MIZORAM PUBLIC SERVICE COMMISSION

COMPETITIVE EXAMINATIONS FOR JUNIOR GRADE OF M.E.S.
UNDER PUBLIC WORKS DEPARTMENT, AUGUST, 2018.

CIVIL ENGINEERING
PAPER - III

Time Allowed : 3 hours   FM : 200

SECTION - A *(Multiple Choice questions)*
### *(100 Marks)*
All questions carry equal mark of 2 each. Attempt all questions.
*This Section should be answered only on the **OMR Response Sheet** provided.*

1. The total neutral and effective vertical stresses (in t/m^2) at a depth of 5m below the surface of a fully saturated soil deposit with a saturated density of $2t/m^2$ would, respectively, be
   (a) 5, 5 and 10
   (b) 10, 5 and 5
   (c) 5, 10 and 10
   (d) 10, 5 and 10

2. A saturated clay layer with double drainage takes 5 years to attain 90% degree of consolidation under a structure. If the same layer were to be single drained, what would be the time (in years) required to attain the same consolidation under the same loading conditions?
   (a) 10
   (b) 15
   (c) 20
   (d) 25

3. Two circular footing of diameters D1 and D2 are resting on the surface of a purely cohesive soil. The ratio D1/D2 = 2. If the ultimate load carrying capacity of the footing of diameter D1 is 200 kN/m2, then the ultimate bearing capacity of the footing of diameter D2 will be
   (a) $100 \ kN/m^2$
   (b) $200 \ kN/m^2$
   (c) $300 \ kN/m^2$
   (d) $314 \ kN/m^2$

4. A saturated soil mass has a total density $22kN/m^3$ and water content of 10%. The bulk density and dry density of this soil are
   (a) $12kN/m^3$ and $20kN/m^3$ respectively
   (b) $22kN/m^3$ and $20kN/m^3$ respectively
   (c) $19.8kN/m^3$ and $19.8kN/m^3$ respectively
   (d) $23.2kN/m^3$ and $19.8kN/m^3$ respectively

5. The coefficient of permeability K for gravel is
   (a) 0.01 or Lesser than 0.01 cm/s
   (b) 0.5 or Lesser than 0.5 cm/s
   (c) 1.0 or Lesser than 1.0 cm/s
   (d) 1.0 or More than 1.0 cm/s

6. The coefficient of permeability of the soil sample is found to be $1x10^{-3}$ cm/s at a void ratio of 0.4. Its permeability at the value of 0.6 is
   (a) $1.26 \ x10^{-3}$ cm/s
   (b) $2.25 \ x10^{-3}$ cm/s
   (c) $3.62 \ x10^{-3}$ cm/s
   (d) $4.15 \ x10^{-3}$ cm/s

7. Two soil specimens with identical geometric dimensions were subjected to falling head permeability tests in the laboratory under identical conditions. The fall of water head was measured after an identical time interval. The ratio of initial to final water heads for the test involving the first specimen was 1.25.If the coefficient of permeability of the second specimen is 5-times that of the first, the ratio of initial to final water heads in the test involving the second specimen is

(a) 3.05
(b) 3.80
(c) 4.00
(d) 6.25

8. A layer of normally consolidated, saturated silty clay of 1m thickness is subjected to 1-D consolidation under a pressure increment of 20kPa. The properties of the soil are : specific gravity = 2.7, natural moisture content = 45%, compression index = 0.45, and recompression index = 0.05. The initial average effective stress within the layer is 100 kPa. Assuming Terzaghi's theory to be applicable, the primary consolidation settlement (rounded off to the nearest mm) is

(a) 2
(b) 4
(c) 8
(d) 16

9. A pavement designer has arrived at a design traffic of 100 million standard axles for a newly developing national highway as per IRC:37 guidelines using the following data: design life = 15 years, commercial vehicle count before pavement construction =4500 vehicles/day, annual traffic growth rate = 8%. The vehicle damage factor used in the calculation was

(a) 1.56
(b) 2.24
(c) 3.20
(d) 4.42

10. The following data are related to a horizontal curved of a two lane highway: length of curve = 200 m, radius of curve = 300 m and width of pavement = 7.5 m. Inorder to provide a stopping sight distance (SSD) of 80 m, the set back distance (in m) required from the centre line of the inner lane of the pavement is

(a) 2.64
(b) 4.55
(c) 7.10
(d) 7.96

11. A two-lane urban road with one-way traffic has a maximum capacity of 1800 vehicles/hour. Under jam condition, the average length occupied by the vehicles is 5.0 m. The speed versus density relationship is linear. For a traffic volume of 1000 vehicles/ hour, the density is

(a) 46 vehicles/km
(b) 58 vehicles/km
(c) 67 vehicles/km
(d) 73 vehicles/km

12. Brake is applied on a vehicle which then skids a distance of 16m before coming to stop. If the developed average coefficient of friction between the tyres and the pavement is 0.4, then, the speed of the vehicle before skidding would have been nearly

(a) 50 kmph
(b) 20 kmph
(c) 30 kmph
(d) 40 kmph

13. The effective stress friction angle of a saturated, cohesionless soil is 38°. The ratio of shear stress to normal effective stress on the failure plane is

(a) 0.378
(b) 0.488
(c) 0.616
(d) 0.781

14. Two series of compaction tests were performed in the laboratory on an inorganic clayey soil employing two different levels of compaction energy per unit volume of soil. With regard to the above tests, the following two statements were made.

  (i) The optimum moisture content is expected to be more for the tests with higher energy

  (ii) The maximum dry density is expected to be more for the tests with higher energy

   (a) Only (i) is true   (b) Only (ii) is true

   (c) Both are true   (d) Both are false

15. As per the Indian Standard soil classification system, a sample of silty clay with liquid limit of 40% and plasticity index of 28% is classified as

   (a) CH   (b) CI

   (c) CL   (d) CL-ML

16. A smooth rigid retaining wall moves as shown in the sketch causing the backfill material to fail. The backfill material is homogeneous and isotropic and obeys the Mohr-Coulomb failure criterion. The major principal stress is
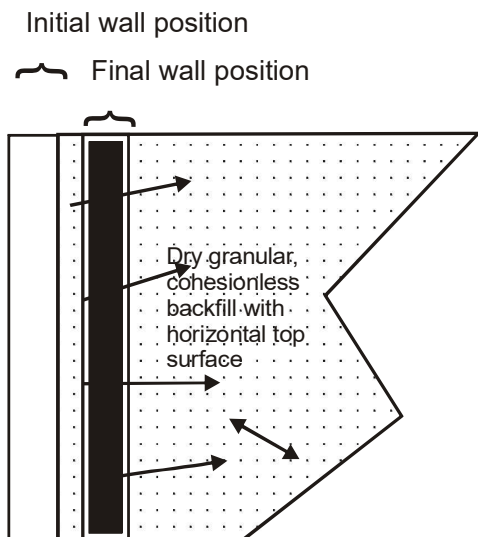
   (a) Normal to the wall face

   (b) Oblique to the wall face acting downwards

   (c) Oblique to the wall face acting upwards

   (d) Parallel to the wall face and acting downwards

17. An embankment is to be constructed with a granular soil (bulk unit weight $= 20$ kN/m^3) on a saturated clayey silt deposit (undrained shear strength $= 25$ kPa). Assuming undrained general shear failure and bearing capacity factor of 5.7, the maximum height of the embankment at the point of failure is

   (a) 2.5 m   (b) 5.0 m

   (c) 7.1 m   (d) 7.5 m

18. Design rate of super elevation for horizontal highway curve of radius 450 m for a mixed traffic condition, having a speed of 125 kmph is

   (a) 0.05   (b) 0.07

   (c) 0.157   (d) 1.0

19. Two major roads with two lanes each are crossing in an urban area to form an un-controlled intersection. The number of conflict points when both roads are one-way is "X" and when both roads are two-way is "Y". The ratio of X and Y is

    (a) 0.25   (b) 0.33

    (c) 0.50   (d) 0.75

20. Two bitumen samples "X" and "Y" have softening points 45°C and 60°C, respectively. Consider the following statements:

    I. Penetration value of "X" will be lesser than that of "Y" under standard conditions.

    II. Viscosity of "X" will be higher than that of "Y" at the same temperature.

The CORRECT option evaluating the above statements is

    (a) Both I and II are TRUE   (b) I is FALSE and II is TRUE

    (c) Both I and II are FALSE   (d) I is TRUE and II is FALSE

21. Road roughness is measured using

    (a) Bump integrator   (b) Benklman beam

    (c) Dynamic cone penetrometer   (d) Falling weight deflectometer

22. Which of the following errors can be eliminated by reciprocal measurements in differential leveling?

    i. Error due to atmospheric-refraction

    ii. Error due to earth's curvature

    (a) i only   (b) ii only

    (c) Both i and ii   (d) Neither i nor ii

23. A clayey soil has a maximum dry density of 16kN/m3 and optimum moisture content of 12%. A contractor during the construction of core of an earth dam obtained the dry density 15.2kN/m3 and water content 11%. This construction is acceptable because

    (a) The density is less than the maximum dry density and water content is on dry side of optimum.

    (b) The compaction density is very low and water content is less than 12%

    (c) The compaction is done on the dry side of the optimum

    (d) Both the dry density and water content of the compacted soil are within the desirable limits

24. Negative skin friction in a soil is considered when the pile is constructed through a

    (a) fill material   (b) dense coarse sand

    (c) over consolidated stiff clay   (d) dense fine sand

25. There are two footings resting on the ground surface. One footing is square of dimension 'B'. The other is strip footing with width 'B'. Both of them are subjected to a loading intensity of q. The pressure intensity at any depth below the base of the footing along the centreline would be

    (a) Equal in both footings

    (b) Large for square footing and small for strip footing

    (c) Large for strip footing and small for square footing

    (d) More for strip footing at shallow depth ($\leq$B) and more for square footing at large depth ($\geq$B)

26. Root time method is used to determine

    (a) a_v, coefficient of compressibility   (b) c_v, coefficient of consolidation

    (c) m_v, coefficient of volume compressibility   (d) T, time factor

27. The length of Summit Curve on a two lane two way highway depends upon

    (a) Allowable rate of change of centrifugal acceleration

    (b) Coefficient of lateral friction

    (c) Required Stopping Sight Distance

    (d) Required Overtaking Sight Distance

28. Bituminous concrete is a mix comprising of

    (a) Coarse aggregate, fine aggregate, filler and bitumen

    (b) Coarse aggregate, filler and bitumen

    (c) Fine aggregate, filler and bitumen

    (d) Fine aggregate and bitumen

29. The GIVE WAY control

    (a) Requires the driver in the minor road to slow down to a minimum speed and allow the vehicle on the major road to proceed.

    (b) Requires the driver in the major road to slow down to a minimum speed and allow the vehicle on the minor road to proceed.

    (c) Requires the drivers on both minor and major roads to stop.

    (d) Is similar to one way control.

30. Traffic signal is an example of

    (a) Passive control   (b) No control

    (c) Active control   (d) None of these

31. Saturation flow rate can be computed as,

    (a) 3600/h   (b) h/3600

    (c) 3600×h   (d) None of these

32. A portion of an embankment having a uniform up-gradient 1 in 500 is circular with radius 1000 m of the centre line. It subtends 180° at the centre. If the height of the bank is 1 m at the lower end, and side slopes 2:1, the earth work involved.

    (a) 26,000 m³   (b) 26,500 m³

    (c) 27,000 m³   (d) 27,500 m³

33. The correct prismoidal formula for volume is

    (a) D [first area + last area + å Even area + 2 å odd areas]

    (b) D/3 [first area + last area + 4 å Even area + 2 å odd areas]

    (c) D/3 [first area + last area + 2 å Even area + 4 å odd areas]

    (d) D/6 [first area + last area + 2 å Even area + 4 å odd areas]

34. The reduced levels of points, 30 metres apart along the longitudinal section of a road portion between chainages 5 and 9 are shown in the given figure. If there is a uniform up-gradient of the road 120 in 1, the chainage of the point with no filling or cutting is
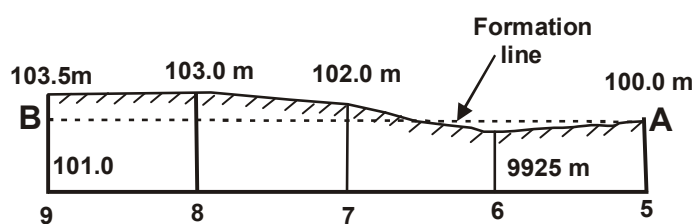
    (a) (6 + 12) chains   (b) (6 + 15) chains

    (c) (6 + 18) chains   (d) None of these

35. Pick up the correct statement from the following:

    (a) The estimated value of the work excluding the amount for contigencies, work charged establishment, tool and plants, is called work value.

    (b) The actual expenditure involved to complete a work including incidental, establishment and travelling charges, is called actual cost.

    (c) The formal acceptance by the administrative department for incurring an expenditure on the work, is called administrative approval.

    (d) All of these.

36. In a liquid limit test, the moisture content at 10 blows was 70% and that at 100 blows was 20%. The liquid limit of the soil, is

    (a) 35%   (b) 50%

    (c) 65%   (d) None of these

37. The lateral earth pressure on a retaining wall

    (a) is equal to mass of the soil retained

    (b) proportional to the depth of the soil

    (c) proportional to the square of the depth of the soil

    (d) proportional to the internal friction of the soil

38. Stoke's law states that the velocity at which a grain settles out of suspension, the other factors remaining constant, is dependent upon

    (a) shape of grain   (b) weight and size of grain

    (c) shape and size of grain   (d) shape, size and weight of grain

39. Pick up the correct statement from the following:

    (a) Failure plane carries maximum shear stress

    (b) Failure plane does not carry maximum shear stress

    (c) Failure plane carries shear stress equal to maximum shear stress

    (d) None of these

40. For determining the moisture content of a soil sample, the following data is available Weight of container = 260 g, Weight of soil sample = 320 g container, Weight of soil sample (dried) = 310 g container. The moisture content of the soil sample, is

    (a) 15%   (b) 18%

    (c) 20%   (d) 28%

41. The soil moisture driven off by heat, is called

    (a) free water   (b) hydroscopic water

    (c) gravity water   (d) none of these

42. Pick up the correct statement from the following:

    (a) If the ratio of depth to width is less than 2, it is shallow foundation

    (b) If the ratio of depth to width is more than 2, it is deep foundation

    (c) If the length is large as compared to width, it is a strip foundation

    (d) All of these

43. If the cohesive force, (c), is 1.5 t/m^2, the density (γ) of the soil is 2.0 t/m^3, factor of safety (F_S) is 1.5 and stability factor (Sn) is 0.05, the safe height of the slope is

    (a) 5 metres   (b) 8 metres

   (c) 10 metres   (d) 15 metres

44. Terzaghi's analysis assumes :

    (a) soil is homogeneous and isotropic

    (b) elastic zone has straight boundaries inclined at $\psi = \varphi$ to the horizontal and plastic zones fully developed

    (c) failure zones do not extend above the horizontal plane through the base of the footing

    (d) all of these

45. A soil sample has passing 0.075 mm sieve = 60% liquid limit = 65% and plastic limit = 40%. The group index of the soil, is

    (a) 5   (b) 20

    (c) 40   (d) none of these

46. The void ratio of a soil sample decreases from 1.50 to 1.25 when the pressure is increased from 25 t/m^2 to 50 t/m^2, the coefficient of compressibility is

    (a) 0.01   (b) 0.02

    (c) 0.05   (d) 0.001

47. Depending upon the properties of a material, the failure envelope may

    (a) be either straight or curved   (b) pass through the origin of stress

    (c) intersect the shear stress axis   (d) all of these

48. When the seepage pressure becomes equal to the pressure due to submerged weight of a soil, the effective pressure is reduced to zero and the soil particles have a tendency to move up in the direction of flow. This phenomenon is generally known

    (a) quick condition   (b) boiling condition

    (c) quick sand condition   (d) all of these

49. Fuller law is expressed as

    (a) $p = 100\left(\dfrac{d}{D}\right)^n$ (b) $p = 100\left(\dfrac{d^2}{D}\right)^n$

    (c) $p = 100\left(\dfrac{d^2}{D^2}\right)^n$ (d) $p = 100\left(\dfrac{d}{D}\right)$

50. Broken lines

    (a) Allows crossing with discretion

    (b) Does not allow crossing except for entry or exit from a side road

    (c) Allows crossing only in case of extreme emergency

    (d) Are not at all used as road markings

SECTION - B *(Short answer type question)*
### *(100 Marks)*

*All questions carry equal marks of **5** each.*

*This Section should be answered only on the **Answer Sheet** provided.*

1. For a tri-axial shear test conducted on a sand specimen at a confining pressure of $100 kN/m^2$ under drained conditions, resulted in a deviator stress $(s_1 - s_3)$ at failure of $100 kN/m^2$. What will be the angle of shearing resistance of the soil.

2. The flow net around a sheet pile wall is shown in Fig. The properties of the soil are : permeability coefficient = 0.09 m/day (isotropic), specific gravity = 2.70 and void ratio = 0.85. The sheet pile wall and the bottom of the soil are impermeable. Find the seepage loss of water and factor of safety against the occurrence of piping failure.
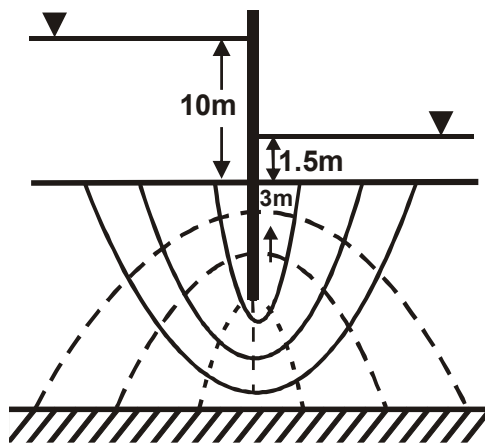
3. The ground conditions at a site are as shown in the figure. The water table at the site which was initially at a depth of 5m below the ground level got permanently lowered to a depth of 15m below the ground level due to pumping of water over a few years. Assume the following data
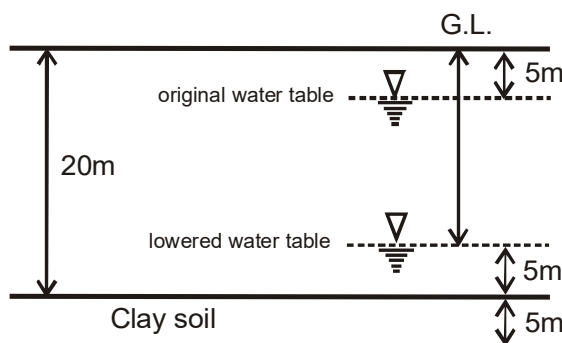

   i.   unit weight of water = $10 kN/m^3$
   ii.   unit weight of sand above water table = $18 kN/m^3$
   iii.   unit weight of sand and clay below the water table = $20 kN/m^3$
   iv.   coefficient of volume compressibility = $0.25 m^2/MN$

Find the change in the effective stress in kN/m^2 at mid-depth of the clay layer due to the lowering of the water table? Also find the compression of the clay layer in mm due to the lowering of the water table?

4. The ground conditions at a site are shown in the figure below
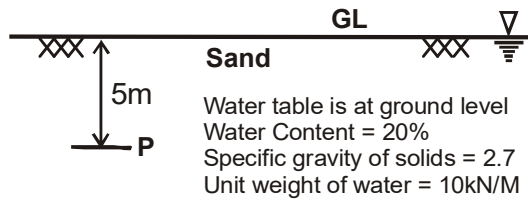
Find the saturated unit weight of the sand, also find the total stress, pore water pressure and effective stress at the point P.

5. A column is supported on a footing as shown in the figure below. The water table is at a depth of 10m below the base of the footing. Find the net ultimate bearing capacity of the footing based on Terzaghi's bearing capacity equation. Also find the safe load that the footing can carry with a factor of safety=3.

6. A bench mark has been established at the soffit of an ornamental arch at the known elevation of 100.0m above sea level. The back sight used to establish height of instrument is an inverted staff reading of 2.105m. A forward sight reading with normally held staff of 1.105m is taken on a recently constructed plinth. Find the elevation of the plinth.

7. Find the average horizontal and vertical permeability of a soil massmade up of 3-horizontal layers. The first and second layers have the same thickness of 0.5m each. The third layer is 1m thick. The coefficient of permeability of the first second and third layers are respectively 1×10^{-3} cm/s, 2×10^{-2} cm/s and 5×10^{-4} cm/s.

8. A concentrated point load of 200kN acts at the ground surface. Find the intensity of vertical pressure at the depth of 10m below the ground surface, and estimated on the axis of the loading. What will be the vertical pressure at a depth 5m and at a distance of 2m from the axis of loading? Use Boussineq analysis.

9. If 6, 9, and 15 days are t_o, t_m and t_p estimates of an activity respectively. Calculate the expected time, variance and standard deviation of the activity.

10. The three time estimates t_o, t_m and t_p of each activities of a project are given below:

Activity	t_o (days)	t_m (days)	t_p (days)
1-2	2	7	12
1-3	7	12	19
2-4	3	12	21
3-4	1	8	9
4-5	6	15	30
3-5	2	5	8

Draw the network diagram and find the expected duration and variance of each activity.

11. Draw a PERT network for the following project:
   (i) A is the first event and K is the end event.   (ii) J is a successor event to F.
  (iii) C and D are successor events to B.   (iv) D is a preceding event to G.
   (v) E and F occur after event C.

12. In a closed travers, 'latitudes' and 'departures' of the sides were calculated and it was observed that total summation of latitude = 1.39, and total departure= -2.17. Calculate the length and bearing of the closing error.

13. A road embankment 40m wide at formation level with side slope 1 to 1 and with an average height of 15m is constructed with an average gradient of 1 in 40 from contour 150m to 590 m. The ground has an average slope of 10 to 1 in direction transverse to the centre line. Find
    (i) Length of the road
    (ii) Volume of embankment in cubic metres

14. What is angle of repose? What is its relevance in the excavation of foundations?

15. Expain the various mode of slope failure.

16. A soft normally consolidated soil layer is 20m thick with moisture content of 45%. The clay has a saturated unit weight of 20kN/m^3, specific gravity=2.7, W_L=60% and subjected to a vertical stress increment of 10kpa. Water level is at the surface of clay. Estimate the initial effective stress at the centre of clay layer. (Assume density of water = 10kN/m^3).

17. Explain the various design aspects for footings.

18. A square footing is shown in figure. The footing will carry a gross mass of 30000kg. Determine the size of the footing. Assume factor of safety = 3.0.
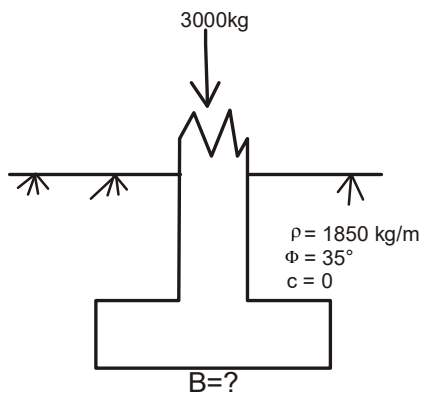
19. The length of a road stretch used for conducting the moving observer test is 0.5 km and the speed with which the test vehicle moved is 20 km/hr. Given that the number of vehicles encountered in the stream while the test vehicle was moving against the traffic stream is 107, number of vehicles that had overtaken the test vehicle is 10, and the number of vehicles overtaken by the test vehicle is 74, find the flow, density and average speed of the stream.

20. Let the cycle time of an intersection is 60 seconds, the green time for a phase is 27 seconds, and the corresponding yellow time is 4 seconds. If the saturation headway is 2.4 seconds/vehicle, the start-up lost time is 2 seconds/phase, and the clearance lost time is 1 second/phase, find the capacity of the movement per lane?

21. Derive the relationship between void ratio(e), specific gravity (G), water content (ω) and degree of saturation (Sr).

* * * * * * *