DIRECTORATE OF WATER SUPPLY
DIRECTORATE GENERAL CIPTA KARYA
MINISTRY OF PUBLIC WORKS
REPUBLIC OF INDONESIA

DIRECTORATE GENERAL
INTERNATIONAL COOPERATION
MINISTRY OF FOREIGN AFFAIRS
KINGDOM OF THE NETHERLANDS

MDP PRODUCTION TEAM

TRAINING MATERIALS FOR WATER ENTERPRISES

VOLUME 4

- GUIDE FOR USERS OF TRAINING MATERIALS
- ● TRAINING MODULES
  - GENERAL
  - ORGANISATIONAL
    - Basic knowledge / skills
    - Processes/procedures
    - Equipment/materials
  - ● TECHNICAL
    - ● Basic knowledge/skills
    - Processes/procedures
      - withdrawal
      - treatment
      - distribution
      - consumption
    - Equipment/materials
- TAPE / SLIDE PROGRAMMES

MDP PRODUCTION TEAM

DHV - IWACO - TGI

DIRECTORATE OF WATER SUPPLY
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DEPARTMENT OF PUBLIC WORKS
GOVERNMENT OF INDONESIA

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FOR INTERNATIONAL COOPERATION
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GOVERNMENT OF THE NETHERLANDS

MDP PRODUCTION TEAM

TRAINING MATERIALS FOR WATER ENTERPRISES

VOLUME 4
TRAINING MODULES
TECHNICAL (basic knowledge/skills)

DHV CONSULTING ENGINEERS
IWACO B.V.
T.G. INTERNATIONAL

JAKARTA
APRIL 1985

PREFACE

This volume is part of the Final Report of the MDP Production Team which produced Training Materials for Water Enterprises as part of a project under the bilateral cooperation programme between the Government of the Republic of Indonesia and the Government of the Kingdom of the Netherlands.

This Final Report contains the following volumes:

Volume 1	Guide for users of training materials	
Volume 2A	Training Modules,	GENERAL + ORGANIZATIONAL (basic knowledge/skills)
Volume 2B	Training Modules,	GENERAL + ORGANIZATIONAL (basic knowledge/skills)
Volume 3	Training Modules,	ORGANIZATIONAL (processes/procedures; equipment/materials)
Volume 4	Training Modules,	TECHNICAL (basic knowledge/skills)
Volume 5A	Training Modules,	TECHNICAL (processes/procedures)
Volume 5B	Training Modules,	TECHNICAL (processes/procedures)
Volume 6A	Training Modules,	TECHNICAL (Withdrawal + Treatment)
Volume 6B	Training Modules,	TECHNICAL (Withdrawal + Treatment)
Volume 7	Training Modules,	TECHNICAL (Distribution + Consumption)
Volume 8	Training Modules,	TECHNICAL (equipment/materials)
Volume 9	Tape/slide programmes	

TABLE OF CONTENTS

TRAINING MODULES

CODE	TITLE
TBG 360	Fundamental equations for pipeline hydraulics
TBG 365	Local losses in pipelines
TBG 508	Progress reports in construction
TBG 509	Engineering drawings
TBG 512	Concrete technology
TBG 513	Concrete testing
TBG 514	Plans
TBG 701	Maps

Module : FUNDAMENTAL EQUATIONS OF PIPELINE HYDRAULICS	Code : TBG 360
	Edition : 13-03-1985
Section I : INFORMATION SHEET	Page : 01 of 01/14

Duration :	135 minutes.
Training objectives :	After the session the trainees will be able to : - list the basic hydraulic equations relating to the design of pipelines in a water distribution system; - write down and explain the formula of Bernoulli, Chèzy, White-Colebrook and Darcy-Weisbach.
Trainee selection :	- Head of Technical Department; - Head of Section Distribution; - Head of Section Planning & Supervision; - Head of Sub-section Planning.
Training aids :	- Viewfoils : TBG 360/V 1-6; - Handout : TBG 360/H 1.
Special features :	This module gives the theoretical background for modules TBG 361-365.
Keywords :	Pipeline hydraulics/continuity equation/energy equation/equation of motion.

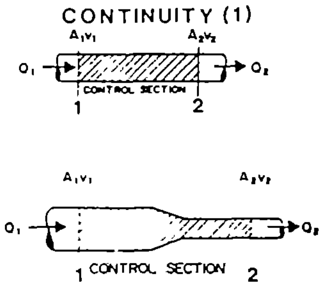
Module : **FUNDAMENTAL EQUATIONS OF PIPELINE HYDRAULICS**	Code : TBG 360 Edition : 13-03-1985
Section 2 : SESSION NOTES	Page : 01 of 01

1. **Introduction**	
- Fundamental equations in pipeline design for steady and one-dimensional flow: . continuity . energy . motion.	Use white board
2. **Continuity equation**	
- The following continuity equations are used:	
. continuity of a single section; . continuity of a section in which the diameter of the pipe is changing;	Show V 1 (a-b)
. continuity of a junction; . continuity of a reservoir.	Show V 2 (a-b)
3. **Energy equation**	
- Energy line. - Pressure + velocity head. - Losses.	Show V 3-5
4. **Equation of motion**	
- Relationship between flow and losses. - Chèzy and White - Colebrook. - Darcy - Weisbach and White - Colebrook.	Show V 6
5. **Summary**	Give H 1

Module : **FUNDAMENTAL EQUATIONS OF PIPELINE HYDRAULICS**	Code : TBG 360
	Edition : 13-03-1985
Section 3 : T R A I N I N G A I D S	Page : 01 of 02

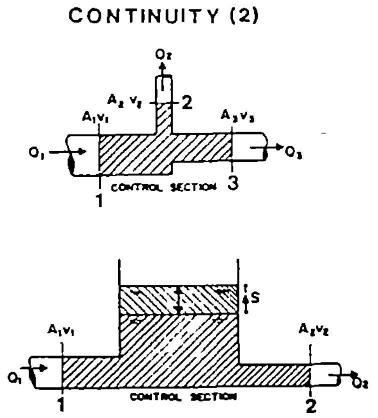
Continuity I

TBG 360/V 1 (a-b)



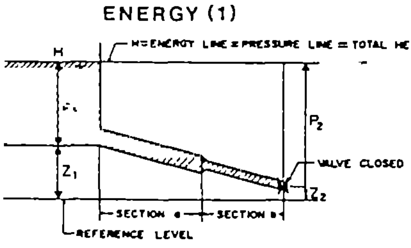
Continuity II

TBG 360/V 2 (a-b)



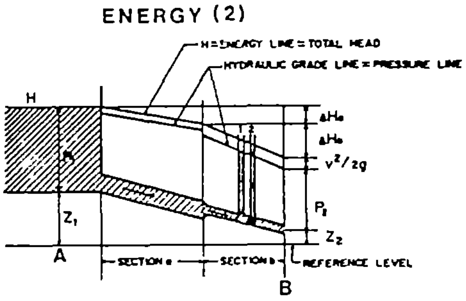
Energy I

TBG 360/V 3



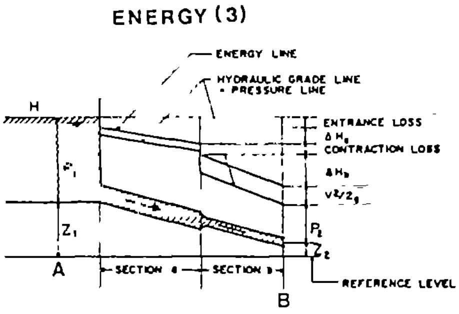
Energy II

TBG 360/V 4



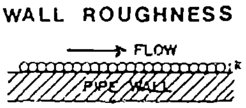
Energy III

TBG 360/V 5



Wall roughness

TBG 360/V 6



PIPE MATERIAL	k (in mm)	
	LOW	HIGH
uPVC / HPE	0.01	0.05
AC (asbestos cement)	0.02	0.10
DUCTILE IRON	0.5	1.0
GALVANIZED STEEL	0.5	0.5

Fundamental equations of pipeline hydraulics TBG 360/H 1

1. INTRODUCTION

The hydraulics of pipelines are described by three equations namely:
- the continuity equation;
- the energy equation;
- the motion equation.

These equations will be elaborated for steady, incompressible, one-dimensional flow conditions.
By 'steady flow' is meant that there is no variation in velocity (discharge) with time at any point. By 'incompressible flow' is meant that the volume of the water is not changed by pressure differences. Lastly, 'one-dimensional flow' implies that the flow is in one and only one direction, as constricted by the water conducting pipe. Hereafter each equation will be shown for the specified flow conditions.

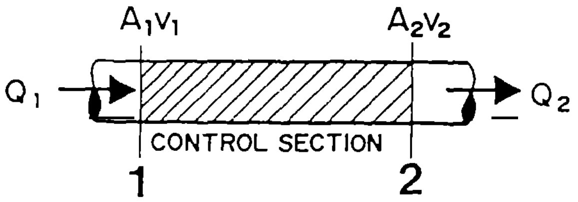
2. CONTINUITY EQUATION

For a steady, incompressible and one-dimensional flow the continuity equation is simply obtained by equating the flow rate at any section to the flow rate at another section. This equating can be done over a single pipe section, or over a branched section or even over a reservoir.

Over a single pipe section (control section) the continuity equation reads as follows :

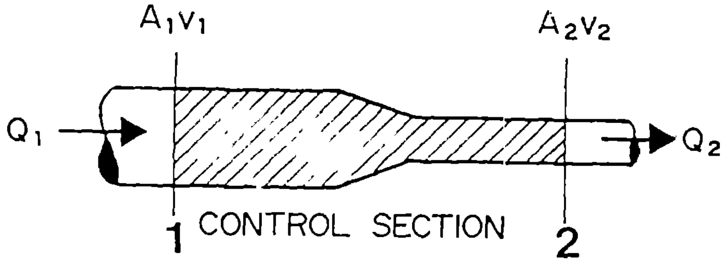
$$Q_1 = Q_2 \quad \text{(in = out)}$$

Where Q is the discharge (flow) in [m^3/s] or [l/s].



As $Q_1 = Q_2$ and $Q_2 = A_2v_2$ we may write $A_1v_1 = A_2v_2$, where A is the cross-sectional area in [m^2] and v is the mean velocity in [m/s].

For a pipe section in which the diameter is varying, the equation remains the same, as can be seen in the following figure:

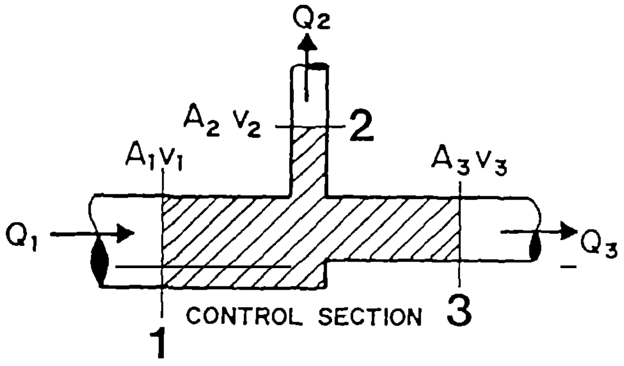


For instance, knowing Q_1, A_1 and A_2 the velocity at cross-section 2 (v_2) can be calculated out of the continuity equation by :

$$v_2 = \frac{Q_1}{A_2} = \frac{Q_2}{A_2} = \frac{A_1}{A_2} v_1$$

Over a branched pipe section the continuity equation becomes :

$$Q_1 = Q_2 + Q_3 \quad \text{(in = out)}$$



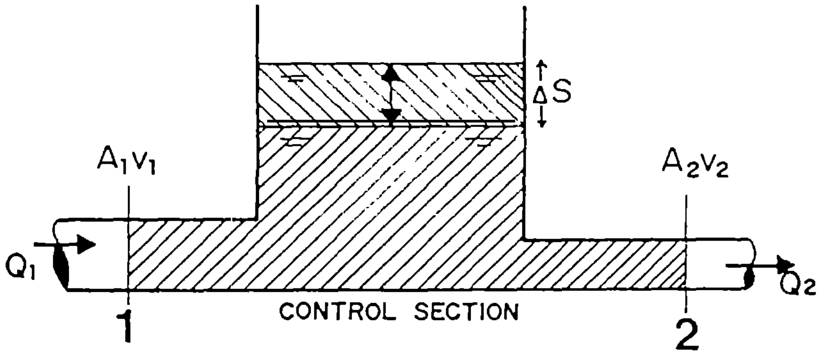
When outgoing flows (Q_2 and Q_3) are counted as negative, and ingoing flows (Q_1) as positive, the continuity equation can be written as:

$$Q_1 + Q_2 + Q_3 = 0 \quad (\text{in} - \text{out} = 0)$$

or

$$v_1 A_1 + v_2 A_2 + v_3 A_3 = 0$$

If a storage reservoir is incorporated in the control section the continuity equation can not be derived by equating the flow rates only, but a term must be included accounting for the change in storage s [m^3] during a certain time span t [s].



In this case the continuity equation reads:

$$(\text{ in} = \text{out} + \text{ storage })$$

$$Q_1 \Delta t = Q_2 \Delta t + \Delta S$$

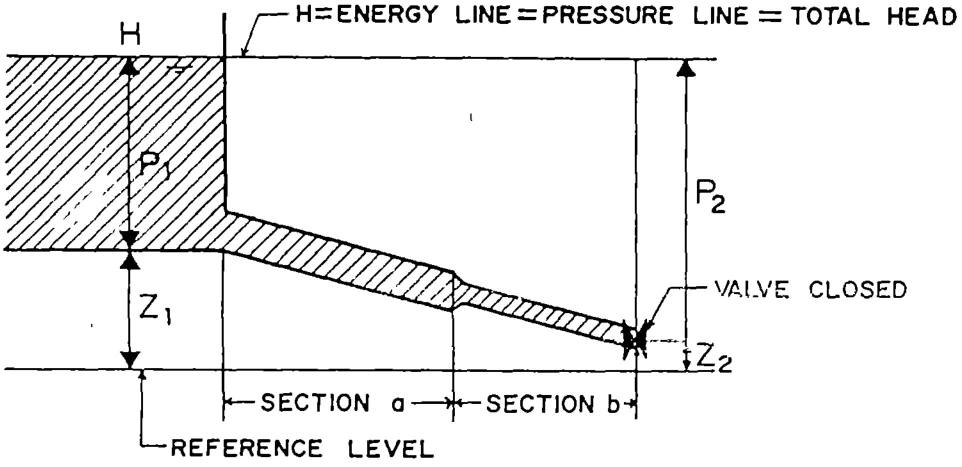
We see here that the time is introduced in the equation by t [s]. For instance, knowing the ingoing (Q_1) and outgoing (Q_2) flows, the change in storage S over a certain time span t can be calculated with :

$$\Delta S = Q_1 \Delta t - Q_2 \Delta t$$

3. ENERGY EQUATION

Energy is needed to let the water actually flow through the pipes. Normally energy is provided by gravity or by mechanical devices such as pumps. The energy of water in pipes is expressed as the total head of the water.

The total head along a pipeline containing water that is not flowing (energy line) is shown in the following figure:

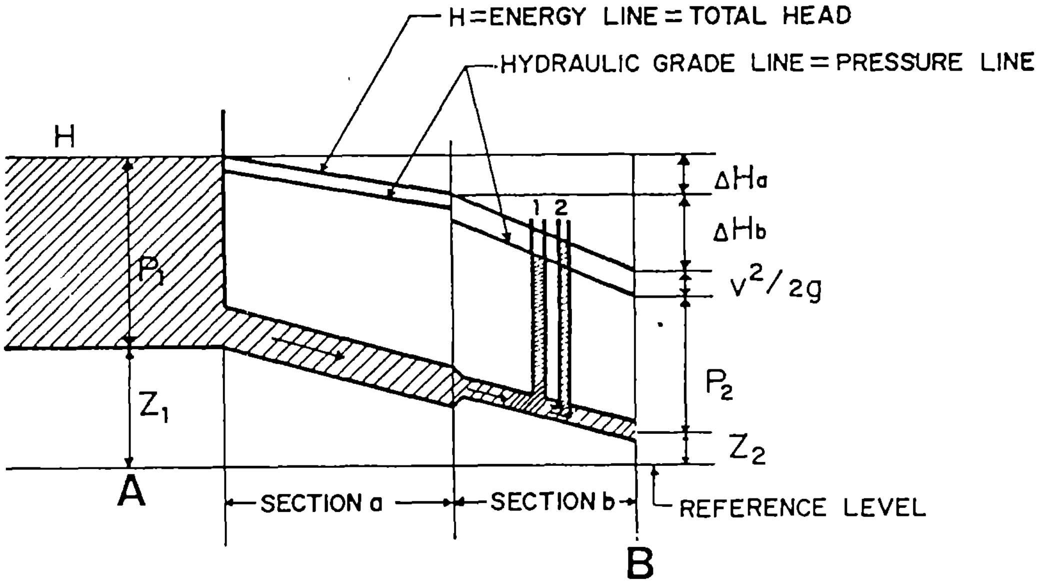


In the above case the energy line is horizontal as no water is flowing. To quantify the total head (energy line) an arbitrary reference level is introduced. The energy can then be expressed as $H = z + p$ [m]. Normally the same reference level is chosen as that used for surveying. In non-flowing water the energy line is the same as the pressure line.

After opening the valve at the end of the pipeline the water starts to flow. This will consume energy, so the energy line will gradually decline in a downstream direction. Thus H_a is the head loss over section a and H_b that over section b, as shown in the figure on the next page.

Note that for the same rate of flow the head loss over a certain distance in section a is smaller than over the same distance in section b, because the pipe diameter of section b is smaller.

In the above figure the hydraulic grade line (or pressure line) is drawn as well. It must be understood that the energy (total head) consists of three elements viz.:
- the pressure head;
- the velocity head;
- the elevation with respect to the reference level.



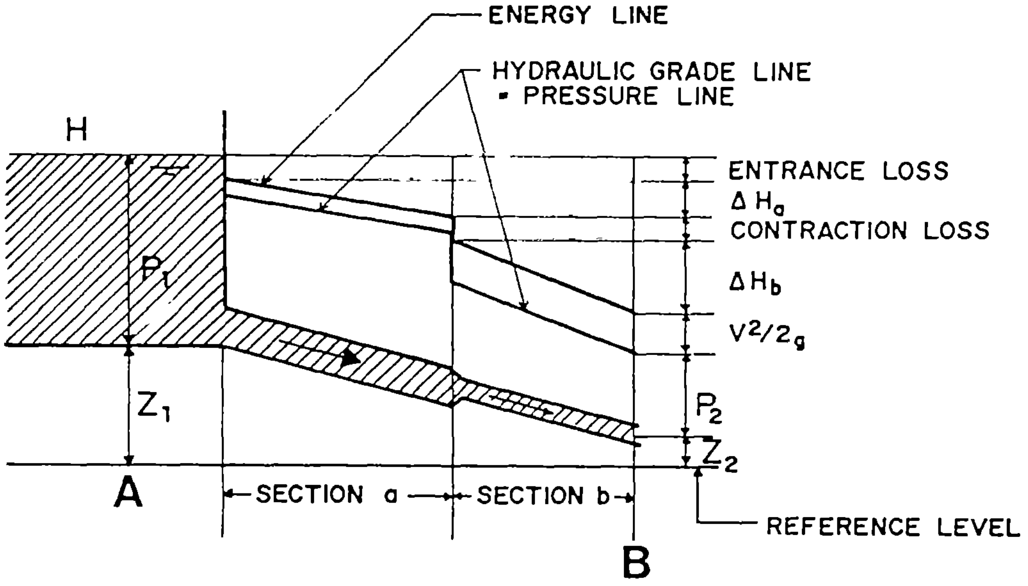
In flowing water the energy line is not the same as the pressure line (hydraulic grade line): the velocity head must be added to the pressure head to obtain the energy (head) line.

The velocity head equals $v^2/2g$ [m] where v [m/s] is the mean velocity of the water in the pipe and g [m/s^2] is the gravitational acceleration.
The velocity head can be explained by connecting two tubes to the water pipe as shown in the above figure.
In tube 1 the water level will rise to the pressure line, but in tube 2 the water level rises to the energy line. In this tube, of which the opening faces upstream, the flow (velocity) pushes up the water level to the energy line.
In fact these tubes form a flow measurement device. As the difference in water levelsΔH can be read from the tubes and equals $v^2/2g$, or :$\Delta H = v^2/2g$, thus:

$$v = \sqrt{2g\Delta H}\ , \text{ where } g = 9.82 \text{ m/s}^2$$

However, this picture is not yet complete, as other, local, energy losses (non-frictional losses) occur at places where :
- the pipe diameter changes (contraction, expansion);
- the flow direction changes (bends, branches);
- obstructions are placed in the pipe (valves, flow and pressure measurement devices, air and pressure release valves, joints etc.);
- water enters or leaves a pipeline.

With these local energy losses in mind the same figure is regarded again:



By equating the energy over A and B we get

$$H = Z_1 + P_1 = Z_2 + P_2 + v^2/2g + \Sigma \Delta H$$

where $\Sigma \Delta H$ is the summation of all kinds of losses between the points A and B.
The above equation is called the Bernoullis equation.
In a distribution system the total head H is normally provided by pumps or boosters or is dictated by the water level in a reservoir (as shown here).

In designing water distribution networks the pressure at the taps is decisive. So the work of the hydraulic engineer, involved in designing, consists essentially of determining the losses H along the pipeline. In the following section the equations are presented to calculate the friction losses, whereas the local losses are dealt with in a separate module.

4. EQUATION OF MOTION

The equation of motion gives the relationship between the flow through a pipe section and the total head loss over that section, due to the friction only.

Various empirical relationships have been established in the past, but only in the last few decades semi-empirical relationships were established on a more theoretical base. Two of them are widely accepted and used. They are the formula of Chèzy and Darcy-Weisbach.

In its original form the formula of Chèzy reads:

$$Q = AC\sqrt{RI}$$

where : Q = discharge [m^3/s]
A = wet cross section [m^2]
C = friction coefficient [$m^{1/2}/s$]
R = hydraulic radius [m]
I = gradient of energy line [m/m]

The gradient I can also be written as $\Delta H/L$, where ΔH [m] represents the frictional loss and L [m] the length of the relevant pipe section. The hydraulic radius for fully filled circular pipes equals 1/4 D (D = internal pipe diameter) and A equals $1/4\ \pi\ D^2$, so we can re-write the Chèzy formula as:

$$Q = 0.39\ D^2 C \sqrt{D\ (\Delta H/L)}$$

The value of the friction coefficient C was originally obtained from laboratory tests (empirical), but White and Colebrook developed a more theoretical expression:

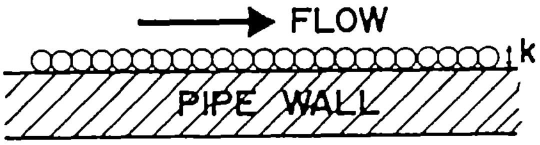
$$C = 18 \log \frac{3D}{k + \dfrac{2.5\ \nu}{\sqrt{D\ (\Delta H/L)}}} \quad \text{(for fully filled circular pipes)}$$

Substitution in the formula of Chèzy yields :

$$Q = 7.02\ D^2\ \log \left\{ \frac{3D}{k + \dfrac{2.5}{D\ (\Delta H/L)}} \right\} \sqrt{D\ (\Delta H/L)}$$

Where:
k = the equivalent roughness of Nikuradse [m];
ν = the kinematic viscosity of water in [m^2/s].

Nikuradse's equivalent roughness k can be explained by imagining that the roughness of the inside of the pipe is caused by a layer of spherical grains, as shown in the next figure:



The value of k depends on the actual pipe material. Some specific values are given below:

PIPE MATERIAL	k in [mm] = $[10^{-3}m]$
uPVC/HPE	0.01 - 0.05
AC (asbestos cement)	0.02 - 0.10
Ductile iron	0.5 - 1.0
Galvanized steel	0.10 - 0.5

The kinematic viscosity is a special property of water, which varies with its temperature. The following table shows the kinematic viscosity of water at various temperatures.

TEMPERATURE in [°C]	VISCOSITY in $[10^{-6}\ m^2/s]$
0	1.79
10	1.30
20	1.01
30	0.80
40	0.66

In circumstances as prevailing in water distribution networks for clean water the value of the term $\frac{2.5\nu}{\sqrt{D(\Delta H/L)}}$ is small compared to the value of k. For easy use, the formula of Chèzy may thus be simplified and a good approximation is:

$$Q = 7.02 \times D^2 \log(3D/k)\sqrt{D(\Delta H/L)}$$ (approximation for Chèzy formula)

This formula can be rearranged into:

$$H = f \times L/D \times v^2/2g$$ (Darcy - Weisbach formula)

The form in which the equation is written now, is called the Darcy - Weisbach formula, in which :

$$f = 8g/C^2 \quad \text{and where} \quad C = 18 \log 3D/k$$ (approximation)

Note that f is dimensionless, and is called the Darcy - Weisbach friction coefficient.
White and Colebrook have also developed an expression for f, which reads :

$$f = \frac{1}{4.0\left[\log\left(\frac{1.96\nu D}{Q\sqrt{f}} + \frac{k}{3.7\,D}\right)\right]^2}$$ (White - Colebrook for Darcy Weisbach equation)

This formula is basically the same (except for a slight difference in the empirical constants) as can be found by substituting the complete White-Colebrook expression for C into $f = 8g/C^2$. This means that the formulae of Chèzy and Darcy-Weisbach are in fact the same, but written in rearranged ways. Calculating f with this equation for given values of ν, D, Q and k is rather complicated as f appears also at the right hand side of the equation.

An iteration process would thus be required. Therefore, the relationship between flow and total head loss has been calculated already for the most common pipe materials and diameters. The results are presented in nomograms or in tables.
In cases not covered by the nomograms, the approximation formula as given above may be used, for minor extensions of existing distribution networks. For calculation of headlosses in mains with relatively long lengths, preferably the complete formula of Darcy-Weisbach or of Chèzy in combination with that of White-Colebrook should be used.

5. SUMMARY

Three equations describing the hydraulics of pipelines have been presented. They are:
- the continuity equation;
- the energy equation;
- the motion equation.

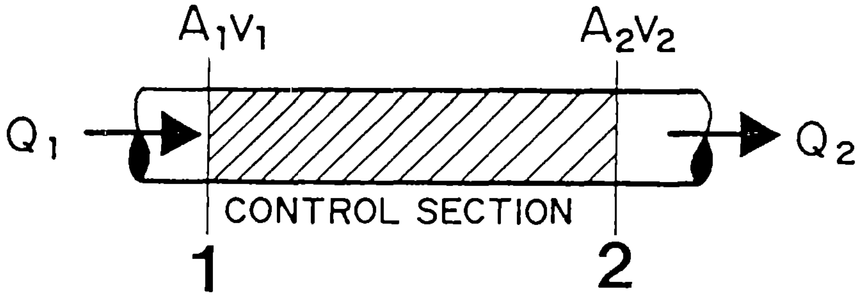
These equations have been presented for steady, incompressible and one-dimensional flow conditions.
A number of widely used formula for the equation of motion are given, which may be used under specific conditions.

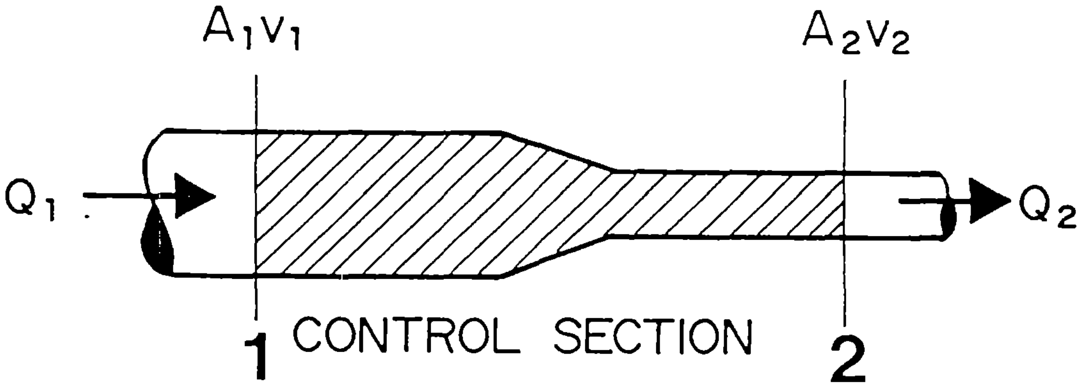
* * *

Module	: FUNDAMENTAL EQUATIONS OF PIPELINE HYDRAULICS	Code	: TBG 360
		Edition	: 13-03-1985
Annex	: VIEWFOILS	Page	: 01 of 07

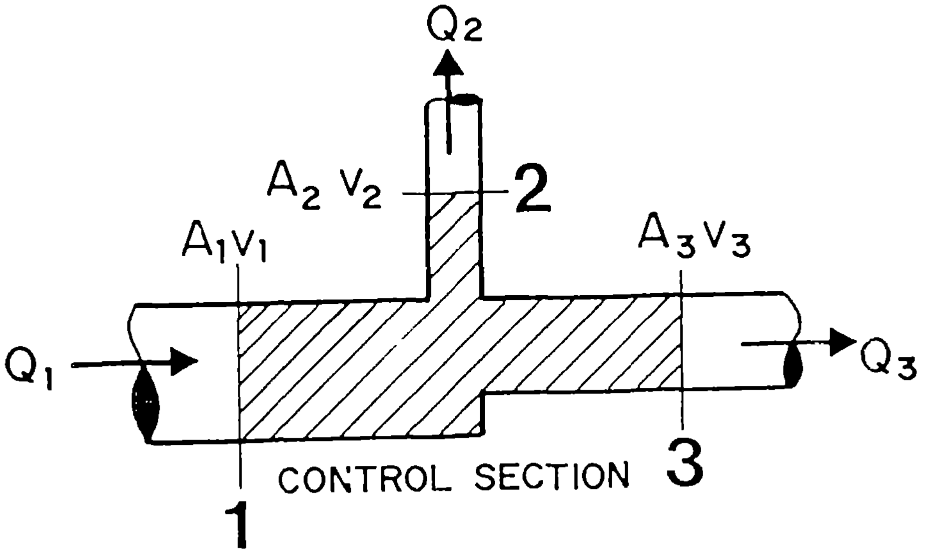
TITLE :	CODE :
1. Continuity (1)	TBG 360/V 1
2. Continuity (2)	TBG 360/V 2
3. Energy (1)	TBG 360/V 3
4. Energy (2)	TBG 360/V 4
5. Energy (3)	TBG 360/V 5
6. Wall roughness	TBG 360/V 6

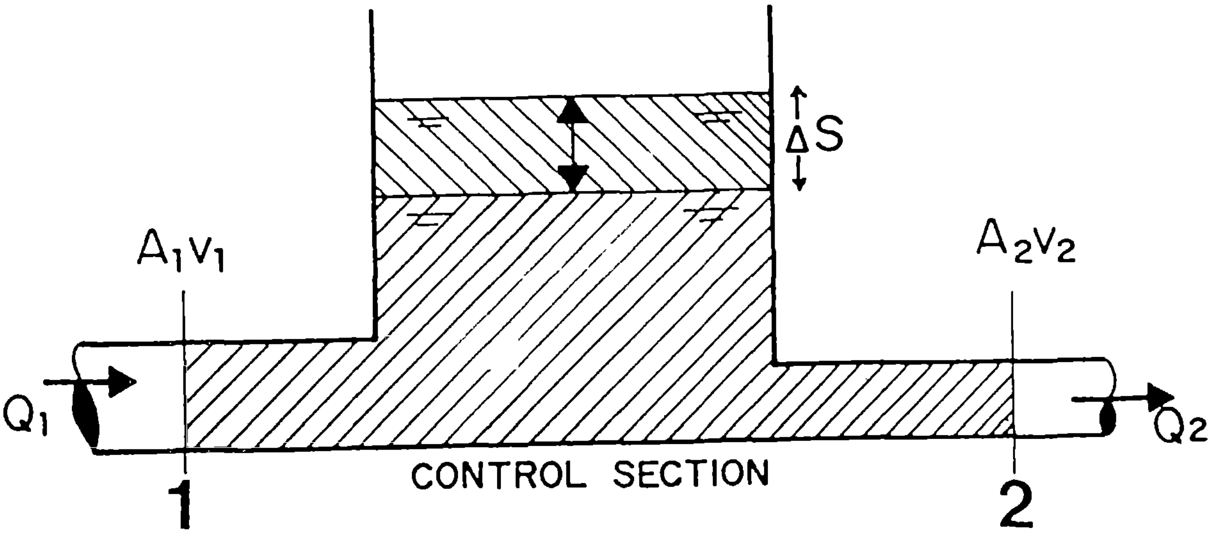
CONTINUITY (1)



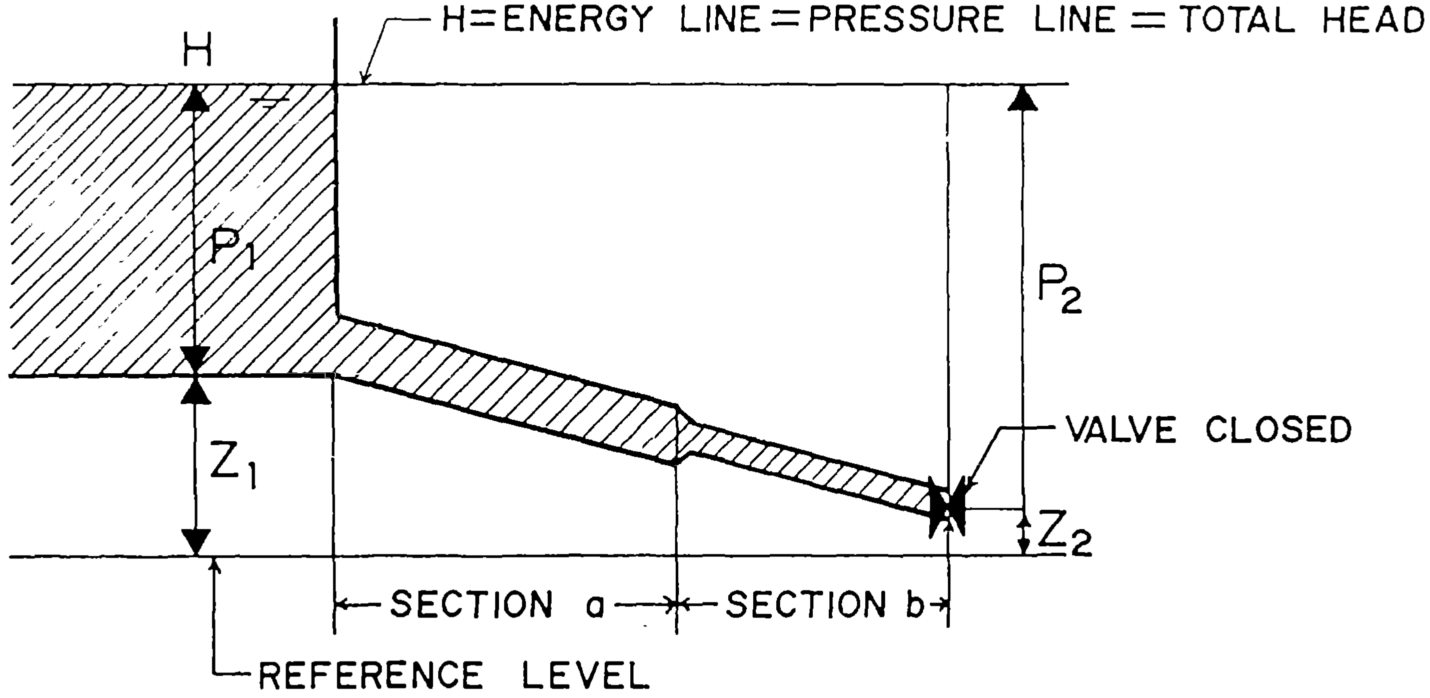


CONTINUITY (2)

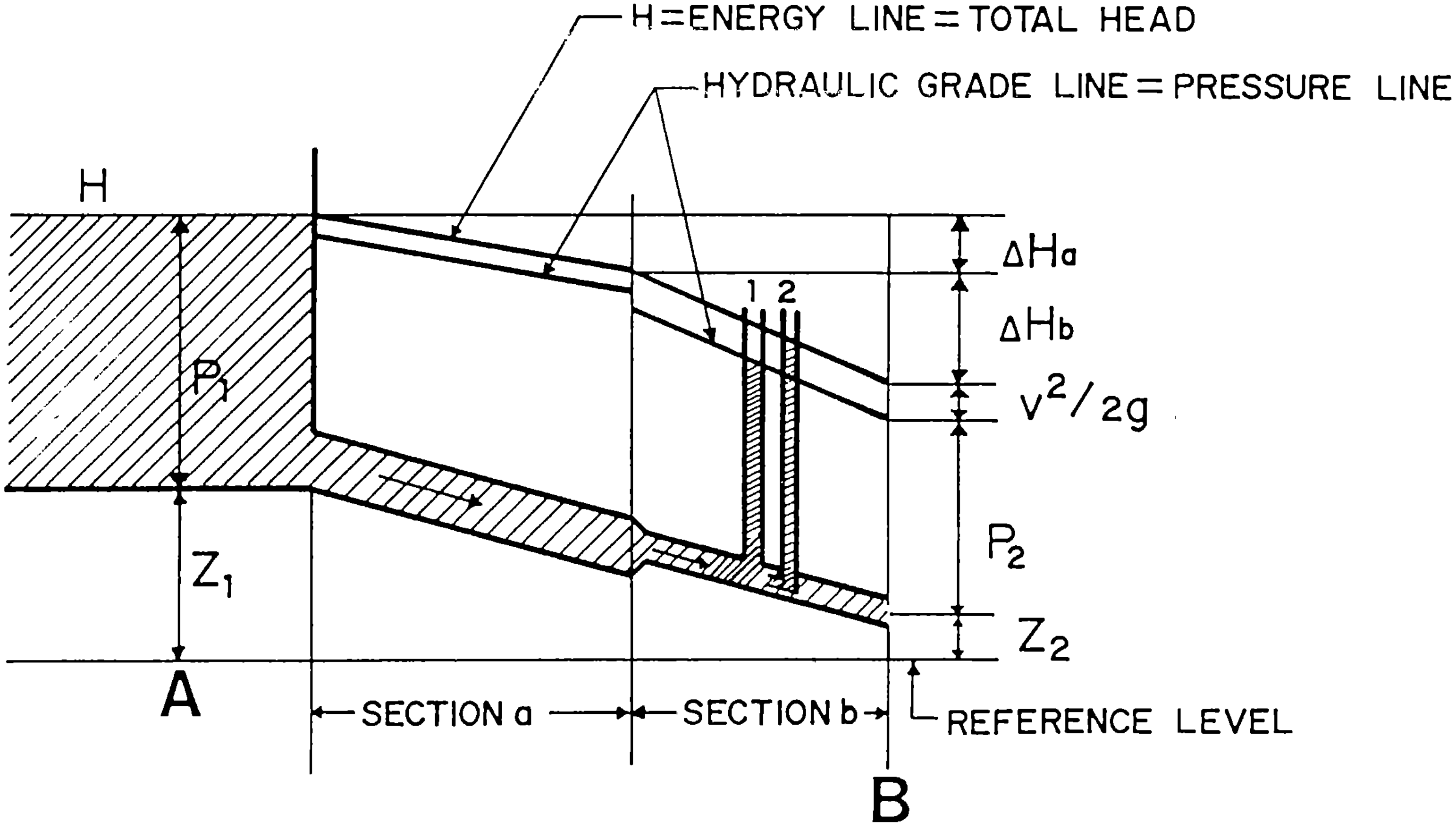




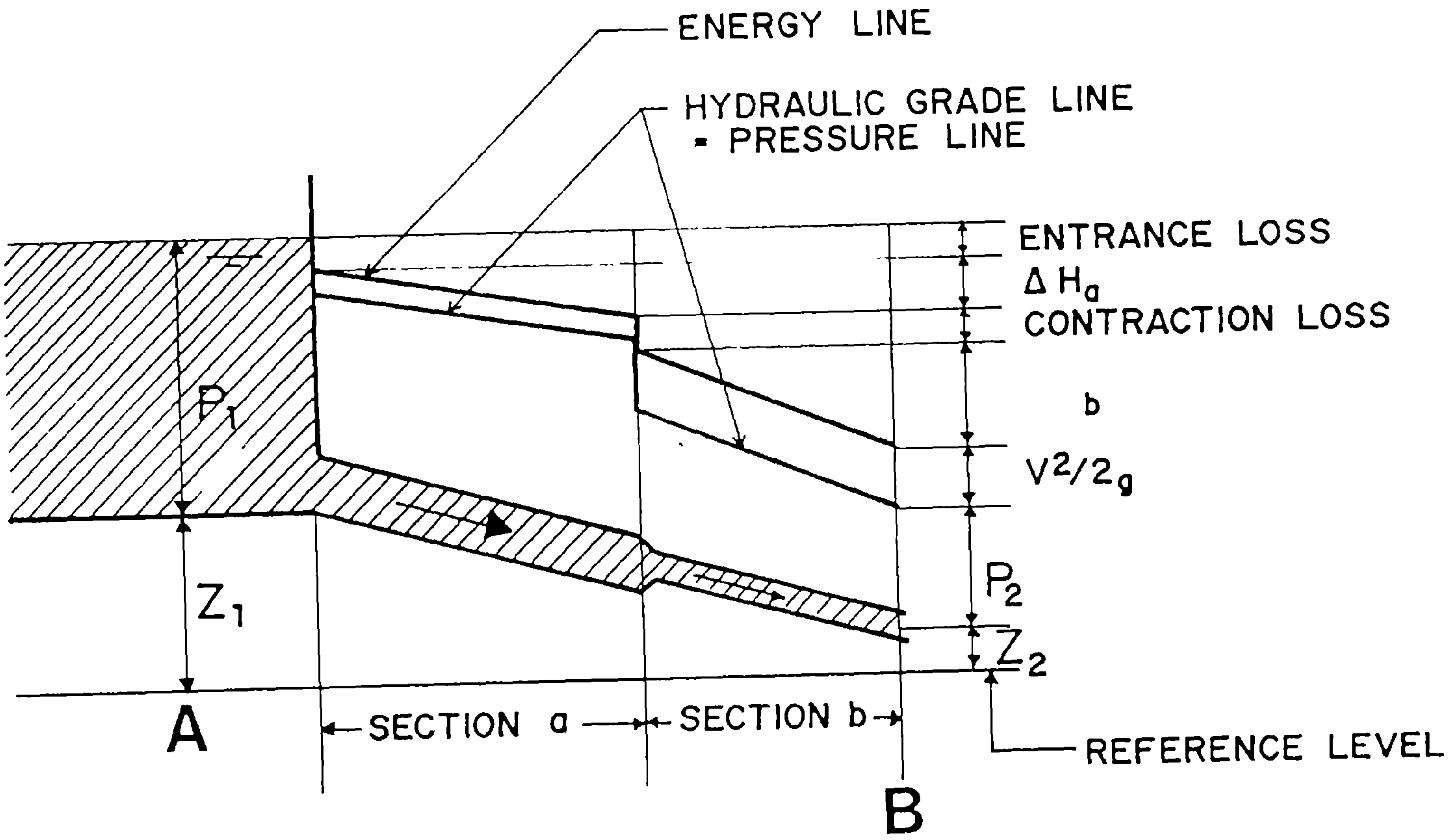
ENERGY (1)


H=ENERGY LINE=PRESSURE LINE=TOTAL HEAD
H
P_1
Z_1
P_2
VALVE CLOSED
Z_2
SECTION a
SECTION b
REFERENCE LEVEL

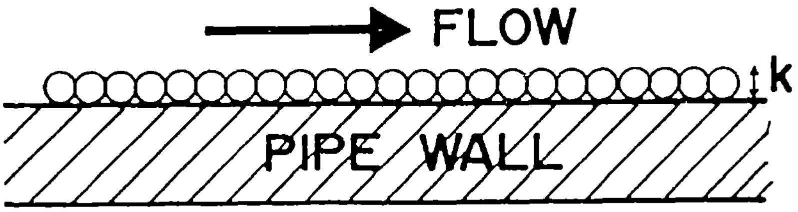
ENERGY (2)


H=ENERGY LINE=TOTAL HEAD
HYDRAULIC GRADE LINE=PRESSURE LINE
H
P_1
Z_1
A
1
2
ΔH_a
ΔH_b
$V^2/2g$
P_2
Z_2
SECTION a
SECTION b
REFERENCE LEVEL
B

ENERGY (3)


ENERGY LINE
HYDRAULIC GRADE LINE
= PRESSURE LINE
ENTRANCE LOSS
ΔH_a
CONTRACTION LOSS
b
$V^2/2g$
P_1
Z_1
P_2
Z_2
A
SECTION a
SECTION b
B
REFERENCE LEVEL

WALL ROUGHNESS



PIPE MATERIAL	k (in mm) LOW	 HIGH
uPVC / HPE	0.01	0.05
AC (asbestos cement)	0.02	0.10
DUCTILE IRON	0.5	1.0
GALVANIZED STEEL	0.5	0.5

DEPARTMENT OF PUBLIC WORKS
DIRECTORATE GENERAL CIPTA KARYA
DIRECTORATE OF WATER SUPPLY

MDPP
DHV
TGI
IWACO

Module : LOCAL LOSSES IN PIPELINES	Code : TBG 365
	Edition : 13-03-1985
Section I : INFORMATION SHEET	Page : 01 of 01/17

Duration :	90 minutes.
Training objectives :	After the session the trainees will be able to: - calculate local head losses in pipelines.
Trainee selection :	- Head of Technical Department; - Head of Section Distribution; - Head of Sub-section Distribution and Connections; - Head of Section Planning & Supervision; - Head of Sub-section Planning; - Technical Planning Assistant.
Training aids :	- Viewfoils : TBG 365/V 1-12; - Handout : TBG 365/H 1.
Special features :	To be used in conjuction with TBG 363-364.
Keywords :	Pipeline hydraulics/local losses/equivalent pipe length.

Module : LOCAL LOSSES IN PIPELINES	Code : TBG 365 Edition : 13-03-1985
Section 2 : SESSION NOTES	Page : 01 of 01

1. Introduction

- Head losses in pipeline systems comprise:
  - friction losses;
  - local losses, at:
    - bends;
    - junctions;
    - change in pipe diameter;
    - location of devices.

Show V 1-2

2. Local losses

- Can be expressed as factors, to be multiplied with the velocity head:

$$\Delta H = \zeta (v^2/2g)$$

Write on whiteboard

- The value of ζ (the loss coefficient) depends on the specific local situation, and has been calculated for many situations.

Show V 3-8

3. Equivalent pipe length

- To simplify the calculation, equivalent pipe lengths are sometimes used.
- Equivalent pipe length produces the same head loss as the actual local loss.

Show V 9

- Total pipe length becomes:

$$L + \Delta L$$

(actual length + equivalent length).

4. Example of calculation

- With loss coefficients.
- With equivalent pipe length.

Show V 10

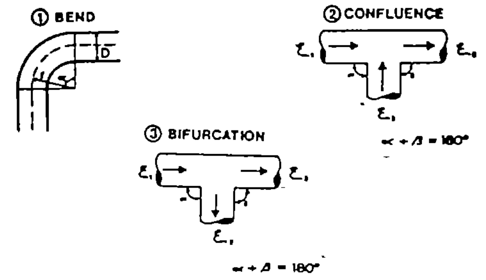
Show V 11-12

5. Summary

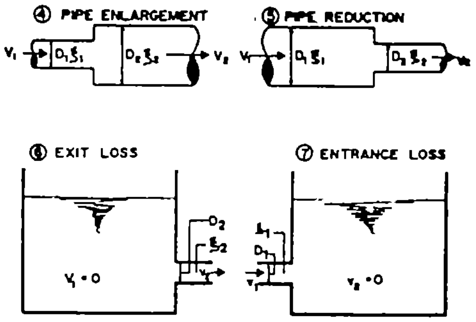
Give H 1

Module : LOCAL LOSSES IN PIPELINES	Code : TBG 365
	Edition : 13-03-1985
Section 3 : TRAINING AIDS	Page : 01 of 03

Local losses (1) TBG 365/V 1



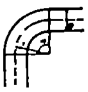
Entrance/Exit losses TBG 365/V 2



Losses in bends TBG 365/V3

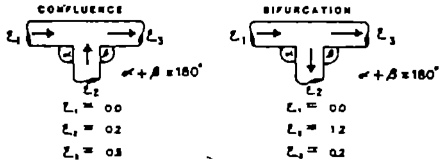
LOCAL LOSSES : BENDS

α \ r/D	0	1	2	3	4
15°	0 10	0.06	0.04	0.03	0.03
22.5°	0 13	0.08	0.06	0.05	0.04
30°	0 18	0 10	0.08	0.07	0 06
45°	0.32	0.13	0.10	0.09	0.08
60°	0.68	0.19	0 13	0 10	0.09
90°	1.27	0.30	0.16	0.13	0.11



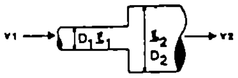
Losses in tees TBG 365/V 4

LOCAL LOSSES



Increase in pipe diameter TBG 365/V 5

LOCAL LOSSES
INCREASE IN PIPE DIAMETER

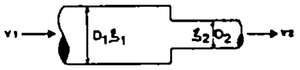


D1/D2	0.1	0.2	0.3	0 4	0 5	0.6	0.7	0.8	0.9	1.0
ξ_2	0 98	0 92	0 83	0 71	0 56	0 41	0.26	0.13	0.04	0.00

$\xi_2 = 0$

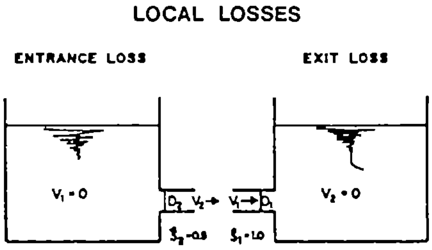
Reduction of pipe diameter TBG 365/V 6

LOCAL LOSSES
REDUCTION OF PIPE DIAMETER

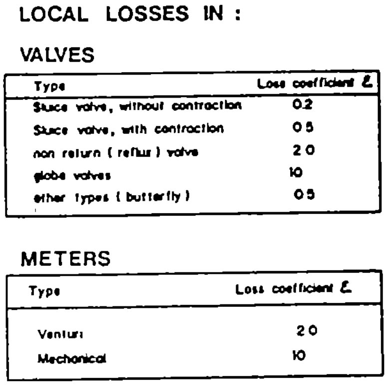


D2/D1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
ξ_2	0.44	0.43	0.41	0.39	0.36	0.31	0.25	0.17	0.09	0.00

Entrance/Exit losses TBG 365/V 7



Losses in valves and meters TBG 365/V 8



LOCAL LOSSES IN :

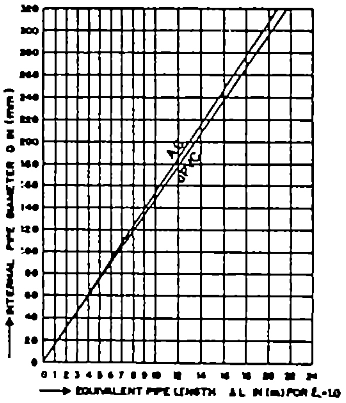
VALVES

Type	Loss coefficient ξ
Sluice valve, without contraction	0.2
Sluice valve, with contraction	0.5
non return (reflux) valve	2.0
globe valves	10
other types (butterfly)	0.5

METERS

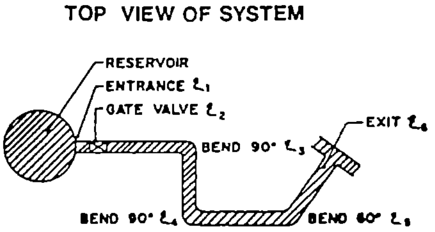
Type	Loss coefficient ξ
Venturi	2.0
Mechanical	10

Equivalent pipe length TBG 365/V 9

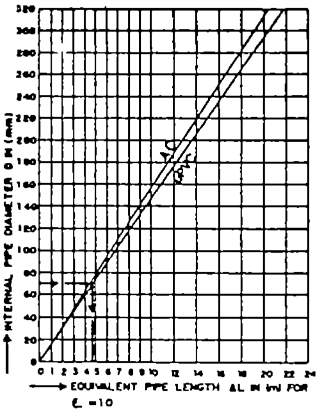


EQUIVALENT PIPE LENGTH (ξ=1.0)

Example (1) TBG 365/V 10

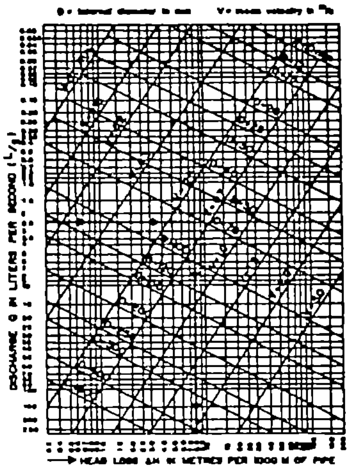


Example (2) TBG 365/V 11



RELATIONSHIP BETWEEN INTERNAL PIPE DIAMETER AND EQUIVALENT PIPE LENGTH FOR ξ=1.0

Example (3) TBG 365/V 12



RELATIONSHIPS BETWEEN DISCHARGE AND HEAD LOSS IN uPVC AND HPE PIPES

Module : LOCAL LOSSES IN PIPELINES	Code : TBG 365 Edition : 13-03-1985
Section 3 : TRAINING AIDS	Page : 03 of 03

	Local losses in pipelines TBG 365/H 1

Module : **LOCAL LOSSES IN PIPELINES**	Code : TBG 365
	Edition : 13-03-1985
Section 4 : HANDOUT	Page : 01 of 12

1. INTRODUCTION

Apart from frictional head losses, other local losses will occur in water conveying pipelines. Local losses occur at any point where the direction of the flow (streamlines) is forced to change. Such points for instance are bends in pipelines, junctions of pipelines, connections of pipes with different diameters and points where devices are installed in the pipelines.
Such devices can be valves, meters and pressure blow-offs.
Also at places where water enters the pipe, for instance out of a reservoir, losses will occur (entrance losses). On the other hand exit losses will occur at places where the water leaves the pipeline.

These losses can be calculated in terms of velocity head loss [m]. As the formula to calculate a local loss is basically the same as that for frictional losses (Darcy-Weisbach), it is also possible to calculate an equivalent hydraulic pipe length. This is an imaginary pipe section (of the same material and diameter), the friction loss of which is equal to the actual local head loss. The total head loss is then established by calculating the friction loss of the pipe, but with a total pipe length equal to the actual length plus the equivalent pipe length. This exercise eases the hydraulic calcuations to be performed in designing the pipeline and pipeline system analysis.

For long pipelines, such as transmission mains and many distribution mains, local losses are normally relatively small and may be neglected.
For complicated piping systems such as in pumping stations, local losses are an important part of the total head losses, however, and need to be calculated accurately.

2. LOCAL LOSSES

Local losses occur at any point where the direction of the flow is forced to change. They can be calculated in terms of velocity head loss by the following formula:

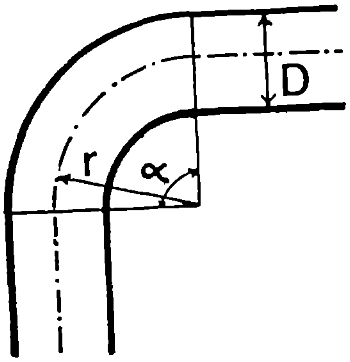
$$H = \zeta\,(v^2/2g)$$

Where H is the local head loss in [m], ζ is the loss coefficient and $v^2/2g$ is the velocity head (v = mean velocity in the pipe and g = 9.82 is the gravitational acceleration).
Extensive laboratory tests have been carried out to determine ζ for bends etc. and results have been published in literature.

A compilation of these results is shown below:

BENDS

For bends in pipelines the loss coefficient ζ depends on the angle of bend (α) and the radius of the bend (r) in relation to the pipe diameter (D) as shown in the table below.



r/D α	0	1	2	3	4
15°	0.10	0.06	0.04	0.03	0.03
22.5°	0.13	0.08	0.06	0.05	0.05
30°	0.18	0.10	0.08	0.07	0.06
45°	0.32	0.13	0.10	0.09	0.08
60°	0.68	0.19	0.13	0.10	0.09
90°	1.27	0.30	0.16	0.13	0.11

Note that for a sharp-edged bend r/D = 0.

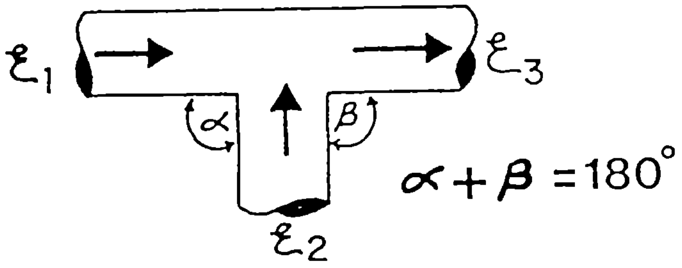
JUNCTIONS

For junctions of pipes the value of the loss coefficient ζ depends on the following factors :
- whether the flows come together or separate;
- whether all pipe diameters at the junction are the same or not;
- what is the ratio between the flow rate in the main pipe and that in the branch pipe;
- what is the angle between the pipes at the junction.

To avoid laborious iteration procedures, values for the loss coefficients will be presented which apply to most situations.

The average loss coefficients for junctions are:

CONFLUENCE

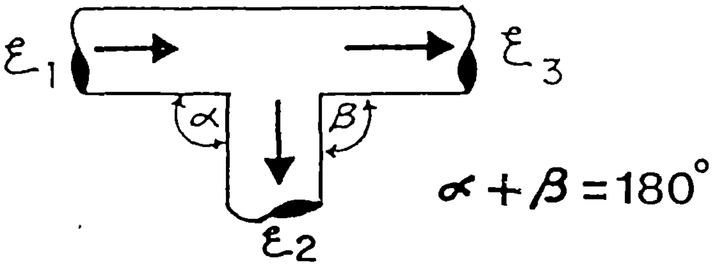


$\xi_1 = 0.0$

$\xi_2 = 0.2$

$\xi_3 = 0.5$

BIFURCATION



$\xi_1 = 0.0$

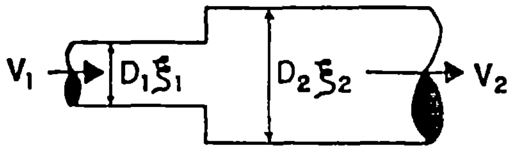
$\xi_2 = 1.2$

$\xi_3 = 0.2$

EXPANSIONS AND CONTRACTIONS

In water distribution networks the pipes gradually decrease in diameter in the direction of flow. At such points where the diameter is changing, local losses will occur due to the disturbance of the straight streamlines.

For expansions the following loss coefficients are found empirically:



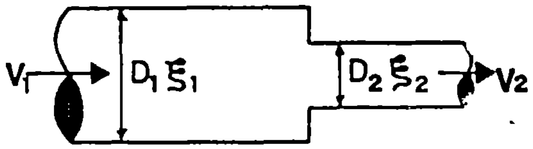
D_1 and D_2 are the internal pipe diameters

$\zeta_2 = 0.0$

Expansions

D_1/D_2	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
ζ_1	0.98	0.92	0.83	0.71	0.56	0.41	0.26	0.13	0.04	0.00

For contractions the following values apply:



$\zeta_1 = 0.0$

Contractions

D_2/D_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
ζ_2	0.44	0.43	0.41	0.39	0.36	0.31	0.25	0.17	0.09	0.00

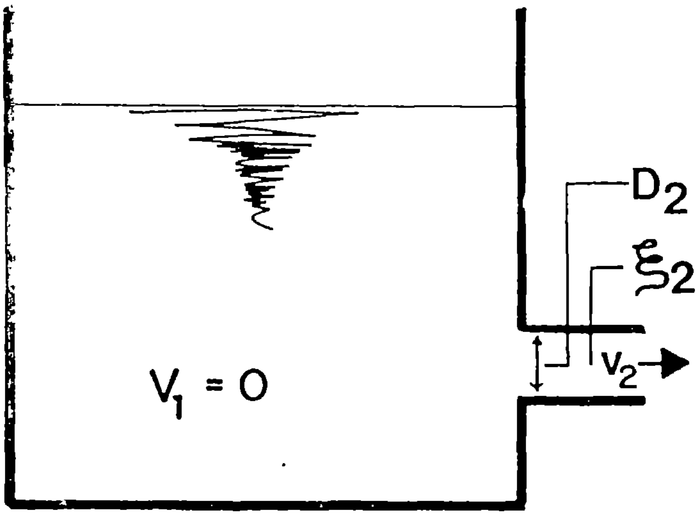
Note that ζ is assigned to a certain pipe section, and should hence be incorporated in the head loss calculations of that particular section only.

EXIT and ENTRANCE losses

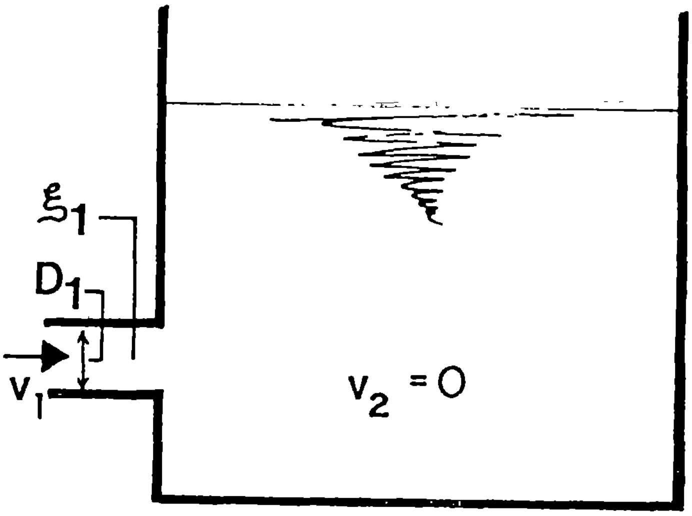
When a pipe enters a reservoir, or anything else in which the flow velocity becomes virtually nil, an exit loss will occur.
The loss coefficient is 1.0 is such cases.

Entrance losses occur when water enters a pipe from a reservoir or any other storage facility (break-pressure tank) in which the flow velocity is virtually nil. The average loss coefficient for entrance amounts to 0.5.

EXIT LOSS



ENTRANCE LOSS



DEVICES

In pipe systems devices such as gate valves, check valves, meters, pressure release valves, air release valves etc. will have to be installed. Such devices also give local losses. The manufacturers of those devices normally specify the loss coefficients, which are obtained from laboratory tests.

However, for some typical devices average loss coefficients will be presented here, as during the design phase the make of the devices is generally not yet known.

Typical values for the loss coefficients are :

VALVES (Fully opened)

TYPE	LOSS COEFFICIENT ξ
gate valve, without contraction	0.2
gate valve, with contraction	0.5
non-return (reflux) valve	2.0
globe valves	10
other types (butterfly valves, etc)	0.5

Note that for only partly opened valves the loss coefficient is increasing very rapidly, for instance for half-opened gate valves it may easily reach 6.0.
Pressure blow-offs and air release valves have an average loss coefficient of 1.0 (related to the flow in the pipeline itself).

METERS

TYPE	LOSS COEFFICIENT ζ
Venturi	2
Mechanical	10

3. HYDRAULIC PIPE LENGTH

In order to simplify head loss calculations, the local losses can be thought of as caused by an equivalent (but imaginary) pipe section. The equivalent pipe length can be calculated with the following equation :

$$\Delta L = \Sigma \zeta \times 4.1 \times D \times (\log 3D/k)^2$$

where $\Sigma \zeta$ is the summation of all local loss coefficients of the relevant pipe section, D is the internal pipe diameter and k the pipe wall roughness (Nikuradse).

In this way the actual pipe section with bends, devices, etc. is simulated in the calculations by a straight pipe with a hydraulic length of $L + \Delta L$.
(L = actual length, ΔL = equivalent length).

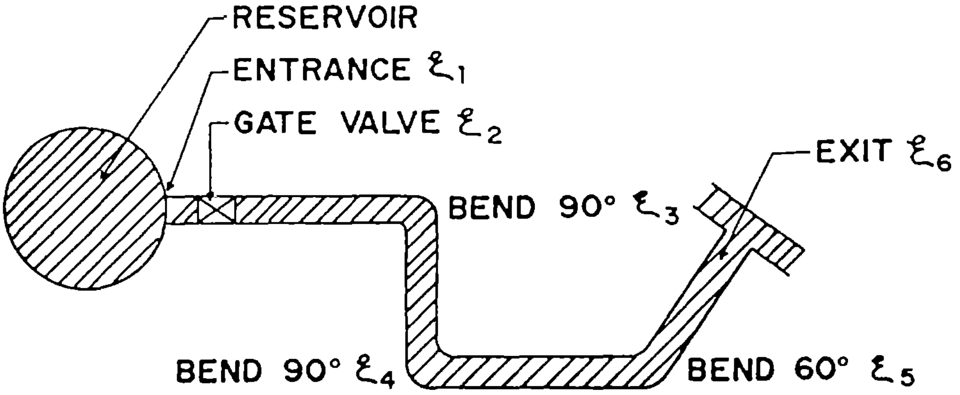
Doing so, the local losses are simulated by frictional losses for calculation purposes.
For $\zeta = 1.0$ the equivalent pipe length can be read from the nomogram. The work of the hydraulic engineer now consists only of determining the actual value of ζ over the pipe section and multiply this figure with the result as read from the nomogram.

4. EXAMPLE CALCULATIONS

Example 1

Given :	Design discharge	$Q = 2.5$ l/s
	Pipe diameter (internal)	$D = 70$ mm
	Pipe material:	uPVC
	Pipe length	$L = 300$ m
	Bends	2 x 90°; 1x 60°; $r/D = 2$
	Entrance from reservoir	
	At the end a T-junction	

TOP VIEW OF SYSTEM



Wanted : Total head loss ΔH from reservoir up to T-junction

Solution : Identify all local losses and quantify the loss coefficients

$\xi_1 = 0.5$
$\xi_2 = 0.2$
$\xi_3 = 0.16$
$\xi_4 = 0.16$
$\xi_5 = 0.13$
$\xi_6 = 0.0$

$\Sigma \xi = 1.15$

- From the nomogram read the equivalent pipe length ΔL for $\xi = 1.0$, D = 70 mm and uPVC pipe material;
  Hence $\Delta L = 4.6$ m (see nomogram).

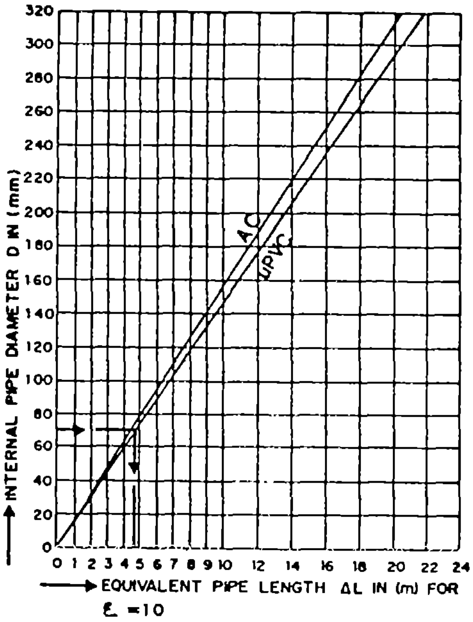
- Multiply this figure with 1.15 ($\Sigma \xi$), thus obtaining the equivalent pipe length simulating the local losses
  $1.15 \times 4.6 = \underline{5.3 \text{ m}}$

- Add the equivalent pipe length to the actual pipe length
  $300 + 5.3 = \underline{305.3 \text{ m}}$

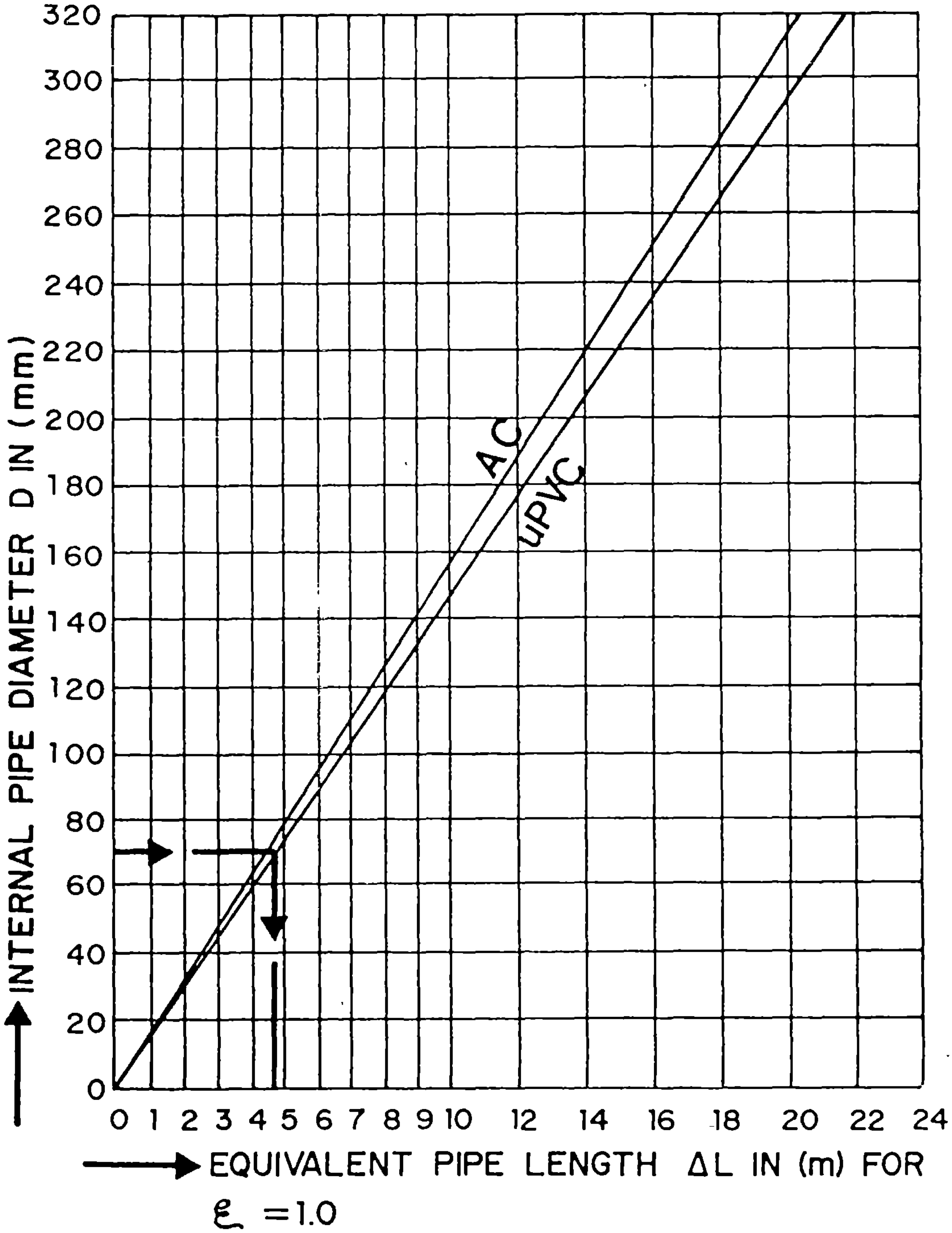
- From the nomogram which shows the relationship between discharge and head loss for uPVC pipes read head loss ΔH [m/1000 m] at the given Q and D :

  Thus $\Delta H = 8.0$ m per 1000 m of pipe length.
  For 305.3 m this yields a headloss ΔH of

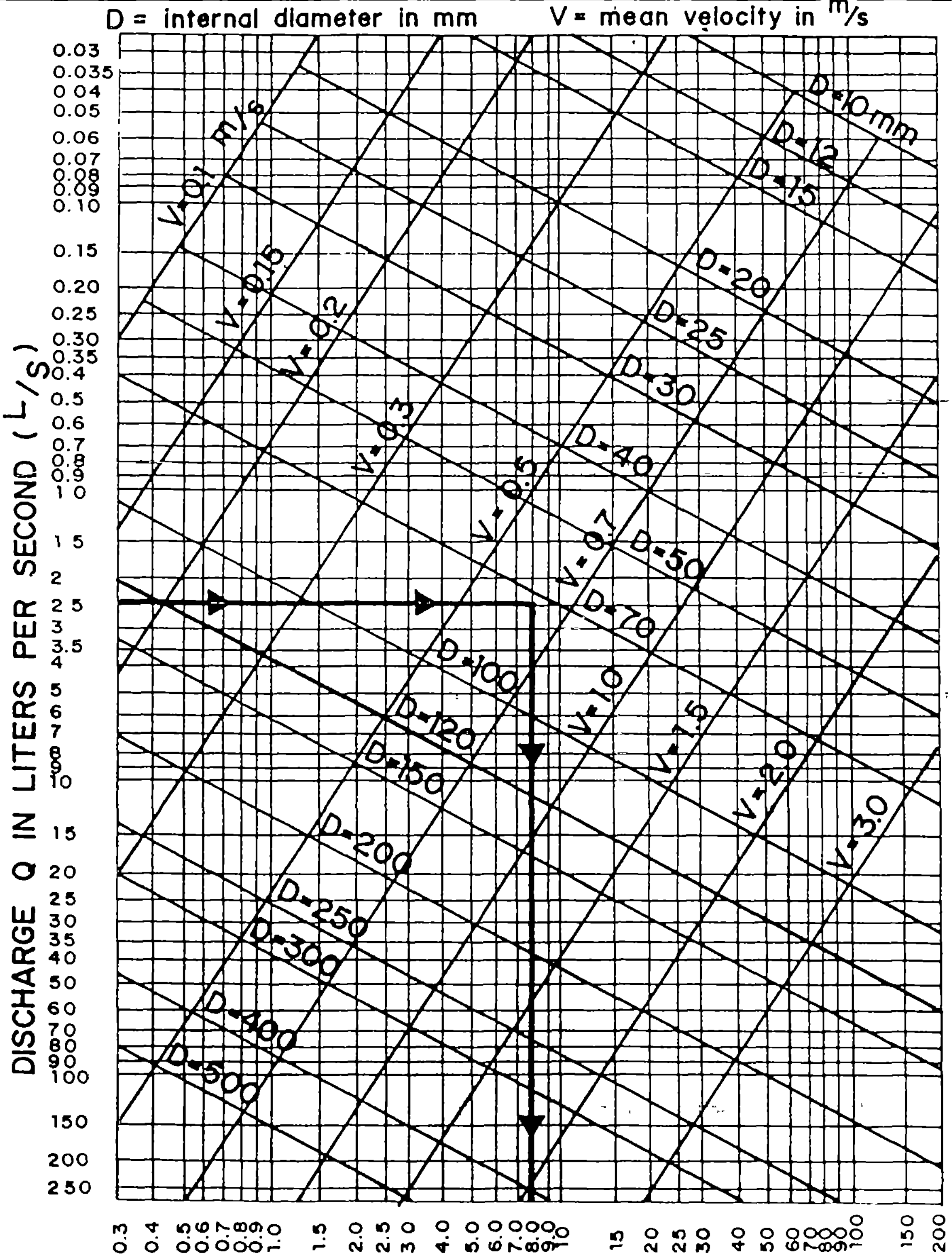
$$\Delta H = (305.3/1{,}000) \times 8.0 = \underline{2.44 \text{ m}}$$



RELATIONSHIP BETWEEN INTERNAL PIPE DIAMETER AND EQUIVALENT PIPE LENGTH FOR ξ=10



RELATIONSHIP BETWEEN INTERNAL PIPE DIAMETER AND EQUIVALENT PIPE LENGTH FOR ξ=1.0



→ HEAD LOSS ΔH IN METRES PER 1000 M OF PIPE LENGTH (m/1000 m) RELATIONSHIPS BETWEEN DISCHARGE AND HEAD LOSS IN uPVC AND HPE PIPES

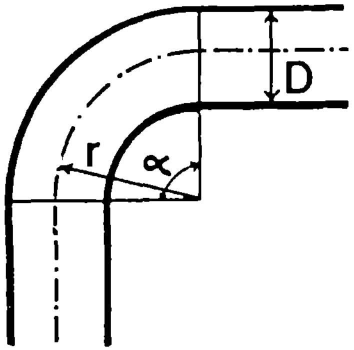
5. SUMMARY

Local head losses will occur at bends, junctions, connections of pipes with different diameters, places where devices are installed etc.
Local losses can be simulated in the calculation of frictional losses by adding a certain equivalent pipe length to the actual pipe length. Local head loss coefficients are presented for the most common cases and a nomogram is given to determine the equivalent pipe length.

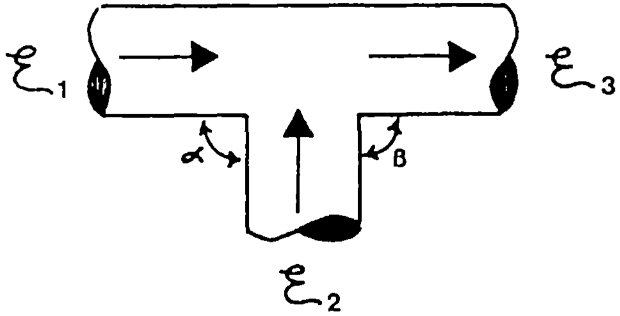
* * *

TITLE :	CODE :
1. Local losses (1)	TBG 365/V 1
2. Entrance/exit losses	TBG 365/V 2
3. Losses in bends	TBG 365/V 3
4. Losses in Tee	TBG 365/V 4
5. Increase in pipe diameter	TBG 365/V 5
6. Reduction of pipe diameter	TBG 365/V 6
7. Entrance/exit losses (2)	TBG 365/V 7
8. Losses in valves & meters	TBG 365/V 8
9. Equivalent pipe length	TBG 365/V 9
10. Local losses in pipelines (1)	TBG 365/V 10
11. Local losses in pipelines (2)	TBG 365/V 11
12. Local losses in pipelines (3)	TBG 365/V 12

① BEND

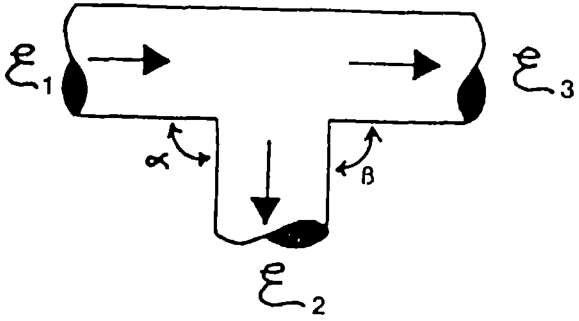


② CONFLUENCE

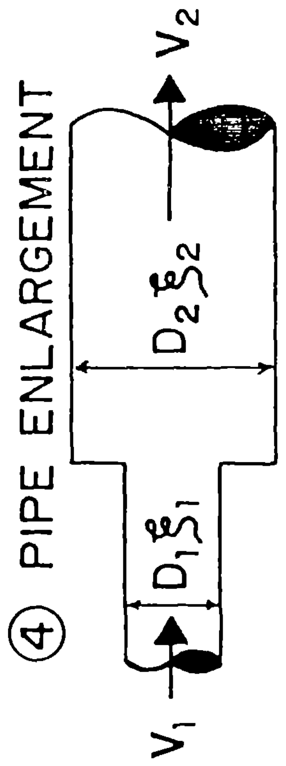


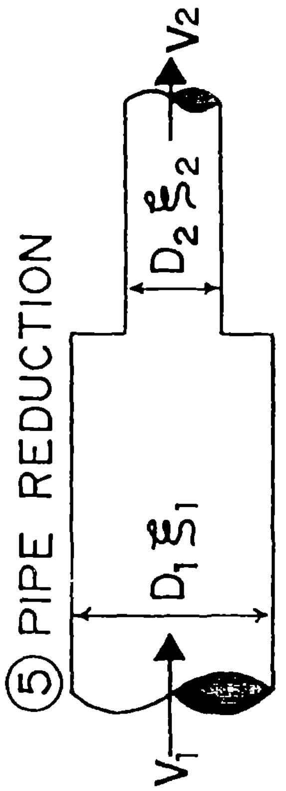
$\alpha + \beta = 180°$

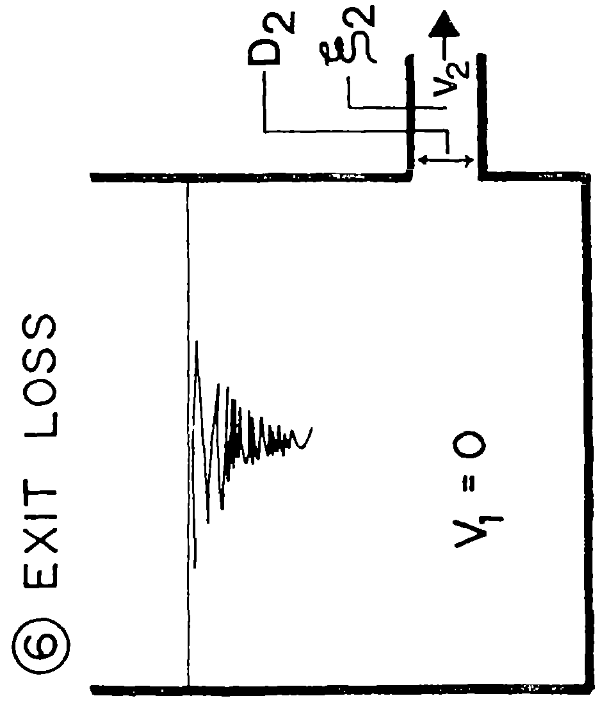
③ BIFURCATION

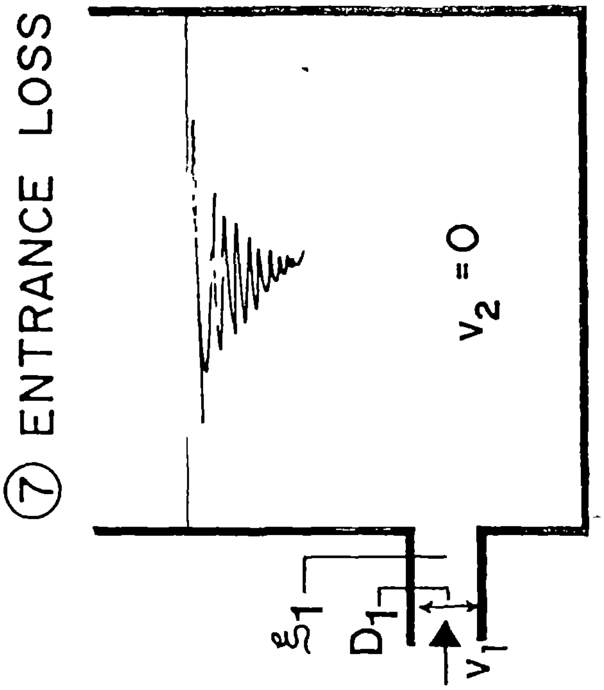


$\alpha + \beta = 180°$


④ PIPE ENLARGEMENT
V_1
D_1 $ξ_1$
D_2 $ξ_2$
V_2

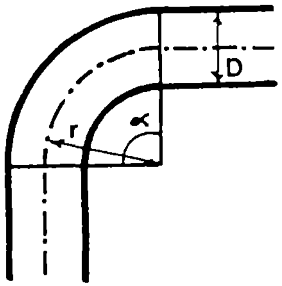

⑤ PIPE REDUCTION
V_1
D_1 $ξ_1$
D_2 $ξ_2$
V_2


⑥ EXIT LOSS
$V_1 = 0$
D_2
$ξ_2$
v_2


⑦ ENTRANCE LOSS
$v_2 = 0$
$ξ_1$
D_1
v_1

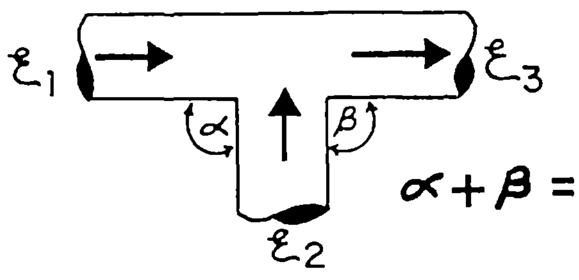
LOCAL LOSSES : BENDS

r/D α	0	1	2	3	4
15°	0.10	0.06	0.04	0.03	0.03
22.5°	0.13	0.08	0.06	0.05	0.04
30°	0.18	0.10	0.08	0.07	0.06
45°	0.32	0.13	0.10	0.09	0.08
60°	0.68	0.19	0.13	0.10	0.09
90°	1.27	0.30	0.16	0.13	0.11



LOCAL LOSSES

CONFLUENCE



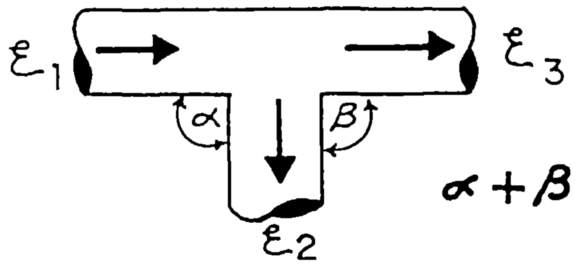
$\alpha + \beta = 180°$

$\varepsilon_1 = 0.0$

$\varepsilon_2 = 0.2$

$\varepsilon_3 = 0.5$

BIFURCATION



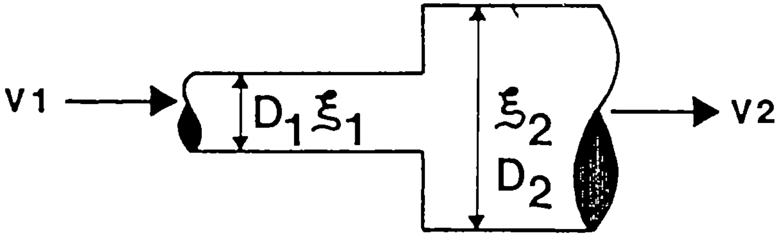
$\alpha + \beta = 180°$

$\varepsilon_1 = 0.0$

$\varepsilon_2 = 1.2$

$\varepsilon_3 = 0.2$

LOCAL LOSSES
INCREASE IN PIPE DIAMETER

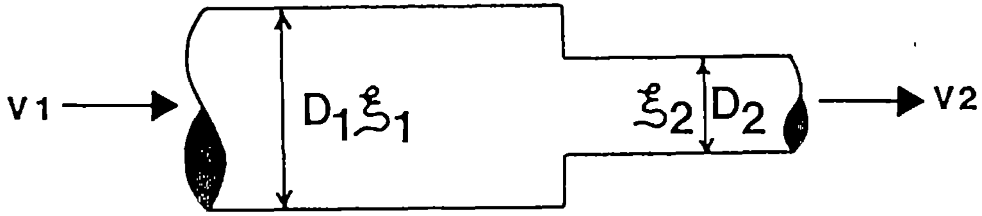


D1/D2	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
ξ_2	0.98	0.92	0.83	0.71	0.56	0.41	0.26	0.13	0.04	0.00

$$\xi_2 = 0$$

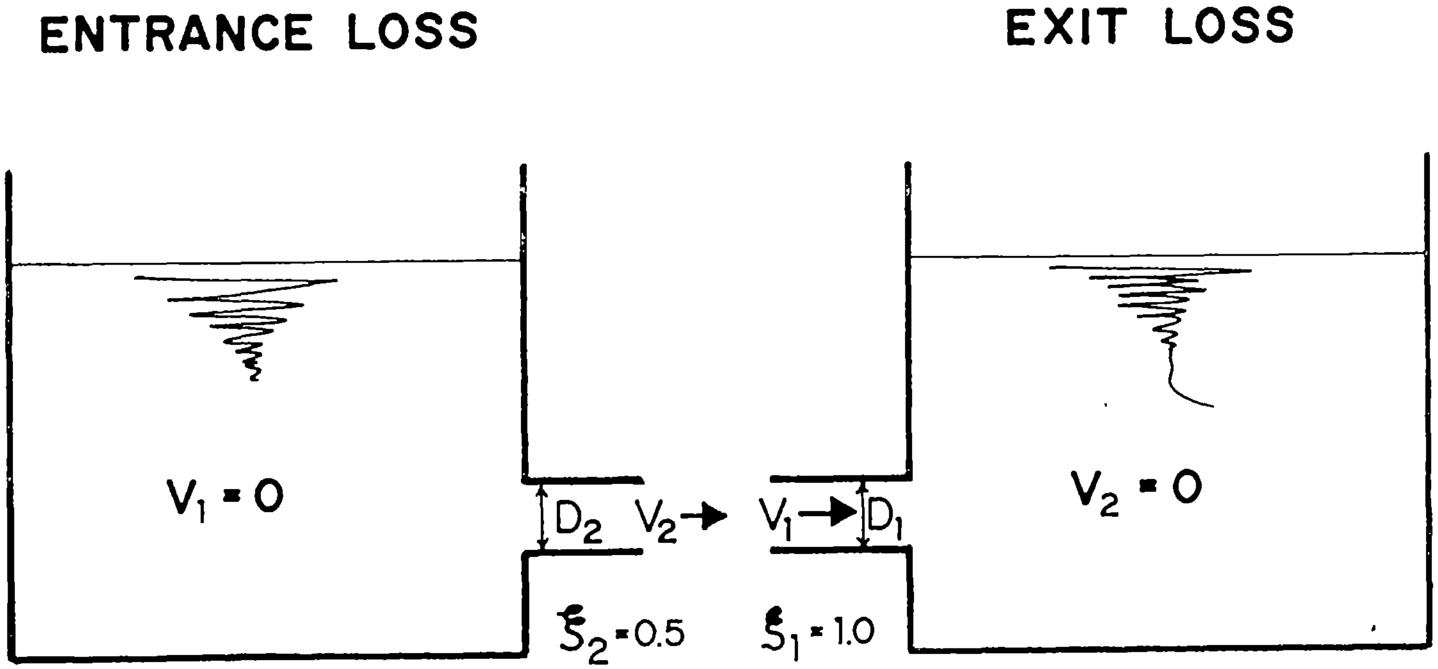
LOCAL LOSSES

REDUCTION OF PIPE DIAMETER



D2/D1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
ξ_2	0.44	0.43	0.41	0.39	0.36	0.31	0.25	0.17	0.09	0.00

LOCAL LOSSES



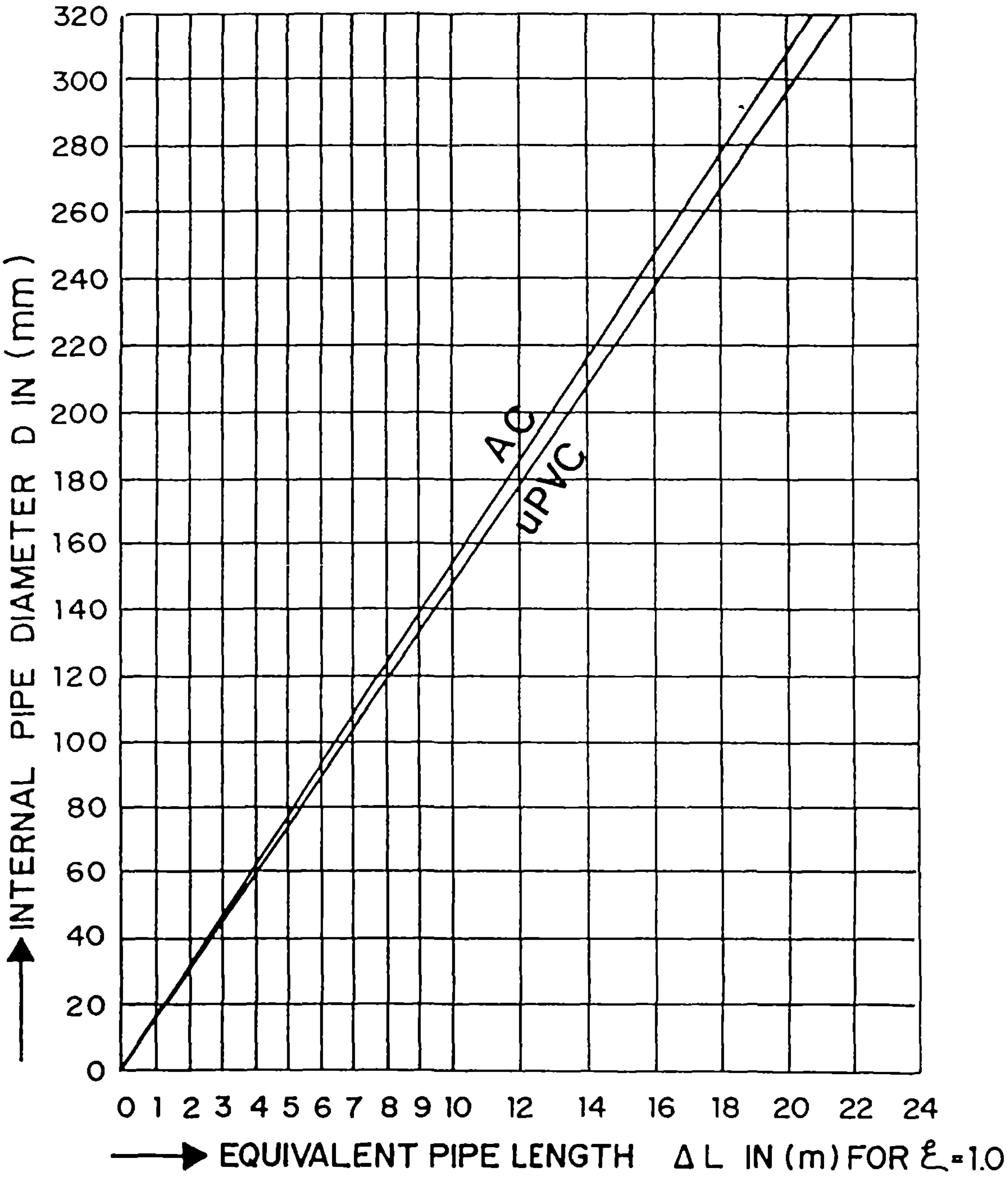
LOCAL LOSSES IN :

VALVES

Type	Loss coefficient $\mathcal{E}$
Sluice valve, without contraction	0.2
Sluice valve, with contraction	0.5
non return (reflux) valve	2.0
globe valves	10
other types (butterfly)	0.5

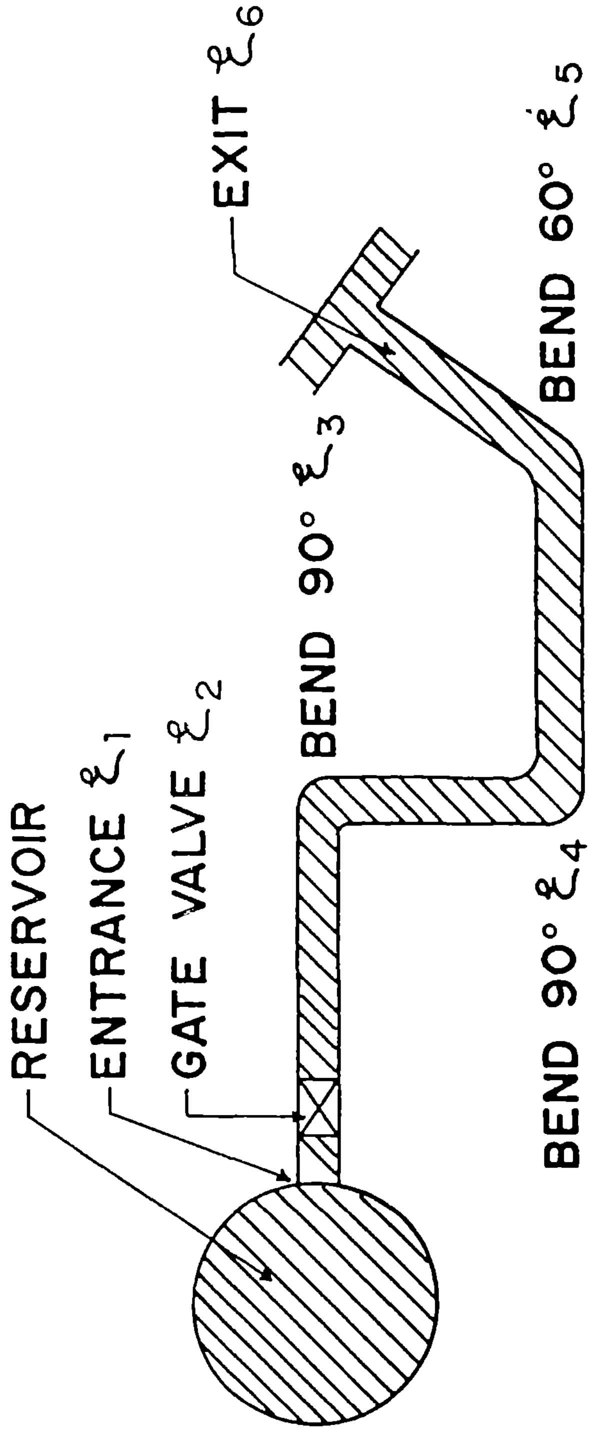
METERS

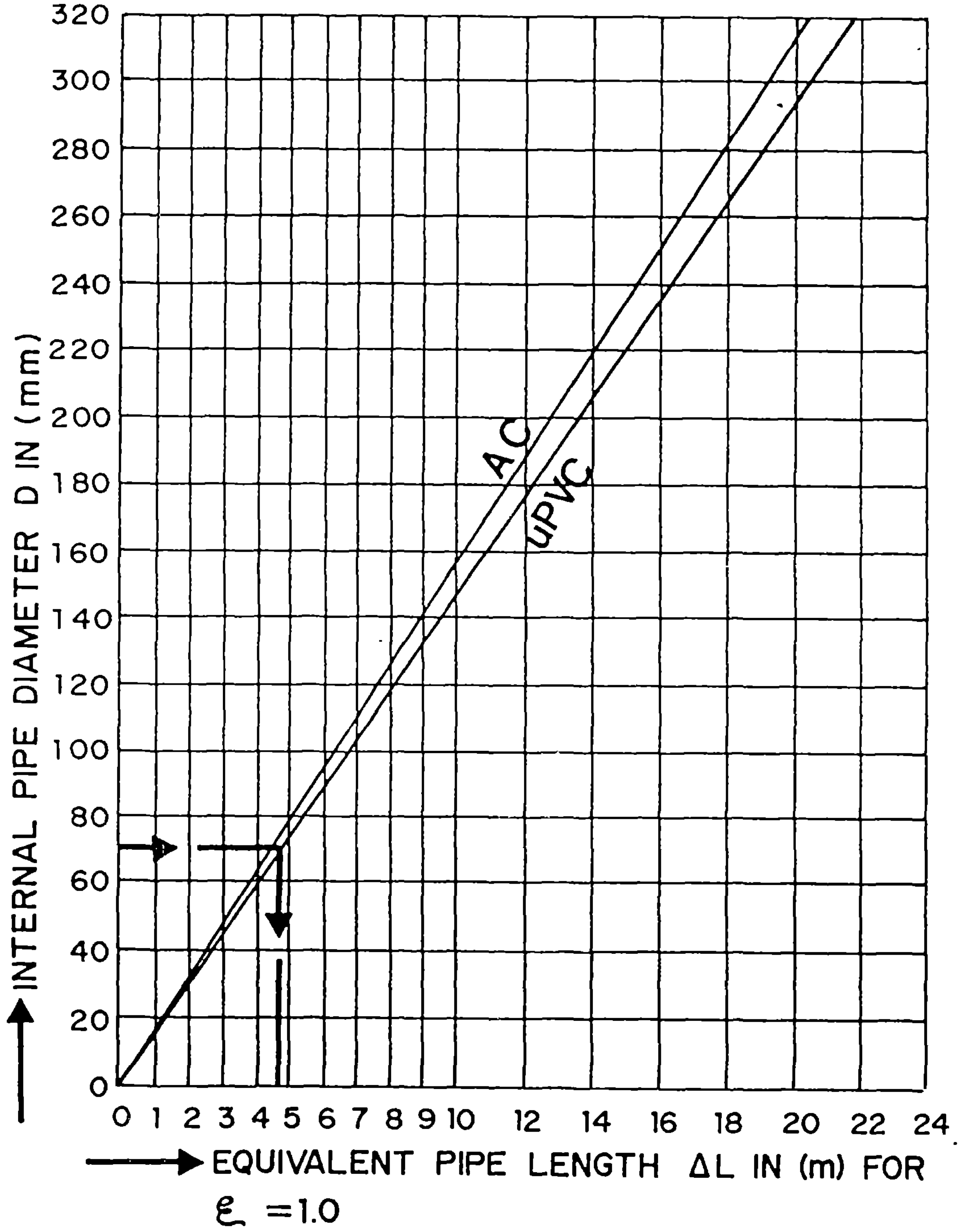
Type	Loss coefficient $\mathcal{E}$
Venturi	2.0
Mechanical	10



EQUIVALENT PIPE LENGTH (ξ=1.0)

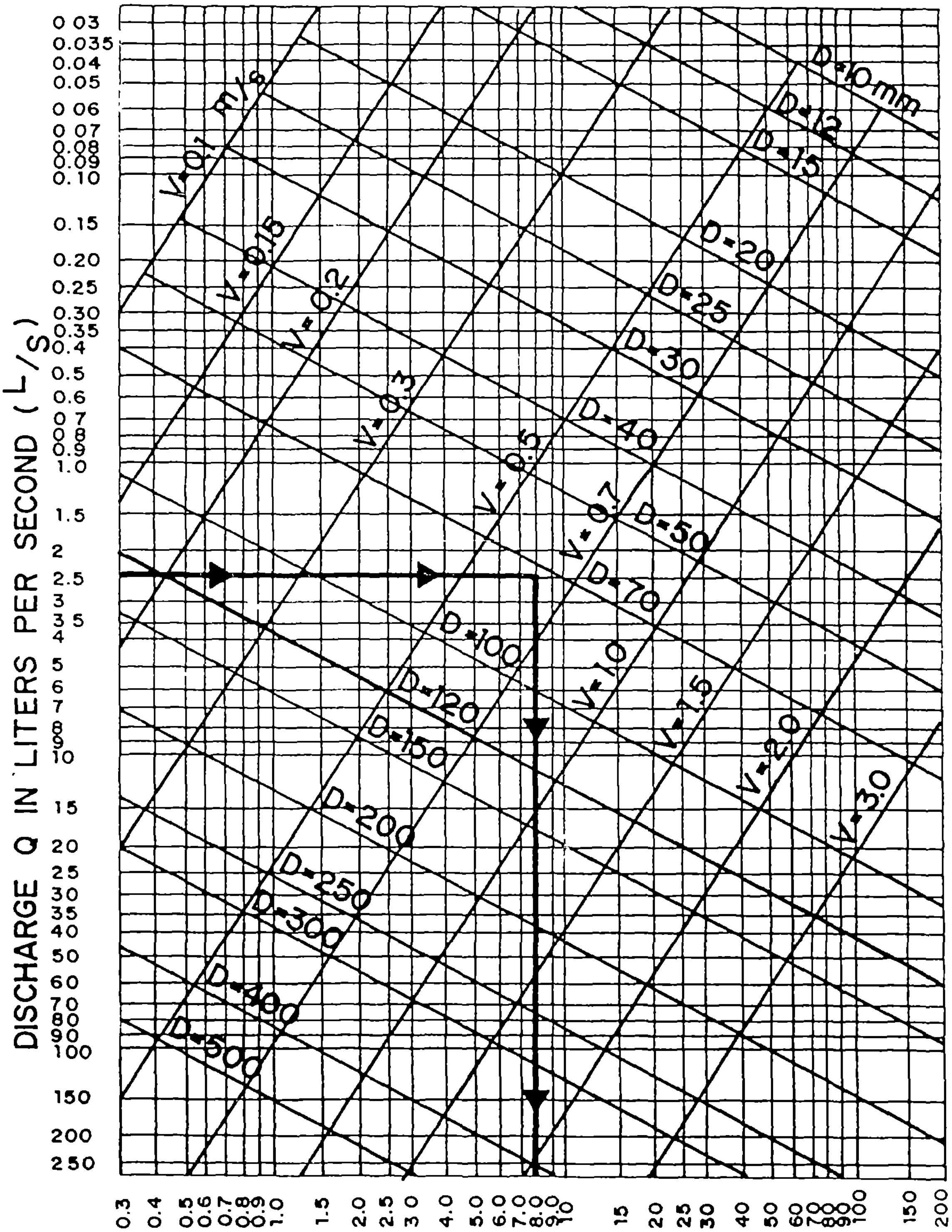
TOP VIEW OF SYSTEM





RELATIONSHIP BETWEEN INTERNAL PIPE DIAMETER AND EQUIVALENT PIPE LENGTH FOR ξ=1.0

D = internal diameter in mm V = mean velocity in m/s



→ HEAD LOSS ΔH IN METRES PER 1000 M OF PIPE LENGTH (m/1000 m) RELATIONSHIPS BETWEEN DISCHARGE AND HEAD LOSS IN uPVC AND HPE PIPES

Module : CONSTRUCTION PROGRESS REPORTS	Code : TBG 508
	Edition : 17-09-1984
Section 1 : INFORMATION SHEET	Page : 01 of 01/06

Duration	45 minutes.
Training objectives	After the session the trainees will be able to : - state the frequency of normal reporting procedures; - state the type of information required in each report.
Trainee selection	- Head of Section Planning Supervision; - Head of Sub-section Supervision; - Construction Supervisor.
Training aids	- Copies of prepared reporting forms (if available); - Viewfoils : TBG 508/V 1-4; - Handout : TBG 508/H 1.
Special features	-
Keywords	Construction progress reports.

1. Introduction

- Supervisors are required to report events on a regular basis.

- Normal report period :
  . daily;
  . weekly;
  . monthly.

Show V 1

2. Daily reports

- Daily reports give immediate details.

Show V 2
Show examples

- They are checked and signed by :
  . contractor
  . supervisor.

- Information required for daily reports :
  . materials received on site;
  . materials used during day;
  . weather conditions;
  . number of men on site;
  . deviations.

3. Weekly reports

- Weekly reports:
  . give a summary of the daily reports;
  . report on progress of the contract.

Show V 3
Show examples

- Details required for weekly reports :
  . total work done during week;
  . percentage of total contract completed during that week;
  . percentage of cost of contract spent during that week;
  . summary of Daily Reports.

4. Monthly Reports	
- Monthly reports are a summary of weekly reports;	Show V 4 Show examples
- Important addition of remarks from Contractor and Supervisor.	
5. Summary	Give H 1

Module : CONSTRUCTION PROGRESS REPORTS	Code : TBG 508 Edition : 17-09-1984
Section 3 : TRAINING AIDS	Page : 01 of 01

Construction reporting periods TBG 508/V 1

CONSTRUCTION
REPORTING PERIODS

1. DAILY
2 WEEKLY
3 MONTHLY

Daily progress report TBG 508/V 2

DAILY PROGRESS REPORT

A. CONTAINS :

- MATERIALS - RECEIVED
  - USED
- WEATHER CONDITIONS
- PERSONNEL
- DEVIATIONS

B. SIGNED BY :

- SUPERVISOR / SITE ENGR.
- CONTRACTOR

Weekly progress report TBG 508/V 3

WEEKLY PROGRESS REPORT

CONTAINS :

- TOTAL WORK DONE
- % OF WORK DONE
- % OF MONEY SPENT
- SUMMARY OF DAILY REPORTS

Monthly progress report TBG 508/V 4

MONTHLY PROGRESS REPORT

CONTAINS :

- SUMMARY OF WEEKLY REPORTS
- REMARKS

Construction progress reports TBG 508/H 1

1. INTRODUCTION

It is essential that both the supervisor and the contractor report the events and progress of the contract or project.

Reporting must be done on a regular basis and it is normal to report with the following frequency :
. daily
. weekly
. monthly.

2. DAILY REPORTING

Daily reporting gives an immediate record of the progress of the contract. It should be presented in a systematic manner and the Daily Report must be agreed upon and signed by both the Supervisor and the Contractor's representative.

The information which is required in a Daily Report is as follows:
- all materials received on site during the day;
- all materials used on site during the day;
- weather conditions;
- number of men on site;
- any deviations from the contract.

3. WEEKLY REPORTS

Weekly reports are essentially a summary of the daily reports but add the financial implications of the work done during the week on the contract as a whole.

The information required for a Weekly Report is generally as follows:

a. summary of Daily Reports;
b. general progress of the contract;
c. total work done during the week;
d. percentage of total contract completed during the week;
e. percentage of the total contract costs spent during the week.

4. MONTHLY REPORTS

Monthly reports are a detailed summary of all Weekly Reports but with the important addition of remarks both by the contractor and the supervisor.

5. SUMMARY

Reporting on the progress of any contract of project is extremely important and normally the following types of reports are prepared:

a. Daily
b. Weekly
c. Monthly.

* * *

Module : CONSTRUCTION PROGRESS REPORTS		Code : TBG 508	
		Edition : 17-09-1984	
Annex : VIEWFOILS		Page : 01 of 05	

TITLE :	CODE :
1. Construction reporting period	TBG 508/V 1
2. Daily progress report	TBG 508/V 2
3. Weekly progress report	TBG 508/V 3
4. Monthly progress report	TBG 508/V 4

CONSTRUCTION REPORTING PERIODS

1. DAILY
2. WEEKLY
3. MONTHLY

DAILY PROGRESS REPORT

A. CONTAINS :

- MATERIALS - RECEIVED
  - USED
- WEATHER CONDITIONS
- PERSONNEL
- DEVIATIONS

B. SIGNED BY :

- SUPERVISOR / SITE ENGR.
- CONTRACTOR

WEEKLY PROGRESS REPORT

CONTAINS :

* TOTAL WORK DONE
* % OF WORK DONE
* % OF MONEY SPENT
* SUMMARY OF DAILY REPORTS

MONTHLY PROGRESS REPORT

CONTAINS :

* SUMMARY OF WEEKLY REPORTS
* REMARKS

DEPARTMENT OF PUBLIC WORKS
DIRECTORATE GENERAL CIPTA KARYA
DIRECTORATE OF WATER SUPPLY

MDPP
DHV
TGI
IWACO

Module : ENGINEERING DRAWINGS	Code : TBG 509
	Edition : 13-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/29

Duration :	90 minutes.
Training objectives :	After the session the trainees will be able to : - identify scales and symbols used on drawings; - sketch the symbols used on drawings.
Trainee selection :	- Head of Section Production; - Head of Sub-section Water Treatment; - Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipeline Inspector; - Head of Section Planning & Supervision; - Head of Sub-section Planning; - Draughtsman; - Technical Planning Assistant; - Head of Sub-section Constuction Supervision; - Construction Supervisor; - Head of Section Maintenance; - Head of Sub-section General (Building) Maintenance; - Head of Sub-section Electrical/Mechanical Maintenance;
Training aids :	- Drawings to different scales; - Viewfoils : TBG 509/V 1-11; - Handout : TBG 509/H 1-2.
Special features :	-
Keywords :	Drawings/scales/drawing title/plan elevation.

1. Introduction

- Drawings represent on paper what exists or is proposed on site.
- Water supply engineering drawings may differ in symbols, sizes and scales.

2. Drawing title

- All drawings must have titles.

- Drawing title is usually given in a box in the bottom right-hand corner of the drawing.

- Information regarding the drawing is contained within the box:
  a. Drawing number;
  b. Title of drawing;
  c. Designer's name;
  d. Draughtsman's name;
  e. Scale of drawing;
  f. Date of drawing;
  g. Details of revisions.

Show V 1

3. Scales

- For practical reasons a drawing is a smaller representation of what exists on-site.
- The reduction is made using a fixed SCALE.
- Drawing sizes are standard so the scale varies depending on size of feature on-site.
- Examples of common used scales are:

1 : 10 = Details
1 : 20 = Details
1 : 100 = Site plans
1 : 200 = Site plans
1 : 1,000 = Site plans
1 : 2,000 = Town maps
1 : 2,500 = Town maps
1 : 5,000 = Town maps
1 : 10,000 = Rural development
1 : 20,000 = Rural development
1 : 50,000 = Rural development
1 : 100,000 = Reconnaisance

- Scales are chosen in such a way that the details on the drawing show all the information required for identifying the subject. An exaggerated scale is used for longitudinal profiles.	Show V 2-3 Show examples of drawings
4. **Sizes**	
- Drawings are made on sheets of standard dimensions. - Sizes of comprehensive plan and of sectional plan are related as scales are related.	Show V 4
5. **Reading drawings**	
- Most drawings of water mains etc. will use a PLAN ELEVATION. - This is the view when looking down on the object. - Detailed drawings will give various elevations : a. Plan elevation - looking down on the object; b. Side elevation - view from the side; c. Front elevation - view from the front; d. Rear elevation - view from the rear.	Show V 5
6. **Symbols**	
Besides the common engineering symbols, there are symbols used mainly in water supply. For the greater part these comprise symbols for pipes and accessories, as used in longitudinal profiles and detailed pipe clusters.	Show V 6-10 Give H 2
7. **Standard drawings**	
Summarizing slightly different structures on one single drawing is economical.	Show V 11

8. **Exercise**

- Give one drawing to each trainee;
- Ask trainees to take measurements using SCALE-RULE and also to identify elevations;
- Do exercise (20 minutes);
- Discuss results.

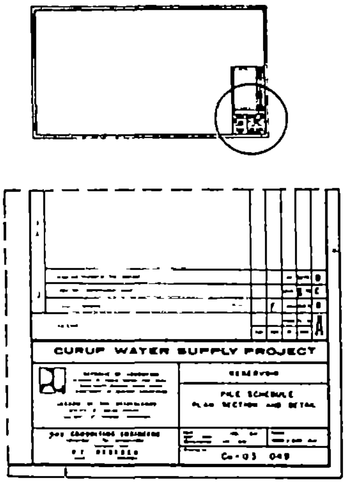
Give drawings

9. **Summary**

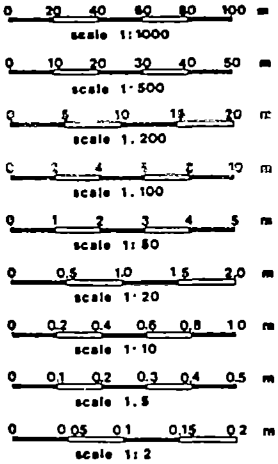
Give H 1

Module : ENGINEERING DRAWINGS	Code : TBG 509 Edition : 13-03-1985
Section 3 : TRAINING AIDS	Page : 01 of 03

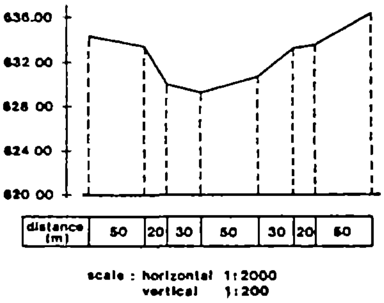
Drawing title box TBG 509/V 1



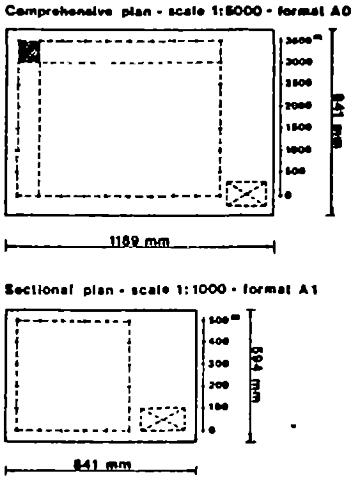
Scale markers TBG 509/V 2



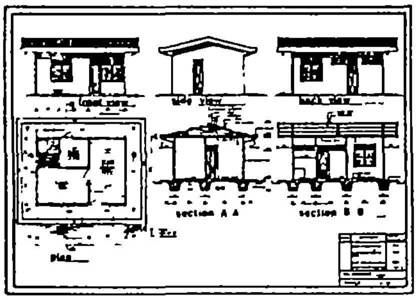
Use of different scales TBG 509/V 3



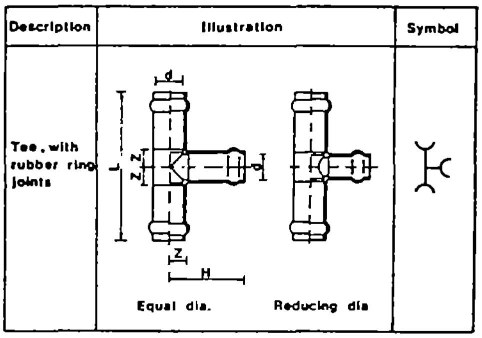
Drawing sizes TBG 509/V 4



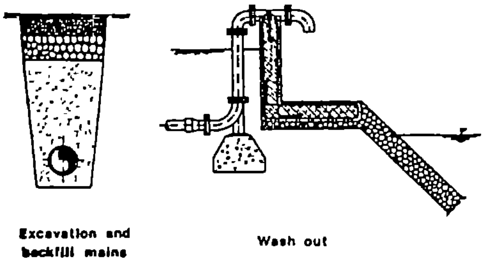
Elevations on drawings TBG 509/V 5



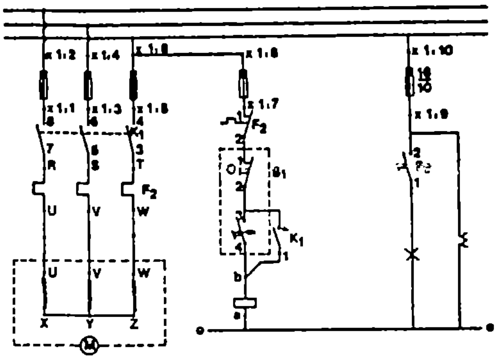
Pipe symbol (example) TBG 509/V 6



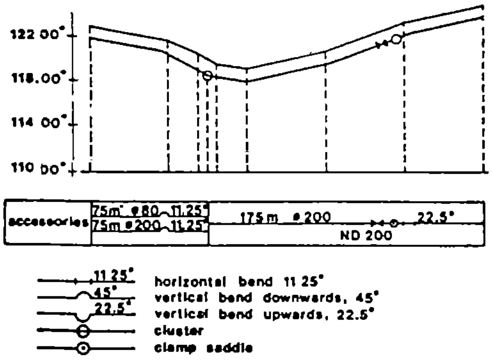
Civil engineering symbols (example) TBG 509/V 7



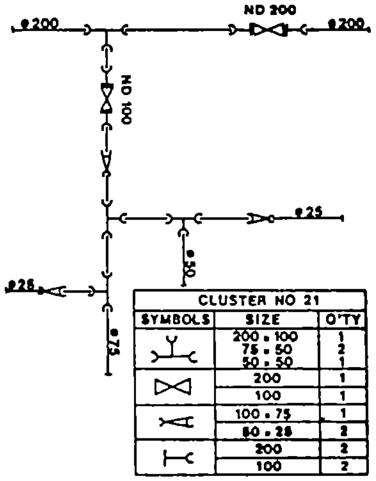
Electrical diagram (example) TBG 509/V 8



Longitudinal profile TBG 509/V 9

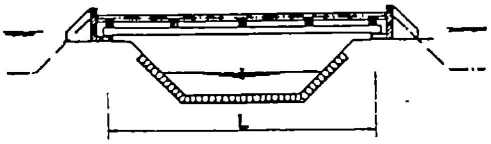


Cluster details TBG 509/V 10



CLUSTER NO 21		
SYMBOLS	SIZE	Q'TY
	200 • 100 75 • 50 50 • 50	1 2 1
⋈	200	1
	100	1
	100 • 75	1
	50 • 25	2
	200	2
	100	2

Standard drawing pipe bridge TBG 509/V 11



L (m)	supporting structure for mains up to ø 250 mm	mains ø300 and ø400
0 – 5	no support required	.. . ...
5 – 10	2 •][NP 200	... .
10 – 14	2 •][NP 240	....

Engineering drawings TBG 509/H 1	Engineering drawings TBG 509/H 2 Annex I-IV

1. INTRODUCTION

Drawings are a representation on paper of what exists on site or is about to be constructed.
Engineering drawings used in a water enterprise do not differ so much from common practice in engineering.
However, some specific differences do exist.
Especially symbols and to a certain degree also sizes of drawings are typical.

2. DRAWING TITLE

All drawings must have a title so that the drawings can be identified and also information is given to the person reading the drawing.
The information is usually contained in a title box that is located in the bottom right-hand corner of the drawing. It normally comprises:

a. Drawing number;
b. Title of drawing;
c. Designer's name;
d. Draughtsman's name;
e. Scale of drawing;
f. Date of drawing;
g. Details of any revisions.

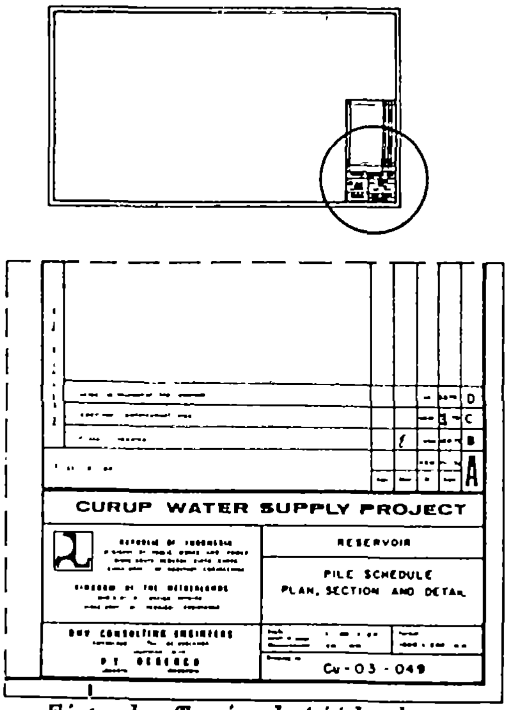


Fig. 1 Typical title box

3. SCALE

Like maps and plans, engineering drawings are made to a certain scale.

Contrary to maps and plans, however, which inform people of features already existing, drawings are there to allow things to be built exactly as the designer wants them to be built.

For that a clear drawing is needed and it is essential to select the right scale..

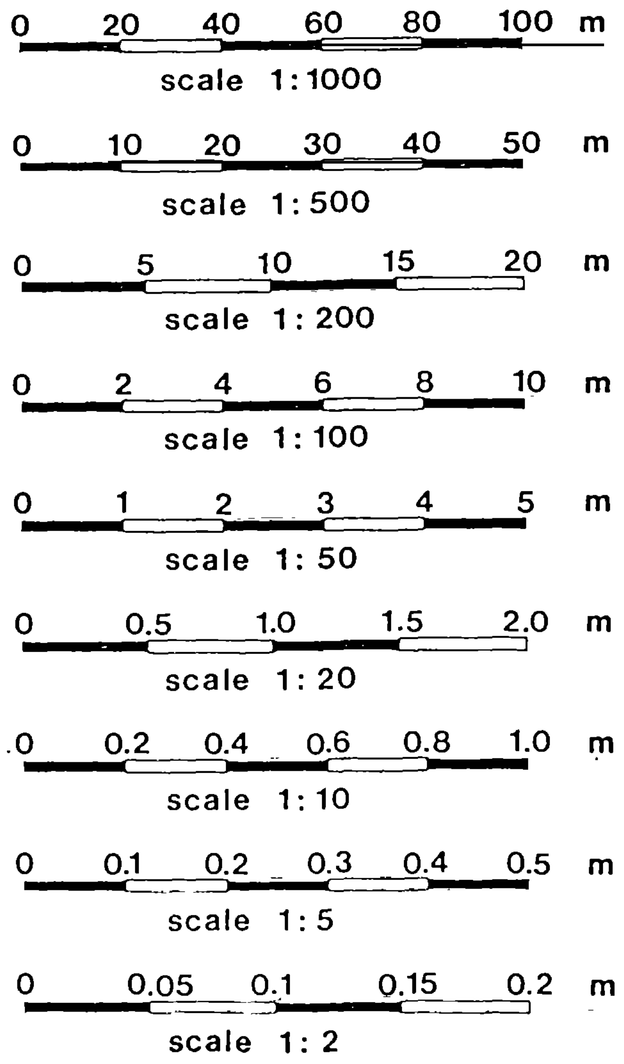


Fig. 2. Scales

For construction drawings this generally means a large scale.
Scales of 1:100, 1:20, 1:10, and for mechanical parts scales of 1:5, 1:2 or even 1:1 are required to attain suitably detailed drawings.
Overall views can be drawn satisfactorily using scales of 1:200 or 1:500.

In Indonesia the following scales are often used :

1 : 10 = Details
1 : 20 = Details
1 : 100 = Site plans
1 : 200 = Site plans
1 : 1,000 = Site plans
1 : 2,000 = Town maps
1 : 2,500 = Town maps
1 : 5,000 = Town maps
1 : 10,000 = Rural development
1 : 20,000 = Rural development
1 : 50,000 = Rural development
1 : 100,000 = Reconnaisance

Some practical examples are :

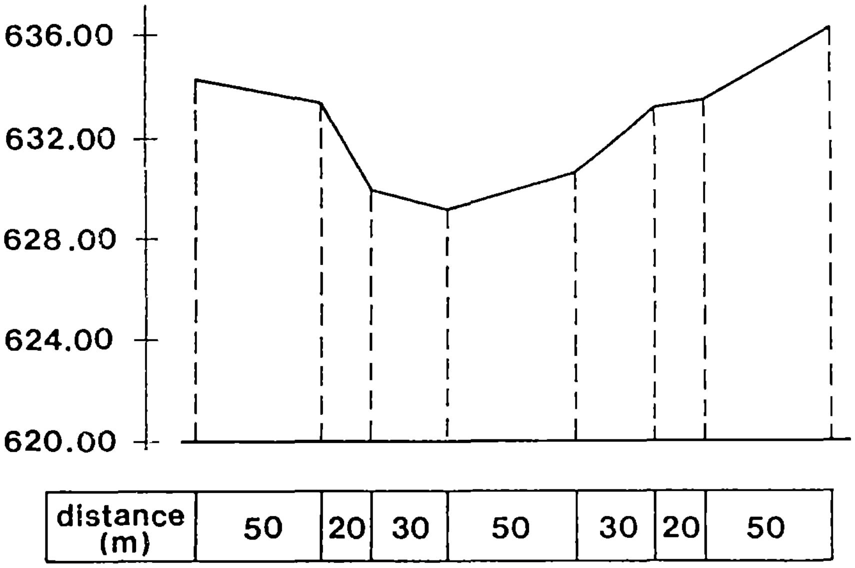
1:100	typical cross section of road with main.
1: 20	cross section, crossing main/culvert.
1: 10	detail pipe support.
1: 5	water meter pit/house connection.

No other, non-standard, scales should be used.

Exaggerated scale

The section alongside the longitudinal axis of e.g. a transmission main - named the longitudinal profile - is usually drawn to two different scales.
The horizontal dimensions (the length of the main) may be given at a scale of 1:2000, whereas the vertical distances (the differences in level) may be drawn at a scale of 1:200.
Drawing these levels to the scale of 1:2000 would mean that e.g. ground level and main could not be drawn as two separate lines anymore.

On the other hand, applying a scale of 1:200 not only for the levels but also for the length would produce ten times as many sheets, thus obscuring the overall view without adding substantial details.
The compromise with two different scales is called the exaggerated scale.



scale : horizontal 1:2000
vertical 1:200

Fig. 3. Exaggerated scale

4. SIZES

The sizes of engineering drawings but also of plans are standardized. The smallest size is A4, which measures 297 x 420 mm. All other sheet sizes are a multiple of this basic format.

Format	Width x Height (mm)
A4	297 x 210
A3	420 x 297 = 2 x A4
A2	594 x 420 = 4 x A4
A1	841 x 594 = 8 x A4
A0	1189 x 841 = 16 x A4

Note: Dimensions are paper-cut dimensions.

There are several reasons for strictly adhering to these recommended standard sizes :

- The dimensions of filing systems for drawings are based on the A4 unit.
- Paper and film dimensions are such, that when using A4 units minimal cutting losses will occur.
- Printing machines (lichtdruk) and more importantly the dimensions of photo-sensitive printing paper are chosen in accordance with standard formats.
- When printing is done by a commercial printer sometimes a machine is used for folding the prints; this machine is capable of handling standard-size drawings only.
- For several reasons sets of drawings are bound. It has some advantage when all drawings are of the same size. This will keep cutting losses to a minimum and prevent pages in the book with excessive blank margins. To obtain a better presented book, the drawings are usually reduced before binding. Then it is advantageous when all drawings can be reduced by the same factor, which can only be done with drawings of the same standard size.

Apart from the above, there is a more specific reason why drawings within a water enterprise should be of a certain standard size.
The scale of the comprehensive plans and the sectional plans are such, that the comprehensive plan on an A0 format contains a whole number of sectional plans on an A4 format.
This will be explained in more detail in the following sketch.

The shaded part in the comprehensive plan represents exactly one sectional plan.
With the A0 and A1 formats enough space is left for the title block and legend (see figure on next page).

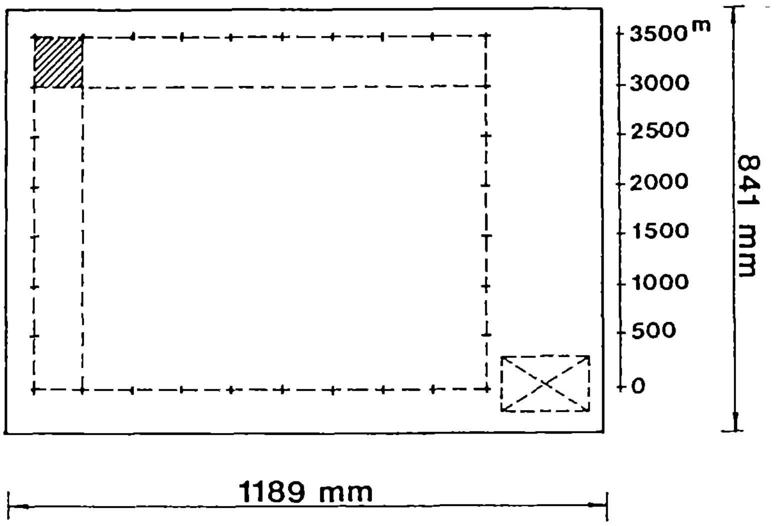
5. READING DRAWINGS

Most drawings of water mains show the site and the line of the water main, as seen from above. This is called a PLAN ELEVATION.

However, more detailed drawings show the feature from different angles :

a. PLAN ELEVATION - seen from the top.
b. SIDE ELEVATION - seen from the side.
c. FRONT ELEVATION - seen from the front.
e. REAR ELEVATION - seen from the rear.

Comprehensive plan - scale 1:5000 - format A0



Sectional plan - scale 1:1000 - format A1

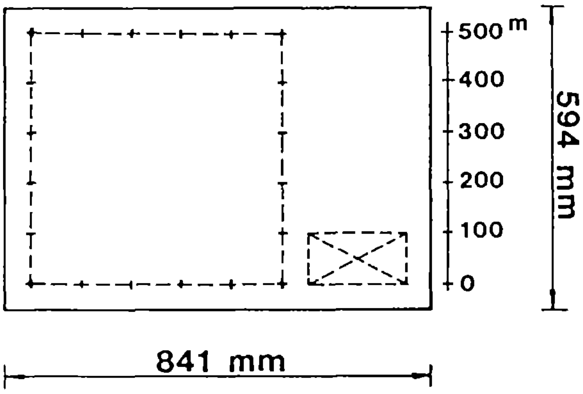


Fig. 4. Comprehensive/sectional plans

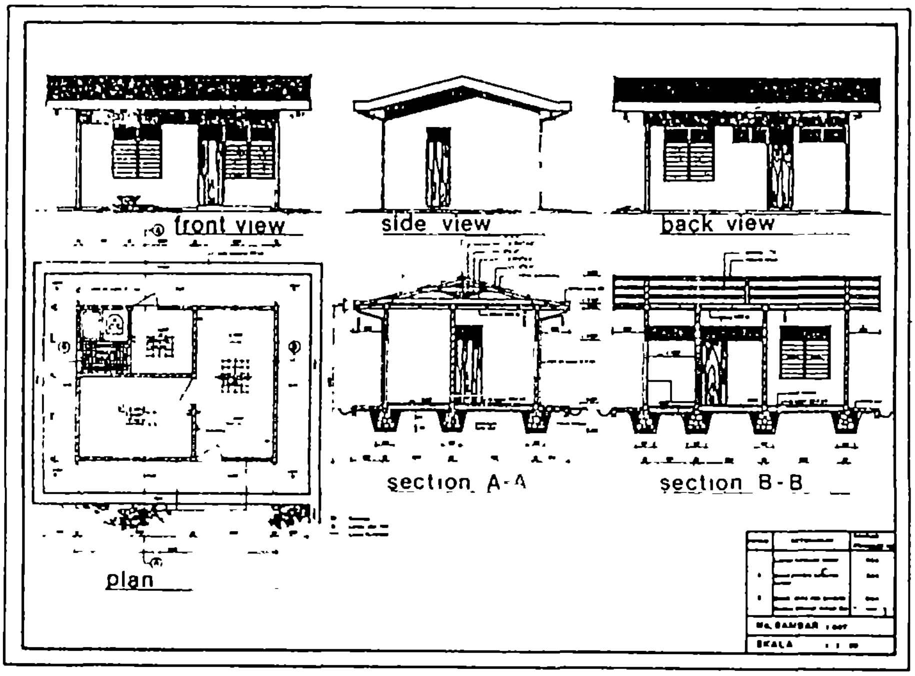


Fig. 5. Example of various elevations on drawing

6. SYMBOLS

Sectional Plans

The greater part of the information on sectional plans is given with the help of symbols. These symbols mostly represent mains, including their dimensions and the various types of fittings and accessories. Annex I of this module gives names of fittings, together with matching pictures and symbols for different pipe materials.
For the greater part, the symbols are already widely used throughout Indonesia. These symbols correspond to those suggested by ISO (*). As the symbols are not related to any make or manufacturer they can be used without reservation.
For polyethylene (PE or HPE) fittings the same symbols apply as for unplasticized polyvinyl chloride fittings (uPVC).

(*) International Standardization Organization

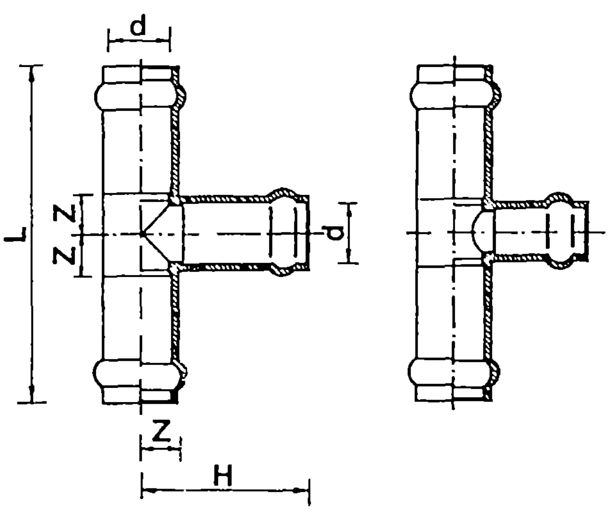
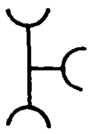
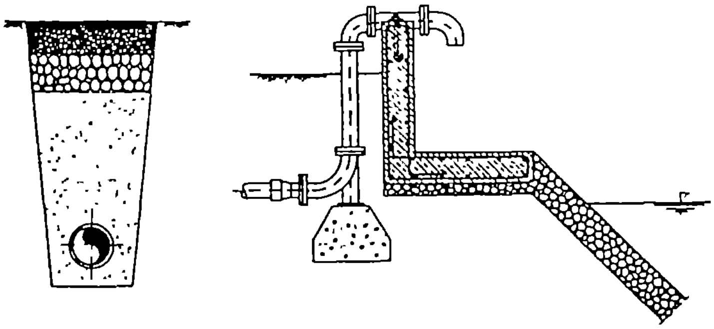
Description	Illustration	Symbol
Tee , with rubber ring joints	 Equal dia. Reducing dia.	

Fig. 6. Example of pipe symbols

Civil and mechanical engineering

Even on engineering drawings, which are usually made to such a scale that all details can be drawn, symbols are widely used.
Here symbols replace items like non-return valves, fire hydrants, valves, regulators, bends and all kind of fittings, which otherwise would cost much time in drawing, particularly as they may appear many times on one single drawing.
Apart from these symbols, different ways of hatching or shading are used in sections to indicate the material of which the structure concerned consists. The hatching indicates that it concerns a section and not a view, which makes the drawing clearer.
At the same time the material is known, which avoids much explanatory text on the drawing and as such also contributes to a clear engineering drawing (see figure 7).

The lists of symbols for civil and mechanical engineering as well as for electrical engineering are given only as extensive examples of which symbols are used (see Annexes II-IV).
However, no completeness was intended and it will be advisable to consult the legend on the drawing concerned, as long as symbols are not officially standardized.



excavation and backfill main *wash-out*

Fig. 7. Example of civil engineering symbols

Electrical engineering

The electrical installation of e.g. a pumping station is drawn in the form of a diagram. Such a diagram is mostly made up of symbols only. There is no visual connection with the real installation anymore and hence the diagram is difficult to understand by non-professionals. Annex IV summarizes the most usual symbols on an electrical diagram (see figure 8).

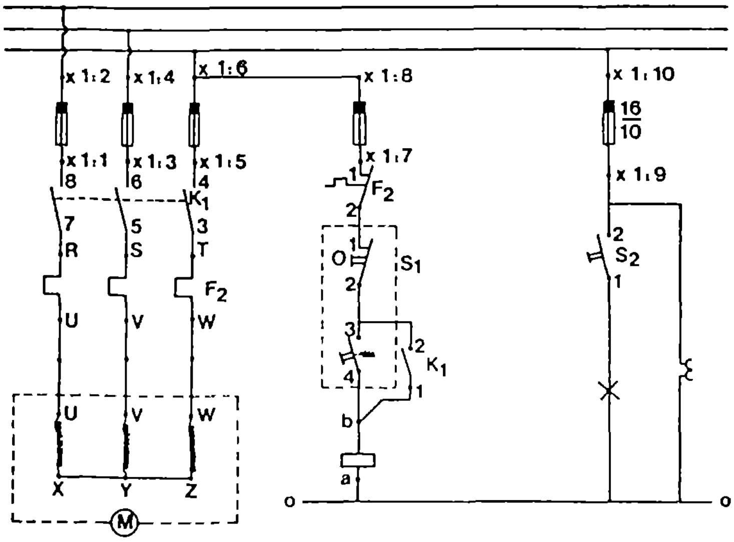
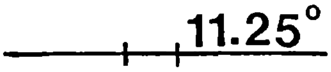


Fig. 8. Typical electrical diagram

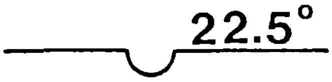
Longitudinal profile

In the longitudinal profile e.g. a long-drawn distribution system or a transmission main, accessories such as bends, valves, air release valves etc. are indicated by symbols that are sometimes different from those used on sectional plans.
The symbols for horizontal and vertical bends, clusters and clamp saddles, being the most common ones, are given below :



horizontal bend 11.25°

vertical bend upwards, 45°



vertical bend downwards, 22.5°

cluster

clamp saddle

Although usually the longitudinal scale is large, symbols can be used without too much trouble, as the fittings are mostly far apart.

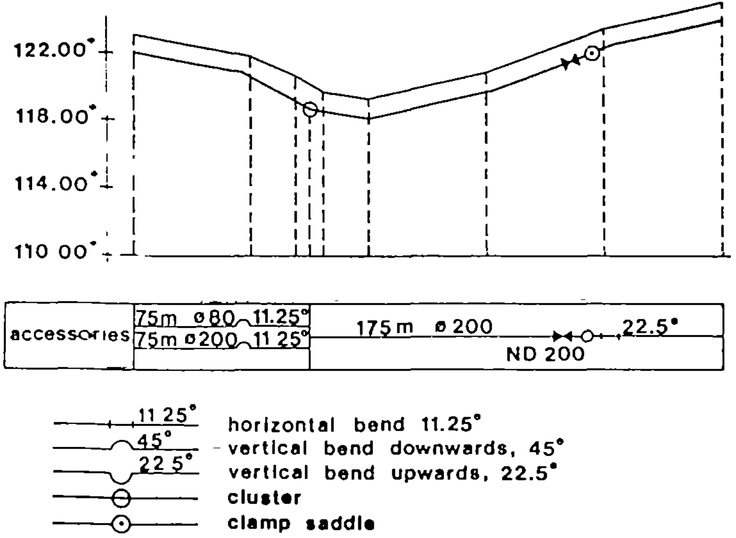
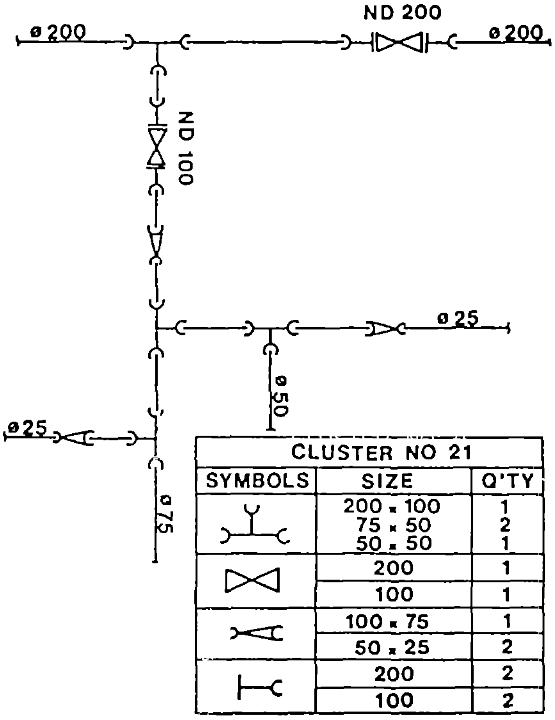


Fig. 10 Symbols in longitudinal profile



CLUSTER NO 21

SYMBOLS	SIZE	Q'TY
	200 × 100 75 × 50 50 × 50	1 2 1
⋈	200	1
	100	1
	100 × 75	1
	50 × 25	2
	200	2
	100	2

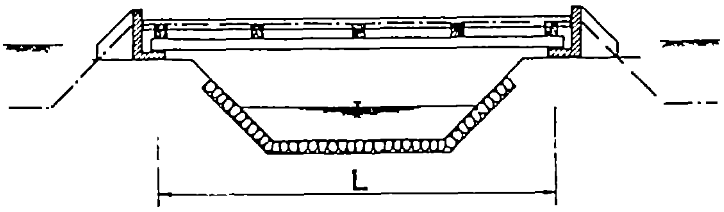
Fig. 11. Example of cluster details

Only occasionally fittings are at such a short distance, that the details of the cluster have to be given on a separate drawing. These clusters are drawn not to scale, using only symbols and they are usually completed with a list summing up all the fittings involved.

7. STANDARD DRAWINGS

Within a water enterprise a considerable number of the engineering drawings cover structures that are the same or almost the same, except for a few measures, details or materials.
In such cases time and money can be saved by using standard drawings. These give an accurate picture of the subjects concerned, except for those dimensions and other items that vary. These are indicated by letters. In a separate list these letters are given their real values.

An example is the crossing of a canal by a water main. The supporting structure, e.g. two steel beams, will vary with the diameter of the main and with the width of the canal.



L (m)	supporting structure for mains up to ø 250 mm	mains ø300 and ø400
0 - 5	no support required	....
5 - 10	2 ▪]C NP 200	....
10 - 14	2 ▪]C NP 240	....

Fig. 12. Standard drawing pipe bridge

The use of standard drawings is suitable for, amongst others, the following subjects :

- public tap
- yard connection
- alley connection
- house connection
- water meter pit
- valve (pit)
- fire hydrant
- air-release valve
- wash-out
- thrust blocks
- river crossing
- canal crossing
- culvert crossing

8. SUMMARY

- Drawings are a representation on paper of what occurs on site.

- They are drawn to scale and the various views of the feature are known as elevations.

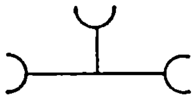
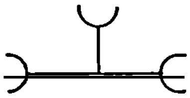
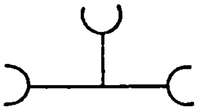
- Water supply drawings may have their own typical symbols.

- For longitudinal profiles exaggerated scales are used.

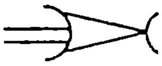
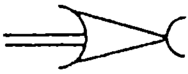
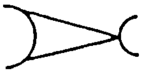
- Standard drawings considerably reduce the number of drawings required.

* * *

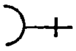
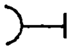
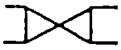
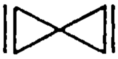
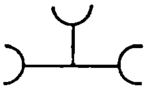
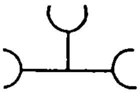
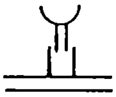
Annex I STANDARD LIST OF PIPE ACCESSORIES

No.	Type	Symbol	Nominal (= outside) dimensions (in mm, unless indicated otherwise)
A.	PVC Accessories		
A.1	Tee, all socket solvent cement joints		25 x 16, 25 x 25 32 x 16, 32 x 25, 32 x 32 50 x 16, 50 x 25, 50 x 32 50 x 50
A.2	Tee, all socket rubber ring joint		63 x 63 90 x 63, 90 x 90 110 x 63, 110 x 90, 110 x 110 160 x 63, 160 x 90, 160 x 110, 160 x 160
A.3	Tee, all socket rubber ring joint + solvent cement joint for branch		63 x 50, 90 x 50, 110 x 50, 160 x 50
A.4	Clamp saddle, with valve socket		63 mm x 0.5" (20 mm valve socket) 63 mm x 3/4" (25 mm valve socket) 63 mm x 1 " (32 mm valve socket) 90 mm x 0.5", 90 mm x 3/4", 90 mm x 1" 110 mm x 0.5", 110 mm x 3/4", 110 mm x 1", 110 mm x 1.5" 160 mm x 0.5", 160 mm x 3/4", 160 mm x 1" 160 mm x 1.5"
A.5	Bend, 22.5° one integral socket with solvent cement joint		50

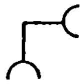
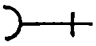
Annex I (continued).

No.	Type	Symbol	Nominal (= outside) dimensions (in mm, unless indicated otherwise)
A.6	Bend, 45°; one integral socket with solvent cement joint		16, 25, 32, 50
A.7	Knee, 90°; one integral socket with solvent cement joint		16, 25, 32, 50
A.8	Bend, 22.5°, 45°, 90° one integral socket with rubber ring joints		63, 90, 110, 160
A.9	Reducer, all socket solvent cement joint		16 x 25 25 x 32, 25 x 50 32 x 50
A.10	Reducer, all socket rubber ring joints		63 x 90 90 x 110 110 x 160
A.11	Reducer, all socket solvent cement joint (Ø 40 mm) and rubber ring joint (Ø 50 mm)		50 x 63
A.12	Cap, solvent cement joint		16, 25, 32, 50
A.13	Cap, rubber ring joint		63, 90, 110, 160

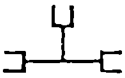
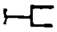
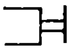
Annex I (continued).

No.	Type	Symbol	Nominal (= outside) dimensions (in mm, unless indicated otherwise)
A.14	Male thread-socket piece, with solvent cement joint		25, 32, 50
A.15	Flange socket piece, with rubber ring joint		50, 63, 60, 110, 160
A.16	Valve, with threaded sockets		25, 32, 50
A.17	Valve, with flanges		63, 90, 110, 160
B.	HDPE Accessories		
B.1	Tee, with sockets as specified for hdpe pipes		25 x 16, 25 x 25 32 x 16, 32 x 25, 32 x 32 50 x 16, 50 x 25, 50 x 32 50 x 50 63 x 50, 63 x 63
B.2	Tee, with two rubber ring joints for uPVC pipe and adaptor to HDPE pipe (branch)		90 x 50, 110 x 50, 160 x 50 90 x 63, 110 x 63, 160 x 63
B.3	Clamp saddle for uPVC pipe with valve socket branch incl. adaptor to HDPE pipe		63 x 16, 63 x 25, 63 x 32 90 x 16, 90 x 25, 90 x 32 110 x 16, 110 x 25, 110 x 32 110 x 50 160 x 16, 160 x 25, 160 x 32 160 x 50

Annex I (continued).

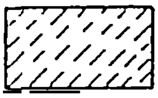
No.	Type	Symbol	Nominal (= outside) dimensions (in mm, unless indicated otherwise)
B.4	Knee (HDPE), 90° with two sockets to HDPE pipe		16, 25, 32, 50, 63
B.5	Reducer, all socket; for HDPE pipe		16 x 25 25 x 32, 25 x 50 32 x 50 50 x 63
B.6	Cap, HDPE		16, 25, 32, 50, 63
B.7	Male, thread-socket piece for HDPE pipe		16, 25, 32, 50, 63

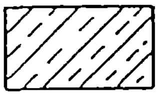
Annex I (continued)

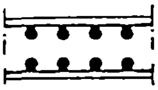
No.	Type	Symbol	Nominal dimensions (in mm, unless indicated otherwise)
C.	**Galvanized steel accessories**		
C.1	Tee, female pipe thread		75 x 50, 75 x 75 100 x 50, 100 x 75, 100 x 100 150 x 75, 150 x 100, 150 x 150
C.2	Flange socket (thread)		50, 100, 150
C.3	Bend, 45°; male pipe thread		50, 75, 100, 150
C.4	Bend, 90°; flanged		50, 100, 150
C.5	Reducer; female thread		75 x 100 100 x 150
C.6	Cap, with pipe thread		75, 100, 150
C.7	Screwed flange		50, 75, 100, 150
C.8	Clamp saddle for galvanized steel pipe		75 mm x 1" 100 mm x 1" 150 mm x 1"

Annex II SYMBOLS CIVIL ENGINEERING (FOR SECTIONS)

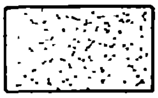

Thin layer of lean concrete

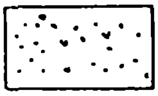

Mass concrete

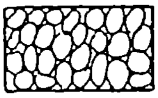

Reinforced concrete

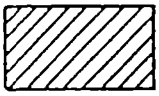

Reinforced concrete, reinforcement indicated

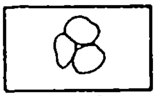
Note :
Conrete sections can be made grey as well, leaving the dotted lines out.

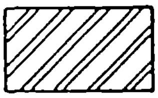

Sand

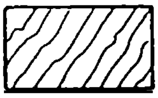

Gravel


Rip-rap


Stone masonry

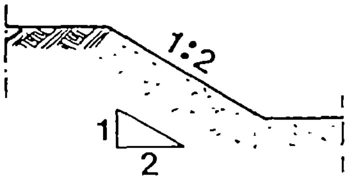

Stone masonry (in plans)

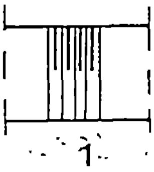

Brickwork masonry


Timber

Annex II (continued)

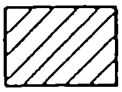
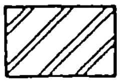
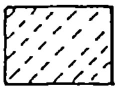
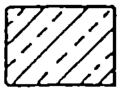
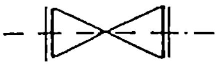
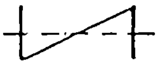
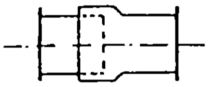
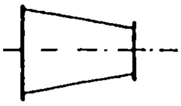
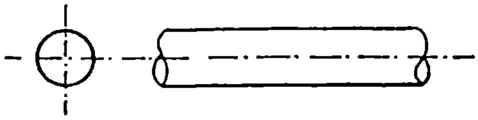
Ground level



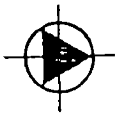


Slope with indication

Annex III SYMBOLS MECHANICAL ENGINEERING (FOR SECTIONS)

	Steel, only for relatively thin parts
	Steel
	Cast iron
	Ductile iron
	Copper/brass
	Aluminium
	Gate-valve
	Non-return valve
	Movable E-piece
	Reducer
	Pipe; material and diameter indicated (view)

Annex IV SYMBOLS ELECTRICAL ENGINEERING



Pump; flow direction indicated

Alternator/generator

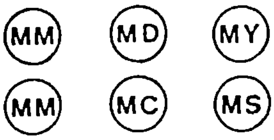
Electro-motor

Voltmeter

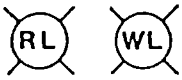
Ampere meter

Frequency meter

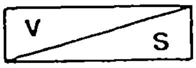
Hour counter



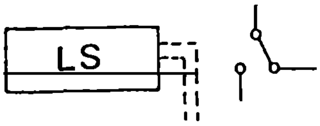
Magnetic contactor



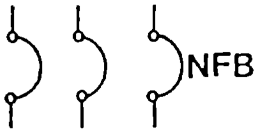
Pilot lamp



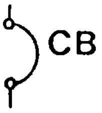
Voltmeter switch



Level control with lock and unlock

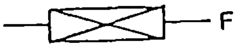


No-fuse breaker, 3-phase

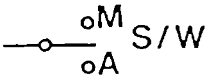


Circuit breaker, 1-phase

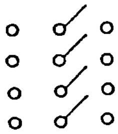
Annex IV (continued)



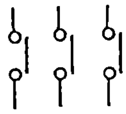
Fuse



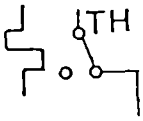
Selector switch



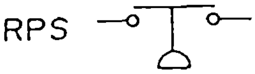
Change-over switch



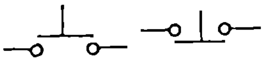
Contactor



Thermol with mechanical lock and unlock



Pressure switch

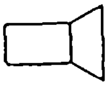


Push button switch on/off

Terminal block

Earth

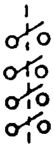
Failure lamp



Claxon, acoustic alarm

Failure relay

Pressure switch relay

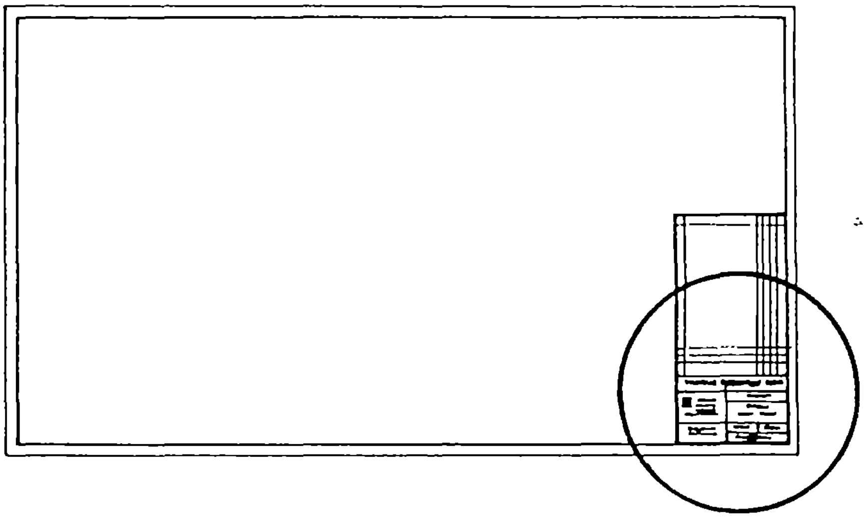


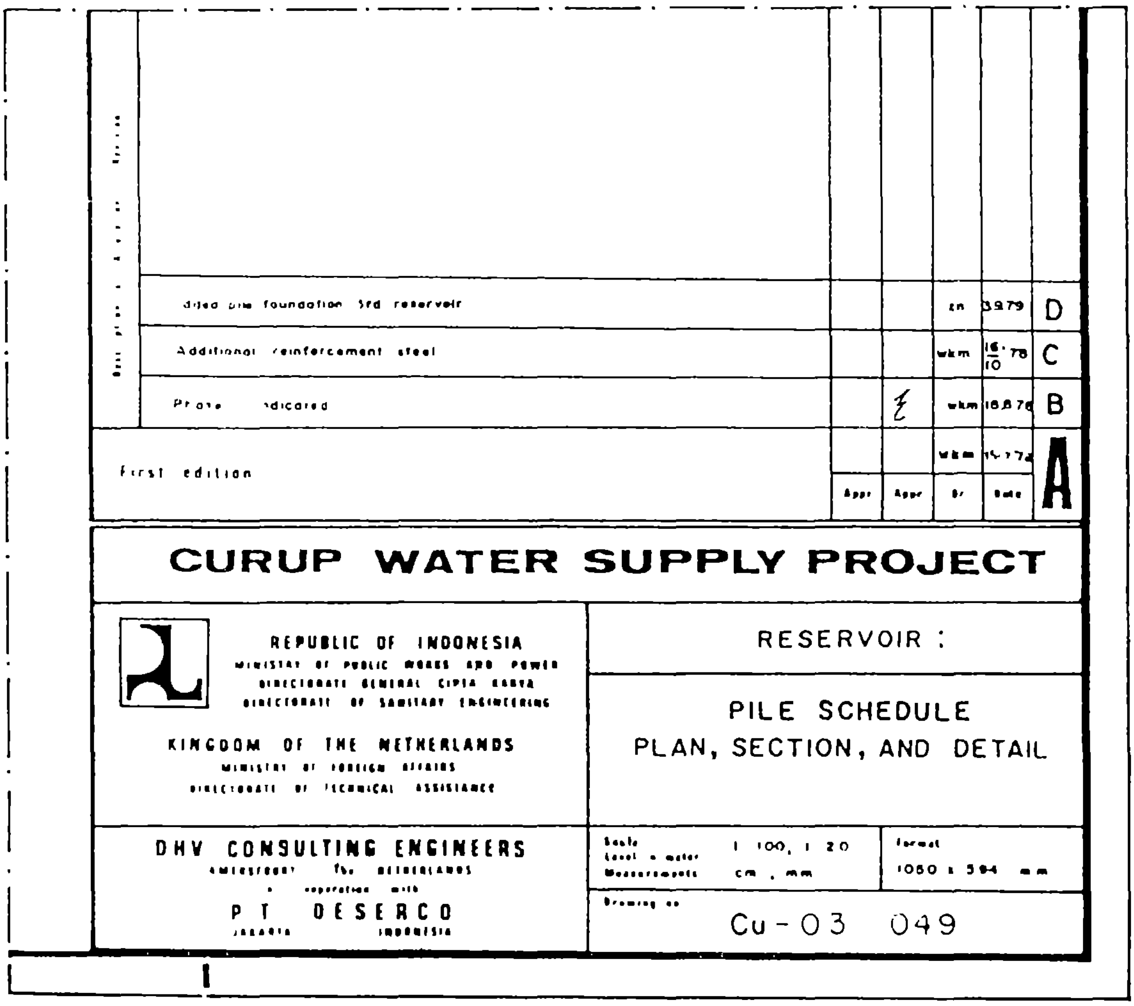
Main switch

* * *

Module : ENGINEERING DRAWINGS	Code : TBG 509
	Edition : 13-03-1985
Annex : VIEWFOILS	Page : 01 of 12

TITLE :	CODE :
1. Drawing title box	TBG 509/V 1
2. Scale markers	TBG 509/V 2
3. Use of different scales	TBG 509/V 3
4. Drawing sizes	TBG 509/V 4
5. Elevation of drawings	TBG 509/V 5
6. Pipe symbol (example)	TBG 509/V 6
7. Civil engineering symbols (example)	TBG 509/V 7
8. Electrical diagram	TBG 509/V 8
9. Longitudinal profile	TBG 509/V 9
10. Cluster details	TBG 509/V 10
11. Standard drawing pipe bridge	TBG 509/V 11





Added pile foundation 3rd reservoir			zn	3.9.79	D
Additional reinforcement steel			wkm	16/10 78	C
Phase indicated		ℨ	wkm	18.8.76	B
First edition			wkm	15.7.76	A
	Appr	Appr	Dr	Date	

CURUP WATER SUPPLY PROJECT

REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS AND POWER
DIRECTORATE GENERAL CIPTA KARYA
DIRECTORATE OF SANITARY ENGINEERING

KINGDOM OF THE NETHERLANDS
MINISTRY OF FOREIGN AFFAIRS
DIRECTORATE OF TECHNICAL ASSISTANCE

RESERVOIR :

PILE SCHEDULE
PLAN, SECTION, AND DETAIL

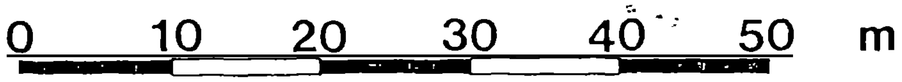
DHV CONSULTING ENGINEERS
AMERSFOORT The NETHERLANDS
in cooperation with
P T DESERCO
JAKARTA INDONESIA

Scale 1 100, 1 20
Level = meter
Measurements cm , mm

Format 1060 x 594 mm

Drawing no Cu-03 049

scale 1:1000



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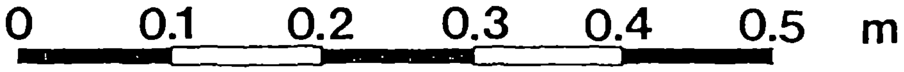
scale 1:200

scale 1:100

scale 1:50

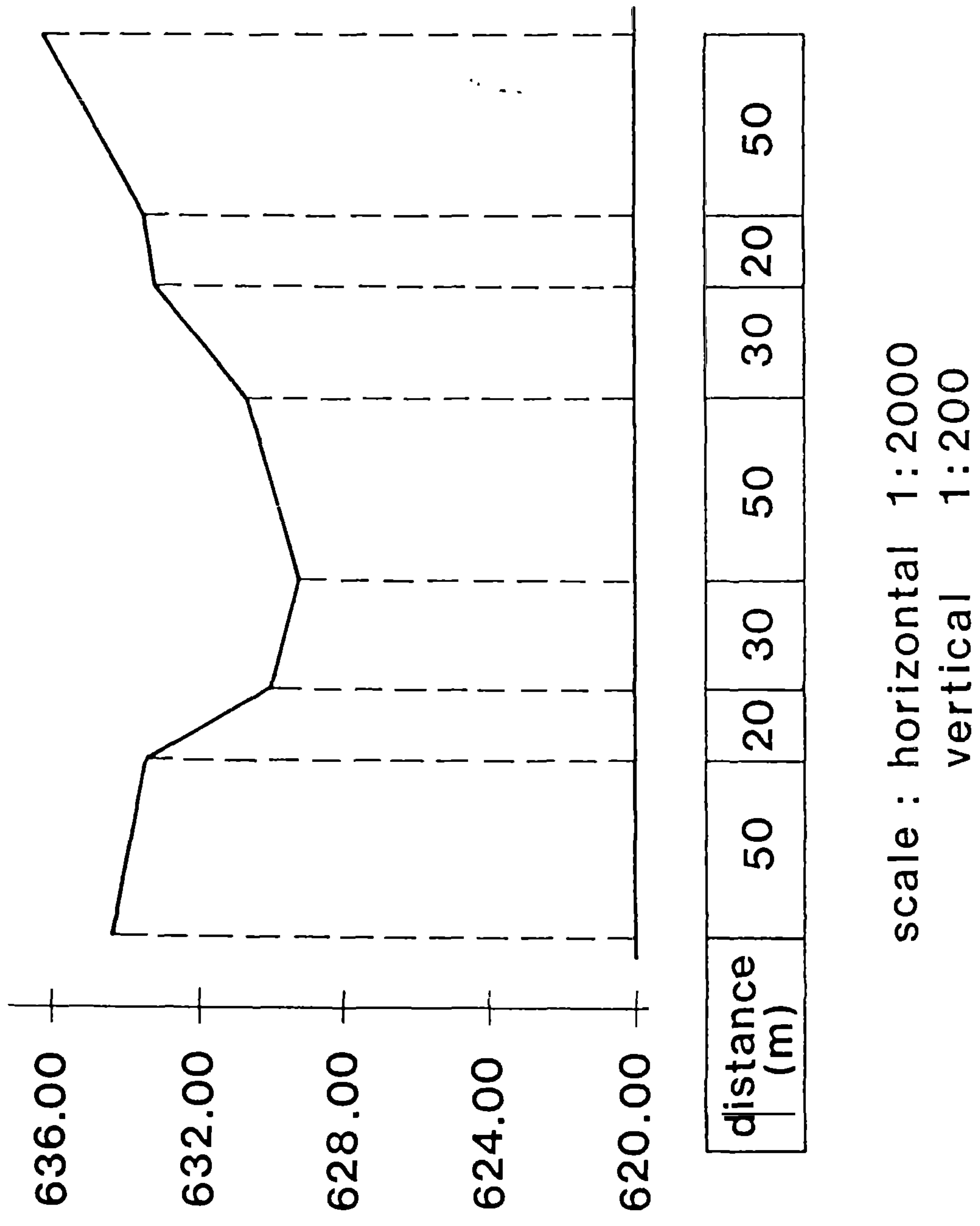
scale 1:20

scale 1:10



scale 1:5

scale 1:2


636.00
632.00
628.00
624.00
620.00
distance (m)
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20
30
50
30
20
50
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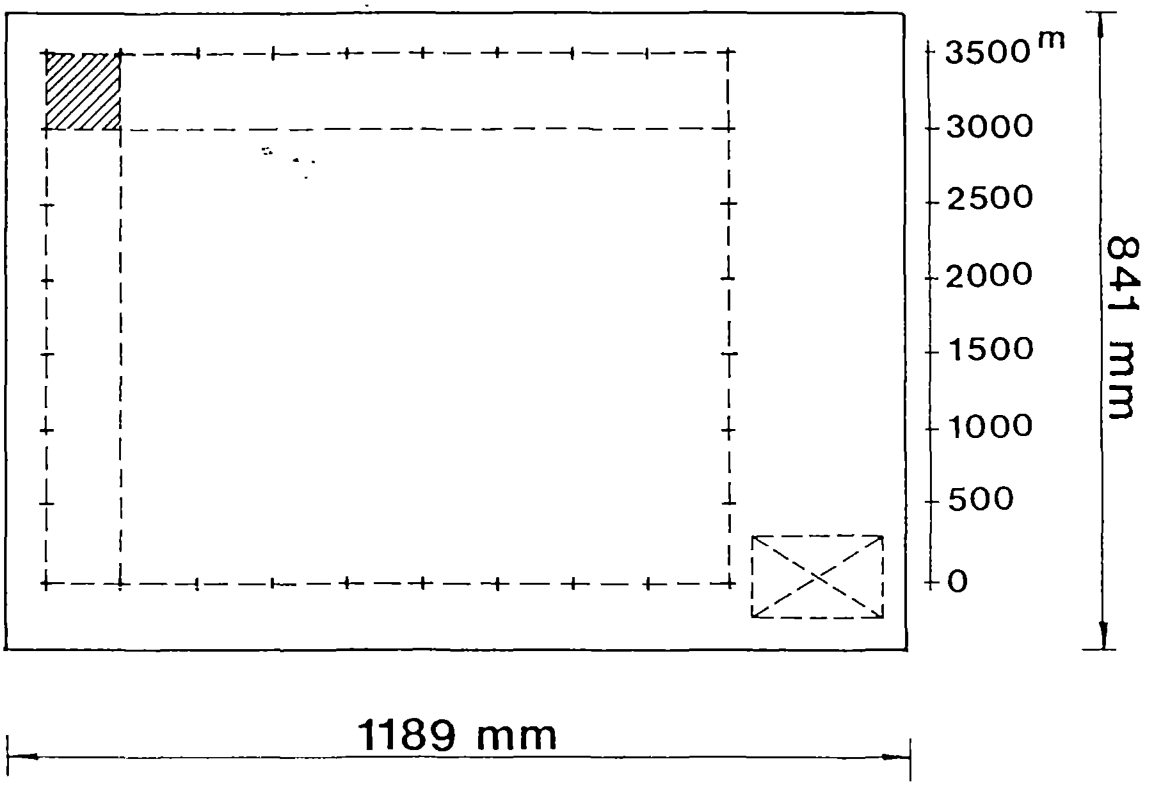
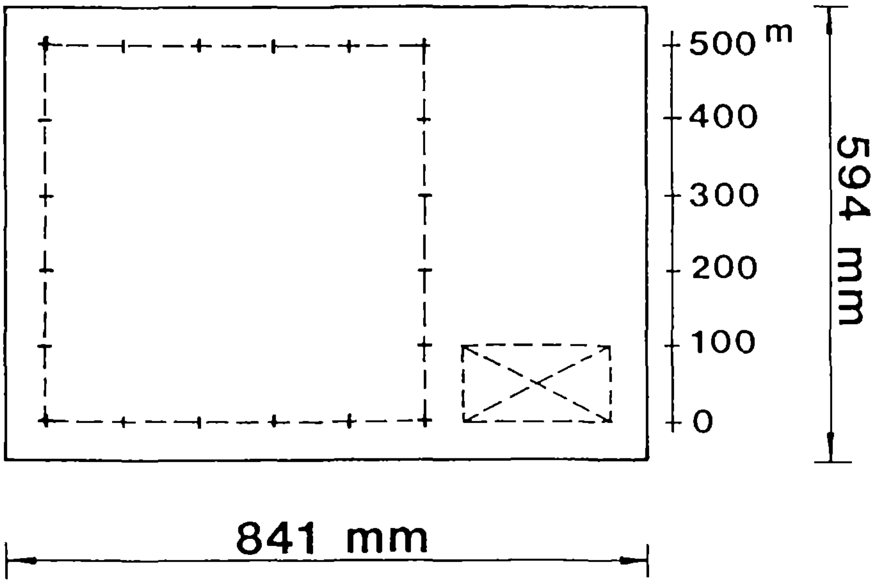
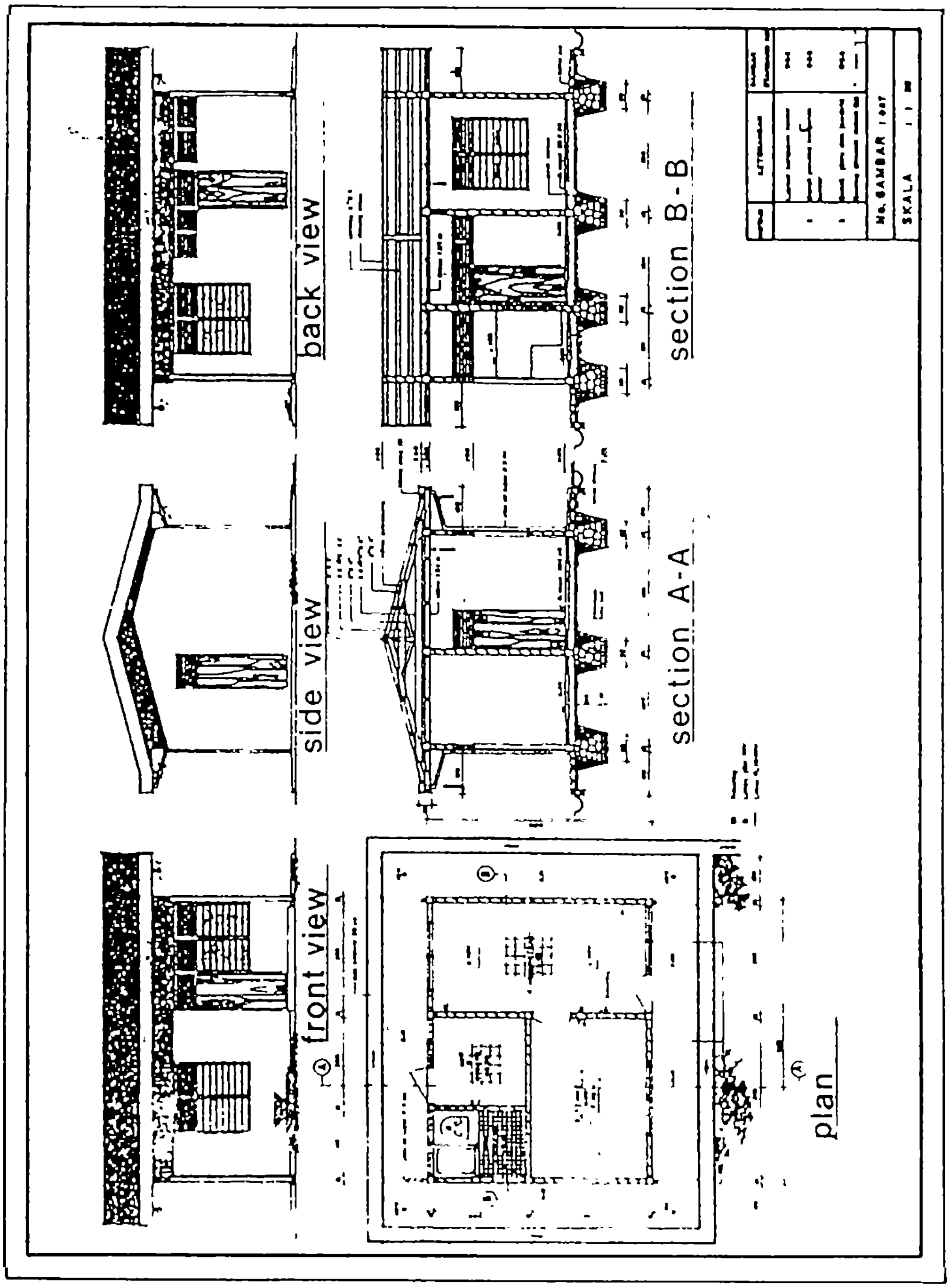
vertical 1:200

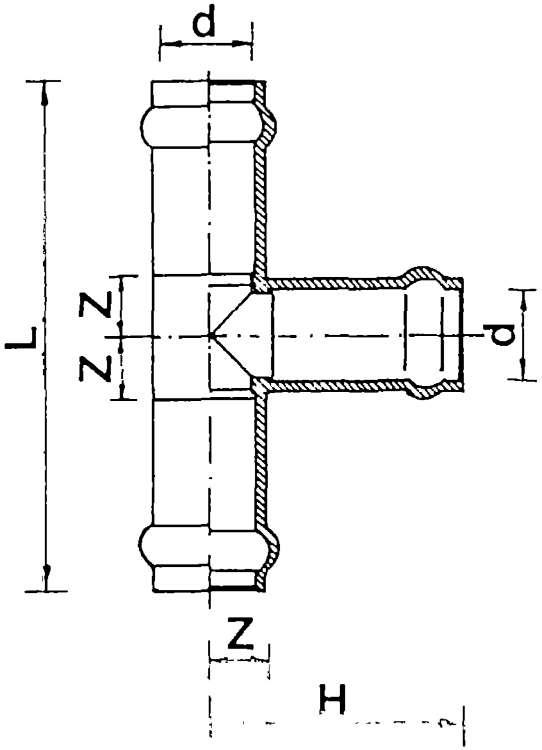
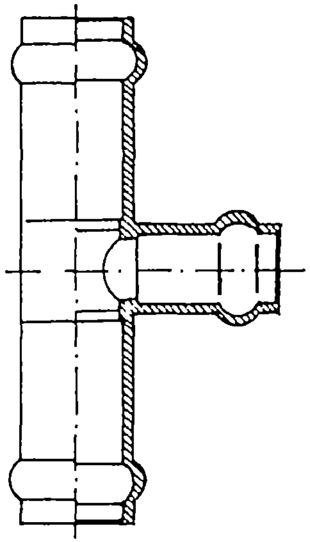
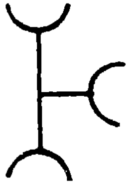
Comprehensive plan - scale 1:5000 - format A0

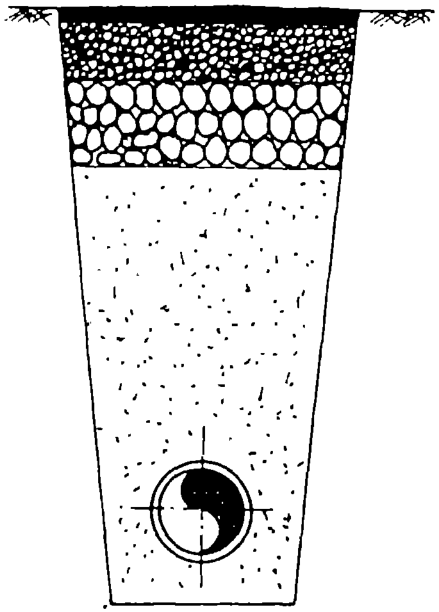


Sectional plan - scale 1:1000 - format A1

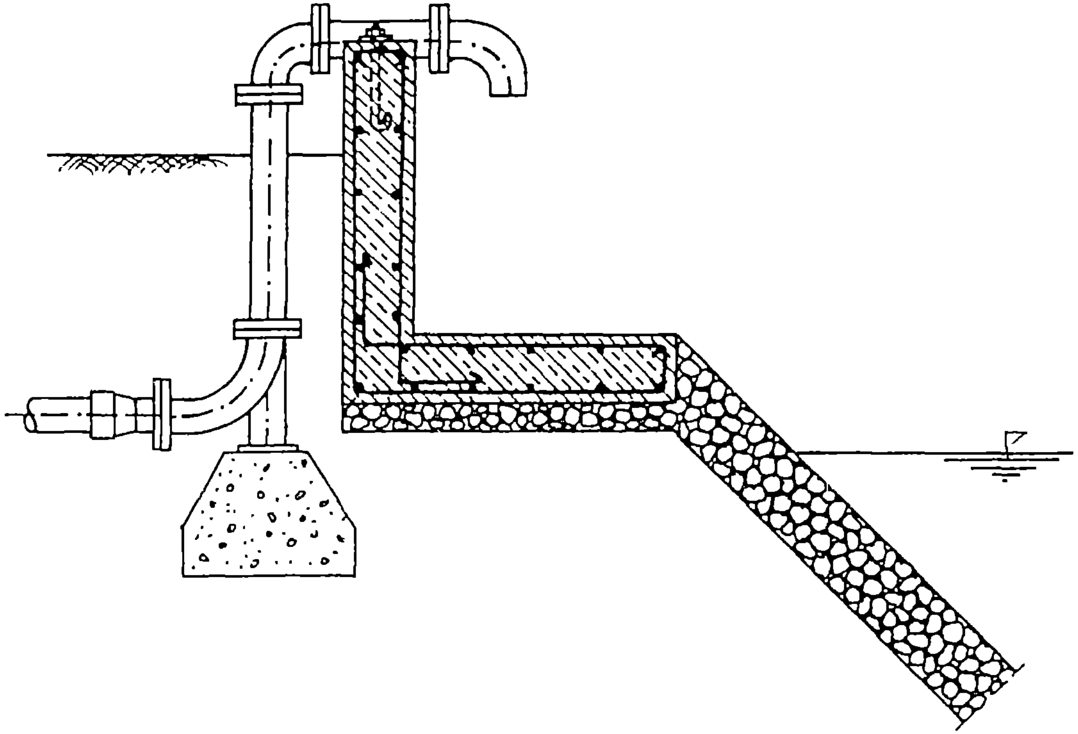



back view
side view
front view
section B-B
section A-A
plan

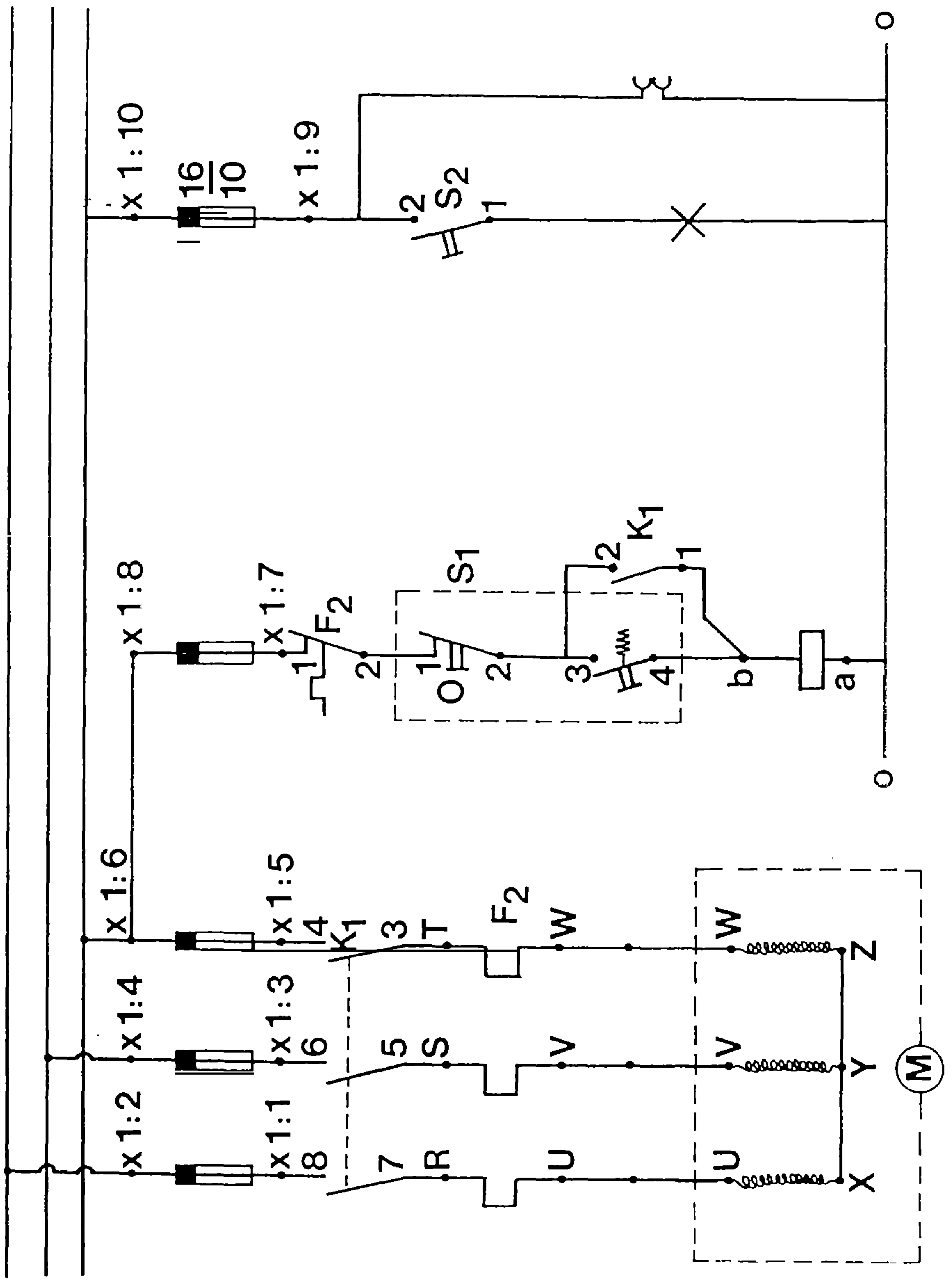
Description	Illustration	Symbol
Tee, with rubber ring joints	 Equal dia.  Reducing dia.	



Excavation and backfill mains



Wash out


x 1:10
16/10
x 1:9
2
S2
1
o
x 1:8
x 1:7
F2
1
2
S1
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K1
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a
o
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x 1:5
x 1:4
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x 1:2
x 1:1
4
K1
3
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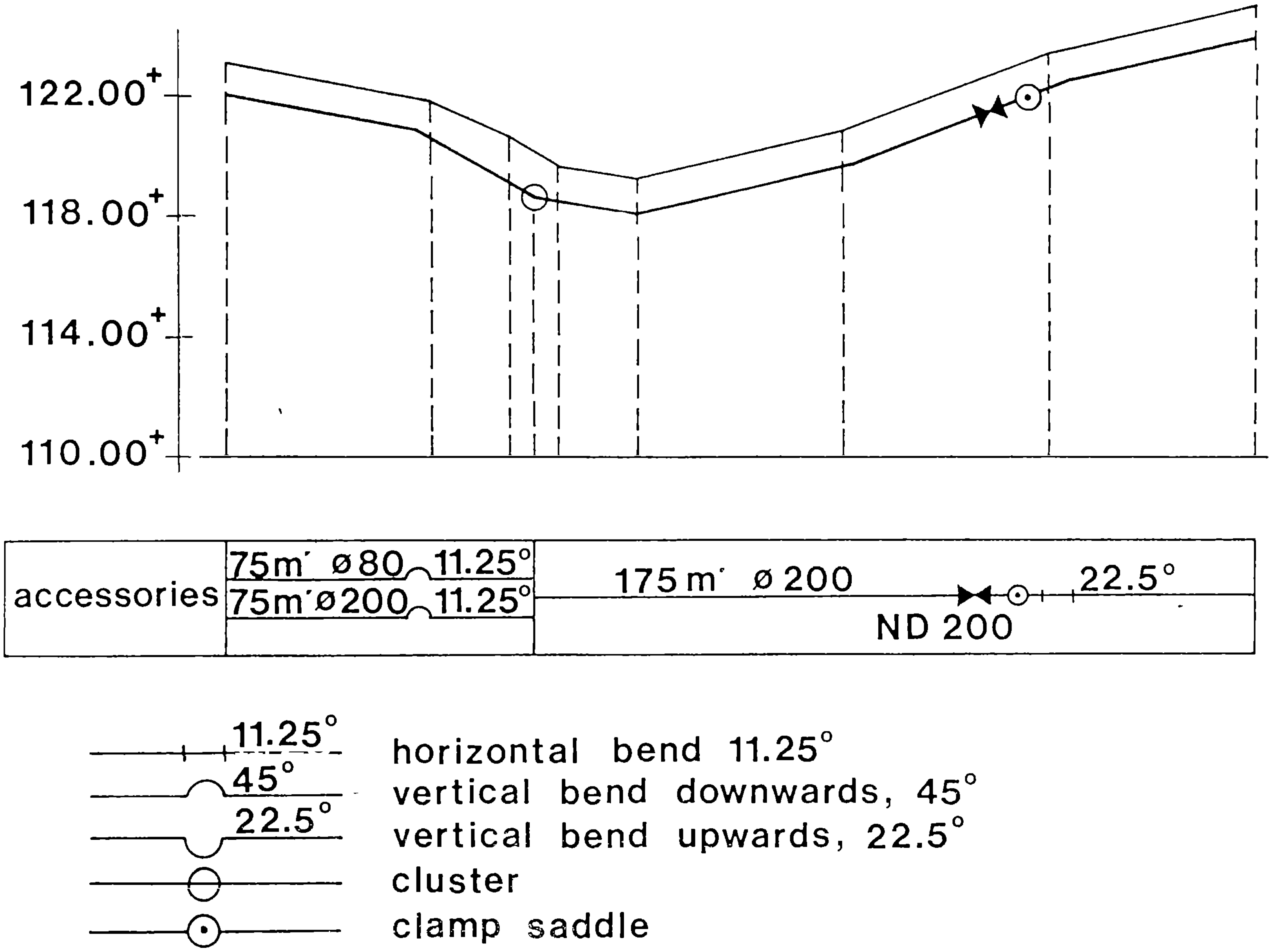
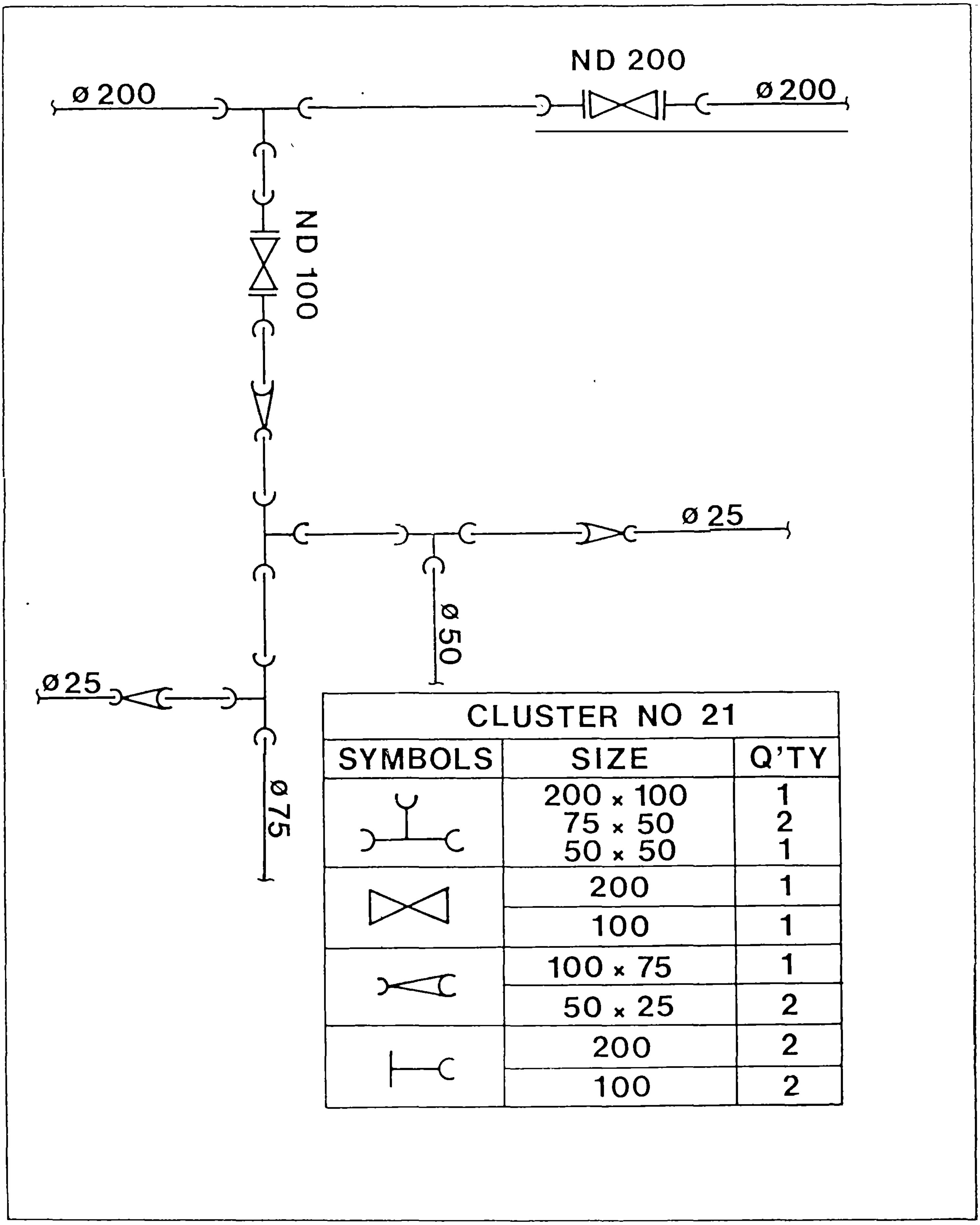
6
5
S
8
7
R
F2
W
V
U
W
V
U
Z
Y
X
M

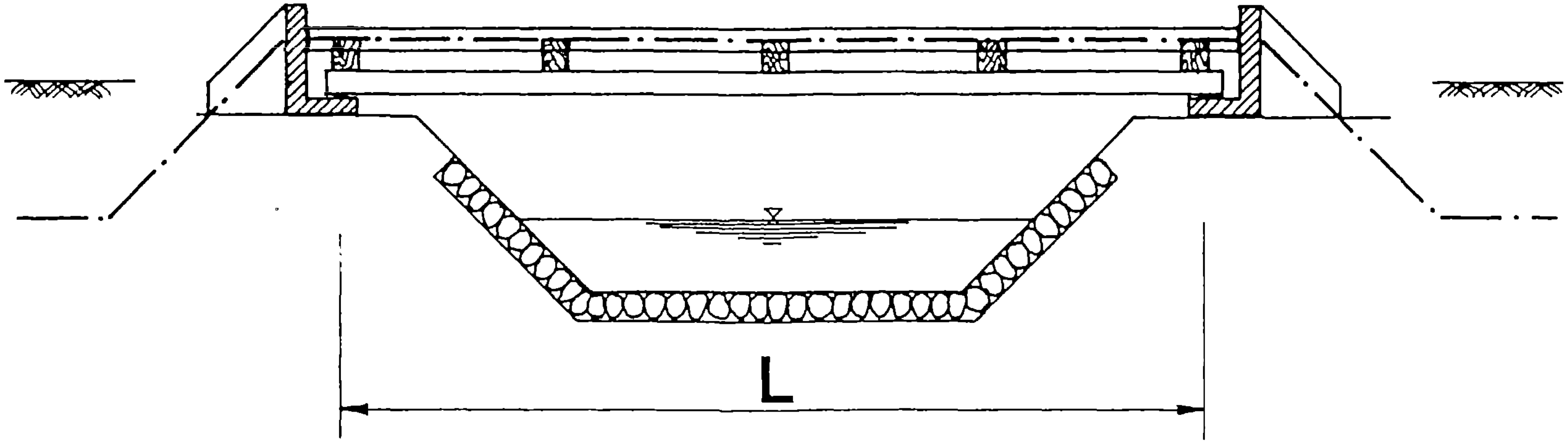
Longitudinal profile





CLUSTER NO 21		
SYMBOLS	SIZE	Q'TY
┴	200 × 100 75 × 50 50 × 50	1 2 1
⋈	200	1
	100	1
◁	100 × 75	1
	50 × 25	2
⊢	200	2
	100	2

Standard drawing pipe bridge



L (m)	supporting structure for mains up to ø 250 mm	mains ø 300 and ø 400
0 – 5	no support required	....
5 – 10	2 ×][NP 200	....
10 – 14	2 ×][NP 240	....

Module : CONCRETE TECHNOLOGY	Code : TBG 512 Edition : 14-03-1985
Section I : INFORMATION SHEET	Page : 01 of 01/21

Duration : 135 minutes.

Training objectives : At the end of the session the trainees will be able to :
- define the concrete mixture;
- state how to store concrete;
- state how to sample and sieve aggregates;
- state how to determine the most suitable water content of the concrete;
- state how to mix and place concrete.

Trainee selection :
- Head of Section Planning & Supervision;
- Head of Sub-section Supervision;
- Construction Supervisor.

Training aids :
- Cement;
- Sand;
- Chipping;
- Tools;
- Water;
- Viewfoils : TBG 512/V 1-8;
- Handout : TBG 512/H1.

Special features : -

Keywords : Concrete technology / storing cement / concrete aggregates / sampling sand & aggregate / water-cement ratio / formwork / reinforcement / mixing concrete / placing concrete / curing concrete.

Module : CONCRETE TECHNOLOGY	Code : TBG 512 Edition : 14-03-1985
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1. Introduction

- Concrete is a mixture of :
  - . Sand
  - . Cement
  - . Gravel
  - . Water.

Show V 1 (a-e)

- For taking up tensile stresses reinforcement is used.

Show V 2 (a-c)

2. Bonding and hardening

- The bonding process can be divided in :
  - . initial bonding;
  - . actual bonding.

2. Storage of cement

- Cement is normally :
  - . supplied in bags;
  - . stored in a dry clean room;
  - . stacked.

Show V 3

4. Impurities in concrete

- Impurities reduce the strength of concrete.

- Impurities reduce :
  - . hardness
  - . compactness.

- Salt water is a major problem.

5. Aggregates

- There are two groups of aggregates :
  - . fine
  - . coarse.

6. Sieving

- Sand should be sieved to achieve correct grain size for concrete.

7. Sampling sand and aggregate

- Samples taken of sand from :
  . top
  . centre
  . bottom.
  of heap (approximately 50 litres).

Show V 4 (a-c)

- Aggregate samples taken from :
  . top
  . centre
  . bottom
  of heap (approximately 100 litres).

- Check grain size.

8. Formwork

- Formwork is temporary.
- Determines final shape of construction.
- Must be clean and secure.

Show V 5 (a-b)

9. Reinforcement

- Reinforcement rods must be cut and bent according to plans.

Show V 6 (a-d)

- Must be free of dirt and corrosion.
- Must be placed correctly according to plans, using spacers to guarantee sufficient cover.

Show V 7 (a-b)

10. Mixing

- Concrete can be mixed.
  . manually
  . mechanically

- Correct ratios must be used.

- Correct mixing time is important.

Show V 8

10. **Placing concrete**

    - Concrete is placed in layers.
    - Each layer should be rammed or vibrated to remove air.
    - Final surfaces should be tamped.

12. **Curing concrete**

    - Concrete should be kept damp by spraying surface with water.
    - Leave for 1 week after placing.

13. **Summary**

Give H 1

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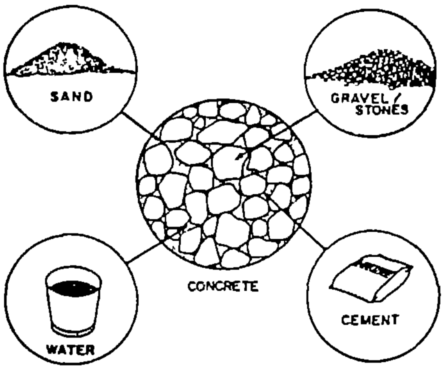
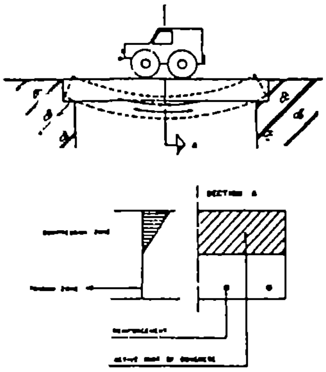
Section 3 : TRAINING AIDS	Page : 01 of 02

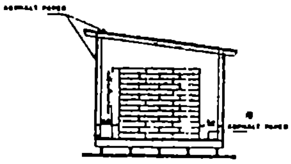
Concrete mixture TBG 512/V 1 (a-c)



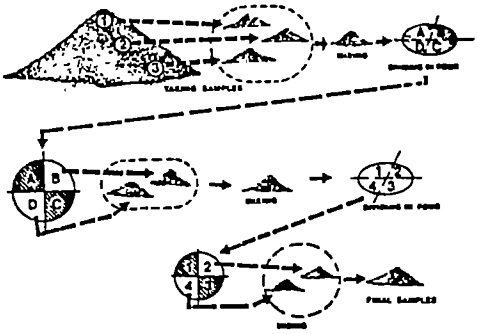
Forces in concrete TBG 512/V 2 (a-c)



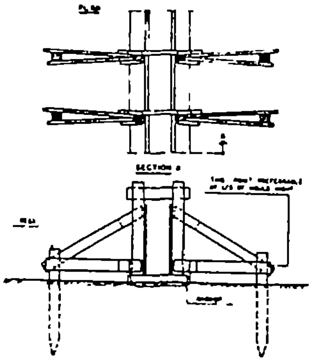
Cement store TBG 512/V 3



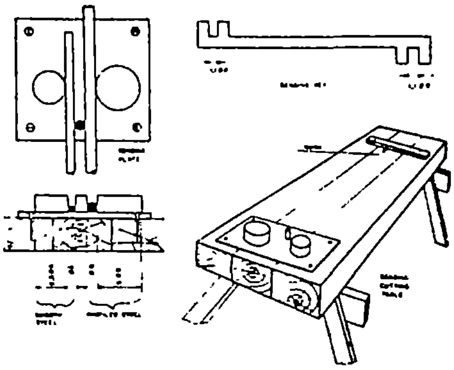
Making aggregate sand samples TBG 512/V 4 (a-c)



Formwork for wall TBG 512/V5 (a-b)



Bending tools for reinforcement TBG 512/V6 (a-d)



Module : CONCRETE TECHNOLOGY

Code : TBG 512

Edition : 14-03-1985

Section 3 : TRAINING AIDS

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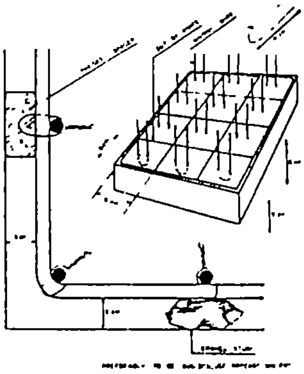
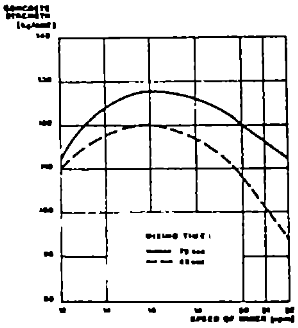
Spacers for reinforcement TBG 512/V 7 (a-b)



Effect of mixing time TBG 512/V 8



Concrete technology TBG 512/H 1

Module : **CONCRETE TECHNOLOGY**	Code : TBG 512
	Edition : 14-03-1985
Section 4 : **HANDOUT**	Page : 01 of 15

1. DEFINITIONS

Concrete is a mixture consisting of :

- Cement
- Sand
- Gravel and stones (split stones)
- Water (See Fig. 1).

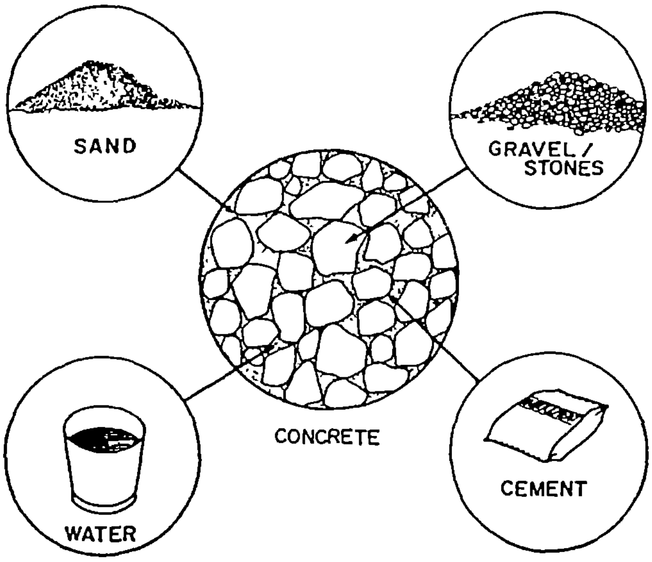


Fig. 1. Concrete mixture

These materials are mixed at a specific ratio until they are really even, composite and homogeneous.
This mixture will then harden like rock (dry up and become hard as rock).

Explanation : Cement is a bonding material that, together with sand and water, fills the holes/pores between gravel and stones, thus bonding them together.

Note :
The ratio of fine particles (sand) to larger particles (gravel and stones) is important. Ideally there should be just enough fine particles to fill the gaps between the large particles, if a good strong concrete is to be obtained.

Concrete has proven to be very strong in resisting pressure. However, concrete is unable to resist tensile stresses.
If a concrete structure will be exposed to tensile stresses at the point where load is applied, we have to provide some reinforcement (for example in the form of beams/bars of iron/steel) so that the concrete and reinforcement can really stick together strongly and can withstand the forces or load acting on the construction. This combination of concrete and reinforcing materials is called reinforced concrete (See Fig. 2).

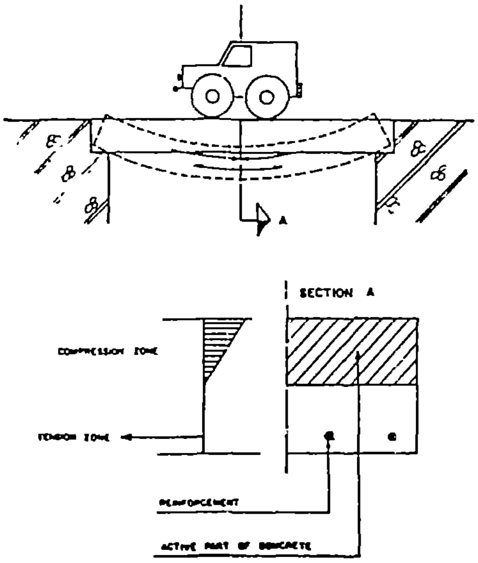


Fig. 2. Forces in concrete

Thus : Reinforced concrete is concrete which contains steel bars. Both materials work together in taking up the forces caused by the load acting on it.

2. BONDING & HARDENING

If cement is mixed with water, after some time the mixture will become viscous (bonding) and then harden.
The bonding process can be divided into 2 parts :

- Initial bonding

  - The time required from the start of mixing cement and water until the moment the mixture become viscous.

- Actual bonding
  - . The time required, starting when the mixture becomes viscous, until the moment the mixture becomes solid.

3. STORING CEMENT

In concrete construction there must be facilities for storing the cement. This store must be made strong, and the floor, roof and walls must be waterproof and wind (air) proof.

There is no need for windows; a dark room is even better for storing the cement (See Fig. below).

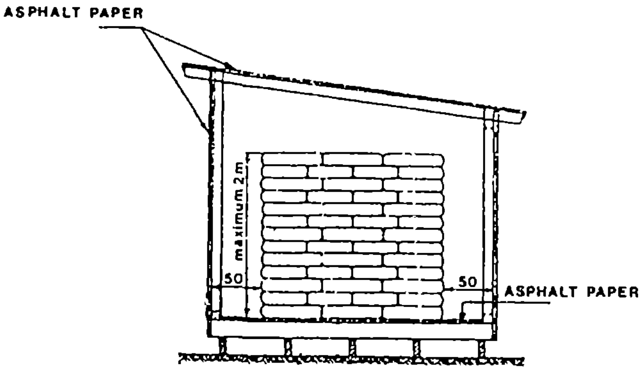


Fig. 3. Cement store

The external walls should be coated with asphalt (bitumen) paper to help keeping out water and dampness. The floor of the warehouse must be at least 30 cm above the ground. The floor of the warehouse should also be coated with asphalt paper.
The floor must be strong, because cement sacks piled as high as 2 m will cause a pressure of 2500 kg/m^2 on the floor.

These cement sacks must not be arranged so as to stick against the walls. A 50 cm distance must be allowed to prevent the transfer of dampness from the walls to the cement.

Note : The cement piles must not be higher than 2 m. This is to prevent the cement sacks from bursting and to prevent the cement from solidifying and forming into hard clusters. If inside the cement mixture there appear small clusters of cement, and these clusters can be broken by hand, the cement can still be used.

4. EFFECT OF IMPURITIES

In a concrete mixture there may not be any impurities.
Impurities will cause :
- a reduction in compactness and hardness of the concrete;
- possible damage to the cement and the steel reinforcement;
- a reduction of the useful life of the concrete structure.

Frequently observed impurities (which cause much trouble) are clay and mud. Furthermore, if the dirt (impurities) stick to the gravel or stones of the concrete mixture, they will prevent the bonding of sand, gravel and split stones. In that case the compactness of the concrete will deteriorate.

Other impurities

- Plant residuals reduce the compactness and hardness of the concrete.

- Various acids, salts and gypsum found in the gravel or stones will damage the concrete. Sea sand contains high concentrations of salts and should not be used.

5. GRAIN SIZES

The roughness, fineness and proportion of sand grains, gravel and split stones have a very great effect on :
- the use of the mixture;
- the compactness and hardness of the concrete.

Two groups of concrete aggregates are distinguished :

A. FINE AGGREGATES

- Sands and fine gravel.
- Materials to be used as fine aggregate should meet the following specification :
  - . 98% (by dry weight) must pass a 4 mm sieve;
  - . 90% (by dry weight) must pass a 1 mm sieve;
  - . 80% (by dry weight) must pass a 0.5 mm sieve.

B. COARSE AGGREGATES

- Large gravel and split stones.
- Material for coarse aggregate should be hard, non-porous, non-degradable.
- The maximum size of stone allowed is determined as follows :
  either (a) 1/5 of the smallest dimension of the shape being cast,
  or (b) 3/4 of the space between any reinforcing bars,
  whichever of (a) and (b) is smaller.

For most concrete mixes the specified proportions (by volume) of cement, fine aggregate and coarse aggregate are as follows

	1	:	2	:	3
	cement		fine aggregate		coarse aggregate
or	1	:	1 1/2	:	2 1/2
	cement		fine aggregate		coarse aggregate

6. **SIEVING**

To obtain a general picture of the roughness and fineness of the sand grains and/or gravel to be used, checks are carried out by sieving the materials, using various sieves with different sizes of holes.

These sieves are assembled as a combined unit, arranged one on top of the other, with adequate distances in between. The sieve with the largest holes is placed at the top and they are gradually getting finer, so that the finest sieve is placed at the bottom. In this way the fine sieves will not be damaged by rough materials.
The sieves are operated either manually or mechanically.
The roughness or fineness of the sieves can be determined by stating the size of the holes in mm.
In Indonesia the following sizes of sieves are known : 0.15 mm; 0.30 mm; 0.60 mm; 1.20 mm; 4.80 mm; 9.60 mm; 19 mm; and 38 mm.

7. SAMPLING SAND AND AGGREGATE

To take sand and aggregate samples for sieving, a small heap of sand or aggregate (gravel) must be taken.
Equal parts must be taken from the top of the heap of the sand (or gravel), from the middle part and from the bottom part. This is necessary as the rough/large grains tend to collect at the bottom. The total volume must be approximately 50 litres in case of sand, and approximately 100 litres in case of gravel and other coarse aggregates.
The total sample must be mixed evenly.

Each sample is then put on a platform base and arranged in the shape of a circle with uniform thickness. Reducing the volume of the sample is accomplished as follows :

- The sample is divided in four equal parts : A, B, C, D;
- Parts A and C are returned to the heap;
- The remaining B and D are formed into a full circle, and the procedure is repeated
- If necessary this can be repeated until a volume is obtained that is considered adequate.

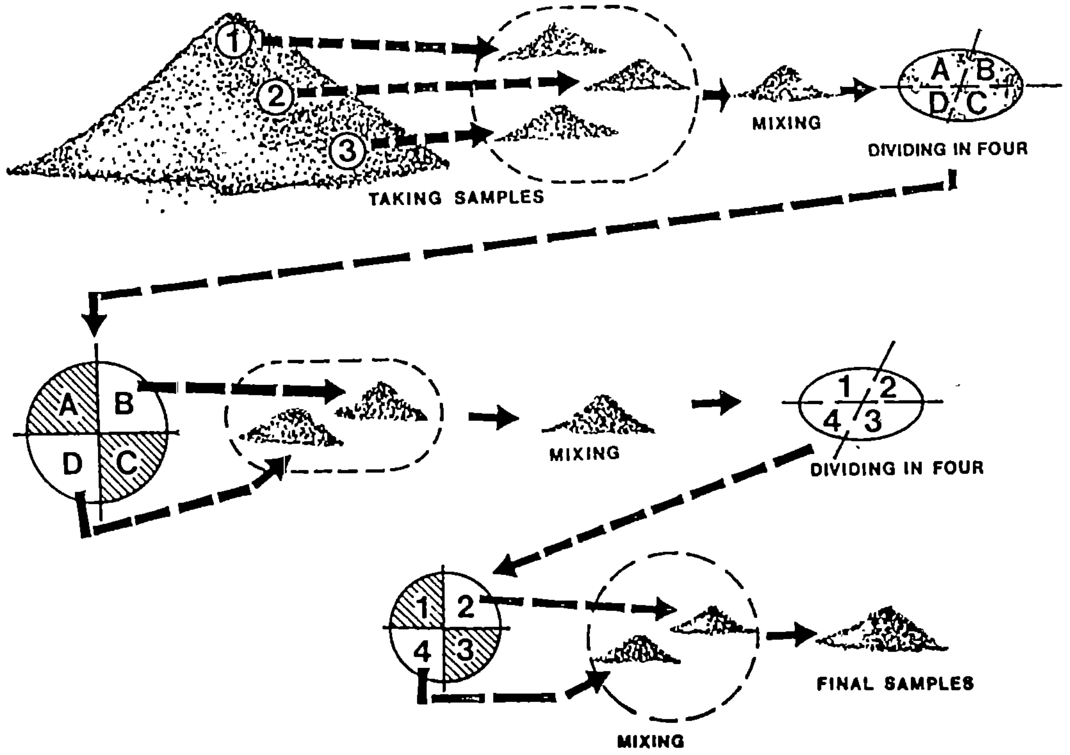


Fig. 4. Taking aggregate/sand samples

8. MEASURING - OUT MATERIALS

When the sand and aggregate have been sampled and are found to be of acceptable grain sizes, they must be mixed in correct proportions with the cement.
This is a most important step, as any errors at this stage can seriously effect the quality of the concrete.
The basis for measurement is the bag of cement.
Remember, the specification is for 1 : 2 : 3 or 1 : 1 1/2 : 2 1/2 proportions (by volume) of cement, fine aggregate, coarse aggregate.
Either :

- suitable containers can be used, which are calibrated to contain the correct volumes of fine and coarse aggregate per bag of cement,

or :

- the volumes can be converted into ratios of weight, and the subsequent measurement carried out using a weighing machine. (But care must be taken to allow for the weight of any water contained in the aggregates).

When all materials have been measured out in correct proportions they are ready to receive the final ingredient - water.

9. WATER

The water used for the concrete mixture must be pure, clean and fresh, which means that the water must not contain any mud, sludge, acid, salt, sulphate, plant residuals and other dirt (impurities) that can damage the concrete.

10. WATER CONTENT

Water is not only necessary for the hardening process of the concrete, but it is also useful for softening the concrete mixture for easy use when it is still in the "porridge" condition.
For the hardening requirements a water-cement ratio of approximately 1 : 3 is needed.
However, if we only use that much water we have to apply pressure when casting.
Therefore, a somewhat higher water-cement ratio (approximately 1 : 2) is normally used, to ensure that the concrete can be handled without difficulty during the placing/casting stage.

Concrete can be classified according to its water content, as follows

a. Damp concrete : only a little amount of water is used for the mixture;
b. Plastic concrete : a fair amount of water is used for the mixture;
c. Soft concrete : a lot of water is used for the mixture.

Explanation :

a. Damp concrete contains only enough water for hardening (It can be formed into a ball, by hand). It is often used in concrete-producing industries. There the concrete is cast in different shapes, with thicknesses of 10-15 cm.
The castings can be made by hand and also by pneumatic pressure. Concrete produced by such an industry is called precast concrete. If we are working with a large mass of concrete, or also on road constructions, puddled concrete is used, in which a little bit more water is used than in damp concrete.
However, this puddled concrete is not suitable for reinforced concrete constructions because of cracks/gaps between the concrete and the reinforcement. The mixture is also difficult to push in between the reinforcement rods.

b. Plastic concrete is used to overcome the difficulties mentioned above.
This plastic concrete is like a viscous "porridge".
Although more water is used here than in damp concrete, the addition of water must follow a certain rule.
If too much water is used, the concrete will be of poor quality, losing much of its strength. The heavier particles will separate from the mixture during placing, much cement runs out with the excess water through joints in the formwork and the concrete will shrink considerably (and probably crack) during the curing process.

c. Measuring the amount of water for the mixture can be done in 2 ways :
   (a) In litres for every m^3 of concrete, or the percentage of the weight of water with respect to the total weight of dry elements in the concrete mixture (cement + aggregates).
   When using the latter method of measurement :
   - damp concrete contains 6% - 8% of water;
   - plastic concrete contains 8% - 10% of water.

   (b) A better way is to use the comparison factor of cement to water, abbreviated as : W.
   Definition :

$$W = \frac{\text{Weight of water used in the mixture}}{\text{Weight of cement used in the mixture}}$$

By using this method of measurement, we find :

- damp concrete : W = 0.40 - 0.60;
- plastic concrete : W = 0.65 - 0.75.

To determine the most suitable value of W as accurately as possible, we must bear in mind the final purpose of the concrete, and the way in which the mixture will be handled during the construction process itself.

11. FORMWORK

Formwork is the temporary construction which determines the final shape of the concrete.

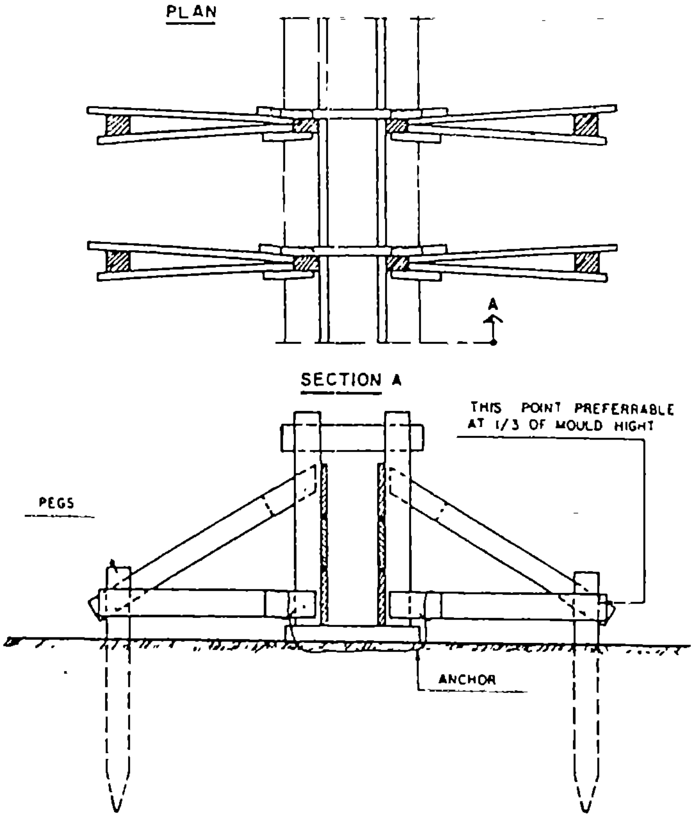


Fig. 5. Formwork for wall

It should be strong and rigid so that it does not bend or twist when the wet concrete is poured into it (remember wet concrete behaves rather like water). Usually panels of wood are satisfactory if they are sufficiently braced on the outside (see Fig. 5 on previous page).

However, the panels must also fit tightly together so that they do not allow liquid cement to leak out when the concrete is placed, as this will leave holes in the concrete.
Before concrete is placed, the formwork should be checked to ensure :
- that it is clean and does not contain loose debris which would contaminate the concrete;
- that it is fixed to the correct line and level, as shown on the drawings;
- that it is rigid enough to withstand the weight of the wet concrete without bending.
- that there are no gaps for liquid cement to leak out;
- that any reinforcement fixed within the formwork will have sufficient covering when the concrete is placed (see Fig 7).

It is common practice to coat the inside of the formwork with a thin layer of oil so that it can be more easily removed when the concrete has hardened.
This oil should not contaminate the reinforcement.

12. REINFORCEMENT

- Reinforcement rods must be cut and bent according to the plan design.
- Reinforcement rods must be free of dirt, fat, rust and other materials that tend to reduce the adhesive power;
- Reinforcement that has been exposed to the open air is usually very rusty;
- The rust can be removed by hitting the rod, or by brushing it with a wire brush.

Permanent rust (not "loose" rust) is actually not that bad, because the cement can chemically eliminate the rust; furthermore the adhesive strength increases. However, if this permanent rust is very thick, this will decrease the effective diameter of the rod and also cause it to become brittle (so that it can break easily).

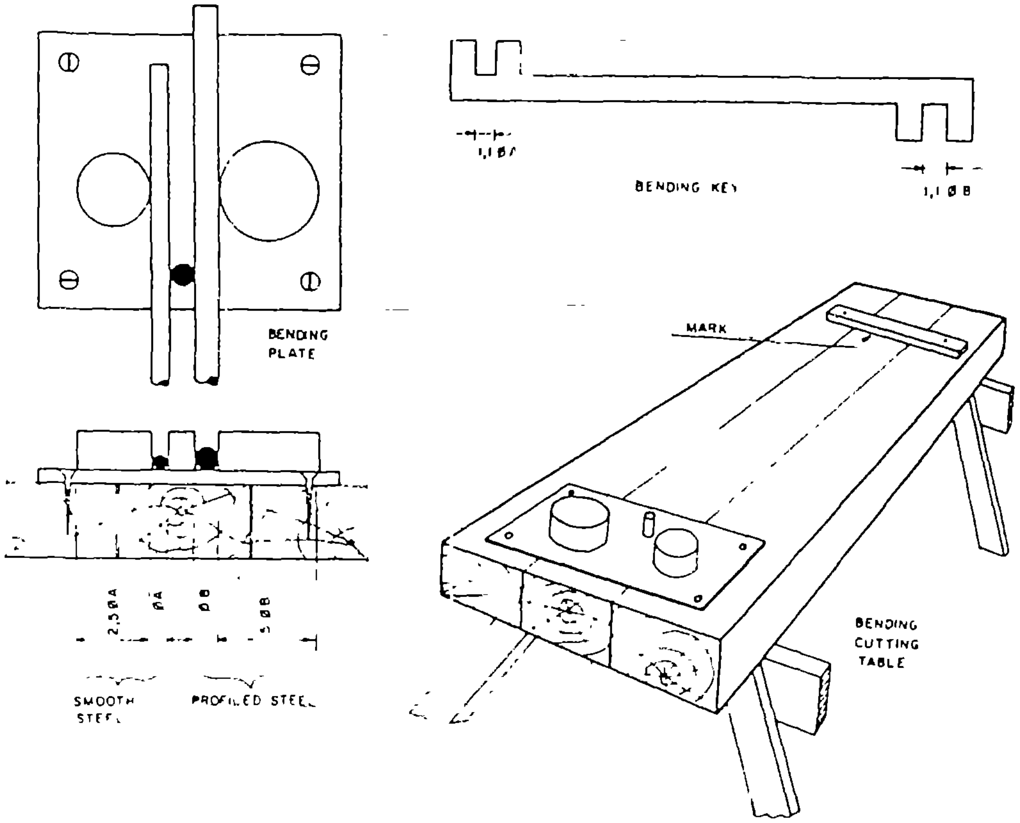


Fig. 6. Bending tools

It is important that reinforcement is sufficiently protected by the concrete against further corrosion, as this would also lead to cracking of the concrete. Therefore, no reinforcement should be closer than approx. 4 cm from an outside surface. This is accomplished by using so-called spacers (See Fig. 7 below).

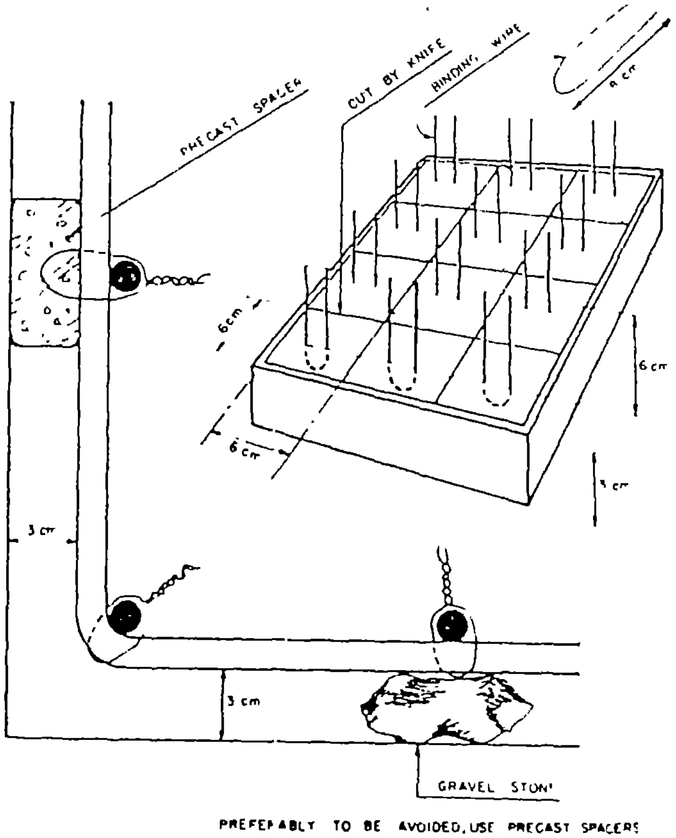


Fig. 7. Spacers for reinforcement

13. MIXING CONCRETE

Mixing of concrete can be done manually, or mechanically by using a "mixer". Mixing the concrete mechanically is far more advantageous because the strength/compactness increases by 20% to 30% due to the fact that the elements are more evenly mixed.

We cannot always use a mixer, however. When the mechanical mixer has broken down, for instance, the mixing must be done by hand.

The location of the mixing container must be chosen so that it is :
- not too far from the place where the concrete is cast;
- not too far from the place where the aggregate materials are stored.

a. Mixing by hand

If mixing is done by hand, it must be done at a place where the floor is hard and does not absorb water.
This is necessary in order that no dirt or soil (earth) is mixed in and no water is lost or being absorbed. If a large amount of concrete is required, it would be better if mixing is done under a roof, so that the mixture is protected from the heat of the sun and from rain.
The first thing which must be done is to pour the cement (be careful not to let too much cement get blown away by the wind). Then mix the sand and cement as well as possible using a spade (if necessary this is done by two people) until the whole mixture has a uniform colour. After that pour in the gravel, then pour in the water, and mix continuously. Half the total volume of water is poured into the mixture first, and the same amount later again. The mixing is continued until a type of homogeneous "porridge" is obtained.

b. Mixing using a machine

The capacity of the mixer drum is the volume of the dry material which can be contained by the drum during each filling. Typical drum capacities are:
50 litres, 150 litres, 250 litres, 375 litres, 500 litres and 1000 litres.

Although the capacity of the drum, expressed as volume of dry material, is as mentioned above, its actual volume is approx. 3 times larger to ensure a mixture that is as homogeneous as possible. The mixing time is at least 1 minute, and often 2 minutes.

A mixing time which is too long gives a bad uniformity of the mixture and reduces the compactness and hardness of the concrete. Although the speed (rpm) of the mixer can be adjusted, the manufacturer always gives recommendations for the optimum speed for mixing concrete.

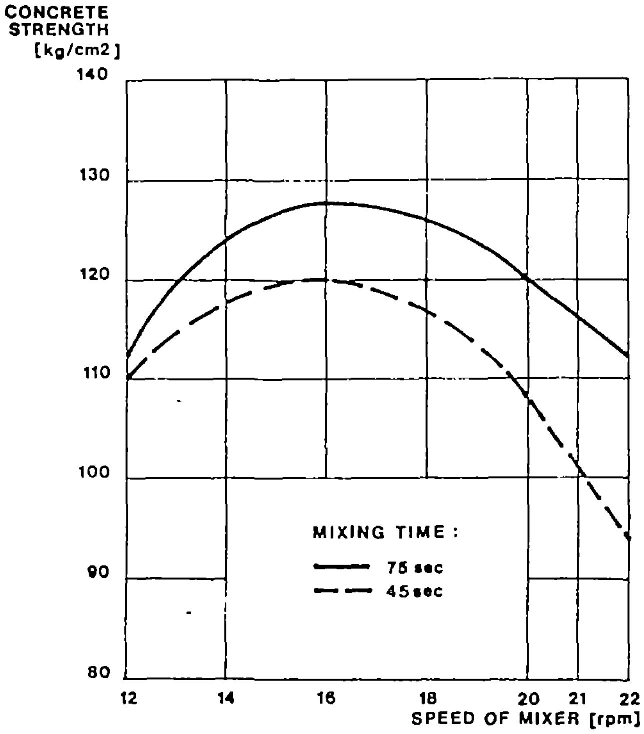


Fig. 8. Effect of mixing time

From the graph, it can be seen that a speed that deviates from the manufacturer's instructions results in a reduction in concrete strength. At very high speeds, the mixture will stick to the walls of the container (due to the large centrifugal force) so that it cannot "fall freely" and will no longer be really mixed.

14. PLACING CONCRETE

This is a most important step in the process.
First, the formwork and reinforcement must be checked as described in sections 11 and 12. Then, if concrete is to be cast against an exisiting concrete surface, that surface should be roughened to enable a good bond. The surface should then be thoroughly moistened with water just before the new concrete is placed, so that it does not adsorb too much water from the new concrete.

The concrete should be placed carefully in layers (not dropped from a great height). Each layer should be rammed with a blunt rod or vibrated with a mechanical vibrator to compact it and to ensure that there are no bubbles of air trapped within it, and it completely fills the gaps between the reinforcing bars. When all concrete has been placed, any exposed (final) surfaces should be smoothed with a wooden float. The concrete should then be covered, to protect it from sunlight, which would cause it to dry too rapidly and would result in cracking.

15. CURING CONCRETE

During the period that the concrete is setting and hardening, it is said to be "curing". During this time all exposed surfaces should be covered up and kept damp by spraying with water.
Usually it is necessary to continue moistening the concrete surfaces for at least 1 week after the concrete has been cast.

During the rainy season, concrete which has not yet hardened, must be protected from heavy rain.

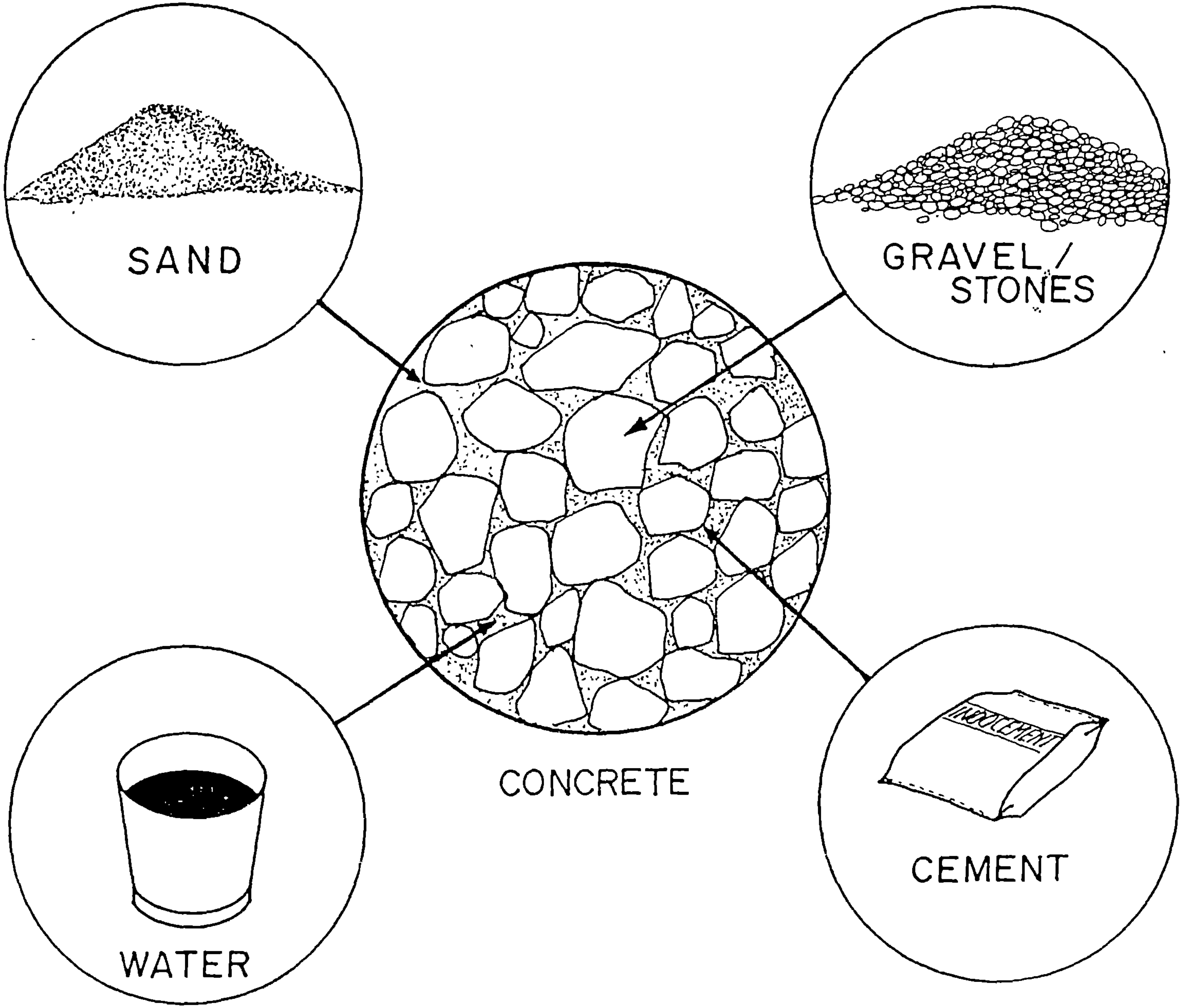
16. SUMMARY

- If a concrete structure is exposed to tensile stresses, reinforcement has to be applied.
- Cement must be stored dry and in stacks up to 2 m.
- Impurities reduce hardness and compactness of concrete.
- There are fine and coarse aggregates.
- Aggregates, sand and cement should be measured and mixed in the correct proportions.
- The water content and mixing time also determine the compactness and hardness of concrete.
- Concrete should be placed in layers.

* * *

Module : CONCRETE TECHNOLOGY	Code : TBG 512
	Edition : 14-03-1985
Annex : VIEWFOILS	Page : 01 of 09

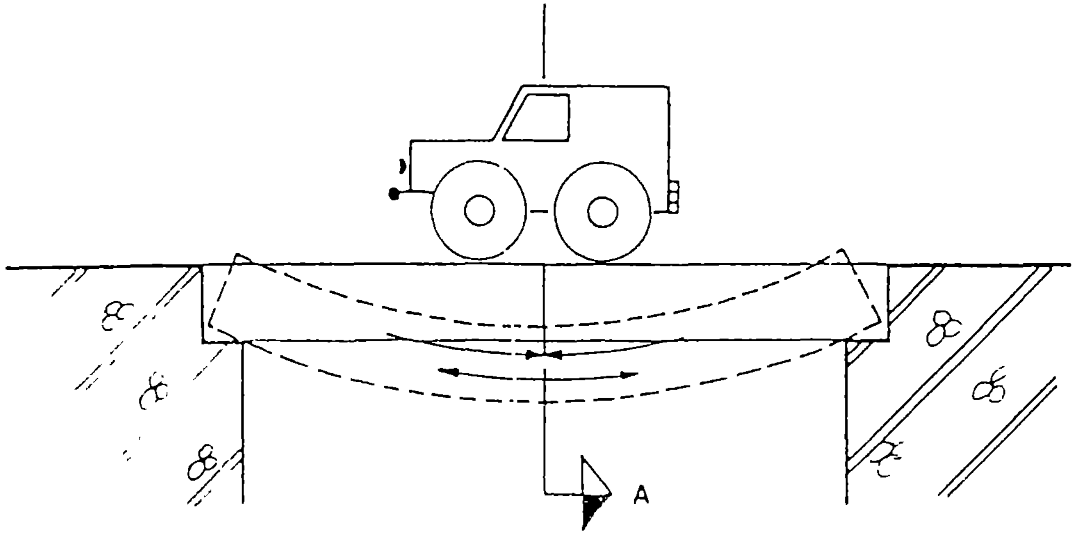
TITLE :	CODE :
1. Concrete mixture	TBG 512/V 1 (a-e)
2. Forces in concrete	TBG 512 (a-c)
3. Cement store	TBG 512/V 3
4. Taking aggregate/cement samples	TBG 512/V 4 (a-c)
5. Formwork for wall	TBG 512/V 5 (a-g)
6. Bending tools for reinforcement	TBG 512/V 6 (a-d)
7. Spaces for reinforcement	TBG 512/V 7 (a-b)
8. Effect of mixing time	TBG 512/V 8

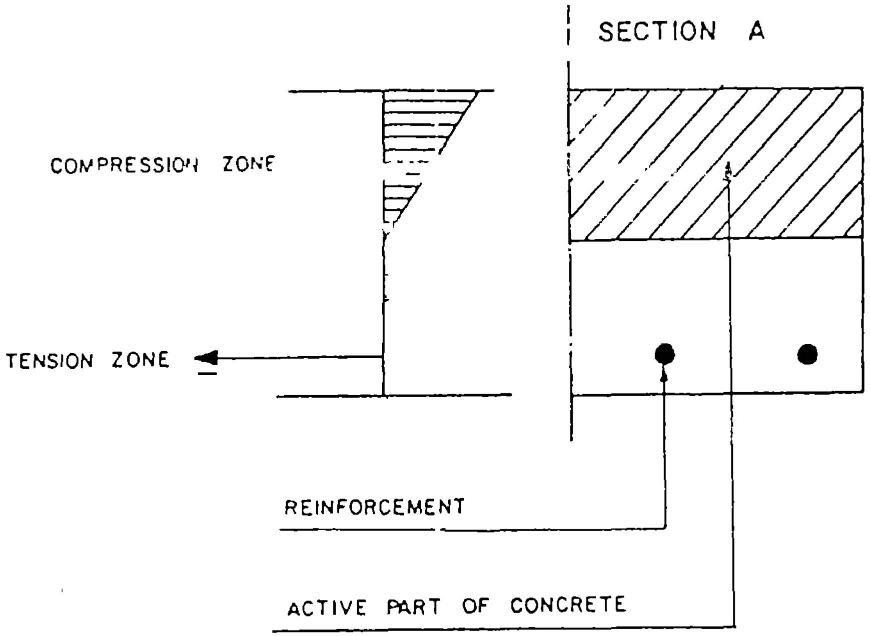


Concrete mixture

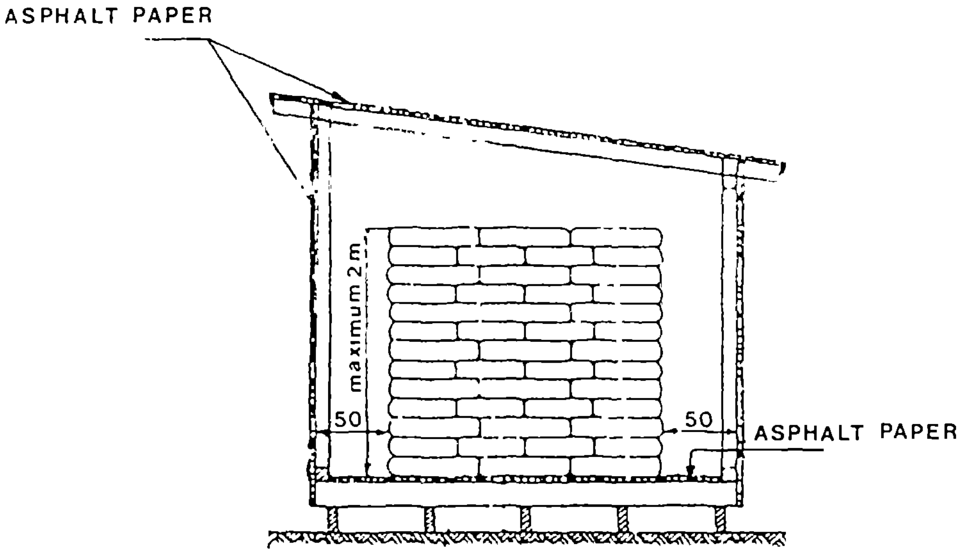
TBG 512/V 1 (a-e)

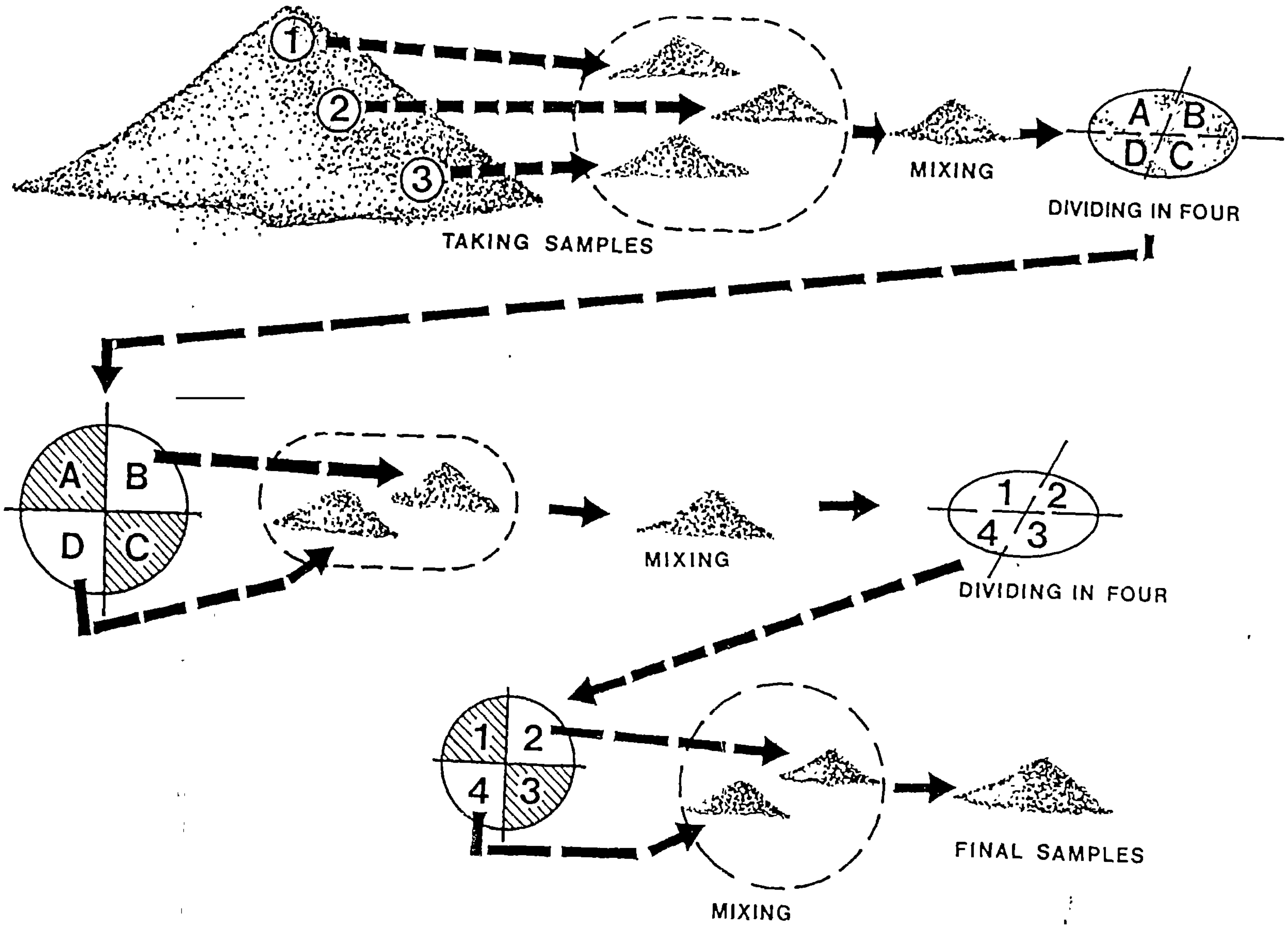
Forces in concrete



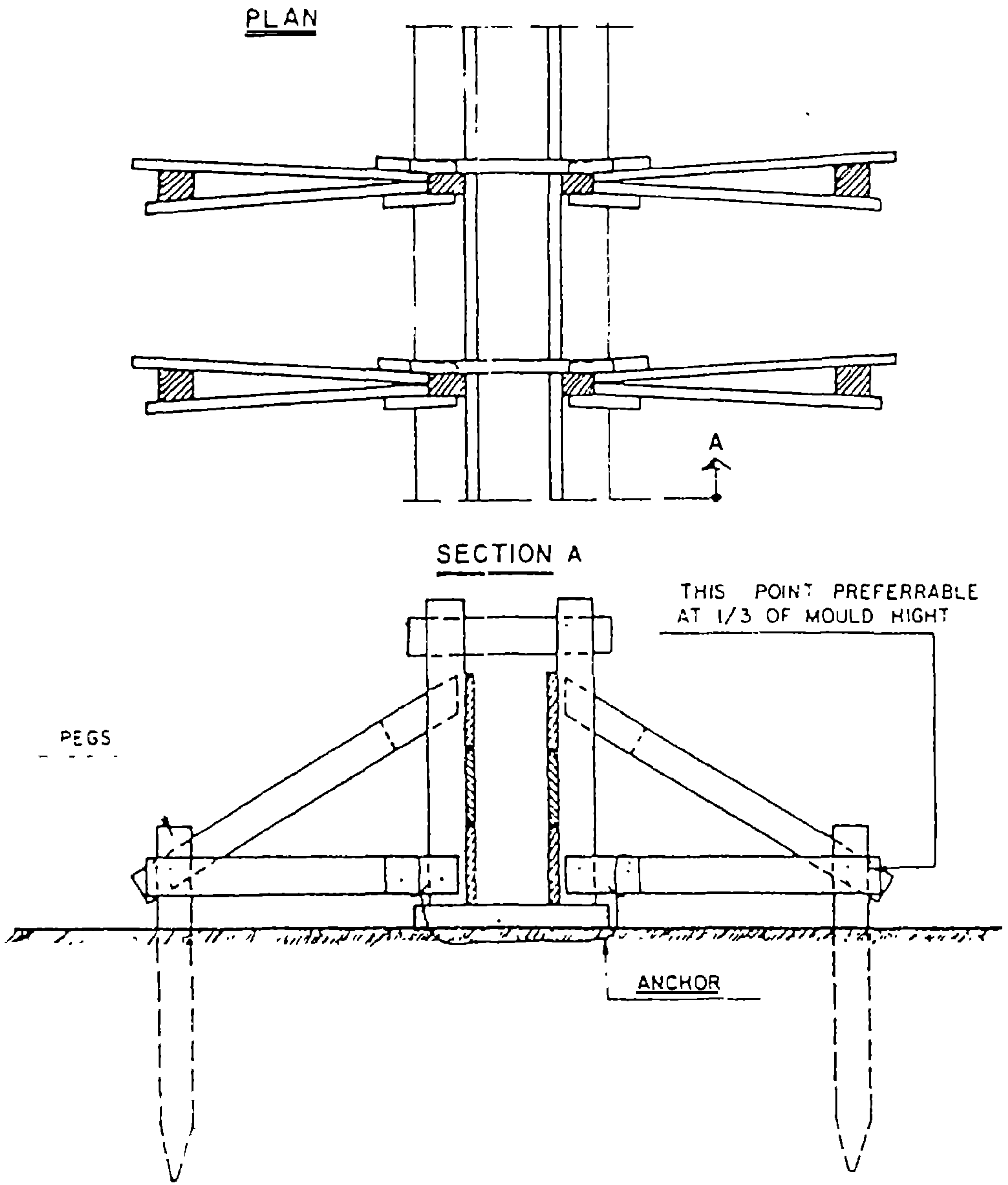


TBG 512 (a-c)


ASPHALT PAPER
maximum 2 m
50
50
ASPHALT PAPER

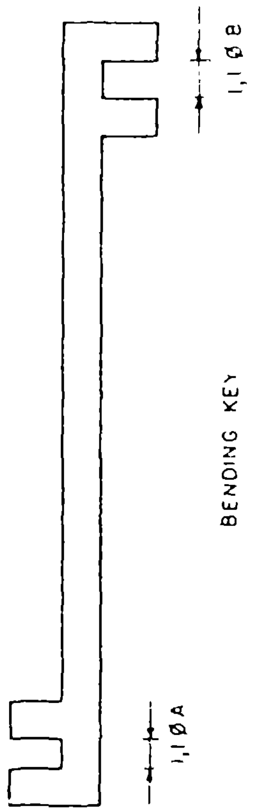


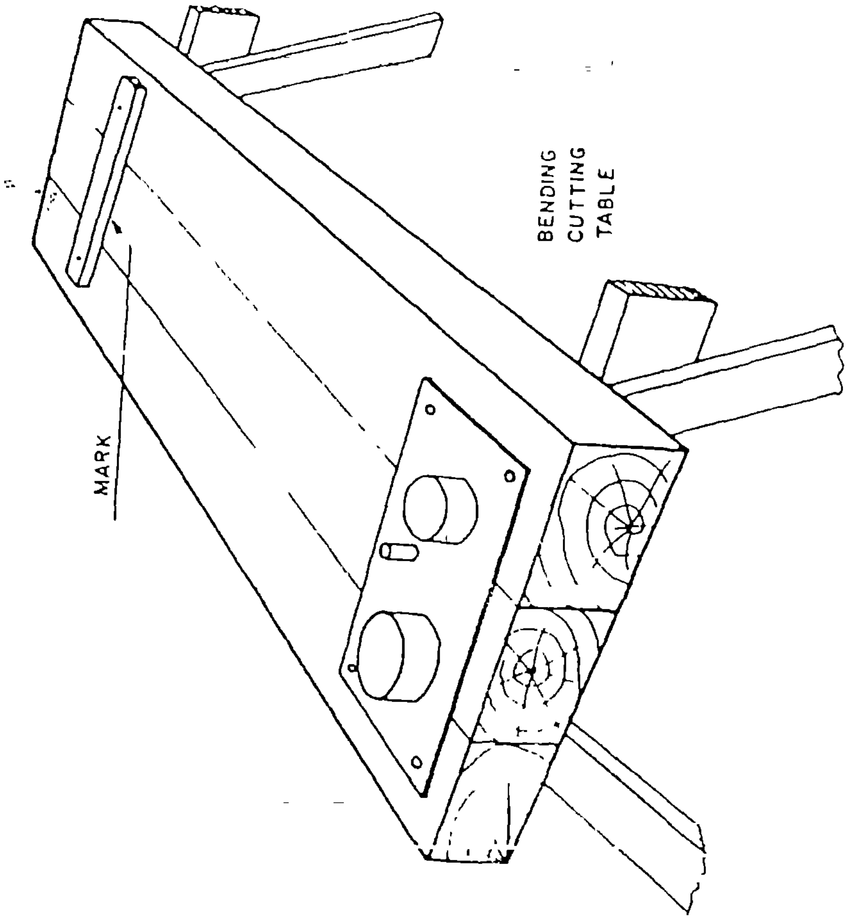
Taking aggregate/cement samples

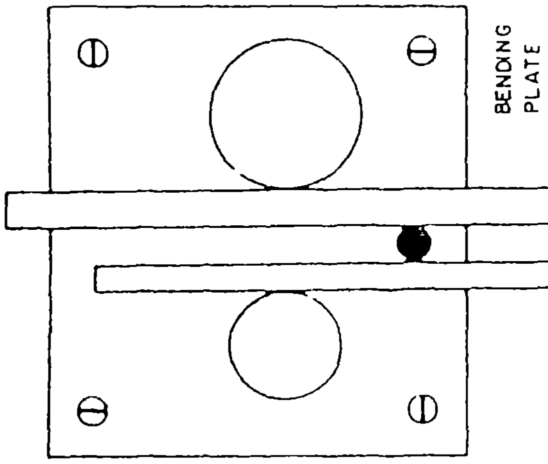


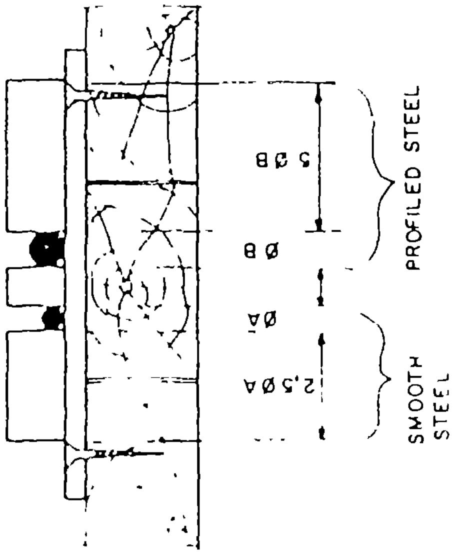
Formwork for wall

TBG 512/V 5 (a-g)


1,1 Ø B
BENDING KEY
1,1 Ø A

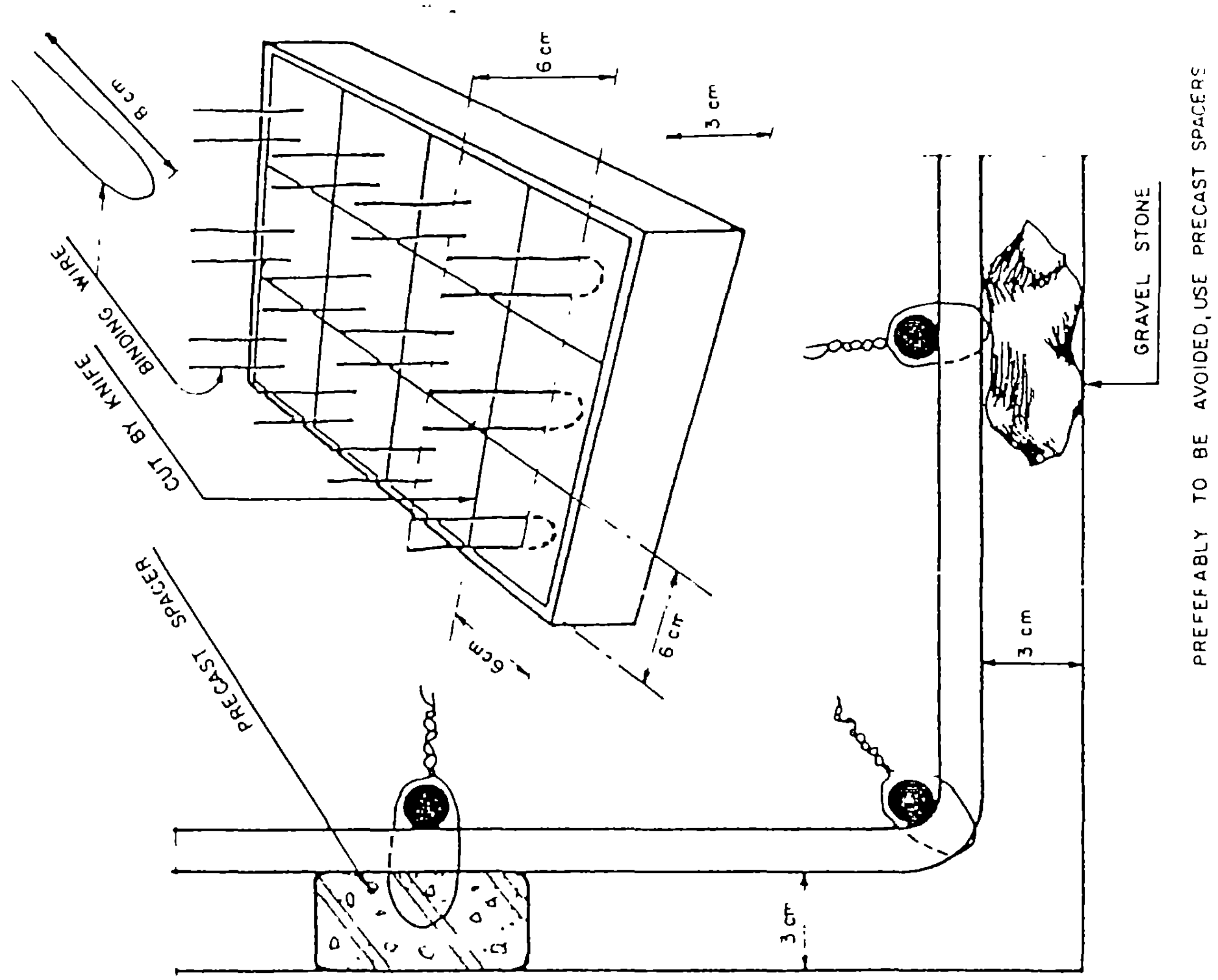

MARK
BENDING
CUTTING
TABLE


BENDING
PLATE

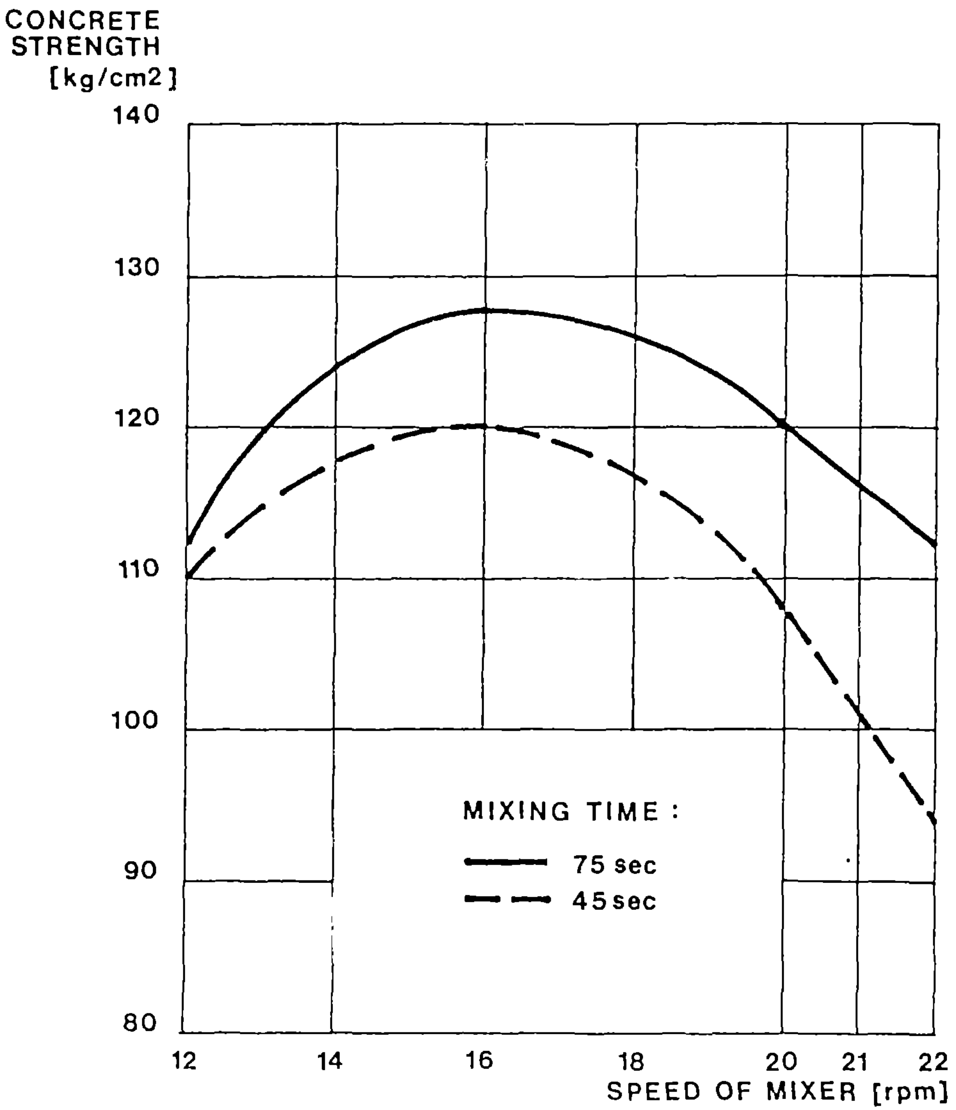

5 Ø B
Ø B
Ø A
2,5 Ø A
PROFILED STEEL
SMOOTH
STEEL

Spaces for reinforcement

TBG 512/V 7 (a-b)



Effect of mixing time



Module : CONCRETE TESTING	Code : TBG 513
	Edition : 14-03-1985
Section 1 : INFORMATION SHEET	Page : 01 of 01/06

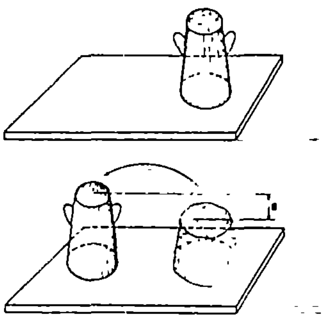
Duration	45 minutes.
Training objectives :	After the session the trainees will be able to : - state the reasons for testing concrete; - carry out a slump test on a concrete sample.
Trainee selection :	- Head of Section Planning & Supervisor; - Head of Sub-section Supervision; - Construction Supervisor.
Training aids :	- Abram's cone; - Concrete; - Viewfoils : TBG 513/V 1-2; - Handout : TBG 513/H 1.
Special features :	-
Keywords :	Concrete testing/slump test/Abram's cone.

Module : CONCRETE TESTING	Code : TBG 513 Edition : 14-03-1985
Section 2 : SESSION NOTES	Page : 01 of 01

1. Introduction	
- Quality of the concrete depends on viscosity; - Test of viscosity is required.	Use whiteboard
2. Slump test	
- Abram's Cone is used; . fill cone with concrete in 3 equal layers; . ram concrete with steel bar 10 times (Bar = 60 cm length - 16 mm diameter); . level-off top; . leave for 30 seconds; . remove cone; . measure slump. - Limits of slump as per table in Handout.	Show V 1 (a-b)
3. Exercise	
- Allow trainees to practice with Abram's cone (10 minutes).	
4. Summary	Give H 1

Module : CONCRETE TESTING	Code : TBG 513
	Edition : 14-03-1985
Section 3 : TRAINING AIDS	Page : 01 of 01

Slump test TBG 513/V 1 (a-b)



SLUMP TEST

Slump test, criteria TBG 513/V 2

SLUMP TEST, CRITERIA

USAGE	CONCRETE CLASSIFICATION	SLUMP (cm)
Pre-cast concrete	Damp concrete	0
Concrete for road construction	"Dry" Pounded concrete	0
Large mass of concrete	"Wet" Pounded concrete	0 – 5 cm
Reinforced concrete (with large reinforcements)	"Dry" Plastic concrete	5 - 12 cm
Normal reinforced concrete	Normal Plastic concrete	10 – 17 cm
Reinforced concrete (with narrow gaps between reinforcement rods)	"Wet" Plastic concrete	15 - 20 cm
Cast concrete	Soft concrete	18 – 22 cm
Poor concrete (cannot be used at all)	Very soft	more than 22 cm

Concrete testing TBG 513/H 1

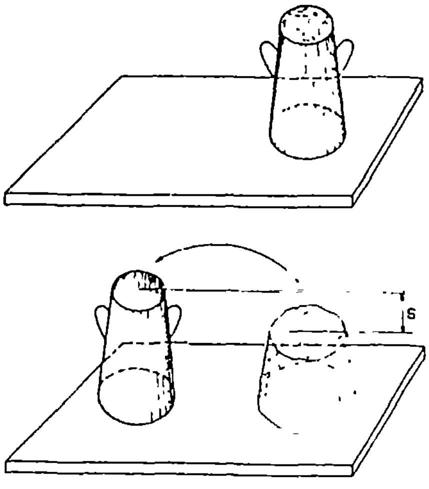
1. INTRODUCTION

The appropriate viscosity of the concrete mixture (workability) is determined by transport requirements, compacting method, type of construction and how close the reinforcement rods are to each other. The viscosity depends on many factors, amongst others the types and structure of grains and possibly also the use of additional materials.
As the quality of concrete is directly influenced by its viscosity, this must be kept as uniform as possible. For that reason the viscosity of the concrete mixture must be checked.

2. SLUMP TEST

The viscosity of the concrete mixture can be examined through a simple test, called the slump test. The word "slump" comes from the English language and means : immediate reduction.
The concrete mixture for this slump test must be taken directly from the mixer, with a pail or other container that does not absorb water (for example a zinc pail, iron pail, or plastic pail).
If necessary, the concrete mixture should be mixed again before carrying out the test. The slump test is carried out as follows:

- An Abram's cone (a cut off cone having a diameter of 10 cm at the top, a diameter of 20 cm at the bottom and a height of 30 cm) is placed on an even surface that does not absorb water (See Fig. 1).



SLUMP TEST

Fig. 1. Abram's cone

- The Abram's cone is filled with the concrete mixture while being pressed downwards.
  The concrete mixture is put into the cone in 3 layers of approximately equal thickness. Each layer is rammed 10 times with a steel stick (16 mm in diameter, 60 cm long, having a blunt point).

- After the top layer is made level with the top edge of the cone, this is left standing for half a minute.
  During this time the excess of concrete mixture having falling off around the cone is cleaned away.

- Then the cone is carefully pulled vertically upwards.

- Soon after that, the decrease in level at the top is measured against the height of the Abram's cone.

- The result of measuring this decrease in level is called slump. This slump is an indicator of the viscosity of the concrete mixture.

The slump test mentioned above gives a quite satisfactory result for measuring the viscosity of plastic concrete and soft concrete, but it was found to be unsatisfactory for damp concrete.
Remember that the method of filling the Abram's cone and of pulling it upwards has a very great effect on the result of this test.

3. SLUMP VALUES

Below is a list of the allowable slump values for a concrete mixture, for various types of usage.

USAGE	CONCRETE CLASSIFICATION	SLUMP
Pre-cast concrete	Damp concrete	0
Concrete for road construction	"Dry" Pounded concrete	0
Large mass of concrete	"Wet" Pounded concrete	0 cm - 5 cm
Reinforced concrete (with large reinforcement)	"Dry" Plastic concrete	5 cm - 12 cm
Normal reinforced concrete	Normal Plastic concrete	10 cm - 17 cm
Reinforced concrete (with narrow gaps between rerods)	"Wet" Plastic concrete	15 cm - 20 cm
Cast concrete	Soft concrete	18 cm - 22 cm
Poor concrete (cannot be used at all)	Very soft	more than 22 cm.

If the "slump" of the concrete is greater than that specified above for its specific purpose, too much water has been added and the mixture should be rejected.

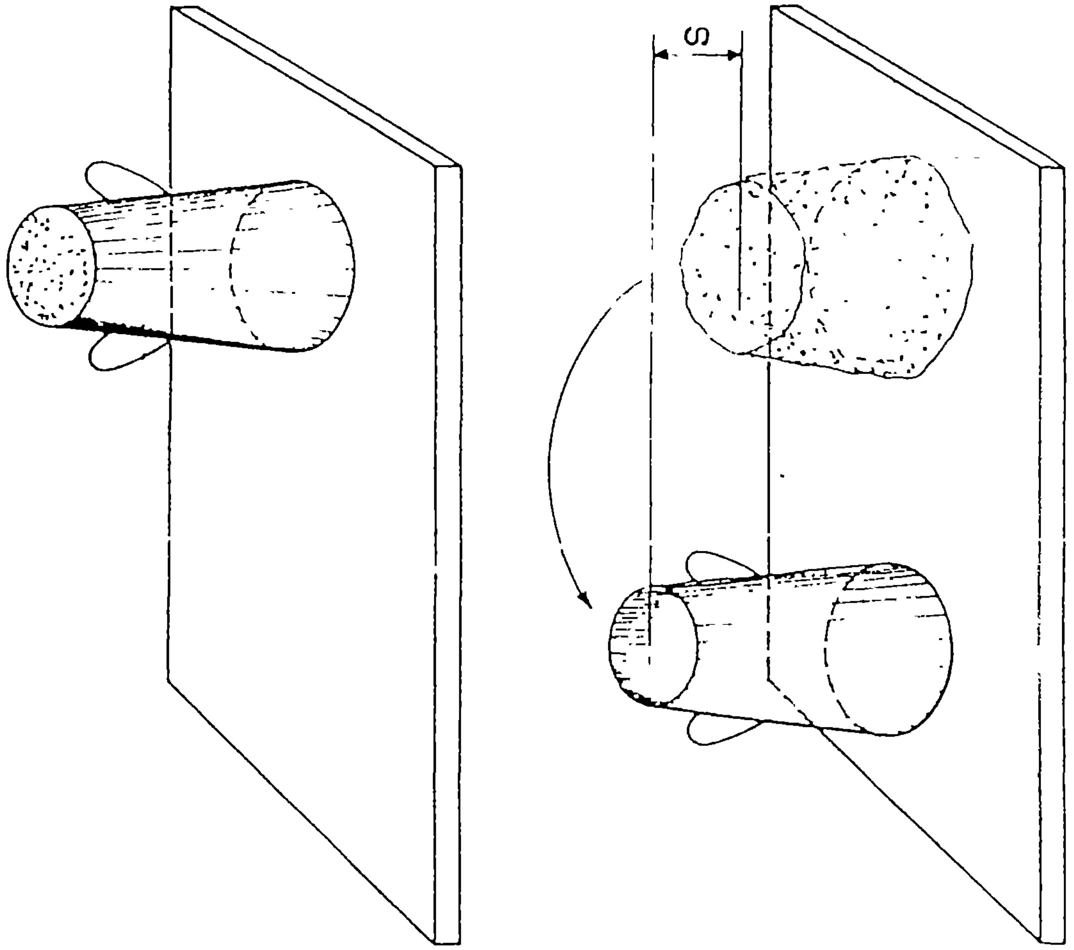
4. SUMMARY

- The quality of concrete depends very much on its viscosity.
- A useful tool to test concrete viscosity is Abram's cone.
- Allowed slump values depend on the usage of the concrete.
- The Abram's cone test is unsatisfactory for damp concrete.

* * *

Module	: CONCRETE TESTING	Code	: TBG 513
		Edition	: 14-03-1985
Annex	: VIEWFOILS	Page	: 01 of 03

TITLE :	CODE :
1. Slump test	TBG 513/V 1 (a-b)
2. Slump test, criteria	TBG 513/V 2



SLUMP TEST

SLUMP TEST, CRITERIA

USAGE	CONCRETE CLASSIFICATION	SLUMP (cm)
Pre-cast concrete	Damp concrete	0
Concrete for road construction	"Dry" Pounded concrete	0
Large mass of concrete	"Wet" Pounded concrete	0 – 5 cm
Reinforced concrete (with large reinforcements)	"Dry" Plastic concrete	5 - 12 cm
Normal reinforced concrete	Normal Plastic concrete	10 - 17 cm
Reinforced concrete (with narrow gaps between reinforcement rods)	"Wet" Plastic concrete	15 - 20 cm
Cast concrete	Soft concrete	18 - 22 cm
Poor concrete (cannot be used at all)	Very soft	more than 22 cm

Module : PLANS	Code : TBG 514
	Edition : 17-09-1984
Section 1 : INFORMATION SHEET	Page : 01 of 01/16

Duration : 45 minutes.

Training objectives : After the session the trainees will be able to :
- distinguish different kinds of mapped records;
- identify scales and symbols used on plans;
- sketch the symbols used on plans.

Trainee selection :
- Member of Management Board;
- Head of Technical Department;
- Head of Section Distribution;
- Head of Sub-section Distribution & Connections;
- Pipelayer;
- Pipeline Inspector;
- Head of Section Planning & Supervision;
- Head of Sub-section Planning;
- Draughtsman;
- Technical Planning Assistant;
- Head of Sub-section Supervision;
- Construction Supervisor;
- Head of Section Maintenance.

Training aids :
- Plans of various types;
- Viewfoils : TBG 514/V 1-7;
- Handout : TBG 514/H 1.

Special features : -

Keywords : Plans/valve plans/scale/symbols/coordinates.

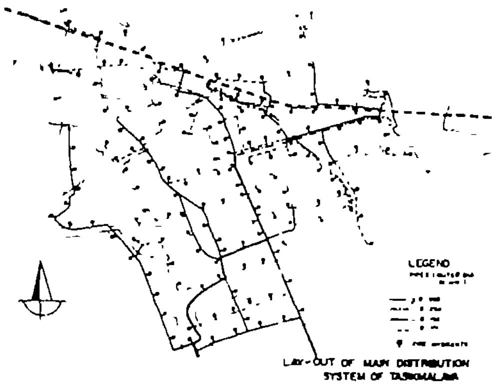
Module : PLANS	Code : TBG 514 Edition : 17-09-1984
Section 2 : SESSION NOTES	Page : 01 of 02

1. Introduction	
- A plan is a top view of an area, showing largely technical data: . to different scales; . using symbols; . provided with coordinates.	Use whiteboard
2. Scales	
- Scale depends on type of plan. Plans may give: . an overall view; . detailed information.	Show V 1-2
3. Symbols	
- Symbols represent objects that can not be drawn to scale.	Show V 3
4. Coordinates/Reference maps	
- Coordinates and/or reference maps enable plans to be used in the right position.	Show V 4-5
5. Comprehensive plan	
- A comprehensive plan gives a picture of the whole distribution system, drawing only the main structures. - It is primarily an operating record but will be used for planning improvements and extensions.	Show V 1
6. Sectional plan/cluster plan	
- A sectional plan gives a picture of part of the system. - It is used for day-to-day operations.	Show V 2
- Details of pipes and accessories are given on cluster plans.	Show V 6

Module : PLANS	Code : TBG 514 Edition : 17-09-1984
Section 2 : SESSION NOTES	Page : 02 of 02
7. **Valve plan and valve list** - A valve plan and valve list are indispensable for operating valves.	Show V 7
8. **Summary**	Give H 1

Module : PLANS	Code : TBG 514
	Edition : 17-09-1984
Section 3 : TRAINING AIDS	Page : 01 of 02

Overall plan water supply system TBG 514/V 1

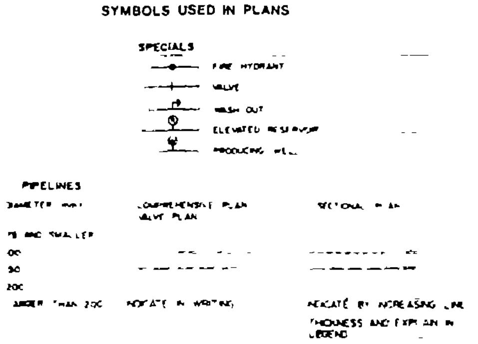


LAY-OUT OF MAIN DISTRIBUTION SYSTEM OF TASIKMALAYA

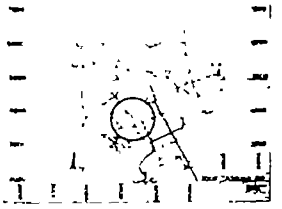
Sectional plan TBG 514/V 2

SECTIONAL PLAN

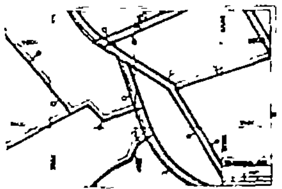
Symbols used in plans TBG 514/V3



Use of coordinates for reference TBG 514/V 4

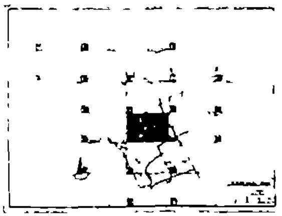


OVER-ALL PLAN WITH COORDINATES

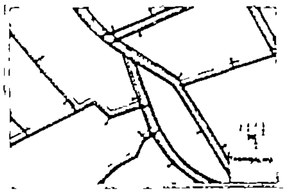


SECTIONAL PLAN WITH COORDINATES

Use of reference map TBG 514/V 5



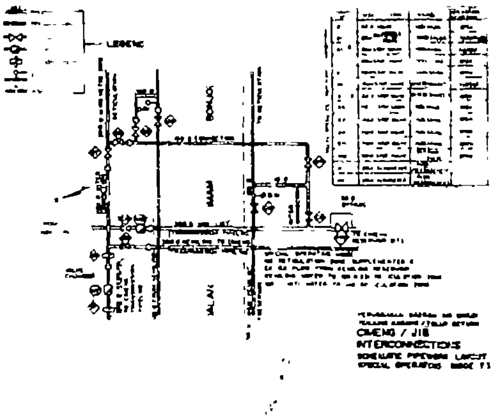
OVER-ALL PLAN WITH SECTIONAL PLAN GRID



SECTIONAL PLAN WITH REFERENCE MAP

Plan of cluster TBG 514/V 6

Valve plan with valve list TBG 514/V 7



Plans TBG 514/H 1

Module : PLANS	Code : TBG 514
	Edition : 17-09-1984
Section 4 : HANDOUT	Page : 01 of 11

1. INTRODUCTION

A plan, like a map, is a bird's-eye view of an area but, unlike a map, a plan is made to give technical information.
Plans should provide the information adjusted to the ultimate goals they are made for and as these goals differ, plans differ. Scales, symbols, the way in which data are given, etc. will vary accordingly.

During the design phase of a distribution system for instance, other information is needed than when the system has been built and is being operated.
Although this does not necessarily lead to different kinds of plans, most of the time it is considered more useful to make separate plans for operating the system.

This module will deal with plans required for operating a water supply system.
Generally speaking the following plans can be distinguished within a water enterprise :
- comprehensive plans;
- sectional plans;
- valve plans.

Sectional plans and valve plans are subdivisions, sometimes at a different scale, of the comprehensive plan.
To fit the plans together in the right position a system of coordinates is used on the plans.

Symbols are used for indicating valves, fire hydrants etc. as they cannot be drawn to (the right) scale.

2. SCALES

The direct function of a plan is to give a clear picture of a water supply system, or part of it.
A field crew, involved in maintenance and repair of e.g. valves needs a plan with many more details that the manager of the water enterprise who primarily needs an overall view of the system he manages.

A comprehensive plan is normally drawn to a scale of 1:5,000 but when the system is large and not too congested, 1:10,000 may give satisfactory results (see Fig. 1).

Sectional plans are drawn mostly to a scale of 1:1,000. However, in congested areas 1:500 is sometimes better, whereas in rural areas a scale of even 1:2,000 may provide a clear and complete picture (see Fig. 2).

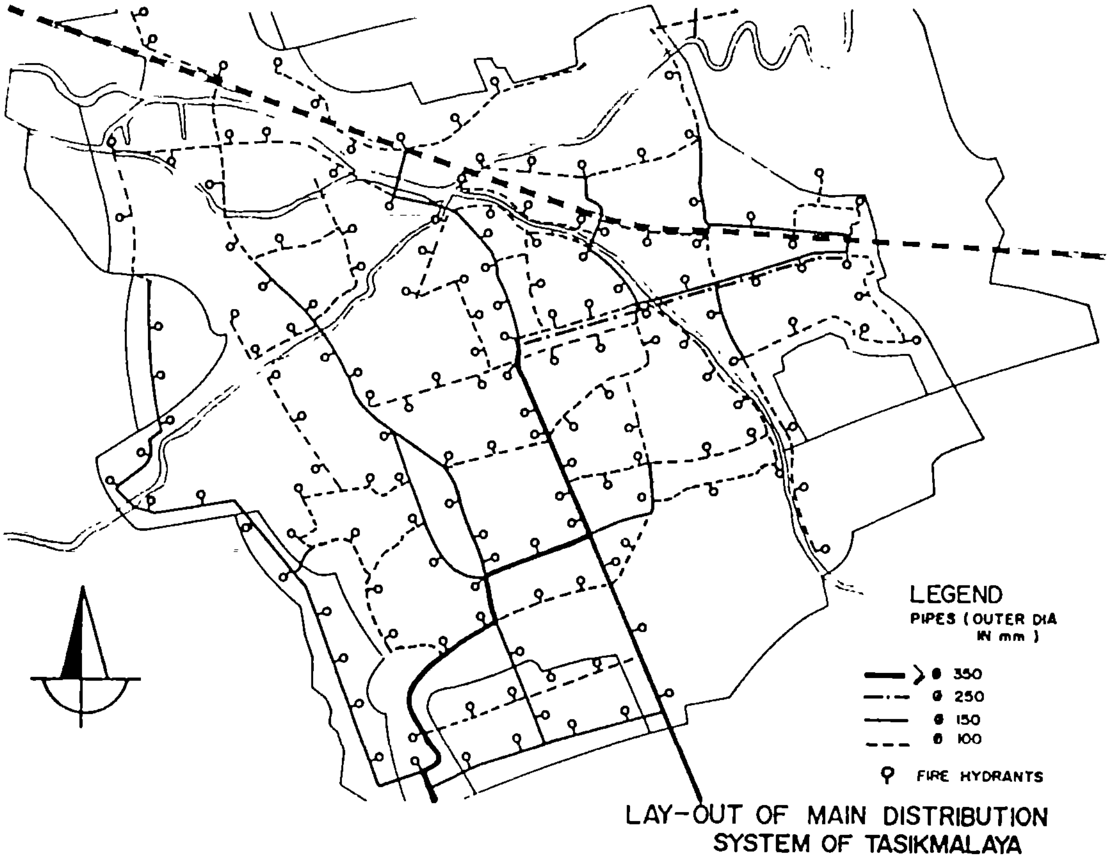


Fig. 1. Over-all plan of water supply system

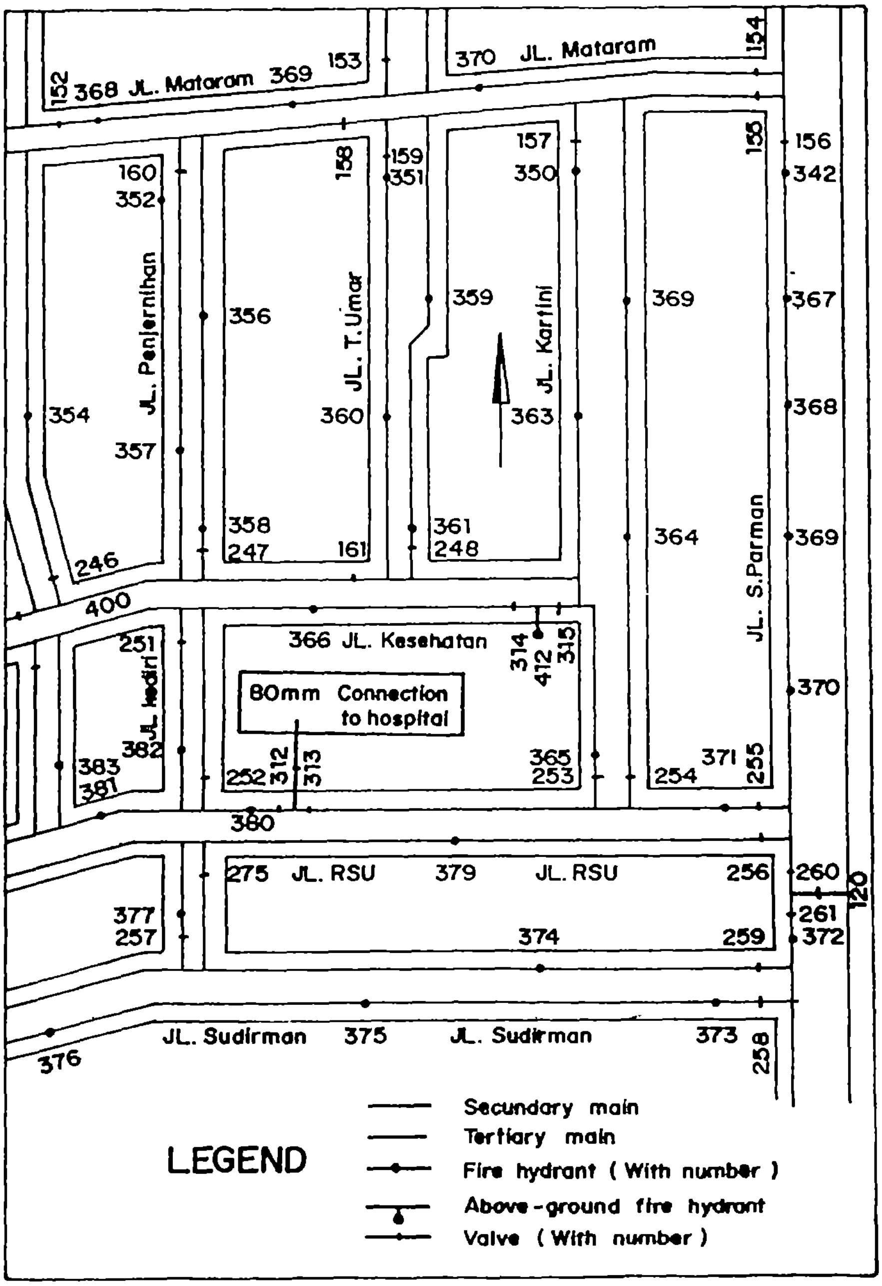


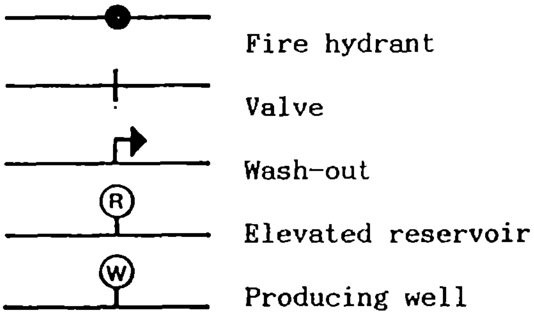
Fig. 2. Sectional plan

The scale of valve plans usually is the same as that of the comprehensive map, that is 1:5,000, except in rural areas where a scale of 1 : 10,000 is sufficient.

3. SYMBOLS

Symbols represent, in a standardized way, objects such as valves, etc. that cannot possibly be drawn to the scale of a plan, but which have to be indicated anyway.
Due to the limited number of subjects to be indicated on comprehensive plans and on valve plans the number of symbols is not so large.

The most important symbols are :



The dimension of the mains are always given in writing.
Dimensions are also indicated by the type and thickness of the lines on the plans.

DIAMETER (mm)	- COMPREHENSIVE PLAN - VALVE PLAN	- SECTIONAL PLAN
75 and smaller :	- - - - - - - - - - - -	- - - - - - - - - - - - - -
100 :	— — — — — — — — —	— — — — — — — — —
150 :	——— ——— ——— ——— ———	——— ——— ——— ——— ———
200 :	————————————	————————————
larger than 200 :	indicate in writing	indicate by increasing line thickness and explain in legend.

4. COORDINATES/REFERENCE MAPS

In case the water supply system is so extensive that the comprehensive plan cannot be drawn on a single sheet, a system of coordinates becomes necessary to be able to lay maps together in the right order. The X=0 and Y=0 coordinates are chosen in such way that future extensions of the network are possible without having to use negative figures. For that reasons coordinates usually do not start with zero, but e.g. with 1000 (m) (see Fig. 3).

Coordinates on the comprehensive plan are preferably given at such intervals that subdivision in areas covered by a sectional plan can be done without interpolation.
When the comprehensive plan is drawn at a scale of 1:5,000 and the sectional plan at 1:1,000, the coordinates on the comprehensive plan may thus be given at intervals not exceeding 500 m.

The sectional plan then only provides one sector measuring 500 x 500 m.

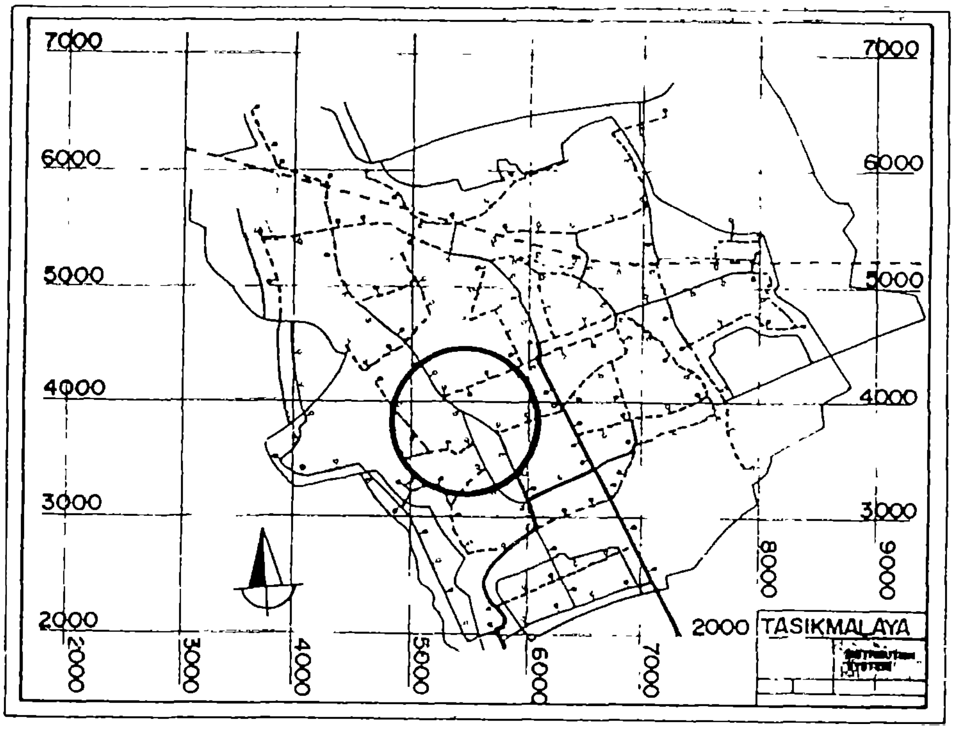
Another way to indicate the position of a sectional plan relative to the comprehensive plan is to incorporate a strongly reduced drawing of the comprehensive plan in each sectional plan. By using a "box" or shading the position of the sectional plan is then indicated on the reduced reference map (see Fig. 4).

5. COMPREHENSIVE PLAN

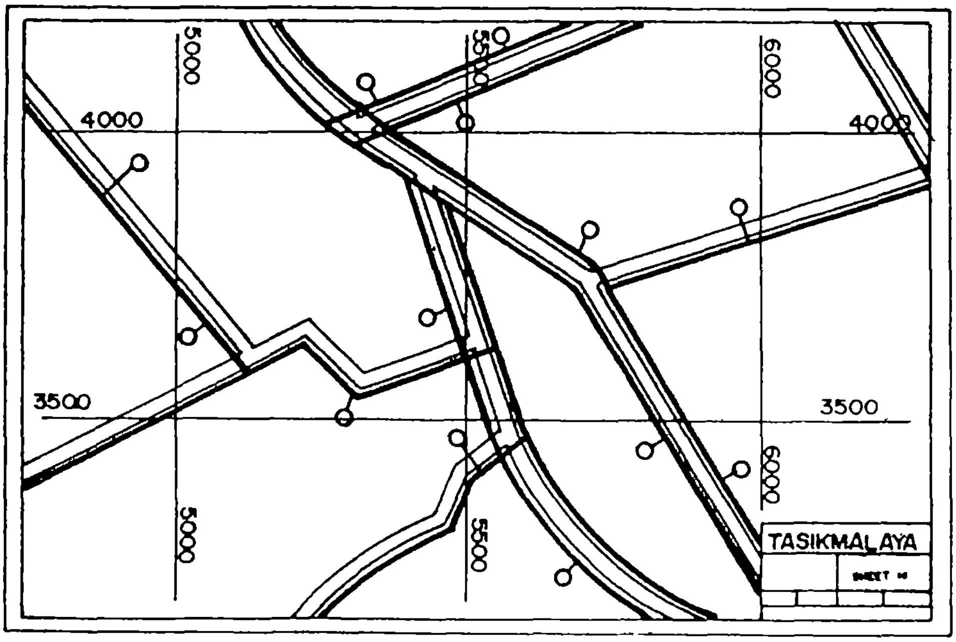
A comprehensive plan gives the manager of a water enterprise a clear picture of the water supply system he operates.
The plan is primarily an operating record but it will be used for planning extensions and modifications of the system as well.
On this plan usually only the mains, with diameters, the valves and the fire hydrants are given, but of course also reservoir(s), treatment plant and other structures are indicated when they fall within the limits of the plan.

For orientation, street names are written, but to keep the plan clear, no street or property lines are drawn, and dimensions of valves and hydrants and valve numbers are left out for the same reason. This can be done without any problem as the manager does not need this kind of information.

From a plan like this it can be concluded whether the network in all areas is as complete as required to supply water not only in normal conditions but also under peak demand and fire fighting conditions.

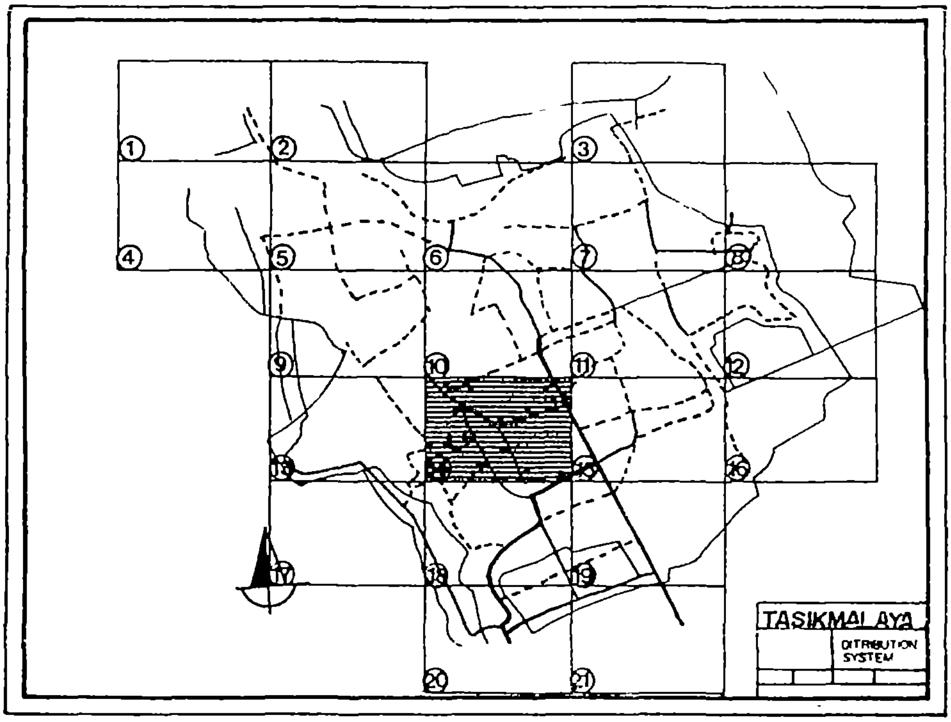


OVER-ALL PLAN WITH COORDINATES

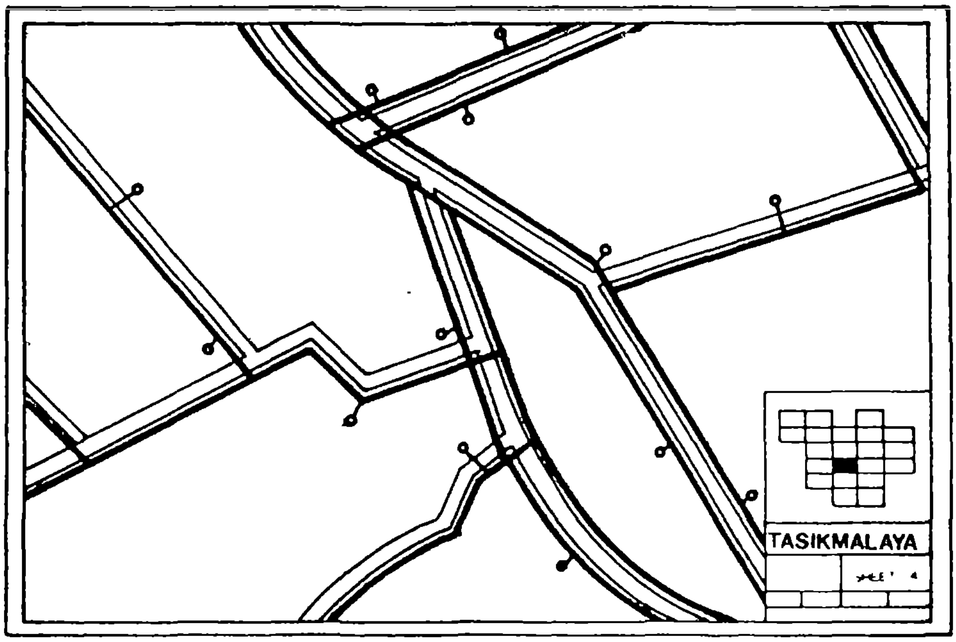


SECTIONAL PLAN WITH COORDINATES

Fig. 3. Use of coordinates for reference



OVER-ALL PLAN WITH SECTIONAL PLAN GIRD



SECTIONAL PLAN WITH REFERENCE MAP

Fig. 4. Use of reference map

The plan will also indicate in which areas fire hydrants are too far apart and thus where hydrants should be added.
Consumer areas, fully depending on only two or even less supply mains can be spotted easily.
In this situation a maintenance job or a failure of one main will interrupt the water supply of the entire area.
The plan shows where additional feeder mains could be constructed to improve this situation.
With the help of this plan it can be decided where the improvement can be made most economically regarding the network as a whole.

6. SECTIONAL PLAN/CLUSTER PLAN

A sectional plan is a part of the comprehensive plan at a larger scale. This record provides the location of the mains up to the house connections, the location of valves, valve numbers, location and number of fire hydrants and all other information needed for the day to day operation of the distribution system.
As all data about valves and hydrants are given in details on the valve plan and in the valve list, no further information except location and number is given on the sectional plan.

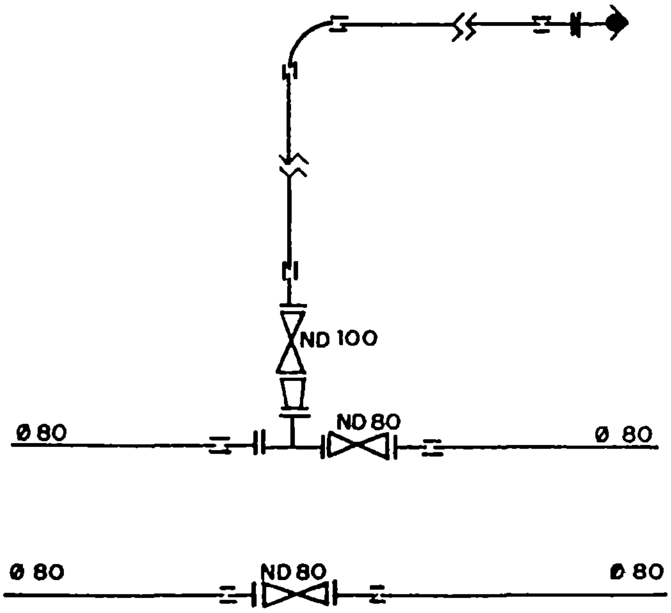
Apart from the above the sectional plans usually also show lot-numbers, house numbers and water account numbers, sizes and materials of mains and service lines, distances to property lines, fittings by means of symbols, distances of these fittings from adjacent buildings (to be able to locate them again), etc.

Details of pipes, accessories, valves, etc. are given on "cluster plans". For clarity these plans are usually not to scale (see Fig. 5).

7. VALVE PLAN AND VALVE LIST

Operating a water distribution system means mainly operating valves. Valves are so essential that mapped records of only valves are considered indispensable.

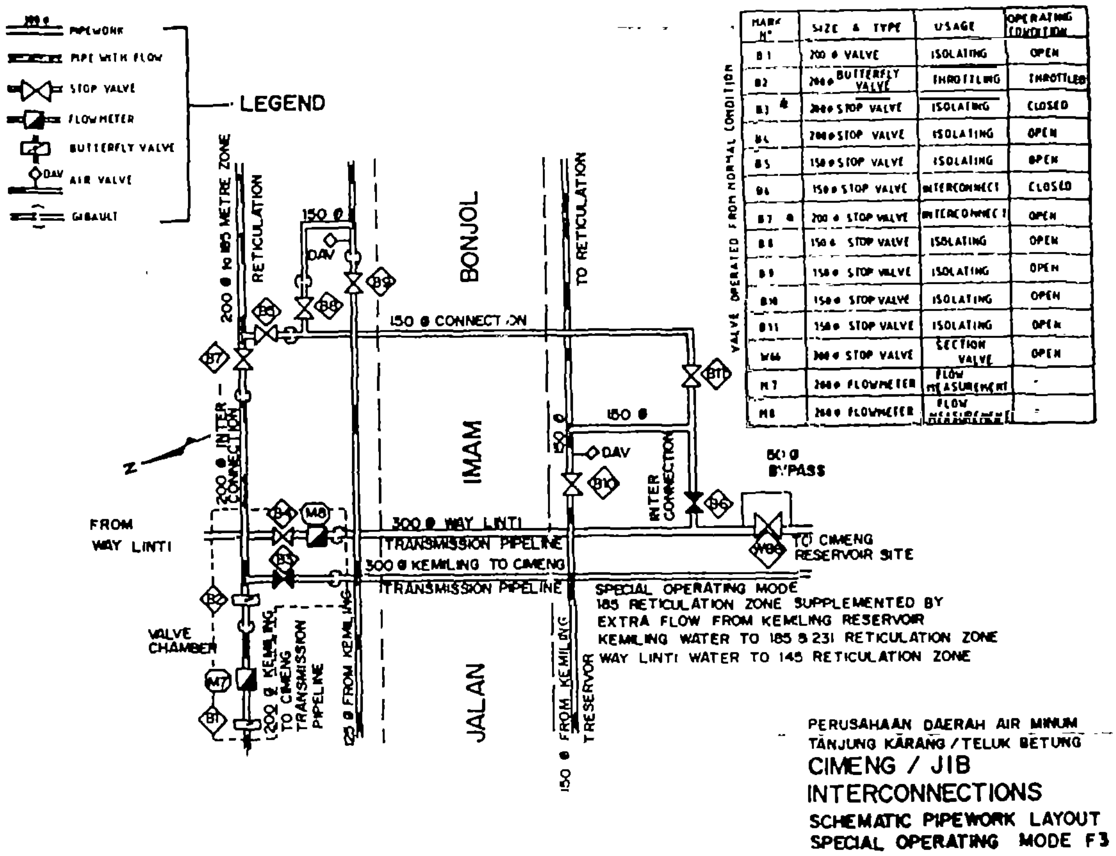
At a scale of 1:5,000, or for rural areas 1:10,000, mains are indicated with their sizes, valves with valve numbers, hydrants with numbers, regulators with numbers, etc.



SIZE	SYMBOLS	Q'ty
80 · 80	—⊣	4
100 · 100	—⊣	2
80 . 80	⊢┬⊣	1
ND . 100	⋈	1
ND · 80	⋈	2
100. 90°	◡	1
100	⊢◆	1
80 . 100	⊏	1

SIZE	ACCESSORIES	Q'ty
80	GASKET	6
100	GASKET	3
M 16 X 80	BOLT + NUT	72

Fig. 5. Plan of cluster



VALVE OPERATED FROM NORMAL CONDITION

MARK N°	SIZE & TYPE	USAGE	OPERATING CONDITION
B1	200 ø VALVE	ISOLATING	OPEN
B2	200 ø BUTTERFLY VALVE	THROTTLING	THROTTLED
B3 *	200 ø STOP VALVE	ISOLATING	CLOSED
B4	200 ø STOP VALVE	ISOLATING	OPEN
B5	150 ø STOP VALVE	ISOLATING	OPEN
B6	150 ø STOP VALVE	INTERCONNECT	CLOSED
B7 *	200 ø STOP VALVE	INTERCONNECT	OPEN
B8	150 ø STOP VALVE	ISOLATING	OPEN
B9	150 ø STOP VALVE	ISOLATING	OPEN
B10	150 ø STOP VALVE	ISOLATING	OPEN
B11	150 ø STOP VALVE	ISOLATING	OPEN
W66	300 ø STOP VALVE	SECTION VALVE	OPEN
M7	200 ø FLOWMETER	FLOW MEASUREMENT	-
M8	200 ø FLOWMETER	FLOW MEASUREMENT	-

Fig. 6. Valve plan with valve list

On a separate valve list the information is provided that is not so easily indicated on a plan, such as make, direction to open, reference measurements, distances to property lines, etc (see Fig. 6).

Copies of these records are used by crews in the field, for day-to-day operation of the system, maintenance, repair and construction.

8. SUMMARY

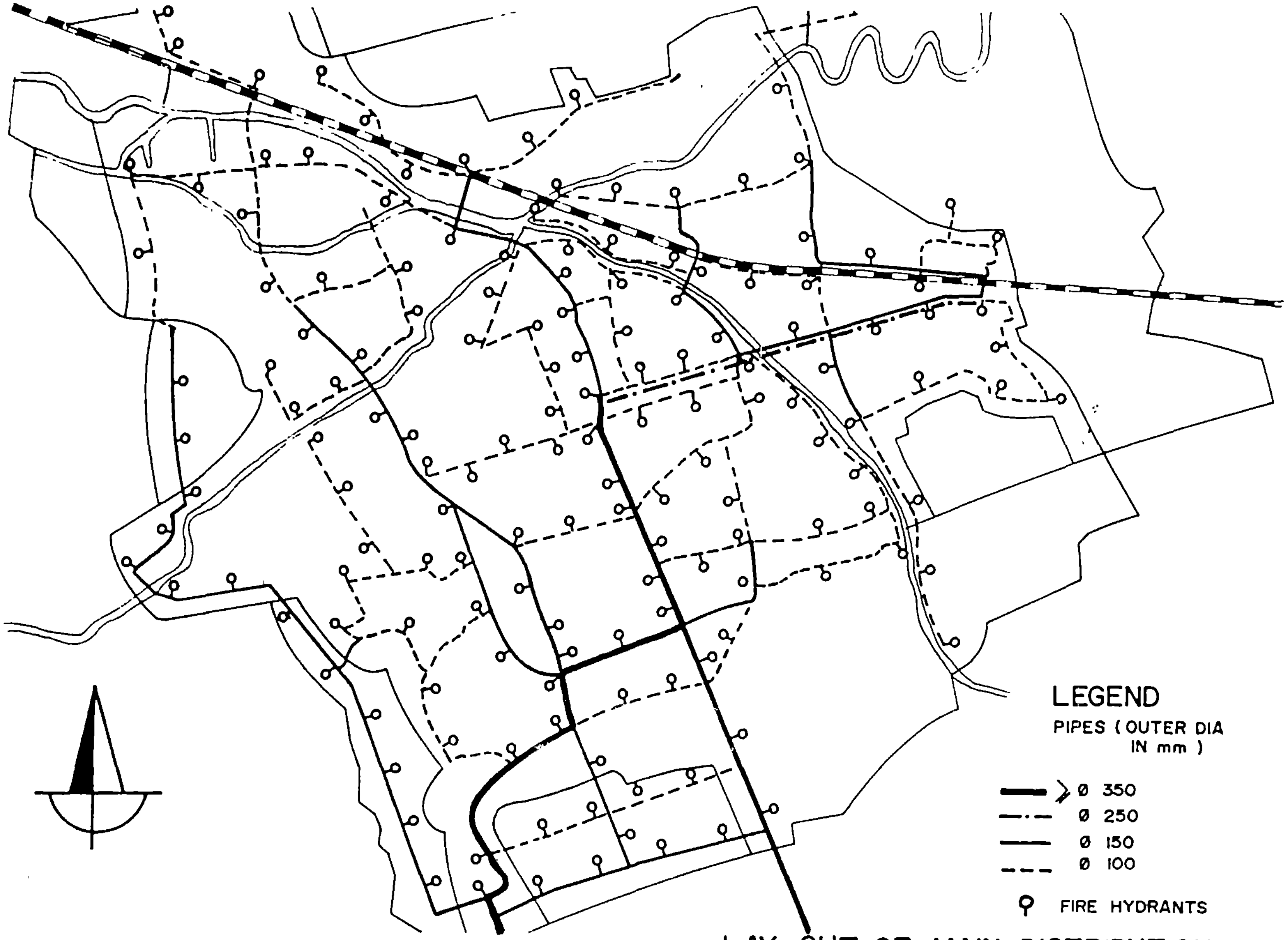
A plan is a top view of an area, providing mostly technical information. Plans may differ in scale and the type of symbols used, depending on their specific goals and use.

* * *

Module : PLANS	Code : TBG 514
	Edition : 17-09-1984
Annex : VIEWFOILS	Page : 01 of 08

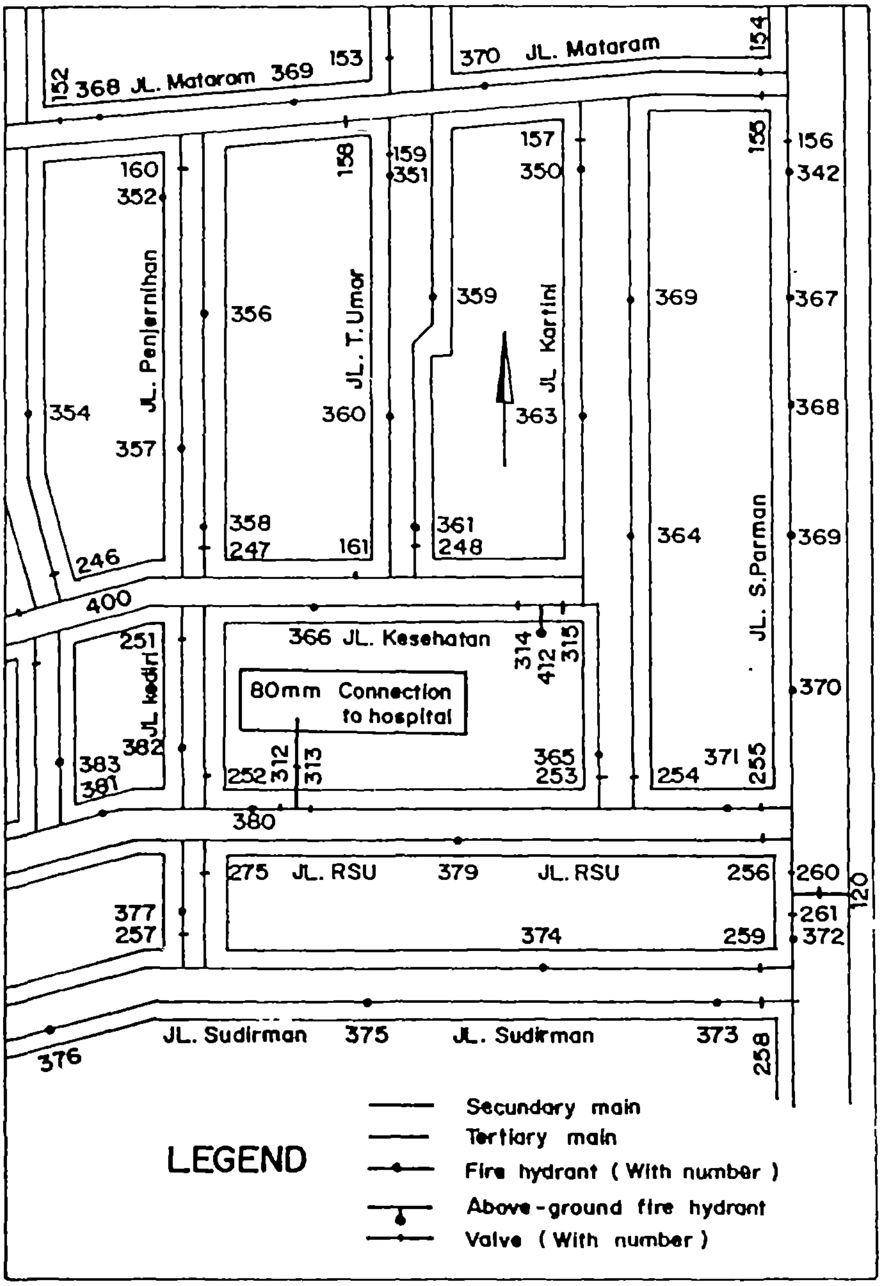
TITLE :	CODE :
1. Over-all plan water supply system	TBG 514/V 1
2. Sectional plan	TBG 514/V 2
3. Symbols used in plans	TBG 514/V 3
4. Use of coordinates for reference	TBG 514/V 4
5. Use of reference map	TBG 514/V 5
6. Plan of cluster	TBG 514/V 6
7. Valve plan with valve list	TBG 514/V 7

Over-all plan water supply system



LAY-OUT OF MAIN DISTRIBUTION SYSTEM OF TASIKMALAYA

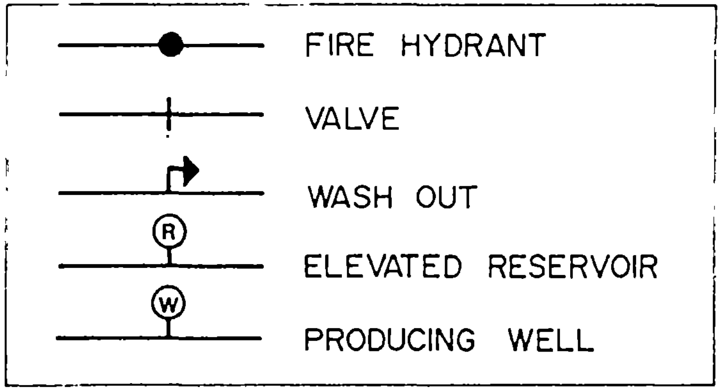
TBG 514/V 1



SECTIONAL PLAN

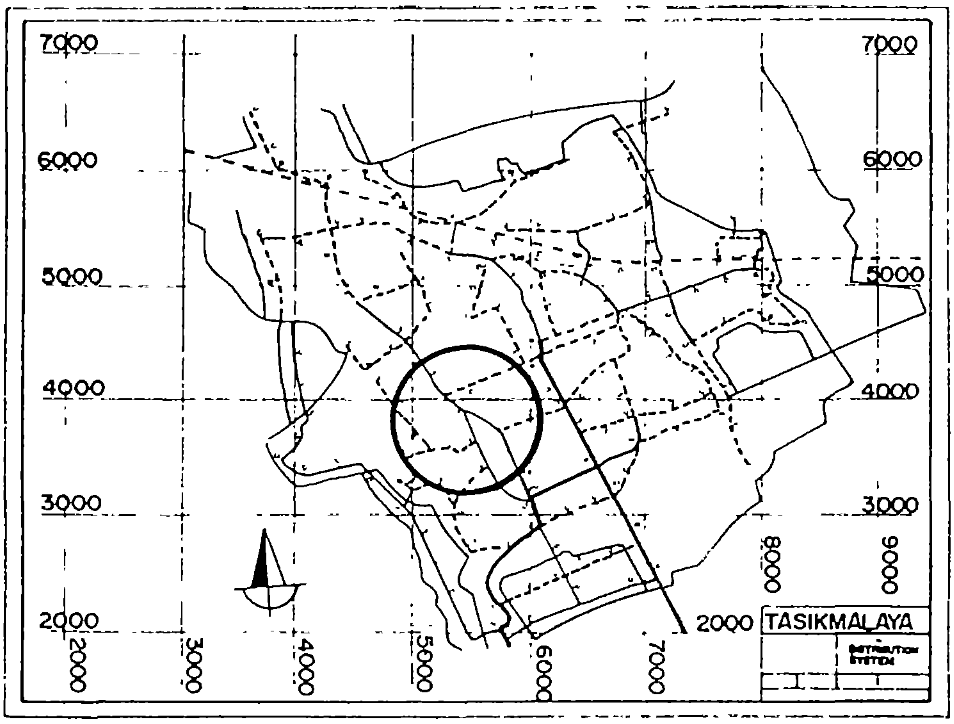
SYMBOLS USED IN PLANS

SPECIALS :

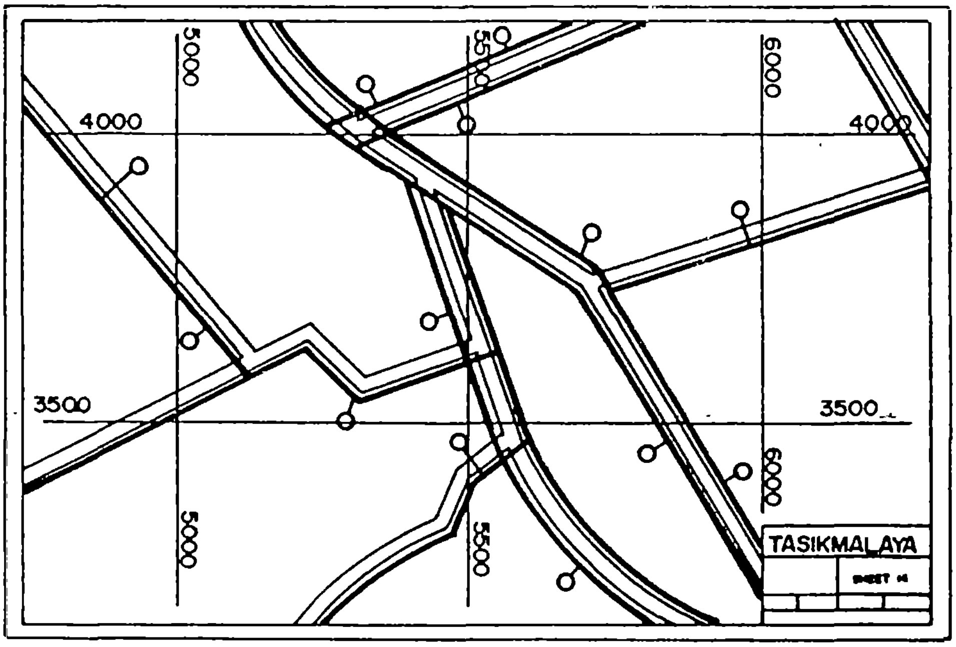


PIPELINES

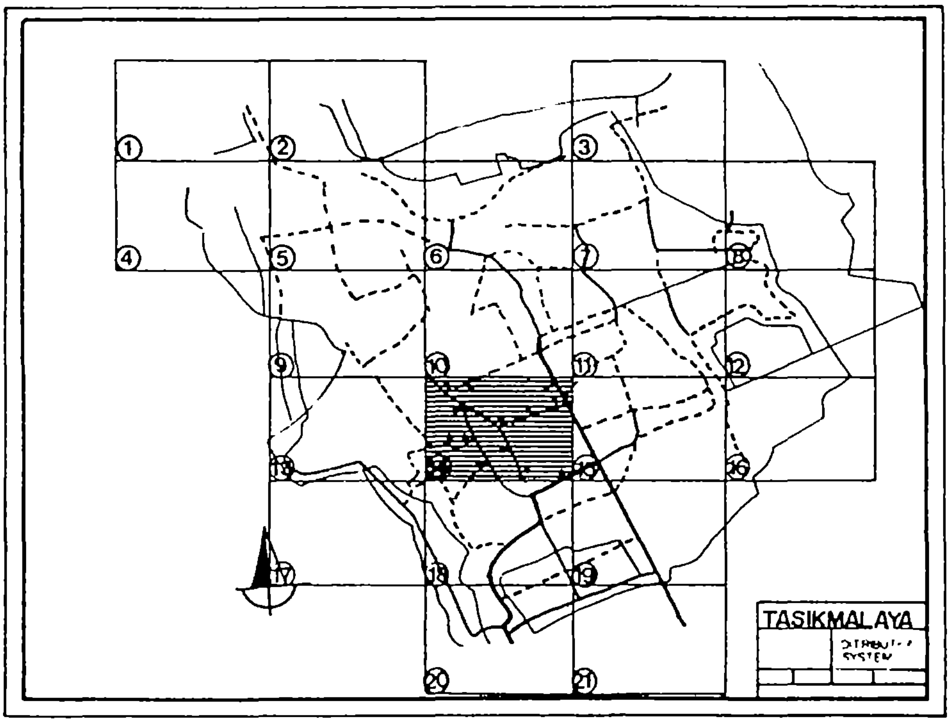
DIAMETER (mm)	– COMPREHENSIVE PLAN – VALVE PLAN	– SECTIONAL PLAN
75 AND SMALLER		
100		
150		
200		
LARGER THAN 200	INDICATE IN WRITING	INDICATE BY INCREASING LINE THICKNESS AND EXPLAIN IN LEGEND



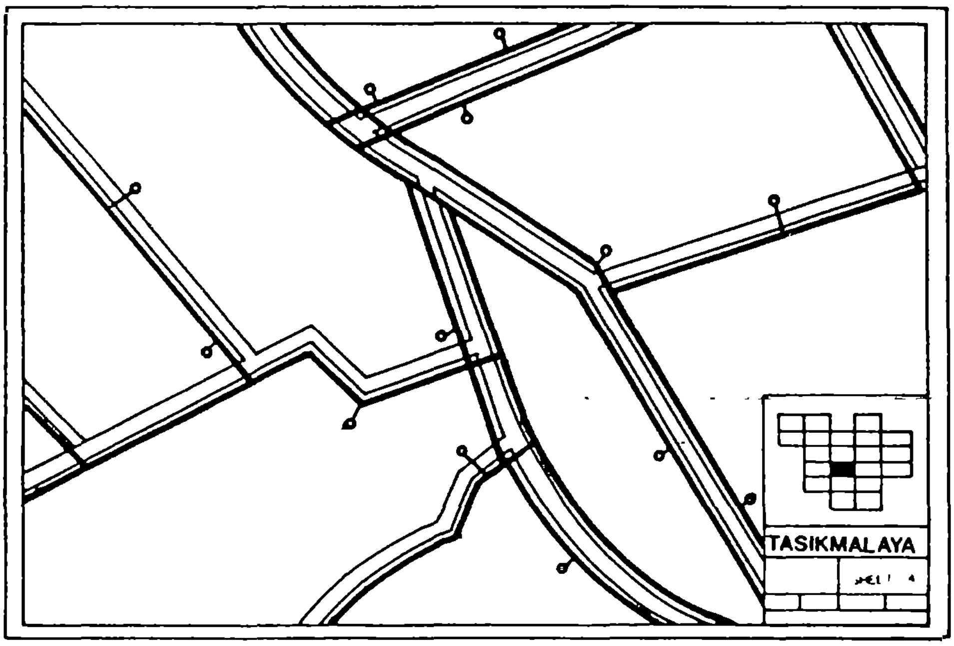
OVER-ALL PLAN WITH COORDINATES



SECTIONAL PLAN WITH COORDINATES

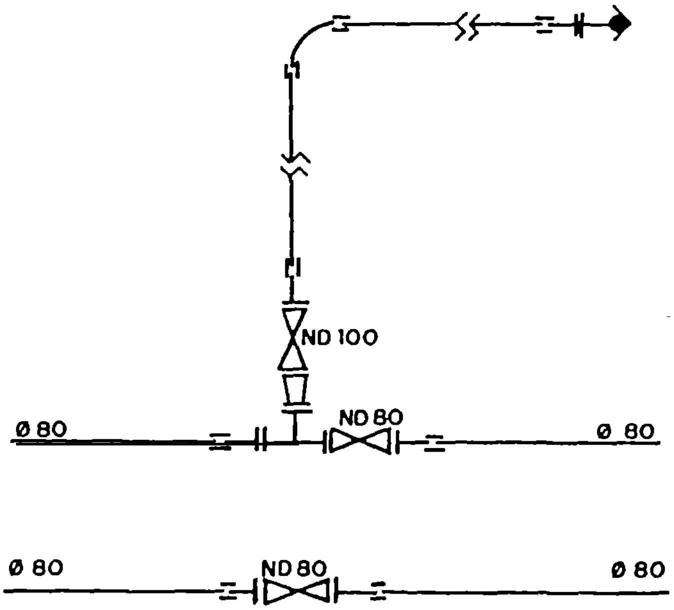


OVER-ALL PLAN WITH SECTIONAL PLAN GIRD



SECTIONAL PLAN WITH REFERENCE MAP

Plan of cluster

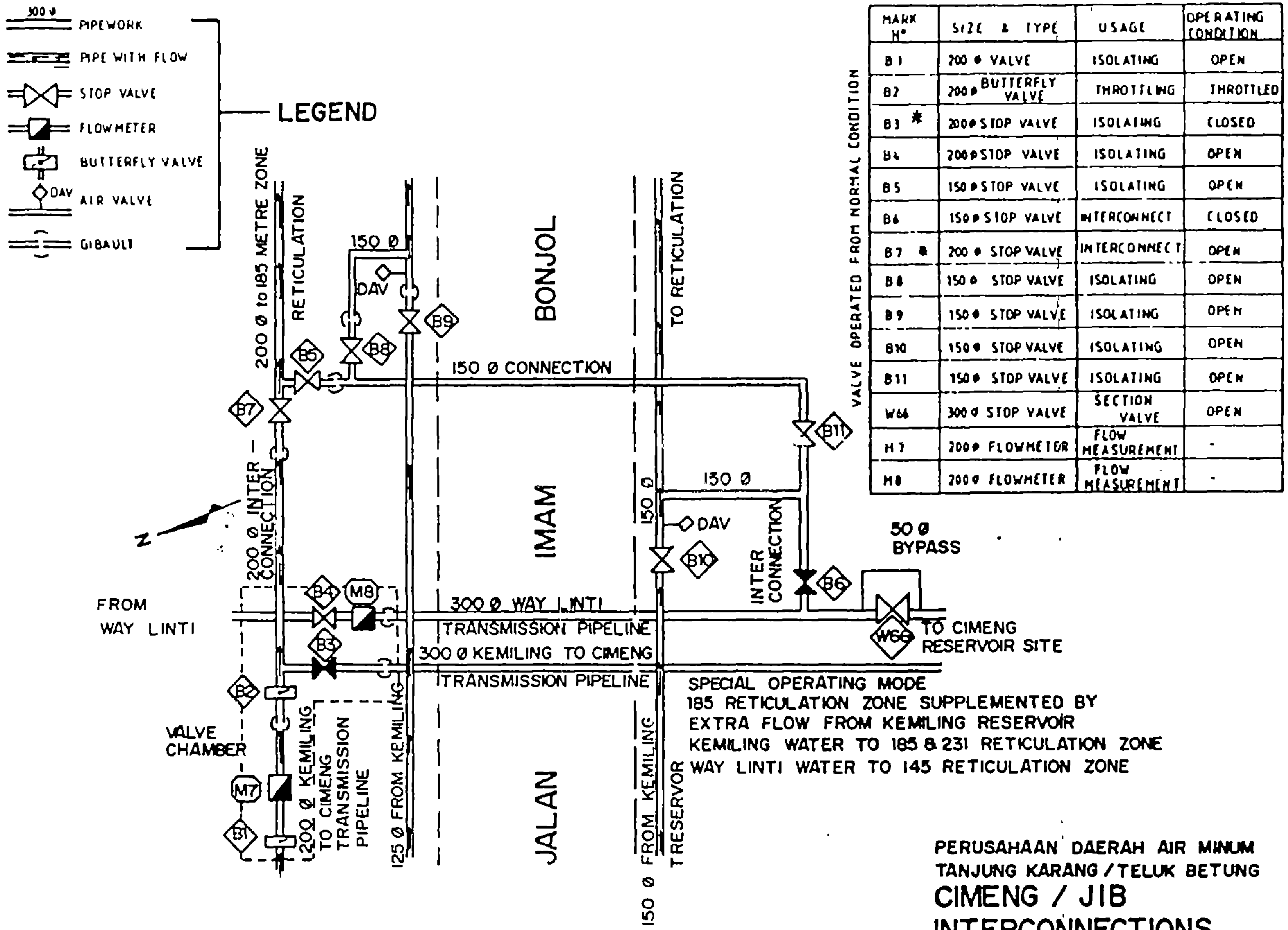


SIZE	SYMBOLS	Q'ty
80 · 80	—┤	4
100 · 100	—┤	2
80 · 80	├┬┤	1
ND . 100	⋈	1
ND · 80	⋈	2
100. 90°	◡	1
100	├→◆	1
80 . 100	⊏	1

SIZE	ACCESSORIES	Q'ty
80	GASKET	6
100	GASKET	3
M16 X 80	BOLT + NUT	72

TBG 514/V 7

Valve plan with valve list



MARK N°	SIZE & TYPE	USAGE	OPERATING CONDITION
B 1	200 Ø VALVE	ISOLATING	OPEN
B2	200 Ø BUTTERFLY VALVE	THROTTLING	THROTTLED
B3 *	200 Ø STOP VALVE	ISOLATING	CLOSED
B4	200 Ø STOP VALVE	ISOLATING	OPEN
B 5	150 Ø STOP VALVE	ISOLATING	OPEN
B6	150 Ø STOP VALVE	INTERCONNECT	CLOSED
B 7 *	200 Ø STOP VALVE	INTERCONNECT	OPEN
B 8	150 Ø STOP VALVE	ISOLATING	OPEN
B 9	150 Ø STOP VALVE	ISOLATING	OPEN
B10	150 Ø STOP VALVE	ISOLATING	OPEN
B 11	150 Ø STOP VALVE	ISOLATING	OPEN
W66	300 Ø STOP VALVE	SECTION VALVE	OPEN
M 7	200 Ø FLOWMETER	FLOW MEASUREMENT	-
M8	200 Ø FLOWMETER	FLOW MEASUREMENT	-

SPECIAL OPERATING MODE
185 RETICULATION ZONE SUPPLEMENTED BY
EXTRA FLOW FROM KEMILING RESERVOIR
KEMILING WATER TO 185 & 231 RETICULATION ZONE
WAY LINTI WATER TO 145 RETICULATION ZONE

PERUSAHAAN DAERAH AIR MINUM
TANJUNG KARANG / TELUK BETUNG

CIMENG / JIB INTERCONNECTIONS

SCHEMATIC PIPEWORK LAYOUT
SPECIAL OPERATING MODE F3

DEPARTMENT OF PUBLIC WORKS
DIRECTORATE GENERAL CIPTA KARYA
DIRECTORATE OF WATER SUPPLY

MDPP
DHV
TGI
IWACO

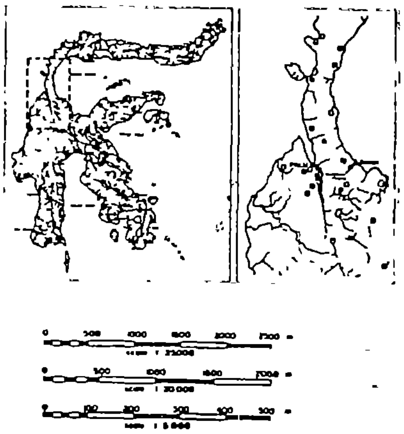
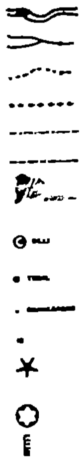
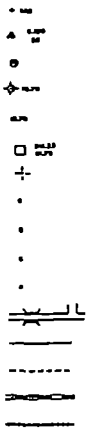
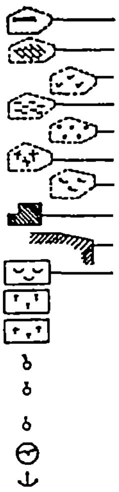
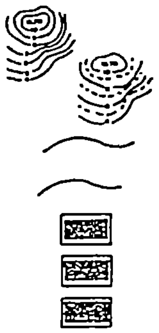
Module : MAPS	Code : TBG 701
	Edition . 17-09-1984
Section 1 : INFORMATION SHEET	Page : 01 of 01/13

Duration :	90 minutes.
Training objectives :	After the session the trainees will be able to : - identify the different kind of maps in use in a water enterprise; - identify scales and symbols used on maps; - sketch the symbols used on maps.
Trainee selection :	- Member of Management Board; - Head of Technical Department; - Head of Section Distribution; - Head of Sub-section Distribution & Connections; - Pipeline Inspector; - Head of Section Planning & Supervision; - Head of Sub-section Planning; - Technical Planning Assistant; - Junior Engineer.
Training aids :	- Maps to different scales; - Viewfoils : TBG 701/V 1-7; - Handout : TBG 701/H 1.
Special features :	-
Keywords :	Map reading/map symbols/legend.

Module : MAPS	Code : TBG 701 Edition : 17-09-1984
Section 2 : SESSION NOTES	Page : 01 of 02
1. **Introduction**	
- Maps is a top view of an area . to scale; . with symbols; . with an indication of levels.	Use whiteboard
2. **Scales**	
- Scale is the relationship between map and reality.	Show V 1
3. **Symbols**	
- There are basically three kinds of symbols : . signs . colours . full text.	Use whiteboard Show V 2-4
4. **Levels**	
- Levels are indicated by contour lines.	Show V 5
5. **Geology**	
- Different soils are indicated by different colours or symbols.	Show E 1
6. **Orientation**	
- Geographical North is given for orientation. - Difference between geographical and magnetic North sometimes given on map.	Show V 6

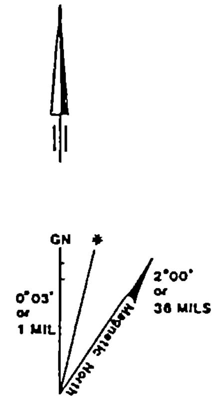
Module : MAPS	Code : TBG 701 Edition : 17-09-1984
Section 2 : SESSION NOTES	Page : 02 of 02
7. Legends	
- Legends are necessary because symbols are not standardized.	Show V 7
8. Summary	Give H 1

Module : MAPS	Code : TBG 701
	Edition : 17-09-1984
Section 3 : TRAINING AIDS	Page : 01 of 02

Map scales TBG 701/V 1 	Symbols I TBG 701/V 2 
Symbols II TBG 701/V 3 	Symbols III TBG 701/V 4 
Contour lines and levels TBG 701/V 5 	Map TBG 701/E 1

Module : MAPS		Code : TBG 701	
		Edition : 17-09-1984	
Section 3 : TRAINING AIDS		Page : 02 of 02	

North direction TBG 701/V 6



Legend TBG 701/V 7

SEMARANG	PROVINCIAL CAPITALS AND CITIES THAT CAN BE DRAWN TO SCALE
KUPANG	PROVINCIAL CAPITALS THAT CANNOT BE DRAWN TO SCALE
SUKA BUMI	REGENCY CAPITALS AND CITIES THAT CANNOT BE DRAWN TO SCALE
WAIMANGURA	SUB REGENCY CAPITALS AND OTHER CITIES
	NATIONAL BOUNDARY
	PROVINCIAL BOUNDARY
	REGENCY BOUNDARY

Maps TBG 701/H 1

Module : MAPS	Code : TBG 701
	Edition : 17-09-1984
Section 4 : HANDOUT	Page : 01 of 08

1. INTRODUCTION

A map is a bird's-eye view of a part of a town, a country or an even larger area, drawn on a flat piece of paper with the objective to give as much information as possible of the three-dimensional reality.

The imagery of the bird's eye view is not chosen by accident, as more and more maps are drawn on the basis of pictures taken from airplanes (aerial survey).

For practical reasons maps are made to a certain scale.
To keep the map clear and readable without losing too much information, symbols are used to represent certain features.

Depending on their later use, maps differ in scales and in the way and to the extent information is given.

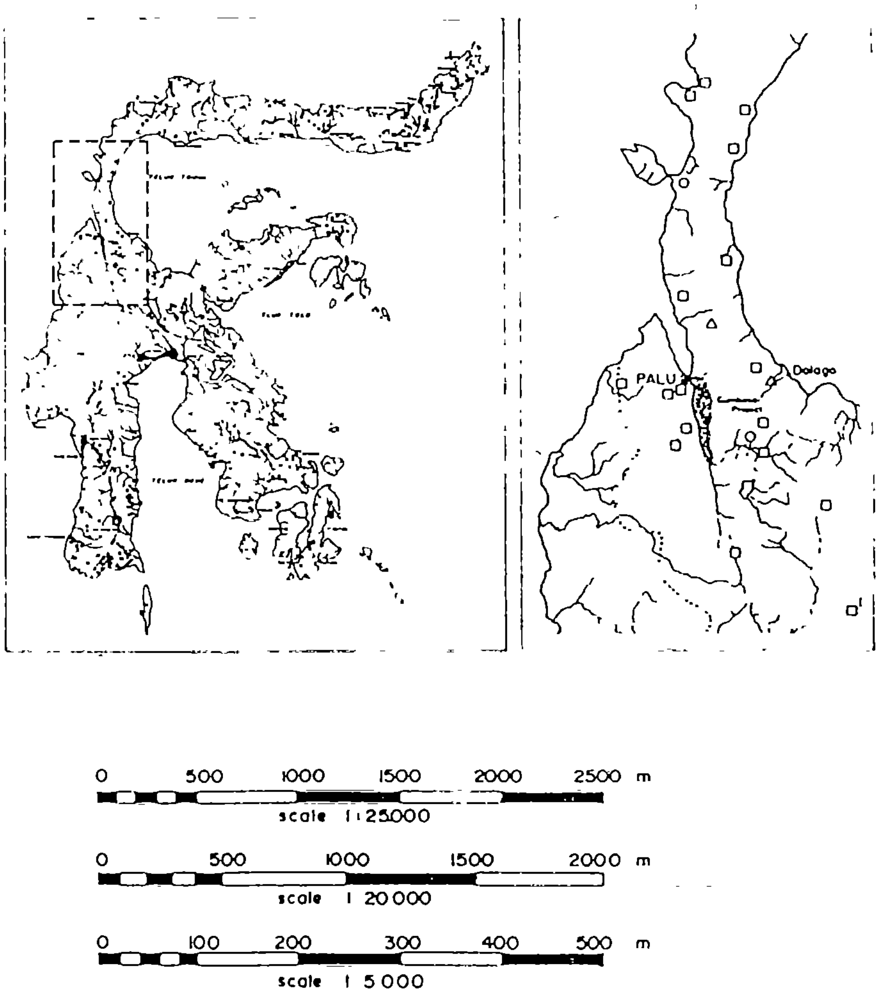
2. SCALES

Maps are used to obtain an overall view of a certain area. For practical reasons maps are drawn to a certain scale, but at the same time to such a scale that the overall view required is still ensured. The scale gives the relationship between the dimensions on the map and the distances in reality.

For example on a topographical map a distance of 1 cm may represent 250 m in the field. The scale is written as 1 : 25,000 which is short for : 1 cm on the map represents 25,000 cm in reality.
On a town map, however, 1 cm may correspond to 1,000 cm only.

A small scale, e.g. 1 : 100,000 gives an excellent overall view but little detailed information, whereas a larger scale, say 1 : 500, allows for more details to be drawn, but of a smaller area.
So the scale itself depends on the proposed use of the map concerned.

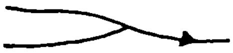
The scale of a map is given in figures, e.g. 1 : 100,000. Maps are sometimes copied. When copied, enlarged or reduced it is possible that the scale of the map is lost when the magnitude of the change from original to copy is not indicated.
Therefore, the scale is sometimes (and preferably) also drawn, like e.g.



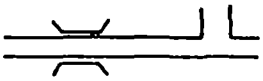
Showing an area to different scales

3. SYMBOLS

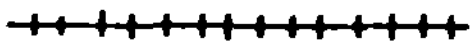
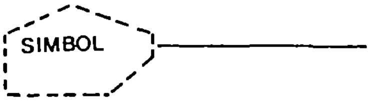
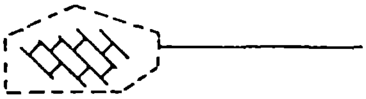
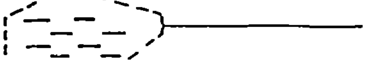
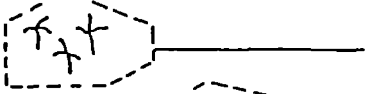
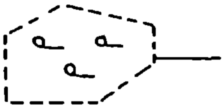
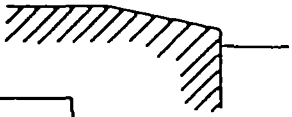
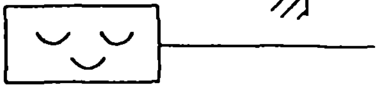
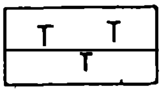
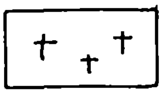
A map should give as much information as possible of a certain area, but at the same time be clear and easy to read. An important expedient to reach this aim is the use of symbols. Symbols can be small signs, colours or full text.

SYMBOLS	
	River, with flow direction
	Stream, with flow direction
	Intermittent stream or stream of which position is not known exactly
+ + + + + + + +	Frontier
—·—·—·—·—	Provincial boundary
— — — — — — — —	Municipal boundary
 BANDUNG	Provincial capital
◉ DILLI	Provincial capital when scale does not allow drawing to scale
○ TEGAL	Capital of regency and municipality, not drawn to scale
• CENGKARENG	Subdistrict town and other cities
18	Regency number
★	Wildlife reserve

SYMBOLS (continued)

	Historical site/monument
	Weir
+ 835	Mountain with top level
△ S.129 53	Triangulation point (x, y, z)
⊙	Traverse point
⌖ 10.70	Secondary benchmark
10.70	Spot elevation
⊡ BM.23 81.75	Benchmark with reference number and level
┼	Point of grid system
B	Weir, structure
G	Volcano
K	River
P	Island
	Main road with bridge
———————	Road
– – – – – – –	Footpath

SYMBOLS (continued)

	Railroad
	Industrial railroad
	Type of cultivation or land use, with or without boundaries, details are given in symbols and/or writing
	Rice field
	Arable land
	Swamp
	Grass, weeds
	Palm or coconut trees
	Trees, forest
	House, building
	Village
	Cemetery, grave (Muslim)
	Cemetery, grave (Buddhist)
	Cemetery, grave (Christian)
	Mosque, shrine
	Temple, shrine

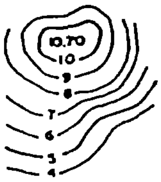
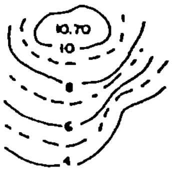
SYMBOLS (continued)

	Church, shrine
	Airport
	Harbour

4. LEVELS

As a map is a flat piece of paper, the difference in level between two places has to be indicated by some kind of symbol. On small-scale maps usually darker colours indicate higher levels. Levels can also be given by means of contour lines. A contour line connects all points of the same level. The level itself is given in writing.
When comparing the distance between two different colours or between two contour lines the average slope of the are can be estimated.

For easier reading of a map, contour lines sometimes have different colours.

	Contour lines with indication of levels according to a certain zero level and with highest spot level
	Dashed contour lines are approximated
	Brown contour line; interval 1 m
	Grey contour line; interval 25 m (or 5 m or 10 m etc)
░	1,000 meters and more
░	500 1,000 meters
▒	100 500 meters

5. GEOLOGY

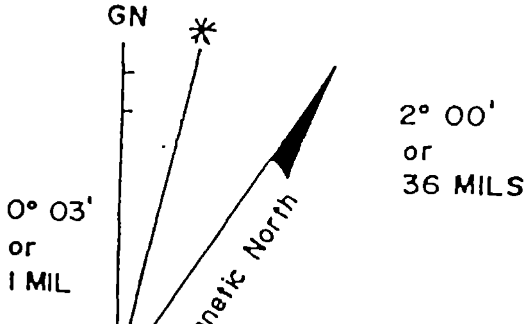
Colours can tell the difference between land and sea, or between kinds of soil, e.g. clay (mostly green) and sand (mostly yellow).

6. ORIENTATION

Normally the top of the map represents the geographical north direction; mostly the north-south orientation is given by a symbol, like the north arrow.

In some cases where a high accuracy is required, the difference, that is the angle, between geographic north and magnetic north is given, for a certain year, together with the annual change of that difference.

North arrow, pointing to the north.



Approximate mean declination 1943 for center of sheet.
Annual magnetic change 2' increase.

7. LEGENDS

Some symbols are standardized, see the Buku Politeknik, others are widely used but not accepted by everyone.
However, every map has a legend in which is explained what is to be understood by the symbols given on that particular map.
It is obvious that the use of always the same symbols for the same object avoids mistakes and allows for using maps from different origins without too much confusion.

Legend (example)

	SEMARANG	Provincial capital, drawn to scale.
⊙	KUPANG	Provincial capital, not drawn to scale.
○	SUKABUMI	Capital of regency and municipality, not drawn to scale.
●	Waimangura	Subdistrict town and other cities.
++++++	State boundary.	
—·—·—·—	Provincial boundary.	
— — — — — —	Regency boundary.	

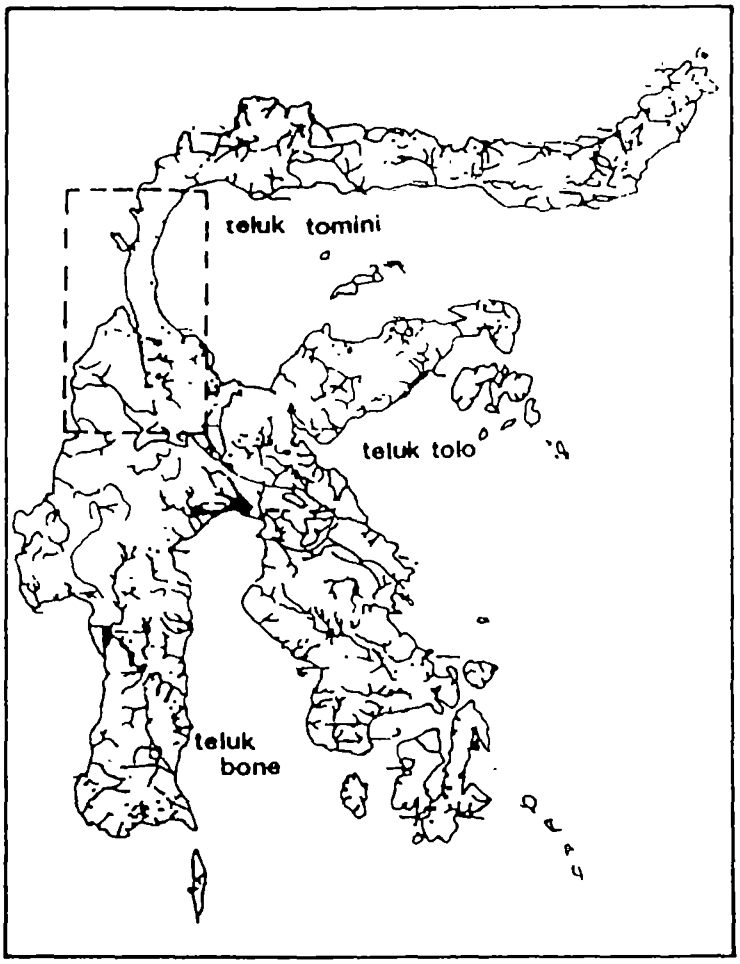
8. SUMMARY

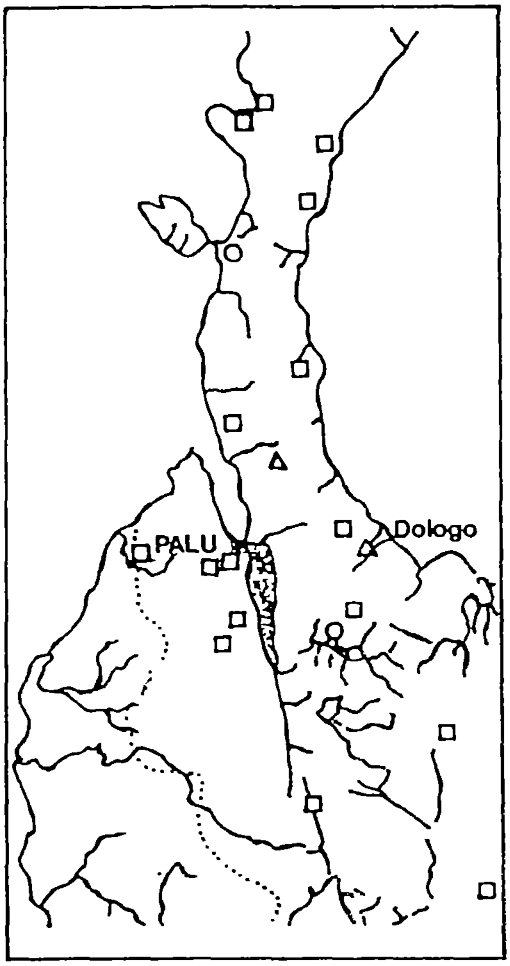
Maps give a bird's eye view of an area.
For practical reasons scales and symbols are used to have clear maps.
The symbols are explained in the legend.

* * *

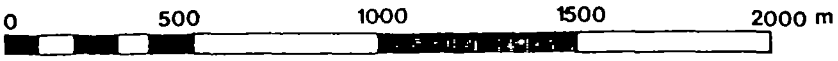
Module : MAPS	Code : TBG 701
	Edition : 17-09-1984
Annex : VIEWFOILS	Page : 01 of 08

TITLE :	CODE :
1. Map scales	TBG 701/V 1
2. Symbols (I)	TBG 701/V 2
3. Symbols (II)	TBG 701/V 3
4. Symbols (III)	TBG 701/V 4
5. Contour lines and levels	TBG 701/V 5
6. North direction	TBG 701/V 6
7. Legend	TBG 701/V 7





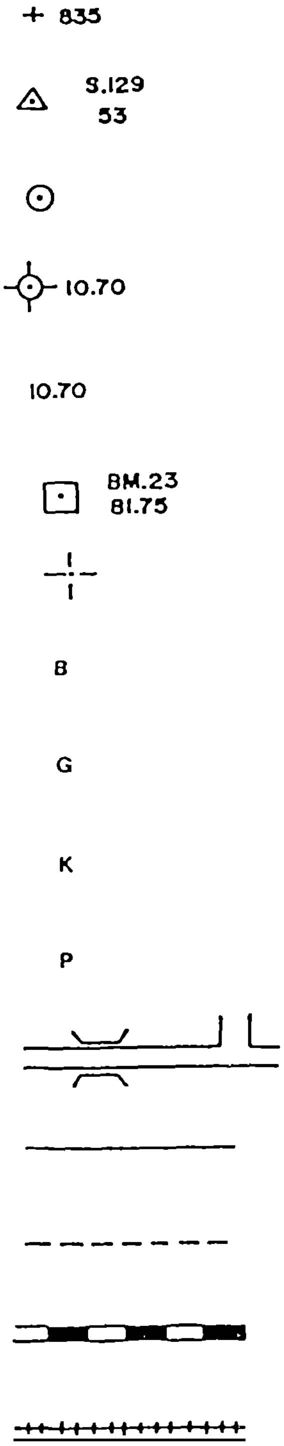
SCALE 1 : 25000

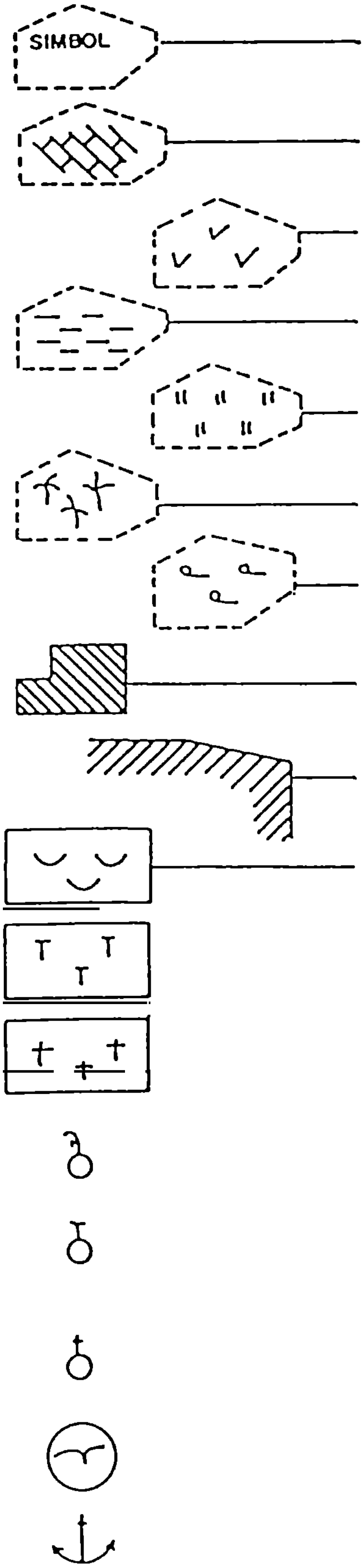


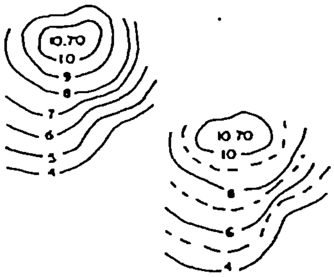
SCALE 1 : 20,000

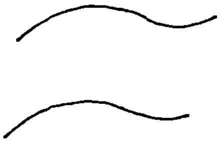
SCALE 1 : 5000

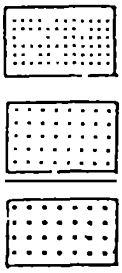

BANDUNG
DILLI
TEGAL
CENGKARENG
18

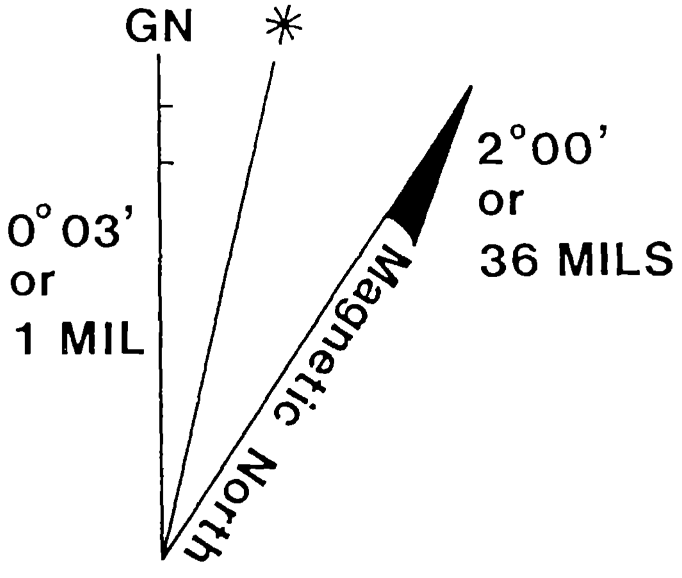

835
S.129
53
10.70
10.70
BM.23
81.75
B
G
K
P


SIMBOL


10.70
10
9
8
7
6
5
4
10 70
10
8
6
4






GN
✳
0° 03'
or
1 MIL
2°00'
or
36 MILS
Magnetic North

Legend

	**SEMARANG**	PROVINCIAL CAPITALS AND CITIES THAT CAN BE DRAWN TO SCALE
⊙	**Kupang**	PROVINCIAL CAPITALS THAT CANNOT BE DRAWN TO SCALE
○	SUKA BUMI	REGENCY CAPITALS AND CITIES THAT CANNOT BE DRAWN TO SCALE
●	Walmangura	SUB REGENCY CAPITALS AND OTHER CITIES
+ + + + + +		NATIONAL BOUNDARY
—·—·—·—·—		PROVINCIAL BOUNDARIY
— — — — — —		REGENCY BOUNDARY