Water and wastewater system

CT 263

Dr. Mary Shafeek Awadalla

tribution system,

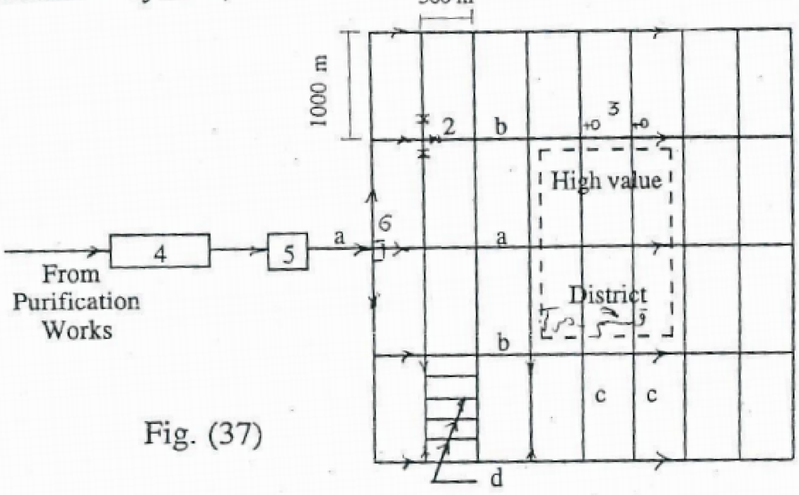


Fig. (37)

The distribution system consists of :

1 - The complete network of pipes

a) Main Feeder　　b) Primary Feeders

c) Secondary Feeder　　d) Lateral (distributors)

2 - Valves

3 - Fire Hydrants.

4 - Clear water tanks or Ground storage reservoir

5 - Pumping station (H.L.P.) & boosters.

6 - Elevated tanks or water towers.

7 - Service pipe lines or house connections.

8 - Water Meters.

DISTRIBUTION RESERVOIRS

Distribution reservoirs are used for sorting water within or near the distribution area.They are of two general types:

(1) Clear Water Reservoirs or Ground Storage Reservoirs

They are closed tanks which have little or no elevation above the ground and which are usually built of R.C. High Lift pumps should be used in delivering water from such storage tanks, and forcing it into pipe distribution network. (see the fig.)

These tanks are necessary in connection with :

1 - They are essential for uniformity of operation of water treatment plant.

2 - They provide proper detention of water (contact period) after chlorination.

(2) Elevated Tanks or Water Towers (INZA Tanks)

They are built above the ground. They are made of R.C. or steel. (see figure)

1 - To supply water at time of high demand at peak hours.

2 - To control the pressure in the distribution system.

3 - To allow a uniform rate of pumping through out the day.

Water Distribution System

Planning:

Types of distribution systems:

1- Tree system:

- يستخدم في القرى أو التجمعات السكنية الصغيرة .

Advantages:

1. low cost
2. easy calculations (determination of Q , h @ any point)

Disadvantages:

1. dead ends: → decrease water pressure
   → affect the water quality
2. there is one source of water thus the water is cut off when main pipe is to be repaired

2- Loop system:

- يستخدم في التجمعات السكنية المتوسطة

Advantages:

1. Cost is relatively high
2. Easy of determination of Q, h @ any point
3. There are two directions of water supply

Disadvantages:

1. dead ends: → decrease water pressure
   → affect the water quality
2. If there is damage in minor pipe a small district is affected

3- Grid iron system:

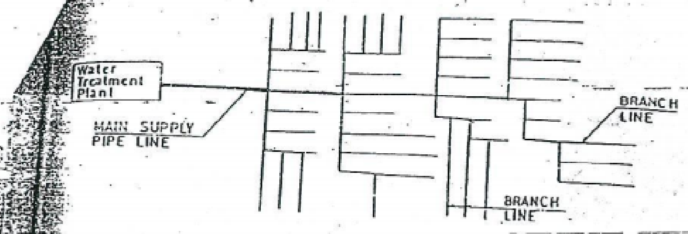
- لا يوجد نهاية لأي ماسورة ويوجد لكل ماسورة بدايتان
- يستخدم في المدن الكبيرة و الهامة

Advantages:

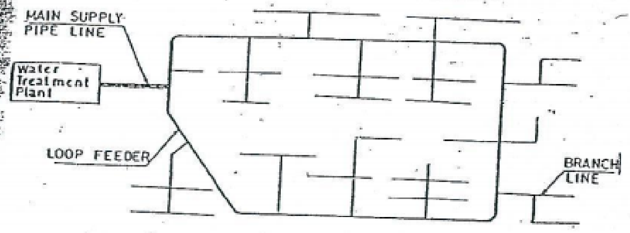
1. No dead ends
2. Supply is not affected by breakdown

Disadvantages:

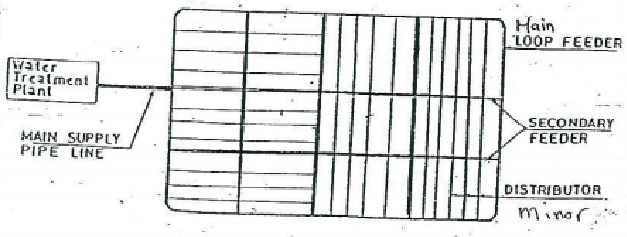
1. high cost
2. Complicated analysis



TREE SYSTEM (DEAD END SYSTEM)



loop
CIRCLE SYSTEM (RING SYSTEM)



GRIDIRON SYSTEM.

Fig 4.2 TYPES OF WATER DISTRIBUTION SYSTEM.

Types of Valves:

1- **sluice valve: محبس قفل**

- at intersections between main pipes
  no. of valves = n – 1 (n = no. of pipes)
- at intersection between main and minor
  no. of valves = n – 2

- if Ø < 500 mm → gate valve
- if Ø ≥500 mm → butter fly valve

- if Ø ≤ 200 mm → surface box
- if Ø > 200 mm → valve chamber

• أقصى مسافة بين محبسين = 400 متر

2- **Wash valve : محبس غسيل للشوائب داخل المواسير**

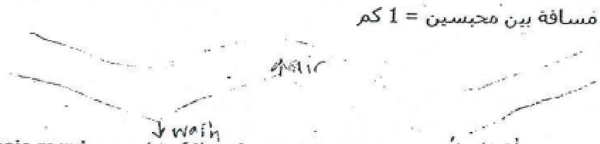
- At lowest point of pipes

• عند امتلاء الغرفة يتم سحب المياه عن طريق طلمبة تقالي ورميها في مصرف
• أقصى مسافة بين محبسين = 1 كم

3- **Air valve: محبس هواء لتفريغ الهواء من المواسير**

- At highest point of pipes

• أقصى مسافة بين محبسين = 1 كم



Basic requirements of the pipe network system : wash

1- Sufficient capacity to meet maximum demand at any time (flow & head)
2- More than one main feeder to insure continuity of supply
3- control of flow by valves & meters
4- Well laid pipe network of durable materials
5- Absence of dead ends
6- Complete protection against contamination

Design of Network:

1- Main supply pipe line = $Q_{max.\ daily} + Q_{fire}$

Main feeders = the max. of $(Q_{max.\ daily} + Q_{fire})$ or $(Q_{max.\ hourly})$

Minor system = Q_{fire}

2- Velocity = [0.6 – 1.5] m/s
If v < 0.6 → Ø will be big (Q = a x v)
If v > 1.5 → high losses ($h = 4FLv^2 / 2gØ$)

3- Ø: → $Ø_{min}$ for main pipes = 200 mm
→ $Ø_{min}$ for minor system = 100 mm

4- Slope of hydraulic gradient = (1 – 3) ‰ (m / km) = (10 -30) cm / 100 m

Hydraulic design:

(Hazzen Williams formula):

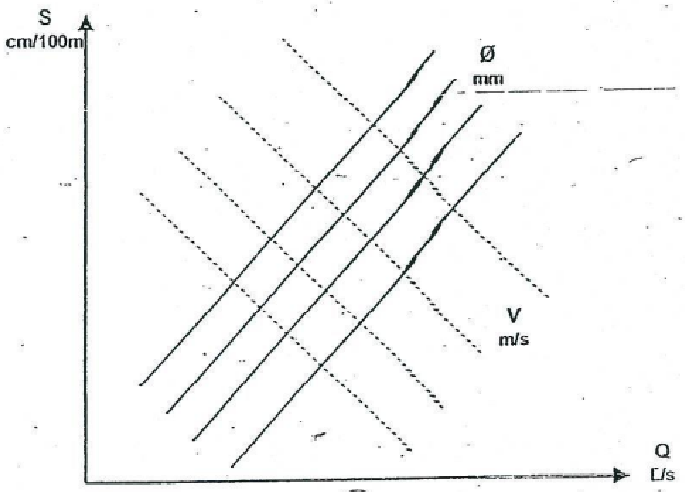
$$V = 0.344\ C\ R^{0.63}\ S^{0.54}$$

Where:

C → friction coefficient (100)
R → hydraulic radius
S → (1 – 3)‰ = الميل الهيدروليكي

Hazen William chart

المنحنى عبارة عن علاقة بين (S ، V ،Q ،Ø) وبمعرفة أي عنصرين يمكن إيجاد العنصرين المجهولين



if given (2) → (2) you can get them

S_{chart} = cm / 100 m = $(\Delta H/L) \times 10^4$

Methods of Network Analysis;

1- Main Network :
   a) Equivalent pipe method
   b) Hardy cross method
   c) method of Sections

2- Minor Network :
   d) Method of Circle

a) **Equivalent pipe method :**

تعتمد فكرة هذه الطريقة على مكافأة مجموعة مواسير موصلة على التوالي أو التوازي بماسورة واحدة لها نفس (Q , h) وتختلف عن المجموعة في (Ø , L)

1- **Pipes in series:**

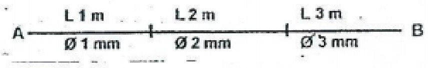
Q constant (can be assumed = 100 or 50 L/s)

From chart:

$(Ø_1 , Q) \rightarrow (S_1), L_1 \rightarrow h_1$

$(Ø_2 , Q) \rightarrow (S_2), L_2 \rightarrow h_2$

$(Ø_3 , Q) \rightarrow (S_3), L_3 \rightarrow h_3$



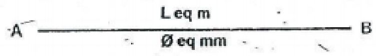
By Equivalent:

Q constant = Q

$h_{eq} = h_1 + h_2 + h_3$

assume $Ø_{eq} \rightarrow Ø_1$ or $Ø_2$ or $Ø_3$ (حتى لا تبحث عنها مرة أخرى)

$(Q , Ø_{eq}) \rightarrow (S_{eq}) , h_{eq} \rightarrow L_{eq}$



2- **Pipe in parallel:**

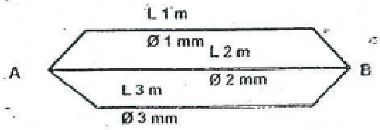
h constant (can be assumed = 10 m)

From chart:

$(Ø_1 ,S_1) \rightarrow Q_1$

$(Ø_2 ,S_2) \rightarrow Q_2$

$(Ø_3 ,S_3) \rightarrow Q_3$



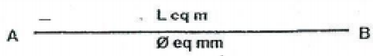
By Equivalent:

h constant = 10 m

$Q_{eq} = Q_1 + Q_2 + Q_3$

assume $Ø_{eq}$

$(Q_{eq} , Ø_{eq}) \rightarrow (S_{eq}) , h \rightarrow L_{eq}$



note:

for n pipes in series with the same Ø

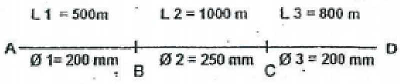
$Ø_{eq} = Ø$

$L_{eq} = \sum L$

h = S*L

Example:
Req

Find the equiv pipe AD



Sol

Assume Q = 50 L / sec

For pipe AB
From chart:
Q = 50 L / s, $Ø_1$ = 200mm → S = 120 cm / 100 m

S = h x 10^4 / L → 120 = h x 10^4 / 500→ h_1= 6 m

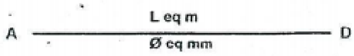
For pipe BC
From chart:
Q = 50 L / s,$Ø_2$ = 250mm → S = 40 cm / 100 m

S = h x 10^4 / L → 40= h x 10^4 / 1000 → h_2= 4 m

For pipe CD
From chart:
Q = 50 L / s,$Ø_3$ = 200mm → S = 120 cm / 100 m

S = h x 10^4 / L → 120= h x 10^4 / 800→ h_3= 9.6 m

By Equivalent:
Q constant = 50 L / sec



$h_{eq} = h_1 + h_2 + h_3$
= 6 + 4 + 9.6 = 19.6

Assume $Ø_{eq}$ = 200 mm → from chart S = 120 cm / 100 m

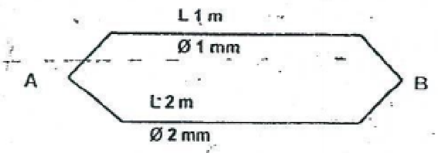
S = h x 10^4 / L → L = 1633.33 m

Example

Given

L_1 = 1000 m $Ø_1$ = 200 mm

L_2 = 1200 m $Ø_2$ = 250 mm



Required

Find the Equivalent pipe AB

Solution:

Assume h =10 m

For pipe 1

S = 10 x 10^4 / 1000 → S = 100 cm / 100 m

S = 100, Ø = 200 → from chart Q_1 = 44 L / sec

For pipe 2

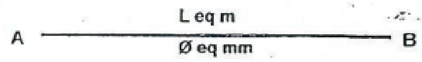
S = 10 x 10^4 / 1200 → S = 83.33 cm / 100 m

S = 83.33 , Ø = 250 → from chart Q_2 = 73 L / sec

By Equivalent:

h constant = 10 m

$Q_{eq} = Q_1 + Q_2$ = 44 +73 = 117 L / sec

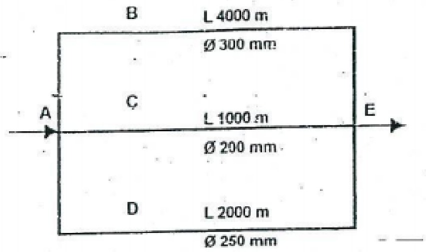


assume $Ø_{eq}$ = 250 mm

from chart (Q_{eq} , $Ø_{eq}$) → (S_{eq} = 200 cm / 100 m)

S =h x 10^4 / L → L_{eq} = 500 m

Example 2



Given:
$H_A = 40$ m , $H_E = 20$ m , C = 100

Required:
The flow in each branch of the loop

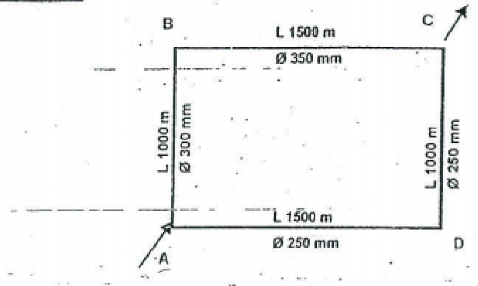
Solution:
For all pipes :
$h = H_A - H_E = 40 - 20 = 20$ m

for pipe ABE:
$S = h / L = 20 / 4000 \times 10^4 = 50$ cm /100m
(from chart)→ Q = 90 L / s
Ø = 300 mm

for pipe ACE:
$S = h / L = 20 / 1000 \times 10^4 = 200$ cm /100m
(from chart)→ Q = 65 L / s
Ø = 200 mm

for pipe ADE:
$S = h / L = 20 / 2000 \times 10^4 = 100$ cm /100m
(from chart)→ Q = 80 L / s
Ø = 250 mm

Example 3



Given:
C = 100
Required:
The equivalent pipe for the network
Solution:
for pipes AD&DC:(series)
$Ø_{eq}$ = 250 mm
L_{eq} = 1500 + 1000 = 2500 m

for pipes AB&BC:(series)
assume Q = 100 L / s
pipe AB:
Q = 100
→ (from chart)S = 60 cm /100 m
Ø = 300

→ $h = 60 \times 1000 / 10^4 = 6$ m

pipe BC:
Q = 100
→ (from chart)S =28 cm /100 m
Ø = 350

→ $h = 28 \times 1500 / 10^4 = 4.2$ m

pipe ABC:
h = 6 + 4.2 = 10.2 m

take Ø = 350 → S = 28 cm /100 m

→ $L = 10.2 \times 10^4 / 28 = 3642.86$ m

for pipes ADC & ABC (parallel):

assume h = 10 m

<u>pipe ADC :</u>

$S = h / L = 10 / 2500 \times 10^4 = 40$ cm /100m

(from chart) → Q = 50 L / s

Ø = 250 mm

<u>pipe ABC</u>

$S = h / L = 10 / 3642.86 \times 10^4 = 27.45$ cm /100m

(from chart) → Q = 100 L / s

Ø = 350 mm

<u>pipe AC :</u>

Q = 50 + 100 = 150 L/s

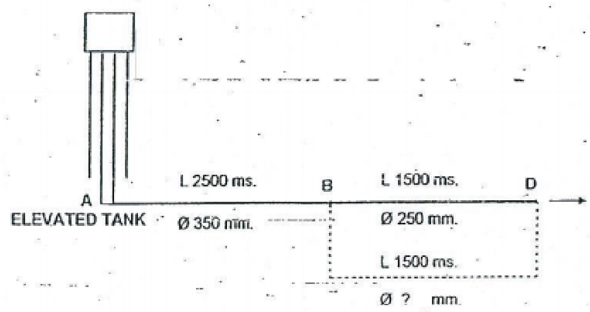
→ S = 60 cm /100m (from chart)

take Ø = 350

→ $L = 10 \times 10^4 / 60 = 1666.67$ m

∴ **the equivalent pipe : Ø = 350 mm & L = 1666.67 m**

Example 4



- Case (1) : Q = 120 L/s , H_D = 25m
- Case (2) : Q = 165 L/s, H_D = 35m

1 kg / cm^2 = 10 m
1- in case (1) : calculate $H_{constant}$ for the elevated tank
2- in case (2) : calculate h_{BD} then $Ø_{BD}$

case (1) : **Q = 120 L/s**

pipe BD :
Q = 120 L/s
(from chart) → S = 200 cm /100m
Ø = 250

→ h = 200 x 1500 / 10^4 = 30 m
$H_B = H_D + h = 25 + 30 = 55m$

pipe AB :
Q = 120 L/s
(from chart) → S =38 cm /100m
Ø = 350

→ h = 38 x 2500 / 10^4 = 9.5 m
$H_A = H_B + h = 55 + 9.5 = 64.5m$

case (2) : **Q = 165 L/s , H_A =64.5m H_D = 35m**

pipe AB :

Q = 165 L/s

(from chart)→ S =60 cm /100m

Ø = 350

→ $h = 60 \times 2500 / 10^4 = 15$ m

$H_B = 64.5 - 15 = 49.5$m

∴ for B D

$h = H_B - H_D = 49.5 - 35 = 14.5$ m

pipe BD :

$S = 14.5 / 1500 \times 10^4 = 96.67$ cm /100m

(from chart)→ Q = 80 L/s

Ø = 250

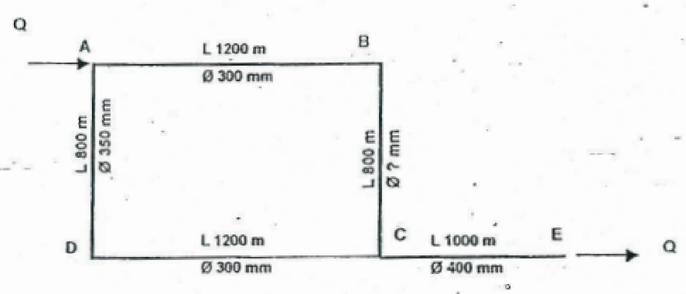
For the new pipe (dotted pipe)

Q = 165 – 80 = 85 L/s

→ Ø = 250 mm(from chart)

S = 96.67 cm /100m

Example 7



Given:

$H_A = 50$m , $H_E = 30$m , Q = 200 L / s

Solution:

For CE:

$Q = 200$

From chart: → $S = 55$ cm /100 m

$Ø = 400$

55 cm /100 m = (h / 1000) x 10^4 → $h_{CE} = 5.5$ m

$\therefore H_C = 30 + 5.5 = 35.5$ m

for pipe AD&DC:

assume Q = 100 L / s

for AD

$Q = 100$

→ S = 28 cm /100 m

$Ø = 350$

$\therefore h_{AD} = 28 \times 800 / 10^4 = 2.24$ m

for DC

$Q = 100$

→ S = 64 cm /100 m

$Ø = 300$

$\therefore h_{DC} = 64 \times 1200 / 10^4 = 7.68$ m

for ADC

$h_{ADC} = h_{AD} + h_{DC} = 2.24 + 7.68 = 9.92$ m

assume Ø = 350 , Q = 100 L/s → S = 28 cm /100 m

(بدون الدخول في chart لأنه تم حسابها في أول المسألة)

$28 = (h_{ADC} / L_{eq}) \times 10^4$ → $L_{eq} = 3542.86$ m

$\therefore L_{eq} = 3542.86$ m , Ø = 350 mm

$h_{AC} = H_A - H_C = 50 - 35.5 = 14.5$ m

$\therefore S = (h_f / L_{eq}) \times 10^4 = (14.5 / 3542.86) \times 10^4 = 40.9$ cm /100 m

From chart:

$S = 40.93$

→ Q = 120 L / s

$Ø = 350$

$\therefore Q_{ABC} = 200 - Q_{ADC} = 200 - 120 = 80$ L / s

for pipe (AB):

L = 1200m , Ø = 300mm , Q = 80 L / s

$Q = 80$

From chart → S = 40 cm /100 m

$Ø = 300$

40 cm /100 m =(h / 1200) x 10^4 → h_{AB} = 4.8 m

∴ $h_{BC} = h_{ABC} - h_{AB}$ = 14.5 – 4.8 = 9.7 m

for pipe BC :

L = 800m , h_{BC} = 9.7m , Q = 80 L / s → S = (9.7 / 800) x10^4 = 121.25

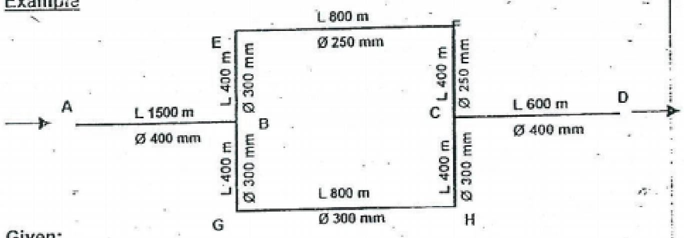
S = 121.25

From chart → Ø = 240 mm taken 250 mm

(Ø = 250 mm يجب أخذ :يتم كتابة ملحوظة)

Q = 80

Example



Given:

10 PM to 6 AM Q_A = 100 L/s

6 AM to 10 PM Q_A = 150 L/s with booster pump at B

HD=20 m constant

required:

Total head of HLP at A

head of the booster pump at B

Solution:

Case 1

Q=100 L/s , H_D = 20 m → get H_A

Case 2

Q=150 L/s , HD = 20 m & HA → get $H_{booster}$ at B

For BE&EF&FC:

[BE] assume Q = 100 L/s, Ø = 300 mm from chart → S = 64

h = (64 /10^4) x 400 = 2.56m

[EC] assume Q = 100 L/s , Ø = 250 mm from chart → S = 140

h = (140 /10^4) x 1200 = 16.8m

for equivalent pipe BEFC:

Q = 100 L/s , assume $Ø_{eq}$ = 300 mm → from chart S = 64

h = 2.56+16.8 =19.36 m

→ L_{eq} = (19.36 / 64) x 10^4 = 3025 m

for equivalent pipe BGHC:

$Ø_{eq}$ = 300 mm & L_{eq} = 400+800+400 = 1600 m

For pipes BEFC & BGHC: (parallel)

assume h = 10 m

pipe BEFC :

S = (10 / 3025) x 10^4 = 33 cm /100 m

→ Q = 70 L/s

Ø = 300

pipe BGHC :

S = (10 / 1600) x 10^4 = 62.5 cm /100 m

→ Q = 100 L/s

Ø = 300

for equivalent pipe BC:

Q_{eq} = 170 , assume Ø = 300 chart → S = 180

→ L_{eq} = (10 / 180) x 10^4 = 555.56 m

Case (1) from 10 Pm to 6 Am :

For pipe CD :

Q = 100 L/s , Ø = 400 mm , S = 14

h_{CD} = (14 / 10^4) x 600 = 0.84 m

→ H_C = 20 + 0.84 = 20.84 m

For pipe BC :

Q = 100 L/s , Ø = 300 mm , S = 64

h_{BC} = (64 / 10^4) x 555.5 = 3.55 m

→ H_B = 20.84 + 3.55 = 24.4 m

For pipe AB :

Q = 100 L/s , Ø = 400 mm , S = 14

h_{AB} = 14 x 1500/ 10^4 = 2.1 m

→ H_A = 24.4 + 2.1 = 26.5 m

Case (2) from 6 Am to10 Pm:

Q = 150 L/s

H_{B1} from A

H_{B2} from D

$_{pooster} = H_{B2} - H_{B1}$

For pipe CD :

Q = 150 L/s , Ø = 400 mm , S = 32

$h_{CD} = (32 / 10^4) \times 600 = 1.92$ m

→ $H_C = 20 + 1.92 = 21.92$ m

For pipe BC :

Q = 150 L/s , Ø = 300 mm , S = 140

$h_{BC} = (140 / 10^4) \times 555.5 = 7.78$ m

→ $H_{B2} = 21.92 + 7.78 = 29.7$ m

For pipe AB :

Q = 150 L/s , Ø = 400 mm , S = 32

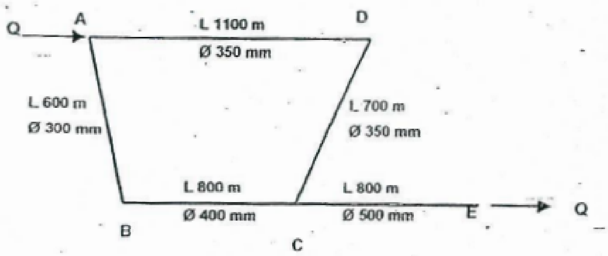
$h_{AB} = 32 \times 1500 / 10^4 = 4.8$ m

→ $H_{B1} = 26.5 - 4.8 = 21.7$ m

head of the booster pump = 29.7- 21.7 = 8 m

Example :

For the shown network, if the discharge increased from 200 L/s to 250 L/s. Find the diameter of the new line between A & C if its length 1200 m, Knowing that the pressure at points A ,E constant at both cases.



Case (1) :

Q = 200 L/s → get ΔH_{AE}

Case (2) :

Q = 250 L/s& ΔH_{AE} const → get $Ø_{AC}$

Solution :

AB&BC:

Assume Q = 100 L / s

For pipe AB:

Q = 100

→ S = 65 cm /100 m (from chart)

Ø = 300

→ h_{AB} = 65 x 600 / 10^4 = 3.9 m

For pipe BC:

Q = 100

→ S = 14 cm /100 m (from chart)

Ø = 400

→ h_{BC} = 14 x 800 / 10^4 = 1.12 m

for equivalent pipe ABC:

Q = 100 L/s

h_{eq} = 3.9 + 1.12 = 5.02 m

assume $Ø_{eq}$ = 400 mm

Q = 100

→ S = 14 cm /100 m (from chart)

Ø = 400

→ L_{eq} = 5.02 x 10^4 / 14 = 3585.714 m

AD&DC:

for equivalent pipe ADC:

$Ø_{eq}$ = 350 mm

L_{eq} = 1800m

for pipes ABC & ADC are in parallel :

assume h_{AC} = 10 m

for pipe ABC:

S = Δh x 10^4 / L = 10 x 10^4 / 3585.714 = 28 cm /100m

(from chart)→ Q = 140 L / s

Ø = 400

for pipe ADC:

S = Δh x 10^4 / L = 10 x 10^4 / 1800 = 55.5 cm /100m

(from chart)→ Q = 150 L / s

Ø = 350

for equivalent pipe AC:

Q_{eq} = 140+150 = 290 L/s

→ S_{eq} = 40 cm / 100m (from chart)

ass $Ø_{eq}$ =500 mm

h = 10m

For pipes AC & CE :

$Q_{act} = 200$ L/s

For pipe AC

$Q = 200$

$\rightarrow S = 18$ cm /100 m (from chart)

$Ø = 500$

$\rightarrow h_{AC\ act} = 18 \times 2500 / 10^4 = 4.5$ m

For pipe CE

$Q = 200$

$\rightarrow S = 18$ cm /100 m (from chart)

$Ø = 500$

$\rightarrow \Delta h_{CE\ act} = 18 \times 800 / 10^4 = 1.44$ m

$\therefore h_{AE\ act} = 4.5 + 1.44 = 5.94$ m

Case (2) :

Q = 200 L/s with new pipe AC' , h_{AE} const. = 5.94 m

For pipe CE

$Q = 250$

$\rightarrow S = 27$ cm /100 m (from chart)

$Ø = 500$

$\rightarrow h_{CE\ act} = 27 \times 800 / 10^4 = 2.16$ m

For pipe AC old

$h_{AC\ act} = 5.94 - 2.16 = 3.78$ m

$S_{AC} = 3.78 \times 10^4 / 2500 = 15.12$ cm /100 m

$\rightarrow Q_{act} = 185$ L/s

(from chart) $Ø = 500$

For pipe AC new

L = 1200mm

$Q_{act} = 250 - 185 = 65$ L /s

$h_{act} = 3.78$ m $\rightarrow S = 3.78 \times 10^4 / 1200 = 31.5$ cm /100 m

(From chart) $\rightarrow Ø = 300$ *mm*

Method of sections:

هي طريقة تستخدم لعمل الدراسات الأولية أو لعمل check of design و هي طريقة تقريبية

- مواضع دراسة ال section :
  1. عمودي على اتجاه ال flow
  2. في بداية تغيير قطر الماسورة (الحالة critical علشان نأخذ كل المساحة المخدومة)

The method may be described in the following steps:
For each section:

a) Q_{design} حسب مكان القطع

Q_{design} = The max of ($Q_{max\ daily} + Q_{fire}$) or ($Q_{max\ hourly}$)

b) calculate Q act from the cut pipes
ass s = 2‰ (1-3) = 20 cm/100m
From chart (Ø&s) → Q for each pipe

$$Q\ act = \sum Q\ pipes$$

c) compare Qd & Qact

- Check 1 $((Q_{act} - Q_{design}) / Q_{design}) \times 100$
  - ✓ If < ± 10% → safe
  - ✓ If > ± 10% → Check (S & V) equivalent pipe

- Check 2 Equivalent pipe

From chart (Q act & S=2‰) → Ø eq

From chart (Q d & Ø eq)→ check that S = 1 – 3 ‰ & V = 0.6 – 1.5

d) If S > 5‰ or V > 1.5 m/sec:

It means that $Q_{act} < Q_{design}$ → increase area of the section

- for new network → increase Ø
- for existing network → increase no of pipes

$\Delta Q = Q_{design} - Q_{act}$

e) If S < 1 ‰ or V < 0.6 m / sec :

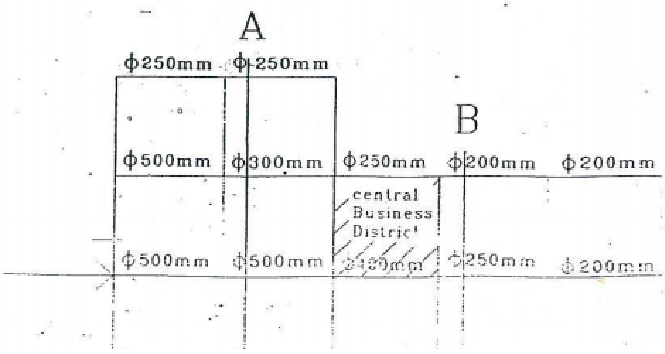
It means that $Q_{act} > Q_{design}$ → decrease area of the section

- For new network → decrease Ø
- for existing network → more safe but not economic design

- Fire demand remain the same until the high value district(HVD) , then according to population

Example:

Check the shown existing network at sec (A-A) & (B-B) given the following:
Pop of the city = 150,000 C
Pop up to sec (A-A) = 40% of total Pop
Pop up to sec (B-B) = 80% of total Pop
Annual average rate of water consumption = 120 L/c/d
Fire demand = 300 L/sec



Solution:

FOR SEC (A-A):

Q design

P =(60/100)x150,000=90000C

Q_{av} = (90000 x 120)/ (24 x3600) = 125 L/sec

Q_{md} = 1.8x125=225 L/sec

Q_f = 300 L/sec

→ Q_{mh} = 3 x125=375 L/sec

$Q_{md}+Q_f$ = 225 + 300 = 525 L/sec

→Take Q_d = 525 L/sec الأكبر

PIPES CUT BY SEC (A-A):

	Q at s=2‰
1Φ500mm	200 L/sec
2Φ300 mm	2x55 = 110 L/sec
1Φ250 mm	34 L/sec

→Q_{act} = 344 L/sec

Check 1

(Qd-Qact) / Qd x 100 = 34.48 % > 10%

Equivalent pipe:

At Q = 344 L/sec, s=2‰ = 20 cm/100m →Φ_{eq} = 610 mm (from chart)

Check 2:

(From chart) At Qd = 525 L/sec, Φ_{eq}= 610mm→

S=46 cm/100m=4.6‰ >3‰ & V>1.5 m/sec → Unsafe

for existing network → increase no of pipes

We need network reinforcement.

Q_{add} = 525-344=181 L/sec

⇒ add pipes (n<4)

1Φ300 = 55 L/sec

1Φ400 = 125 L/sec

∑ = 180 L/sec

The new section:

1Φ500mm	200 L/sec
1Φ400	125 L/sec
3Φ300 mm	3x55 = 165 L/sec
1Φ250 mm	34 L/sec

∑ = 524 L/sec ≈ Qd → OK

For sec (B-B):

Q design:

P=0.2x150, 000=30000 C

Q_{av} =30000x120/(24x3600)=41.67 L/sec

Q_{md} = 1.8x 41.67=75 L/sec

Q_f =0.2x300=60 L/sec

Q_{mh} = 3 x 41.67=125 L/sec

Q_{md} +Q_f = 75 + 60 = 135 L/sec

→Q_d = 135 L/sec

pipes cat by sec(B-B):

	Q_{act} (at S = 2‰)
1Φ250mm	1x34 = 34 L/sec
2Φ200mm	2x19 = 38 L/sec

→ Q_{act} = 72 L/sec

Check 1

(Qd-Qact) / Qd x 100 = 46.67 % > 10%

Equivalent pipe:

At Q act =72 L/sec, S=2‰, → Φ_{eq} = 335 mm (from chart)

Check 2:

At Q_d = 135 L/sec , Φ_{eq} = 335 mm → S >30 cm/100m(3‰) → unsafe

We need net work reinforcement:

Q_{add} = 135 -72=63 L/sec

→ add pipes

2Φ250 = 2x34 L/sec = 68 L/s

The new section:

3Φ250	3x34 = 102 L/sec
2Φ200	2x19 = 38 L/sec
	∑ = 140 L/sec ≈ Qd → OK

Method of Circle (for minor system)

Design on Q_{fire}

- يتم افتراض أماكن لحدوث الحريق (منطقة تقاطع خطين او منتصف ماسورة أو منتصف مساحة)
- طول خرطوم الحريق ١٥٠ متر و قطر دائرة الخدمة ٣٠٠ م
- لا يمكن للدوائر أن تقطع main system
- يتم دراسة المكان الذي تقطع فيه الدائرة أقل عدد من المواسير

Steps

- ✓ Critical circle cuts minimum number of pipes
- ✓ fire demand = 60 L / sec
- ✓ Calculate flow through each pipe which equals to fire demand divided by the number of cutting minor distributor pipes for the same diameter.
  Q pipe = Q fire / no of cut pipes
- ✓ From chart (Q pipe &Ø) → get S

  - يتم رسم الشكل بمقياس رسم مناسب ، بعد ذلك يتم قياس أطوال المواسير من محيط الدائرة حتى بداية feeder

- ✓ Measure the average length of the minor distributor pipes from their feeder pipes to the hydrant within the circle.

$$L_{av} = (L-300) / 2$$

  - ➢ if horizontal length varies with vertical length

$$L = (L_1 + L_2)/2$$

- ✓ Determine head loss ($S = h \times 10^4 / L_{av}$) → $h = S \times L_{av} / 10^4$
- ✓ Determine the pressure in the main pipe = 28 m
- ✓ Determine pressure at the circle = 28 – head loss ≥ 14 m
- ✓ If the pressure at the circle < 14 m → unsafe

• يتم تحويل جميع المواسير المقطوعة الى نفس القطر المكافئ

Size of pipe in mm →	100	150	200	250
Number of 100mm pipes to carry same flow	1	3	6.6	12
Number of 150mm pipes to carry same flow	0.33	1	2.2	4

Example 6

Check for the shown minor pipes if the required fire flow 500 L/sec, normal pressure in the feeders is 2.8 kg/cm^2

Solution

Different circles

C1 → cut 6 Ø 200 + 8 Ø 150 = 6x2.2 + 8 = 21.2
C2 → cut 6 Ø 200 + 10 Ø 150 = 6 x 2.2 + 10 =23.2
C3 → cut 4 Ø 200 + 8 Ø 150 = 4 x 2.2 + 8 =16.8 Ø 150→ the critical circle
C4 → cut 4 Ø 200 + 10 Ø 150 =4 x 2.2 + 10 =18.8

Q pipe = 500 / 16.8 = 29.8 L/s

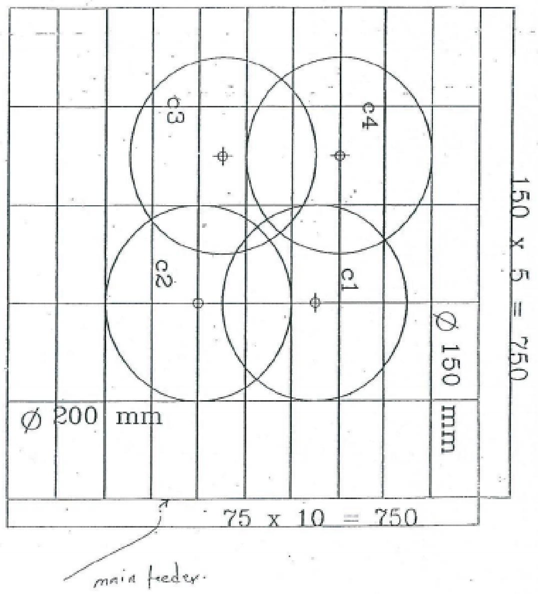
From chart (Q=29.8 & Ø=150 mm) → S=170 cm/100m

L =(750+750)/2 =750 m

Lav = (750-300) / 2 =225 m

h= 170 x 225 / 10^4 = 3.825 m

H (pressure at circle)= 28 – 3.825 =24.175 m > 14 m → safe


c3
c4
c2
c1
150 x 5 = 750
Ø 150 mm
Ø 200 mm
75 x 10 = 750
main feeder.