THE UNIVERSITY OF ZAMBIA

SCHOOL OF ENGINEERING

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

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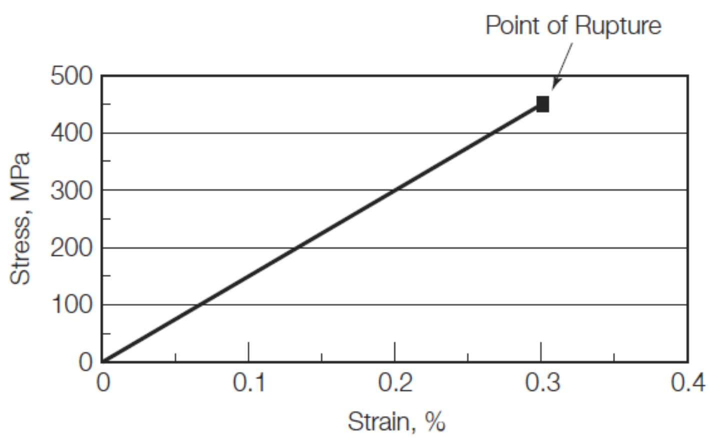
CEE 3111 – CIVIL ENGINEERING MATERIALS AND PRACTICES

TOPICS 1-3 Question Bank

1. State three examples of a static load application and three examples of a dynamic load application.
2. A material has the stress–strain behavior shown in the figure below. What is the material strength at rupture? What is the toughness of this material?



3. Three steel bars have a diameter of 25 mm and carbon contents of 0.2, 0.5, and 0.8%, respectively. The specimens were subjected to tension until rupture. The load versus deformation results were as shown in the Table below. If the gauge length is 50 mm, determine the following:
   i. The tensile stresses and strains for each specimen at each load increment.
   ii. Plot stresses versus strains for all specimens on one graph.
   iii. The proportional limit for each specimen.
   iv. The 0.2% offset yield strength for each specimen.
   v. The modulus of elasticity for each specimen.
   vi. The strain at rupture for each specimen.
   vii. Comment on the effect of increasing the carbon content on the following:
   viii. Yield strength
   ix. Modulus of elasticity
   x. Ductility

Specimen No.	1	2	3
Carbon Content (%)	0.2	0.5	0.8
Deformation (mm)	Load (kN)		
0.00	0	0	0
0.07	133	133	133
0.10	137	191	191
0.15	142	196	285
0.50	147	201	324
1.00	140	199	383
2.50	155	236	447
5.00	196	295	491 (Rupture)
7.50	226	336	
10.00	241	341	
12.50	218	304 (Rupture)	
13.75	196 (Rupture)		

4. A 32-mm rebar with a gauge length of 200 mm was subjected to tension to fracture according to ASTM E-8 method. The load and deformation data were as shown in the table below.

Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)
0	0	472.9	8.4
62.2	0.1	487.1	9.7
188.9	0.2	496.4	11.1
329.8	0.4	505.7	12.4
383.4	1.7	512.8	13.7
426.0	4.0	522.6	15.3
447.3	5.9	532.4	18.5
462.5	7.2	525.9	22.4

Using a spreadsheet program obtain the following:

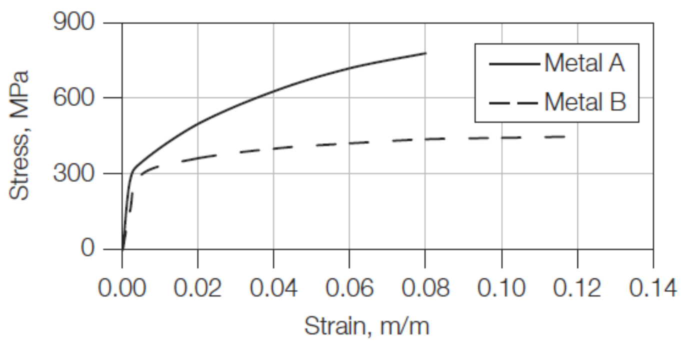
i. A plot of the stress–strain relationship. Label the axes and show units.
ii. A plot of the linear portion of the stress–strain relationship. Determine modulus of elasticity using the best-fit approach.
iii. Proportional limit.
iv. Yield stress.
v. Ultimate strength.
vi. If the rebar is loaded to 390 kN only and then unloaded, what is the permanent change in length?

5. A cylinder with a 150 mm diameter and 300 mm length is put under a compressive load of 665 kN. The modulus of elasticity for this specimen is 55 GPa and Poisson's ratio is 0.35. Calculate the final length and the final diameter of this specimen under this load assuming that the material remains within the linear elastic region.
6. A cylindrical rod with a diameter of 15.24 mm and a gauge length of 400 mm is subjected to a tensile load. If the rod is to experience neither plastic deformation nor an elongation of more than 0.45 mm when the applied load is 31000 N, which of the four metals or alloys listed below are possible candidates? Justify your choice(s).

Material	E (GPa)	Yield Strength (MPa)	Tensile Strength (MPa)
Steel alloy 1	180	860	502
Steel alloy 2	200	400	250
Titanium alloy	110	900	730
Copper	117	220	70

7. The figure below shows the stress–strain relations of metals A and B during tension tests until fracture. Determine the following for the two metals (show all calculations and units):

   i. Proportional limit
   ii. Yield stress at an offset strain of 0.002 m/m.
   iii. Ultimate strength
   iv. Modulus of resilience
   v. Toughness
   vi. Which metal is more ductile? Why?



8. In a ready-mix plant, cylindrical samples are prepared and tested periodically to detect any mix problem and to ensure that the compressive strength is higher than the lower specification limit. The minimum target value was set at 34 MPa. The compressive strength data is shown in the Table below.

Sample No.	Compressive Strength (MPa)	Sample No.	Compressive Strength (MPa)
1	38.6	11	46.1
2	35.4	12	37.6
3	43.8	13	36.4
4	35.8	14	46.2
5	35.77	15	35.8
6	36.1	16	41.5
7	41.1	17	36.7
8	40.5	18	39.0
9	42.4	19	45.5
10	35.3	20	36.1

   i. Calculate the mean, standard deviation, and the coefficient of variation of the data.
   ii. Using a spreadsheet program, create a control chart for these data showing the lower specification limit. Is the plant production meeting the specification requirement? If not, comment on possible reasons. Comment on the data scatter.

9. Define alloy steels. Explain why alloys are added to steel.
10. What are the typical uses of structural steel?
11. Specifically state the shape and size of the structural steel section: W 920 * 271.
12. Why is reinforcing steel used in concrete? Discuss the typical properties of reinforcing steel.
13. Name three mechanical tests used to measure properties of steel.
14. What is high-performance steel? State two HPS products that are currently being used in structural applications and show their properties.
15. Discuss five different desirable characteristics of aggregate used in Portland cement concrete
16. Discuss five different desirable characteristics of aggregate used in asphalt concrete.
17. A sample of wet aggregate weighed 297.2 N. After drying in an oven, this sample weighed 281.5 N. The absorption of this aggregate is 2.5%. Calculate the percent of free water in the original wet sample.
18. The shape and surface texture of aggregate particles are important for both portland cement concrete and asphalt concrete.
    i. For preparing PCC, would you prefer round and smooth aggregate or rough and angular aggregate? Briefly explain why (no more than two lines).
    ii. For preparing HMA, would you prefer round and smooth aggregate or rough and angular aggregate? Briefly explain why (no more than two lines).

19. 46.5 kg of fine aggregate is mixed with 72.3 kg of coarse aggregate. The fine aggregate has a moisture content of 2.0% and absorption of 3.4%, whereas the coarse aggregate has a moisture content of 1.3% and absorption of 3.8%. What is the amount of water required to increase the moisture contents of both fine and coarse aggregates to reach absorption? Why is it important to determine the amount of water required to increase the moisture content of aggregate to reach absorption?
20. Calculate the percent voids between aggregate particles that have been compacted by rodding, if the dry-rodded unit weight is 1161 kg/m3 and the bulk dry specific gravity is 2.639.
21. Coarse aggregate is placed in a rigid bucket and rodded with a tamping rod to determine its unit weight. The following data are obtained: Volume of bucket = 14 L
    Weight of empty bucket = 9.21 kg
    Weight of bucket filled with dry rodded coarse aggregate:
    Trial 1 = 34.75 kg
    Trial 2 = 34.06 kg
    Trial 3 = 35.74 kg
    i. Calculate the average dry-rodded unit weight
    ii. If the bulk dry specific gravity of the aggregate is 2.620, calculate the percent voids between aggregate particles for each trial.
22. The following laboratory tests are performed on aggregate samples:
    i. Specific gravity and absorption
    ii. Soudness
    iii. Sieve analysis test

    What is the significance and use of each of these tests?
23. Students in the materials lab performed the specific gravity and absorption test (ASTM C127) on coarse aggregate and they obtained following data:
    Dry weight = 3862.1 g
    SSD weight = 3923.4 g
    Submerged weight = 2452.1 g
    Calculate the specific gravity values (dry bulk, SSD, and apparent) and the absorption of the coarse aggregate.
24. A sieve analysis test was performed on a sample of coarse aggregate and produced the results in the table below.

Sieve Size, mm	Amount Retained, g
75.0	0
50.0	0
37.5	1678
25.0	7212
19.0	5443
12.5	6124
9.5	12111
4.75	4581
Pan	590

i. Calculate the percent passing through each sieve.
ii. What is the maximum size?
iii. What is the nominal maximum size?
iv. Plot the percent passing versus sieve size on a semilog gradation chart.
v. Plot the percent passing versus sieve size on a 0.45 gradation chart.
vi. Referring to ASTM C33, what is the closest size number and does it meet the gradation for that standard size?

25. The following laboratory tests are performed on aggregate samples:
    i. Specific gravity and absorption
    ii. Soudness
    iii. Sieve analysis test

    What is the significance and use of each of these tests?

26. Three aggregates are to be mixed together in the following ratio:
Aggregate A: 35%
Aggregate B: 40%
Aggregate C: 25%
For each aggregate, the percent passing a set of five sieves is shown in the table below.

Sieve Size, mm	% Passing Aggregate A	% Passing Aggregate B	% Passing Aggregate C
9.5	85	50	40
4.75	70	35	30
0.6	35	20	5
0.3	25	13	1
0.15	17	7	0

Determine the gradation of the blend aggregate.

27. The table below shows the grain size distribution for two aggregates and the specification limits for an asphalt concrete. Determine the blend proportion required to meet the specification and the gradations of the blend.

Percent Passing									
Sieve Size, mm									
	19	12.5	9.5	4.75	2.36	0.60	0.30	0.15	0.075
Specification limits	100	80–100	70–90	50–70	35–50	18–29	13–23	8–16	4–10
Aggregate A	100	85	55	20	2	0	0	0	0
Aggregate B	100	100	100	85	67	45	32	19	11

i. On a semilog gradation graph, plot the gradations of aggregate A, aggregate B, the selected blend, and the specification limits.

ii. Define the fineness modulus of aggregate. What is it used for?

iii. Calculate the fineness modulus of aggregate B. Is your answer within the typical range for fineness modulus? If not, why not?

iv. Laboratory specific gravity and absorption tests are run on two coarse aggregate sizes, which have to be blended. The results are as follows:
Aggregate A: Bulk specific gravity = 2.491; absorption = 0.8,
Aggregate B: Bulk specific gravity = 2.773; absorption = 4.6,
    i. What is the specific gravity of a mixture of 60% aggregate A and 40% aggregate B by weight?
    ii. What is the absorption of the mixture?

v. Referring to the table below, plot the specification limits of Superpave gradation with a nominal maximum size of 19 mm on a 0.45 gradation chart (Figure A.25). What is the maximum aggregate size of this gradation? Is this a dense, open, or gap graded gradation? Why?

	Nominal Maximum Size (mm)					
Sieve Size, mm	37.5	25	19	12.5	9.5	4.75
50	100	—	—	—	—	—
37.5	90–100	100	—	—	—	—
25	90 max	90–100	100	—	—	—
19	—	90 max	90–100	100	—	—
12.5	—	—	90 max	90–100	100	100
9.5	—	—	—	90 max	90–100	95–100
4.75	—	—	—	—	90 max	90–100
2.36	15–41	19–45	23–49	28–58	32–67	—
1.18	—	—	—	—	—	30–60
0.075	0.0–6.0	1.0–7.0	2.0–8.0	2.0–10.0	2.0–10.0	6.0–12.0

vi. The mix design for an asphalt concrete mixture requires 2 to 6% minus 0.075 mm. The three aggregates shown in the table below are available.

	Minus 0.075 mm
Coarse	0.5%
Intermediate	1.5%
Fine Aggregate	11.5%

Considering that approximately equal amounts of coarse and intermediate aggregate will be used in the mix, what is the percentage of fine aggregate that will give a resulting minus 0.075 mm in the mixture in the middle of the range, about 4%?

28. Aggregates from three sources having the properties shown in the table below were blended at a ratio of 55:25:20 by weight. Determine the properties of the aggregate blend.

Property	Aggregate 1	Aggregate 2	Sand
Coarse aggregate angularity, percent crushed faces	100	87	N/A
Bulk specific gravity	2.631	2.711	2.614
Apparent specific gravity	2.732	2.765	2.712

29. The following laboratory tests are performed:
    i. Setting time test of cement paste samples
    ii. Compressive strength of mortar cubes

    What are the significance and use of each of these tests?
30. Discuss the effect of water–cement ratio on the quality of hardened concrete.
    Explain why this effect happens.
31. Students in the materials class prepared three mortar mixes with water to cement ratios of 0.50, 0.55, and 0.60. Three 50-mm mortar cubes were prepared for each mix. The cubes were cured for 7 days and then tested for compressive strength. The test results were as shown in the table below.

Mix No.	w/c Ratio	Cube No.	Maximum Load (kN)	Compressive Strength (MPa)	Average Compressive Strength (MPa)
1	0.50	1	79.4		
		2	80.1		
		3	81.9		
2	0.55	1	74.7		
		2	74.5		
		3	72.5		
3	0.60	1	65.8		
		2	69.3		
		3	71.2		

Determine the following:

i. The compressive strength of each cube.
ii. The average compressive strength for each mix.
iii. Plot the average compressive strength versus w/c ratios for all mixes.
iv. Comment on the effect of increasing w/c ratio on the compressive strength of the cubes.

32. 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 such as the Phoenix area
    iv. Concrete structure without any specific exposure condition
    v. Building foundation in a soil with severe sulfate exposure
33. If a water reducer is added to the concrete mix without changing other ingredients, what will happen to the properties of the concrete? If the intention of adding the water reducer is to increase the compressive strength of hardened concrete, how can this be achieved?
34. How can the water reducer be used to achieve each of the following functions?
    i. improve strength
    ii. improve workability
    iii. improve economy
35. A concrete mix includes the following ingredients per cubic meter:
    a. Cement = 400 kg
    b. Water = 176 kg
    c. No admixture

The table below shows possible changes that can be made to the mix ingredients. Indicate in the appropriate boxes in the table what will happen in each case for the workability and the ultimate compressive strength as increase, decrease, or approximately the same.

			What Will Happen?	
Cement (kg)	**Water (kg)**	**Admixture**	**Workability**	**Ultimate Compressive Strength**
400	240	None		
449	176	None		
400	176	Water reducer		
400	128	Water reducer		
400	176	Superplasticizer		
400	176	Air entrainer		
400	176	Accelerator		

36. As a materials engineer in charge of designing concrete mix and facing the following problems, which admixture would you use in each case during mixing or at the jobsite?

    i. There is a large quantity of freshly mixed concrete and the work at the jobsite had to stop because of rain.
    ii. More time is expected to be needed for finishing concrete.
    iii. The structure is subject to freezing.
    iv. Concrete is to be around tightly spaced reinforcing steel.
    v. Concrete mix will be hauled a long distance.
    vi. High early strength concrete is required, but not necessarily high ultimate strength.

37. The results of an experiment to evaluate the effects of a water reducer are shown in the table below.

i. Calculate the water–cement ratio in each of the three cases.
ii. Using water reducer, how can we increase the compressive strength of concrete without changing workability? Refer to the appropriate case in the table.
iii. Using water reducer, how can we improve workability without changing the compressive strength? Refer to the appropriate case in the table.
iv. Using water reducer, how can we reduce cost without changing workability or strength? (Assume that the cost of the small amount of water reducer added is less than the cost of cement.) Refer to the appropriate case in the table.
v. Summarize all possible effects of water reducers on concrete.

		With Water Reducer		
	Without Water Reducer	Case 1	Case 2	Case 3
Cement content, kg/m^3	436	436	436	393
Water content,* kg/m^3	218	218	174	196
Slump, mm	50	100	50	50
28-Day compressive strength, MPa	28.27	28.30	34.85	28.29

*Assume that the water content is above the saturated surface-dry (SSD) condition of the aggregate.

38. A materials engineer is working in a research project to evaluate the effect of one type of admixture on the compressive strength of concrete. He tested eight mortar cubes made with admixture and eight others without admixture after 28 days of curing. The compressive strengths of cubes in MPa with and without admixture are shown in Table P6.38. Using the statistical *t*-test, is there a significant difference between the means of the compressive strengths of the two cement mortars at a level of significance of 0.10?

	Compressive Strength, MPa	
Cube No.	With Admixture	Without Admixture
1	24.2	24.4
2	25.1	26.0
3	25.6	25.6
4	24.1	25.1
5	23.5	24.5
6	25.4	25.1
7	24.4	23.4
8	24.2	24.5

39. A project specifies a concrete strength of at least 20.7 MPa. Materials engineers will design the mix for a strength higher than that. Calculate the required average compressive strength of the mix design if the standard deviation is s = 2.4 MPa. Estimate the modulus of elasticity of the concrete at the required average compressive strength (the calculated strength, not the given strength).

40. What is your recommendation for the maximum size of coarse aggregate for the following situation? A continuously reinforced concrete pavement cross section contains a layer of 19-mm reinforcing bars at 150 mm. centers, such that the steel is just above mid-depth of a 250 mm. thick slab. Cover over the top of the steel is therefore about 100 mm.
41. A concrete mix with a 75 mm slump, w/c ratio of 0.50, and sand with a fineness modulus of 2.4 contains 1009 kg/m3 of coarse aggregate. Compute the required mass of coarse aggregate per cubic meter. To adjust the mix so as to increase the compressive strength, the water–cement ratio is reduced to 0.45. Will the quantity of coarse aggregate increase, decrease, or stay the same? Explain your answer.
42. You are working on a concrete mix design that requires each cubic yard of concrete to have 0.45 water–cement ratio, 1165 kg/m3 of dry gravel, 4% air content, and 335 kg/m3 of cement. The available gravel has a specific gravity of Ggravel = 2.7, a moisture content of 1.6%, and absorption of 2.4%. The available sand has a specific gravity of Gsand = 2.5, a moisture content of 4.8%, and absorption of 1.5%. For each cubic meter of concrete needed on the job, calculate the mass of cement, moist gravel, moist sand, and water that should be added to the batch. Summarize and total the mix design when finished (don't include air entrainer in summary).
43. Using the following data for an unreinforced PCC Pavement slab:
    - Design strength fc = 28 MPa
    - Slab thickness = 300 mm
    - Standard deviation of fc obtained from 20 samples = 1.4 MPa
    - Ignore any exposure requirement
    - Use air-entrained concrete
    - Fineness modulus of fine aggregate = 2.60
    - Maximum aggregate size = 50 mm and nominal maximum aggregate size = 37.5 mm
    - Bulk oven-dry specific gravity of coarse aggregate = 2.6
    - Oven-dry rodded density of coarse aggregate = 2002 kg/m3

    Find the following:
    1. Required compressive strength
    2. w/c ratio
    3. Coarse aggregate amount (kg/m3)

If the w/c ratio is 10% reduced, will the quantity of coarse aggregate increase, decrease or remain the same? Explain your answer.

44. Design the concrete mix according to the following conditions:
    -Design Environment
    -Pavement slab, subjected to freezing
    -Required design strength = 21 MPa
    -Slab thickness = 300 mm
    -Statistical data indicate a standard deviation of compressive strength of 1.7 MPa is expected (more than 30 samples).
    -Only air entrainer is allowed.
    Available Materials
    -Air entrainer: Manufacture specification is 9.5 mL/1% air/100 kg cement.
    -Coarse aggregate: 2 in. nominal maximum size, crushed stone
    -Bulk oven-dry specific gravity = 2.573, absorption = 2.8,
    -Oven-dry rodded density = 1922 kg/m3
    -Moisture content = 1,
    -Fine aggregate: Natural sand
    -Bulk oven-dry specific gravity = 2.540, absorption = 3.4,
    -Moisture content = 4.5,
    -Fineness modulus = 2.68

45. What do we mean by curing concrete? What will happen if concrete is not cured?
46. Discuss five different methods of concrete curing.

47. Draw a graph showing the typical relation between the compressive strength and age for continuously moist-cured concrete and concrete cured for 3 days only. Label all axes and curves.
48. Why is extra water harmful to fresh concrete, but good for concrete after it reaches its final set?
49. Three concrete mixes with the same ingredients, except the amount of mixingwater, and their slump values were obtained. Three 100 mm * 200 mm concrete cylinders were prepared for each mix. The cylinders were cured for 7 days and then tested for compressive strength. The test results are as shown in the table below. Assume that the aggregate was at the saturated surface-dry condition before adding mixing water.

Mix No.	Mass of Cement (kg)	Mass of Water* (kg)	Slump (mm)	Cylinder No.	Maximum Load (kN)	Compressive Strength after 7 Days (MPa)	Average Compressive Strength after 7 Days (MPa)	Estimated Compressive Strength after 28 Days (MPa)
1	10	5	40	1	138.2			
				2	175.9			
				3	136.9			
2	10	5.5	55	1	100.7			
				2	115.2			
				3	113.6			
3	10	6	75	1	73.3			
				2	78.4			
				3	76.0			

It is required to do the following:

i. Plot the relationship between slump and amount of mixing water for all mixes. Comment on the effect of increasing the amount of water on workability.
ii. Determine the compressive strength of each cylinder after 7 days.
iii. Determine the average compressive strength of each mix after 7 days.
iv. Using Figure 7.24, estimate the compressive strength after 28 days (f_c) for each mix.
v. Determine the w/c ratio for each mix. Plot the average f_c values versus w/c ratios for all mixes. Comment on the effect of increasing the w/c ratio on the compressive strength.

50. A concrete masonry unit is tested for compressive strength and produces the following results:

Failure load = 726 kN
Gross area = 0.081 m2
Gross volume = 0.015 m3
Net volume = 0.007 m3
What is the compressive strength of this masonry unit? Does the compressive strength satisfy the ASTM requirements for load bearing units shown in the table below?

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

51. A half-block concrete masonry unit is subjected to compression until failure. 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 38 mm. The load is applied perpendicular to the hollow cross section and the maximum load is 296 kN.
    i. Determine the gross area compressive strength.
    ii. Determine the net area compressive strength.

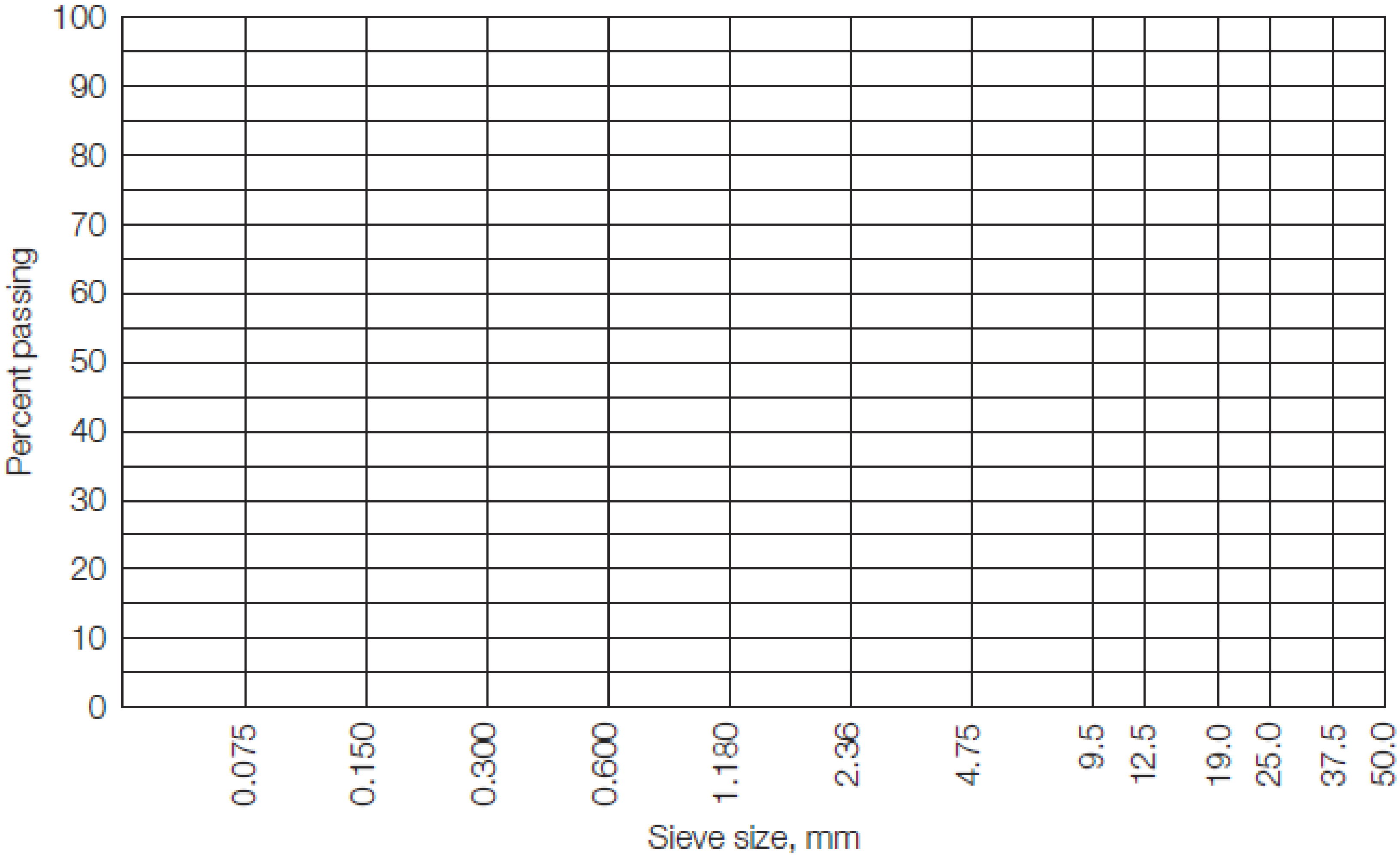


Figure 1: Semi Log Graph

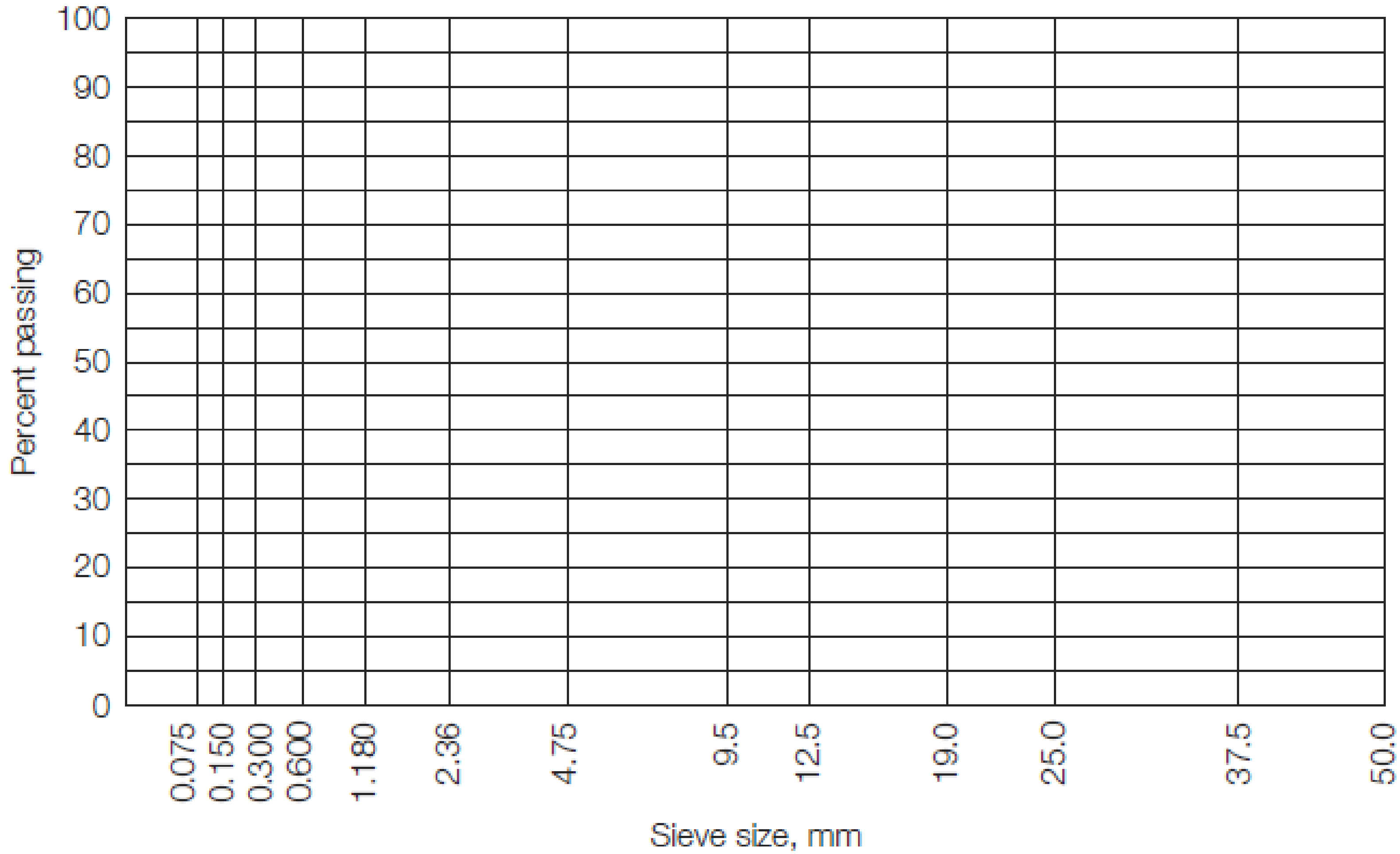


Figure 2: 0.45 Power Gradation Chart