UNIVERSITY OF CALIFORNIA AT BERKELEY
FALL SEMESTER, 2019
Instructor: P.J. M. Monteiro
Total points:

1	28
2	40
3	41
Total	109

Question 1 (28 points)

I) A cement paste after 58% hydration had a porosity of 16%. Compute the original water-to-cement ratio. (8 points)

$2 * 0.58\, V_{c1} = 1.16\, V_{c1} = V_{p2}$

$(1 - 0.58)\, V_{c1} = 0.42\, V_{c1} = V_{c2}$

Porosity = $\frac{V_{w2}}{V_{c2}+V_{p2}+V_{w2}} = 0.16 \;\rightarrow V_{W2} = \frac{32}{105} V_{c1} = 0.305 V_{c1}$

$V_{W1} = 0.5 V_{p2} + V_{W2} = 0.885 V_{c1}$

Original w/c = $\frac{V_{w1}}{V_{c1} \times 3.14} = \frac{V_{w1}}{V_{c1} \times 3.14} = 0.282$

II) What will happen if not enough gypsum is added to the cement? (4 points)

1. Rapid hydration of C_3A and generate calcium aluminate hydrate
2. Cement set immediately after mixing
3. Releasing a lot of heat at early stage
4. Cement will be not functional

III) Which compound is primarily responsible for rapid stiffening and setting of portland cement? (4 points)

C_3A because its reaction with gypsum produces long rod-like crystals of ettringite at early age.

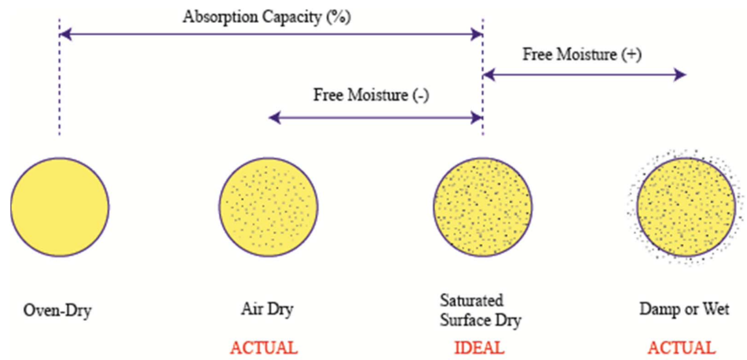
IV) If the dry-rodded unit weight of an aggregate is 105 pcf and its specific gravity 2.65, compute the percentage of voids (8 points)

unit weight of water as 62.4 pcf

62.4*2.65 = 165.36 pcf

Percent of void = $\frac{V_{total} - V_s}{V_s} = \frac{1/105 - 1/165.36}{1/165.36} = 0.575$

V) By sketches show the four possible moisture conditions of an aggregate. (4 points)



Absorption Capacity (%)
Free Moisture (+)
Free Moisture (-)
Oven-Dry
Air Dry
Saturated
Surface Dry
Damp or Wet
ACTUAL
IDEAL
ACTUAL

Question 2 (40 points)

In one or two sentences, explain if the statements are right or wrong (4 points each):

I) The fineness modulus of an aggregate defines its particle size distribution.

Wrong, the same value of fineness modulus may be obtained from several different particle size distributions.

II) The higher the percentage of coarse aggregate that can be employed, the greater the economy of the mix.

Right. Coarse aggregates have a lower surface-to-volume ratio and require less paste.

III) For a given workability, the water requirement of a concrete containing crushed aggregate is lower than one containing rounded aggregate.

Wrong, comparing with rounded aggregates, crushed aggregates have a higher surface-to-volume ratio and require more cement paste to produce same workability. More water is required for crushed aggregate.

III) For a cement of given composition, the strength and porosity of the paste-structure are dependent almost entirely upon the W/C ratio and degree of hydration.

Right. Porosity and strength of the paste is mainly dominated by the w/c ratio and degree of hydration. This is not true for concrete in general but only for the paste-structure.

IV) The ACI method of proportioning concrete mixtures is based on the assumption that for a given consistency and size of aggregate, the water content remains practically constant regardless of W/C and cement content.

Right. In the ACI method, water content is obtained by using only the specified slump and maximum size of aggregate. Then, w/c ratio is chosen according to the aimed compressive strength and cement content is found using it.

V) High bleeding is a desirable property of a concrete mixture because it tends to reduce the water-to-cement ratio.

Wrong. Excessive bleeding causes strength loss and durability problems.

VI) For use in the computation of concrete mixes, the bulk specific gravity of aggregates is always determined on an oven-dry basis.

Wrong. Mix design is done assuming SSD conditions, so the bulk specific gravity of aggregates should be determined in SSD.

VII) For a given specific gravity, the greater the dry rodded unit weight, the smaller the percentage of voids.

Right. Material is denser if it has smaller volume of voids, for the same specific gravity.

VIII) A low slump concrete mixture may have a higher W/C than a high slump mix.

Right. Slump is the “wetness” of the concrete and it does not depend on w/c ratio. This is also observed in the lab, same w/c mixtures resulting in different slumps.

IX) Concrete mixtures containing different proportion of component materials, but having identical slump (consistency), may vary in workability.

Right. Workability does not solely depend on slump; it is also characterized by cohesiveness.

X) High-early strength cement is produced by either fine grinding or by controlling the chemical composition of portland cement.

Right. Fine grinding increases the surface area of the cement grains, accelerating the hydration reaction. Also, cements with high C3A content can be used to achieve high early strength.

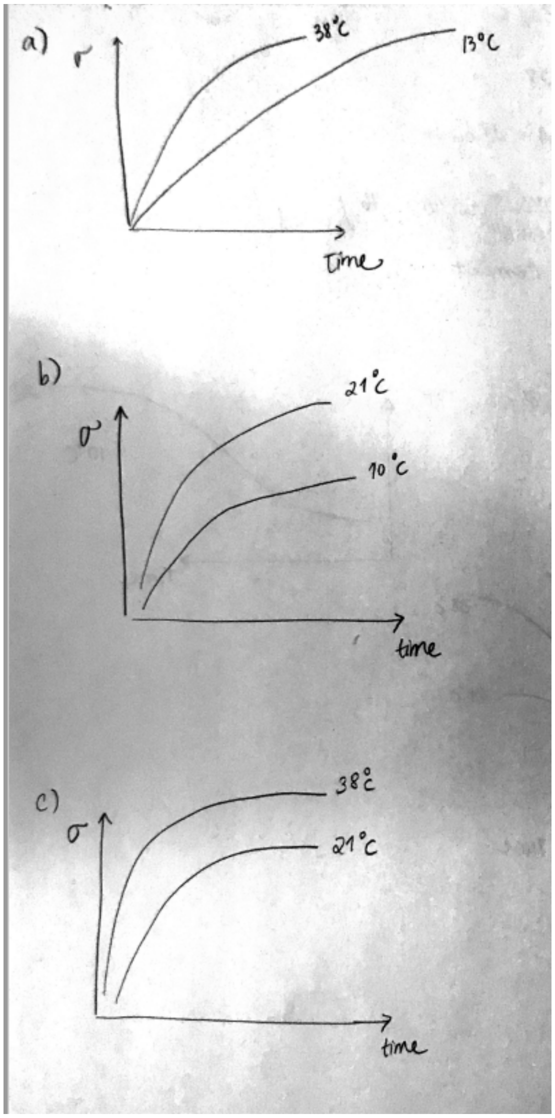
Question 3 (41)

I) Compare the elastic modulus of specimen tested in a saturated condition and of a corresponding concrete specimen tested in an air-dry condition. Note that both samples were cured in a fog-room until the day of the test. (8 points)

Saturated condition would have a higher elastic modulus. This is because the absorbed water in the C-S-H is load bearing, so it contributes to the elastic modulus.

II) Compared the 28-day strength of the following concrete samples (18 points)

a) a concrete sample is cast and cured at 13 and the other at 38 C
b) both concrete samples are cast at 21 C and maintained at 21 C for 6 hours. After that one sample is cured at 10 C and the other at 21 C
c) a sample is cast, sealed and maintained at 10 C for 2 hours then stored at 21 C until tested. The other sample is sample is cast, sealed and maintained at 10 C for 2 hours then stored at 38 C until tested



III) Based on the ACI tables, compute the dry-rodded unit weight of the coarse aggregate (lb/ft^3) for a concrete mix proportion with the following properties: (8 points)

water content: 320 lb/yd^3, w/c=0.6, air content= 1.5%, coarse aggregate content: 2060 lb/yd^3,

Characteristics of the materials: Bulk density of the cement: 196 lb/ft^3, Bulk density of the fine aggregate: 153 lb/ft^3, Bulk density of the coarse aggregate: 160 lb/ft^3, fineness modulus 2.5, maximum size aggregate 1in

The ACI tables are given in the next page

Values from table are:

2.40-0.71 and 2.60-0.69. Now interpolating for a fineness modulus of 2.5 we obtain:

$$\frac{(0.70-0.69)}{(2.60-2.40)} = \frac{(x-0.69)}{(2.50-2.40)}$$

Now, solving for x we have:

X=0.695

Now, finding the dry-rodded unit weight we have:

$$0.695 * 27 = 18.765 \frac{cu\,ft}{cu\,yd}$$

$$2060 \frac{lb}{cu\,yd} = 18.765 \frac{cu\,ft}{cu\,yd} * DRUW$$

Solving for DRUW:

DRUW=109.78 lb/cu ft

IV) Compute the cement content of a concrete mix in lb/cu. yd. if its unit weight is 149 lb/cu. ft. and having the following mix proportions by mass. (7 points)

Proportion by Weight	
Cement	1
Water	0.53
Sand	2.50
Gravel	3.50

The total mass of the materials is 1+0.53+2.5+3.5= 7.53 (so cement is 1/7.53)
Assume a volume of 1 cu yd = 27 cu ft
the mass of concrete is 149x27 lb
the mass of cement per cubic yard is 149x27/7.53=534.26 lb/cu yd

Water, lb/yd³ of Concrete for Indicated Nominal Maximum Sizes of Aggregate								
Slump, in.	**3/8 in.***	**½ in.***	**¾ in.***	**1 in.***	**1½ in.***	**2 in.*,†**	**3 in.†**	**6 in.†**
Non-Air-Entrained Concrete								
1 to 2	350	335	315	300	275	260	220	190
3 to 4	385	365	340	325	300	285	245	210
6 to 7	410	385	360	340	315	300	270	—
More than 7*	—	—	—	—	—	—	—	—
Approximate amount of entrapped air in non-air-entrained concrete, percent	3	2.5	2	1.5	1	0.5	0.3	0.2
Air-Entrained Concrete								
1 to 2	305	295	280	270	250	240	205	180
3 to 4	340	325	305	295	275	265	225	200
6 to 7	365	345	325	310	290	280	260	—
More than 7*	—	—	—	—	—	—	—	—
Recommended averages total air content, percent for level of exposure:								
Mild exposure	4.5	4.0	3.5	3.0	2.5	2.0	1.5†,§	1.0†,§
Moderate exposure	6.0	5.5	5.0	4.5	4.5	4.0	3.5†,§	3.0†,§
Severe exposure§	7.5	7.0	6.0	6.0	5.5	5.0	4.5†,§	4.0†,§

Maximum Size of Aggregate (in.)	**Volume of Dry-Rodded Coarse Aggregate* per Unit Volume of Concrete for Different Fineness Moduli of Sand**			
	2.40	**2.60**	**2.80**	**3.00**
3/8	0.50	0.48	0.46	0.44
½	0.59	0.57	0.55	0.53
¾	0.66	0.64	0.62	0.60
1	0.71	0.69	0.67	0.65
1½	0.75	0.73	0.71	0.69
2	0.78	0.76	0.74	0.72
3	0.82	0.80	0.78	0.76
6	0.87	0.85	0.83	0.81