CTC 450 Review

- Friction Loss
  - Over a pipe length
    - Darcy-Weisbach (Moody's diagram)
  - Connections/fittings, etc.

Objectives

- Know how to set up a spreadsheet to solve a simple water distribution system using the Hardy-Cross method

Pipe Systems

- Water municipality systems consist of many junctions or nodes; many sources, and many outlets (loads)
- Object for designing a system is to deliver flow at some design pressure for the lowest cost
- Software makes the design of these systems easier than in the past; however, it’s important to understand what the software is doing

Two parallel pipes

- If a pipe splits into two pipes how much flow will go into each pipe?
- Each pipe has a length, friction factor and diameter
- Head loss going through each pipe has to be equal

Two parallel pipes

$f_1*(L_1/D_1)*(V_1^2/2g)= f_2*(L_2/D_2)*(V_2^2/2g)$

Rearrange to:

$V_1/V_2=[(f_2/f_1)(L_2/L_1)(D_1/D_2)]^{.5}$

This is one equation that relates v1 and v2; what is the other?

Hardy-Cross Method

- Q’s into a junction=Q’s out of a junction
- Head loss between any 2 junctions must be the same no matter what path is taken (head loss around a loop must be zero)

Steps

1. Choose a positive direction (CW=+)
2. # all pipes or identify all nodes
3. Divide network into independent loops such that each branch is included in at least one loop

4. Calculate K' for each pipe

- Calc. K' for each pipe

  $K' = (0.0252) fL/D^5$
- For simplicity f is usually assumed to be the same (typical value is .02) in all parts of the network

5. Assume flow rates and directions

- Requires assumptions the first time around
- Must make sure that $Q_{in}=Q_{out}$ at each node

6. Calculate Q_t-Q_a for each independent loop

- $Q_t - Q_a = -\sum K' Q_a^n / n \sum |Q_a^{n-1}|$
- n=2 (if Darcy-Weisbach is used)
- $Q_t - Q_a = -\sum K' Q_a^2 / 2 \sum |Q_a^{n-1}|$
- Q_t is true flow
- Q_a is assumed flow
- Once the difference is zero, the problem is completed

7. Apply Q_t-Q_a to each pipe

- Use sign convention of step one
- Q_t-Q_a (which can be + or -) is added to CW flows and subtracted from CCW flows
- If a pipe is common to two loops, two Q_t-Q_a corrections are added to the pipe

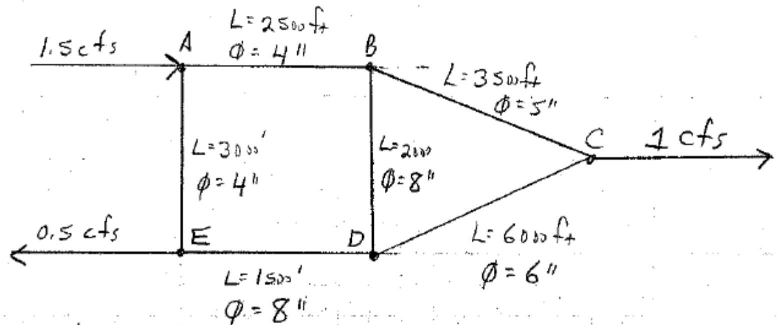
8. Return to step 6

- Iterate until $Q_t - Q_a = 0$

Example Problem

- 2 loops; 6 pipes
  - By hand; 1 iteration
  - By spreadsheet

Calculate Q in each pipe of the network shown.



1. CW = +

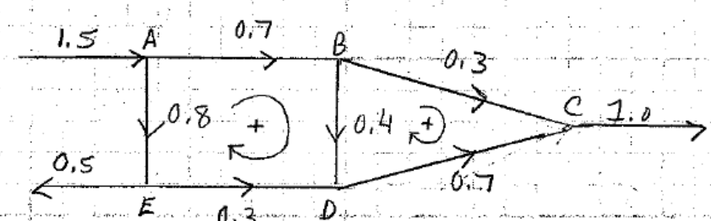
2/3. <u>2 loops</u>
Loop ABDE
Loop BCD

4. $k' = \dfrac{(0.0252) f L}{D^5}$ — f assumed to be 0.02 for all pipes

Pipe AB $\quad k' = \dfrac{(0.0252)(0.02)(2500)}{(0.3333)^5} = 306.2$

Pipe BC	k' = 140.5
DC	k' = 96.8
BD	k' = 7.7
ED	k' = 5.7
AE	k' = 367.4

5.



6. $$\delta = \frac{-\sum k' Q_a^2}{2\sum |k' Q_a|}$$

δ ABDE

$$\frac{-\left[(306.2)(0.7)^2 + (7.7)(0.4)^2 - (5.7)(0.3)^2 - (367.4)(0.8)^2\right]}{2\left[(306.2)(0.7) + (7.7)(0.4) + (5.7)(0.3) + (367.4)(0.8)\right]}$$

$\delta_{ABDE} = +0.08$

δ BCD

$$\frac{-\left[(140.5)(1.3)^2 - (96.8)(0.7)^2 - (7.7)(0.4)^2\right]}{2\left[(140.5)(0.3) + (96.8)(0.7) + (7.7)(0.4)\right]}$$

$\delta = +0.16$

7. Corrected flows

pipe	
AB	0.7 + (0.08) = 0.78
BC	0.3 + (0.16) = 0.46
DC	0.7 − (0.16) = 0.54
BD	0.4 + (0.08) − (0.16) = 0.32
ED	0.3 − (0.08) = 0.22
AE	0.8 − (0.08) = 0.72

Hardy-Cross Solution to example problem

2-loops (6 pipes)

				Lng (ft)	Dia. (ft)		
AB	K'=	306	AB	2500	0.33		
BD	K'=	7.7	BC	3500	0.42		
DE	K'=	5.7	DC	6000	0.50		
EA	K'=	368	BD	2000	0.67		
BC	K'=	140	ED	1500	0.67	f=	0.02
CD	K'=	97	AE	3000	0.33		
DB	K'=	7.7					

	Loop 1				Loop 2			Loop 1	Loop 2	Corrected Loop 1				Corrected Loop 2		
Iteration	Qa-b	Qb-d	Qd-e	Qe-a	Qb-c	Qc-d	Qdb	correction	correction	Qa-b	Qb-d	Qd-e	Qe-a	Qb-c	Qc-d	Qdb
1	0.70	0.40	0.30	0.80	0.30	0.70	0.40	0.08	0.16	0.78	0.32	0.22	0.72	0.46	0.54	0.32
2	0.78	0.32	0.22	0.72	0.46	0.54	0.32	0.00	-0.01	0.78	0.33	0.22	0.72	0.45	0.55	0.33
3	0.78	0.33	0.22	0.72	0.45	0.55	0.33	0.00	0.00	0.78	0.33	0.22	0.72	0.45	0.55	0.33
4	0.78	0.33	0.22	0.72	0.45	0.55	0.33	0.00	0.00	0.78	0.33	0.22	0.72	0.45	0.55	0.33