Case C :	Design CBR: > 12%	
	Number of equivalent axle repetitions:	100,000
	Total thickness of granular material with CBR larger than 60:	15 cm
	Total thickness of pavement	15 cm

1.4.4.4 Drainage Design

(1) Side Ditch

(a) Design Rainfall Intensity

Figure 1.5 shows rainfall intensity curves by duration and frequency in Zone 1, which are applied to the design of side ditch.

Duration of design storm are determined as concentration time of 10 minutes. In terms of probability of design storm, the following criteria are selected for the respective roads considering their function, importance, etc.

Road	Return Period (years) for Side Ditch Design
Access Road	5

Intensity of the respective design storm could be read from the curves shown in Figure 1.5 according to the criteria of duration of 10 minutes and probability as shown in the above. The design rainfall intensities are tabulated as follows;

Design Rainfall Intensity for Side Ditch (duration of 10 minutes)

Unit : mm/hour

Zone	Access Road (5 year)
1	160

(b) Run-off

Design peak flood discharge is estimated using Rational Formula as follows :

$$Q = 1/3.6 \cdot C \cdot I \cdot A$$

where, Q : design peak discharge (m^3/sec)
C : runoff coefficient
I : Intensity of design storm (mm/hour)
A : drainage area (km^2)

Runoff coefficients are the values shown below for the design of side ditches.

Surface Condition of Drainage Area	Runoff Coefficient	
	Minimum	Maximum
Pavement of cement or asphalt cement	0.75	0.95
Pavement of asphalt macadam or gravel	0.65	0.80
Pavement of gravel, macadam etc.	0.25	0.60
Sandy soil, cultivated land or with scarce Vegetation	0.15	0.30
Sandy soil, forest or thick bushes	0.15	0.30
Gravel, non or scarce vegetation	0.20	0.40
Gravel, forest or scarce bushes	0.15	0.35
Clay soil, non or scarce vegetation	0.35	0.75
Clay soil, forest or abundant vegetation	0.25	0.60

The drainage area is defined as the area in which rainfall flows into the side ditch, that is, the area of road surface and excavation slope between stream catch basins.

(2) Cross Drainage Facility

(a) Design Rainfall Intensity

For the design of cross drainage facilities such as culvert and bridge having a drainage area of less than 5 km^2 (= 500 ha), concentration time of flood through their river course are applied to a duration of design storm and will be calculated by the following formula.

$Tc = 0.0195 \cdot (L^3/H)^{0.385}$ (California Culvert Practice)

where, Tc : time of concentration (min.)

L : length of main river course (m)

H : difference in elevation (m) between the remotest point of drainage area and structure site

A minimum concentration time of 10 minutes for the whole area is recommended. In case a drainage area at structure site is less than 5 km^2, a design rainfall intensity could be read from Figure 1.5 for the respective duration of rainfall to be estimated by the above formula. In case of drainage area larger than 5 km^2, a duration of design storm is selected at 1 hour.

Probability of design storm is determined as shown in the following table for the respective roads considering their function, importance, etc.

Road	Return Period (years) for Cross Drainage Facility Design
Access Road	5

(b) Run-off

Design peak flood discharge are estimated using Rational formula as same as side ditch design for cross drainage facility with a drainage area of less than 5 km^2.

The drainage area are measured on topographic maps with scales of 1 : 50,000, 1; 25,000, 1 : 10,000 and 1 : 5,000. Runoff coefficients are determined at a constant value of 0.4 on a whole drainage area.

For cross drainage facilities with a drainage area of more than 5 km^2, HYMO model is applied to runoff calculation using a design rainfall with a duration time specified above.

HYMO model is basically the same as the Hydrograph Evaluation of the Hydrologic Model Package of the Agricultural Research Service of the US. Department of Agriculture. The model is briefly explained in Main Report Annex 1 "Hydrological Study" and the details could be referred to " Instituto Nacional de Reforma y Desarrollo Agrario (IRYDA), 1986, Diseño y Construcción de Pequeños Embalses, Madrid - España".

(3) Dimension of Drainage Structures

Based on the design flood discharge estimated referring to the criteria as described in Subsection 1.4.4.1 and 1.4.4.2, dimensions of the drainage structures will be determined using Manning's formula as follows :

$$Qa = 1/n \cdot R^{2/3} \cdot i^{1/2} \cdot A$$

where, Qa : allowable runoff (m^3/sec) more than design peak discharge (Q)
n : roughness coefficient
R : hydraulic mean radius (m)
i : energy gradient or slope of energy line (m/m)
A : flow cross-sectional area (m^2)

1.5 Drafting Standard

(1) General Description

This drafting standards is prepared for standardizing the form of drawings, simplifying various details of drafting work and securing uniformity of appearance, size and style.

(2) Drawing Size

For uniformity and convenience, the overall standard size for the design drawings is 821 mm of 574 mm of A-1 size with an approved title block.

(3) Scale

Scale varies in accordance with purpose of drawings. A graphic scale is provided on all drawings. If its is needed to use more than one scale on a drawing, all views of the same scale are grouped and graphic scale is provided for each group. The standard form of graphic scale is shown in an approval drawing form.

Adopted scale:

1/5,000	1/4,000	1/2,000	1/1,000	1/500	1/400
	1/300	1/200	1/100	1/50	1/30
1/20					
	1/10	1/5	1/2		

(4) Unit of Dimension

Dimensions of the structures are expressed in millimeters, but that of the road is expressed in centimeters except accumulated distance in meters except otherwise specified.

(5) Line and Letter

Lines are primarily divided into five kinds in thickness. The thickness of each line and its usage are shown in Figure 1.6

Capitals letters are used for explanation of title or subtitle such as Title of Structure, Plan, Profile, Section, etc. The standard for lettering are illustrated in Figure 1.7.

(6) Number of Station

In the longitudinal and cross sectional drawings, numbering of section is increased from left to right for the dam and related structures and from upstream to downstream for waterway.

(7) Sectional Vies

Sectional views are provided in order to explain shape of sections or other part of detail. A sectional view shows a section which can be seen toward the direction shown by an arrow. An arrow with a capital letter showing direction is commonly placed outside of dimension lines.

(8) Abbreviations

Abbreviations for detailed drawings are shown in Table 1.1.

(9) Legend, Notes and References

The legend, noes and references shall occupy, the space immediately above the title block. Width of the space shall in general be 15 cm as shown Figure 1.8.

(10) Symbols

Symbols for detailed drawings are shown in Figure 1.9.

2. HYDROMECHANICAL EQUIPMENT

2.1 General

The hydromechanical equipment to be installed in this scheme is expected as mentioned below.

(1) Severino Pumping Station

- Pumps with ancillary equipment
- Penstock
- Trashrack

(2) Conguillo Inlet

- Inlet valve

(3) Poza Honda Inlet

- Inlet valve
- Trashrack

2.2 Standards to be Applied

The design follows "Design Standards for Pumping Station" published by the Agriculture Improvement Department of the Japanese Ministry of Agriculture, Forestry and Fisheries and "The Technical Standards for Water Gate and Penstock" published by the Water Gate and Penstock Association of Japan. The Design Standards NO.7 (Valves, Gates and Steel Conduits) issued by Bureau of Reclamation, USA are also referred to.

For the materials to be used and workmanships of the Works, the Japanese Industrial Standards (JIS) are mainly adopted.

2.3 Work Items and Functions

(1) Pumps with ancillary equipment

The purpose of pumps is to supply water from La Esperanza to Poza Honda for keeping the optimum reservoir water level corresponding to the water demand under integrated reservoir operation.

(2) Penstock

The purpose of penstock is to conduct water from the Severino Pumping Station to the Severino Head Tank.

(3) Inlet valves

The purpose of inlet valves is to regulate the inflow for keeping the optimum reservoir water level to the water demand under integrated reservoir operation.

(4) Outlet gates/stoplogs

The purpose of outlet gates/stoplogs is to close the diversion tunnel for protection of the diversion tunnel against the backflow in flood and for inspection and maintenance service.

(5) Trashrack

The purpose of trashracks is to prevent the entrance of injurious matters into the pumps and the inlet valves.

2.4 Selection of Type of Component

(1) Pump type

Type of pump shall be determined from the viewpoints of the required purpose, pumping head and discharge, and from the economical viewpoint.

The following types are generally adopted. (see Figures 2.1.)

- Volute pump
  - Horizontal
    - Single suction
    - Double suction
  - Vertical
    - Single suction
    - Double suction
- Mixed flow
  - Horizontal
  - Vertical
- Axial flow
  - Horizontal
  - Vertical

(2) Valve and gate type

Type of valve and gate shall be determined from the viewpoints of the required purpose, functions, frequency of operation, installed location, convenience of operation and maintenance etc., and from the economical viewpoint.

The following types are generally adopted.

- Inlet valve
  - Sleeve valve
  - Hollow jet valve
  - Fixed corn valve
- Outlet gate
  - Slide gate
  - Roller gate
- Stoplog
  - Slide gate type
  - Roller gate type

(3) Penstock type

There are two (2) types of penstock, i.e., exposed type and embedded type, and they are classified as follows:-

- Exposed type
  - Free support
    - Saddle support
    - Ring support
  - Fixed support (Anchor block)
- Embedded type
  - Backfilled with concrete
  - Backfilled with earth

2.5 Approach to Design

Basic design is usually commenced for selecting the fundamental dimensions in accordance with the basic requirements and carried out by repeating study on alternatives until the technically and economically suitable type and size are found.

The procedures for basic design including those required to completion of the works are summarized in Figure 2.2.

2.6 Design Criteria

(1) Pumping facilities

(a) Planned water amount and number of pump unit

The planed water amount shall be determined according to the maximal delivery quantity based on the study result of integrated reservoir operation. The capacity and number of pump units should be so determined as to be able to operate at as near the point of the maximum efficiency as possible.

(b) Selection of pumps

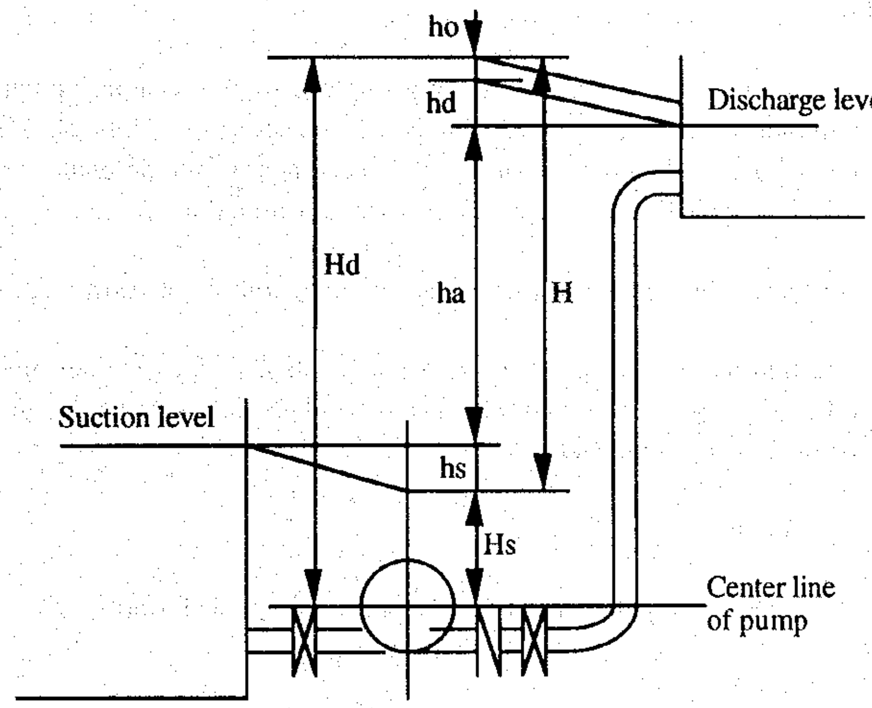
Type of pumps shall be determined according to the discharge and total head in consideration of no occurrence of cavitation at the specified suction head.

(c) Bore of pump

The bore of pump shall be determined in view of the delivery quantity and the flow velocity of suction and delivery. The standard rate of flow at the suction of pump shall be 1.5 ~ 3 m/sec. In actual use, however, it shall be determined according to the revolving speed of selected motor.

(d) Total head

The total head of pump shall be determined according to actual head and head loss in the suction pipe/delivery pipelines.



The total head (H) is calculated as follows:

H = Hd - Hs
= ha + hd + ho + hs

where,

H	:	Total head of pump (m)
Hd	:	Total head on the delivery side (m)
Hs	:	Total head on the suction side (m)
ha	:	Actual head (m)
hd	:	Pipe loss on the delivery side (m)
ho	:	Velocity -head on the delivery side (m)
hs	:	Pipe loss on the suction side (m)

(e) Output of prime motor

The output of prime motor shall be determined according to the required axial power of pump including allowance. The output is calculated by the following formula.

$$Pm = (0.163\ g\ Q\ H / h) (1+ a)$$

where,

Pm	:	Output of prime motor
g	:	Weight of water per unit volume (kg/l)
Q	:	Delivery quantity (m^3/min)
H	:	Total head (m)
h	:	Pump efficiency (decimal)
a	:	Allowance (0.1 ~ 0.2)

(f) Water hammering in pump system

When a pump in operation suddenly stop due to power supply interruption, a water hammering phenomenon will happen in penstock. A study on water hammering phenomenon, therefore, shall be carried out and a suitable countermeasure shall be selected on the basis of construction cost evaluation, if necessary.

A considerable countermeasure is such as air-chamber, backflow method etc.

The minimum shell thickness of penstock shall be bigger than those given by the following empirical formula which is to avoid possible deformation in handling during fabrication, transport and field erection.

$$t_{min} = (D + 800) / 400$$

where, t_{min} : Minimum thickness of pipe shell (mm)
D : Inside diameter (mm)

The thickness of penstock shall be considered under the both cases of exposed type and embedded type .

<For exposed type>

$$t \geq H D / (2 \sigma a \, h) + \varepsilon$$

where, t : Thickness of pipe shell (cm)
D : diameter (cm)
H : Design head (kgf/cm^2)
σa : Allowable stress (kgf/cm^2)
h : Welding efficiency
ε : Corrosion allowance (cm) 0.15 - 0.2

<For embedded type>

$$t \geq \frac{0.5DH + \sqrt{[0.5]^2 + 24\alpha \ \sigma a M]}}{[2\sigma a \ n] + \varepsilon}$$

where, t : Thickness of pipe shell (cm)
D : Inside diameter (cm)
H : Design head (kgf/cm^2)
M : Maximum bending moment at pipe per 1 cm due to external pressure (kgf cm/cm)

a	:	Tensile stress/bending stress (kgf/cm^2)	0.7
σa	:	Allowable stress (kgf/cm^2)	
h	:	Welding efficiency	
ε	:	Corrosion allowance (cm)	0.15 - 0.2

(2) Gate and trashrack

(a) Design loads

The gate shall be designed with the worst or possible combination of the acting loads considering the operating conditions and the frequency of operation, etc. Loads to be considered fo the design of the gate are as follows :

<For gate leaf, and trashrack>

(i) Hydrostatic pressure : Water head difference between upstream and downstream sides of the gate and trashrack

(ii) Dead weight : Reaction due to self weight

(iii) Sediment pressure : The vertical force should be taken as the weight of sedimentary silt in the water.
The horizontal force should be determined from the following formula.

$$Pe = Ce\ W1\ d$$

where,	Pe	:	Horizontal force (tf/m^2)
	Ce	:	Sediment pressure factor (0.4 ~ 0.6)
	W1	:	Unit weight of sedimentary silt in water (tf/m^3)
	d	:	Depth from deposit level of sediment (m)

(iv) Wind load : The basic wind load of 20 kgf/m^2 for a vertical projected area shall be applied by the type of structures to be designed upon multiplying by the following corresponding factors .

For plane surface	1.2
For cylindrical surface	0.7
For lattice member at front side	1.6
For lattice member at rear side	1.2

(v) Operating load : Operating load shall be calculated in accordance with clause "Hoist".

(vi) Wave height due to earthquake : In calculating the wave height due to earthquake, the following formula shall be used.

$$he = k\tau / 2\pi\sqrt{gH}$$

where,
- he : Wave height (m)
- k : Seismic intensity of horizontal direction 0.15
- g : Gravity acceleration 9.8 (m/sec^2)
- t : Seismic period 1.0 (sec)
- H : Head water from the foundation ground (m)

(vii) Dynamic water pressure

during earthquake : In calculating the dynamic water pressure during earthquake, Westergard's formula shall be used as follows.

$$pa = 7/8\ Wo\ k\ \sqrt{Hh}$$

where,
- pa : Dynamic water pressure (tf/m^2)
- Wo : Specific weight of water (1.0 tf/m^3)
- k : Seismic intensity (0.15)
- H : Head water from the foundation ground (m)
- h : Water depth from the water surface (m)

(viii) Inertial force during earthquake :

Inertial force during earthquake shall be of the multiplication value the dead weight by the seismic intensity of 0.15.

(ix) All loads imposed during raising the gate due to the overload hoist or gate jammed conditions.

<For stationary type hoist>

(i) Dead weight of the gate leaf and ballast weight if any

(ii) Friction force due to rotating and/or sliding parts

(iii) Friction force due to seal rubbers and sediment

(iv) Buoyancy

(v) Uplift force and down pull force

(vi) All loads resulting from the maximum torque of hoist motor under gate jammed conditions

(vii) Closing force of all gates shall have an allowance of more than 25 per cent against the sum of all upward forces.

<For movable type hoist and crane>

(i) Horizontal inertia force and/or centrifugal force

(ii) Wind load

(iii) Braking load and other friction loads

(iv) Seismic load

(v) Closing force of all gates shall have an allowance of more than 25 per cent against the sum of all upward forces.

(b) Allowable stresses

In general, the allowable stresses on the design are obtained as follows :

(i) Tensile and compressive stresses (sa)

$\sigma a = 0.5\ \sigma y$

where, σy = yield point stress

(ii) Shearing stress (τas)

$\tau as = 0.3\ \sigma y$

The stress in the bar elements of trashrack shall not exceed the following critical stress.

$fcr = 0.6\ fy\ (1.23 - 0.0153\ L/t)$

where, fcr : Critical allowable stress (kgf/cm^2)

fy : Yield stress of the material (kgf/cm^2)

L : Laterally unsupported length of bar elements (cm), but $L \leq 70t$

t : Thickness of the bar elements (cm), decreased a corrosion allowance as specified

The allowable concrete bearing and shearing stresses shall be 60 kgf/cm^2 and 8 kgf/cm^2 respectively.

The attention should be paid to the fact that the allowable stresses on some materials tend to change by its characteristics as referred to in various standards.

(c) Deflection due to beam bending

The maximum deflection of main beams shall be less than the following value at full load against the supporting span.

$$Allowable\ deflection > \frac{Max.\ deflection}{Supporting\ span}$$

Kind	Allowable deflection
For metal touch seal type gate	1/1,000 - 1/5,000
For rubber seal gate	1/800 - 1/1,000
For trashrack	1/600

(d) Corrosion allowance

In the general practice, an extra thickness of 1.0 mm to 2.0 mm is added to the members normally submerged in water to cope with decrease of plate thickness due to corrosion or abrasion.

(e) Minimum thickness and critical slenderness ratio

(i) Minimum thickness of strength members = 6 mm

(ii) Critical slenderness ratio for buckling (i)

$i = l / r < 120$ for main compressive members

< 150 for secondary members

where, l : Buckling length of member (cm)
r : Minimum radius of gyration of member's sectional area

$$r = \sqrt{I/A}$$

I : Moment of inertia (cm^4)
A: Sectional area (cm^2)

Allowable stress should be reduced by this ratio for compressive members.

(f) Skin plate

The thickness of skin plate for gate is calculated by the following equation.

$$s = k a^2 P / (100 t^2)$$

where, s : Bending stress (kgf/cm^2)
k : Factors determined by b/a
a : Short side of a rectangle (cm)
b : Long side of a rectangle (cm)
P : Water pressure (kgf/cm^2)
t : Plate thickness (cm)

(g) Operating load

Operating load of the hoist is the sum of self-weight of gate leaf, self-weight of ballast if any, friction loads due to roller, bearing and sealing parts, and other loads.

(h) Operating speed

- For general use 0.3 - 1.0 (m/min)
- For emergency closure gate 1.0 - 5.0 (m/min)

(i) Motor output

The capacity of motor is to be more than those calculated from the following equation.

$$\text{Output} = (W V) / (6.12 h) \quad \text{(kW)}$$

where, W : Operating load (tf)

V : Operating speed (m/min)

h : Total efficiency obtained by multiplying respective efficiency of the mechanical parts as given below

Parts	Efficiency (Average)
1. Drum	0.95
2. Sheave (plane bearing)	0.95
3. Super & bevel gear	0.95
4. Cyclo gear reducer (gear ratio in 1/59 ~ 1/11)	0.80 ~ 0.85
5. Worm gear reducer	0.5

- Friction coefficient

Spindle screw	0.2
Worm gear screw	0.06 ~ 0.1

(j) Diameter of wire drum and sheave

- 19 times diameter of wire rope for drum
- 17 times diameter of wire rope for sheave

(k) Factor of safety of wire rope

In general, it should be more than 8 as calculated by the following equation.

$$8 > F / (L/N)$$

where, F : Breaking strength of the rope

L : Normal tensile force acting on wire rope

N : Numbers of wire rope to be used

The hoisting rope shall also withstand the loads due to maximum hoist motor torque, without exceeding 90 per cent of the yield strength.

(3) Valve

(a) Selection of valve

The type of valve shall be determined according to the discharge, head, installed location and required operation in consideration of entire construction cost including civil structure.

(b) Bore of valve

In general, the bore of valve is calculated by the following formula.

$$A = Qmax / (C \sqrt{2\ g\ Ho})$$

where,
- A : Area of inflow part of valve (m^2)
- $Qmax$: Projected maximum discharge (m^3/sec)
- C : Coefficient of discharge
- g : Gravity acceleration (m/sec^2) 9.8
- Ho : Minimum actual head (m)

$$Dv = \sqrt{\frac{4\ A}{\pi}}$$

where,
- Dv : Bore of valve (m)
- π : Circular constant

For sleeve valve

$$Dvmin = \sqrt{\frac{4Qmax}{(\pi\ Vmax)}}$$

where,
- $Dvmin$: Minimum bore of valve (m)
- $Qmax$: Projected maximum discharge (m^3/sec)
- π : Circular constant
- $Vmax$: Limited maximum velocity (m/sec)

(c) Coefficient of cavitation

The coefficient of cavitation is calculated by the following formula.

$$\sigma = (H2 + 10) / (H1 - H2)$$

where,
- σ : Coefficient of cavitation
  $\sigma > \sigma l$
- σl : Sleeve valve 0.2 ~ 0.4
- $H1$: Water head of primary side (mAq)
- $H2$: Water head of secondary side (mAq)

3. ELECTRICAL EQUIPMENT

3.1 General

This part has been prepared for giving explanation on the design criteria for the following major components of the electrical equipment provided for the Severino pumping station and Severino substation.

(a) Electrical motors
(b) Transformers
(c) Switchgears
(d) Switchboards and control boards
(e) DC power supply unit
(f) Emergency diesel engine generator unit

3.2 Standards to be applied

The standards to be applied to electrical equipment are basically JIS(Japanese Industrial Standard) and JEC(Standard of the Japanese Electrotechnical Committee). However, the following standards applied in various countries are also employed in design of particular items.

IEC	-	International Electrotechnical Commission
NEMA	-	National Electrical Manufacturers Association
ANSI	-	American National Standards Institute
IEEE	-	Institute of Electrical and Electronic Engineers
BS	-	British standard
DIN	-	Deutsches Standards Institute
ASTM	-	American Society for Testing and Materials
ASME	-	American Society of Mechanical Engineers
AWS	-	American Welding Society

3.3 Electrical Motor

(1) General provision

The electric motor has been in a wide range of use, less than 1 kW to thousands kW in output as a prime source of power to drive pumps and various types of machines. These are classified into the induction motor, synchronous motor, DC motor and AC commutator motor.

The small capacity induction motor mostly used is of cage rotor type and for great capacity, wound-rotor type is used. And in particular cases, the synchronous motor, DC motor and AC commutator motor are used.

The electric motor including the starting system and protective system should be selected in consideration of;

- load of the pump and characteristics of the motor
- reliability and durability
- difficulty or facility in maintenance
- costs of the equipment and operational costs

(2) Type

Structure of the three phase induction motor is endurable and simple in composition, easy of operation and maintenance. This type is therefore, used widely.

The three phase induction motor is classified into squirrel-cage rotor type and the wound-rotor type, according to the structure of rotor.

The conductor of the squirrel-cage induction motor is endurable and inexpensive. The wound-rotor is provided with insulated three-phase winding and slip ring.

Besides, in low tension pump of large capacity, the synchronous motor is more efficient than the induction motor, and by regulating the exciting circuit, power-factor can be adjusted and so it is convenient in a unit station operating another load of low power factor.

And DC machine, thylister motor and commutator motor are in use for variable speed motor in response to loads in special cases.

(3) Rated voltage, output and efficiency

The rated voltage is generally chosen according to the motor output as follows.

Rated Voltage of Motor

Motor output (kW)	Terminal voltage (V)
Under 75	220
45 - 150	440
75 - 1,000	3,300
Over 150	6,600
	13,800

Rated output of the motor is produced in succession in the shaft of the motor under the rated voltage and frequency. The rated output is expressed in kW.

Although the efficiency of motor varies in a degree with its type, rated voltage and pole number, and also with the manufacturer and the technique for recording the noise generated.

(4) Style

Types of the electric motor are classified into protection type, drip-proof type, splash-proof type, immersion- proof type, corrosion-proof type and outdoor type. These are adopted according to the installing location and environmental conditions.

The representative types of electric motors are as follows;

(a) Protective type

Open type, in which all openings are protected with wire net and the like to prevent contact of foreign matter with the rotating part (except the shaft surface) and conduction part. These openings should be protected from piercing by rod of 12 mm in diameter, provided that at the opening over 100 mm distant from the rotating and inducting parts, only the rod of 20 mm in diameter be used.

(b) Drip-proof type

Being open type, in which drips dropping perpendicularly or at less than 15° angle, directly, run along or repulsed by the surface of the motor body, enter it without contact with the iron core on the insulator.

(c) Splash-proof type

Open type, in which drip and foreign matter coming perpendicularly at less than 100° angle, not directly enter the inner part, passing along the surface of body or repulsed by the surface.

(d) Immersion-proof type

Drip-proof, horizontal, splash-proof type, in which even if the outside of the body is temporally immersed to the low part of shaft, operation is not interrupted.

(e) Corrosion-proof type

Open type or totally closed type used without any trouble in location where specified corrosive acid, alkali or poisonous gas present.

(f) Open, outdoor type

Protective type, in which rain, snow or dust prevented from entering the conduction parts to the minimum, of endurable structure.

(g) All closed outdoor type

Totally closed type of endurable structure to be used outdoors.

(5) Starting Mechanism

In the squirrel-cago three phase induction motor, in case of line-start, the starting current flows 500 - 800% of the rated current, so the current must be restricted by installing a starting device except the small capacity motor (usually less than 3.7 kW squirrel type and less than 4.5 kW special squirrel-cage type).

The three-phase motor should be provided with such starting device as is most adequate for the type and use of the motor except small capacities squirrel-cage type.

These starting system of these are shown below;

Type of motor	Starting device
Squirrel cage induction motor	Star-delta Starting compensator Reactor
Wound rotor induction motor	Start resistance

(a) Starting of the squirrel cago type induction motor

In the star-delta starting system, the starting current is reduced by lowering the voltage in the winding than the rating, connecting the stator winding of the motor to the star at the time of starting, and when speed of rotation fully rises, switched to the delta and the regular operation started with the rated voltage.

The starting system by the starting compensator and the reactor is to reduce the starting current by lower voltage than the rated by connecting the voltage in the terminal of the motor to the circuit of the starting at the time of starting. When the speed range fully rises, operation conducted by passing the rated voltage to the terminal of the motor by removing or short-circuiting the starting compensator or reactor.

(b) Starting of the wound-rotor type induction motor

In case of starting by connecting the resistance to the wound-rotor type induction motor, the starting current is lessened within a certain range, simultaneously with a comparatively great starting torque; this nature is utilized in the starting system of this type. By connecting the rotor winding to the outside resistor through slip-ring and brush and reducing the resistance value, acceleration from starting to full speed can be attained.

In this starting system the starting torque as in pump, can be limited to the starting current or under. In case the pump is operated for long after the starting, wear of the brush can be prevented by fixing a device which automatically short-circuit the slip-ring after the starting and lifts the brush.

As to the resistor for starting, the stainless plate-made resistor is generally employed rather than the liquid one from viewpoint of maintenance.

The heat capacity of resistor for the starting is made as to meet the starting time as required by respective application for control of the speed of rotation, therefore, by means of a secondary resistor, larger one needed.

(6) Control of Revolution

In controlling the speed range of motor, such techniques as are required by the features of the facilities shall be employed.

The principle techniques used to control the speed range for load are as follows;

(a) Secondary resistance system

By putting a resistance in the rotor of induction motor through slip-ring and by converting this resistance value, control of the speed range can be attained. The slide loss of the motor is emitted from resistor in the form of heat.

Although the loss is great, the speed range can be controlled rather simply around 95-70% of the synchronous speed, and comparatively inexpensive.

(b) Scherbius system

This is a system to return the secondary power of the wound-rotor motor to the source. The secondary power is rectified to direct current by silicon diode.

The devices to return direct current to the electric source includes the rotor type (M-G Scherbius) using direct motor and AC generator and stationary type (thylister Scherbius) using separately excited thylister inverter.

Recently the thylister Scherbius has been technically developed by improvement of the rectifier, providing an easy treatment and maintenance and comparatively low cost of equipment, and is in popular use.

Different from Craemer system, the control device can be installed separately from the main units, with the advantage of facile maintenance and inspection, but in comparison with thylister system, maintenance of brush and noise are its demerits.

The range of the revolution speed control is about 92 - 50 % of the synchronous speed in all cases.

(c) Creamer system

The system aims to control the speed range by adjusting the electromotive force on the secondary side of the wound rotor type motor by regulating the exciting current of DC motor by mechanically connecting the DC motor with the wound-rotor induction motor. The control range of revolution speed is nearly same as Scherbius system in (b) above.

The characteristic of this system are constant output featured by adding electrical input of the DC motor to mechanical output of prime motor.

In case of employing the vertical shaft type, the height of the building becomes great, and for the horizontal shaft type, the installation area becomes comparatively large.

As to the costs of the equipment, economical effects are slight unless the capacity exceeds a certain range.

In addition, as a special Craemer system, there is a non-commutator Creamer (thylister Cramer)system. In this system, the operation can be continued without stopping even in case of a momentary power interruption (about 0.6 sec.). And saving of maintenance labor, especially with great output, proves beneficial.

(d) Thylister system

This is a system used with the squirrel-cage induction motor and the synchronous; there are cyclo-converter system (by use of Thylister, AC source of variable frequency and variable voltage can be produced from electric source frequency) to rotate and control the electric frequency by directly making variable frequency source from the commercial electric source, and the system to rotate and control the motor by making variable frequency electric source with the inverter, converting to the direct current by Thylister converter from the commercial electric source.

These systems are, any of them, suitable for medium and small output motors, because they afford controlling of high precision and broad scope of application.

(e) Other systems

As other systems there are pole conversion system, and systems using as prime motor, AC commutator or DC motor, but these are in rare use.

(7) Protective devices

As for protection device for the electric motor, the following shall be observed;

- Never fail to installed a proper breaking device for overload and abnormally low voltage.
- An interlocking device shall be provided each between the switch, the starting device and the secondary short-circuit device to prevent misoperation

In the switch board or box device preventing an excessive load and abnormally low voltage, shall be installed for prevention of burning damage by an excessive load in the motor and danger brought about by the recovered transmission after power suspension.

(a) In the case of low tension motor

The electromagnetic switch with thermal expansion interruption device shall be installed, and if there is no such device, a single negative-phase protective relay must be provided.

(b) In case of high tension motor

Sufficient-capacitied interruption device with an overcurrent relay or overload relay and abnormally low voltage relay must be installed. In the case of combination (combination starter) of electric fuse and electro-magnetic contactor without an interruption device, 3E relay should be installed.

(c) Interlock

This standard has been established for prevention of electric accidents due to an error in the operation process for the wound-rotor type induction motor equipped with a starting regulator (or starting resistor). This is safety device which interrupts the operation of breaker without returning of the start regulator (or starting resistor) to the starting condition.

3.4 Transformers

(1) Type

Both oil-immersed type and dry type are available depending on the insulation method.

(a) Oil-immersed transformers

This comprises the inner assembly containing the main portion of core and winding, the outer box assembly containing insulating and cooling oil, and bushings for connecting the inner and outer conductors.

Depending on the oil preservation types, the oil-immersed breather type, oil immersed nitrogen-sealed type and oil-immersed air-sealed type are available.

Three cooling methods are available; self-cooling, forced-air cooling and water cooling.

(b) Mold and dry type transformers

Windings are molded with heat-resisting class H epoxy resin having self-extinguishing properties. Thus, this transformer has no danger of fire or explosion and its insulation is very stable against dust and moisture. Also, its coils create no looseness and this makes inspection and maintenance easier. When compared to the oil-immersed type, the size and weight are smaller.

(2) Capacity

(a) Main transformer for pumping substation

The capacity shall be the total of simultaneous load for pumping motors and station service with a certain degree of allowance, converted to the apparent power (kVA). To covert kW into kVA, the total value of the electric load must be divided by the total power factor.

The load equipment is rarely operated by the rated output. Generally, the design load output and power factor include some error, and it is desirable to increase a degree for the load value.

In calculation of the capacity, the total load capacity (kVA) should be divided by the total power factor, with about 10 - 20 % allowance.

(b) Station service transformers

Load in pumping station service are determined by DC power supplies, auxiliary equipments, lighting facilities and building appurtenant equipment.

(3) Voltages

(a) For main transformer

The voltage of transmission line is applied to primary winding, and the pumping motor voltage is taken from the secondary winding.

The transmission line voltage utilized in Manabi area is 138 kV and the pumping motor voltage is determined based on the capacity of pumping motor among 3.3 kV, 6.6 kV and 13.8 kV.

(b) For station service

The pumping voltage is applied to the primary winding, and the secondary winding is determined based on the voltage for station loading equipment. The low voltage system in Ecuador is 230 V, three phase and 115 V, single phase. Therefore, the secondary winding voltage is selected to 230 V, three phase. As a special case, 400 V, three phase may be adopted considering the capacity of auxiliary equipment.

(4) Connections

The following methods are available as typical connecting method.

(a) Delta - delta connection

This is suited to distribution transformer with capacity of lower than 33 kV.

(b) Star - star connection

This is hardly used for transmission. But connection with a delta stabilizing winding is need as tertiary winding.

(c) Star - delta or delta - star connection

Star - delta connection is used for step-up transformer in power station and delta - star connection for step-down transformer in receiving substation.

(5) Tap-changer

The tap-changer is of off-circuit type or on-load type considering the voltage variation due to load variation during a certain period. In the pumping substation, the pumping motor voltage can be effectively controlled by pump load control and on-load tape changing is therefore unnecessary.

(6) Temperature rise

Allowable temperature rise for the main transformer are as follows.

Winding	:	65 ° C (resistance method)
Top oil	:	60 ° C (thermometer)

3.5 Switchgears

(1) Circuit breakers

Circuit Breakers are important for the operation of the power system. Where troubles occurs in the power system or the connected load, the breakers instantaneously interrupt the power and disconnect the trouble points.

Various kinds of circuit are avilable and are selected depending on the voltage, the current and short-circuit current.

Special-high voltage (240, 138 and 69 kV)	:	Gas circuit breaker(GCB) Air circuit breaker(ACB) Oil circuit breaker(OCB)
High voltage (13.8, 6.6 and 3.3 kV)	:	Vacuum citcuit breaker(VCB) Air circuit breaker Oil circuit breaker
Low voltage	:	Air circuit breaker Molded case circuit breaker(MCCB)

(2) Disconnecting switches

These switches do not have ability of switching the load current. They are selected depending on the voltage and current used.

(3) Instrument transformers

Instrument transformers are used for transforming the high voltage or large current into a proportional low voltage or small current which is to be used for instruments and protection relay. There are potential transformers(PT), current transformers(CT), grounding type potential transformer(GPT) and zero phase sequence current transformer(ZCT). These are available and are selected depending on the voltage and the current. The dry resin mold type has been mostly used for high voltage and low voltage circuits.

(4) Lighting arresters

These are installed in order to protect the equipment against lightning surge and can restrict the lightning surge.

(5) Surge absorbers

The surge absorbers consist of arresters and capacitors. The surge absorbers are not only for reducing the crest value of entering surges as a result of the discharge of lightning arresters and protecting the insulation to the ground but also for reducing the steepness of wave front by means of the capacitor absorbing effect, thereby protecting the insulation of motor windings.

(6) Power factor improving capacitors

In order to improve the system of the power factor, power capacitors are somtimes connected. They are called the power factor improving capacitors.

(7) Air-load breaker switches

These are used in high voltage AC lines for switching the lines. The load current can be switched but can not be switched short-circuit of the line.

(8) Power fuses

Fuses for voltages greater than 1,000 V are normally called power fuses.

3.6 Switchboards and Control Boards

The switchboard contains switchgear for transmitting the received power and the control board mount devices for supervising and controlling the operation of the pump and motor.

(1) Type

These can be classified below.

Appearance and construction	:	Self-standing vertical type,stand type, desk type, wall-mounted type.
Protecting construction (ordinary)	:	Open type, semi-enclosed type,) enclosed type, indoor type, outdoor type.
Protecting construction (special)	:	Drip-proof type, dust-proof type, corrosion-proof type, explosion-proof type.
Door designation	:	Front door type, rear fixing type, front and rear door type

Indoor, self-standing vertical enclosed type are normally utilized in pumping stations. Instruments and operating switches are attached on the front panel, and the hooked rear panel is adopted in many cases.

(2) Configuration

The switchboard configuration varies depending on the system arrangement. That is, the configuration and dimensions of switchboards greatly vary depending on whether the motor is high or low voltage type, whether the transmission switch gear is of special-high, high or low voltage type and also depending on the kind of protective relay and of the DC power supply unit.

In addition to the above, control switch board such as motor control panels, protective relay panels, motor starting panels and automatic control sequence switchboard, and DC power supply panels are used in the pumping station.

3.7 DC Power Supply Unit

A DC power source is used as the operating power source for circuit breakers and so forth, and also as control power source for supervisory control.

Also, this unit may be used as DC power source unit of motor-operated regulating machine and valves for small scale.

The DC power source unit consists of batteries and chargers.

(1) Storage batteries

Vent, clad type and seal, clad type lead storage battries are normally used.

The batteries have some feature as follows;

- Long life
- Suited to the case where the ripple or load fluctuation are large or where the ambient temperature is high

Sintered type and pocket type alkaline storage batteried are available, but the pocket type is normally used.

Both vent type and seal type are available for the pocket type. These feature is as follows;

- Suited to various uses ranging from short-time discharge to longtime discharge
- Installation space is more advantagous compared to lead storage batteries
- Seal type requires no water supply for a long period and is better for maintenance
- Long life

(2) Chargers

These are rectifiers for charging batteries and supply the electric power to battery load required.

To lengthen the life of storage battery and save the trouble of charging, it seems desirable for charging of battery to employ the floating type and it is still better to use automatic charging system.

3.8 Emergency Diesel Engine Generator Unit

(1) Type

Care must be used for the following in selecting diesel engine.

- To adopt on engine of high or medium speed.
  The classification of high, medium and low speed is not clear, but roughly, less than 500 rpm is called low speed, 500 - 1,000 rpm for medium speed and upwards of 1,000 rpm for high speed. The low speed engine is high-price, having the large weight and size.

- In the case of penumatic starting with engine of cylinders
  There is non-starting part in the air distributing valve, so not suitable for automatic operation.

- For diesel engine, there are two type (four-cycle engine and two-cycle engine).

Generally four cycle engine is superior in the respects such as low vibration, endurance, maintenance, low exhaust sound and fuel consumption, but two-cycle engine for the same output is generaly low in price.

(2) Output

Capacity of the generator and output of the diesel engine should be the largest value of the following items;

- Constantly required capacity
- Capacity required in starting of the largest load electric motor
- Capacity required by allowance value in voltage falling at the time of starting of the largest load electric motor

These three point should be checked and the greatest value in each should be adopted. Capacity of the generator and output of the engine should be continuous rated value.

(3) Appurtenant equipment

Since the switch-board is used for operation cotrol, protection and monitoring of equipment, it should be determined in consideration of capacity, characteristics and locational conditions.

In case of switch-over to commercial electric source, parallel connection between the exclusive-use motor source and commercial electric source is dangerous and so a switch-over is required to be provided with interlock for preventing parallel connection.

In the diesel engine, fuel tank, starting device and cooling-water equipment should be installed.

The fuel tank shall be installed 1 - 2 m higher than the top of engine, the fuel sent to the engine by gravity, and the capacity should be such as capable of operation with total load for ten hours. For the necessity of long hour's operation and for emergency like hurricane. etc., the oil is sent to the fuel tank by fuel pump. And in case of feeding the fuel tank from drum can, it should be pumped by manual pump.

For starting mechanism of diesel engine, there are two systems. ie. penumatic and electric. In the pneumatic system, the tank of compressed air and air compressor must be provided. In the electric system, accumulator and charger must be provided. The starting motor is usually of DC 24 V, and capacity of accumlator should be capacity of more than three times operation.

For diesel engine except that of small size air-cooled system, cooling water for the cylinders and lubricating oil are required, so that cooling water facilities such as suitabe water source and water tank must be provided.

It is desirable to install a ceiling cran or hoist where a large size diesel engine is installed.

4. TRANSMISSION LINE

4.1 Applied Standard

The standard to be applied for the Project will be basically IEC (International Electrotechnical Commission) standards, JIS (Japan Industrial Standards), JEC (Japanese Electrotechnical Committee) standards, other international standards and design practices applied in Ecuador, Japan or international market will also be used in the design of particular items.

4.2 Transmission Line Route

The route shall be selected in consideration of easy economical construction, operation and maintenance of the line, selected route of the transmission line is shown on Figure 4.3.6 of Main Text. The route length is approximately 32 km.

4.3 Basic Features of Transmission Line

Basic features of transmission line are as follows.

(1)	Transmission line voltage:	AC 138 kV, 3 phase
(2)	Power frequency	60 HZ
(3)	Nos. of circuit	1 CCT
(4)	Conductor	336 MCM equivalent to ACSR Oriole (170 mm^2) single conductor.
(5)	Overhead earth wire	55 mm^2 galvanized steel stranding wire, two wires.
(6)	Design condition for sags of conductor	

(a)	Most severe design condition:	Maximum wind pressure under minimum conductor temperature
(b)	Max. wind pressure on conductor:	20 kg/m^2
(c)	Max. conductor temperature:	60 °C
(d)	Average conductor temperature:	25 °C
(e)	Minimum conductor temperature:	5 °C

(f) Ultimate tensile strength: 7,590 kg

(7) Maximum working stress of conductor: 2,500 kg

(8) Maximum sags and minimum sags of conductor at equivalent span length of 350 m are shown as follows.

Span length (m)	100	200	300	350	400	500	800	1.000
Max. sag (m)	0.56	2.22	4.97	6.80	8.88	13.87	35.52	55.50
Min. sag (m)	0.48	1.92	4.31	5.87	7.66	11.98	30.66	47.90

4.4 Insulator

(1) Type of insulator unit: Ball and socket type toughened glass or porcelain standard suspension insulator of 254 mm in diameter and 146 mm spacing.

(2) Electrical and mechanical characteristics

(a) Minimum flashover voltage

Power frequency	:	dry:	78 kV
-do-	:	wet:	45 kV
50 % impulse	:	positive	120 kV
-do-	:	negative:	125 kV

(b) Minimum withstand voltage

Power frequency	:	dry:	70 kV
Power frequency	:	wet:	40 kV

(c) Electromechanical failing load : 12,000 kg

(3) Insulator Sets

(a) Normal system voltage : 138 kV

(b) Maximum operating voltage : 155 kV

(c) Switching surge : 355 kV

(d) Required withstand voltage.
for switching surge : 391 kV
for short period over-voltage : 128 kV

(e) Required nos. of insulator unit : 10 units for tension set
9 units for suspension set

(f) Withstand voltage of insulator sets :

for switching surge : 575 kV for tension set
530 kV for suspension set
for short period over-voltage : 330 kV for tension set
300 kV for suspension set

(g) Length of insulator set : 1,460 mm for tension set
1,314 mm for suspension set

(h) Design horn, gap length : 1,170 mm for tension set
1,050 mm for suspension set

(i) Impulse withstand voltage of horn gap : 520 kV for tension set
480 kV for suspension set

(j) Power frequency withstand voltage of horn gap : 340 kV for tension set
310 kV for suspension set

4.5 Support

(1) Type of towers.

Self-standing and broad base galvanized steel lattice type on concrete foundation.

(2) Height of towers.

(a) Body and hill side extension: 3 m and 1 m each step.

(b) Minimum ground clearance of conductors.
(i) Above general terrain: 8 m
(ii) Above major road: 10 m
(iii) Above other lines: 4 m

(3) Typical type of towers

Five (5) kind of towers will be provided corresponding to horizontal angle deviation according to expected route map, named by type-SA, LA, MA, HA and TA which are used for the tower point for horizontal deviation of up to 2, 20, 40, 60 degree and terminal tower or up to 90 degree of horizontal angle tower.

(4) Design load.

(a) Wind load

(i) On power conductor and overhead earthwires: 39 kg/m^2
(ii) On tower structure: 60 kg/m^2
(iii) On insulator sets: 30 kg/m^2

(b) Maximum working tensions of power conductor and earthwires.

(i) Power conductor: ACSR Hawk: 2,500 kg
(ii) Overhead earth wire: galvanized steel stranded wire 55 mm^2: 1,050 kg

(c) Vertical load

(i) Tower structure:
Actual weight of tower structure with accessories
(ii) Power conductors:
Weight of conductors of specified weight span
(iii) Over head earth wires:
Weight of earth wires of specified weight span on tower members, reaction of temporary back stays during stringing.
(iv) Such load as worker's weight on tower members, reaction of temporary back stays during stringing

(d) Horizontal angle effect of power conductors and overhead earthwires: Horizontal component of maximum working tension of conductors and earthwires due to the specified horizontal angle deviation.

(5) Design Condition

(a) Assumed normal loading condition.

Following loads are assumed to work simultaneously on a tower.

(i) Vertical loads

(ii) Transverse loads:
Wind loads and horizontal angle deviation effects

(iii) Longitudinal loads:
Wind loads and erection loads but together with maximum working tension of power conductors and overhead earthwires for their termination for type TA tower.

(b) Assumed broken-wire condition

Under the condition, any one (1) power conductor or any one (1) earthwire is assumed to be broken at their maximum working tension in addition to the loads under the normal condition.

(c) Factor of Safety

Following factors of safety to tower structures are taken in design

(i) More than 1.5 for the synthetic maximum load under the normal loading condition.

(ii) More than 1.1 for the synthetic maximum load under the broken-wire condition but 1.5 for cross-arms.

(d) Application of towers

For applying the specified types of towers for the selected tower positions economically, angle-span chart is used in the profile design.

(e) Tower Foundation

Sub-soil conditions at all tower positions will be examined by a construction contractor using a soil sounding equipment for obtaining general information of sub-soil characteristics.

Results of the tests will be used for determination of foundation type.

Standard foundations are of concrete pad and chimney type and are classified into the following types.

Type of Foundation	Ultimate Bearing Capacity (ton/m^2)	Unit weight of Soil (ton/m^3)	Angle of Repose (degree)
Light (L)	60	1.6	30
Medium (M)	40	1.5	20
Heavy (H)	20	1.4	10

TABLES

Table 1.1 Recommended Abbreviations (1/4)

General use

A.	and	&	automatic	auto.
	alternate	alt.	auxiliary	aux.
	alternating current	A.C.	average	avg.
	approximate	approx.		
	at (spacing)	@		
B.	benchmark	B.M.	beam	bm.
	bituminous	bitm.	bearing	brg.
	bridge	br.		
C.	capacity	cap.	column	col.
	cast iron	C.I.	cover	cov.
	center line	C	cubicle	cub.
	center to center	c to c	constant	const.
	coefficient	coef.		
	control point	C.P.		
D.	diameter	dia	down	Dn.
	direct current	D.C.	downstream	d/s
	ditto	do	drawing (s)	Dwg(s)
E.	each	ea.	expansion	exp.
	enclose	encl.	engineer	engr.
	end to end	e to e	equipment	equip.
	equivalent	equiv.	excavation	exc.
	etcetera	etc.	elevation	EL.
	existing	exist.		
F.	figure	Fig.	flange	flg.
	finish	fin.	flat bar	F.B.
	fixed	fix.	flexible	flex.
G.	galvanized	galv.	governor	gov.
	generator	gen.		
H.	head	hd.	highway	Hwy
	horizontal	horiz.	hydraulic, hydrant	hydr.
	hexagonal	hex.		

Table 1.1 Recommended Abbreviations (2/4)

I.	inside diameter	i.d.	invert	inv.
	inch	in.		
	including	incl.		
J.	joint	jt.		
K.	kip (1,000 b)	k		
L.	lateral,latitude	lat.	Live load	L.L
	limit	lim.		
M.	maximum	max.		
	minimum	min.		
	miscellaneous	misc.		
N.	number	No. or #		
O.	outside diameter	o.d.		
	opposite	opp.		
P.	percent	%	Point	Pt.
	plate	PL or PL		
R.	radius	R	required	req'd
	railway	Rlwy.	revision	rev.
	roadway	Rdwy.		
	reference	ref.		
	reinforcement	reinf.		
S.	sheet	sht.	substation	substa.
	square	sq.	substructure	substr.
	steel	st'l	superstructure	supstr.
	standard	str.	symmetrical	symm.
	station	sta.	synchronous	syn.
	stiffener	stiff.		
T.	temperature	temp.	typical	typ.
	transformer	Tr.	thickness	thk.
	transverse	transv.	transmission line	T.L.
U.	unfinished	unfin.	upstream	u/s

Table 1.1 Recommended Abbreviations (3/4)

V.	ventilate	vent.	volume	vol.
	verse, versus	vs.	vertical	vert.
W.	washer	wash.	weight	wt.

<u>Unit</u>

Elevation	El.	centigrade	°C
milimetre	mm	watt	w(or W)
centimetre	cm	kilowatt	kw (or kW)
metre	m	megawatt	MW
kilometre	km	kilowatt-hour	kW (or kW)
million cubic meter	MCM	volt	V
gram	g	ampere	A
kilogram	kg	kilovoltampere	kVA
ton	t	revolution per minute	rpm
hour	hr	hectare	ha
degree	°	horsepower	hp(or HP)
minute	min(or ')		
second	sec, s(or ")		
cubic metre per second	cms		

<u>Structure</u>

Block	BL.
contraction joint	cont. jt.
construction joint	const. jt.
expansion joint	exp. jt.
column	col.
building	bldg.

<u>Material</u>

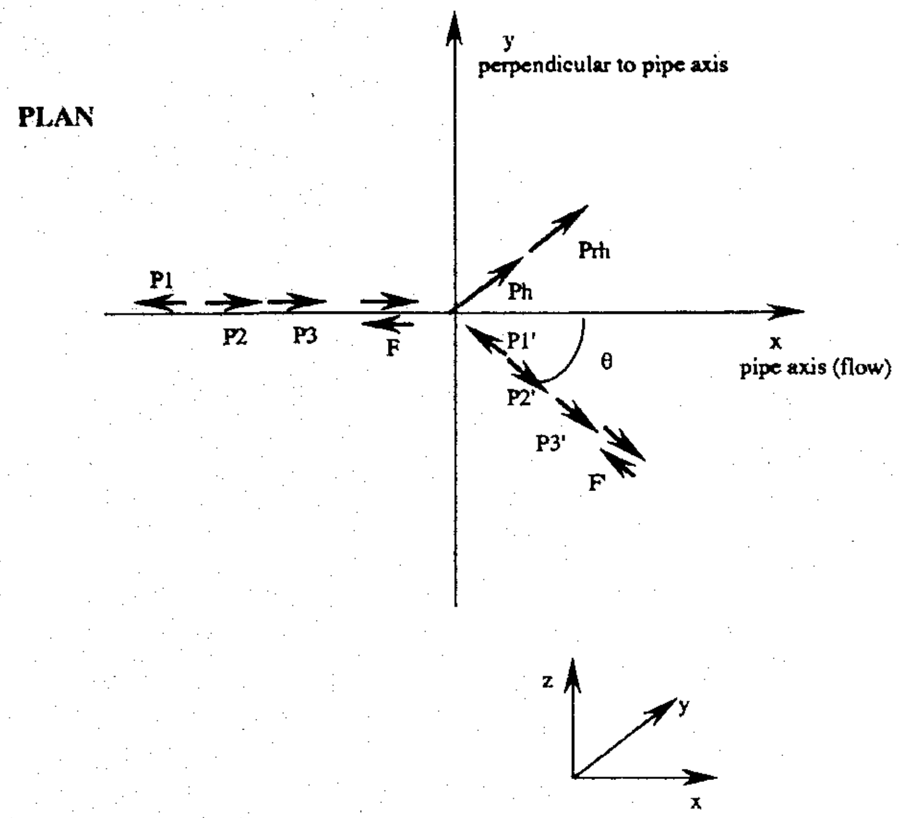
concrete	conc.	polyvinyl chloride	PVC
steel	st'l	reinforcerd	reinf.
cast iron	C.I.	galvanized	galv.
flat bar	F.B.		

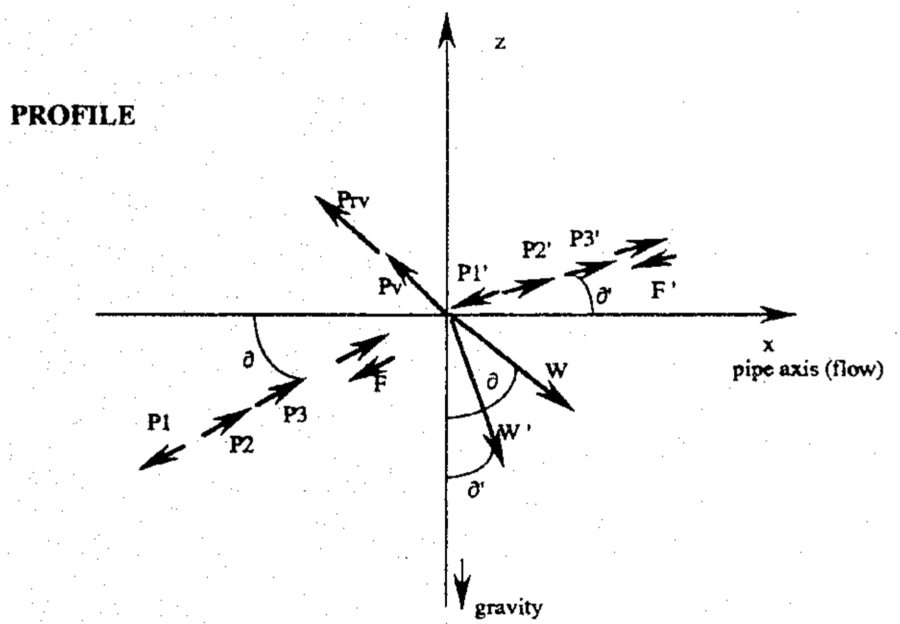
Table 1.1 Recommended Abbreviations (4/4)

Curve and Bend		
	radius	R.
	intersecting point	I.P.
	intersecting angle	I.A.
	curve length	C.L.
	tangent length	T.L.
	secant length	S.L.
	beginning point of curve	B.C.
	ending point of curve	E.C.
	tangent point of curve	T.P.
	beginning point	B.P.
	ending point	E.P.
Hydraulic		
	full supply level	F.S.L.
	minimum operation level	M.O.L.
	flood water level (or surface)	F.W.L. (or F.W.S)
	normal high water level	N.H.W.L.
Electrical		
	generator	gen.
	transformer	tr.
	exciter	ex.
	cubicle	cub.
	low tension	L.T.
	motor control center	M.C.C.

FIGURES

FIGURE 1.1





GOVERNMENT OF THE REPUBLIC OF ECUADOR CENTRO DE REHABILITACION DE MANABI (CRM) *THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS*	TITLE Direction of Thrust
JAPAN INTERNATIONAL COOPERATION AGENCY	

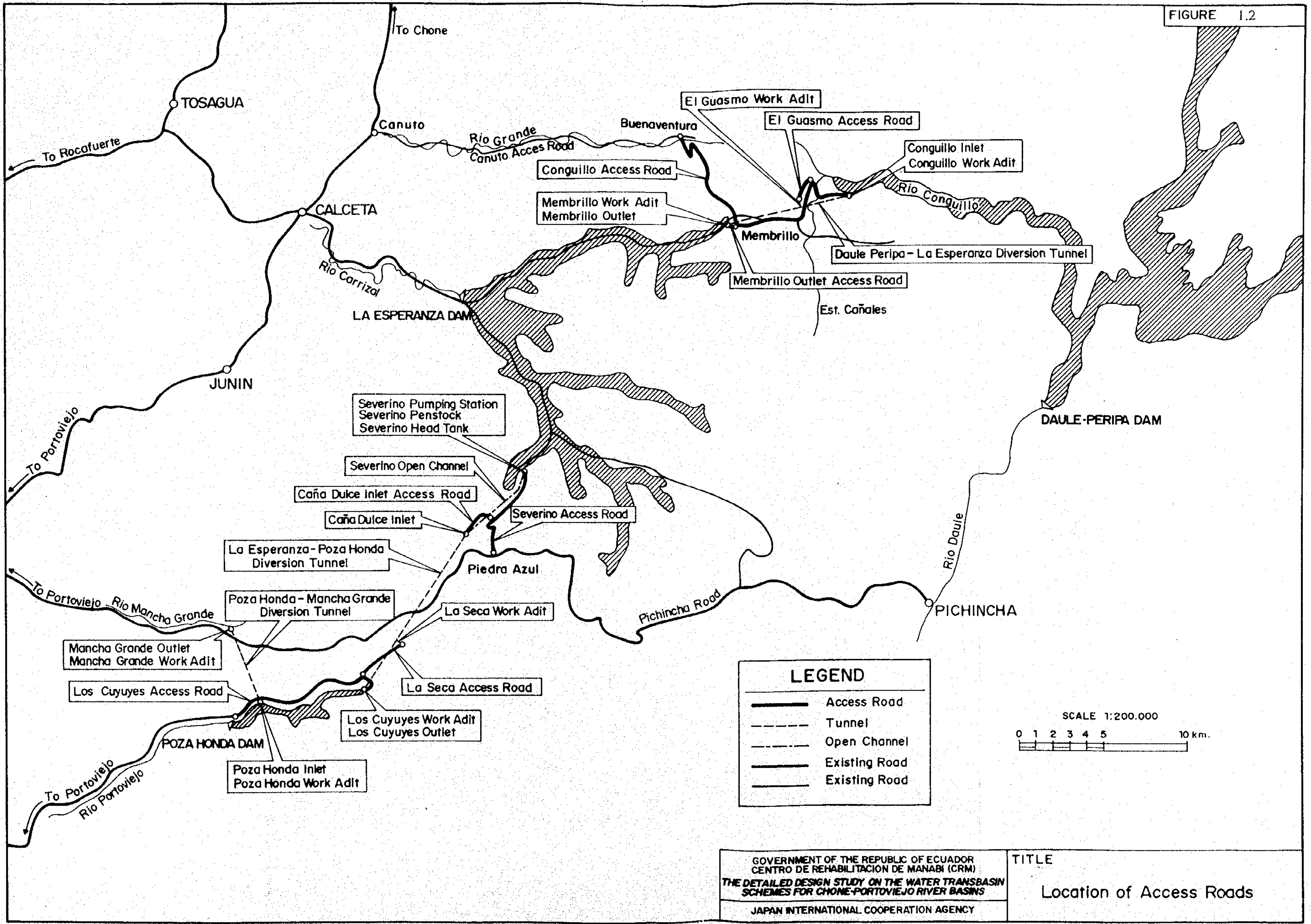
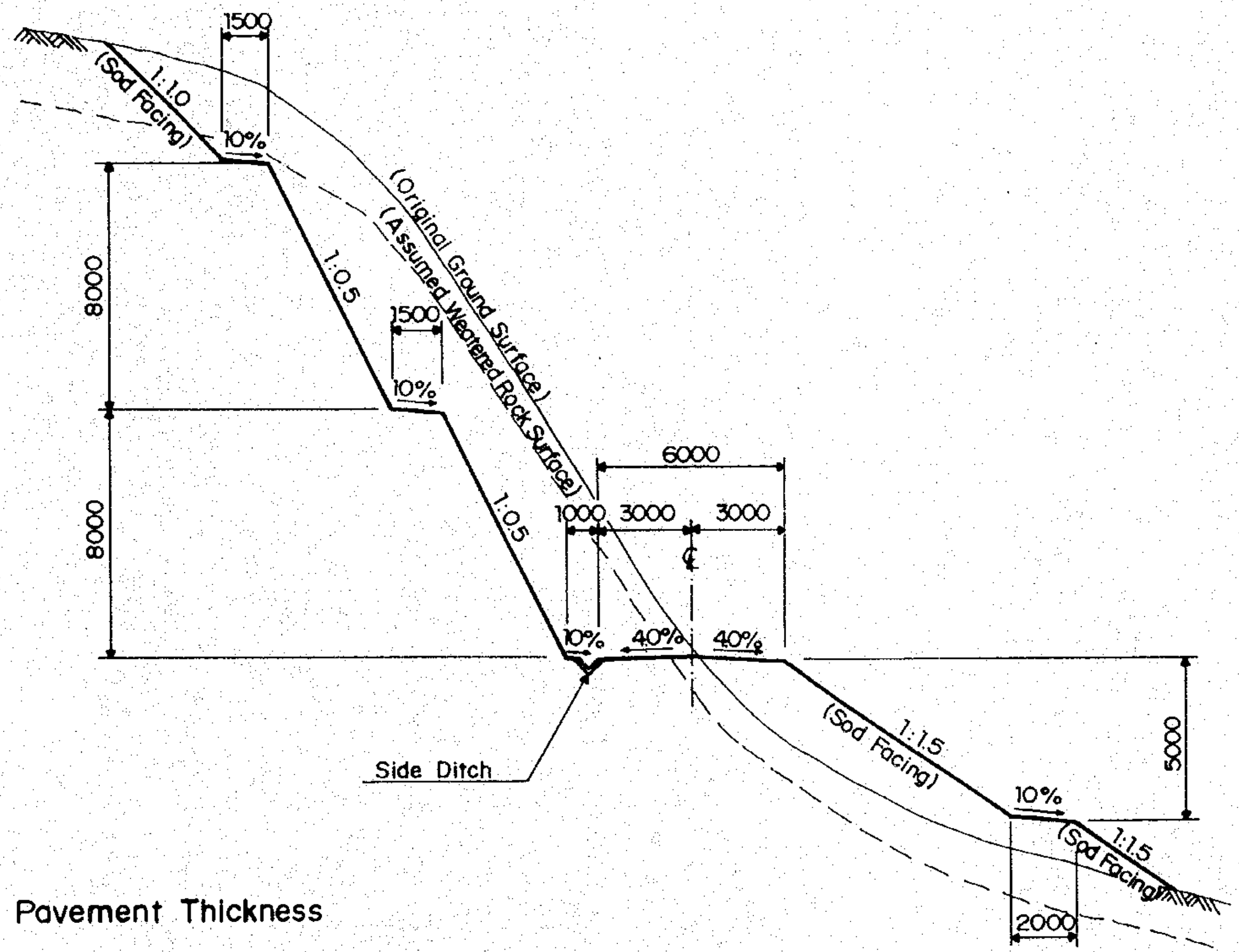


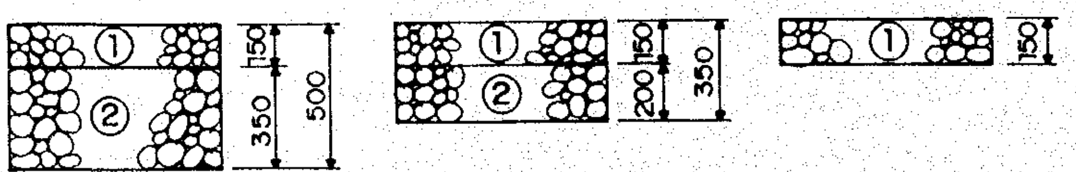
FIGURE 1.2
To Chone
TOSAGUA
To Rocafuerte
Canuto
Rio Grande
Canuto Acces Road
Buenaventura
El Guasmo Work Adit
El Guasmo Access Road
Conguillo Inlet
Conguillo Work Adit
Conguillo Access Road
Rio Conguillo
CALCETA
Membrillo Work Adit
Membrillo Outlet
Membrillo
Daule Peripa - La Esperanza Diversion Tunnel
Membrillo Outlet Access Road
Est. Cañales
Rio Carrizal
LA ESPERANZA DAM
JUNIN
To Portoviejo
Severino Pumping Station
Severino Penstock
Severino Head Tank
DAULE-PERIPA DAM
Severino Open Channel
Caña Dulce Inlet Access Road
Caña Dulce Inlet
Severino Access Road
La Esperanza - Poza Honda
Diversion Tunnel
Piedra Azul
Rio Daule
To Portoviejo
Rio Mancha Grande
Poza Honda - Mancha Grande
Diversion Tunnel
La Seca Work Adit
Pichincha Road
PICHINCHA
Mancha Grande Outlet
Mancha Grande Work Adit
La Seca Access Road
Los Cuyuyes Access Road
Los Cuyuyes Work Adit
Los Cuyuyes Outlet
POZA HONDA DAM
Poza Honda Inlet
Poza Honda Work Adit
To Portoviejo
Rio Portoviejo
LEGEND
Access Road
Tunnel
Open Channel
Existing Road
Existing Road
SCALE 1:200.000
0 1 2 3 4 5 10 km.
GOVERNMENT OF THE REPUBLIC OF ECUADOR
CENTRO DE REHABILITACION DE MANABI (CRM)
THE DETAILED DESIGN STUDY ON THE WATER TRANSBASIN SCHEMES FOR CHONE-PORTOVIEJO RIVER BASINS
JAPAN INTERNATIONAL COOPERATION AGENCY
TITLE
Location of Access Roads

FIGURE 1.3



Determination of Pavement Thickness

CASE A	CASE B	CASE C
Design CBR ≦ 3%	3% < Design CBR < 12%	12% ≦ Design CBR



① Granular Material ≧ Corrected CBR 60
② Material of Subgrade Improvemet ≧ Corrected CBR 12

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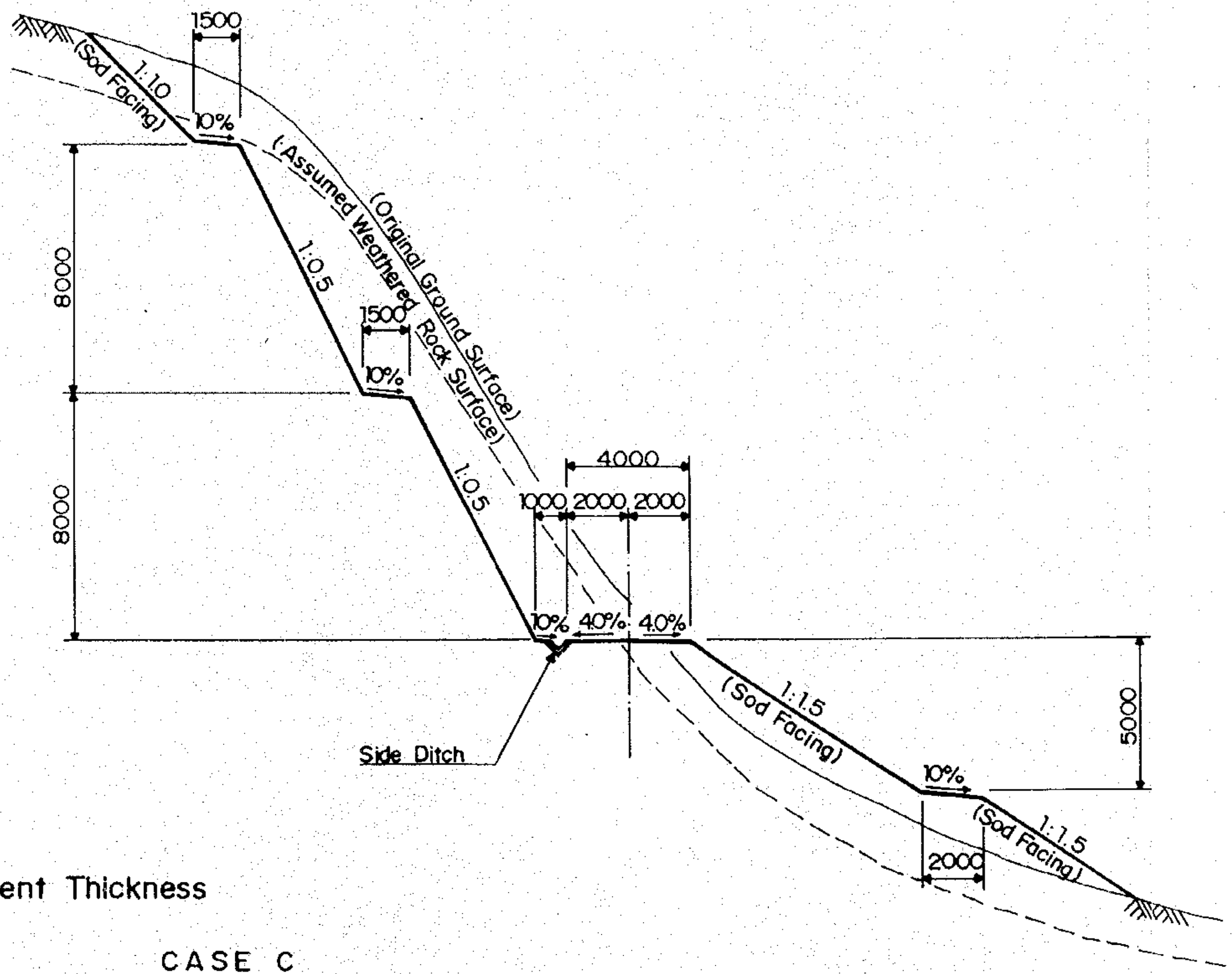
JAPAN INTERNATIONAL COOPERATION AGENCY

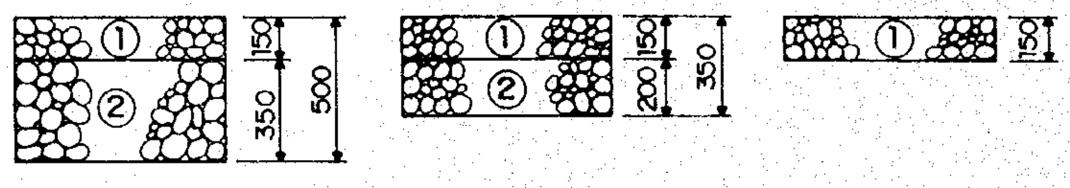
TITLE
Typical Section of Permanent Access Road

FIGURE 1.4



Determination of Pavement Thickness

CASE A	CASE B	CASE C
Design CBR ≦ 3%	3% < Design CBR < 12%	12% ≦ Design CBR



① Granular Material ≧ Corrected CBR 60

② Material of Subgrade Improvemet ≧ Corrected CBR 12

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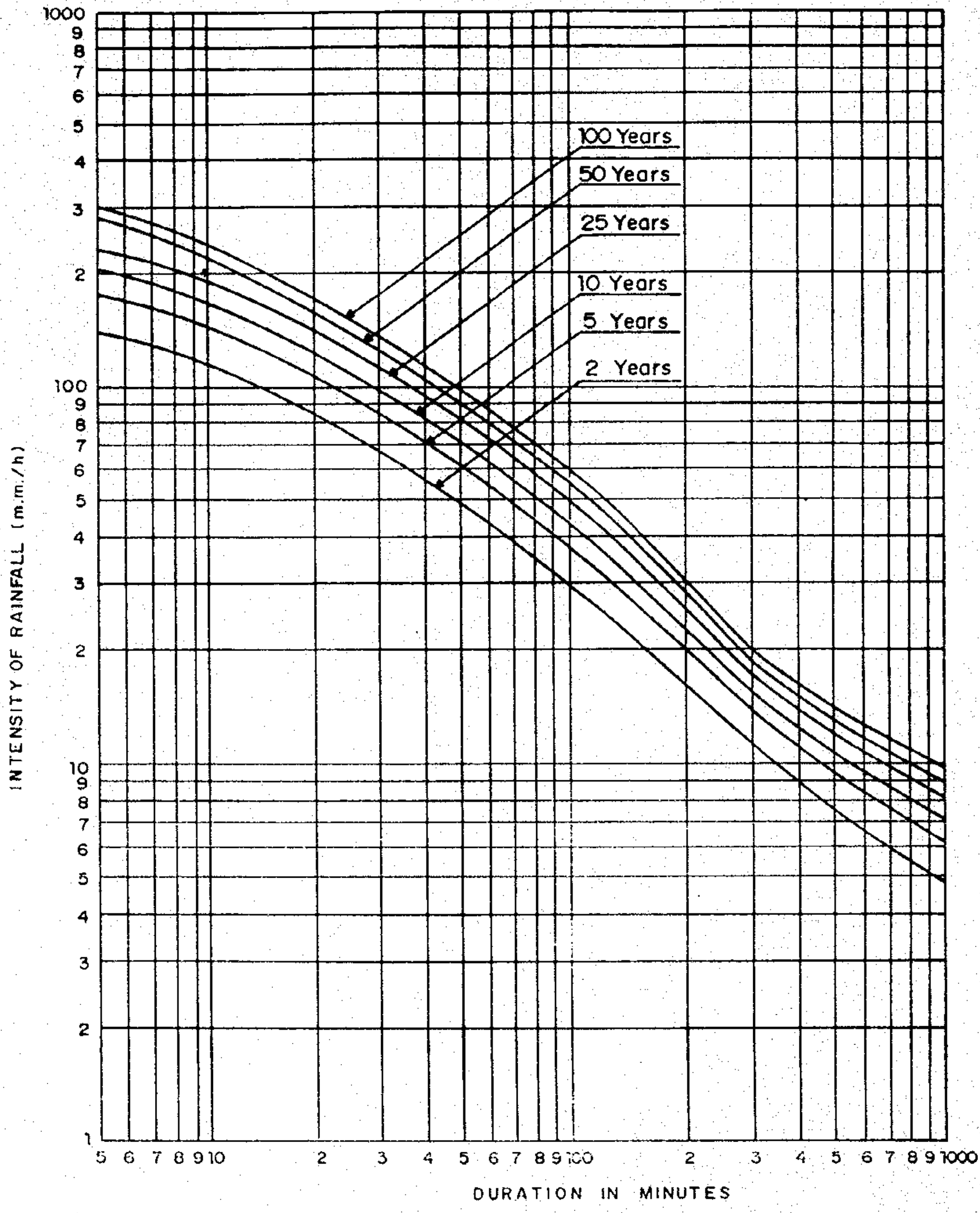
TITLE
Typical Section of Temporary Access Road

FIGURE 1.5



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TITLE

Rainfall Intensity Curve in Zone 1

FIGURE 1.6

Line	Description	Thickness
	Reinforcement bar	0·5 mm
	Boundary, Outline Visible part of works	0·5~ 0·3 mm
	Original ground line Earthfill, Backfill Excavation line	0·2 mm
	Dimension line, Extension line	0·1 mm
	Invisible, Hidden part	0·5 ~ 0·2 mm
	Center line Imaginary line, Alternative	0·2 ~ 0·1 mm
	Outline at adjacent structure	0·4 ~ 0·2 mm
	Showing parts partially broken	0·2 mm
	Original contour line (hidden part)	0·3 ~ 0·1 mm
	Break line	0·2 ~ 0·1 mm

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TITLE
LINES

FIGURE 1.7

a) Sub-title for general drawing

PLAN PROFILE ELEVATION 5 mm

UPSTREAM ELEVATION 5mm

b) Notation for parts of structure

Wet masonry Foundation concret. 3mm 2mm

Original ground line

c) Sub-title for parts of structures

DETAIL A, SECTION A-A 4mm

TABLE OF DIMENSIONS 4mm

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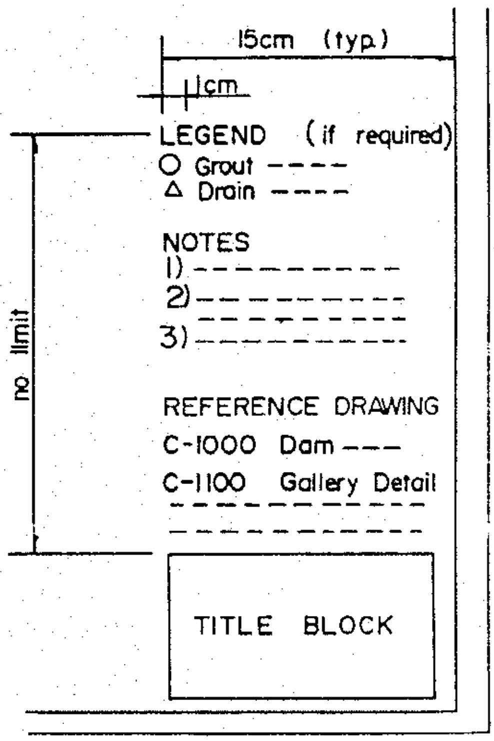
JAPAN INTERNATIONAL COOPERATION AGENCY	



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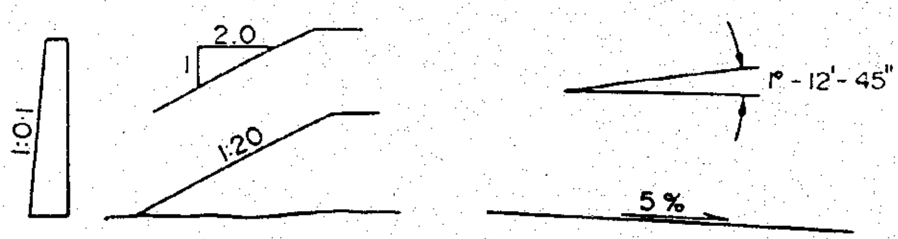
JAPAN INTERNATIONAL COOPERATION AGENCY	

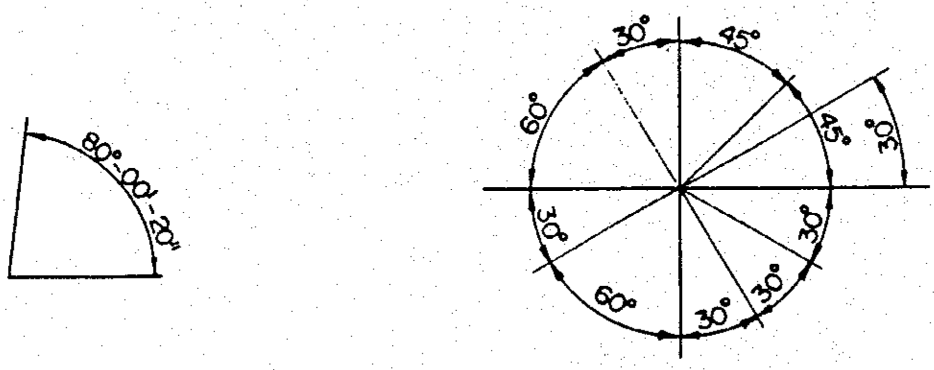
FIGURE 1.9 (1/2)

a) Slopes



Section

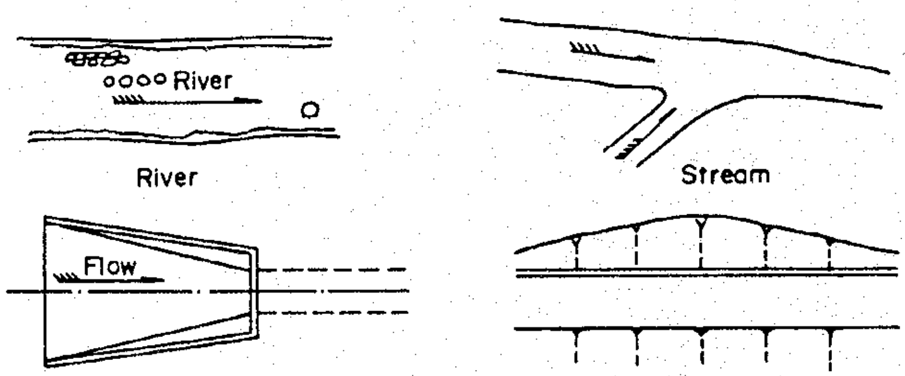
b) Angle



Angles

c) Direction mark

Flow direction in water



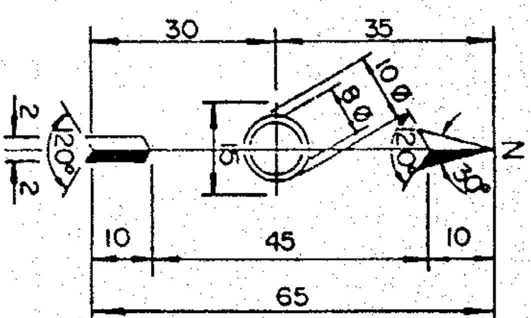
River

Stream

Hydraulic Structure

Drain Channel

North direction



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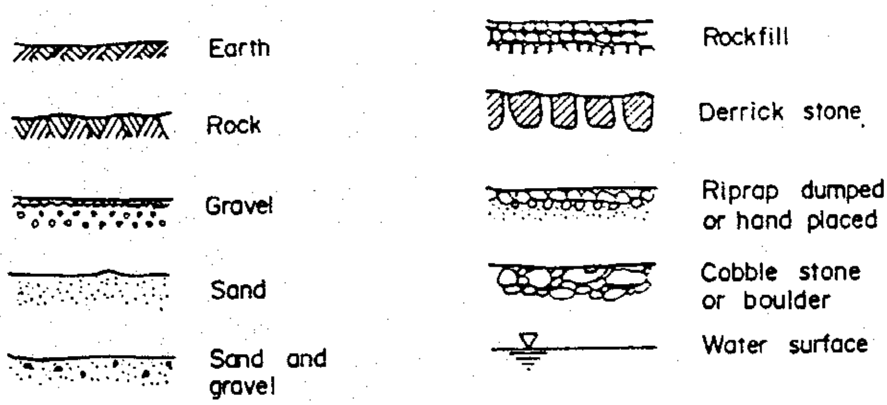
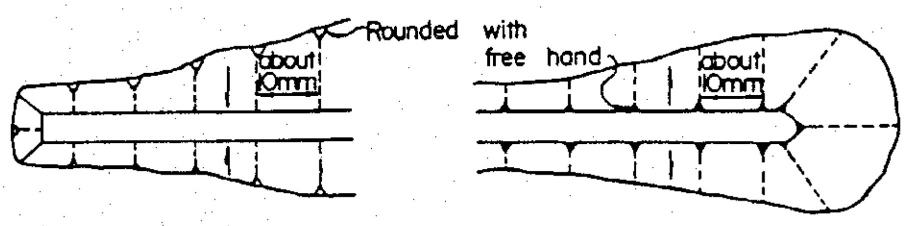
JAPAN INTERNATIONAL COOPERATION AGENCY	

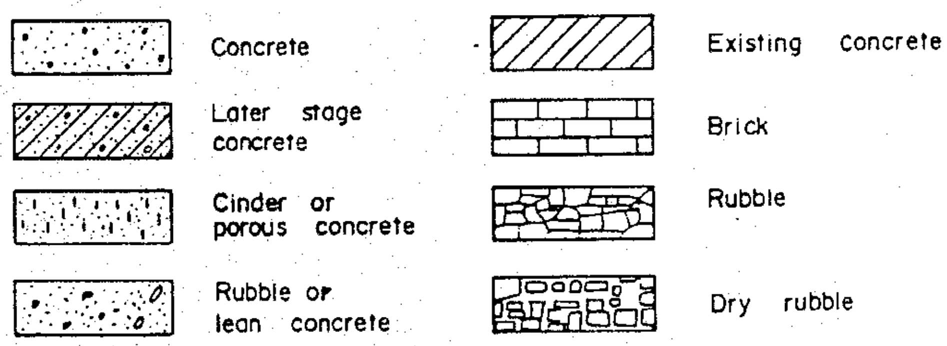
d) Earthwork





Excavation   Embankment

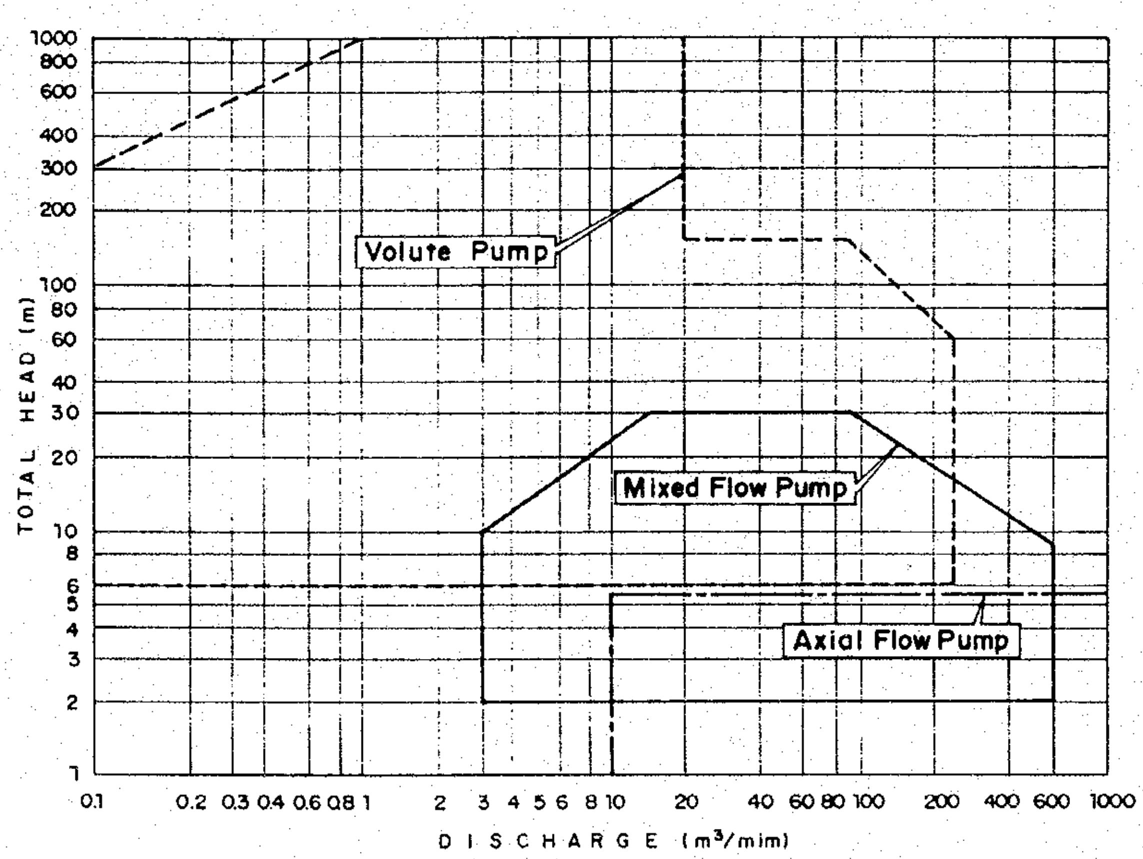
e) Concrete and Masonry



TITLE

SYMBOLS

FIGURE 2.1



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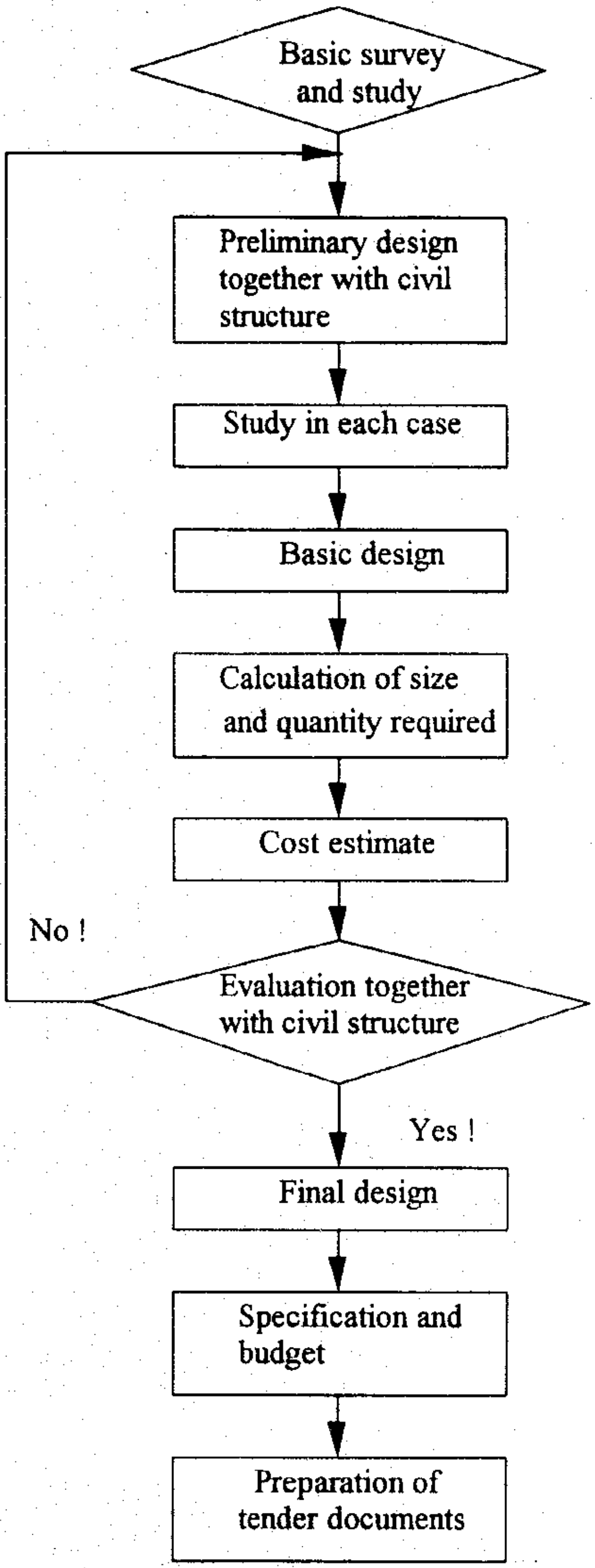
TITLE

PUMP TYPE SELECTION CHART

FIGURE 2.2



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TITLE
FLOW CHART OF DESIGN