(1)

Pipe	Length (m)	Diameter (m)	f’
AJ	450	0.45	0.0075
BJ	600	0.3	0.01
CJ	300	0.3	0.0075

(2) Find the discharges for the system tree reservoirs with the following pipe data and reservoir elevations

L1=3000 m	D1=1m	f’=0.014	h=30m
L2=600m	D2=0.45m	f’=0.024	h=18m
L3=1000m	D3=0.6m	f’=0.02	h=9m

PIPE NETWORKS Flow in a water distribution network however complicated must satisfy the basic relations of continuity and energy.

Diagram (Figure)

CRITERIA

(i) Sum of discharges at a node is zero, i.e. the flow into any junction or node must equal the flow out of it (continuity equation)

(ii) Sum of all head losses around a closed circuit must be zero

(iii) The flow in each pipe must satisfy the pipe friction laws (Darcy Weisbach or equivalent exponential friction formula) for flow in a single pipe

Since it is complicated to solve network problems analytically, methods of successive approximation are utilized.

HARDY CROSS METHOD

The Hardy-Cross method is one in which flows are assumed for each pipe so that continuity is satisfied at every junction. A correction to the flow in each circuit is the computed in turn and applied to bring the circuits into closer balance.

From Figure:

(a) Main Circuit

$$r_1Q_1^{\,2} + r_2Q_2^{\,2} + r_3Q_3^{\,2} - r_4Q^2{}_4 - r_5Q_5^{\,2} = 0$$

(b) Sub Circuit 1

$$r_1Q_1^{\,2} + r_6Q_6^{\,2} - r_5Q_5^{\,2} = 0$$

(c) Sub-Circuit 2

$$r_2Q_2^{\,2} + r_3Q_3^{\,2} - r_4Q_4^{\,2} - r_6Q_6^{\,2} = 0$$

PROCEDURE FOR ANALYSIS

(i) Assume an initial (trial) value for each discharge (Q_a) bearing in mind criteria 1 i.e. $\sum_{1}^{n} Q = 0$

(ii) Compute the corresponding value $h_{fa} = rQ_a^{\ 2}$

(iii) Determine the algebraic sum of all head losses in each closed circuit. (Normally not equal to zero).

(iv) Compute values of $\sum \left(\frac{h_{fa}}{Q_a} \right)$ for each closed circuit

(v) Determine the correction to the assumed values of Q_a to be applied to each closed circuit. Using $\Delta Q = \frac{-\sum h_{fa}}{2\sum \left(\frac{h_{fa}}{Q_a} \right)}$

(vi) Revise flows in each pipe by $Q = (Q_a + \Delta Q)$

Repeat from (ii) until $\sum h_f = 0$ in all circuits.

NOTE: The derivation of ΔQ expression could be checked from any advanced text on this subject.

SIGN CONVECTION

In allocating signs to the discharges move around each closed circuit in a clockwise direction given all flows in a clockwise direction positive sign (+ve) and all flows opposing this a negative sign (-ve).

When computing $h_{fa} = rQ_a^{\;2}$ use the form $h_{fa} = Q_a \,|Q_a\,|$ to preserve the negative sign when present, by inspection, it can be seen that when the flow direction is reversed in a pipe, the direction of the slope of hydraulic gradient is also changed.

EXAMPLE

Water enters the four sided ring min shown below at A at the rate of 0.4m^3/s and is delivered at B, C and D at the rate of 0.15,0.10 and 0.15 m^3/s. All pipes are 0.6m in diameter with a friction coefficient of 0.0132 and their lengths are AB and CD 150m, BC 300m and DA 240m. Determine the flow through each pipe and the pressures at B, C and D if that at A is 105KN/m^2.

NOTE:

1. ALL PROBLEMS AND EXERCISES WILL BE SOLVED IN THE CLASS AND SOME WILL BE TAKEN AT TUTORIAL CLASS
2. THIS CLASS NOTE WILL NOT REPLACE THE RECOMMENDED TEXTS
3. SOME OF THE BOOKS ARE AVAILABLE IN THE MAIN LIBRARY AND COLLEGE LIBRARY