OCD057

UNIVERSITY OF BOLTON

WESTERN INTERNATIONAL COLLEGE FZE

BENG (HONS) CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2018/2019

GROUND AND WATER STUDIES 2

MODULE NO: CIE5005

Date: Tuesday 28th May 2019 **Time: 10.00am - 1.00pm**

INSTRUCTIONS TO CANDIDATES:

There are SIX questions on this paper.

Answer ANY FIVE questions.

Answer SECTION A and SECTION B on separate answer books.

All questions carry equal marks. Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Formula sheet/supplementary information is provided at the end of each section or along with it.

Graph paper will be provided in the examination hall.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

University of Bolton
Western International College FZE
BEng (Hons) Civil Engineering
Semester 2 Examination 2018/2019
Ground and Water Studies 2
Module No. CIE5005

SECTION A

Question 1

Consolidated drained triaxial tests were carried out on three identical specimens (each 38mm diameter and 76mm long) of the same soil sample (saturated clay) and the following data was recorded as shown in Table 1

Table 1

Specimen		**1**	**2**	**3**
Cell Pressure	(kPa)	100	200	400
Ultimate Axial Load	(kN)	0.168	0.344	0.696
Change in length	(mm)			
During consolidation ,	ΔHc	0.73	1.77	2.82
During axial loading ,	ΔHa	9.38	12.24	15.38
Change in Volume	(ml)			
During consolidation ,	ΔVc	2.48	6.02	9.90
During axial loading ,	ΔVa	5.93	6.05	6.07

Using the Mohr-Coulomb failure criterion, determine the **drained shear strength parameters.**

Note :

(i) To draw the Mohr circle, use the graph paper provided.

(ii) The cross sectional area at failure ,

$$A = A_0 \frac{1-\left(\frac{\Delta V}{V_0}\right)}{1-\left(\frac{\Delta h}{h_0}\right)}$$

Total 20 marks

Please turn the page

Question 2

(a) A flexible raft foundation of length 36m and breadth 12m imposes a contact pressure of 155kN/m^2 on the surface of the foundation soil. Determine the vertical stress at a depth of 12m :

i. Below one corner of the foundation

ii. Below the centre of the foundation.

(8 marks)

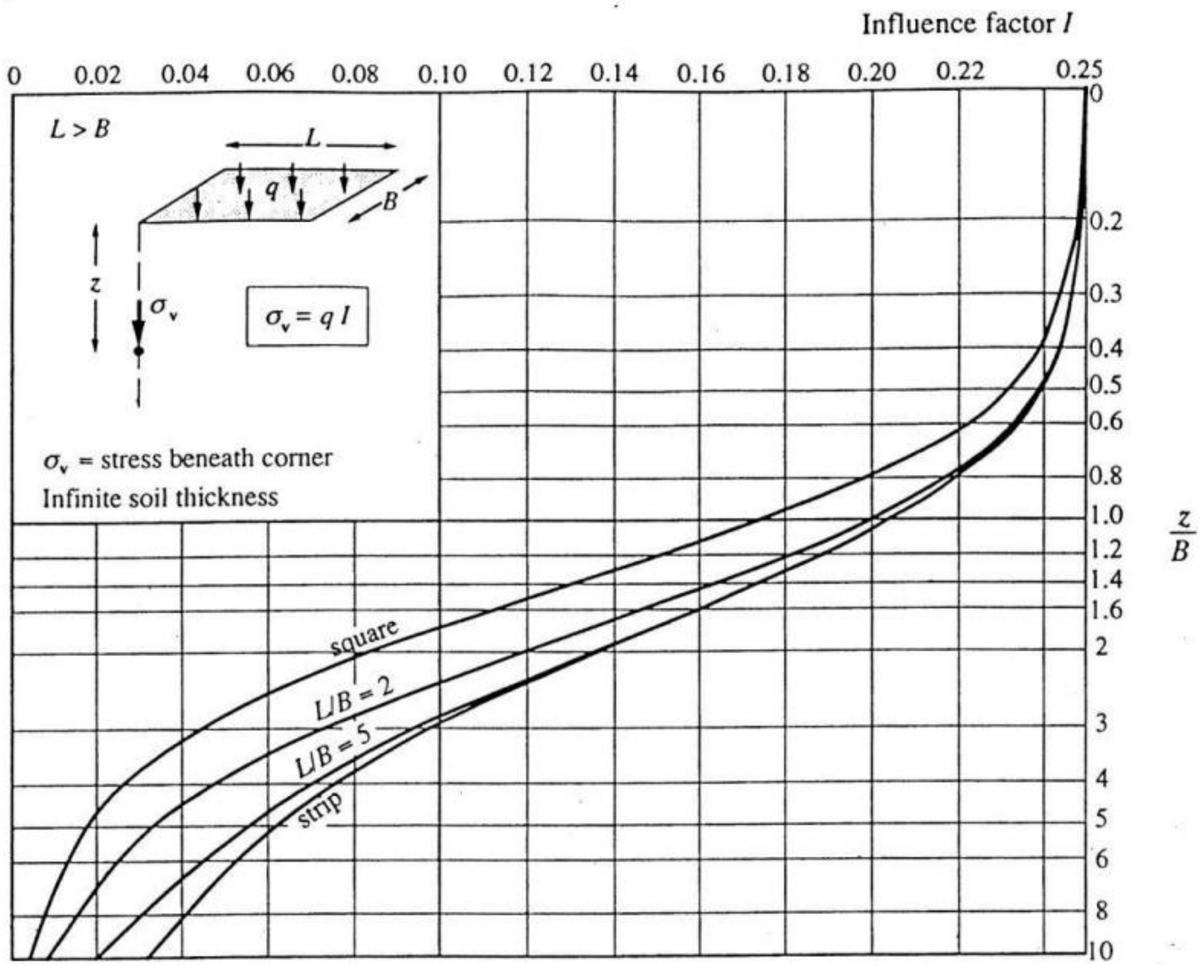

Figure Q2(a). Influence values for vertical stress (Giroud's chart)

Question 2 is continued over to the next page

Please turn the page

Question 2 continued.

(b) A sediment settling lagoon has a depth of water of 4m above the saturated sand base. The sand layer is 3m thick and this overlies 5m thick clay, which in turn overlies impermeable rock as shown in **Figure Q2(b).**

i. Calculate the effective stress, pore water pressure and total stress at each layer and sketch the stress profiles with respect to the depth.

ii. Calculate the total stress and effective stress after draining the lagoon and the water table remains **at** the surface of the soil. Comment on how the depth of water above the soil affects the effective stress of soil.

(12 marks)

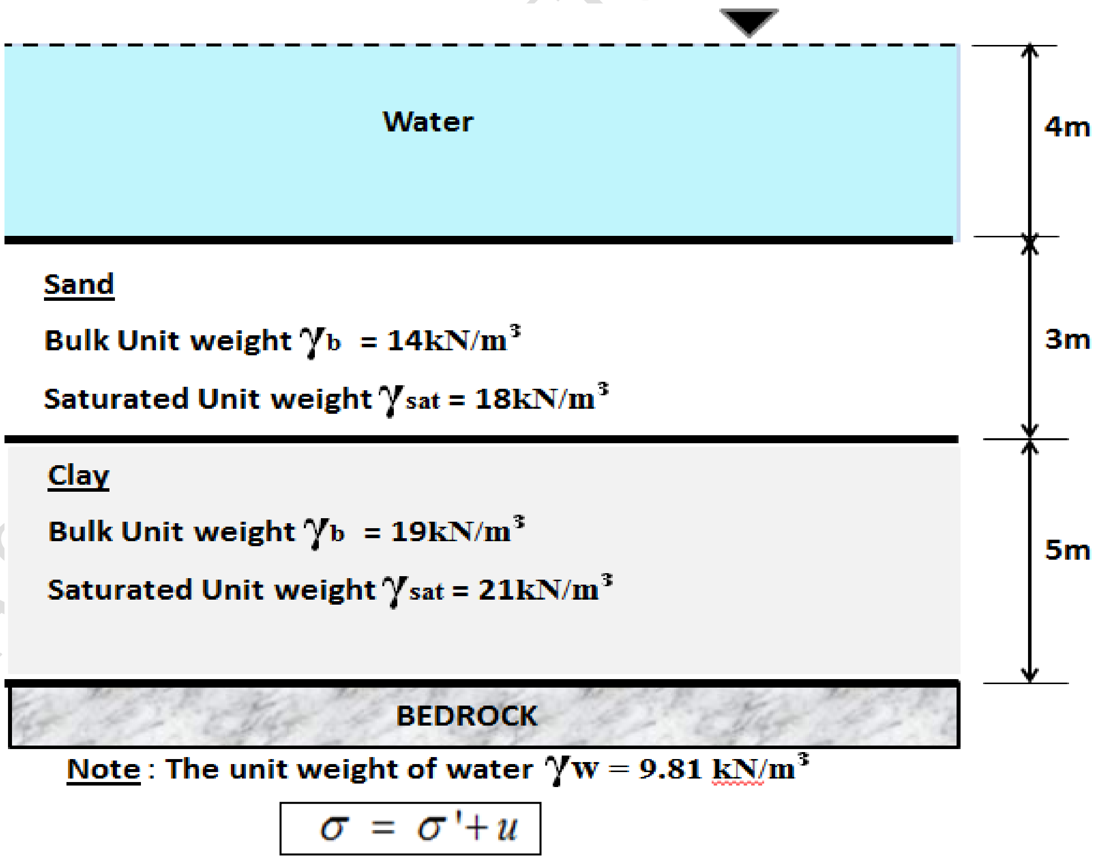

Figure Q2(b)

Total 20 marks

END OF SECTION A

Please turn the page for Section B

Please turn the page

SECTION B

Question 3

(a) State the basic hydraulic principles which apply in water network analysis.

(4 marks)

(b) A pipe network System A is shown below in **Figure Q3**. Water flows from reservoir A to two service reservoirs B and C as shown. Using the information given in **Table Q3-1**,

i. Make a sensible first estimate for the head at the pipe junction J in the given system. Briefly explain the reasons for your selections.

(2 marks)

ii. Using Flow balancing method, ascertain a first estimate of the level of error in your initial assumption using Table Q3-2. Explain how you have determined the errors.

(12 marks)

iii. Determine the correction factor for pipe junction height and the new head at the pipe junction.

(2 marks)

Candidates should complete **Table Q3-2 provided** on page 12 and hand in with the answer. HRS tables are provided.

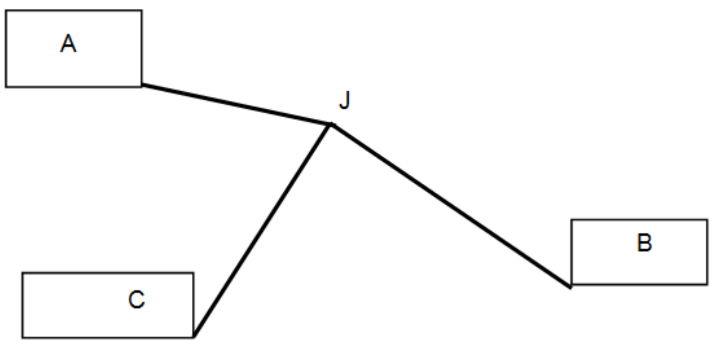

Figure Q3. Pipe Network system A

Question 3 is continued over to the next page

Please turn the page

Question 3 continued.

Table Q3-1

Reservoir	Pipe	Diameter (mm)	Length (m)	Ks(mm)	Water Level AOD (m)
A	A - J	300	800	0.03	200
B	B - J	250	1000	0.03	175
C	C - J	150	400	0.03	185

Total 20 marks

Question 4

(a) Explain what is meant by the term "separate sewerage system" and outline its operational benefits and drawbacks as compared to other sewerage systems.

(5 marks)

(b) Details of an existing surface water drainage system are given in **Table Q4-1.** Using the Rational Method of design, check the suitability of the drainage design and select a suitable pipe diameter for pipe 1.2. Use **Table Q4-2** on page 13. The rainfall return period is 1 in 10 years, the time of entry is 5.0 minutes and the pipe roughness k_s is 1.5mm.**Rainfall Table and HRS tables are provided.**

(15 marks)

Table Q4-1

Pipe Ref No	Pipe Length, L (m)	Pipe gradient (1 in)	Imp. Area (ha)	Pipe dia. (mm)
1.00	50	56	0.025	100
1.01	60	105	0.20	250
2.00	125	83	0.04	125

1.02	75	125	0.08	…..

Total 20 marks

Please turn the Page

Question 5

(a) Water flows from reservoir A to reservoir B through a 300 mm dia, 2500 m long pipe and λ= 0.02.

i. Calculate the discharge through the pipe if the top water level in the reservoir A is 400.0m AOD and level at Reservoir B is 335.0m AOD. (5 marks)

ii. If the discharge is to be increased to 250 litres/s, what will be diameter of a parallel pipeline of length 1500m to be provided to accommodate the flow if the frictional head loss remains the same? Take λ= 0.02 for both pipes. Neglect all minor losses. (10 marks)

(b) A 200mm diameter sewer (k_s = 0.03mm) is required to deliver 0.045m^3/s from a residential area. Determine the minimum gradient at which the sewer should be laid for it not to be surcharged. Comment on the velocity of flow for the same (**HRS Tables is provided.)** (5 marks)

Total 20 marks

Question 6

(a) An old water main, having a k_s value of 1.5mm, has a diameter of 150mm and is 800m in length with a flow rate of 27 litres/sec. Find the value of friction factor using Barr's Equation. Also determine the difference in the pipe levels at the inlet and outlet, if the pressure recorded at the inlet is 2.5 bar and the pressure recorded at the outlet is 1.851 bar. Take the coefficient of dynamic viscosity μ for water as 1.14 x 10^{-3} kg/ms. (13 marks)

(b) With the aid of sketches explain what is meant by the laminar sub-layer and

and how it varies with Reynolds Number. Use suitable diagrams and equations to support your findings. (7 marks)

Total 20 marks

END OF QUESTIONS

Please turn the page for supplementary information for SECTION B

Please turn the page

<u>Formulae Sheet</u>

$$h_f = S_0.L$$

$$\Delta H = \frac{2\Delta Q}{\sum Q/h_f}$$

$$z_1 + \frac{v_1^2}{2g} + \frac{P_1}{\rho g} = z_2 + \frac{v_2^2}{2g} + \frac{P_2}{\rho g} + h_f$$

$$Q = AV$$

$$h_f = \frac{\lambda L Q^2}{12.1.d^5} = \frac{\lambda L v^2}{2gd}$$

$$R_e = \frac{\rho v D}{\mu} = \frac{vD}{\upsilon}$$

$$\upsilon = \frac{\mu}{\rho}$$

$$\frac{1}{\sqrt{\lambda}} = -2\log\left[\frac{k_s}{3.7d} + \frac{5.1286}{R_e^{0.89}}\right]$$

$$Q = 2.78.A_p.i$$

Supplementary information continued over the page.

Please turn the page

Supplementary information continued.

TABLE 7

Rates of Rainfall in mm/h for a range of duration and return period for a specified location in the United Kingdom

National Grid Reference 4833E 1633N

RETURN PERIOD (YEARS)

DURATION	1	2	5	10	20	50	100
2.0 MINS	85.6	93.4	120.5	138.3	158	187	213
2.5 MINS	76.5	87.5	113.4	130.4	149	177	202
3.0 MINS	66.3	82.3	107.2	123.4	141	168	192
3.5 MINS	62.8	77.8	101.7	117.3	135	161	184
4.0 MINS	59.6	73.8	96.8	111.8	128	154	176
4.1 MINS	59.1	73.1	95.9	110.8	127	152	174
4.2 MINS	58.5	72.3	95.0	109.8	126	151	173
4.3 MINS	57.9	71.6	94.1	108.8	125	150	172
4.4 MINS	57.4	71.0	93.2	107.9	124	149	170
4.5 MINS	56.9	70.3	92.4	106.9	123	148	169
4.6 MINS	56.3	69.6	91.6	106.0	122	146	168
4.7 MINS	55.8	69.0	90.8	105.1	121	145	166
4.8 MINS	55.3	68.3	90.0	104.2	120	144	165
4.9 MINS	54.8	67.7	89.2	103.4	119	143	164
5.0 MINS	54.3	67.1	88.5	102.5	118	142	163
5.1 MINS	53.9	66.5	87.7	101.7	117	141	162
5.2 MINS	53.4	65.9	87.0	100.9	116	140	160
5.3 MINS	53.0	65.4	86.3	100.1	115	139	159
5.4 MINS	52.5	64.8	85.6	99.3	115	138	158
5.5 MINS	52.1	64.3	84.9	98.5	114	137	157
5.6 MINS	51.7	63.7	84.2	97.8	113	136	156
5.7 MINS	51.2	63.2	83.5	97.0	112	135	155
5.8 MINS	50.8	62.7	82.9	96.3	111	134	154
5.9 MINS	50.4	62.2	82.3	95.6	110	133	153
6.0 MINS	50.0	61.7	81.6	94.9	110	132	152
6.2 MINS	49.3	60.7	80.4	93.5	108	130	150
6.4 MINS	48.5	59.8	79.2	92.2	107	129	148
6.6 MINS	47.8	58.9	78.1	90.9	105	127	146
6.8 MINS	47.1	58.0	77.0	89.6	104	125	144
7.0 MINS	46.4	57.2	75.9	88.4	102	124	143
7.2 MINS	45.8	56.4	74.9	87.3	101	122	141
7.4 MINS	45.2	55.6	73.9	86.1	100	121	139
7.6 MINS	44.5	54.8	72.9	85.0	99	119	138
7.8 MINS	44.0	54.1	71.9	84.0	97	118	136
8.0 MINS	43.4	53.4	71.0	82.9	96	117	135
8.2 MINS	42.8	52.7	70.1	81.9	95	115	133
8.4 MINS	42.3	52.0	69.3	81.0	94	114	132
8.6 MINS	41.8	51.4	68.4	80.0	93	113	131
8.8 MINS	41.2	50.7	67.6	79.1	92	112	129
9.0 MINS	40.8	50.1	66.8	78.2	91	110	128
9.2 MINS	40.3	49.5	66.0	77.3	90	109	127
9.4 MINS	39.9	49.0	65.3	76.4	89	108	125
9.6 MINS	39.4	48.4	64.6	75.6	88	107	124
9.8 MINS	39.0	47.9	63.8	74.8	87	106	123
10.0 MINS	38.6	47.4	63.1	74.0	86	105	121
10.5 MINS	37.6	46.1	61.5	72.1	84	102	118
11.0 MINS	36.7	44.9	59.9	70.2	82	100	116
11.5 MINS	35.8	43.8	58.4	68.5	80	97	113
12.0 MINS	35.0	42.8	57.0	66.9	78	95	111
12.5 MINS	34.2	41.8	55.7	65.4	76	93	108
13.0 MINS	33.4	40.8	54.4	64.0	75	91	106
13.5 MINS	32.7	39.9	53.3	62.6	73	89	104
14.0 MINS	32.0	39.1	52.1	61.3	72	87	102
14.5 MINS	31.4	38.3	51.0	60.0	70	86	100
15.0 MINS	30.8	37.5	50.0	58.8	69	84	98
16.0 MINS	29.6	36.1	48.1	56.6	66	81	94
17.0 MINS	28.6	34.8	46.3	54.6	64	78	91
18.0 MINS	27.6	33.5	44.7	52.7	62	76	88
19.0 MINS	26.7	32.4	43.2	51.0	60	73	85
20.0 MINS	25.9	31.4	41.8	49.3	58	71	83

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Supplementary information continued.

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3
continued

ks = 0·030 mm
i = 0·004 to 0·1
ie hydraulic gradient = 1 in 250 to 1 in 10

Water (or sewage) at 15° C
full bore conditions.
velocities in m/s
discharges in l/s

Gradient	Pipe diameters in mm: 50	75	80	100	125	150	175	200	225	250	275	300
0.00400	0.372	0.494	0.516	0.601	0.699	0.790	0.874	0.955	1.031	1.104	1.175	1.243
1/ 250	0.730	2.181	2.595	4.722	8.578	13.952	21.033	29.995	41.003	54.216	69.782	87.847
0.00420	0.382	0.507	0.530	0.618	0.718	0.811	0.898	0.980	1.059	1.134	1.206	1.276
1/ 238	0.750	2.241	2.666	4.851	8.811	14.329	21.598	30.798	42.099	55.661	71.639	90.179
0.00440	0.392	0.521	0.544	0.634	0.736	0.832	0.921	1.005	1.086	1.163	1.237	1.308
1/ 227	0.770	2.300	2.736	4.977	9.038	14.697	22.151	31.584	43.170	57.074	73.454	92.460
0.00460	0.402	0.534	0.558	0.649	0.755	0.852	0.943	1.030	1.112	1.191	1.267	1.340
1/ 217	0.790	2.357	2.804	5.100	9.260	15.057	22.692	32.353	44.219	58.457	75.230	94.692
0.00480	0.412	0.546	0.571	0.665	0.772	0.872	0.965	1.054	1.138	1.218	1.296	1.371
1/ 208	0.809	2.414	2.870	5.221	9.478	15.410	23.222	33.107	45.246	59.812	76.970	96.878
0.00500	0.421	0.559	0.584	0.680	0.790	0.892	0.987	1.077	1.163	1.246	1.325	1.401
1/ 200	0.828	2.469	2.936	5.339	9.692	15.756	23.742	33.845	46.253	61.140	78.675	99.020
0.00550	0.445	0.589	0.616	0.716	0.832	0.939	1.039	1.134	1.225	1.311	1.394	1.474
1/ 182	0.873	2.602	3.095	5.626	10.210	16.594	24.999	35.633	48.689	64.353	82.802	104.205
0.00600	0.467	0.618	0.646	0.751	0.872	0.984	1.089	1.189	1.283	1.374	1.461	1.544
1/ 167	0.916	2.731	3.247	5.901	10.706	17.397	26.204	37.345	51.023	67.431	86.753	109.169
0.00650	0.488	0.646	0.675	0.785	0.911	1.028	1.138	1.241	1.340	1.434	1.525	1.612
1/ 154	0.958	2.854	3.393	6.165	11.183	18.168	27.363	38.991	53.265	70.388	90.550	113.938
0.00700	0.509	0.673	0.703	0.817	0.949	1.070	1.184	1.292	1.394	1.492	1.586	1.677
1/ 143	0.999	2.973	3.534	6.420	11.643	18.913	28.479	40.578	55.427	73.238	94.210	118.534
0.00750	0.529	0.699	0.730	0.849	0.985	1.111	1.229	1.340	1.447	1.548	1.646	1.740
1/ 133	1.038	3.088	3.671	6.667	12.088	19.632	29.559	42.111	57.517	75.992	97.746	122.975
0.00800	0.548	0.724	0.757	0.879	1.020	1.150	1.272	1.388	1.497	1.602	1.703	1.801
1/ 125	1.076	3.200	3.803	6.906	12.519	20.329	30.605	43.596	59.540	78.660	101.170	127.276
0.00850	0.567	0.749	0.782	0.909	1.054	1.189	1.315	1.434	1.547	1.655	1.759	1.860
1/ 118	1.113	3.308	3.932	7.138	12.938	21.006	31.620	45.038	61.504	81.249	104.493	131.449
0.00900	0.585	0.773	0.807	0.938	1.087	1.226	1.356	1.478	1.595	1.706	1.814	1.917
1/ 111	1.149	3.413	4.057	7.364	13.345	21.664	32.607	46.440	63.414	83.766	107.724	135.506
0.00950	0.603	0.796	0.831	0.966	1.120	1.262	1.396	1.522	1.642	1.756	1.867	1.973
1/ 105	1.184	3.516	4.179	7.584	13.741	22.305	33.568	47.805	65.273	86.217	110.869	139.455
0.01000	0.620	0.819	0.855	0.993	1.151	1.298	1.435	1.564	1.687	1.805	1.918	2.027
1/ 100	1.218	3.616	4.298	7.799	14.128	22.930	34.506	49.136	67.086	88.606	113.936	143.306
0.01100	0.654	0.862	0.901	1.046	1.212	1.366	1.510	1.646	1.775	1.899	2.018	2.132
1/ 91	1.284	3.810	4.528	8.214	14.875	24.137	36.316	51.706	70.586	93.218	119.855	150.737
0.01200	0.686	0.904	0.945	1.096	1.270	1.431	1.582	1.724	1.860	1.989	2.113	2.233
1/ 83	1.347	3.996	4.748	8.611	15.590	25.293	38.049	54.166	73.935	97.632	125.519	157.849
0.01300	0.717	0.945	0.987	1.145	1.326	1.494	1.651	1.799	1.940	2.075	2.205	2.330
1/ 77	1.408	4.174	4.960	8.993	16.278	26.403	39.714	56.529	77.153	101.872	130.959	164.678
0.01400	0.747	0.984	1.027	1.192	1.380	1.555	1.718	1.872	2.018	2.159	2.293	2.423
1/ 71	1.467	4.346	5.164	9.361	16.940	27.474	41.318	58.807	80.254	105.957	136.201	171.258
0.01500	0.776	1.022	1.067	1.237	1.433	1.613	1.782	1.942	2.094	2.239	2.378	2.513
1/ 67	1.523	4.513	5.361	9.717	17.581	28.508	42.869	61.007	83.249	109.903	141.264	177.613
0.01600	0.804	1.058	1.105	1.281	1.483	1.670	1.845	2.010	2.167	2.317	2.461	2.600
1/ 62	1.578	4.674	5.553	10.061	18.201	29.510	44.370	63.138	86.149	113.724	146.165	183.766
0.01700	0.831	1.093	1.142	1.324	1.532	1.725	1.905	2.076	2.237	2.392	2.541	2.684
1/ 59	1.632	4.831	5.738	10.396	18.804	30.483	45.827	65.205	88.963	117.430	150.920	189.734
0.01800	0.858	1.128	1.178	1.365	1.580	1.778	1.964	2.140	2.306	2.466	2.619	2.766
1/ 56	1.684	4.983	5.919	10.721	19.389	31.428	47.243	67.214	91.698	121.033	155.541	195.534
0.01900	0.883	1.162	1.213	1.405	1.626	1.831	2.021	2.202	2.373	2.537	2.694	2.846
1/ 53	1.735	5.131	6.095	11.038	19.959	32.348	48.622	69.171	94.360	124.539	160.039	201.179
Coefficient for part-full pipes:	35	50	60	70	90	110	130	150	150	200	200	200

ks = 0·030 mm   i < 0·1

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Supplementary information continued.

8 continued

ks = 1·500mm
i = 0·004 to 0·1
ie hydraulic gradient = 1 in 250 to 1 in 10

Water (or sewage) at 15° C
full bore conditions.
velocities in m/s
discharges in l/s

Gradient	Pipe diameters in mm: 50	75	80	100	125	150	175	200	225	250	275	300
0.00400 1/ 250	0.256 0.503	0.342 1.511	0.358 1.799	0.418 3.282	0.487 5.978	0.551 9.743	0.612 14.713	0.669 21.013	0.723 28.762	0.776 38.074	0.826 49.057	0.875 61.816
0.00420 1/ 238	0.263 0.516	0.351 1.549	0.367 1.844	0.428 3.365	0.499 6.127	0.565 9.986	0.627 15.080	0.686 21.536	0.741 29.478	0.795 39.021	0.846 50.277	0.896 63.353
0.00440 1/ 227	0.269 0.528	0.359 1.586	0.376 1.888	0.439 3.445	0.511 6.273	0.579 10.224	0.642 15.438	0.702 22.047	0.759 30.177	0.814 39.946	0.867 51.468	0.917 64.854
0.00460 1/ 217	0.275 0.540	0.367 1.622	0.384 1.931	0.449 3.523	0.523 6.416	0.592 10.456	0.656 15.788	0.718 22.547	0.776 30.860	0.832 40.850	0.886 52.633	0.938 66.320
0.00480 1/ 208	0.281 0.552	0.375 1.658	0.393 1.973	0.458 3.600	0.534 6.555	0.605 10.683	0.671 16.130	0.733 23.035	0.793 31.529	0.850 41.735	0.905 53.773	0.959 67.756
0.00500 1/ 200	0.287 0.564	0.383 1.692	0.401 2.014	0.468 3.675	0.545 6.692	0.617 10.905	0.685 16.466	0.748 23.514	0.809 32.184	0.868 42.602	0.924 54.889	0.978 69.162
0.00550 1/ 182	0.301 0.592	0.402 1.776	0.421 2.114	0.491 3.857	0.572 7.022	0.648 11.443	0.718 17.276	0.785 24.671	0.849 33.766	0.911 44.695	0.970 57.585	1.026 72.558
0.00600 1/ 167	0.315 0.618	0.420 1.856	0.440 2.209	0.513 4.030	0.598 7.337	0.677 11.956	0.750 18.051	0.820 25.776	0.887 35.278	0.951 46.695	1.013 60.161	1.072 75.802
0.00650 1/ 154	0.328 0.644	0.438 1.933	0.458 2.301	0.534 4.197	0.623 7.640	0.704 12.448	0.781 18.794	0.854 26.836	0.924 36.728	0.990 48.614	1.054 62.632	1.116 78.915
0.00700 1/ 143	0.341 0.669	0.454 2.007	0.475 2.389	0.555 4.357	0.646 7.931	0.731 12.922	0.811 19.508	0.887 27.856	0.959 38.123	1.028 50.460	1.095 65.009	1.159 81.910
0.00750 1/ 133	0.353 0.693	0.470 2.078	0.492 2.474	0.574 4.511	0.669 8.212	0.757 13.379	0.840 20.198	0.918 28.840	0.993 39.470	1.064 52.241	1.133 67.303	1.200 84.799
0.00800 1/ 125	0.365 0.716	0.486 2.147	0.508 2.556	0.593 4.661	0.691 8.484	0.782 13.822	0.867 20.865	0.948 29.792	1.025 40.772	1.099 53.964	1.170 69.522	1.239 87.594
0.00850 1/ 118	0.376 0.738	0.501 2.214	0.524 2.635	0.612 4.806	0.713 8.747	0.806 14.250	0.894 21.512	0.978 30.715	1.057 42.034	1.133 55.634	1.207 71.673	1.278 90.303
0.00900 1/ 111	0.387 0.760	0.516 2.279	0.540 2.712	0.630 4.946	0.734 9.002	0.830 14.666	0.920 22.139	1.006 31.611	1.088 43.259	1.166 57.255	1.242 73.761	1.315 92.933
0.00950 1/ 105	0.398 0.781	0.530 2.342	0.555 2.788	0.647 5.083	0.754 9.251	0.853 15.071	0.946 22.750	1.034 32.482	1.118 44.451	1.199 58.832	1.276 75.792	1.351 95.491
0.01000 1/ 100	0.408 0.802	0.544 2.404	0.569 2.861	0.664 5.216	0.774 9.493	0.875 15.465	0.971 23.345	1.061 33.331	1.147 45.612	1.230 60.368	1.309 77.770	1.386 97.983
0.01100 1/ 91	0.429 0.841	0.571 2.522	0.597 3.002	0.697 5.473	0.812 9.960	0.918 16.225	1.018 24.491	1.113 34.967	1.203 47.850	1.290 63.329	1.374 81.583	1.454 102.786
0.01200 1/ 83	0.448 0.879	0.597 2.636	0.624 3.137	0.728 5.718	0.848 10.406	0.959 16.951	1.064 25.586	1.163 36.530	1.257 49.988	1.348 66.158	1.435 85.226	1.519 107.375
0.01300 1/ 77	0.466 0.916	0.621 2.744	0.650 3.266	0.758 5.954	0.883 10.834	0.999 17.648	1.107 26.637	1.210 38.029	1.309 52.039	1.403 68.871	1.494 88.721	1.581 111.776
0.01400 1/ 71	0.484 0.951	0.645 2.849	0.674 3.390	0.787 6.180	0.916 11.246	1.037 18.318	1.149 27.648	1.256 39.472	1.358 54.012	1.456 71.482	1.550 92.083	1.641 116.012
0.01500 1/ 67	0.501 0.984	0.668 2.950	0.698 3.510	0.815 6.399	0.949 11.643	1.073 18.964	1.190 28.623	1.301 40.864	1.406 55.916	1.508 74.001	1.605 95.328	1.699 120.099
0.01600 1/ 62	0.518 1.017	0.690 3.047	0.721 3.626	0.842 6.610	0.980 12.027	1.109 19.590	1.229 29.567	1.344 42.210	1.453 57.758	1.557 76.437	1.658 98.466	1.755 124.051
0.01700 1/ 59	0.534 1.049	0.711 3.142	0.744 3.739	0.868 6.815	1.010 12.400	1.143 20.196	1.267 30.481	1.385 43.515	1.498 59.543	1.605 78.799	1.709 101.507	1.809 127.882
0.01800 1/ 56	0.550 1.079	0.732 3.234	0.766 3.848	0.893 7.014	1.040 12.761	1.176 20.784	1.304 31.369	1.425 44.782	1.541 61.276	1.652 81.092	1.759 104.460	1.862 131.602
0.01900 1/ 53	0.565 1.109	0.752 3.323	0.787 3.954	0.918 7.208	1.069 13.113	1.209 21.357	1.340 32.232	1.465 46.014	1.584 62.961	1.697 83.322	1.807 107.332	1.913 135.220
Coefficient for part-full pipes:	18	25	30	35	45	50	60	70	80	90	100	110

ks = 1·500mm   i < 0·1

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University of Bolton
Western International College FZE
BEng (Hons) Civil Engineering
Semester 2 Examination 2018/2019
Ground and Water Studies 2
Module No. CIE5005

Table Q3-2. Flow balancing Method

	1st estimate H_j = ………………….m				
Pipe	**h_f across Pipe (m)**	**S_O (1 in)**	**Q (litre/s)**	**Q (m^3/s)**	**Q/hf**
A					
B					
C					
Δ Q = ……………………..m^3/s			**ΔH=……………………………………………..m**		

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Table Q4-2.

Pipe length ref No	Pipe length (m)	Pipe gradient (1 in)	Velocity (m/s)	Time of flow (min)	Time of Conc. (min)	Rate of rainfall i (mm/hr)	Imp. Area (ha)	Cumulative Imp. Area A_P (ha)	Flow Q (l/s)	Pipe dia. (mm)
1.00	50	56					0.025			100
1.01	60	105					0.20			250
2.00	125	83					0.04			125
1.02	75	125					0.08			………

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END OF SECTION B

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