\int_0^x \frac{P}{2}\,ds$, $0 \le x \le L/2$

x ≡ Distance, in inches, from the bridge support,

P ≡ Concentrated load in pounds per beam,

y = 0 at x = 0, and $\frac{dy}{dx} = 0$ at $x = \frac{L}{2}$.

For a fixed length and beam material, the chief factor in determining the vertical deflection comes from the moment of inertia. This is defined as the sum of the products of each elementary area of the cross-section of the I-beam multiplied by the square of the distance of that area from the assumed axis of rotation. What

would our moment of inertia need to be if we want the I-beam to deflect no more than one and one-half inches?

REQUIREMENT: Complete and submit your findings and your computations for all three missions no later than **A05 - 030715ZAPR97, B05 - 030820ZAPR97, C05 - 030925ZAPR97**. Prepare a one page (single spaced, 12 cpi) memorandum to the BN S3 that will summarize your findings. Include all calculations and analysis within enclosures to the memorandum.