University of Asia Pacific
Department of Civil Engineering
Final Examination Spring 2013
Program: B. Sc. Engineering (Civil)

Course Title: Engineering Materials | Course Code: CE 201
Time: 3 Hours | Full Marks: 150

There are EIGHT Questions. Answer **SIX QUESTIONS including Question No. 1 and Question No. 2. QUESTIONS 1 & 2 are COMPULSORY.**

1 Concrete mix design is required for columns of UAP City Campus project at Firmgate based on the following data: (40)

Volume ratio of sand to total aggregate = 0.37
Air Content = 2 % (air-entraining admixture is not used)
Specific gravity of cement = 3 (OPC Cement)
Specific gravity of sand (SSD) = 2.6
Specific gravity of coarse aggregate (SSD) = 2.7
Design compressive strength (28 days) = 5000 psi
Minimum required slump = 175 mm
Maximum aggregate size = ¾ inch, Aggregate type = Stone chips
Dosage of superplasticizer = 5 ml/kg of cement if W/C is less than 0.5.

The following graphs are provided :

- Variation of compressive strength (28 days) with W/C,
- Variation of cement content with compressive strength (28 days) for different aggregate size and slump value.

Answer the following:

(i) Prepare a trial mix of concrete based on the given data,
(ii) Calculate the unit weight of the proposed trial mix,
(iii) Prepare a mixture proportion table of the proposed trial mix,
(iv) Calculate the compaction factor of the mix,
(v) Calculate the volume ratio of the mix. Assume unit weights of cement, sand (SSD), and coarse aggregate (SSD) with void are 1400 kg/m^3, 1450 kg/m^3 and 1400 kg/m^3, respectively,
(vi) Calculate cost of concrete per cubic meter based on the current unit rates of materials,
(vii) How do you control the properties of materials (sand, coarse aggregate, cement, water, and admixture) to minimize variation of strength of concrete?
(viii) If at site, CEM Type II B-M cement is used instead of OPC (which was recommended in mix design), what changes in properties of concrete will occur.

2 For a culvert construction project, the recommended FMs are 2.6 for sand and 6.6 for stone chips. From a nearby market, sand and stone chips samples were collected and sent to the Concrete Laboratory of University of Asia Pacific (UAP) for sieve analysis. The sieve analysis data are given below: (22)

ASTM Sieve	Amount Retained (g)	
	Sand	Stone Chips
3 inch	0	0
1.5 inch	0	0
1.06 inch	0	0
¾ inch	0	0
1/2 inch	0	500
3/8 inch	0	500
#4	0	4000
#8	50	0
#12	50	0
#16	70	0
#30	70	0
#40	70	0
#50	50	0
#100	50	0
#200	40	0
Pan	50	0

Answer the following:

(i) Calculate FM of the samples (sand and stone chips),

(ii) Draw grading curves of the samples,

(iii) Discuss the possible ways to improve the FM of the samples to the recommended values,

(iv) Comment on the samples based on the sieve analysis data and grading curves, and

(v) From other source, another sand sample was collected and FM was found to be 3.2. In what proportions, the sand samples are to be mixed to achieve the required FM of sand?

Sieve openings for different sieves are provided (refer to the attached table).

3 (a) Refer to the following data associated with a sand sample: (3)

Volume of the OD sample = 1 m^3
Weight of the OD sample = 1400 kg
Bulk specific gravity (OD Basis) of the sand = 2.7
Absorption Capacity = 1%

Calculate the following:

(i) % Void in the sample and

(ii) SSD unit weight of the sample.

(b) Draw typical stress-strain curves of concrete for different strength (lower to higher). Explain the changes in mechanical properties of concrete with the change of strength. (2)

(c) Define the following mechanical properties of a material: (3)
(i) Toughness,
(ii) Stiffness, and
(iii) Malleability.

(d) Write a short note on worldwide consumption of concrete with its influence to the global environment. (3)

(e) Explain three harmful ingredients of bricks. (3)

(f) Write field tests (three tests only) of bricks. (3)

(g) Write the functions of frog mark on brick. (2)

(h) Discuss the functions of lime, silica, and alumina in brick earth. (3)

4 (a) Draw the flow diagram of cement manufacturing process. (3)

(b) What do you mean by hydration of cement? Write the hydration reactions of cement and discuss the morphology of the hydration product. (4)

(c) Compare fine cement and coarse cement with respect to the following: (3)
(i) Heat of hydration,
(ii) Early strength development, and
(iii) Long-term strength development.

(d) Explain hydration rate of C_23, C_3S, C_3A, and C_4AF of cement with time. What changes are to be made in clinker for making low heat cement, rapid hardening cement and sulfate resistant cement? (5)

(e) After testing a cement in a lab, the following results were found: (3)
Normal Consistency – 34%, Initial Setting Time – 50 minutes, and Final Setting Time – 400 minutes.
Explain the compliance of the cement as per ASTM.

(f) Write short notes on the following: (4)
(i) Flash setting of cement, and
(ii) False setting of cement.

5 (a) Discuss the role of mineral admixtures and chemical admixtures in concrete. (5)

(b) What is the significance of cover concrete in reinforced concrete structural members? "More cover concrete is necessary for structural members in contact with seawater" – Why? (3)

(c) Define workability of concrete. How is it measured? Discuss the effect of the following factors on workability of concrete: (3)
i) Shape of the aggregate,
ii) Cement content,
iii) W/C, and
iv) Fineness modulus of sand.

(d) "W/C ratio is a key factor related to strength and durability of concrete"- Explain briefly. (4)

(e) What are the purposes of using air entraining admixture in concrete? Is it necessary to use air entraining admixture in Bangladesh for general construction works? (4)

(f) Discuss the mechanism of improvement of workability of concrete with the addition of superplasticizer in concrete. (3)

6 (a) Discuss the influence of the following factors on compressive strength of concrete: (5)

(i) Cement content,
(ii) Sand to aggregate volume ratio,
(iii) Shape of aggregate,
(iv) Compaction, and
(v) Curing.

(b) "Cube strength of concrete is higher than the cylinder strength of concrete" – Why? (2)

(c) Write short notes on the following: (5)

(i) Self compacting concrete,
(ii) Porous concrete,
(iii) Maturity of concrete,
(iv) High strength concrete, and
(v) High performance concrete.

(d) Write short notes on the following: (6)

(i) Cold joint,
(ii) Construction joint,
(iii) Laitance,
(iv) Honeycomb,
(v) Segregation, and
(vi) Bleeding.

(e) Discuss the possible measures that are to be carefully considered for casting concrete in a hot environment. (2)

(f) Compare plastic shrinkage and autogeneous shrinkage of concrete. (2)

7 (a) Explain the process of initiation of corrosion of steel in concrete due to carbonation and chloride. (3.5)

(b) Discuss corrosion of steel in concrete with anodic and cathodic reactions. (4)

(c) Write the possible measures to stop early corrosion of steel bars in concrete in marine environment and atmospheric environment. (4)

(d) Write short notes on the following: (7.5)

i) Formation of annual rings of a tree,
ii) Use of plastic in Civil Engineering works,
iii) Production of natural rubber,
iv) Objectives of seasoning of timber, and
v) Use of rubber in Civil Engineering works.

(e) Discuss the following: (3)

i) Cathodic protection of steel in concrete by impressed current, and
ii) Cathodic protection of steel in concrete by discrete anode.

8 (a) Explain three common defects of timber. (3)

(b) Discuss three industrial forms of timber. (3)

(c) Discuss the functions of each ingredient of varnish. (2)

(d) Explain different forms of moisture condition of aggregate. (2)

(e) Explain the empirical relationship between compressive strength and Young's modulus of concrete as per ACI. (3)

(f) Write short notes on the following: (9)

(i) Different methods for seasoning of timber,
(ii) Atomic packing factor for the face centered cubic unit cell,
(iii) Ingredients of paints,
(iv) Electroplating,
(v) Vulcanization, and
(vi) Atomic radius of body centered cubic unit cell.

Table Traditional American and British Sieve Sizes

Aperture mm or μm	*Approximate Imperial equivalent in.*	*Previous designation of nearest size*	
		BS	*ASTM*
125 mm	5	—	5 in.
106 mm	4.24	4 in.	4.24 in.
90 mm	3.5	$3\frac{1}{2}$ in.	$3\frac{1}{2}$ in.
75 mm	3	3 in.	3 in.
63 mm	2.5	$2\frac{1}{2}$ in.	$2\frac{1}{2}$ in.
53 mm	2.12	2 in.	2.12
45 mm	1.75	$1\frac{3}{4}$ in.	$1\frac{3}{4}$ in.
37.5 mm	1.50	$1\frac{1}{2}$ in.	$1\frac{1}{2}$ in.
31.5 mm	1.25	$1\frac{1}{4}$ in.	$1\frac{1}{4}$ in.
26.5 mm	1.06	1 in.	1.06
22.4 mm	0.875	$\frac{7}{8}$ in.	$\frac{7}{8}$ in.
19.0 mm	0.750	$\frac{3}{4}$ in.	$\frac{3}{4}$ in.
16.0 mm	0.625	$\frac{5}{8}$ in.	$\frac{5}{8}$ in.
13.2 mm	0.530	$\frac{1}{2}$ in.	0.530 in.
11.2 mm	0.438	—	$\frac{7}{16}$ in.
9.5 mm	0.375	$\frac{3}{8}$ in.	$\frac{3}{8}$ in.
8.0 mm	0.312	$\frac{5}{16}$ in.	$\frac{5}{16}$ in.
6.7 mm	0.265	$\frac{1}{4}$ in.	0.265 in.
5.6 mm	0.223	—	No. $3\frac{1}{2}$
4.75 mm	0.187	$\frac{3}{16}$ in.	No. 4
4.00 mm	0.157	—	No. 5
3.35 mm	0.132	No. 5	No. 6
2.80 mm	0.111	No. 6	No. 7
2.36 mm	0.0937	No. 7	No. 8
2.00 mm	0.0787	No. 8	No. 10
1.70 mm	0.0661	No. 10	No. 12
1.40 mm	0.0555	No. 12	No. 14
1.18 mm	0.0469	No. 14	No. 16
1.00 mm	0.0394	No. 16	No. 18
850 μm	0.0331	No. 18	No. 20
710 μm	0.0278	No. 22	No. 25
600 μm	0.0234	No. 25	No. 30
500 μm	0.0197	No. 30	No. 35
425 μm	0.0165	No. 36	No. 40
355 μm	0.0139	No. 44	No. 45
300 μm	0.0117	No. 52	No. 50
250 μm	0.0098	No. 60	No. 60
212 μm	0.0083	No. 72	No. 70
180 μm	0.0070	No. 85	No. 80
150 μm	0.0059	No. 100	No. 100
125 μm	0.0049	No. 120	No. 120
106 μm	0.0041	No. 150	No. 140
90 μm	0.0035	No. 170	No. 170
75 μm	0.0029	No. 200	No. 200
63 μm	0.0025	No. 240	No. 230
53 μm	0.0021	No. 300	No. 270
45 μm	0.0017	No. 350	No. 325
38 μm	0.0015	—	No. 400
32 μm	0.0012	—	No. 450

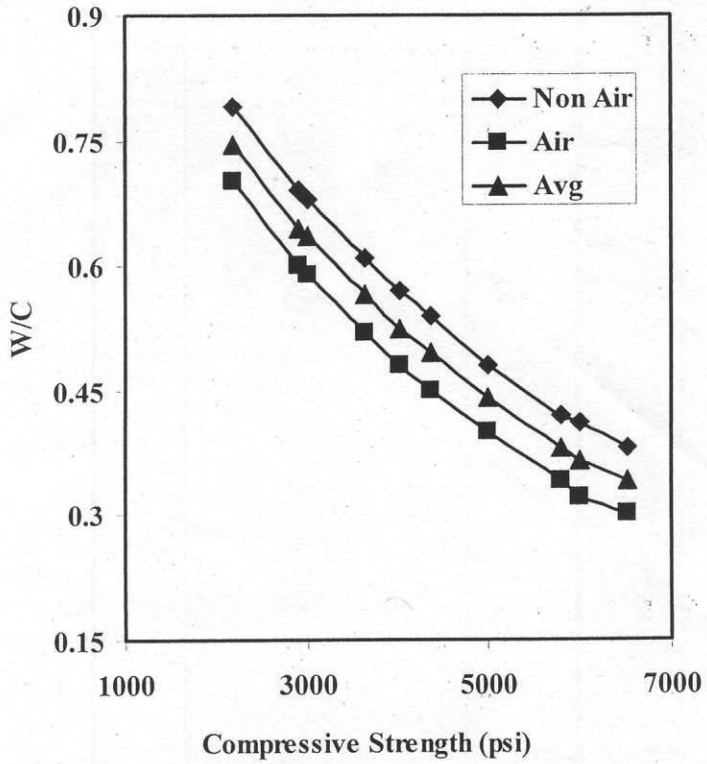

Fig. W/C versus Compressive Strength (aggregate type = stone chips)

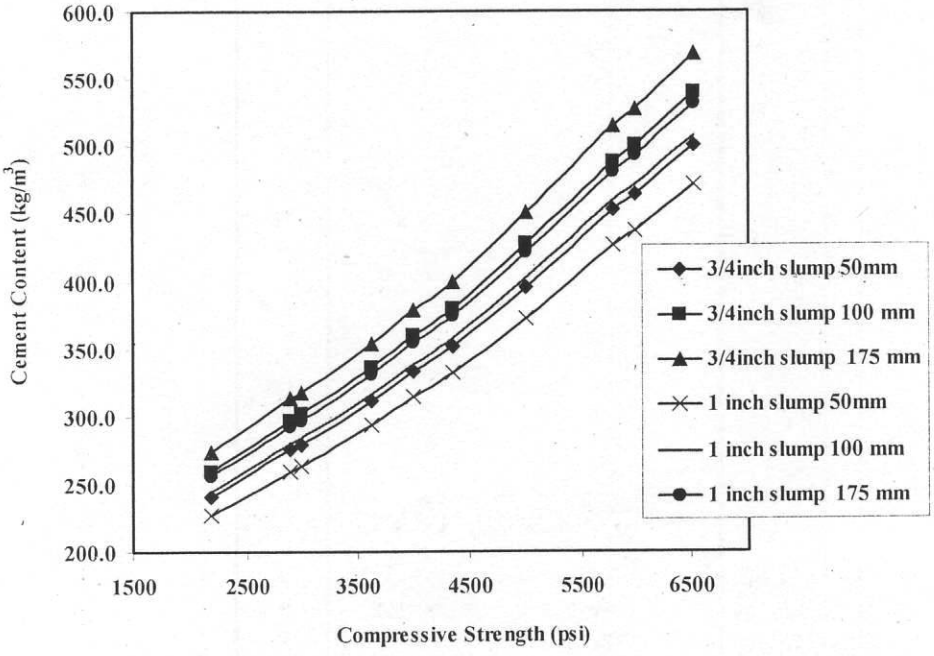

Fig. Cement Content versus Compressive Strength (aggregate type = stone chips)

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SECTION A

(There are **FOUR** Questions. **Answer THREE Questions including Question No. 1. Questions 1 is COMPULSORY)**

1. A concrete mix is to be designed using trial mix method (ACI method) for the construction of a slab of 5 inch thickness using the following data. **(35)**
   Design strength of concrete is 40 MPa (including safety factor).
   Maximum available coarse aggregate size is 25mm.
   Required slump value is 1 inch to 3 inch.
   Coarse aggregate has a dry rodded unit weight of 1360 kg/m^3.
   The water cement ratio is limited to 0.45 by durability criteria.
   Effect of absorption and moisture content of CA is negligible.
   Absorption capacity of FA is 1% and total moisture content of FA is 3%.
   FM of fine aggregate is 2.60. Fine sand is used as fine aggregate.
   Recommended dose of admixture is 0.9 litre/100 kg cement to reduce water requirement by 20%.
   Specific gravity of cement, admixture, CA(OD) and FA(OD) are 3.12, 1.2, 2.4, 2.2 respectively.
   i) Make mix proportion of concrete for 1st lab trial. 0.02 m^3 concrete is needed for 1st lab trial.
   ii) Using 1st lab trial mix result (Table 1) and graph 1 determine the volumetric ratio of cement, CA, FA and water. Properties of aggregate at site are given in Table 2.

2. (a) Write about the hydration characteristics of C_2S and C_3S with equation. **(6)**
   (b) Why slaking of lime is necessary? **(3)**
   (c) Discuss about the reinforcing mesh used in ferrocement with diagram. **(7)**
   (d) What is the advantage of using geotextile in construction of road embankment? **(4)**

3. (a) Write about the properties of two special types of mortar. **(5)**
   (b) Why sand is used in mortar? **(3)**
   (c) Discuss about bulking of sand. **(3)**
   (d) Describe about different types of sand based on source. **(9)**

4. (a) What are the advantage of using timber? **(3)**
   (b) Make a list of methods of artificial seasoning of timber. **(3)**
   (c) What factors must be considered during making choice of preservatives of timber.? **(4)**
   (d) Describe briefly about charring method. **(4)**
   (e) What are the causes of timber decay? **(4)**
   (f) Write about the difference between heart wood and sap wood. **(2)**

SECTION B

(There are **FOUR** Questions. **Answer any THREE Questions)**

5. Aggregate 1 and Aggregate 2 are combined in a ratio of 1:2 to form a mixture. Data derived (individual % retained) from the sieve analysis is given below.
   (i) Draw the sieve analysis graph in semi-log graph paper.
   (ii) Determine the Fineness modulus of the combined mixture. **(25)**

	Aggregate 1	**Aggregate 2**
Sieve (mm)	Individual % Retained	Individual % Retained
No.4(4.75mm)	7	0
No.8(2.36mm)	25	0
No.10(2.00mm)	5	12
No.16(1.18mm)	36	37
No.30(0.60mm)	10	23
No.50(0.30mm)	8	8
No.100(0.15mm)	9	20

6. (a) Write the names, chemical composition and notation of mineral constituents of cement. **(4)**
   (b) Write the difference between **(2.5+2.5)**
      i) Wet and Dry process of cement manufacture
      ii) False and flash setting
   (c) Draw the flow diagram of manufacture of cement. **(6)**
   (d) Describe about Rapid Hardening Cement and Quick Setting Cement. **(6)**
   (e) Discuss about the effect of fineness and soundness of cement. **(4)**

7. (a) Describe the causes and remedies of segregation of concrete. **(4)**
   (b) Define workability of concrete. Discuss the effect of water content and shape of aggregate on workability of concrete. **(5)**
   (c) "Slump test is unreliable for lean mix of concrete" – Explain briefly. **(4)**
   (d) Discuss the effect of water cement ratio and age on compressive strength of concrete. **(5)**
   (e) Write about maturity rule of concrete and its limitation. **(4)**
   (f) "Cube strength of concrete is greater than cylinder strength of concrete" – Explain. **(3)**

8. (a) Briefly describe the method of painting the surface of a new wood work. **(8)**
   (b) Write the difference between **(2.5+2.5)**
      i) Natural and artificial rubber
      ii) Natural and artificial seasoning of timber
   (c) Write about the constituents of paint. **(8)**
   (d) What is the importance of vulcanization of rubber? **(4)**

Table 1: First Lab trial mix result

Slump measured	60mm
Density of fresh concrete	2120 kg/m^3

Table 2:Properties of aggregates at site

Moisture content of fine aggregate	5%
Bulking of Fine sand	20%
Loose Dry Specific Gravity of CA	1.41
Loose Dry Specific Gravity of FA	1.32
Loose Sp. Gravity of cement	1.2

Table 3: ACI recommended dry rodded bulk volume of CA per m^3 of concrete.

Max aggregate size, mm	FM of FA (2.60)
9.5	0.48
12.5	0.57
19	0.64
25	0.69
37.5	0.73

Table 4: ACI recommended mixing water content for 1 m^3 concrete.

Max aggregate size,mm	12.5	20	25	40
Slump value,mm				
25 to 50mm	199	190	179	166
75 to 100	216	205	193	181
Air entrapped (%)	2.5	2	1.5	1

Formula for water cement ratio:

ACI recommended w/c ratio for normal strength concrete is $w/c = 1.1734e^{-0.0259f'c}$. f'c is in MPa.