University of California **Name:________________**
Department of Civil and Environmental Engineering
SEMM
Fall 2014

Preliminary Examination
<u>Materials</u>

Question 1: Concrete (50%)

a) High Strength Concrete (HSC) is often difficult to place due to its low workability. Give three examples how the workability of HSC can be enhanced.

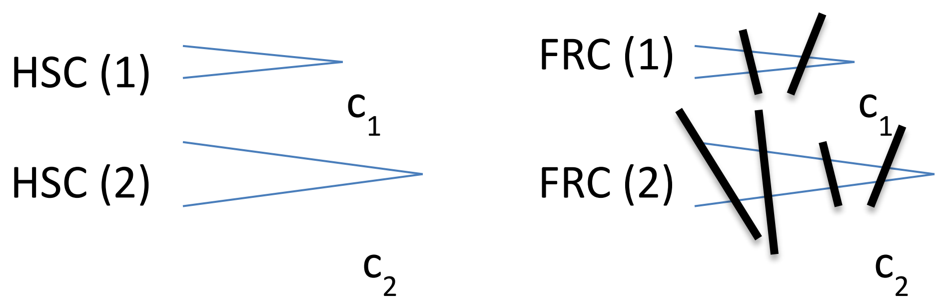
b) i) What w/c ratio is required for zero capillary porosity? Show your calculation. Assume the specific gravity of cement is 3.14.
ii) Do you expect 100% hydration if your w/c ratio is below that value?
iii) Assume your concrete with a lower w/c ratio than you calculated in i) exhibits shrinkage cracks and is exposed to rain water. Do you expect the cracked concrete to be weaker/stronger after exposure to rain water? Please explain.

c) Normal Strength Concrete (NSC) and HSC exhibit different stress strain curves in compression and tension when tested under strain control. What is responsible for the extended strain softening behavior in NSC compared to HSC?

d) Give at least two reasons why strain localization in HSC is delayed to higher stress levels.

f) If you want to increase the toughness of a fiber reinforced cement based composite what are the required toughening mechanisms?

g) HSC specimens (1) and (2) and FRC specimens (1) and (2) contain cracks of length c_1 and c_2 as shown below.



i) Which of the HSC specimens [HSC (1) or HSC (2)] will fail at a higher stress level? Which FRC specimens will fail at a higher stress level? Please explain your answers.

ii) Assume failure occurred in the HSC; do you expect the initial crack length (as shown in the schematic) and final crack length (i.e. at failure) to be of the same length? What about in the FRC specimen?

Question 2: Durability (25%)

Concrete structures may experience problems with durability:

a) Sulfate attack:
   i) What causes sulfate attack and how can it be prevented?
   ii) How can you identify that damage and cracking in a concrete structure is due to sulfate attack?

b) Alkali-Silica reaction:
   i) What causes alkali-silica reaction in concrete and how can it be prevented?
   ii) How can you identify that cracking was caused by alkali-silica reaction?

c) Corrosion:
   i) What causes steel reinforcing bars to corrode when embedded in concrete?
   ii) How could corrosion be prevented?

Question 3: Steel (25%)

a) i) Plastic deformation of steel occurs along certain planes within the crystal structure, called slip planes. Please show these slip planes in the i) fcc and ii) bcc crystal structure.
   ii) Why do materials with a bcc crystal structure in general have a higher yield strength compared to materials with a fcc crystal structure?

b) i) What are the typical microstructural features and mechanical properties of ordinary steel (A-36)?
   ii) How is the microstructure altered when the steel is quenched from the austenite regime?
   iii) Which of the mechanical properties change due to quenching? i) the E-modulus, ii) the yield strength, iii) the ductility? Please explain.

c) What are the most important parameters (list three) that reduce the fracture toughness of steel.

Name: ____

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 SEMM
SPRING SEMESTER, 2010

Name:____________________

Materials Exam

Select 3 out of 4 questions

Question 1

I) Is it a good idea to use quartz sand instead of clays, as a raw material for portland cement?

II) What is the first hydration product to form in portland cement?

III) Draw the evolution of the amount of calcium hydroxide for a portland cement paste containing 50% fly ash.

IV) What concerns would you have if ASTM Type IV cement is used for a tall building?

Question 2

I) Draw the stress x volumetric strain for a simple compression test. Explain how you measure the volumetric strain.

II) Discuss the following statement: The splitting test is often used because it generates a state of uniform tension in the whole specimen

III) A design office discovered that somebody made a mistake in computing thee design stress in a column made of normal-strength concrete. After the new calculations were done, it was found out that the stresses are 90% of the compressive strength. Should you be concerned?

IV) Derive the elastic modulus for the series model

Question 3

I) After hydrating for four weeks, it is observed in a cement paste that the volume of unhydrated cement is three times the amount of hydrated products. Compute the degree of hydration of the paste.

II) Which of the following products can be classified as a pozzolan: portland cement, quartzitic sand, fly ash F, slag, silica fume. Explain.

III) Why is gypsum added to the cement clinker? When is it added?

Question 4

I) Describe how fracture mechanics can predict the influence of the size of a sample on the tensile strength of the material.

II) Describe in details how fibers can influence the toughness of a composite material.

III) How can you measure the pull-out strength of a fiber in a matrix.

PRELIMINARY EXAM: MATERIALS
Answer 2 out of the 3 problems
Please justify all your answers

Problem 1

I) Is it a good idea to use quartz sand instead of clays, as a raw material for portland cement?

II) What is the first hydration product to form in portland cement?

III) Draw the evolution of the amount of calcium hydroxide for a portland cement paste containing 30% fly ash.

IV) What concerns would you have if ASTM Type IV cement is used for a tall building?

V) Do all mineral admixtures increase the workability of concrete?

VI) Explain why ASR manifests itself as map cracks in an unreinforced concrete slab and as vertical cracks in a reinforced column.

Problem 2

I) After hydrating for two weeks, it is observed in a cement paste that the volume of unhydrated cement is equal to the amount of hydrated products. Compute the degree of hydration of the paste.

II) Which of the following products can be classified as a pozzolan: portland cement, quartzitic sand, fly ash F, slag, silica fume. Explain.

III) Why is gypsum added to the cement clinker? When is it added?

IV) Do the cement particles become hydrophilic or hydrophobic when an air-entraining admixture is added to the cement paste?

V) After a cold winter it was observed that the concrete had many pop-outs. The concrete had the following mix proportions:
Cement: 520 (lb/yd^3), Sand: 1280 (lb/yd^3), Limestone Aggregate:2000 (lb/yd^3, maximum size: 1”), Water: 300 (lb/yd^3) and 7% air entrained air void. The portland cement had the following compound composition: C_3S: 62.3%, C_2S:12.5%, C_3A: 2.8%, C_4AF: 14.9%, and an alkali content of 0.8%. Explain the possible reason for the damage and write a memo proposing a solution for future projects.

Problem 3

I) Explain what drying creep is.

II) A concrete sample is prestressed (in compression) to strain εo and then kept under constant strain for one month. The sample is also exposed to low RH. Draw the resulting stress in the sample over time. Indicate clearly the contribution of shrinkage and stress relaxation.

III) A plain concrete column fully restrained at the ends is exposed to low relative humidity. Plot the stress evolution considering the effect of shrinkage and stress relaxation.

IV) Two spring in parallel (E1= 20 GPa and E2 = 80 GPa) are assembled in series with two dashpots in parallel (μ1 = 200 GPa.days, μ2 = 100 GPa.days). A stress of 100 MPa is applied to this system for 30 days and then the load is removed. Compute the strain at 30 days and the permanent strain once the load is removed.

UNIVERSITY OF CALIFORNIA AT BERKELEY SEMM
SPRING SEMESTER, 2008

Name:____________________

Comprehensive Exam: Materials

I) Explain carefully what a pozzolan is.

II) The temperature of a cement rotary kiln is about 1400 C. Describe what happens if there is a problem with the temperature control and the burning temperature is reduced to 1100 C.

III) How is calcium hydroxide produced during the hydration reaction of portland cement.

IV) Your company has just bought a new high resolution microscope. Describe to the microscope operator what compounds you expect to see in a 30-days old cement paste.

V) Explain the mechanism of action for air-entraining agents and superplasticizers. Include in you explanation a discussion when the cement becomes hydrophilic and hydrophobic.

VI) A contractor wants to eliminate the bleeding by dusting cement on top of the slab. Please write a memo describing if you think that this approach is good practice.

VII) List four major consequences if an engineer is foolish enough to build a concrete column without aggregate.

VIII) One concrete sample has air-entrained and the other does not. Plot how the samples will have a length change as the temperature decreases from room temperature to -10 C.

IX) Gypsum is added to clinker to control the hydration of tricalcium aluminate. Do you expect to see the presence of gypsum in concrete after 2 months?

X) A concrete sample containing 5% entrained air has a density of 2400 kg/m3. Estimate the number of entrained air voids per cubic meter of concrete.

UNIVERSITY OF CALIFORNIA AT BERKELEY SEMM
SPRING SEMESTER, 2002

Name:______________________

Materials Exam

Select 3 out of 4 questions

Question 1

I) Give the approximate dimensions for the following:

Cement particle:

Sand grains:

C-S-H: interlayer space in CSH

Air-entrained air voids:

II) A cement paste after 80% hydration had a porosity of 17%. Compute the original water-to-cement ratio.

III) Is there any difference in the concrete specimen if you perform the compression test under constant stress rate or under strain rate? Please justify your answer.

IV) Explain the advantages and disadvantages of improving the interfacial transition zone.

Question 2

I) Draw the stress x volumetric strain for a simple compression test. Explain how you measure the volumetric strain.

II) Discuss the following statement: The splitting test is often used because it generates a state of uniform tension in the whole specimen (7 points)

III) A design office discovered that somebody made a mistake in computing the stress in a column made of normal-strength concrete. After the new calculations were done, it was found out that the stresses are 90% of the compressive strength. Should you be concerned?

IV) Derive the elastic modulus for the series model

Question 3

I) In mass concrete, what is the single overriding consideration underlying the selection of materials and mix proportions? List the types of cement, aggregate, and admixtures normally used for mass concrete construction. (6 points)

II) Why is it necessary to have as little water as possible in concrete mixtures for the construction of conventional concrete gravity dams?

III) Why does the aggregate influence the elastic modulus of concrete but has little effect on its strength?

Question 4

I) Describe some of the characteristics of the Fe-C martensite transformation which occurs in plain carbon steels.

II)A 0.80% C eutectoid plain-carbon steel is slowly cooled from 750 C to a temperature just slightly below 723 C. Assuming that the austenite is completely transformed to a ferrite and cementite:

a) Calculate the weight percent eutectoid ferrite formed.

b) Calculate the weight percent eutectoid cementite formed.

UNIVERSITY OF CALIFORNIA AT BERKELEY
Department of Civil and Environmental Engineering

Name:______________________
Structural Engineering, Mechanicsand Materials
Fall Semester 2001

Preliminary Exam -- Materials

Question 1

I) You are going to cast concrete in Denver during the winter (yes, it is fair to assume that it will be cold). Your local ACME store sells two cements:
Cement A (%): C3S= 50, C2S= 35, C3A= 5, C4AF= 10
Cement B (%): C3S = 65, C2S= 15, C3A= 10, C4AF= 10
Which cement should you select?

II) Compute the water/cement ratio needed to obtain zero porosity in a paste that is only 50% hydrated.

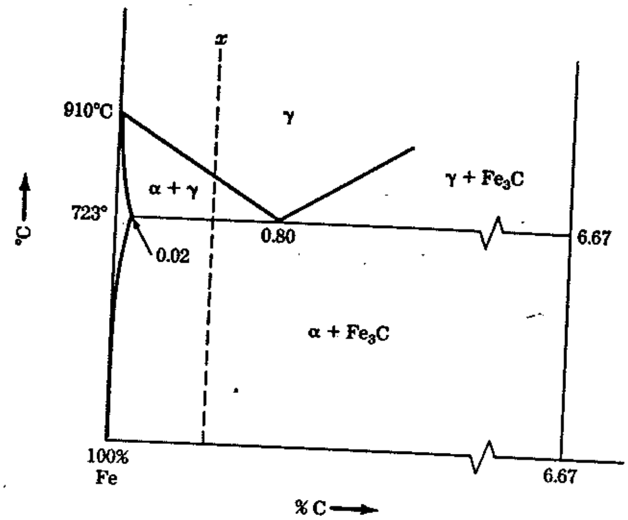
III) Consider the following SSD mix proportion (in pcy): cement: 640, water: 270, fine aggregate: 1250, coarse aggregate: 1870. Determine the trial mix proportions when the moisture deviation from SSD for the coarse aggregate is -0.4% and the moisture deviation from SSD for the fine aggregate is 0.9%.

IV) Consider the two following mix proportions (in pcy):
Mix A) cement: 640, water: 270, fine aggregate: 1250, coarse aggregate: 1870
Mix B) cement: 517, water: 260, fine aggregate: 1327, coarse aggregate: 1902

a)Which one will be have a higher compressive strength at 28 days?
b)Which one will be have a higher slump?
c)Which one will be more expensive? (15 points)

V) What is the difference between ordinary portland cement (Type I) and rapid-hardening cement (Type III)? Which of these cements would you *not* use for mass concrete?

VI)Suppose you are hired to explain why a concrete wall in a structure in New Orleans (hot and humid) had a series of cracks. It was also noted that a gel exudes from the cracks. The concrete had the following mix design:
Cement: 517, Sand: 1272, Siliceous Gravel:1917, Water: 300 (lb/yd^3);
The portland cement had the following compound composition:
C_3S: 62.3%, C_2S:12.5%, C_3A: 2.8%, C_4AF: 14.9%, and a alkali content of 1.4%. The sulfate content in the soil was 0.05% and no air-entrained admixture was used.
What was the most likely cause for the development of the cracks? Please justify your answer.


x
910°C
γ
α + γ
γ + Fe₃C
723°
0.80
6.67
0.02
°C
α + Fe₃C
100%
Fe
6.67
% C

Question 2

I) A 0.69% C hypoeutectoid plain-carbon steel is slowly cooled from 920 C to a temperature just slightly below 723 C

Calculate the weight percent proeutectoid ferrite present in the steel.

Calculate the weight percent eutectoid ferrite and eutectoid cementite present in the steel.

Why doesn't martensite appear in the steel phase diagram ?

II) A hypoeutectoid steel contains 35% wt of eutectoid ferrite. What is its average carbon content?

III) How many atoms per unit cell are there in the BCC crystal structure?

IV) Diamond and graphite are made by atoms of Carbon. Explain why diamond is hard while graphite is soft.

V) Compare the shrinkage of the longitudinal, radial and tangential direction in wood. Please explain the reason for the differences.