Water Supply and Sewerage Network

Environmental Engineering Department

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Type of Pipes

Pipelines may be used for conveying large amounts of water, in which case they serve the same purpose as the open channels and aqueducts. When so used, they may be constructed of reinforced concrete, cast iron, or steel. Pipe is also used for the distribution system in a city. In this case the pipes are of varying sizes, having many connections and branches.

Cast Iron Pipe

Advantage	Disadvantage
• **It has a big size of diameter.** • **It can handle high pressure.** • **It has long-term workability (75-100 years).**	**These pipes are exposed to cavitation with time, so the flow area decreases, and friction losses increase.**

Steel Pipe

Advantage	Disadvantage
• **It has a big size of diameter.** • **It can handle high pressure.** • **It has long-term workability (50 years).**	**These pipes are exposed to corrosion with time, so it needs to be coted from inside and outside**

Concrete Pipe

Advantage	Disadvantage
• **It doesn't need reinforcement bars for D< 24 in.** • **It can handle high pressure.** • **It has long-term workability (75 years).**	**These pipes are weak against sheer stress due to flow. Also, there will be chemical interaction between water and cement over time.**

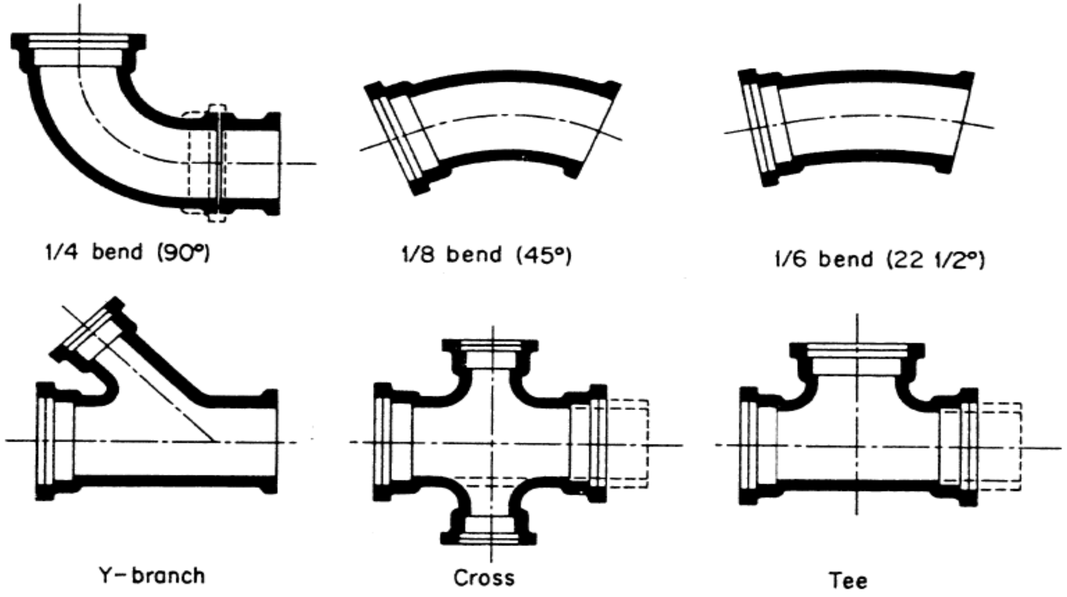
Asbestos Cement Pipe

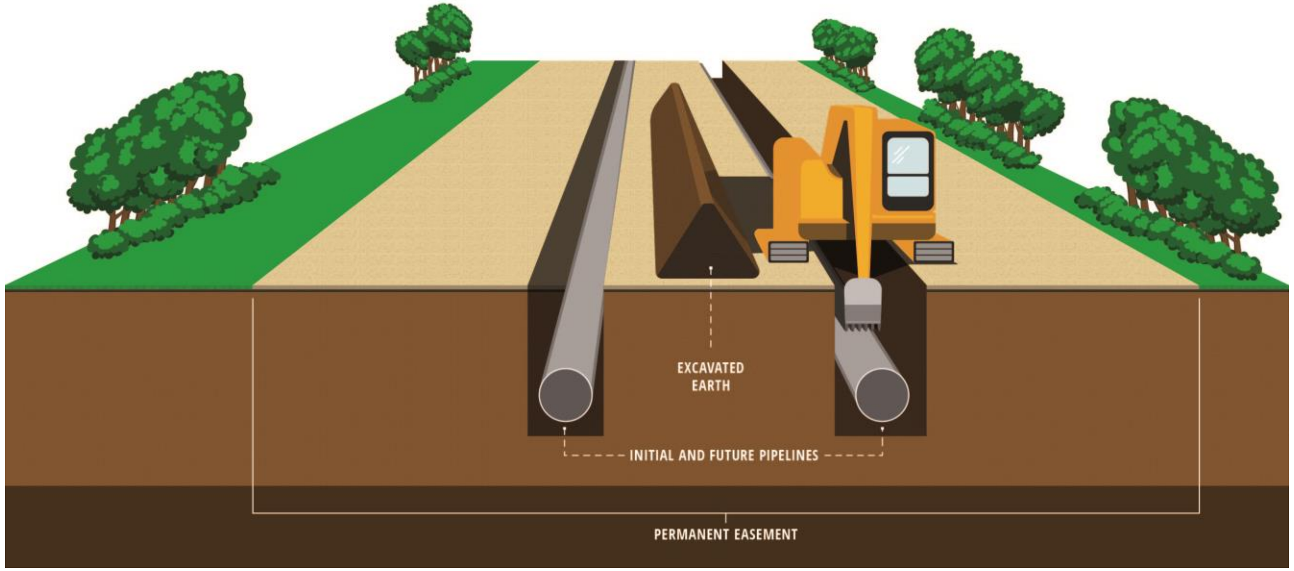
Advantage	Disadvantage
• It can handle little internal and external pressures. • It is not expensive in term of cost. • It has 30 years of workability.	These pipes can’t carry the concentrated load, especially the external loads. Due to risk of cancer, these pipes become less in use, especially in the USA.

Plastic Pipe

Advantage	Disadvantage
• It is easy to handle and light weight. • It is cheep. • It has 20 years of workability.	These pipes can’t handle the high pressure.

Type of Fitting



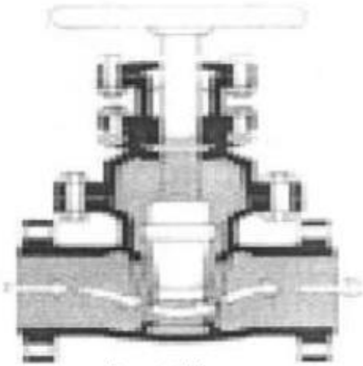


The pipeline must generally follow the profile of the ground, and a location is chosen that will be most favorable with regard to construction cost and resulting pressures. A profile of the pipe location is drawn, and the pipeline is located, with particular attention to the hydraulic grade line. The closer to the hydraulic grade line, the lower will be the pressure in the pipe, a condition that may result in lower pipe costs. High pressures can be avoided at times by breaking the hydraulic grade line with overflows or auxiliary reservoirs. Such overflows will also prevent full static pressure caused by closing the lower end of the pipeline.

Valves:

Valves are used to keep the flow of water under control. They help maintain pressure, prevent back flow, conserve water & isolate segments of pipeline for maintenance & construction.

22mm Gate Valve



Gate Valve

1. **Gate valves(صمامات حجز)**

   These valves permitting free flow of water through their openings. They used to control the flow & shut off the water for repairing. It placed at lines intersect, so that only one block would be cut. Used widely.

   Operation: A gate valve consists of a sliding, flat, metal disk that is moved at right angles to the flow direction by a screw-operated stem(ساق يشغل بيرغي) .

   Need large space, low head loss, & high cost.

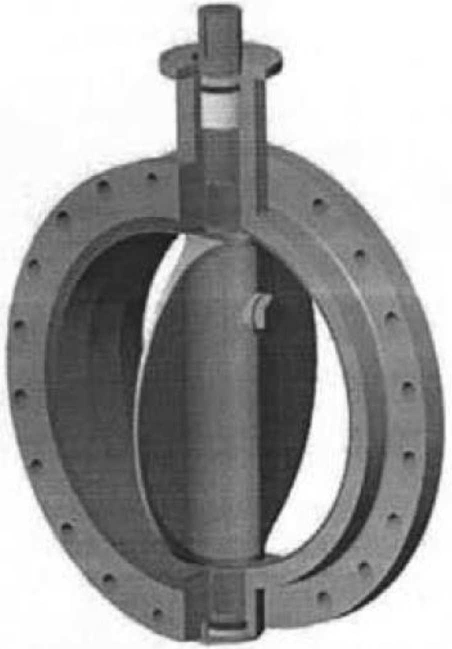
Isolating valves(صمامات عزل) :

They enable pipeline section to be isolated for inspection & repair. When twin or more mains are used, they must be connected at intervals this arrangement is called crossing or bypass. In the event of leakage or pipe burst, only one section of these twin main needs to be taken out of operation whereas the other section of the main & the entire other main can still be used. These valves should be installed at intervals of 1 to 5km.

2. **Butterfly valves(صمامات فراشية)**

Used for control flow. Not used for sewage.

Operation: A butterfly valve has a movable disk(قرص) that rotates on a spindle or axle(محور) set in the shell. The circular disk rotates in only one direction from full closed to full open.



A butterfly valve

Uses:

i. A rate of flow controller to regulate the rate of discharge from sand filters (need low pressure) in a water treatment plant.

ii. Used in high pressure systems 860kPa (125psi).

iii. In large sizes, rubber-seated butterfly valves are being used in distribution systems. They are used with very high velocity 20m/s or more.

Advantages:

- Ease of operation,
- low head loss,
- small space requirement, &
- throttling(خنق) capabilities.

Disadvantage:

i. The disk always being in the flow stream, restricting the use of pipe cleaning tools.

ii. Difficult to tight fit.

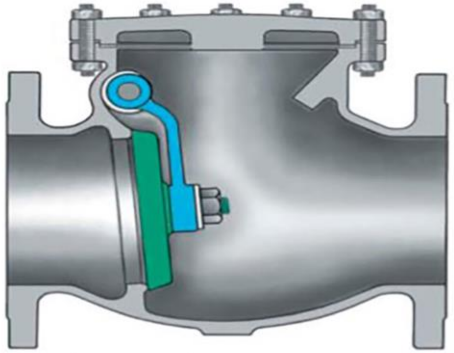
3. Check valves(صمامات سيطرة بطريق واحد)

A check valve is a semiautomatic device designed to permit flow in only one direction. It opens under the influence(تأثير) of pressure & closes automatically when flow ceases(ينتهي) .

Uses:

They used in the discharge piping of centrifugal pumps to prevent backflow (water hammer) when the pump is shutoff.

Foot valves: they are check valves installed at the end of a suction(سحب) line & prevent draining of the suction when the pump stops.



4. AIR- &-VACUUM (Double) and AIR-RELIEF (Single) Valves (صمامات الهواء)

In long pipe lines, air will accumulate in the high points of the line & may interfere(يتداخل) with the flow. Therefore, air valves are placed at those points. Each valve is provided with an isolating valve for maintenance.

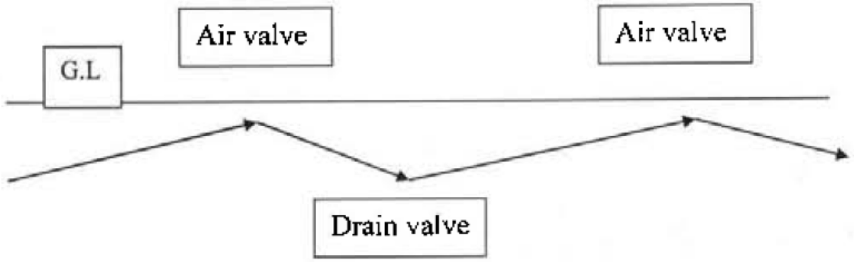
Types:

a) Large double orifice(فوهة مضاعفة): its duties are,

  i. Automatic air venting as main is filled with water.

  ii. Rapid air ingress(دخول) when the main empties, to avoid vacuums conditions.

b) Single orifice(فوهة مفردة) : It permits air to escape from pipes.



5. **Washing out valve(صمام الغسل)**

It is gate valve type. Used to facilitate(تسهيل) emptying of pipeline where repair is required, or for removing stagnant or dirty water. Size between 100 – 400mm, & spaced from 2km to 5km. it located at lowest point of pipeline.

Pressure Regulating Valves(صمامات تخفيف الضغط)

These automatically reduce pressure on the downstream side to any desired magnitude. They used on branches entering low areas of a city & tall building.

Meters

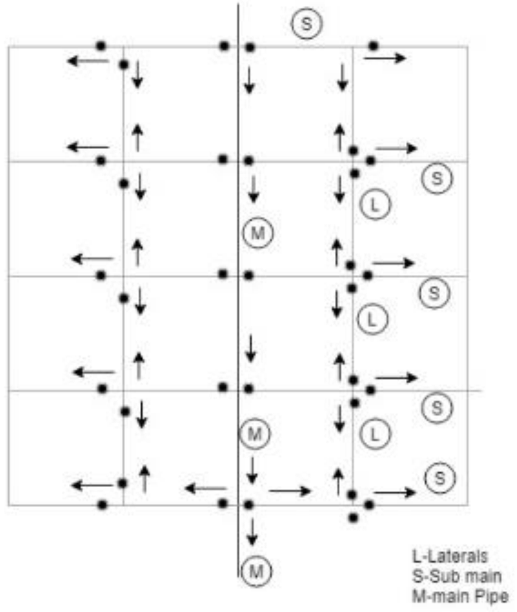
They used to control the consumption.

Factories & hotels are metered.

They tested (1-5) years or each $3000m^3$, or when fluctuations in readings.

Layout of Distribution System

➢ *Gridiron System* All main pipes are looped, no dead ends.



Characteristics:

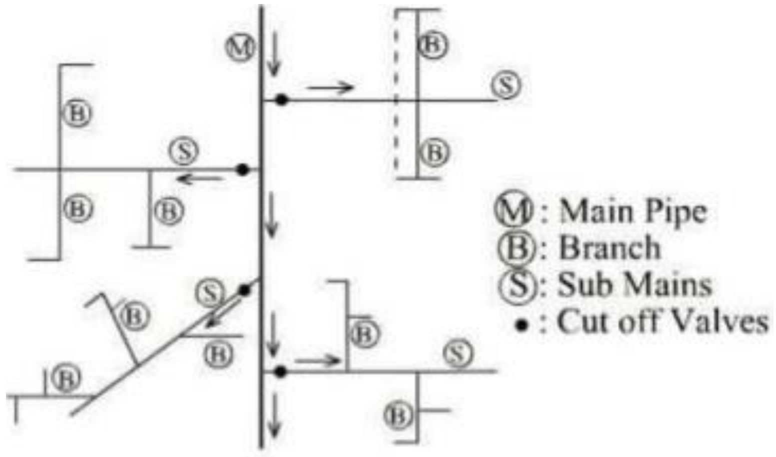
❖ Permitting water circulation & no water stagnation.

❖ When repairs are necessary, the area removed from service can be reduced to one block.

❖ Costly, need more pipe length, & valves,

➢ *Dead-End System (tree system)*

Old System, now it is avoided. This system is suitable to old towns & cities. It contains a Supply main starling from the service reservoir & laid along the main road, with submains running at right angles to it in both direction & lay along other roads joining the main road.



Characteristics:

❖ Due to stagnation(S)) of water, some lines have tastes & odors. This system requiring blow-off or drain valves to remove the settled soil.

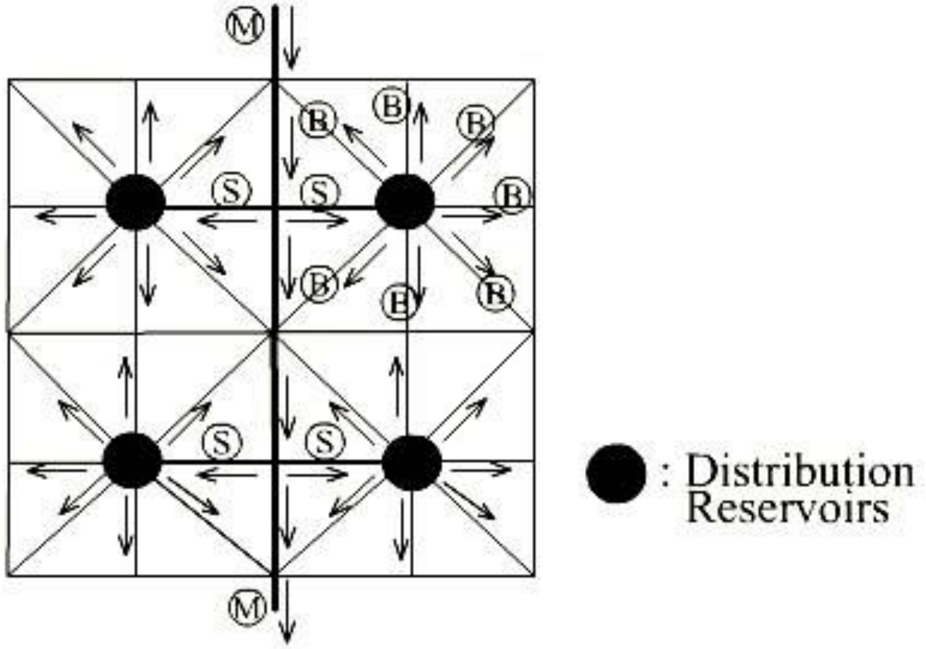
❖ When pipe break occurs, large area may be without water.

❖ Cheaper.

Layout of Distribution System

- *Radial System*

This system is the reverse of the ring system, water flowing towards the outer periphery instead of from it. The entire area is divided into a number of distribution zones, & a distribution reservoir is placed in the center of each zone- The supply pipes arc laid radially away towards the periphery,



Fire Hydrants.

They provide access to water mains for the purposes of,

a) extinguishing fires(أطفاء الحرائق),
b) washing down streets,
c) flushing out(تنظيف) water mains, &
d) providing a temporary water source for construction projects.

STANDARD PIPE SIZE

Nominal Pipe Size (inches)	Nominal Pipe Size (mm)	O.D. (mm)	Sch.10		Sch.20		Sch.30		Standard		Sch.40		Sch.60		Extra Strong		Sch.80		Sch.100		Sch.120		Sch.140		Sch.160		Double Extra Strong	
			Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.	Wall	Wt.
1/8"	6	10.3	0	0	0	0	0	0	1,7	0.36	1,7	0.36	0	0	2,4	0.47	2,4	0.47	0	0	0	0	0	0	0	0	0	0
1/4"	8	13.7	0	0	0	0	0	0	2.2	0.63	2.2	0.63	0	0	3.0	0.8	3.0	0.8	0	0	0	0	0	0	0	0	0	0
3/8"	10	17.1	0	0	0	0	0	0	2.3	0.85	2.3	0.85	0	0	3.2	1.10	3.2	1.10	0	0	0	0	0	0	0	0	0	0
1/2"	15	21,3	2,11	0,99	0	0	0	0	2,8	1,26	2,8	1,26	0	0	3,7	1,62	3,7	1,62	0	0	0	0	0	0	4,8	1,95	7.5	2,54
3/4"	20	26,7	2,11	1,27	0	0	0	0	2,9	1,68	2,9	1,68	0	0	3,9	2,19	3,9	2,19	0	0	0	0	0	0	5,6	2,89	7,8	3,63
1"	25	33.4	2.77	1.59	0	0	0	0	3.4	2.50	3.4	2.5	0	0	4.5	3.23	4.5	3.23	0	0	0	0	0	0	6.4	4.23	9.1	5.45
1 1/4"	32	42.2	2.77	2.69	0	0	0	0	3.6	3.38	3.6	3.38	0	0	4.9	4.46	4.9	4.46	0	0	0	0	0	0	6.4	5.6	9.7	7.75
1 1/2"	40	48,3	2,77	3,11	0	0	0	0	3,7	4,05	3,7	4,05	0	0	5,1	5,40	5,1	5,40	0	0	0	0	0	0	7,1	7,23	10,2	9,54
2"	50	60.3	2.77	3.93	0	0	0	0	3.9	5.43	3.9	5.43	0	0	5.5	7.47	5.5	7.47	0	0	0	0	0	0	8.7	11.1	11.1	13.4
2 1/2"	65	73.0	3.05	5.26	0	0	0	0	5.2	8.62	5.2	8.62	0	0	7.0	11,4	7.0	11,4	0	0	0	0	0	0	9.5	14.9	14	20.4
3"	80	88.9	3,05	6,45	0	0	0	0	5,5	11,3	5,5	11,3	0	0	7,6	15,3	7,6	15,6	0	0	0	0	0	0	11,1	21,3	15,2	27,7
3 1/2"	90	101.6	3,05	7,41	0	0	0	0	5.7	13.6	5.7	13.6	0	0	8.1	18.6	8.1	18.6	0	0	0	0	0	0	0	0	16.2	34.0
4"	100	114.3	3.05	8.36	0	0	0	0	6.0	16.1	6.0	16.1	0	0	8.6	22.3	8.6	22.3	0	0	11.1	28.3	0	0	13.5	33.5	17.1	41.1
5"	125	141.3	3.4	11.6	0	0	0	0	6.6	21.8	6.6	21.8	0	0	9.5	30.9	9.5	30.9	0	0	12.7	40.2	0	0	15.9	49.0	19	57.4
6"	150	168.3	3.4	13.8	0	0	0	0	7.1	28.2	7.1	28.2	0	0	11.0	42.5	11.0	42.5	0	0	14.3	54.2	0	0	18.3	67.5	21.9	79.1
8"	200	219.1	3.76	20	6.4	33.3	7.0	36.7	8.2	42.5	8.2	42.5	10.3	53.1	12,7	64.6	12,7	64.6	15.1	75.8	18.3	90.7	20.6	101	23	112	22,2	108
10"	250	273.0	4.19	27.8	6.4	41.7	7.8	50.9	9.3	60.2	9.3	60.2	12.7	81.5	12.7	81.5	15.1	95.8	18.3	115	21.4	133	25.4	156	28.6	172	25.4	155
12"	300	323.9	4.57	36	6.4	49.7	8.4	65.1	9.5	73.8	10.3	79.7	14.3	109	12.7	97.4	17.4	132	21.4	160	25.4	187	28.6	208	33.3	239	25.4	187
14"	350	355,6	6,4	54,6	7,9	68,1	9,5	81,2	9,5	81,2	11,1	94,3	15,1	126	12,7	107	19,0	158	23,8	195	27,8	224	31,8	253	35,7	281	0	0
16"	400	406.4	6.4	62.6	7.9	77.9	9.5	93.1	9.5	93.1	12.7	123	16.7	160	12.7	123	21.4	203	26.2	245	30.9	286	36.5	333	40.5	365	0	0
18"	450	457.2	6.4	70.5	7.9	87.8	11.1	122	9.5	105	14.3	156	19.0	206	12.7	139	23.8	254	29.4	310	34.9	363	39.7	408	45.2	459	0	0
20"	500	508.0	6.4	78.5	9.5	117	12.7	155	9.5	117	15.1	183	20.6	248	12.7	155	26.2	311	32.5	381	38.1	441	44.4	508	50.0	564	0	0
22"	550	558.8	6.4	86.4	9.5	129	12.7	171	9.5	129	0	0	22.2	294	12.7	171	28.6	373	34.9	451	41.3	526	47.6	600	54.0	671	0	0
24"	600	609.6	6.4	94.7	9.5	141	14.3	210	9.5	141	17.4	255	24.6	355	12.7	187	30.9	441	38.9	547	46	639	52.4	719	59.5	807	0	0
26"	650	660.4	7.9	128	12,7	203	0	0	9.5	153	0	0	0	0	12,7	203	0	0	0	0	0	0	0	0	0	0	0	0
28"	700	711.2	7.9	138	12.7	219	15.9	272	9.5	165	0	0	0	0	12.7	219	0	0	0	0	0	0	0	0	0	0	0	0
30"	750	762.0	7.9	147	12.7	234	15.9	292	9.5	176	0	0	0	0	12.7	234	0	0	0	0	0	0	0	0	0	0	0	0
32"	800	812.8	7.9	157	12.7	250	15.9	312	9.5	108	0	0	0	0	12.7	250	0	0	0	0	0	0	0	0	0	0	0	0
34"	850	863.6	7.9	167	12.7	266	15.9	332	9.5	200	0	0	0	0	12.7	266	0	0	0	0	0	0	0	0	0	0	0	0
36"	900	914.4	7.9	177	12.7	282	15.9	351	9.5	212	0	0	0	0	12.7	282	0	0	0	0	0	0	0	0	0	0	0	0

Design of Water Distribution System

- ✓ Surveying of length of pipes & elevations must be done.
- ✓ - Flow in pipes is calculated depending on estimation of population.
- ✓ - Determine the center of area.
- ✓ - Calculate the diameter of pipes & check the heads to satisfy the requirements.

Used Equations

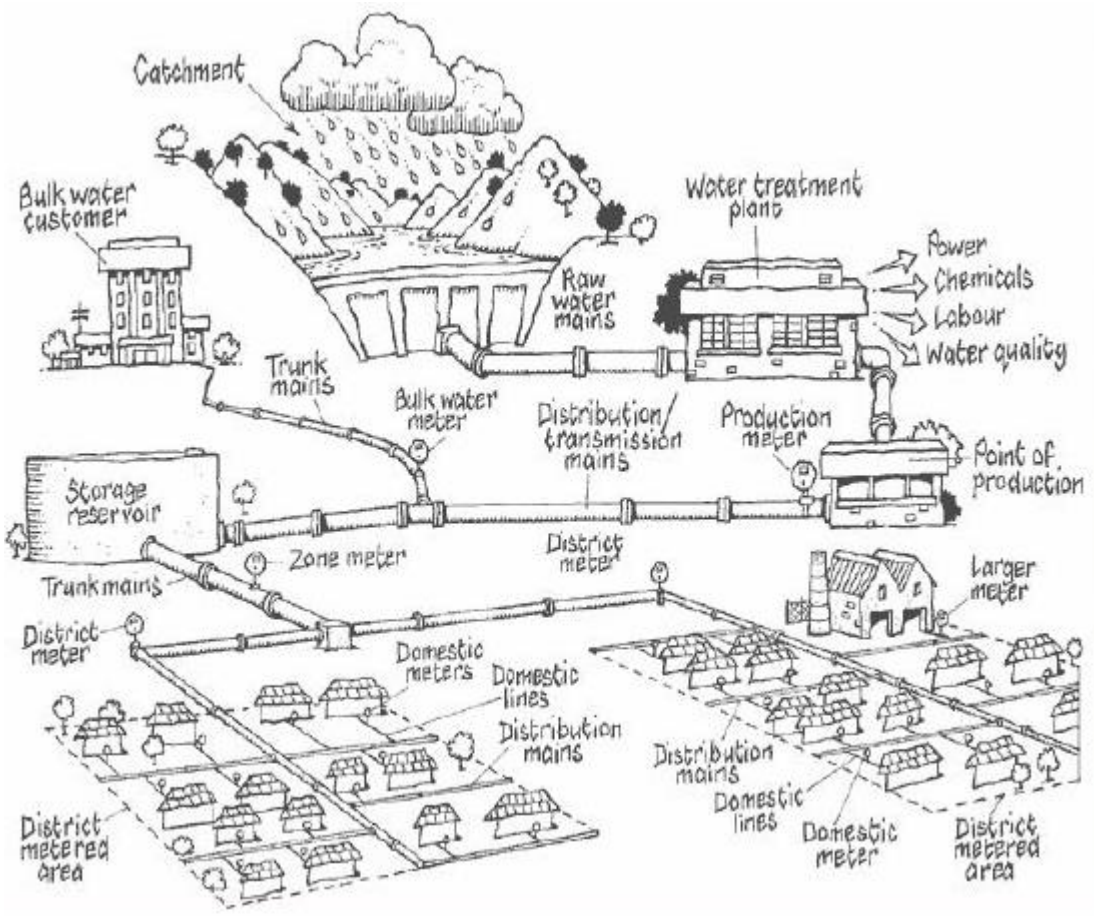
➢ *Manning Equation*

$$Q = \frac{1}{n} A \, R^{\frac{2}{3}} \, S^{\frac{1}{2}}$$

$$S = \left(\frac{n \, Q}{A \, R^{\frac{2}{3}}} \right)^2$$

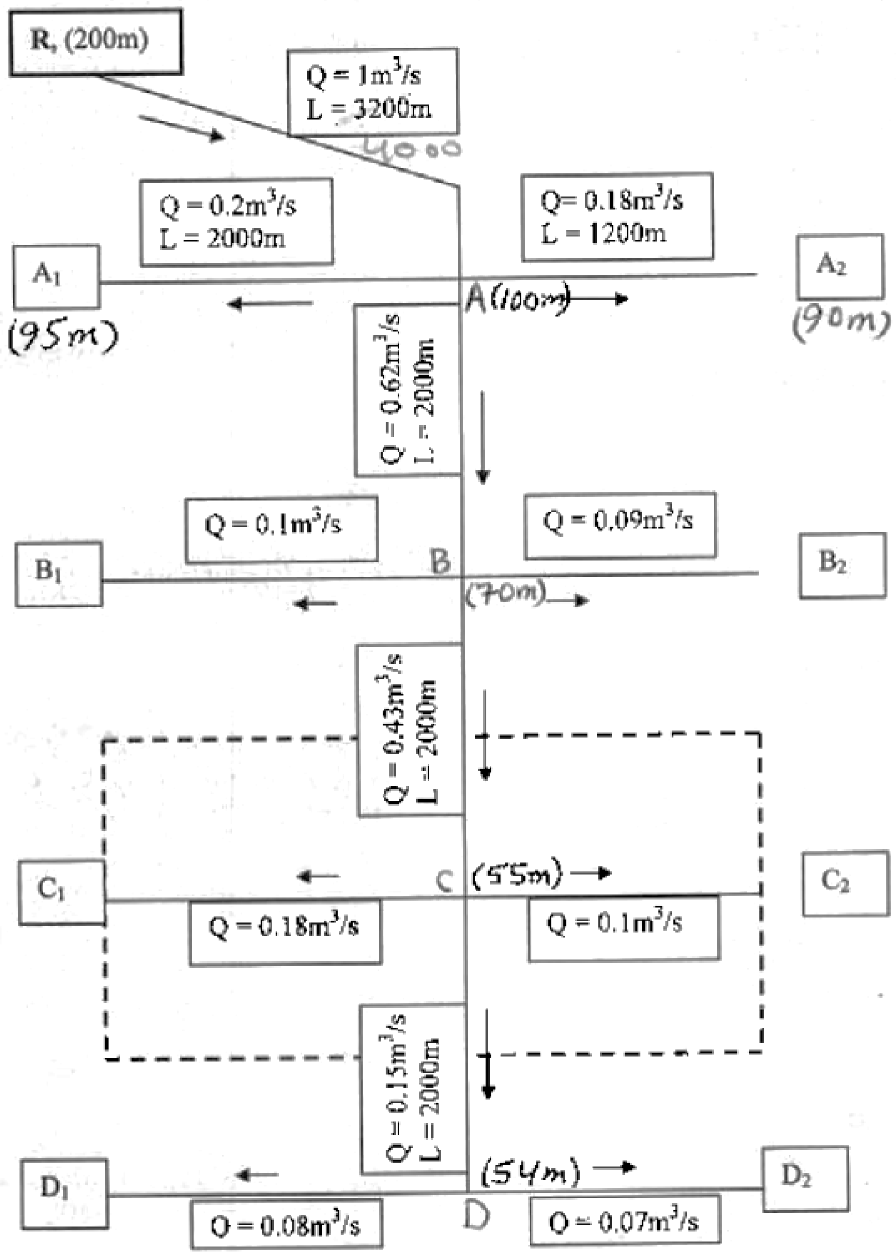
$$R = \frac{A}{P} = \frac{D}{4}$$

Full Flow



Example:

Water is supplied from a reservoir, R at an elevation of 200m, see Fig. The elevations of various points in the pipeline are given in brackets. Design the pipelines RA, AA_1, AA_2, AB, BC, & CD. Assume the minimum pressure in pipes in residential areas must be 35m of water & in center area 50m of water. Use Manning's roughness, n = 0.013.



Solution:

Minimum pressure at each point:

Pressure in pipe + elevation at A = 35 + 100 = 135m

Pressure in pipe + elevation at B = 35 + 70 = 105m

Pressure in pipe + elevation at C = 50 + 55 = 105m

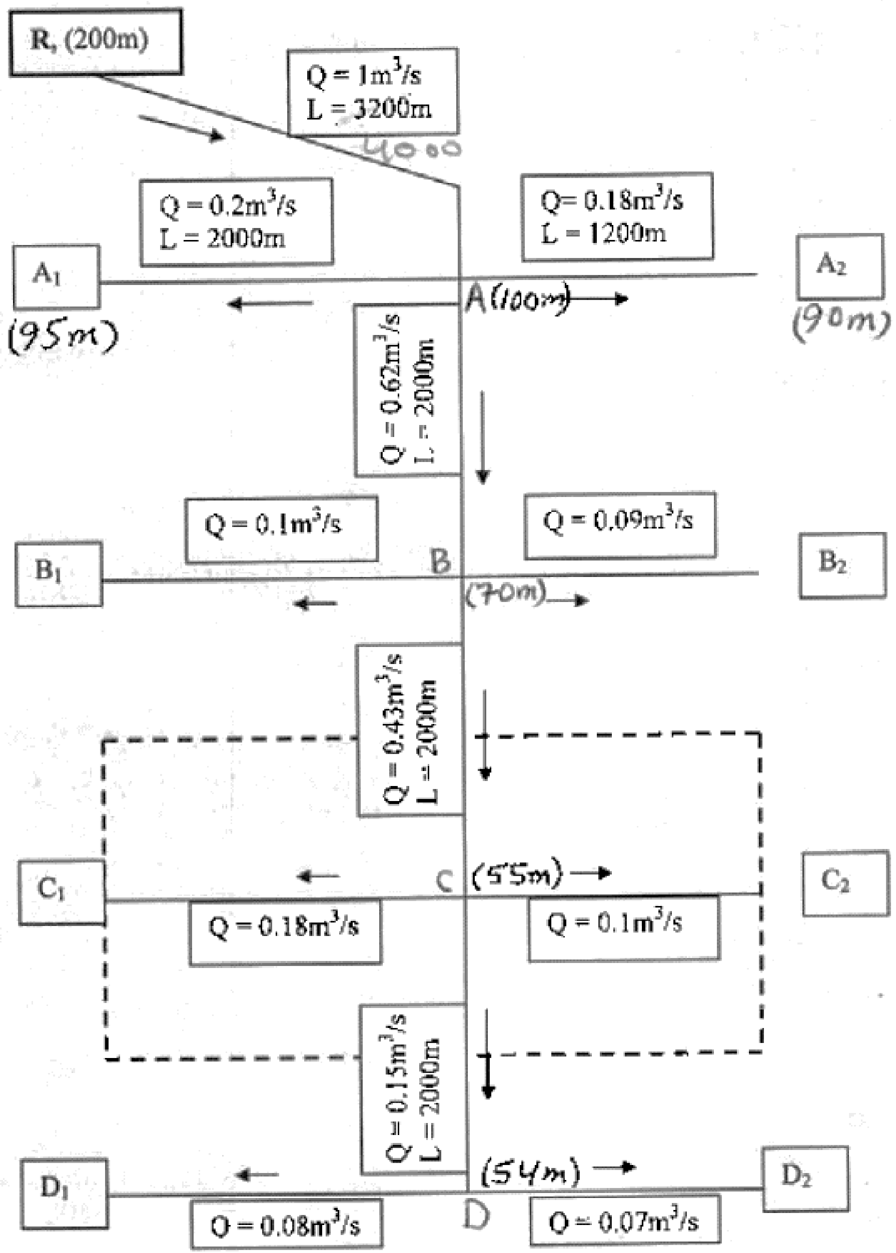
Pressure in pipe + elevation at D = 35 + 54 = 89m

Design of pipeline RA:
Total available head = 200 – 135 = 65m
Allowable loss of head /100m = 100 × (65/3200) = 2.03m
Flow in the pipe RA, $Q_{RA} = 1m^3/s$
Assume diameter, d_{RA} = 700mm
Using Manning formula,

$$\therefore S = \left(\frac{0.013 \times 1}{\frac{\pi(0.7)^2}{4}\left(\frac{0.7}{4}\right)^{2/3}} \right)^2 = 0.011 = 1.1/100 < 2.03/100 \text{ o.k.}$$

Total head loss = 1.1 × (3200/100) = 32m
Piezometric head at A = 200 – 32 = 168m > 135m o.k.
If we select the next standard size pipe of smaller diameter would have resulted in too great a head loss, e.g.
If d = 600mm

$$\therefore S = \left(\frac{0.013 \times 1}{\frac{\pi(0.6)^2}{4}\left(\frac{0.6}{4}\right)^{2/3}} \right)^2 = 0.03 = 3/100 > 2.03/100 \text{ not o.k.}$$



Design of pipelines AA_1 & AA_2:

At A_1 the available head = 168 – (95 + 35) = 38m

Head loss /100m = 100 × (38/2000) = 1.9m

Flow in pipe AA_1 , Q_{AA1} = 0.2m^3/s

Assume d_{AA1} = 350mm

Using Manning formula,

$$\therefore S_{AA_1} = \left(\frac{0.013 \times 0.2}{\frac{\pi (0.35)^2}{4} \left(\frac{0.35}{4} \right)^{2/3}} \right)^2 = 0.019 = 1.9/100 = 1.9/100 \text{ o.k.}$$

At A_2, the available head = 168 – (90 + 35) = 43m

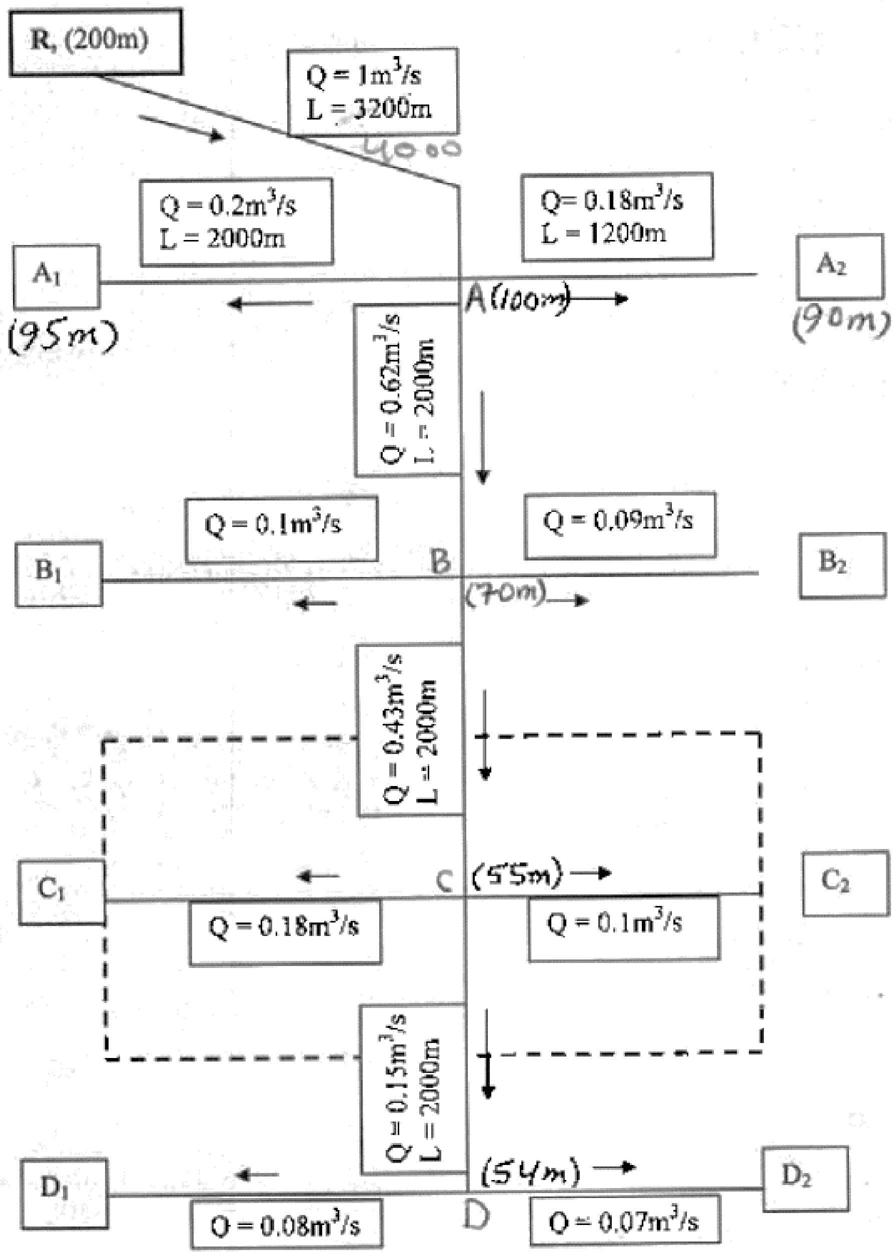
Head loss available /100 = 100 × (43/1200) = 3.6m

Flow in pipe AA_2, Q_{AA2} = 0.18m^3/s

Assume d_{AA2} = 300mm

Using Manning formula,

$$\therefore S_{AA_2} = \left(\frac{0.013 \times 0.18}{\frac{\pi (0.3)^2}{4} \left(\frac{0.3}{4} \right)^{2/3}} \right)^2 = 0.035 = 3.5/100 < 3.6/100 \text{ o.k.}$$



Design of pipeline AB:

At B available head = 168 – (70 + 35) = 60m

Allowable head loss /100 = 100 × (60/2000) = 3m

Flow in pipe AB, $Q_{AB} = 0.62 m^3/s$

Assume d_{AB} = 600mm

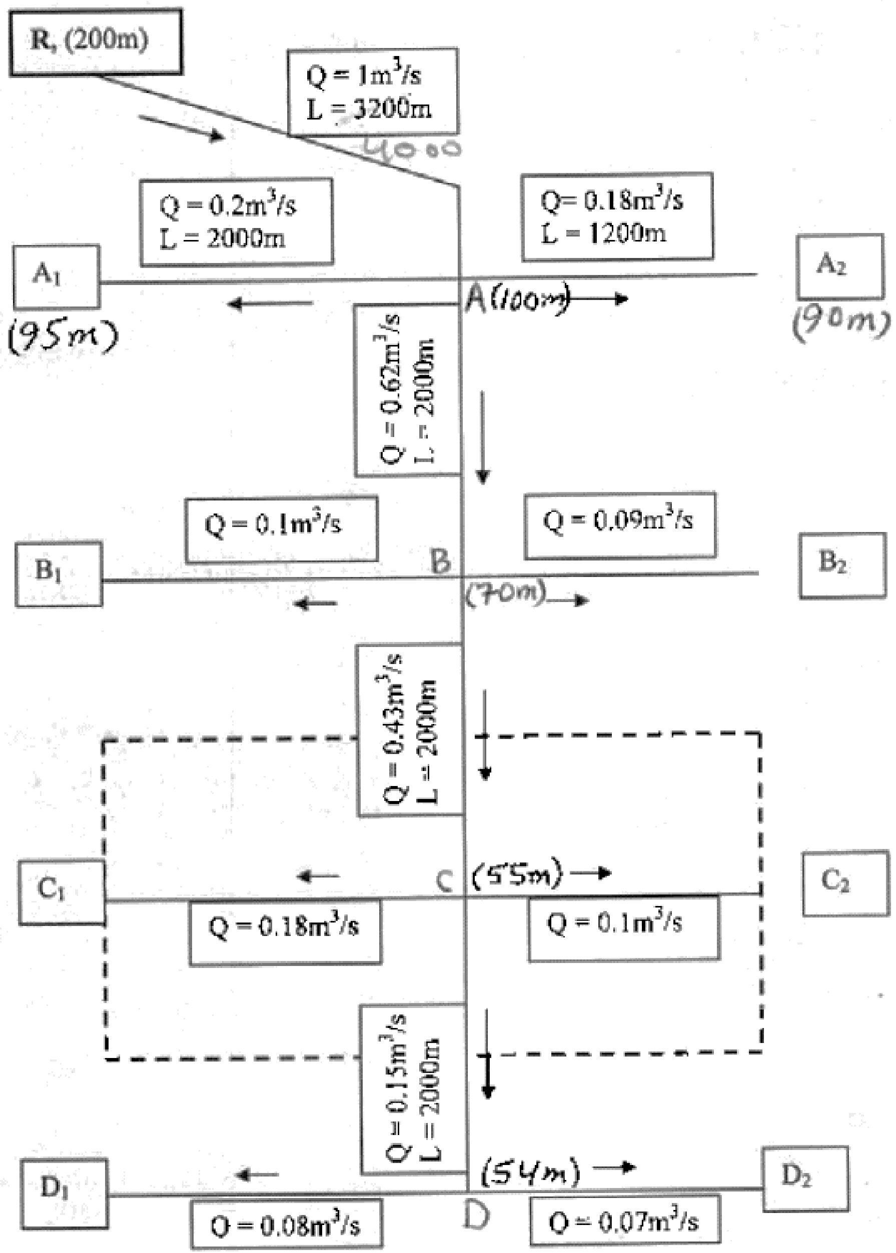
Using Manning formula,

$$\therefore S_{AB} = \left(\frac{0.013 \times 0.62}{\frac{\pi (0.6)^2}{4} \left(\frac{0.6}{4} \right)^{2/3}} \right)^2 = 0.01 = 1/100 < 3/100 \text{ o.k.}$$

Why 1/100 << 3/100?

Total head loss in AB = 1 × (2000/100) = 20m

Piezometric head at B = 168 – 20 = 148m > 105m o.k.



Design of pipeline BC:

At C, the available head = 148 – (55 + 50) = 43m

Head loss available /100 = 100 × (43/2000) = 2.15m

Flow in pipe BC, $Q_{BC} = 0.43 m^3/s$

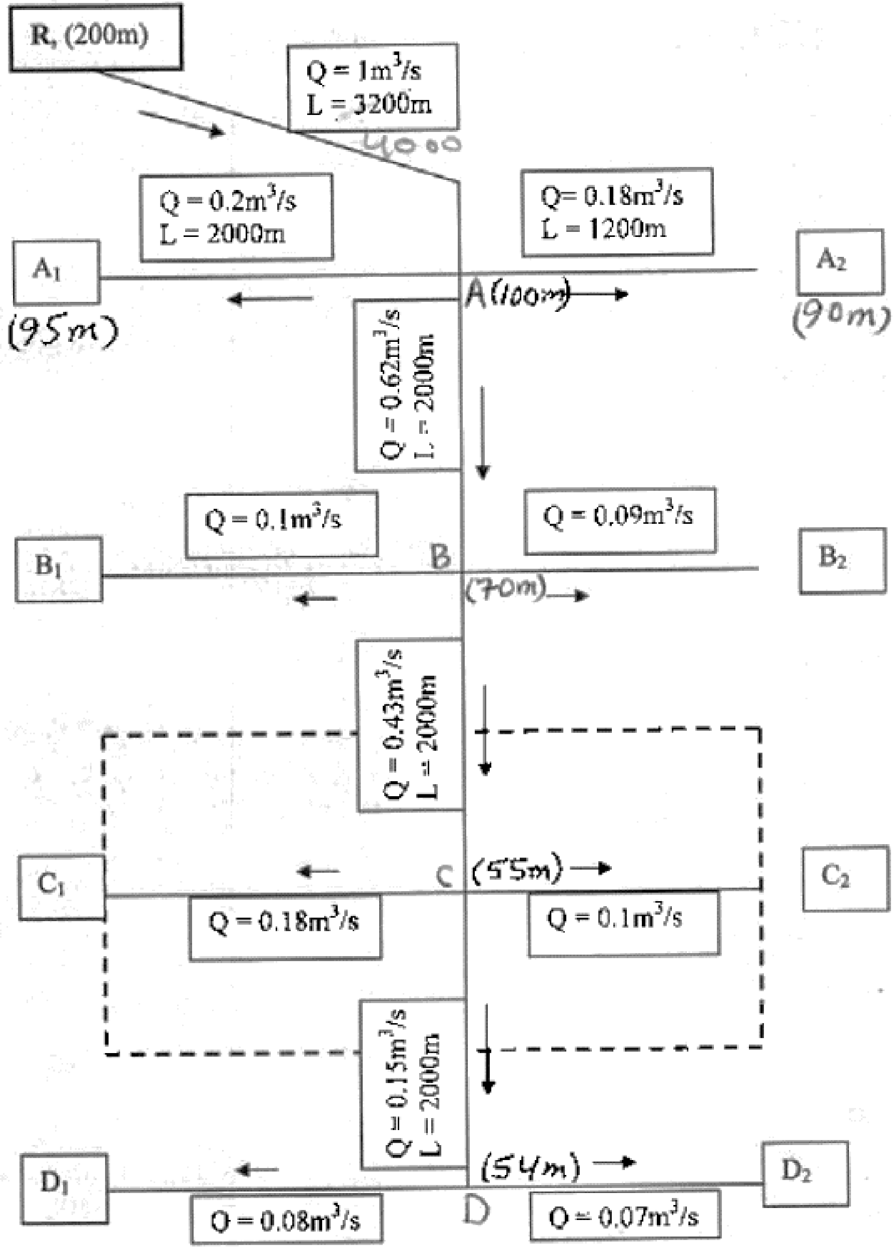
Assume d = 500mm

Using Manning formula,

$$\therefore S_{BC} = \left(\frac{0.013 \times 0.43}{\frac{\pi (0.5)^2}{4} \left(\frac{0.5}{4} \right)^{2/3}} \right)^2 = 0.013 = 1.3/100 < 2.15/100 \text{ o.k.}$$

Total head loss in BC = 1.3 × (2000/100) = 26m

Piezometric head at C = 148 – 26 = 122m > 105m o.k.



Design of pipeline CD:

At D, the available head = 122 – (54 + 35) = 33m

Head loss available /100 = 100 × (33/2000) = 1.65m

Flow in pipe CD, Q_{CD} = 0.15m^3/s

Assume d = 400mm

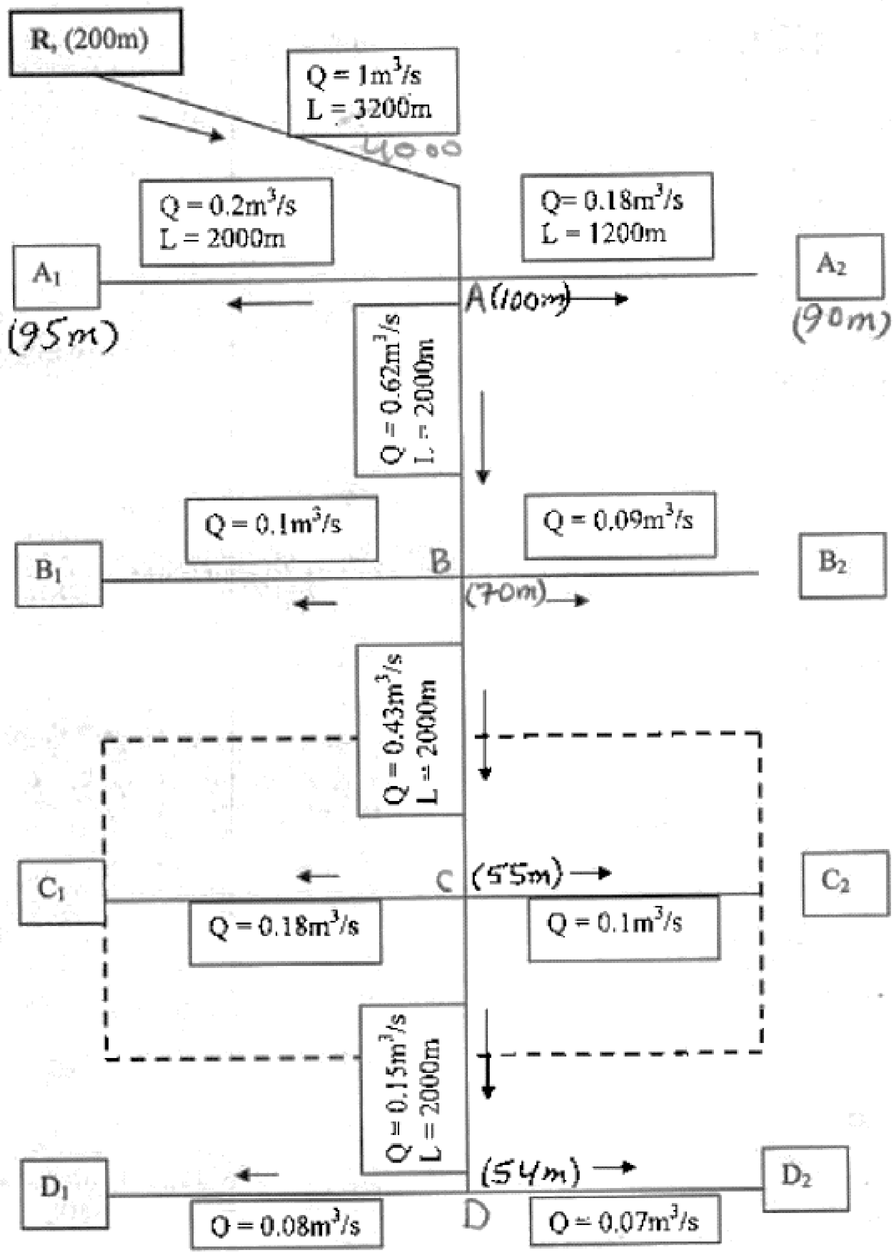
Using Manning formula,

$$\therefore S_{CD} = \left(\frac{0.013 \times 0.15}{\frac{\pi (0.4)^2}{4} \left(\frac{0.4}{4} \right)^{2/3}} \right)^2 = 0.005 = 0.5/100 < 1.65/100 \text{ o.k.}$$

Total head loss in CD = 0.5 × (2000/100) = 10m

Piezometric head at D = 122 – 10 = 112m > 89m o.k.

Why we do not check piezometric head at A_1 & A_2?



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