University of California
Department of Civil and Environmental Engineering
Structural Engineering, Mechanics and Materials
Spring Semester, 2015

Name: _____

MS Comprehensive Examination
Materials

Question 1: (70%)

I) Normal Strength Concrete (NSC) versus High Strength Concrete (HSC)

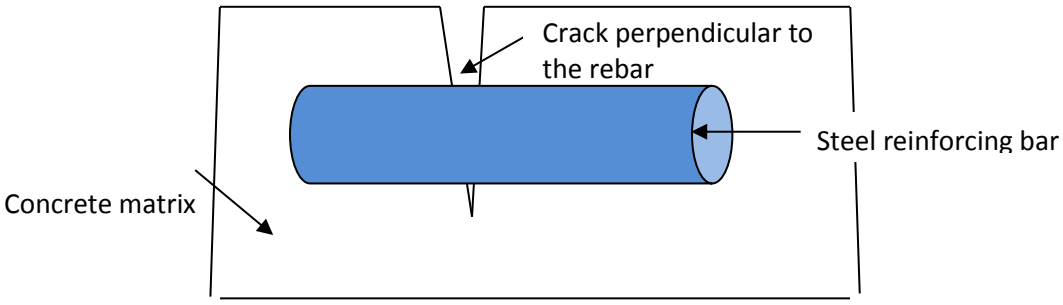
a) What causes the formation of a porous region (i.e. transition zone) between the coarse aggregates and the cement paste in NSC?
b) This transition zone is either absent or considerably reduced in HSC; please explain why.
c) HSC and NSC specimens are being tested in tension.
   i) Draw the stress strain curve of both specimens in the same diagram.
   ii) Explain the reason for their differences in the ascending and descending portion of the stress strain curve.

II) Corrosion

These questions deal with the corrosion of steel reinforcements embedded in concrete.

a) Why does a passive film protect the steel from corrosion?
b) What causes the destruction of the passive film in concrete at high ph (i.e. ph>12)?
c) Corrosion is an electro-chemical process.
   i) Will corrosion be enhanced in a wet or in a dry concrete? Please explain.
   ii) Assume the cathodic reaction consumes less electrons (i.e. cathodic reaction based on water decomposition instead of hydroxyl formation). Will this slow down the corrosion rate? **Yes/No**? (Circle)

d) A cracked specimen shown below is exposed to a moist environment. Indicate in the schematic the location of the cathode and the location of the anode.



e) Why are longitudinal cracks (cracks parallel to rebars) more detrimental compared to crack formations perpendicular to rebars?

Question 2: (30%)

a) Let's compare two types of common construction steels: A36 (yield strength: 36 ksi) and A514 (yield strength: 100ksi).
   i. Do they exhibit the same/different microstructures? Please provide some information on their microstructures.
   ii. What strengthening mechanisms are responsible for the increase in yield strength in A 514 from 36 ksi to 100 ksi?
   iii. Does the increase in yield strength modify the toughness of the steel?
   iv. How do dislocations interfere with the A514 microstructure?

b) Both A514 and the Maraging steel exhibit the same strengthening mechanisms but the Maraging steel is far more ductile even though it contains martensite. Please explain.

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Question 1:

Let's compare a High Strength Concrete (HSC) with compressive strength of 15,000 psi with a Normal Strength Concrete (NSC) of 4,000 psi compressive strength.

a) From a microstructural and macrostructural point of view what are the main differences between a HSC and a NSC?
b) The users of high strength concrete frequently experience thermal cracking in large structural elements. Please explain the reasons for thermal cracking and discuss how the risk of thermal cracking can be minimized.
c) Concrete structures may be exposed to aggressive agents and environments that cause the concrete to deteriorate over time. Do you expect a difference between HSC and NSC with respect to:
   - Fire Resistance
   - Corrosion
   - Frost action
d) Is there a difference in crack growth resistance behavior between a HSC vs. a NSC? Please explain and point out this difference in their stress strain curve (draw the stress strain curve of a HSC and NSC in the same stress strain diagram).
e) Fibers are commonly added to HSC to enhance its crack growth resistance. Which toughening mechanisms are associated with crack wake mechanisms in fiber reinforced concrete? Why are they so effective in resisting crack growth?

Question 2:

A low carbon steel (i.e A36) undergoes different heat treatments.

i) Cooled slowly from Austenite
ii) Quenched from Austenite
iii) Quenched and heat treated

a) What is the name of the phase that forms due to quenching (i.e. case ii)?
b) The treatment induces changes in microstructure and mechanical properties. Which of the mechanical properties changed due to the heat treatment? i) the E-modulus, ii) the yield strength, iii) the ductility?
c) Which one of the three heat treated A36 steel will exhibit the best performance in regards to the properties mentioned in a)?
d) Which construction steel exhibits high hardenability? A low carbon steel (i.e. A36) or a quenched and tempered high alloy steel (i.e. A514). Please explain your answer.
e) Which microstructural feature interacts with dislocations in A514? How does this interaction lead to strength enhancement?

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SPRING 2012

MATERIALS EXAM

Problem 1

I) The production of portland cement is responsible for 6% of the world's CO_2 generation. Describe the two sources for the production of CO_2 during the firing of the clinker in the kiln.

II) You are going to cast concrete in a site during a cold winter. The local market has the two cements available:
Cement A (%): C_3S= 50, C_2S= 35, C_3A= 5, C_4AF= 10
Cement B (%): C_3S = 65, C_2S= 15, C_3A= 10, C_4AF= 10
Which cement should you select?

III) What is the influence of the type and amount of aggregate on the modulus of elasticity of concrete?

Problem 2

I) You are in charge of the construction of a large massive dam:

a) describe four ways to reduce the temperature of fresh concrete. If you can pick only one of the four options, which one should you select?

b) describe three options to reduce the temperature rise

c) should you select an aggregate with low or high elastic modulus?

II) Describe a reason why a concrete mix can develop flash set.

III) High volume fly ash may not have high early strength. Describe how you could optimize a high volume fly ash concrete mix to obtain adequate early strength?

UNIVERSITY OF CALIFORNIA AT BERKELEY DEPARTMENT OF CEE

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SEMM Comprehensive Exam -- Materials

Please justify all your answers

Question 1

I) Compare the advantages and disadvantages of using smooth instead of rough aggregate regarding: a) workability and b) strength.
II) How does the maximum aggregate size affect the paste requirement for a given concrete?
III) A 1" limestone aggregate had soundness problem when exposed to low temperatures. What suggestions can you make to minimize or avoid the problem when this aggregate is used in concrete?
IV) Comment on the following statement: "we can always reduce the heat of hydration by removing some of the sand and adding 15% of fly ash to concrete mix proportion"

Question 2

I) Briefly discuss the following propositions:
a) The crushing strength of an aggregate can have a large influence on the compressive strength of normal strength concrete.
b) The aggregate in concrete is an "inert filler" mainly used because it reduces the cost of concrete.
c) Batching the components of concrete can be either done by volume or by weight. The decision is based on the type of equipment available at the site.
II) Describe the stresses existing in the "splitting test"
III) What cement would you recommend for pavement repair under cold conditions?
IV) Why is it necessary to have as little water as possible in concrete mixtures for the construction of conventional concrete gravity dams?