EXAMINATION OF CANDIDATES FOR CERTIFICATE OF QUALIFICATION AS ENGINEER.

September, 1911.

Laying Out and Constructing Roads, Bridges, &c.

1. What crushing test should be provided for with 18in. and 24in. earthenware drain pipes? Same information respecting circular reinforced concrete pipes of 24in. and 30in. diameter. State how such should be laid in made ground and the minimum amount of covering from the surface of a heavily-trafficed road.
2. Show design in pencil for a concrete culvert, with 15ft. clear span, on square, but crossing under a roadway at an angle of 30deg. Roadway to be 18ft. wide, with surface at least 2ft. clear of crown of arch; latter to be of reinforced concrete, and either semi or elliptic in shape; springing of arch to be 6ft. from rock foundation level; bank of creek 3ft. above latter. Plot at 4 feet to the inch half plan and elevation with section through abutment. Give area of waterway in square feet.
3. In reporting to a Council with respect to the roads of a private subdivision within a town or village, what requirements would you specify, the country being undulating, with a permanent watercourse crossing both the main and the subdivision roads leading out of same.
4. State how you would renew a solid capsill or headstock, 22ft. long x 12in. x 12in., of the centre pier of a timber bridge—the sill having corbels with girders (5) resting on same—the pier consisting of three piles, with 18ft. clearance between capsill and ground level.
5. Give the characteristics of good road metal and blinding, with your views as to the relative value of machine *versus* hand-broken stone.
6. I have a large heap of metal stacked on a piece of ground, falling longitudinally 1 in 20 and transversely 1 in 10, the width on top of heap being 3ft. and length 41ft.; depth in centre, 2ft. 3in. at top end and 3ft. at lower end; slopes 1 to 1. In the centre of the heap there is found a stump, 18in. diameter and 2ft. high, covered over. Give the contents of metal in the heap in cubic yards.

THEORY OF DESIGN OF STRUCTURES AND STRENGTH OF MATERIALS.

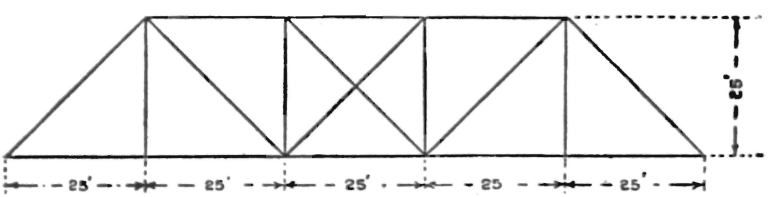
Five Questions only to be attempted.

1. Where does the maximum bending moment occur in a beam of 24 feet span carrying a load of 10 tons, uniformly spread over its whole length, and a further load of 12 tons uniformly spread over 8 feet to the right from a point 6 feet from the left support? What is the amount of the maximum bending moment, and what is the bending moment at mid span?

2. Describe and illustrate by sketches the method of designing a plate web girder, 40 feet span, for a road bridge, the girder to carry a uniformly distributed load of 2 tons per foot run.

3. Explain the terms "hardness," "toughness," and "brittleness" in connection with materials. Describe the behaviour of hard and soft materials when subjected to tension, compression, and transverse stress.

4. Determine the maxima stresses in the truss outlined below for a dead load of 20 tons at each panel point, and a moving load of 1 ton per foot run, the moving load to be placed for each member so as to give the maximum stress on that member.



5. Explain how you would find the deflection in the above truss with a dead loss of 20 tons at each panel point.

6. For the truss in Question 4, make sketches showing the top and bottom systems of lateral wind bracing also the sway and portal bracing. Explain how you would calculate the stresses, assuming all necessary data.

7. The truss in Question 4 is constructed of steel and rests on cast-iron bearings. Write a specification governing the supply of the steel and cast-iron, stating fully what tests you would require.

Drawing.

Make neat pencil drawings, suitable for tendering, of a road bridge over a creek, material to be all timber, with three openings, each 30ft. span, the width between the kerbs being 15ft.; the abutments are in loose ground; the height from bed of the creek to road level is 12ft. at each abutment and 15ft. at each pier.

The following sizes of timber are to be used:—Piles, 16in. diameter at butt for piers and abutments; for wings, 12in. diameter; sheeting behind abutments and wing piles, 8in. x 3in.; outside girders, hewn timbers, 14in. x 12in.; inner girders, round timber, 16in. diameter, hewn on top and bottom; caps of piles, two 12in. x 6in.; decking, 4in. planking; corbels, 14in. x 12in.; bracing of piers, 10in. x 5in.; handrail, 4in. x 4in.

Show, fully, how you would make the various joints.

IV.—Preparation of Specifications, Calculations of Quantities and Costs.

1. A Suburban Council in the metropolitan area proposes letting, by contract, the construction and full completion of a new first-class road, 66 feet wide, to carry heavy traffic, for a distance of half a mile, between certain points.

The following facts are to be assumed by the candidate in preparing the information asked, viz.:—

(1) The formation of the ground to be even.

(2) The Council has authority from owners of land abutting on the road to allow slopes of cuttings or embankments to extend on to private property where the land is vacant and not built on.

(3) The roadway to have a level cross-section; heights of finished building lines and centre of roadway to be level.

(4) Retaining walls to be of squared stone and built dry, axe dressed, rock face.

(5) Footpaths to be 12 feet wide, and to be tar-metalled.

(6) Gutters to be 2 feet wide.

(7) A sandstone quarry is situated a quarter of a mile from the site. The rock from excavations of roadway is suitable for ballasting and retaining walls, but not for kerbing and guttering, which must be obtained from the quarry above mentioned.

(8) Sufficient blue metal and toppings are obtainable in railway trucks, half a mile from the site; cost to the Council, 7s. 6d. per cubic yard.

(9) Surplus material over and above that used on the works may be deposited on a tip, 300 yards from the site of the excavations.

(10) Contractor to have free use of 12-ton steam road-roller and other usual road-making appliances owned by the Council.

The first section of the roadway described is to have an up-grade of 1 in 20; the remaining three sections to be on a regular down-grade of 1 in 75.

For the first section of 320 yards, where the adjoining land is vacant and not fenced in, the formation is in excavation through stiff clay. The cutting in this section will extend from nil, at starting point, to a depth of 9 feet at the end of the section.

In the second section, having a length of 1,200 feet, the formation is through rock, diminishing from 9 feet deep at the commencement to nil at the finish of this section. In this part, the rock is to be excavated vertically on the building line, and neatly scabbled at finish.

For the next 60 yards (section 3) the formation is in embankment, varying from nil to 12 feet deep, adjoining land being vacant.

For the remainder of the distance (4th section) the formation is in embankment, averaging 7 feet deep. It will be necessary in this section to erect vertical masonry walls on both sides of sufficient stability to retain roadway.

Prepare a specification for the full completion, in every detail, of a first-class roadway, including forming (stating slopes to cuttings or embankments), grading (stating convexity of roadway and slope of footpath), ballasting, metalling, kerbing and guttering (sandstone), retaining walls, guard fence, tar-metalling of footpaths, and all other essential work for full completion, giving particulars of quantities, in cubic yards, of each different class of work and material, showing in detail how the quantities have been arrived at; also an estimate of the total cost of the work to the Council, adopting what you consider present ruling prices, and making a fair allowance for contingencies.

Candidates also to give rough sketch, showing the cross-section of the roadway on each of the four different sections.

2. State clearly the general principles to be adopted in the finished formation of a main country road (say) between Penrith and Lawson, embracing flat and hilly country.

3. Draft a specification for a culvert—length, 50ft.; width of waterway, 3ft. 6in.; height from invert to underside of covering, 4ft. 6in., constructed as follows:—Walls of 14in. brickwork; invert of concrete, 3½in. thick; covering of timber, 4in. thick. Calculate the quantities of material, and express same in terms usually applied to each different class of work.

SURVEYING.

Candidates are allowed the use of Chambers's Mathematical Tables.
In calculations, candidates to work to two decimal places and to the nearest minute in angles or bearing.

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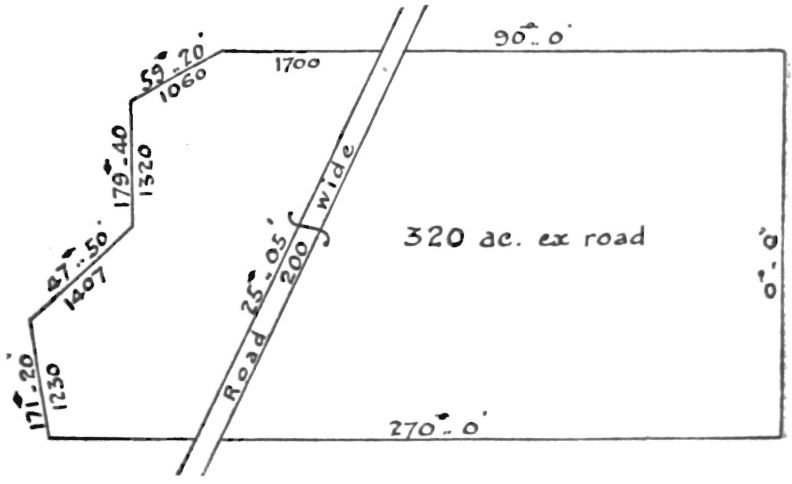
1. On the diagram attached the measurements of length are in links. The portion is to contain 320 acres *ex* road. Calculate the lengths of all the lines required to complete the survey, including the side lines of the road, and check your results by computing the area by double longitudes.



2. A pipe line has been laid on a curve of unknown radius joining two straight lengths. It is found that the tangents measure 83.2 feet, and that the contained angle is 156deg. 30sec.

   Find the length and radius of the curve, also the chord and the distance of the centre of the curve from the point of intersection.

3. The pipe line, as above, has been marked at every 50 feet to the commencement of the curve, which is found to start at 784.6 feet on the continuous chainage. It is desired to carry on this chainage round the curve, fixing the points with a theodolite by tangential angles. Calculate and tabulate the tangential bearings to be set off on the instrument, and fully describe how you would carry out the marking, and check the close of both bearings and chainage:—
   (*a*) If all the points can be observed from the tangent points.
   (*b*) If the two tangent points cannot be seen from one another.
4. In case (*a*) how could the curve be marked without chaining the chords? Describe the process.
5. The following staff readings have been taken with a dumpy level:—

Back sight	13.06	feet at	700 feet.
Intermediate sight ..	10.43	„	800 „
„ „ ..	6.86	„	900 „
Fore sight	1.22	„	1,000 „
Back sight	12.74	„	1,000 „
Intermediate sight ..	8.31	„	1,100 „
Fore sight	2.16	„	1,200 „

   The reduced level at the starting point is 100 feet above datum. Rule off the proper columns for booking these readings, enter the readings, compute the reduced level at each station, make the ordinary test checks of the calculations, and give the gradient between the extreme points.
6. Give method of testing and correcting theodolite:—
   (*a*) For error in collimation in azimuth.
   (*b*) For error in collimation in altitude.
7. State the methods you would adopt, apart from adjusting your theodolite, to eliminate slight errors in adjustment:—
   (*a*) In running a straight line.
   (*b*) In observing horizontal angles.

   State what errors are eliminated by the process you adopt.
8. Describe fully the adjustments of the dumpy level for parallax and collimation, and state what methods you would adopt in observations to eliminate all probable errors in adjustment.
9. In a triangle A.B.C. the length of A.B. is 55 feet, of A.C. 70 feet, and angle A is 53deg. 22sec. Find side B.C. and angles B and C, and compute the area of the triangle in square feet and in acres.

10. In a circle of 40 feet diameter a segment has a chord of 28 feet:—

Find (*a*) The versed sin of the segment.

(*b*) The distance from the centre of an ordinate 5 feet long.

(*c*) The area of the segment in square feet.

Hydraulic and Sanitary Engineering.

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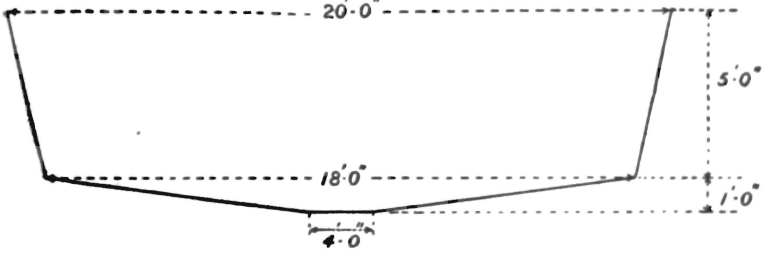
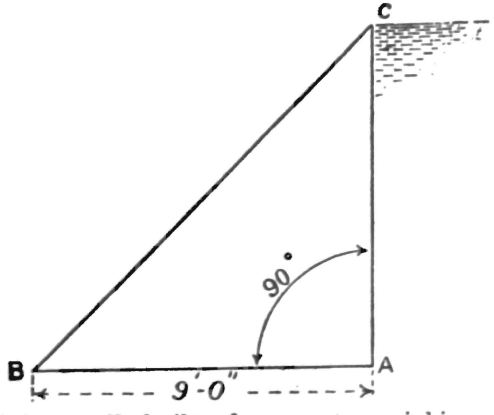
1. Calculate the volume of water which will be discharged per minute from a channel of the following section, which has a slope of 1 in 1,000, when the water is 1 foot from the top, and also when it is 3 feet from the top.



$V = C\sqrt{RS}$; where C = 138, R = the hydraulic mean depth, and S = the slope.



2. A retaining wall, built of concrete, weighing 150lb. per cubic foot, has a section as in sketch. It is just on the point of overturning about B, due to the pressure of the water, which is level with the top. What is the height of the wall AC?

3. A reservoir, made of steel plates, is 60 feet in diameter and 24 feet deep, the plates being in 6 rings; the strength of the vertical joints is 70 per cent. of that of the full section of the plate. What thickness plate is required for each of the rings so that the stress shall not exceed 16,000lb. per square inch?

4. A Pelton wheel, which develops 60 h.p., and has an efficiency of 65 per cent., is driven by water led to it through a 6-inch pipe, 1,000 feet long, from a reservoir at such a level as to give an effective pressure of 300 feet at the wheel. Calculate the quantity of water required per minute, and also the head lost in friction in the pipe, using for the latter the formula—

$$V = 130\sqrt{R}\,\frac{H}{1000} \text{ where}$$

v = Velocity per second.
R = Hydraulic mean radius in feet.
H = Head lost in friction.

5. If a pipe, 10 inches diameter, discharges 40,000 gallons per hour, what will be the discharge of a 14-inch and a 20-inch pipe respectively under the same conditions as to length and slope?

6. The difference in level between the water in the suction-well and the top water level in the reservoir is 250 feet; the quantity of water to be raised is 30,000 gallons per hour; the friction in the pipe is 20 feet. What size pump would you recommend for this work, the piston speed not to exceed 120 feet per minute; and what is the effective horse-power exerted?

7. What is meant by the separate system of sewerage, and what is the advantage claimed for it?

8. Describe a method of purifying sewerage so that it can be discharged into a river without causing a nuisance?

9. What is the pneumatic system of sinking cylinders through water-bearing strata? Give a sketch showing the construction of such a cylinder.

10. A fall of 5 feet and a flow of 100 gallons a minute supplies a hydraulic ram. What quantity of water will it deliver to a height of 80 feet?