THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

2023/2024 ACADEMIC YEAR

CEE 3111 – CVIL ENGINEERING MATERIALS AND PRACTICES

TOPICS 4-5 Question Bank

1. A concrete masonry unit is tested for compressive strength and produces the following results:
   Failure load = 726 kN
   Gross area = 0.081 m^2
   Gross volume = 0.015 m^3
   Net volume = 0.007 m^3
   a. Is the unit categorized as solid or hollow? Why?
   b. What is the compressive strength?
   c. Does the compressive strength satisfy the ASTM requirements for load bearing units shown in the Table below?

	Minimum Compressive Strength Based on Net Area MPa	
Type	**Average of Three Units**	**Individual Units**
Load bearing	13.1	11.7
Non–load-bearing	4.1	3.5

2. A half-block concrete masonry unit is tested for compressive strength. The outside dimensions of the specimen are 190 mm * 190 mm * 190 mm. The cross section is a hollow square with a wall thickness of 25 mm. The load is applied perpendicular to the hollow cross section and the maximum load is 225 kN.
   a. Determine the gross area compressive strength.
   b. Determine the net area compressive strength
3. A concrete masonry unit has actual gross dimensions of 190 mm * 190 mm *190 mm. The unit is tested in a compression machine with the following results:
   Failure load = 436 kN
   Net volume of 224516 mm^3
   a. Is the unit categorized as solid or hollow?
   b. Calculate the gross area compressive strength.
   c. Calculate the net area compressive strength
4. What is mortar made of? What are the functions of mortar?
5. What is grout? What is grout used for?
6. What are the ingredients of plaster? What is it used for?
7. Why is it important that the concrete masonry units meet certain absorption requirements?

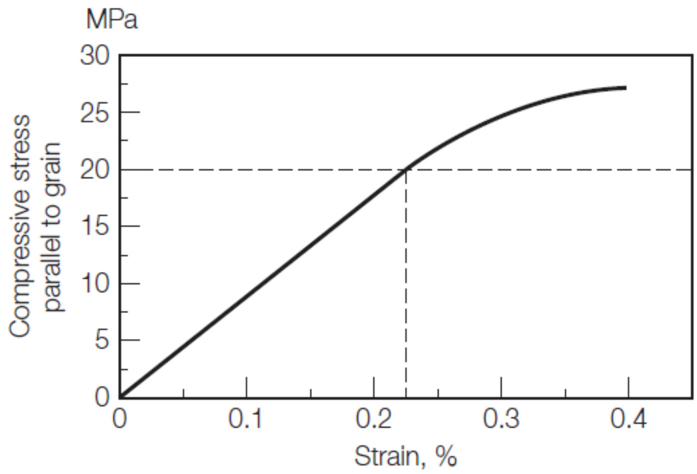
8. A portion of a normal-weight concrete masonry unit was tested for absorption and moisture content and produced the following masses:

mass of unit as received = 1.95 kg
saturated mass of unit = 2.13 kg
oven-dry mass of unit = 1.91 kg
immersed mass of unit = 0.95 kg

   a. Calculate the absorption in kg/m³ and the moisture content of the unit as a percent of total absorption.
   b. Does the absorption meet the ASTM C90 (Table below) requirement for absorption?

Weight Classification	Unit Mass Mg/m^3	Maximum Water Absorption kg/m^3 (Average of 3 units)
Lightweight	Less than 1.68	288
Medium weight	1.68–2.00	240
Normal weight	2.00 or more	208

9. The moisture content of wood test was performed according to ASTM D4442 procedure and produced the following data:
   Mass of specimen in the green condition = 317.5 g
   Mass of oven-dry specimen = 203.9 g
   a. Calculate the moisture content of the given wood.
10. State five different imperfections that may be found in lumber, and briefly define them.
11. Draw a graph to show the typical stress–strain curve for wood. On the graph, show the modulus of elasticity. State three different factors that affect this relationship.
12. Compute the modulus of elasticity of the wood species whose stress–strain relationship is shown in the Figure below.



Compare the results with the typical values shown in the table below and comment about the results.

Material	Modulus GPa	Poisson's Ratio
Aluminum	69–75	0.33
Brick	10–17	0.23–0.40
Cast iron	75–169	0.17
Concrete	14–40	0.11–0.21
Copper	110	0.35
Epoxy	3–140	0.35–0.43
Glass	62–70	0.25
Limestone	58	0.2–0.3
Rubber (soft)	0.001–0.014	0.49
Steel	200	0.27
Tungsten	407	0.28
Wood	6–15	0.29–0.45

13. A 100 mm * 100 mm wood lumber was subjected to bending with a span of 1.5 m until failure by applying a load in the middle of its span. The load and the deflection in the middle of the span were recorded as shown in the table below.

Load (N)	Deflection (mm)
0	0
431	3406
867	5189
1517	6744
3247	8344
6005	9235
8443	9990
10235	10470
13149	11476
15475	12276
17748	13282
19750	14082

a. Plot the load–deflection relationship.
b. Plot the proportional limit on the graph.
c. Calculate the modulus of rupture (flexure strength).

14. A wood specimen was prepared with dimensions of 25 mm * 25 mm* 100 mm and grain parallel to its length. The specimen was subjected to compression parallel to the grain to failure. The load (P) versus deformation (L) results are as shown in the table below.

Observation No.	*P* (kN)	ΔL >(mm)	σ (MPa)	ε (m/m)	u_i (MPa)
0	0	0			N/A
1	3.20	0.51			
2	7.65	1.22			
3	12.23	1.93			
4	16.86	2.74			
5	20.49	3.56			
6	23.75	4.17			
7	27.45	5.08			
8	28.83	5.69			
9	24.02	6.43			
					$u_t =$

a. Complete the table by calculating engineering stress (s) and engineering strain (e).
b. Determine the toughness of the material (u_t) by calculating the area under the stress–strain curve, namely:

$$u_t = \int_0^{\varepsilon^f} \sigma \, d\varepsilon$$

where e_f is the strain at fracture.

This integral can be approximated numerically using a trapezoidal integration technique:

$$u_t = \sum_{i=1}^{n} u_i = \sum_{i=1}^{n} \frac{1}{2}(\sigma_i + \sigma_{i-1})(\varepsilon_i - \varepsilon_{i-1})$$

15. What is the difference between tar and asphalt cement?
16. Discuss the main uses of asphalt.
17. What are the ingredients of asphalt cutbacks? What are the ingredients of asphalt emulsions? Name three uses of asphalt emulsion. Why is asphalt emulsion preferred over asphalt cutback?
18. Draw an asphalt concrete pavement section consisting of an asphalt concrete surface layer, aggregate base, and subgrade. Show the locations of prime coat and chip seal.
19. Define what is meant by temperature susceptibility of asphalt. With the help of a graph showing viscosity versus temperature, discuss the effect on the performance of asphalt concrete pavements. Are soft asphalts used in hot or cold climates?
20. What are the engineering applications of each of these tests?
    a. flash point test
    b. RTFO procedure

c. rotational viscometer test
d. dynamic shear rheometer test
e. penetration test.

21. Discuss the aging that occurs in asphalt cement during mixing with aggregates and in service. How can the different types of aging of asphalt cement be simulated in the laboratory?
22. Define the four methods used to grade asphalt binders. Which method is used in Zambia?
23. For the following temperature conditions, calculate the proper PG grade for both 50% and 98% reliabilities (show your calculation).
    i. Seven-day maximum pavement temperature of 48°C with a standard deviation of 2.5°C.
    ii. Minimum pavement temperature of -21°C with a standard deviation of 3°C.
24. As a materials engineer working for Road Development Agency (RDA), what standard PG asphalt binder grade would you specify for each of the conditions shown in the table below (show all calculations and fill in the table)?

	Seven-Day Maximum Pavement Temperature		Minimum Pavement Temperature		Recommended PG Grade	
Case	Mean, °C	Standard Deviation, °C	Mean, °C	Standard Deviation, °C	50% Reliability	98% Reliability
1	43	1.5	−29	2.5		
2	51	3	−18	4		
3	62	2.5	10	2		

25. What are the components of hot-mix asphalt? What is the function of each component in the mix?
26. What are the objectives of the asphalt concrete mix-design process?
27. Why is it important to have optimum binder content in asphalt concrete? What would happen if a less-than-optimum binder content is used? What would happen if more than the optimum value is used? What is the typical range of binder content in asphalt concrete?
28. An asphalt concrete specimen has a mass in air of 1327.8 g, mass in water of 792.4 g, and saturated surface-dry mass of 1342.2 g. Calculate the bulk specific gravity of the specimen.
29. As part of mix design, a laboratory-compacted cylindrical asphalt specimen is weighed for determination of bulk-specific gravity. The following numbers are obtained:
    Dry mass in air = 1264.7 grams
    Mass when submerged in water = 723.9 g
    Mass of saturated surface dry (SSD) = 1271.9 g
    a. What is the bulk-specific gravity of the compacted specimen (Gmb)?
    b. If the maximum theoretical specific gravity of the specimen (Gmm) is 2.531, what would be the air void content of the specimen in percent?
30. For asphalt concrete, define
    i. air voids
    ii. voids in the mineral aggregate
    iii. voids filled with asphalt
31. An aggregate blend is composed of 59% coarse aggregate by weight (Sp. Gr. 2.635), 36% fine aggregate (Sp. Gr. 2.710), and 5% filler (Sp. Gr. 2.748). The compacted specimen contains 6%

asphalt binder (Sp. Gr. 1.088) by weight of total mix and has a bulk density of 2305 kg/m3. Ignoring absorption, compute the percent voids in total mix, percent voids in mineral aggregate, and the percent voids filled with asphalt.

32. An asphalt concrete mixture includes 94% aggregate by weight. The specific gravities of aggregate and asphalt are 2.65 and 1.0, respectively. If the bulk density of the mix is 2355 kg/m^3, what is the percent voids in the total mix?
33. After 2 years of traffic, cores were recovered from the roadway which has severe rutting and bleeding. The bulk specific gravity and the maximum theoretical specific gravity were measured on these cores and are as follows:
    Bulk specific gravity = 2.487
    Maximum theoretical specific gravity = 2.561
    a. Calculate the air voids
    b. If the design air void content was 4%, explain what effect the calculated air voids had on the rutting and bleeding noted.
34. An asphalt concrete specimen has the following properties:
    - Asphalt content = 5.5% by total weight of mix
    - Bulk specific gravity of the mix = 2.475
    - Theoretical maximum specific gravity = 2.563
    - Bulk specific gravity of aggregate = 2.689

    Ignoring absorption, calculate the percents VTM, VMA, and VFA.
35. An asphalt concrete mixture is to be designed according to the Marshall procedure. A PG 58-28 asphalt cement with a specific gravity of 1.00 is to be used. A dense aggregate blend is to be used, with a maximum size of 19 mm and bulk specific gravity of 2.696. The theoretical maximum specific gravity of the mix is 2.470 at 5% asphalt content. Trial mixes were made, with the average results shown in the table below.

Asphalt Content, % by Weight	Bulk Specific Gravity	Stability, N	Flow, 0.25 mm
4.0	2.303	7076	9
4.5	2.386	8411	10
5.0	2.412	7565	12
5.5	2.419	5963	15
6.0	2.421	4183	22

    a. Plot the appropriate graphs necessary for the Marshall procedure, and select the optimum asphalt content using the Asphalt Institute design criteria for medium traffic. **Assume a design air void content of 4%**
36. Briefly describe the volumetric mix design procedure of Superpave.
37. Name three methods of asphalt pavement recycling. Which one of them is the predominant method? Briefly summarize this method.
38. State four advantages of recycling asphalt pavement materials. Why can we not mix the RAP materials with aggregates in a conventional hot-mix asphalt concrete plant? Show the proper ways of recycling the RAP materials in the two types of hot-mix asphalt plants
39. State four different asphalt modifiers that can be added to asphalt or asphalt mixtures, and indicate the effect of each.
40. What is the purpose of adding fly ash to asphalt concrete?

Assignment 2:

Submit Questions 1, 13, 14, 24, 34, and 35

Due Date: May 9, 2024 at 5 PM