University of Zambia

School of Engineering

Department of Civil and Environmental Engineering

COURSE CODE: CEE 3111 COURSE NAME: CIVIL ENGINEERING MATERIALS AND PRACTICES

FINAL EXAMINATION

06Th December 2021

Time: 3.0 hrs. **Marks: 100**

INSTRUCTIONS:

1. This examination paper consists of two sections: answer **All** questions from **Section A** and Choose **ANY THREE (3)** questions from **Section B.**
2. **MARKS** are indicated in parenthesis at the end of each question. Note that all questions carry equal marks.
3. **MARKS** will be awarded for sketches, illustrations and examples used to aid answers.
4. **All** necessary tables of design data are given in the appendices.
5. **WHERE** information is not given, make and clearly state your **ASSUMPTIONS.**

SECTION A

QUESTION ONE (1)

The University of Zambia Council plans to build student hostels at a new location along Kamloops Road. On the project, the department of civil and environmental engineering has been engaged as a design consultant. Being a student in the department, you are tasked to carry out the concrete mix design for the structures. Design the concrete mix according to the following prevailing site conditions and requirements:

Design Environment

Bridge pier exposed to freezing and subjected to deicing chemicals: Required design strength = 24.1 MPa; Minimum dimension = 300mm; Minimum space between rebar = 64mm; Minimum cover over rebar = 64mm

Statistical data indicate a standard deviation of compressive strength of 2.4 MPa is expected (on more than 30 samples). Also given that only air entrainer is allowed.

Available Materials

Cement: Select type V due to exposure

Air entrainer: Manufacture specification 6.3 ml/1% air/100 kg cement.

Coarse aggregate: 25 mm nominal maximum size, river gravel (rounded)

Bulk oven-dry specific gravity =2.621, Absorption =0.4%, Oven-dry rodded density = 1681 kg/m3, Moisture content = 1.5 %

Fine aggregate: Natural sand

Bulk oven-dry specific gravity =2.572, Absorption =0.8%, Moisture content = 4 %, Fineness modulus = 2.60

[20]

QUESTION TWO (2)

Figure 1 shows the drawing for a distribution chamber to be constructed with the following details.

i) 150mm thick plain in-situ concrete (1:3:6 - 20mm aggregate) to bottom of chamber which is 700mm deep;

ii) 200mm thick precast concrete block wall filled solid in concrete mix 20/20 in cement sand (1:4) with 25 mm thick plaster internally to chamber

iii) 460 x 620mm cast iron frame and cover light-duty bedded in cement sand mortar (1:4)

Prepare a take-off sheet for the distribution chamber shown by considering the details in the items outlined above.

[20]

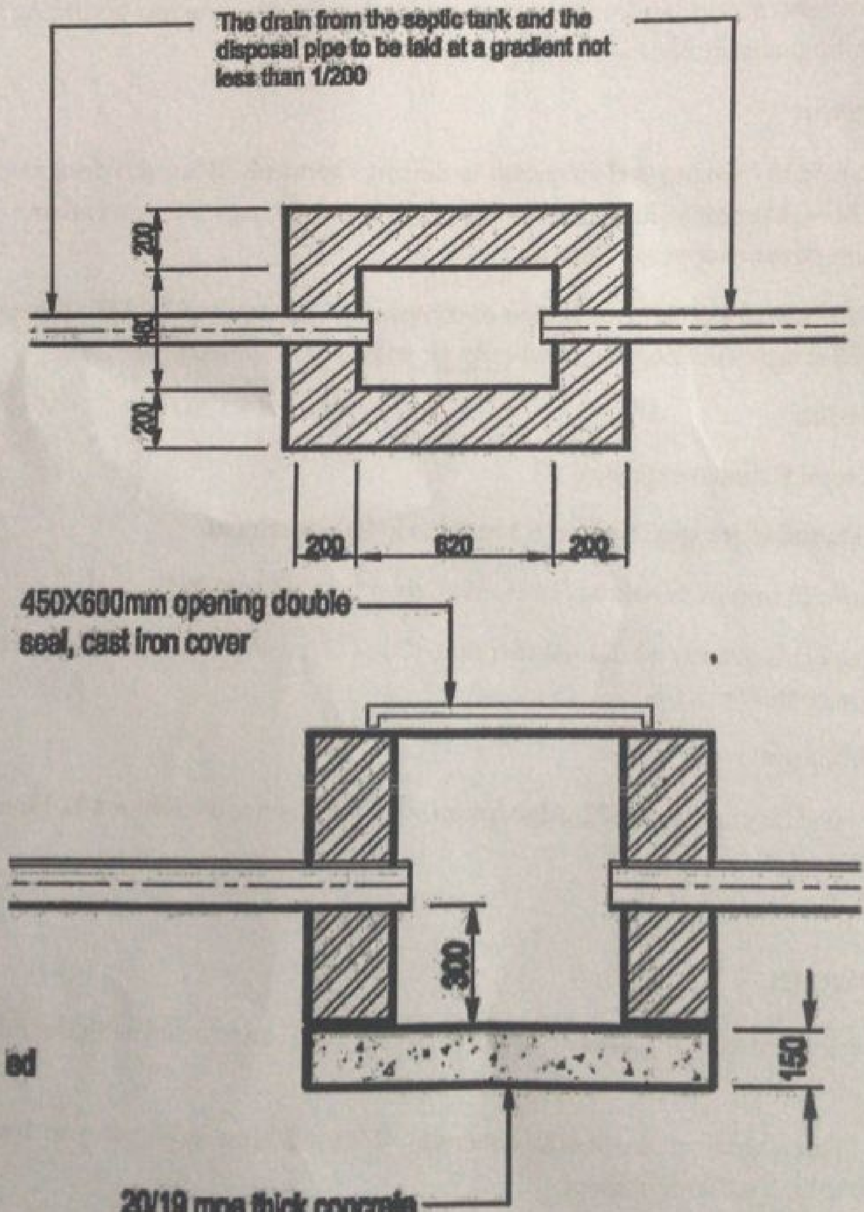

Figure 1 Plan and Section for Distribution Chamber

5, 6, 7

SECTION B

QUESTION THREE (3)

a) In civil engineering construction, steel is normally classified based on production method and use, briefly, describe the various classifications of steel products as applied in the construction industry? [8]

b) A simple lab test for specific gravity, G, on two samples of lumber indicate that sample A has G = 0.4 and sample B has G = 0.5 Based on this information alone, which wood sample would you choose as a structural member for your construction project? Briefly explain why? [4]

c) Wood is a versatile organic material, and the only renewable construction material. Wooden structures have certain properties that make them durable and strong. With an adequate fire retardant treatment, wood can be a reliable construction material with a long service life. Within the context of wood as a construction material answer the following questions:

   i. Untreated wood can deteriorate when four conditions required for decay and insects occur. States these four conditions. How do preservatives reduce or eliminate wood decay?

   ii. What are the two types of preservatives that can be used to protect wood from decay? How are these preservatives applied?

   iii. What are the main types of engineered wood products?

   iv. What are the main advantages of engineered wood products over natural-timber members?

[8]

QUESTIONS FOUR (4)

a) Polymeric materials are classified into three broad categories depending on how they are joined or linked (chemical bonds) and the arrangements of the different chains that form the polymer. Briefly, describe the aforementioned classification? [8]

b) Define the word "Paint" and state four principle uses of paints? [4]

c) What are the engineering applications of each of these tests carried out on bituminous materials?

   i. flash point test

   ii. RTFO procedure

   iii. rotational viscometer test

iv. penetration test. [8]

QUESTIONS FIVE (5)

a) Define the following terms:

   i. Coarse grained-soil [2]

   ii. Fine-grained soils

b) What is soil classification? And state the commonly used soil classification systems for highway construction purposes. [4]

c) The wet weight of a specimen of soil is 340 g and the dried weight is 230 g. The volume of the soil before drying is 210 cm³. If the specific gravity of the soil particles is 2.75, determine the following:

   i. porosity, and

   ii. void ratio [4]

d) You are an engineer in charge of mixing concrete in an undeveloped area where no potable water is available for mixing concrete. A source of water is available that has some impurities. What tests would you run to evaluate the suitability of this water for concrete mixing? What criteria would you use? [6]

e) What type of cement would you use in each of the following cases? Why?

   i Construction of a large pier

   ii Construction in cold weather

   iii Construction in a warm climate region

   iv Concrete structure without any specific exposure condition [4]

QUESTION SIX (6)

a) State the three (3) key players in the construction industry and explain the roles each one plays. [6]

b) What is a bill of quantities? [2]

c) What is the purpose of a bill of quantity to the contractor? [4]

d) Briefly, explain the three (3) stages involved in the preparation of a bill of quantity. [6]

e) Why is cost planning important on construction projects? [2]

QUESTION SEVEN (7)

a) Explain the three roles played by the consultant's team for a proposed construction project. [6]

b) Name two statutory regulators that oversee a housing project to be or under construction in Zambia. [4]

c) Why are consultant's currently preferring polymer products for plumbing and electrical works as compared to the metal-based fixtures in the previous years (give three examples)? [6]

d) Name and state the use of any three equipment found on a construction site. [4]

- excavator -
- compactors -
- Concrete mixer

APPENDICES ON THE NEXT PAGE

...ey are light weight
...ey can be moulded or made into many shapes
...hey ~~have~~ are resistant to corrosion

(b) Consultants team -
... charge of drawing up plans in form of drawings from the client's preference
... ensures that they come up with a BOQ that can be used as a basis for
...ing and providing competitive tenders

Q7 ✓✓

The graphs and tables are excerpted from MATERIALS FOR CIVIL AND CONSTRUCTION ENGINEERS THIRD EDITION by MICHAEL S. MAMLOUK and JOHN P. ZANIEWSKI

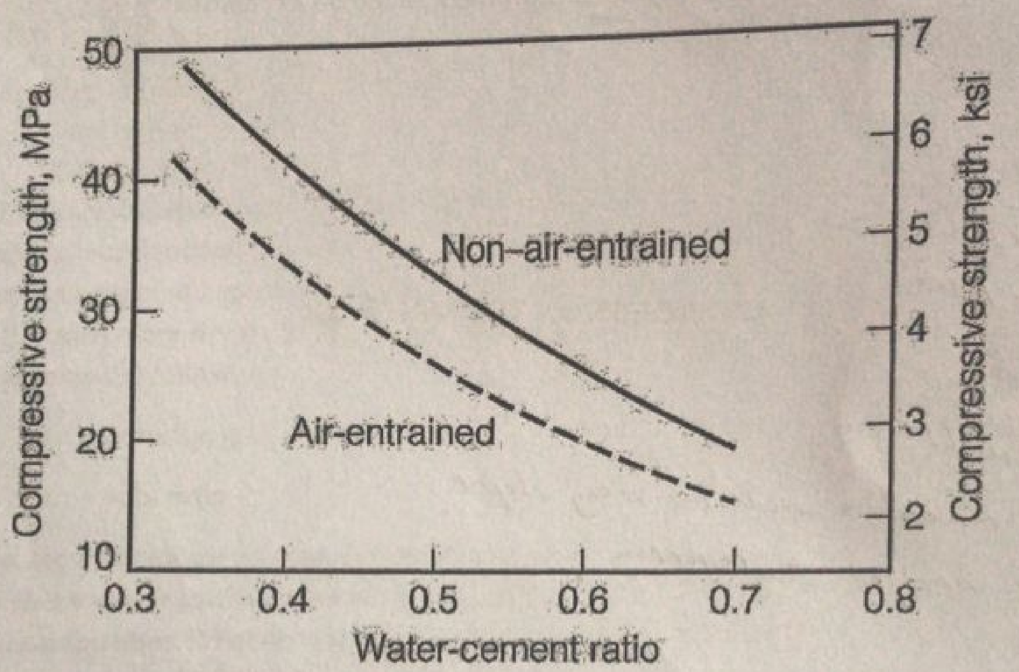

TABLE 7.1 Typical Relationship Between Water–Cement Ratio and Compressive Strength of Concrete*

	Water–Cement Ratio by Weight	
Compressive Strength at 28 days, f'_{cr}, MPa (psi)**	**Non-Air-Entrained Concrete**	**Air-Entrained Concrete**
48 (7000)	0.33	—
41 (6000)	0.41	0.32
35 (5000)	0.48	0.40
28 (4000)	0.57	0.48
21 (3000)	0.68	0.59
14 (2000)	0.82	0.74

*American Concrete Institute (ACI 211.1 and ACI 211.3)

**Strength is based on cylinders moist-cured 28 days in accordance with ASTM C31 (AASHTO T23). Relationship assumes nominal maximum size of aggregate about 19 to 25 mm (3/4 to 1 in.).

TABLE 7.2 Maximum Permissible Water–Cement Ratios for Concrete when Strength Data from Field Experience or Trial Mixtures are not Available*

Specified 28-day compressive Strength, f'_{cr}, MPa (psi)	Water–Cement Ratio by Weight	
	Non-Air-Entrained Concrete	Air-Entrained Concrete
17 (2500)	0.67	0.54
21 (3000)	0.58	0.46
24 (3500)	0.51	0.40
28 (4000)	0.44	0.35
31 (4500)	0.38	**
35 (5000)	**	**

*American Concrete Institute (ACI 318), 1999.

**For strength above 31.0 MPa (4500 psi) (non-air-entrained concrete) and 27.6 MPa (4000 psi) (air-entrained concrete), concrete proportions shall be established from field data or trial mixtures.

TABLE 7.3 Maximum Water–Cement Material Ratios and Minimum Design Strengths for Various Exposure Conditions*

Exposure Condition	Maximum Water–Cement Ratio by Mass for Concrete	Minimum Design Compressive Strength, f'_{c}, MPa (psi)
Concrete protected from exposure to freezing and thawing, application of deicing chemicals, or aggressive substances	Select water–cement ratio on basis of strength, workability, and finishing needs	Select strength based on structural requirements
Concrete intended to have low permeability when exposed to water	0.50	28 (4000)
Concrete exposed to freezing and thawing in a moist condition or deicers	0.45	31 (4500)
Reinforced concrete exposed to chlorides from deicing salts, salt water, brackish water, seawater, or spray from these sources	0.40	35 (5000)

*American Concrete Institute (ACI 318), 2008.

TABLE 7.4 Requirements for Concrete Exposed to Sulfates in Soil or Water*

Sulfate Exposure	Water-Soluble Sulfate (SO_4) in Soil, Percent by Weight**	Sulfate (SO_4) in Water, ppm**	Cement Type***	Maximum Water–Cement Ratio By Weight
Negligible	Less than 0.10	Less than 150	No special type required	—
Moderate****	0.10–0.20	150–1500	II, MS, IP(MS), IS(MS)	0.50
Severe	0.20–2.00	1500–10,000	V, HS, IP(HS), IS(HS)	0.45
Very Severe	Over 2.00	Over 10,000	V, HS, IP(HS), IS(HS)	0.40

*Adopted from American Concrete Institute (ACI 318), 2008.

**Tested in accordance with the Method for Determining the Quantity of Soluble Sulfate in Solid (Soil and Rock) and Water Samples, Bureau of Reclamation, Denver, 1977.

***Cement Types II and V are in ASTM C150 (AASHTO M85), Types MS and HS in ASTM C1157, and the remaining types are in ASTM C595 (AASHTO M240). Pozzolans or slags that have been determined by test or severe record to improve sulfate resistance may also be used.

****Sea water.

Situation	Maximum Aggregate Size
Form dimensions	1/5 of minimum clear distance
Clear space between reinforcement or prestressing tendons	3/4 of minimum clear space
Clear space between reinforcement and form	3/4 of minimum clear space
Unreinforced slab	1/3 of thickness

TABLE 7.5 Bulk Volume of Coarse Aggregate per Unit Volume of Concrete*

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**			
	Fineness Modulus			
	2.40	2.60	2.80	3.00
9.5 (3/8)	0.50	0.48	0.46	0.44
12.5 (1/2)	0.59	0.57	0.55	0.53
19 (3/4)	0.66	0.64	0.62	0.60
25 (1)	0.71	0.69	0.67	0.65
37.5 (1 1/2)	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

*American Concrete Institute (ACI 211.1).

**Bulk volumes are based on aggregates in a dry-rodded condition as described in ASTM C29 (AASHTO T19).

TABLE 7.6 Approximate Target Percent Air Content Requirements for Different Nominal Maximum Sizes of Aggregates*

	Nominal Maximum Aggregate Size							
	9.5 mm (3/8 in.)	12.5 mm (1/2 in.)	19 mm (3/4 in.)	25 mm (1 in.)	37.5 mm (1 1/2 in.)	50 mm (2 in.)	75 mm (3 in.)	150 mm (6 in.)
Non-air-entrained concrete	3	2.5	2	1.5	1	0.5	0.3	0.2
Air-entrained concrete**								
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

*American Concrete Institute (ACI 211.1 and ACI 318).

**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.

Aggregate Shape	Reduction in Water Content, kg/m³ (lb/yd³)
Subangular	12 (20)
Gravel with crushed particles	21 (35)
Round gravel	27 (45)

TABLE 7.7 Recommended Slumps for Various Types of Construction*

Concrete Construction	Slump, mm (in.)	
	Maximum**	Minimum
Reinforced foundation walls and footings	75 (3)	25 (1)
Plain footings, caissons, and substructure walls	75 (3)	25 (1)
Beams and reinforced walls	100 (4)	25 (1)
Building columns	100 (4)	25 (1)
Pavements and slabs	75 (3)	25 (1)
Mass concrete	75 (3)	25 (1)

*American Concrete Institute (ACI 211.1).

**May be increased 25 mm (1 in.) for consolidation by hand methods such as rodding and spading. Plasticizers can safely provide higher slumps.

TABLE 7.9 Minimum Requirements of Cementing Materials for Concrete Used in Flatwork*

Nominal Maximum Size of Aggregate mm (in.)	Cementing Materials, kg/m³ (lb/yd³)**
37.5 (1½)	280 (470)
25.0 (1)	310 (520)
19.0 (¾)	320 (540)
12.5 (½)	350 (590)
9.5 (⅜)	360 (610)

*American Concrete Institute (ACI 302).

**Cementing materials quantities may need to be greater for severe exposure. For example, for deicer exposures, concrete should contain at least 335 kg/m³(564 lb/yd³) of cementing materials.

TABLE 7.8 Approximate Mixing Water in kg/m^3(lb/yd^3) for Different Slumps and Nominal Maximum Aggregate Sizes*

Slump, mm (in.)	Nominal Maximum Aggregate Size in mm (in.)**							
	9.5 (3/8)	12.5 (1/2)	19 (3/4)	25 (1)	37.5 (1 1/2)	50 (2)***	75 (3)***	150 (6)***
	Non-air-entrained concrete							
25 to 50 (1 to 2)	207 (350)	199 (335)	190 (315)	179 (300)	166 (275)	154 (260)	130 (220)	113 (190)
75 to 100 (3 to 4)	228 (385)	216 (365)	205 (340)	193 (325)	181 (300)	169 (285)	145 (245)	124 (210)
150 to 175 (6 to 7)	243 (410)	228 (385)	216 (360)	202 (340)	190 (315)	178 (300)	160 (270)	—
	Air-entrained concrete							
25 to 50 (1 to 2)	181 (305)	175 (295)	168 (280)	160 (270)	150 (250)	142 (240)	122 (205)	107 (180)
75 to 100 (3 to 4)	202 (340)	193 (325)	184 (305)	175 (295)	165 (275)	157 (265)	133 (225)	119 (200)
150 to 175 (6 to 7)	216 (365)	205 (345)	197 (325)	184 (310)	174 (290)	166 (280)	154 (260)	—

*American Concrete Institute (ACI 211.1 and ACI 318).

**These quantities of mixing water are for use in computing cementitious material contents 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 37.5 mm (1½ in.) are based on slump tests made after removal of particles larger than 37.5 mm by wet screening.

TABLE 7.10 Estimate of Weight of Freshly Mixed Concrete

Nominal Maximum Aggregate Size, mm (in.)	Non Air Entrained Concrete kg/m^3 (lb/yd^3)	Air Entrained Concrete kg/m^3 (lb/yd^3)
9.5 ($^3/_8$)	2276 (3840)	2187 (3690)
12.5 ($^1/_2$)	2305 (3890)	2228 (3760)
19.0 ($^3/_4$)	2347 (3960)	2276 (3840)
25.0 (1)	2376 (4010)	2311 (3900)
37.5 (1$^1/_2$)	2412 (4070)	2347 (3960)
50.0 (2)	2441 (4120)	2370 (4000)
75.0 (3)	2465 (4160)	2394 (4040)
150 (6)	2507 (4230)	2441 (4120)