College of Engineering, University of Iowa
Department of Civil & Environmental Engineering
53:086 Civil Engineering Materials
Spring Semester, 2008

Homework Assignment #3 due: Tuesday, February 19, 2008

1) In a short paragraph, describe the role as you understand it, of the dislocations in plastic behavior of steel. (6 pts)

2) There is a size effect that often exists in heat-treated plate steels, in which thicker plates typically have lower strengths and higher ductilities than thinner plates of the same steel type. Please explain this. (6 pts)

3)
   a) What physical differences would you expect to see in steel samples cooled from 1200^{o}C to 20 ^{o}C at rates of 25 ^{o}C/hour, 1000 ^{o}C/hour, and 40,000 ^{o}C/hour, respectively? (6 pts).

   b) Qualitatively, how would each of the mechanical properties (elastic modulus, yield stress, ultimate strength, and ductility) differ with increasing cooling rate? (6 pts)

4) A steel pipe of length 1 m, outside diameter 0.2m, and wall thickness of 10 mm is subjected to an axial compression of 200 kN. Assuming E = 200 Gpa and ν = 0.30, find: (9 points)

   a) The shortening of the pipe;
   b) The increase in the outside diameter; and
   c) The increase in wall thickness.

5) In as much detail as you can find, but no more than a paragraph for each, explain the significant differences between the following ASTM grades of structural steels in terms of their alloying compositions, heat treatments, work hardening, etc. (24 pts total)

   - A 242
   - A 514
   - A 572
   - A 573
   - A 588
   - A 633
   - A 678
   - A 852

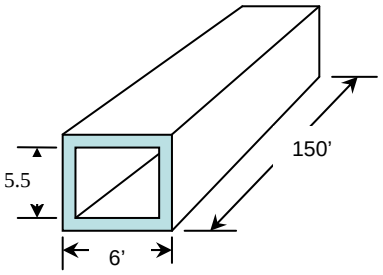
6) A steel sheet-pile wharf structure is being considered in a saltwater coastal port. In the preliminary plans, much of the underwater hardware associated with the wharf's floats is to be of brass. (7 points)

a. Since both metals are to be submersed in saltwater (electrolytic) in close proximity would you expect galvanic corrosion problems?
b. Which metal would you expect to corrode, and why?

7) The decking support of a highway girder bridge crossing the Mississippi River between Iowa and Illinois is to be comprised of four-box girders fabricated of plate steel or plate aluminum. The box girders have outside cross-section dimensions of 6'x6', and are fabricated with 3-inch plate metal. Each girder is actually a sequence of 10 simply supported beams, each of length 150 feet, supported on concrete piers. (The cumulative length of each girder is thus 1500 feet.) The design life of the bridge is to be fifty years. Please consider the total lifetime cost of the following material alternatives and make a recommendation. (36 points)

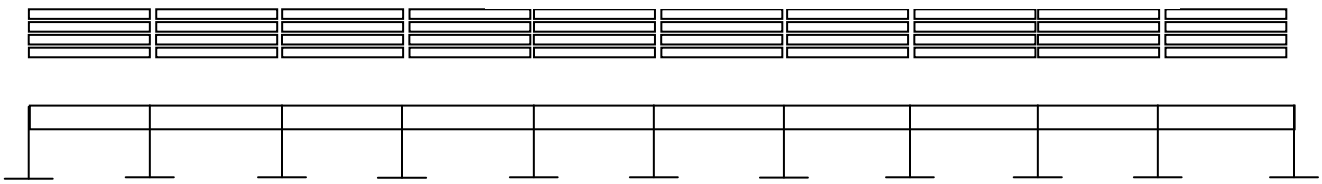
a. Usage of A992 steel which would need to be painted five times during the lifetime of the bridge (at 0, 10, 20, 30, and 40 years into its service life). The total cost of painting the bridge (crew mobilization, sandblasting, environmental impact minimization, and painting) is estimated to be $10 per square foot of painted area, and only the exposed external areas will be painted. The material cost of A992 steel is 50¢ per pound.
b. Usage of A242 weathering steel (75¢ per pound), which would need to be painted once 25 years into its service life. The total painting costs are still $10 per square foot.
c. Usage of A992 steel with hot-dip zinc galvanization. Again, the A992 steel is assumed to cost 50¢ per pound. Assume that the cost of hot-dip zinc galvanization adds $1.50 per square foot of surface area galvanized to the initial material cost of the steel. Further, assume that galvanized girders will not require any re-treatment or maintenance during their fifty year life cycle.
d. Usage of 6061-T6 aluminum alloy which will not need to be painted or treated during its lifetime. The initial material cost of the aluminum is $2.50 per pound.

In making your cost comparisons, neglect inflation, assume an interest rate of 5%, and reduce all material-related expenditures to their present-worth as a basis for comparison.



Orthographic view of individual box-girder segment (not to scale).

Plan view of entire bridge (not to scale)



Profile view