UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: July 2022

Module Number: CE 3201 **Module Name: Concrete Technology**

[Three Hours]

[Answer **ALL questions**, each question carries twelve marks]

Q1 a) List out three deterioration mechanisms in concrete with implication on the durability of concrete structures.

[3 Marks]

b) There is always the threat of sulphate attack to concrete structures. Explain different mechanisms of sulphate attack to concrete structures and means to mitigate sulphate induced damage to concrete structures.

[3 Marks]

c) Use of pozzolanic material to replace cement in concrete is found to be one of the solutions for the most of durability issues including the corrosion of reinforcement in concrete. Explain how pozzolanic material can improve durability performance of concrete.

[3 Marks]

d) Explain the mechanism of plastic shrinkage cracking of concrete and methods to mitigate plastic shrinkage cracking of freshly placed concrete.

[3 Marks]

Q2 It has been found from an initial study that 28 days compressive strength of concrete for a given crushed coarse aggregate (20mm maximum aggregate size) and a manufactured sand at W/C ratio of 0.5 produces an average strength of 48 MPa. Percentage of manufactured sand passing the 600 μm sieve is found to be 35% from the total aggregate content. Assume the specific gravity of the coarse and fine aggregate mix as 2.65.

a) Calculate target strength for Grade 35 concrete mix to be used in building structure.

Note:-

Target strength is the mean strength of the concrete at which no more than 5% of test specimen fall below specified characteristic strength of concrete.

Considering the general variability of the concrete mixing and the materials. Take the standard deviation of the concrete mix to be 4 MPa.

Compressive strength of concrete cube test is assumed to follow standard normal distribution and the value of 95% confidence interval for standard normal distribution is equal to 1.64.

[1 Mark]

b) Find mix proportions for the calculated target strength in part (a) and a design slump between 60-180 mm. During this step of finding mix proportion, assume that both the fine and coarse aggregates are in saturated surface dry condition (SSD).

Note:-
Following tables, charts and instructions are extracts from the British method of mix section are provided.
Trial water contents for the different workability requirements are given in Table Q2.1.
Variation of compressive strength to water/cement ratio is given by Fig. Q2.1.
Variation of fresh concrete density against water content for different values of specific density of fine and coarse aggregate mix is given in Fig. Q2.2.
Fig. Q2.3 indicate content of fine aggregate as a percentage of total aggregate depending on the free water/cement ratio, workability requirement, maximum size of aggregate and fineness ratio of fine aggregate (in this case manufacturing sand) used in the mix.
Water content of the mixed aggregate should be calculated as 1/3 of the water requirement of the coarse aggregate and 2/3 of the water requirement of the fine aggregate.

[5 Marks]

c) For a given day it is found that the natural moisture content of the coarse aggregate is 1.5% and that for manufactured sand is 2.5%. The moisture absorption for the SSD condition of the two aggregates, crushed coarse and manufacturing sand is 0.4% and 0.48% respectively. Calculate the adjusted mix proportions according to the natural moisture content of the coarse and fine aggregates.

[2 Marks]

d) Discuss the implication of the final results of the concrete mix in relation to design parameters (i.e. strength and workability) in an instance adjustment to water content based on the natural moisture content of aggregates and the associated adjustment to aggregate content have not been made.
Use the answer to part c) above to explain the different scenarios of possible variation of strength and workability of the mix in the event adjustments are not done to aggregate content and water content based on the natural moisture content of the aggregate.

[2 Marks]

e) After 28 day strength determination it is found that the mean strength of the concrete was only 36 MPa which is considerably less than the target strength. Given that average strength is greater than the required characteristic strength, explain whether any correction to mix proportions is required. If so explain why, and what would be the potential correction.

[2 Marks]

Q3 a) Explain with examples, cause of occurrence and methods to minimize wastage of materials, human recourses and equipment & plants in the local construction sites.

[3 Marks]

b) It is identified that sources of waste can be classified into four major categories: Operational waste, Design waste, Waste during material handling and Procurement waste. Briefly explain with examples how you minimize the waste due to each category.

[3 Marks]

c) Discuss the legislation and insurance policies in connection with the safety, health and welfare aspects that could be applicable to the local construction industry.

[3 Marks]

d) Discuss the frequent mode of accidents in the construction industry and precautionary measures that would be able to implement to minimize such accidents.

[3 Marks]

Q4 a) List out three types of cements and discuss their properties.

[2 Marks]

b) Discuss a field test to identify quality of cement and river sand used in the construction site.

[2 Marks]

c) Discuss the importance of using Mineral Admixtures in construction projects? List three benefits of using mineral admixtures for each fresh and hardened concrete states.

[3 Marks]

d) Figure Q4 shows a view of a deteriorated reinforced concrete beam of a highway bridge due to corrosion.

i.) Briefly explain a method to investigate the severity of the corrosion of reinforcement bars.

ii.) Briefly explain the process of estimating probable strength reduction of the beam.

iii.) Describe any retrofitting technique that can be applied to mitigate corrosion effects and to strengthen the beam to satisfy the required strength capacities.

[5 Marks]

Q5 a) Briefly explain the formwork design process for a slab panel.

[2 Marks]

b) Compare advantages and disadvantages of using timber formwork and steel formwork.

[3 Marks]

c) List out three probable reasons for formwork failures and precautions that can be taken to ensure proper function of a formwork.

[3 Marks]

d) Spalling is the major potential risk to life safety from concrete in fire. Explain this statement.

[2 Marks]

e) Briefly describe the fire performance evaluation method of concrete.

[2 Marks]

Table Q2.1 Trial water contents to achieve different workability requirements.

Slump (mm)		0-10	10-30	30-60	60-180
Vebe time (s)		>12	6-12	3-6	0-3
Maximum size of aggregate (mm)	Type of aggregate				
10	Uncrushed	150	180	205	225
	Crushed	180	205	230	250
20	Uncrushed	135	160	180	195
	Crushed	170	190	210	225
40	Uncrushed	115	140	160	175
	Crushed	155	175	190	205

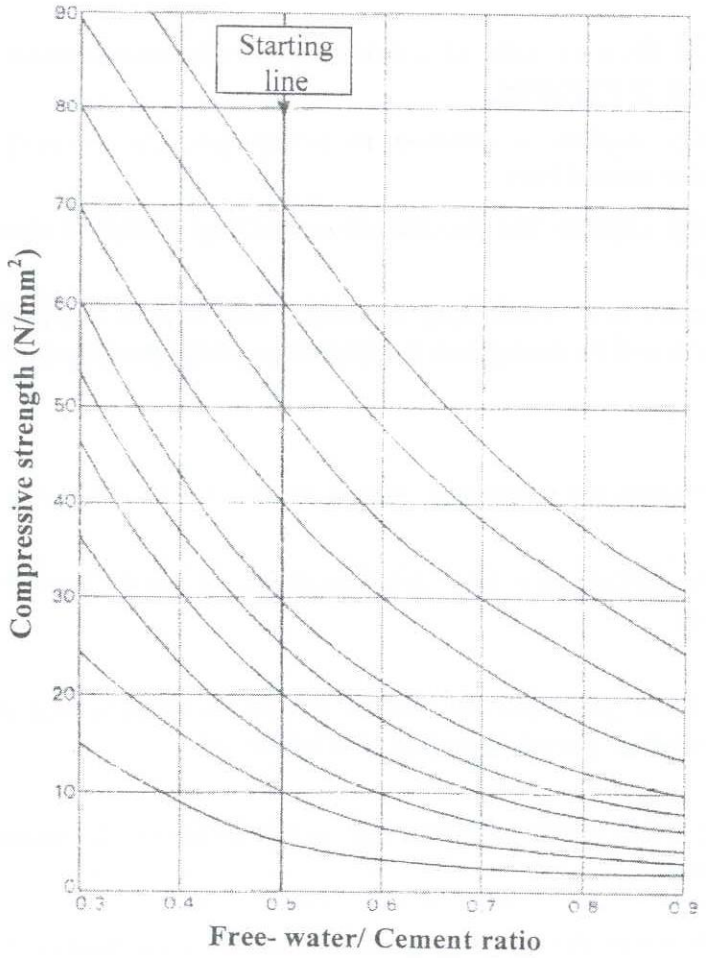

Fig. Q2.1 Compressive strength against free water cement ratio

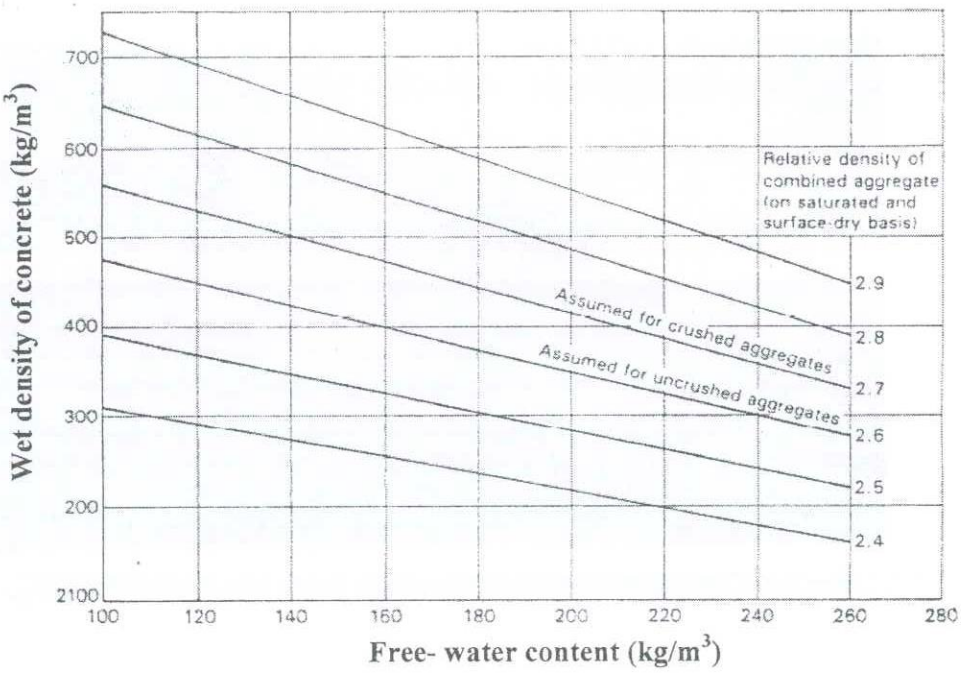

Fig. Q2.2 Wet density of concrete against the free water content for different relative density of the aggregate mix.

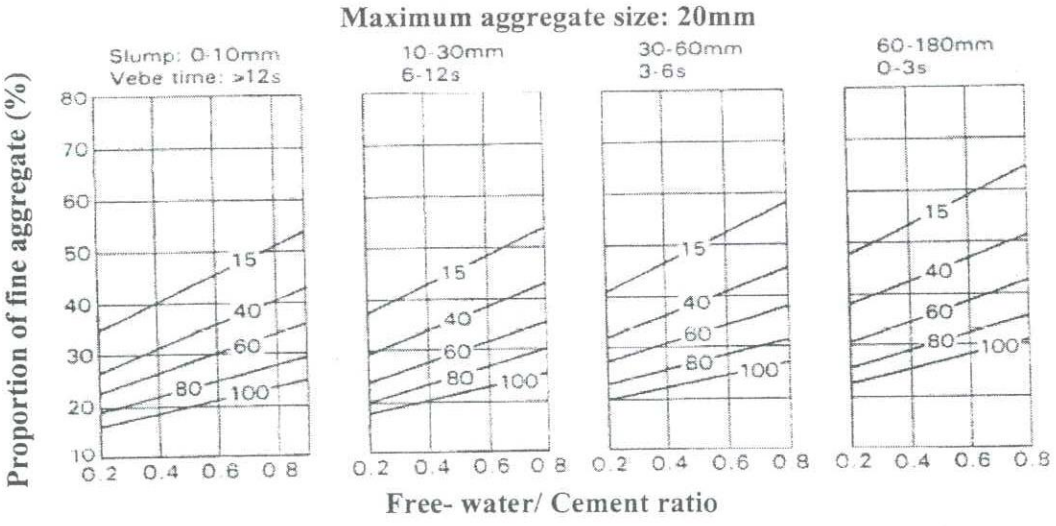

Fig. Q2.3 Fine aggregate content as a percentage of total aggregate content determined for different free water cement ratio and workability for 20mm maximum aggregate size

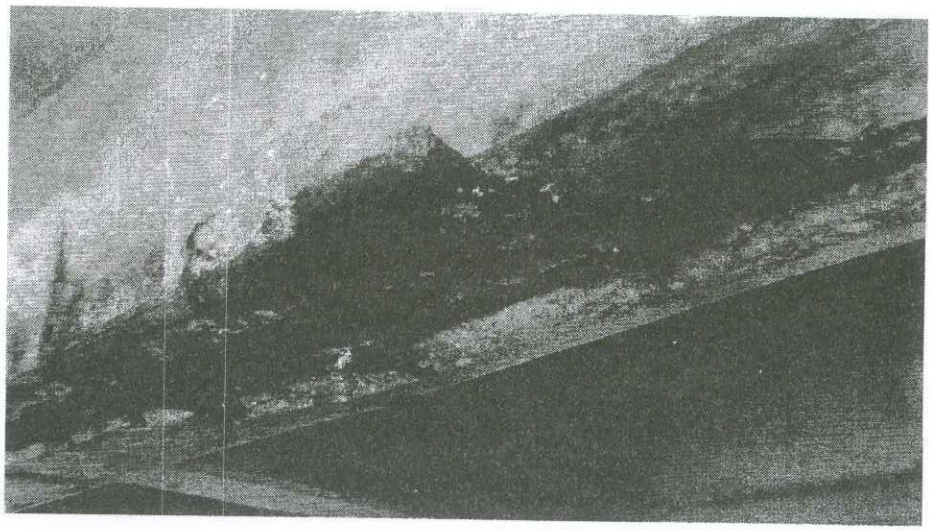

Fig. Q4 Corroded reinforced concrete beam of a highway bridge