UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF ENGINEERING TECHNOLOGY *CIVIL ENGINEERING*
SUBJECT	:	**TRANSPORTATION ENGINEERING 2A**
CODE	:	**TRACIA2**
DATE	:	WINTER EXAMINATION 08 JUNE 2019
DURATION	:	SESSION 1 (08:30 – 11:30)
WEIGHT	:	40: 60
FULL MARKS	:	102
TOTAL MARKS	:	100

EXAMINER	:	Mrs MA Kasenge
MODERATOR	:	Dr HA Quainoo
NUMBER OF PAGES	:	5 PAGES AND 7 ANNEXURES

INSTRUCTIONS	:	**QUESTION PAPERS MUST BE HANDED IN.**
	:	CALCULATOR (ONE PER CANDIDATE)
	:	ANSWER ALL THE QUESTIONS

Programmable calculators will be allowed (one per candidate). Candidates are warned to erase from the memory of any calculator in their possession that can store alpha characters as text, notes or other information that could in any way assist in answering written ("theory") questions. If this instruction is not complied with it will be deemed that the candidate has in his possession under examination rules illegal material and will be disqualified.

QUESTION 1

Two tangents AB and BC intersect at B (see fig.1). Another line DE intersects AB and BC at D and E such that $\angle ADE = 150°$ and $\angle DEC = 140°$. The radius of the first curve is 200 m and that of the second is 300 m. The chainage of B is 950 m.

The necessary information is presented on the diagram below.

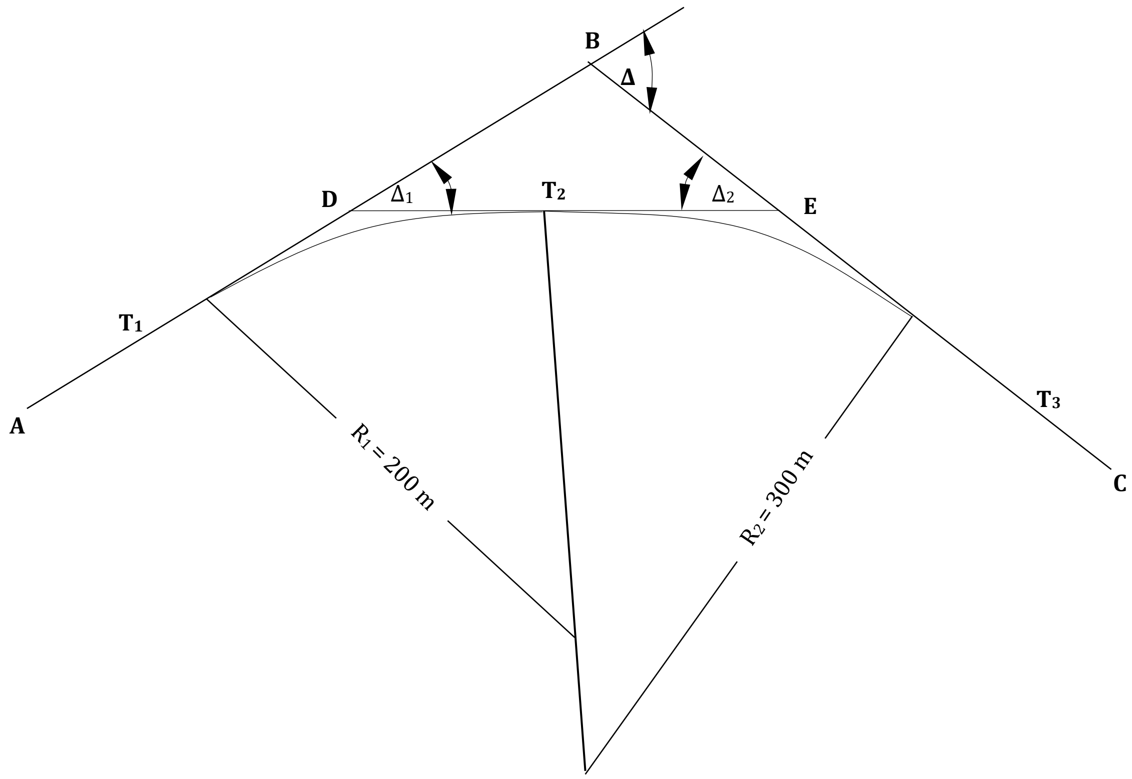

Figure 1: Layout of a compound curve

Calculate:

1.1 The chainages of beginning of curve (BC), point of compound curve (PCC) and end of curve (EC) measured along the centerline of the road. (15)

1.2 What is the length of the forward tangent B to EC (2)

1.3 Compute the deflection angles on full chainages for setting out the compound curve at 50 m intervals. Prepare a table giving chainages, chords, offset angles and deflection angles for staking from PC to PCC. (18)

[35]

QUESTION 2

A highway has the following conditions:

- Design Speed = 110 km/h
- Superelevation = 8.82 %
- Lane Width = 3.7 m
- Longitudinal Grade = +1.5 %
- Cross section = 4-lane undivided highway
- Cross section grade = 2% (Normal Camber)
- Deflection angle between tangents = 32°
- Chainage of the PI is 12 000:
- Elevation of AC = 1200 m.

2.1 Determine the minimum radius of the circular curve (round off to nearest 10 m). (3)

2.2 Determine the length of tangent runout and length of superelevation runoff. (round off to nearest 10 m) (4)

2.3 Draw a fully labelled the superelevation development diagram (SDD). (10)

2.4 Compute the chainages along the SDD at the following points: (5)

A. Normal Camber.

B. Adverse Camber

C. Normal Crossfall

D. Beginning of Curve

E. Full Superelevation

2.5 Determine the elevations along the centreline, on left hand and right hand edges at: (10)

A. Normal Camber.

B. Adverse Camber

C. Normal Crossfall

D. Beginning of Curve

E. Full Superelevation

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QUESTION 3

A grade of -4.2% grade intersects a grade of +3.0% at Chainage11+ 480 of elevations 1220.80 meters. These two centre grade lines are connected by a 260-meter vertical parabolic curve.

3.1. At what chainage is the cross-drainage pipes be situated? (9)

3.2. If the diameter of the reinforced concrete pipe to be installed is 90 cm, and the top of the culvert is 45 cm below the subgrade, what will be the invert elevation at the centre? (6)

[15]

QUESTION 4

The area of the drainage basin upstream of a proposed highway culvert is 1900 hectares (as shown on the fig.2 below). The drainage basin is in Richards Bay and has an average annual rainfall of 1200 mm.

The natural basin has soils and surface cover that is reasonably homogeneous with mostly light woodlands and brush.

There are two distinct flow paths converging in the lower area at C. Path AC is about 500 m of overland flow over medium grass pasture and 2550 m of grassed waterway. Path BC is about 500 m of overland flow over a medium grass pasture and 3510 m grassy waterway. Path CD is a concrete lined channel.

Local zoning allows light industry in an area adjacent to the highway. The combination of highway improvements and growth in the region make full development of the zoned area attractive and likely within the next few years.

Find the peak discharge for a 10-year return period for the Natural drainage basin and the drainage basin after future development in the zoned area (figure 2 on the next page).

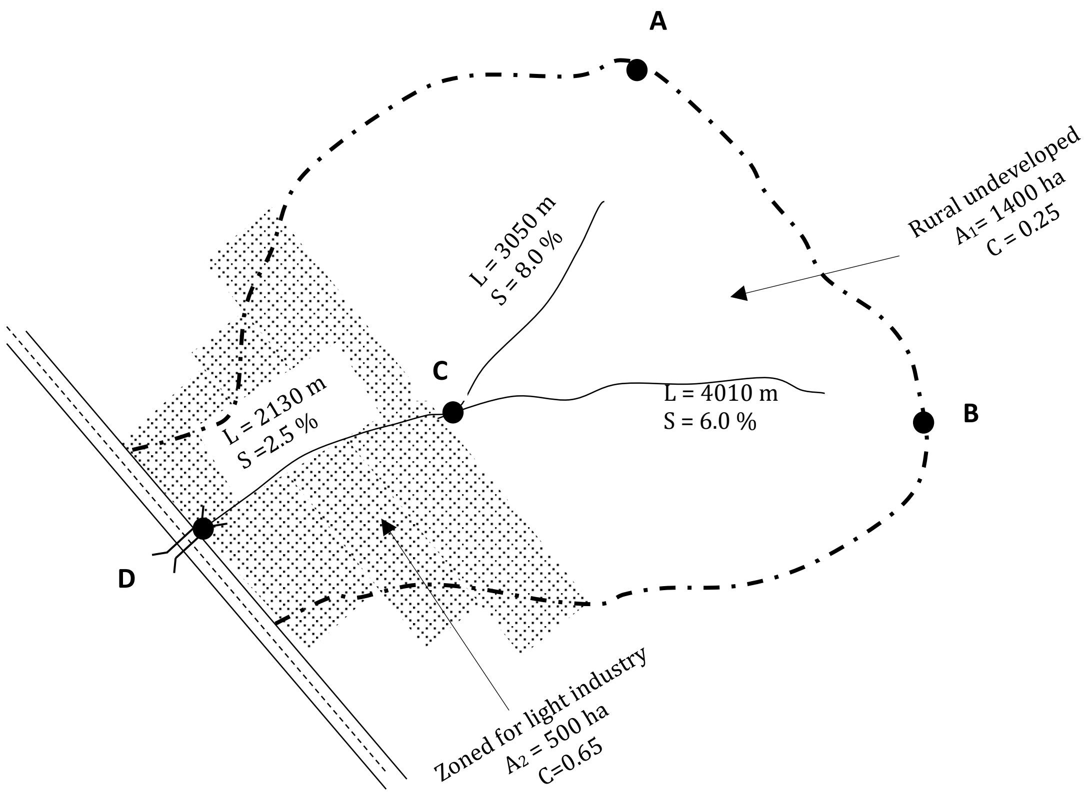

Figure 1: Drainage basin in Richards Bay Coast

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BACHELOR OF ENGINEERING TECHNOLOGY

CIVIL ENGINEERING

TRANSPORTATION ENGINEERING 2B

TRACIA2

FORMULA SHEET

AND

ANNEXURES

WINTER EXAMINATIONS

08 JUNE 2019

PREPARED BY MRS MA KASENGE

Horizontal Alignment	— $L = \frac{R\pi\Delta}{180}$ — $T = R\tan\left(\frac{\Delta}{2}\right)$ — $\text{Deflection angle} = \frac{\text{Chord length(l)}}{\text{Curve length(L)}} * (\frac{\Delta}{2})$ — $\text{Chord length} = 2\,R\,\text{Sin}\,(\frac{\Delta}{2})$ — $M = R\left[1 - \text{Cos}\left(\frac{\Delta}{2}\right)\right]$ — $E = R\left[\text{Sec}\left(\frac{\Delta}{2}\right) - 1\right]$ — $Dc = 100R\ (\text{radian}) = \frac{5729.58}{R}(\text{degrees})$
Superelevation	— $R_{min} = \frac{V^2}{127(e+f_s)}$ — $f_s = 0.21 - 0.001V$ — $L = \frac{(w\ n)e_d}{\Delta} * b$
Vertical Alignment	— $Y = ax^2 + bx + c$ — $A = G_2 - G_1$ — $a = \frac{A}{200L}$ — $b = \frac{G_1}{100}$ — $C = \text{Elev @ BC}$ — $K = \frac{L}{\lvert A\rvert}$ — $\frac{dy}{dx} = 2ax + b$ — $Xhl = K * G1$ — $Y = \frac{Ax^2}{200L}$ — $Ym = \frac{AL}{800}$ — $Yf = \frac{AL}{200}$

Horizontal Alignment **Sight Distance**	— $SSD = vt + \frac{v^2}{2g(f \pm G)}$ — $SSD = 0.278\ V\ t + \frac{V_1^2 - V_2^2}{254(f \pm G)}$ — $SSD = 0.694\ V + \frac{V^2}{254(f \pm G)}$ — $PSD = d_1 + d_2 + d_3 + d_4$ — $d_1 = \frac{t_1(v_1 + v_2)}{2}$ — $d_2 = v_2 t_2$ — $d_4 = \frac{2}{3} d_2$
Vertical Alignment **Sight Distance**	— $L_{min} = \frac{AS^2}{200(\sqrt{H_1} + \sqrt{H_2})^2} = \frac{AS^2}{647.5} (for\ S < L\ ) Crest$ — $L_{min} = 2S - \frac{200(\sqrt{H_1} + \sqrt{H_2})^2}{A} = 2S - \frac{647.5}{A}\ (for\ S > L) Crest$ — $L_{min} = 2S - \frac{200(H + S \tan\beta)}{A} = 2S - \frac{(120 + 3.5S)}{A}\ (for\ S > L) Sag$ — $L_{min} = \frac{AS^2}{200(H + S \tan\beta)} = \frac{AS^2}{120 + 3.5S} (for\ S < L)\ Sag$
Hydrology and Runoff	— $Tc(overland) = 0.604 * \left(\frac{rL}{S^{0.5}}\right)^{0.467}$ — $Tc(watercourse) = [\frac{0.87L^2}{1000S}]^{0.385}$ — $S_o = Lc * \frac{h}{10A}$ — $S = \frac{H1 - H2}{L} * 100$ — $C = (C_S + C_P + C_V) * F_T$ — $Q = \frac{CIA}{3.6}$
Culvert Design	— $ho = \frac{D + dc}{2}$ — $dc_{Portal} = 0.467 * \sqrt[3]{\left(\frac{Q}{B}\right)^2}$ — $HWo = H + ho - LS$

BRAKE FORCE COEFFICIENTS FOR VARIOUS SPEEDS	
Speed (Km/h)	Brake Force Coefficients
40	0.37
60	0.32
80	0.30
100	0.29
120	0.28
140	0.27

Table 4.7: Maximum relative gradients

Design speed (km/h)	Maximum relative gradient (%)	Equivalent maximum relative slope 1:
40	0,72	140
50	0,68	147
60	0,64	156
70	0,60	167
80	0,56	179
90	0,52	192
100	0,48	208
110	0,44	227
120	0,40	250
130	0,35	286

Table 4.8: Lane adjustment factors

Number of lanes rotated, n	Adjustment factor, b	Length increase relative to one lane rotated
1	1	1,00
1,5	0,83	1,25
2	0,75	1,50
2,5	0,70	1,75
3	0,67	2,00
3,5	0,64	2,25

For other values of n, use the equation b = [1 + 0,5(n-1)]/n

Table 4.12: Minimum values of k for crest curves				
Design speed (km/h)	Stopping sight distance (m)	K-Value for height of object (m) equal to		
		0,0	0,15	0,6
40	50	12	6	4
50	70	25	12	8
60	90	40	20	12
70	110	60	30	18
80	140	90	50	30
90	170	140	70	45
100	200	190	100	60
110	230	250	130	80
120	270	350	180	110
130	310	460	240	150

Table 4.14: Minimum k-values for sag curves		
Design speed (km/h)	K-Value	
	Headlight distance	Comfort
40	8	4
50	14	6
60	20	9
70	25	12
80	30	16
90	40	20
100	50	25
110	60	30
120	70	36
130	80	43

Recommended values for r	
Clean compacted soil, no stones	r = 0.10
Paved areas	r = 0.02
Sparse grass over fairly rough surface	r = 0.30
Medium grass cover	r = 0.40
Thick grass cover	r = 0.80

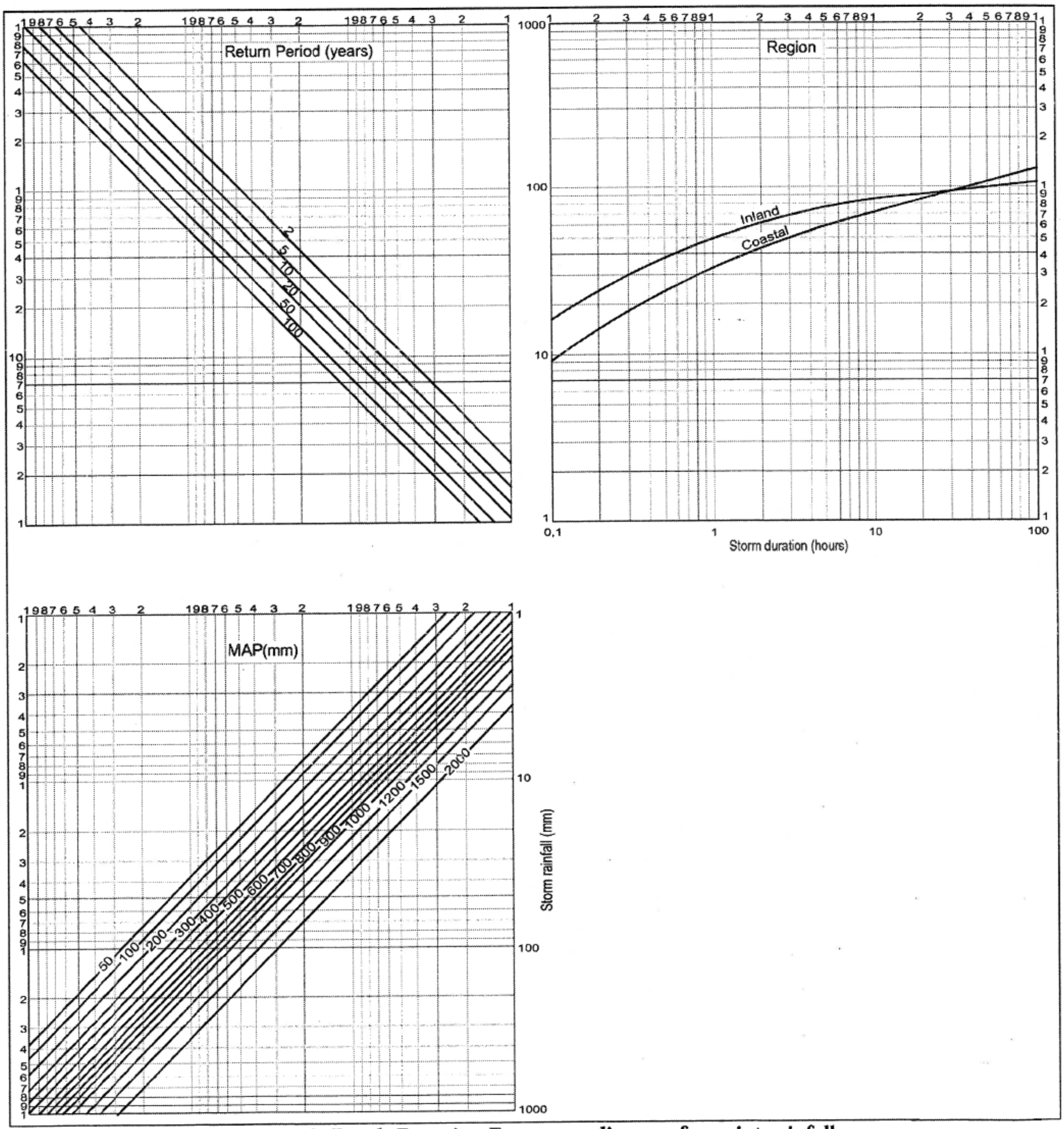

Figure 3.6: Depth-Duration-Frequency diagram for point rainfall

RATIONAL METHOD

LEGEND TABLE Rational method	
ID	**Reference**
⓪	Figure 3.7
①	Table 3C.1
②	Table 3C.2
③	Table 3C.3
④	Table 3C.4
⑤	Table 3C.5
⑥	Figure 3.6
⑦	Figure 3.20 or 3.21

Table 3C.1

Rural (C_1)				
Component	**Classification**	**Mean annual rainfall (mm)**		
		600	**600 - 900**	**900**
Surface slope (C_S)	Vleis and pans (<3%)	0,01	0,03	0,05
	Flat areas (3 to 10%)	0,06	0,08	0,11
	Hilly (10 to 30%)	0,12	0,16	0,20
	Steep areas (>30%)	0,22	0,26	0,30
Permeability (C_P)	Very permeable	0,03	0,04	0,05
	Permeable	0,06	0,08	0,10
	Semi-permeable	0,12	0,16	0,20
	Impermeable	0,21	0,26	0,30
Vegetation (C_V)	Thick bush and plantation	0,03	0,04	0,05
	Light bush and farm-lands	0,07	0,11	0,15
	Grasslands	0,17	0,21	0,25
	No vegetation	0,26	0,28	0,30

Table 3C.2

Urban (C_2)	
Use	**Factor**
Lawns	
Sandy, flat (< 2%)	0,05 - 0,10
Sandy, steep (>7%)	0,15 - 0,20
Heavy soil, flat (< 2%)	0,13 - 0,17
Heavy soil, steep (>7%)	0,25 - 0,35
Residential areas	
Houses	0,30 - 0,50
Flats	0,50 - 0,70
Industry	
Light industry	0,50 - 0,80
Heavy industry	0,60 - 0,90
Business	
City centre	0,70 - 0,95
Suburban	0,50 - 0,70
Streets	0,70 - 0,95
Maximum flood	1,00

Table 3C.3

Surface description	Recommended value of r
Paved areas	0,02
Clean compacted soil, no stones	0,1
Sparse grass over fairly rough surface	0,3
Medium grass cover	0,4
Thick grass cover	0,8

Table 3C.4

Adjustment factor to C_s	
Surface slope classification	D_{factor}
Steep areas (slopes >30%)	0,50
Hilly (10 to 30%)	0,35
Flat areas (3 to 10%)	0,20
Vleis and pans (slopes <3%)	0,10

Table 3C.5

Return period (years)	2	5	10	20	50	100
Adjustment factor (F_t) for steep and impermeable catchments	0,75	0,80	0,85	0,90	0,95	1,00
Adjustment factor (F_t) for flat and permeable catchments	0,50	0,55	0,60	0,67	0,83	1,00