UNIVERSITY OF SWAZILAND

FINAL EXAMINATION PAPER

2013

PROGRAMME: B.SC.

COURSE CODE: ABE 403

TITLE OF PAPER: IRRIGATION DESIGN AND MANAGEMENT

ALLOWED TIME: TWO (2) HOURS

SPECIAL MATERIAL REQUIRED: Calculator, formula sheet, Intake Family Table.

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY TWO OTHER QUESTIONS

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SECTION ONE: COMPULSORY QUESTION

QUESTION ONE

a) Briefly explain five important factors for preliminary irrigation system design. (10 marks)

b) A trial configuration of a hand move sprinkler has a lateral running downslope from a mainline along a constant grade of 0.005 m/m. The design operating pressure of the nozzle is 350 kPa. The lateral has a length of 450 m between the first and last sprinkler.

i) Compute the maximum allowable headloss due to friction. (5 marks)

ii) Determine the required pipe diameter to maintain the actual headloss within the allowable limit if the sprinkler spacing is 12 m and the design discharge is 0.315 l/s per sprinkler. (5 marks)

c) Corn is irrigated by a traveling sprinkler with water having an electrical conductivity of 2.1 dS/m. If the electrical conductivity of the average saturation extract of the soil root zone profile that would give a 10 % yield reduction is 2.5 dS/m,

i) Find the leaching requirement? (5 marks)

ii) If the area of the field is 16 ha, corn water requirement consumption is 5 mm/day, and the moisture to be replaced at each irrigation is 60 mm, calculate the gross depth when the irrigation efficiency is 75 %? (5 marks)

iii) If the required irrigation period is 10 days in a 12 day interval, compute the system capacity, Q, when the system operating time per day is 20 hours (5 marks)

d) Calculate the discharge, Q, of a rectangular channel if the width is 2.438 m, with a depth of flow of 0.610 m and the bed slope of 0.0004 m/m. Use a Manning's roughness coefficient of n = 0.015. (5 marks)

SECTION II: ANSWER ANY TWO QUESTIONS

QUESTION TWO

a) Discuss five advantages and five disadvantages of trickle irrigation system. (10marks)

b) Determine the required diameter for an orifice emitter in a turbulent flow regime with a design discharge of 10 L/h and operating pressure head of 10 m. Assume a value of 0.6 for the orifice coefficient. (5 marks)

c) Compute the required length of a long-path emitter for a system with a design discharge of 4 L/h and operating pressure head of 10 m. Assume the standard value of 1.0×10^{-6} m^2/s for the kinematic viscosity of water. (15marks)

QUESTION THREE

a) Assume that for a given soil the empirical constants for the Kostiakov equation with depth in cm and time in minutes are $\alpha = 0.7$ and $c = 0.21$ and that 10 percent deep percolation is acceptable. If the net irrigation requirement, i_n, is 8 cm,

i) determine the net time of irrigation, T_n, and (3 marks)

iii) the advance time required for the water to reach the end of the field, T_t.(2 marks)

b) Given the following furrow information;

Intake family	If = 0.3
Furrow length	L = 275 m
Furrow slope	S = 0.004 m/m
Furrow spacing	W = 0.75 m
Roughness coefficient	n = 0.04
Net irrigation depth	i_n = 75 mm
Furrow inflow rate	Q = 0.6 L/s

Compute the following design parameters;

i) The advance time, T_t (3 marks)
ii) The adjusted wetted perimeter, P (3 marks)
iii) The net infiltration time, T_n (2 marks)
iv) The design cutoff time, T_{co} (2 marks)
v) The gross application depth, i_g (2 marks)
vi) The average infiltration time, $T_{o\text{-}L}$ (4 marks)
vii) The average infiltration depth, i_{avg} (3 marks)
viii) The surface runoff, d_{ro} (2 marks)
ix) The deep percolation depth, d_{dp} (2 marks)
x) The distribution pattern efficiency, e_d (2 marks)

QUESTION FOUR

Given a sprinkler system designed for a tomato field;

The root depth, Z = 1.00 m, Lateral length = 101 m
The soil water holding capacity W_a = 122 mm/m
The Management Allowed Depletion, MAD = 40 %,
The irrigation Efficiency, E_a = 74 %
The crop consumptive use rate, U_d = 7.0 mm/d, sprinkler stand time = 11 hrs
The sprinkler spacing, S_e = 9.2 m, and S_l = 15.25 m

Calculate the following;

i) The recommended gross depth of application per irrigation, (3 marks)
ii) The irrigation frequency, (3 marks)
iii) The sprinkler application rate. (4 marks)
iv) The sprinkler operating pressure head, H_a, assuming K_d = 2.595 for single nozzle sprinklers with 3.6 mm nozzles (4 marks)

v) The total lateral flow rate, (5 marks)
vi) The number of sprinklers (2 marks)
vii) The lateral inlet pressure head, H_l for 50 mm aluminium pipe (C=130) with an inside diameter of 48.3 mm, and 0.75 m high sprinkler risers. (9 marks)

SOME USEFUL EQUATIONS

$$d = \frac{d_n}{(\frac{Ea}{100})}, \qquad d = \frac{0.9*d_n}{(1.0-LR)*Ea/100}, \quad Q_s = K\frac{A*d}{f*T}, \quad h_f = F_y * \frac{L}{D} * \frac{V^2}{2g}$$

$$J = \frac{h_f}{\frac{L}{100}} = K(\frac{Q}{C})^{1.852}D^{-4.87}, \qquad R_y = K * \frac{Q}{D}, \qquad P_s = \frac{\rho g Q H}{\aleph}$$

$$F = \frac{1}{b+1} + \frac{1}{2N} + \frac{(b-1)^{0.5}}{6N^2}, \ H_l = H_a + \frac{3h_f}{4} + \frac{1\Delta H_e}{2} + H_r, \ NPSHa = P_{atm} - P_v - h_{fs} - Z$$

DRIP EQUATIONS

$$R_n = \frac{V*D}{1000*\vartheta}, \ f = \frac{h_f}{\frac{L}{D}*\frac{V^2}{2g}}, q = 3.6 * A * Co * (2gH)^{0.5}$$

$$q = 0.11384 * A * \left[2g(\frac{HD}{f*L})\right]^{0.5}, \ q = 0.11384 * A * \left[2g(\frac{\sqrt{H}D}{f*L})\right]^{0.5}$$

$$f = 64/R_n, \ \frac{1}{\sqrt{f}} = 2Log\left(\frac{D}{\epsilon}\right) + 1.14, q = k * H^x, \ U_e = 100\left[1.0 - \frac{1.27}{n} * C_v\right] * \frac{q_{min}}{q_{avg}}$$

FURROW EQUATIONS

$$T_{co} + T_d = T_r - T_L, \ E_a = \frac{Z_{req}L}{Q_0 T_{co}}, \quad P = 0.265\left[\frac{Q*n}{S^{0.5}}\right]^{0.425} + 0.227; \qquad i = [at^b + c]\frac{P}{W}$$

$$T_t = \frac{x}{f} exp\left[\frac{g*x}{Q*S^{0.5}}\right]; \qquad T_n = \left[\frac{i_n(\frac{W}{P}) - c}{a}\right]^{1/b}; \qquad T_o = T_{co} - T_t$$

$$T_{co} = T_t + T_n; \qquad \beta = \frac{g*x}{Q*S^{0.5}}; \qquad i_g = \frac{i_n}{\frac{e_d}{100}}; \qquad i_g = \frac{60*Q*T_{co}}{WL}$$

$$T_{0-x} = T_{co} - \frac{0.0929}{f(x)\left[\frac{0.305\beta}{x}\right]^2}[(\beta - 1)\exp(\beta) + 1], \quad d_{ro} = i_g - i_{avg} \ ; d_{dp} = i_{avg} - i_n$$

Table 1. Intake family and advance coefficients for depth of infiltration in mm, time in minutes, and length in meters.

Intake Family	a	b	c	f	g * 10^{-4}
0.05	0.5334	0.618	7.0	7.16	1.088
0.10	0.6198	0.661	7.0	7.25	1.251
0.15	0.7110	0.683	7.0	7.34	1.414
0.20	0.7772	0.699	7.0	7.43	1.578
0.25	0.8534	0.711	7.0	7.52	1.741
0.30	0.9246	0.720	7.0	7.61	1.904
0.35	0.9957	0.729	7.0	7.70	2.067
0.40	1.064	0.736	7.0	7.79	2.230
0.45	1.130	0.742	7.0	7.88	2.393
0.50	1.196	0.748	7.0	7.97	2.556
0.60	1.321	0.757	7.0	8.15	2.883
0.70	1.443	0.766	7.0	8.33	3.209
0.80	1.560	0.773	7.0	8.50	3.535
0.90	1.674	0.779	7.0	8.68	3.862
1.00	1.786	0.785	7.0	8.86	4.188
1.50	2.284	0.799	7.0	9.76	5.819
2.00	2.753	0.808	7.0	10.65	7.451