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UNIVERSITY OF CALIFORNIA
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CE 60 PROPERTIES OF CIVIL ENGINEERING MATERIALS EXAMINATION

Please show your work (when applicable)

Question 1 (32 points)

I) What are some of the reactants that make up Portland cement? (8 points) Select all that apply:

[✓ a)] C_3A
b) C-S-H
[✓ c)] C_4AF
d) CH
[✓ e)] C_3S

II) [✓ True]/False: C_3S is the compound in Portland cement that produces Calcium Silicate Hydrate (C-S-H) and calcium hydroxide (CH). (8 points)

$$2C_3S + 6H \rightarrow C_3S_2H_3 + 3CH + 120 \text{ cal/g}$$

III) True/[✓ False] The slump test is a fast and easy way to measure the workability of the concrete. (8 points)

IV) You are going to cast concrete at a precast plant. The objective is to reach high early strength so you can remove the concrete from the molds and begin the next cast. Which of the following is the best cement to use:

Cement A (%): $C_3S = 50$, $C_2S = 35$, $C_3A = 5$, $C_4AF = 10$
Cement B (%): $C_3S = 65$, $C_2S = 15$, $C_3A = 10$, $C_4AF = 10$
Cement C (%): $C_3S = 58$, $C_2S = 25$, $C_3A = 7$, $C_4AF = 10$

C_3S and C_3A higher early strength

Which cement should you select? (8 points)

a) Cement A
[✓ b)] Cement B
c) Cement C

Question 2 (32 points)

I) When you perform a compression test on aggregates and cement paste separately you get an elastic behavior until fracture for both materials. However, when you test concrete which contains both aggregates and cement paste you get a non-linear behavior. What causes this behavior? (8 points)

When the aggregates and cement paste are mixed the ITZ causes nonlinear behavior.

II) At 3 days, the degree of hydration was 30% with a 0.5 water-to-cement ratio. The initial cement volume, at 0 days, was 100 cm³. Assume 3.14 g/cm³ for the density of cement and 1 g/cm³ for the density of water. What is the volume of water at 3 days? (8 points) Select the correct answer from the following:

a) 60 cm³
b) 257 cm³
c) 70 cm³
[✓ d) 127 cm³]
e) 157 cm³

$w/c = 0.5 = \frac{\rho_w V_{wi}}{\rho_c V_{ci}} \Rightarrow V_{wi} = (0.5)(3.14)(100)$

$doh = .30$ $\qquad V_{wi} = 157$

$V_{ci} = 100$

$V_T = 157 + 100 = 257$

$\rho_c = 3.14$

$\rho_w = 1$ $\qquad V_{cf} = 100(1 - .3)$

$V_{wf} = ? = V_T - V_{cf} - V_P$ $\qquad V_{cf} = 70$

$V_{wf} = 257 - 70 - 60$ $\qquad V_P = 100(2)(.3)$

$V_P = 60$

III) Using the fine aggregate gradation shown below, determine the fineness modulus. (8 points)

Sieve Size	Total (Cumulative) Retained, %
3/8 in.	0
No.4	10
No. 8	20
No. 16	35
~~No. 20~~	~~60~~
No. 30	85
No. 50	95
No. 100	100
~~No. 200~~	~~100~~

Select the correct answer from the following:

a) 4.65
b) 5.05
[✓ c) 3.45]
d) 3.05
e) None of the above

3	0
1½	0
3/4	0
3/8	0
No.4	10
No.8	20
No.16	35
No.30	85
No.50	95
No.100	100

sum: 345

IV) As engineers, we must find ways to impact the environment less. Regarding concrete, which of the following helps reduce the environmental impact? (8 points). Select one of the following.

a) Mineral Admixtures (by-product of other industries) to replace cement
b) Use local aggregates
c) Use mobile ready-mix plants
d) Train ourselves to be more environmentally concise
[✓ e) All the above]

Question 3: (36 points)

Using the material properties, the SSD mix proportions, and the tables found at the end of this exam, answer the following questions.

Material Properties

Coarse Aggregate		**Fine Aggregate**	
Density, lbs / cu ft	170	Density, lbs / cu ft	160
DRUW, lbs / cu ft	100	Fineness Modulus	3
MSA, inch	1/2		
Cement		**Water**	
Density, lbs / cu ft	196.6	Density, lbs / cu ft	62.4

SSD Mix Proportions

Cement, lbs / cu yd	640.35
Water, lbs / cu yd	365
Coarse Agg, lbs / cu yd	1431
Fine Agg, lbs / cu yd	1408.03

I) Using the mix proportions above, calculate the air content in percentage. Please show the work. (8 points)

~~MSA = $\frac{1}{2}$ in~~

~~Using 1st table (Non-Air entrained)~~

~~$\boxed{\text{Air}(\%) = 2.5\%}$~~

cement 640.35 lb/yd^3 / 196.6 lb/ft^3 = 3.26 ft^3/yd^3

water 365 lb/yd^3 / 62.4 lb/ft^3 = 5.85

CA 1431 lb/yd^3 / 170 lb/ft^3 = 8.42

FA 1408.03 lb/yd^3 / 160 lb/ft^3 = 8.8

sum 26.33

$$\text{Air} = \frac{27 - 26.33}{27} \times 100$$

$\boxed{\text{Air}(\%) = 2.5\%}$

II) Calculate the SSD water-to-cement ratio. (8 points)

cement = 640.35 lbs/yd^3 water = 365 lbs/yd^3

$$w/c = \frac{365\ \text{lbs}/\text{yd}^3}{640.35\ \text{lbs}/\text{yd}^3} = \boxed{.57 = w/c}$$

III) Using the information provided to you, approximate the compressive strength. (8 points)

Using second table (Non-Air entrained)

$w/c = .57$

$\boxed{\text{Compressive strength} = 4000 \text{ psi}}$

IV) Using the information provided to you, determine the slump for this mixture. (8 points)

Using first table (Non-Air entrained)

MSA = 1/2 in water = 365 lbs/yd^3

$\boxed{\text{slump} = 3 \text{ to } 4 \text{ in}}$

V) [✓ True]/False: Concrete is Life. (4 points)

duh!

Slump, in.	Water, pounds per cubic yard of concrete, for indicated sizes of aggregate*							
	⅜ 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	—
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	—
Recommended average 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	3.5	3.5	3.0
Severe exposure	7.5	7.0	6.0	6.0	5.5	5.0	4.5	4.0

* These quantities of mixing water are for use in computing cement factors for trial batches. They are maximums for reasonably well-shaped angular coarse aggregates graded within limits of accepted specifications.

** The slump values for concrete containing aggregates larger than 1½ in. are based on slump tests made after removal of particles larger than 1½ in. by wet screening.

† The air content in job specifications should be specified to be delivered within –1 to +2 percentage points of the table target value for moderate and severe exposures.

Adapted from ACI 211.1. Hover (1995) presents this information in graphical form.

Compressive strength at 28 days, psi	Water-cementitious materials ratio by mass	
	Non-air-entrained concrete	Air-entrained concrete
7000	0.33	—
6000	0.41	0.32
5000	0.48	0.40
4000	0.57	0.48
3000	0.68	0.59
2000	0.82	0.74

Strength is based on cylinders moist-cured 28 days in accordance with ASTM C 31 (AASHTO T 23). Relationship assumes nominal maximum size aggregate of about ¾ in. to 1 in.
Adapted from ACI 211.1 and ACI 211.3.

Nominal maximum size of aggregate, mm (in.)	Bulk volume of dry-rodded coarse aggregate per unit volume of concrete for different fineness moduli of fine aggregate*			
	2.40	2.60	2.80	3.00
9.5 (⅜)	0.50	0.48	0.46	0.44
12.5 (½)	0.59	0.57	0.55	0.53
19 (¾)	0.66	0.64	0.62	0.60
25 (1)	0.71	0.69	0.67	0.65
37.5 (1½)	0.75	0.73	0.71	0.69
50 (2)	0.78	0.76	0.74	0.72
75 (3)	0.82	0.80	0.78	0.76
150 (6)	0.87	0.85	0.83	0.81

*Bulk volumes are based on aggregates in a dry-rodded condition as described in ASTM C 29 (AASHTO T 19). Adapted from ACI 211.1.