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B. Sc. Engg. (CEE)/ 4th Sem. — 16 May, 2023 (Group B)

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
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DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

TERM	: FINAL EXAMINATION	SUMMER SEMESTER	: 2021-2022
COURSE NO	: CEE 4411	TIME	: 3 Hours
COURSE TITLE	: Engineering Materials and Concrete Technology	FULL MARKS	: 200

There are 7 (SEVEN) questions. QUESTION NO. 1 AND QUESTION NO. 2 ARE COMPULSORY. Answer 6 (SIX) questions including Question No. 1 and Question No. 2. Programmable calculators are not allowed. Do not write on this question paper. The figures in the right margin indicate full marks, CO, and PO. The symbols have their usual meaning.

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1 Concrete mix design is required for a building project based on the following data: CO3 PO3 (80)

Volume ratio of sand to total aggregate = 0.40
FM of fine aggregate = 2.6
FM of coarse aggregate = 6.6
Location of the Project : Gazipur
Specific gravity of cement = 2.9 (CEM Type II-B/M)
Specific gravity of sand (SSD) = 2.5
Specific gravity of coarse aggregate (SSD) = 2.6
Design compressive strength (28 days) = 4500 psi
Minimum required slump = 175 mm
Maximum aggregate size = ¾ inch, Aggregate type = Stone chips
Dosage of superplasticizer = 1% of cement weight if W/C is less than 0.45.
Air content in concrete = 2%
(assume reasonable data, if necessary)

The following graphs are provided :

- Variation of compressive strength (28 days) with W/C (Fig. 1),
- Variation of cement content with compressive strength (28 days) for different aggregate size and slump value (Fig. 2).

(i) Calculate the unit contents of cement, sand, coarse aggregate, and water in concrete (in kg/m^3) for the target compressive strength. Relationships between target strength and design strength are given in Tables 3 and 4.

(ii) Prepare a mixture proportion table. Typical form of mixture proportion table is attached (Table 1).

(iii) Calculate the unit weight of concrete.

(iv) Calculate the volume ratio of the mix. Assume unit weights of cement, sand (SSD), and coarse aggregate (SSD) with void are 1300 kg/m^3, 1350 kg/m^3 and 1450 kg/m^3, respectively.

(v) Calculate the cost of concrete for one cubic meter. Assume the cost of 1 bag of cement is Tk. 500, cost of 1 cft of sand is Tk. 50, cost of 1 cft of stone chips is Tk. 250, cost of 1 L of superplasticizer is Tk. 100, and cost of 100 L of water is 10 Tk.

(vi) Determine the volume fractions that will be occupied by cement, water, sand, and coarse aggregate in one cubic meter of concrete.

(vii) Calculate the compaction factor of the mix. What does it signify?

(viii) What changes in the mix design would you recommend if the target compressive strength is not achieved with the mix? (Answer in words, calculation is not necessary.)

(ix) If FM of fine aggregate is changed to 2.4 (instead of 2.6 as specified), what changes will occur in fresh and hardened properties of concrete?

(x) The design compressive strength mentioned (4500 psi) is the cylinder strength of concrete. What target strength should be set for the mix if cube specimens are prepared with the mix?

(xi) In summer, the slump is found to be 80 mm during a trial of the proposed mix. Mention three measures that can be taken during mixing to achieve the minimum required slump without compromising the strength requirement.

(xii) If the maximum aggregate size of coarse aggregate is changed to 12 mm (instead of ¾ inch as specified in the mix design), what changes in the mechanical properties of concrete can be expected?

2 From a nearby market, two sand samples were collected for a construction project. The sieve analysis data of the samples are summarized below: CO2 PO2 (20)

ASTM Sieve	Amount Retained (g)	
	Sand 1	Sand 2
3 inch	0	0
1.5 inch	0	0
1.06 inch	0	0
¾ inch	0	0
½ inch	0	0
3/8 inch	0	0
#4	0	0
#8	160	30
#12	170	45
#16	5	100
#30	5	70
#40	5	70
#50	40	80
#100	40	70
#200	45	10
Pan	40	20

(i) Calculate the FM for the samples,

(ii) Draw the grading curves for the samples,

(iii) Comment on the samples based on the FM and grading curves.

(iv) If the required FM is 2.6, calculate the mix ratio of the samples (weight ratio of Sand 1 to Sand 2) to get the required FM.

(v) If 100 g of coarse sand (particle size less than 4.75 mm and higher than 2.36 mm) is added with 1500 g of Sand 1, what will be the FM of the mixed sand sample?

Questions 3 to 7 are mapped with CO1 and PO1.

3 (a) Draw qualitative compressive stress-strain curves for normal strength concrete (e.g., $f_c' \approx$ 3 ksi) and high strength concrete (e.g., $f_c' \approx 6$ ksi). Compare qualitatively between their strain capacities and elastic moduli. How can the yield strengths be determined for a relatively low grade steel (e.g, $f_y \leq 60$ ksi) and a high grade steel (e.g, $f_y \geq 75$ ksi)? (10)

(b) Draw qualitative hysteresis loops and skeleton stress-strain curves for concrete subjected to cyclic compression at low loading rate, high loading rate, and intermediate loading rate. (5)

(c) Write down three advantages of Hoffman's kiln burning process over clamp burning. (5)

(d) Compare briefly among Third Class brick, Picked Jhama brick, and Jhama brick. (5)

4 (a) Compare flash setting and false setting. How can these types of setting be controlled? (5)

(b) Briefly mention about the morphologies of different hydration products like C-S-H, CH, AFt, and AFm. (5)

(c) Comment in one word or phrase on how 'high temperature', 'fine cement', and 'presence of fly ash in cement' can influence the following: (5)
   (i) Heat of hydration,
   (ii) Early strength,
   (iii) Long-term strength,
   (iv) Setting time, and
   (v) Workability of fresh cement paste.

(d) Discuss briefly on construction joint, expansion joint, and isolation joint. (5)

(e) "Bond strength between concrete and steel is less for the top steel bars compared to the bottom steel bars." – Why? (5)

5 (a) Briefly discuss about the chloride induced corrosion and carbonation induced corrosion of steel in concrete. Write down the corrosion reactions (including cathodic and anodic). (10)

(b) Explain sulfate attack of concrete. How can sulfate resisting cement protect the concrete from sulfate attack? (5)

(c) Compare plastic shrinkage and autogenous shrinkage. How does rate of hydration influence autogenous shrinkage and drying shrinkage? (5)

(d) Mention two measures that can be taken to reduce each of the following: (5)
   (i) Bleeding in fresh concrete,
   (ii) Formation of honeycombs in concrete,
   (iii) Slow hardening of concrete in cold weather.

6 (a) Discuss the importance of seasoning of timber. How does moisture content influence the strength and elastic modulus of timber? (5)

(b) Compare briefly among plywood, laminated board, and fiber board. (5)

(c) Discuss the manufacturing process of natural rubber. What is vulcanization of rubber? (5)

(d) Briefly discuss the applications of lead-rubber bearing, rubber stopper, and carbon fiber-reinforced polymer (CFRP). (5)

(e) Compare between heat-convertible and heat-non-convertible plastics. (5)

7 (a) Briefly compare among whitewash, emulsion paint, and weather coat. Which one will provide better resistance against penetration of water? Why? (5)

(b) What are the roles of vehicles in paint and driers in varnish? (5)

(c) Explain the electroplating process with a diagram. Why is it better than hot dipping? (5)

(d) Explain how water molecules are bonded together with hydrogen bond. (5)

(e) Calculate atomic packing factor for face centered cubic unit cell. (5)

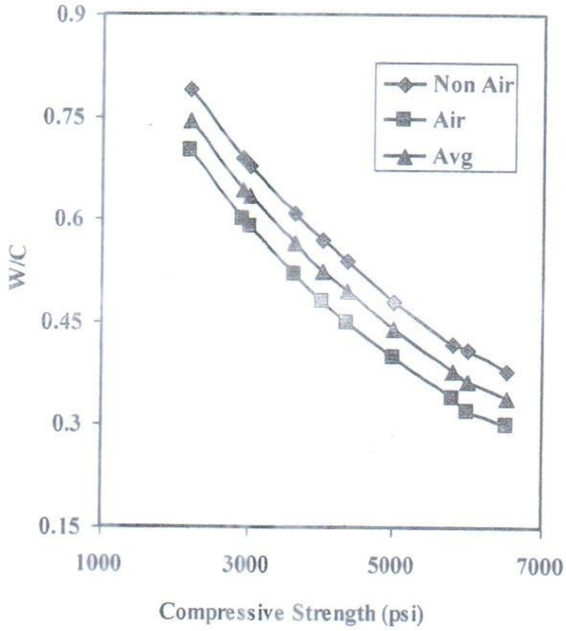

Fig. 1 W/C versus Compressive Strength (aggregate type = stone chips)

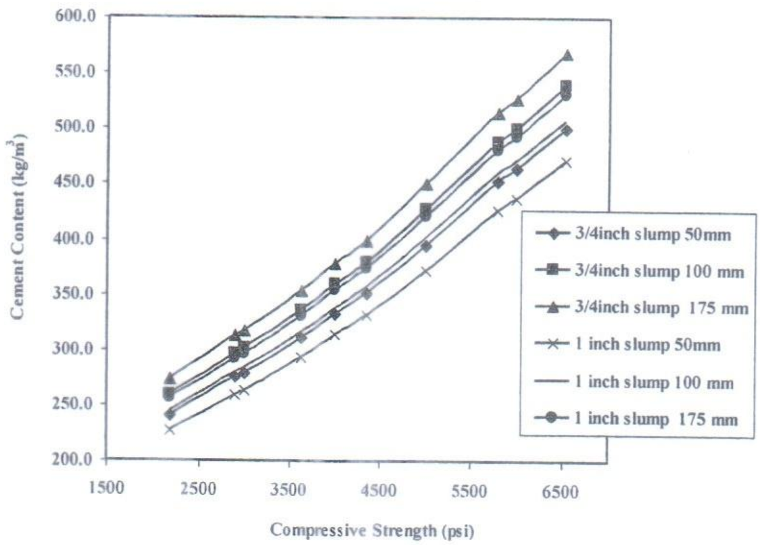

Fig. 2 Cement Content versus Compressive Strength (aggregate type = stone chips)

Table 1. Mixture Proportion of Concrete

W/C	s/a	Maximum Aggregate Size	Slump	Air Content	Unit Contents (kg/m^3)				Superplasticizer
%	%	mm	cm	%	C	W	FA	CA	% of cement

Table 2. Sieve Sizes

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

Table 3. Target Average Compressive Strength When Data are Available to Calculate Sample Standard Deviation

Specified compressive strength, psi	Required average compressive strength, psi
$f'_c \leq 5000$	Use the larger value computed from Eq. (5-1) and (5-2) $f'_{cr} = f'_c + 1.34s_s$ (5-1) $f'_{cr} = f'_c + 2.33s_s - 500$ (5-2)
$f'_c > 5000$	Use the larger value computed from Eq. (5-1) and (5-3) $f'_{cr} = f'_c + 1.34s_s$ (5-1) $f'_{cr} = 0.90f'_c + 2.33s_s$ (5-3)
$S_s = \sqrt{\dfrac{\Sigma (x_i - \bar{x})^2}{(n - 1)}}$	$\bar{X}$ = Sample Average X = Individual values in sample n = Count of values in sample

Table 4. Target Average Compressive Strength When Number of Data is less than 15

Design/ specified compressive strength, psi	Target/ required compressive strength, psi
$f_c' \leq 3000$	$f_{cr}' = f_c' + 1000$
$3000 < f_c' \leq 5000$	$f_{cr}' = f_c' + 1200$
$f_c' > 5000$	$f_{cr}' = f_c' + 0.1f_c' + 700$