Fig. 4.3-2-(6) Discharge Duration Curve

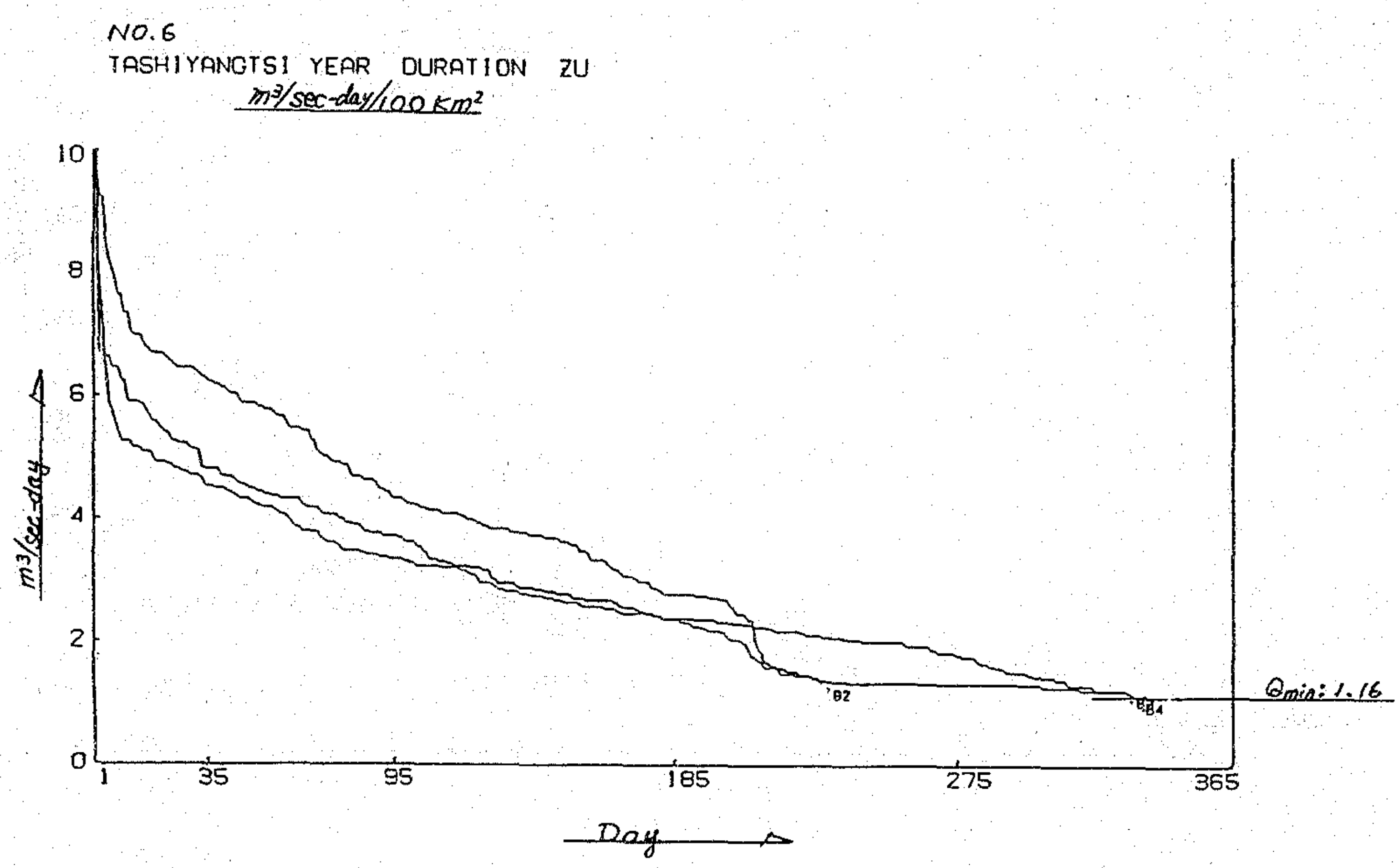


Fig. 4.3-2-(7) Discharge Duration Curve

No.7

NANGLAM YEAR DURATION ZU

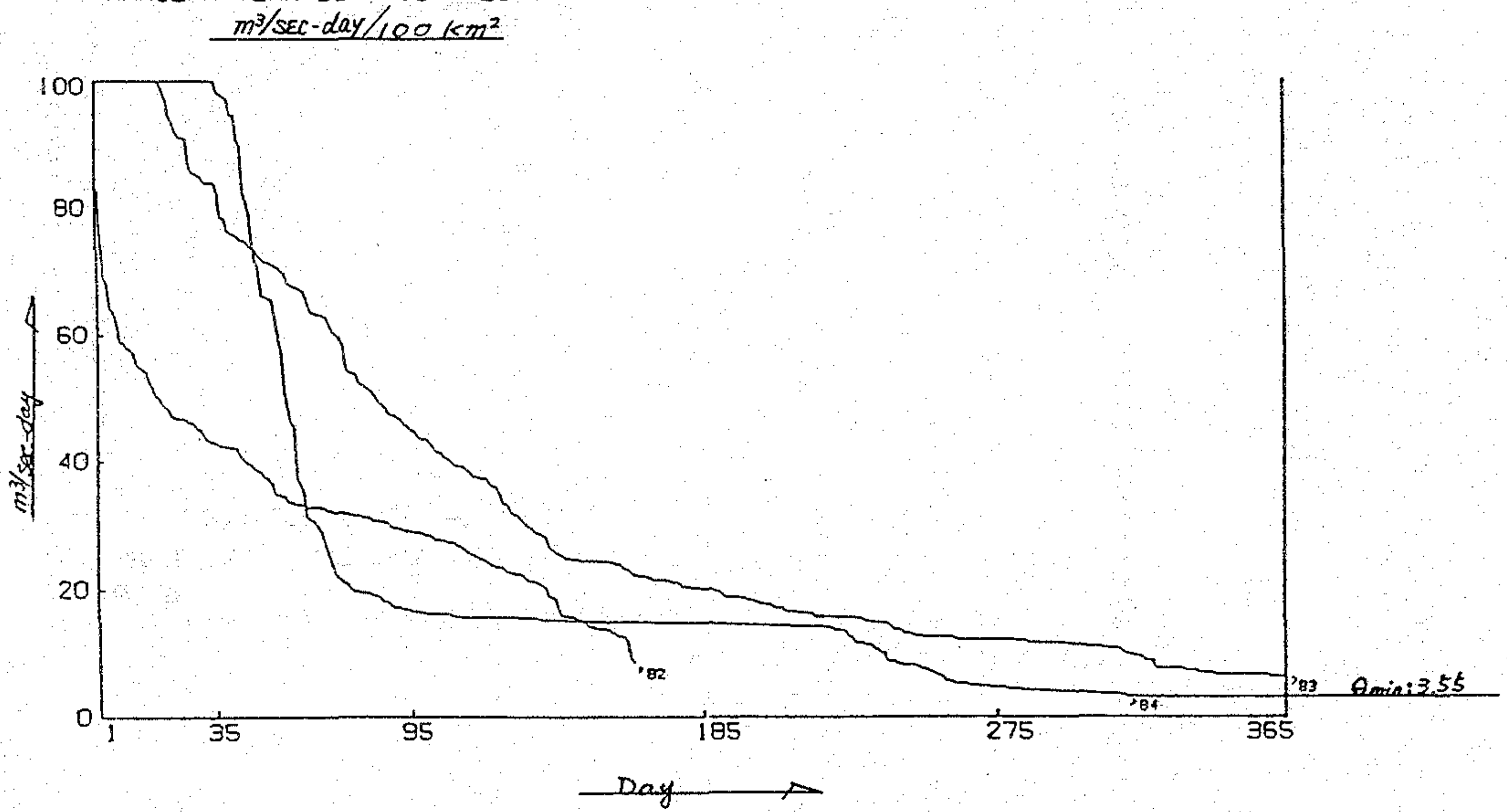
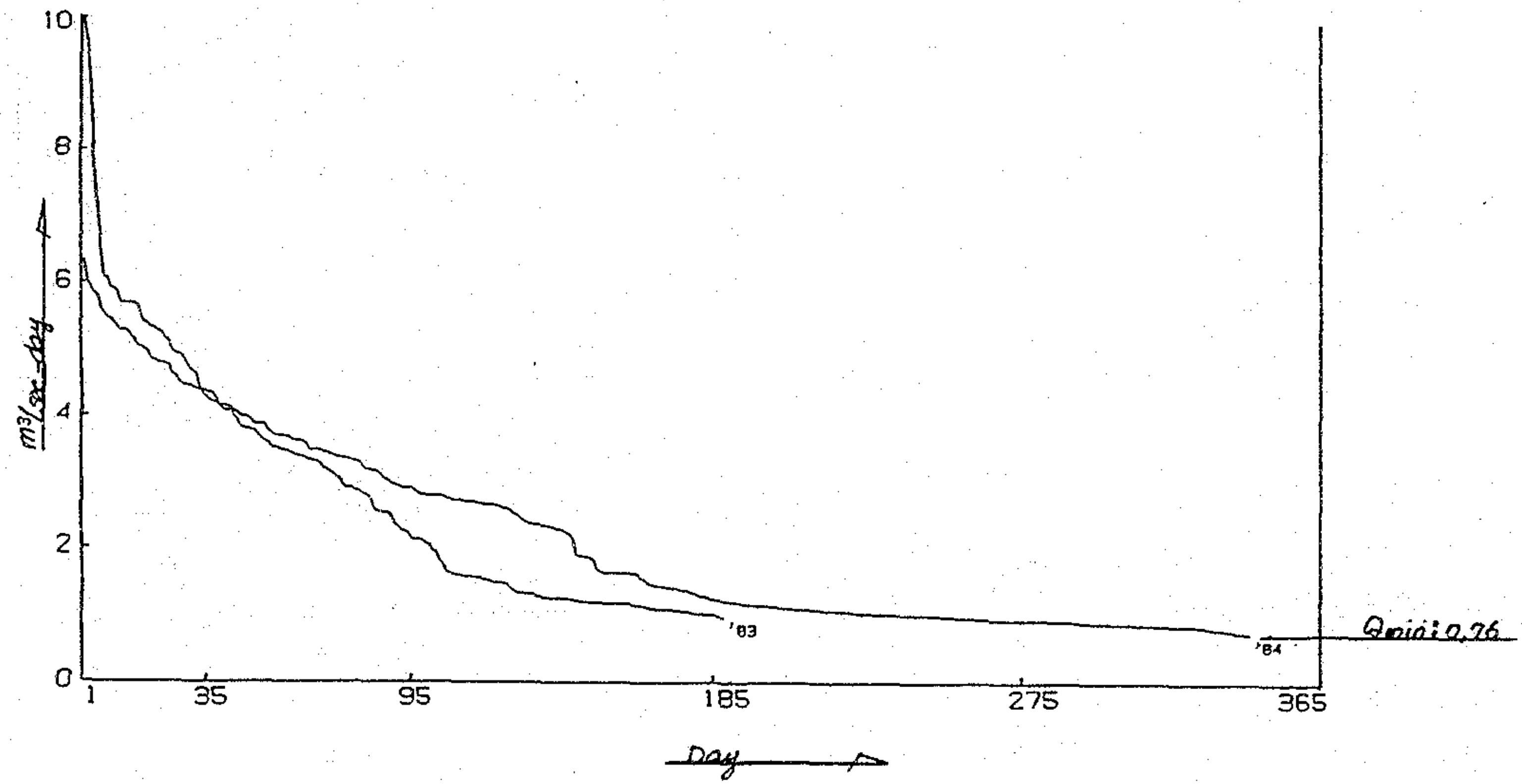


Fig. 4.3-2-(8) Discharge Duration Curve
NO.8
REFEE YEAR DURATION ZU
m³/sec-day/100 km²



ANNEX-10 GENERAL LAYOUT FOR EACH PROPOSED SITE

Fig. 4.3-3-(1) General Layout

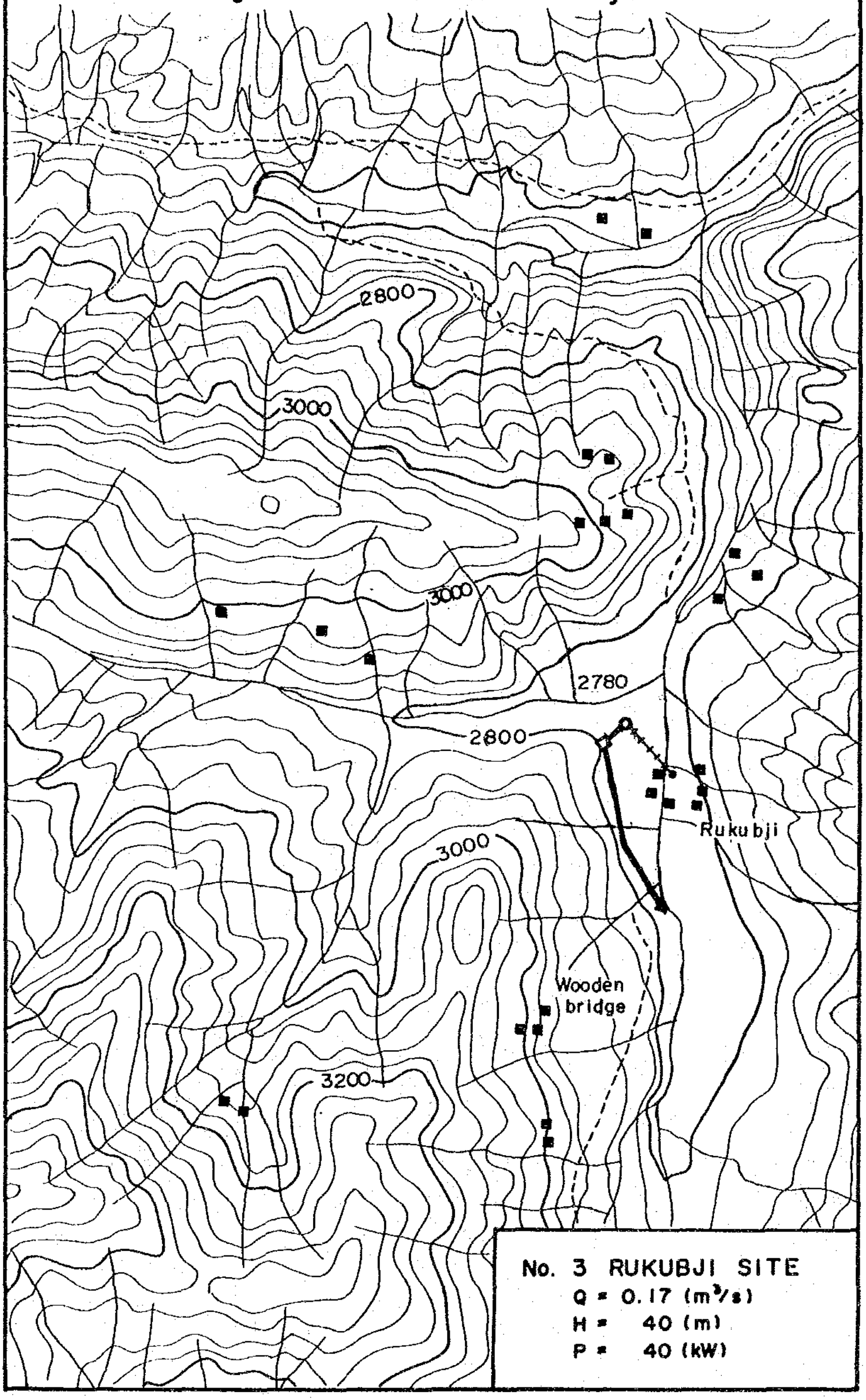


Fig.4.3-3-(2) General Layout

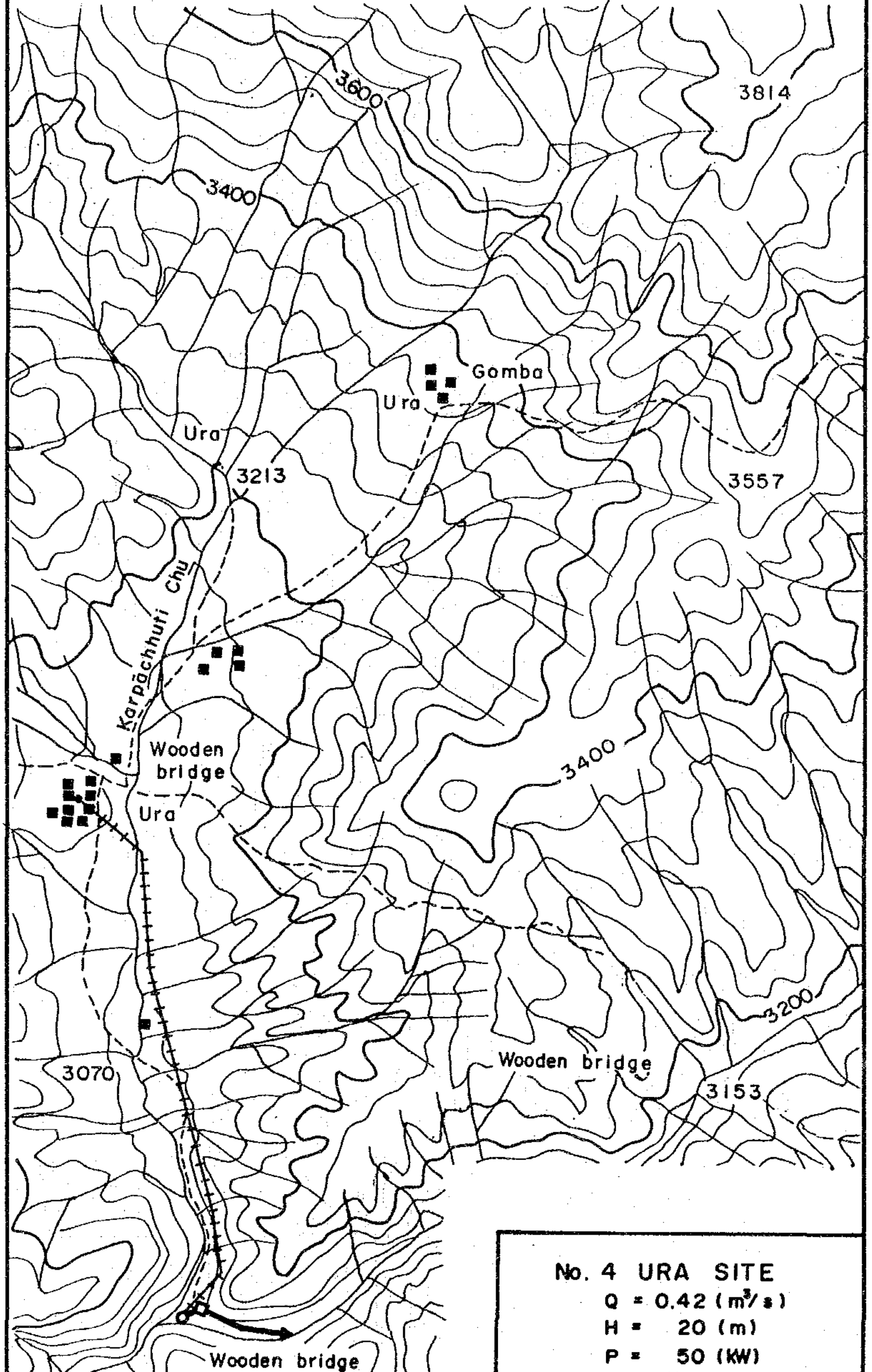


Fig. 4.3-3-(3) General Layout

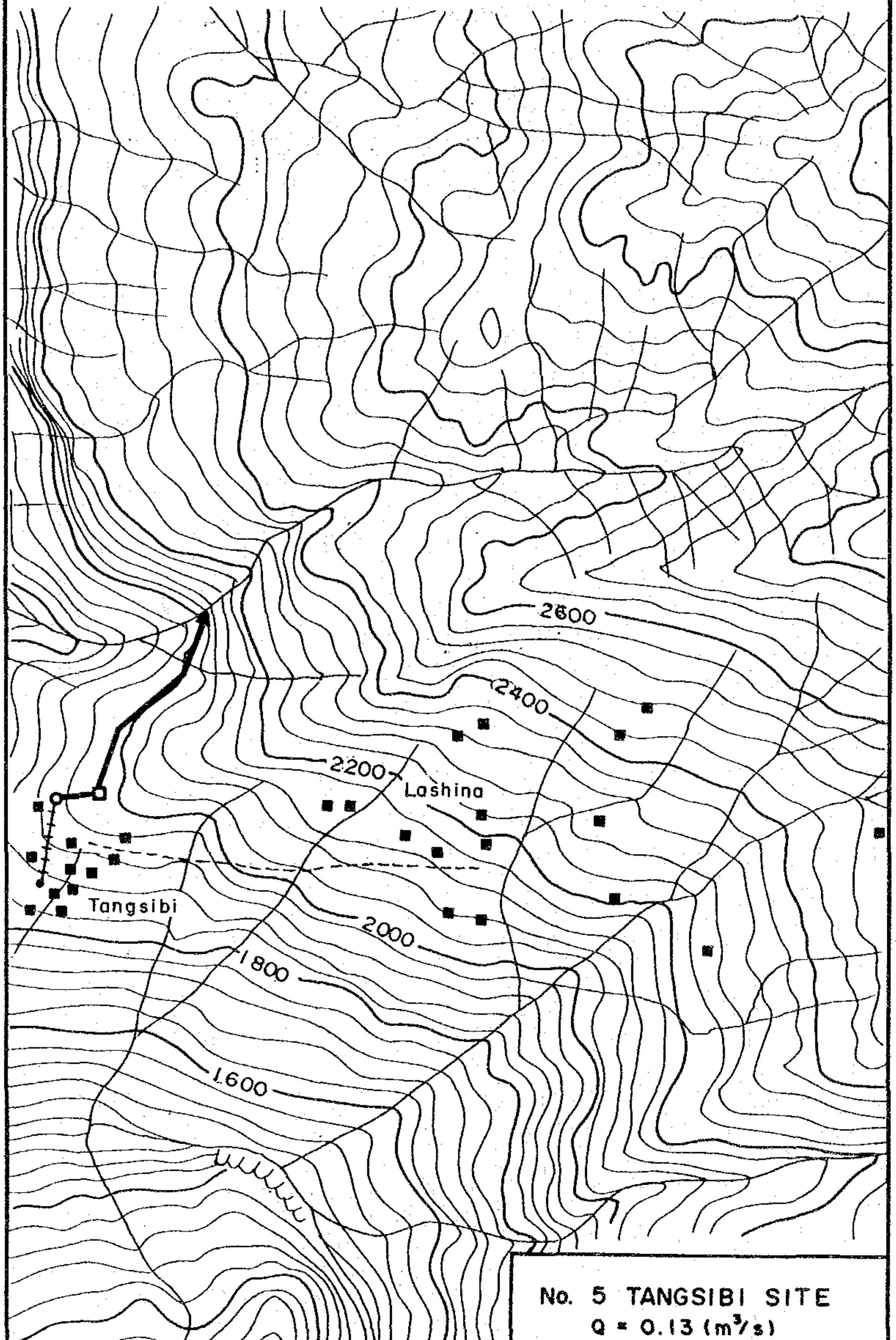


Fig.4.3-3-(4) General Layout

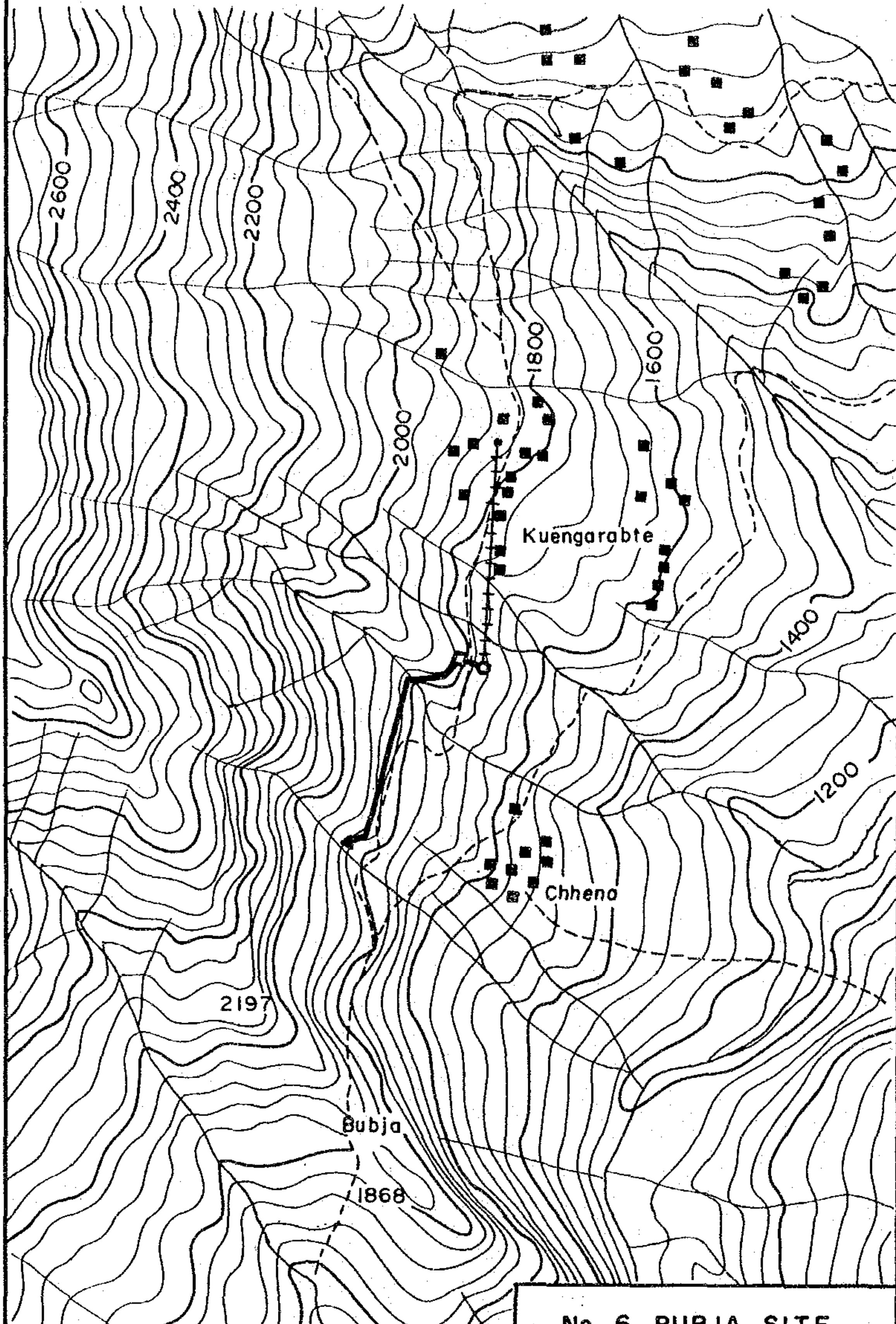


Fig.4.3-3-(5) General Layout

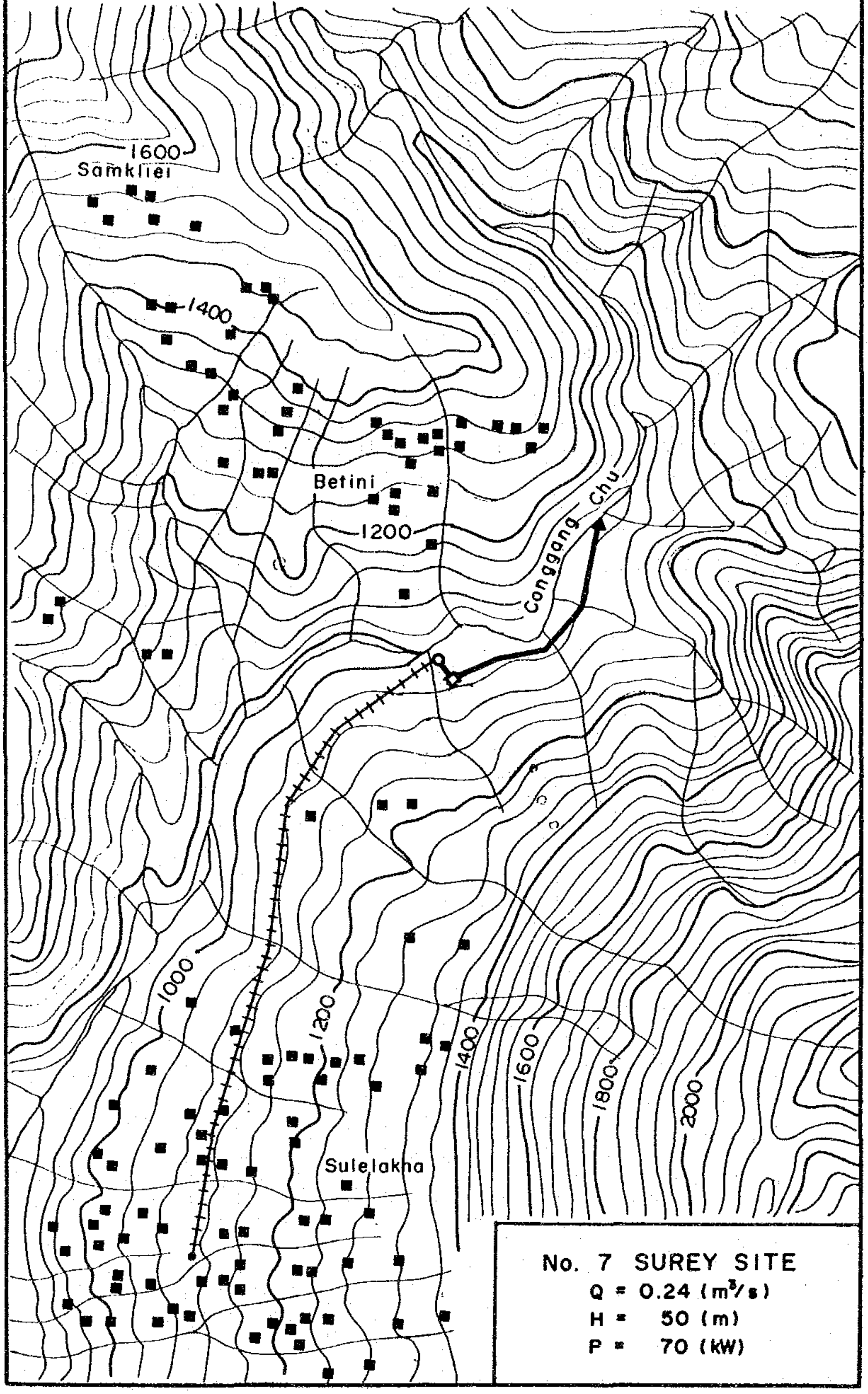


Fig.4.3-3-(6) General Layout

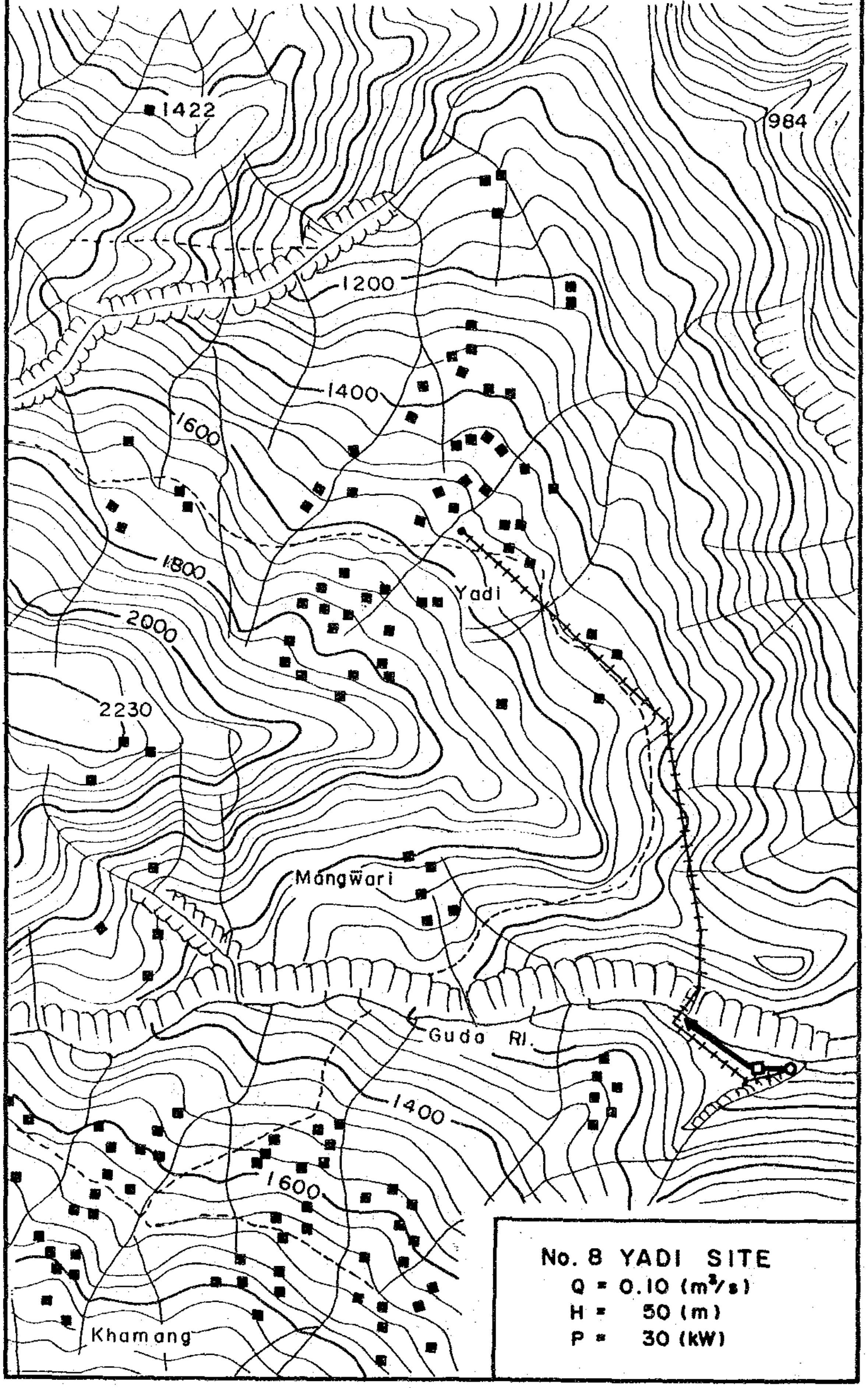


Fig.4.3-3-(7) General Layout

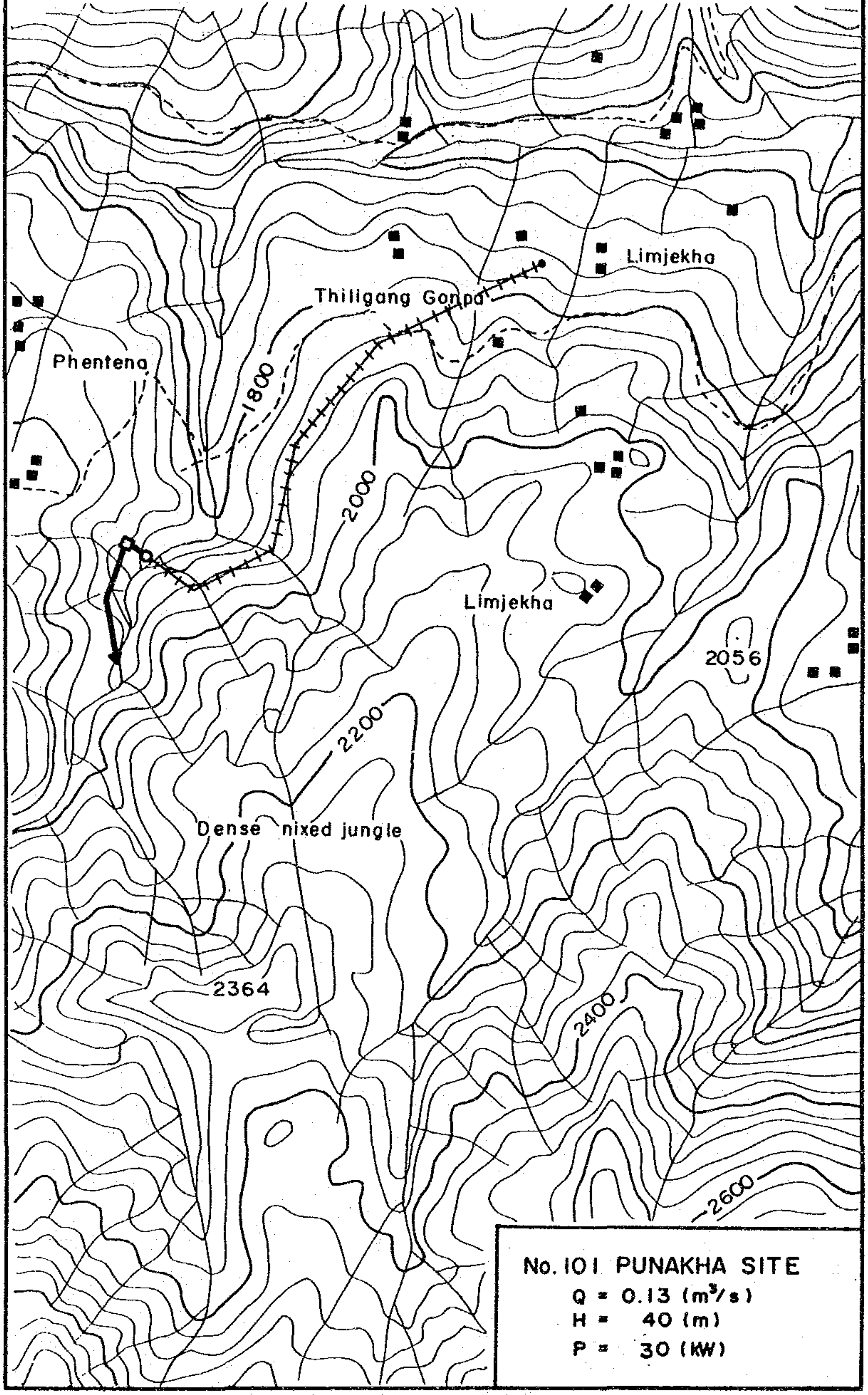
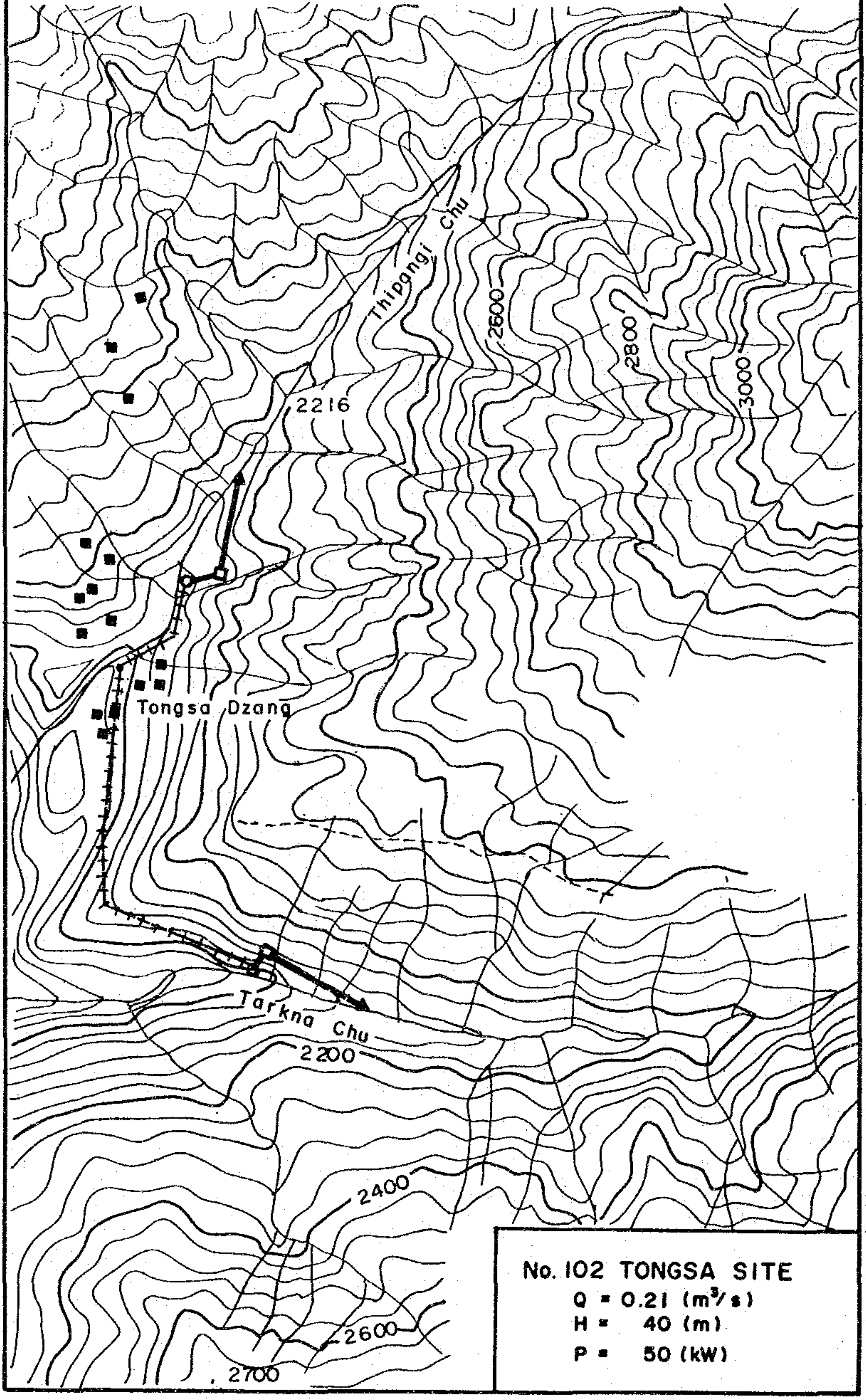


Fig.4.3-3-(8) General Layout



No. 102 TONGSA SITE

$Q = 0.21\ (m^3/s)$
$H = 40\ (m)$
$P = 50\ (kW)$

Fig.4.3-3-(9) General Layout

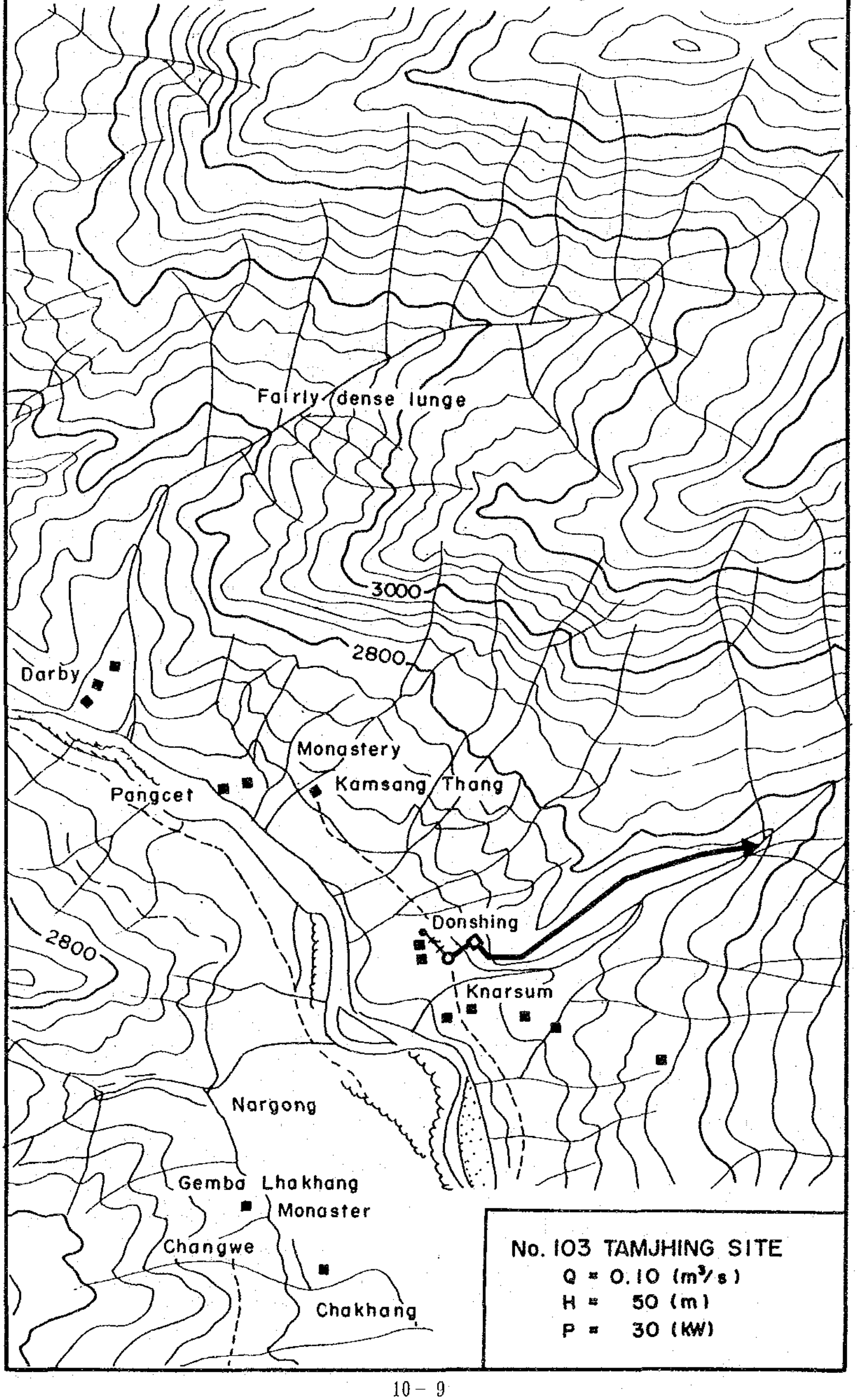
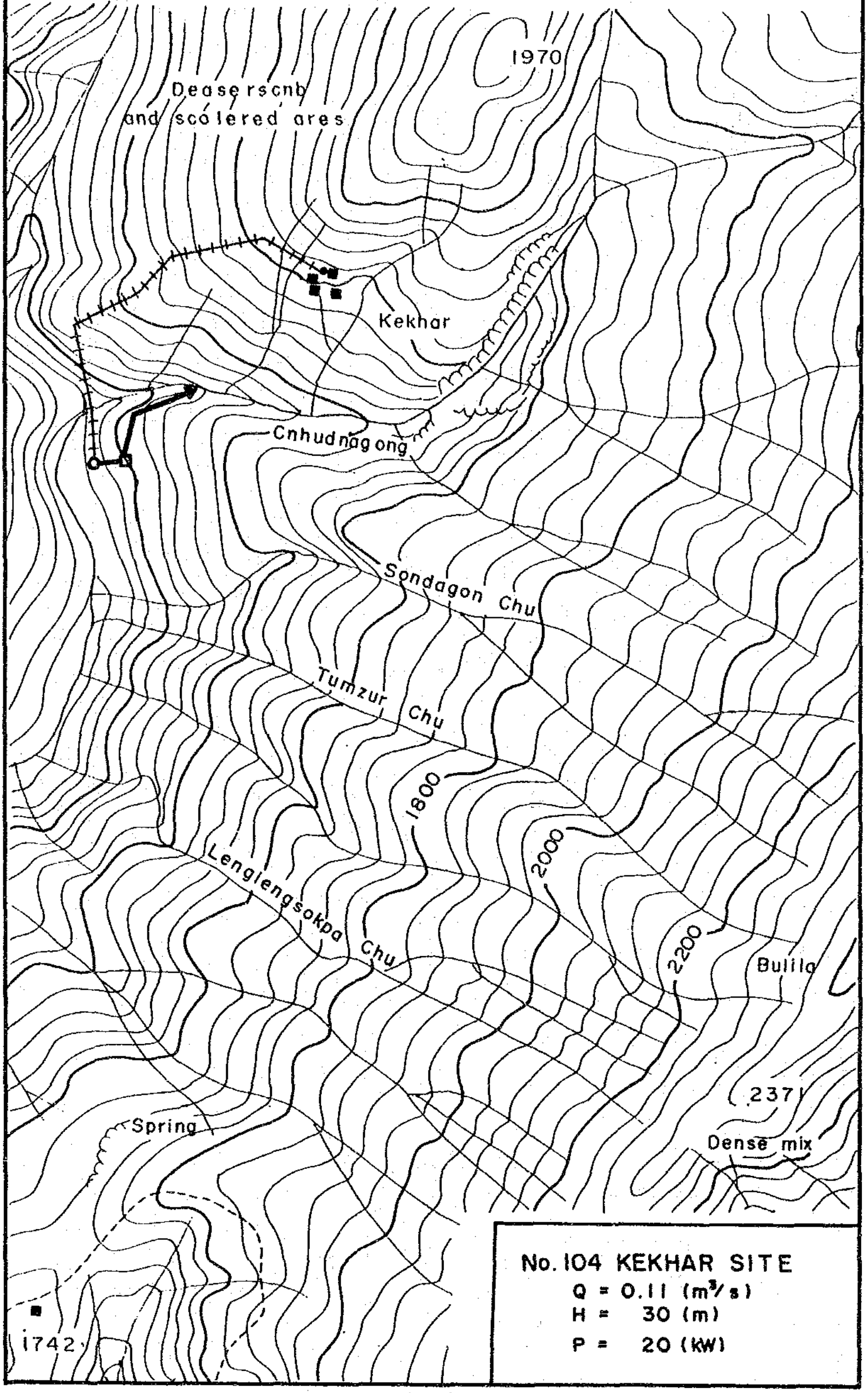


Fig.4.3-3-(10) General Layout



ANNEX-11 CALCULATIONS FOR OPEN CHANNELS

Hydraulically Most Efficient Section of Channels

(i) Trapezoid channel

Provided that the gradient of the channel "I", the sectional area "A" and the roughness coefficient "n" shall be given, the condition of the section, where the largest discharge is available, is to increase (the hydraulic radius) up to the maximum value.

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

$$Q = \frac{1}{n} AR^{2/3} I^{1/2}$$

(Manning's formula).

In other words, it is to decrease "P" to the minimum value (P = Perimetre)

$$A = h\ (b + h \cot \alpha) \qquad P = b + 2h \operatorname{cosec} \alpha = \frac{A}{h} - h \cot \alpha + 2 \operatorname{cosec} \alpha$$

The efficient section may be calculated from $\frac{\partial P}{\partial h} = 0$

$$-\frac{A}{h^2} - \cot \alpha + 2 \operatorname{cosec} \alpha = \frac{-(b+h \cot \alpha)}{h} - \cot \alpha + 2 \operatorname{cosec} \alpha = 0$$

$$b = 2h \frac{1 - \cos \alpha}{\sin \alpha} = 2h \tan \frac{\alpha}{2}$$

Provided that the value is applied into the formula of Manning

$$Q = \frac{1}{n} AR^{2/3} I^{1/2} = \frac{1}{n} I^{1/2} h^{8/3} \left(2 \tan \frac{\alpha}{2} + \cot \alpha\right) \left(\frac{1 + \dfrac{\cot \alpha}{2 \tan \alpha/2}}{1 + \dfrac{1}{\sin \alpha . \tan \alpha/2}} \right)^{2/3}$$

Provided that the gradient of the side wall be 1:0.25,

$\tan\alpha = 4$, $\alpha = 75.96°$ $\quad \frac{\alpha}{2} = 37.98°$, $\sin\alpha = 0.97$

$\cot\alpha = 0.25$, $\cos\alpha = 0.243$ $\quad \tan\frac{\alpha}{2} = 0.781$, $\mathrm{cosec}\,\alpha = 1.03$

$$Q = \frac{1.1412}{n} I^{1/2} h^{8/3}$$

n	Q	I	h
0.014	$81.514786\ I^{1/2}\ h^{8/3}$	$(\frac{0.012268Q}{h^{8/3}})^2$	$(\frac{0.012268Q}{I^{1/2}})^{3/8}$
0.015	$76.080467\ I^{1/2}\ h^{8/3}$	$(\frac{0.013144Q}{h^{8/3}})^2$	$(\frac{0.013144Q}{I^{1/2}})^{3/8}$
0.016	$71.325438\ I^{1/2}\ h^{8/3}$	$(\frac{0.014020Q}{h^{8/3}})^2$	$(\frac{0.014020Q}{I^{1/2}})^{3/8}$
0.017	$67.129824\ I^{1/2}\ h^{8/3}$	$(\frac{0.014897Q}{h^{8/3}})^2$	$(\frac{0.014897Q}{I^{1/2}})^{3/8}$

(ii) Trapezoid channel
(One right angle side)

The most efficient section can be obtained from the following expressions:

$$A = h\ (b + \frac{h}{2}\cot\alpha)$$

$$\therefore\ b = \frac{A}{h} - \frac{h}{2}\cot\alpha$$

$$P = \frac{A}{h} - \frac{h}{2}\cot\alpha + h + h\ \mathrm{cosec}\,\alpha$$

From $\frac{\partial P}{\partial h}$ $\quad b = h\ (1 + \tan\frac{\alpha}{2})$

$$A = h\ \ (b + \frac{h}{2}\cot\alpha) = h^2\left[(1 + \tan\frac{\alpha}{2}) + \frac{\cot\alpha}{2}\right]$$

$$P = h\left[(1 + \tan\frac{\alpha}{2}) + 1 + \mathrm{cosec}\,\alpha\right]$$

$$R = \frac{A}{P} = \frac{h\left[(1 + \tan\frac{\alpha}{2}) + \frac{\cot\alpha}{2}\right]}{(1 + \tan\frac{\alpha}{2}) + 1 + \operatorname{cosec}\alpha}$$

$$Q = \frac{A}{n} R^{2/3} I^{1/2} = \frac{1}{n} I^{1/2} h^{8/3}\left[(1 + \tan\frac{\alpha}{2}) + \frac{\cot\alpha}{2}\right]\left[\frac{(1 + \tan\frac{\alpha}{2})\ \frac{\cot\alpha}{2}}{(1 + \tan\frac{\alpha}{2}) + 1 + \operatorname{cosec}\alpha}\right]^{2/3}$$

Provided that the gradient of the side wall shall be 1:0.25, the discharge "Q" shall be calculated as follows:

$$Q = \frac{1.200564}{n} I^{1/2} h^{8/3}$$

The values of "Q", "I" and "h" against the coefficient "n" are respectively as follows:

n	Q	I	h
0.014	$85.754571\ I^{1/2}\ h^{8/3}$	$(\frac{0.011661Q}{h^{8/3}})^{2}$	$(\frac{0.011661Q}{I^{1/2}})^{3/8}$
0.015	$80.037600\ I^{1/2}\ h^{8/3}$	$(\frac{0.012494Q}{h^{8/3}})^{2}$	$(\frac{0.012494Q}{I^{1/2}})^{3/8}$
0.016	$75.035250\ I^{1/2}\ h^{8/3}$	$(\frac{0.013327Q}{h^{8/3}})^{2}$	$(\frac{0.013327Q}{I^{1/2}})^{3/8}$
0.017	$70.621412\ I^{1/2}\ h^{8/3}$	$(\frac{0.014160Q}{h^{8/3}})^{2}$	$(\frac{0.014160Q}{I^{1/2}})^{3/8}$

(iii) Analysis of hydraulic characteristics of the open channels

$$V = \frac{Q}{A} = \frac{I}{n} R^{2/3}\ I^{1/2}$$

Provided that the stream velocity shall be V = 1 m/sec. in either case of channels of trapezoid section or of such trapezoid section of which one side has a right angle.

$$R^{2/3} = (0.5)^{2/3}\, h^{2/3} = 0.629961\, h^{2/3}$$

$$\therefore h^{2/3} = \frac{n}{0.629961\sqrt{\frac{1}{I}}}$$

$n = 0.014$

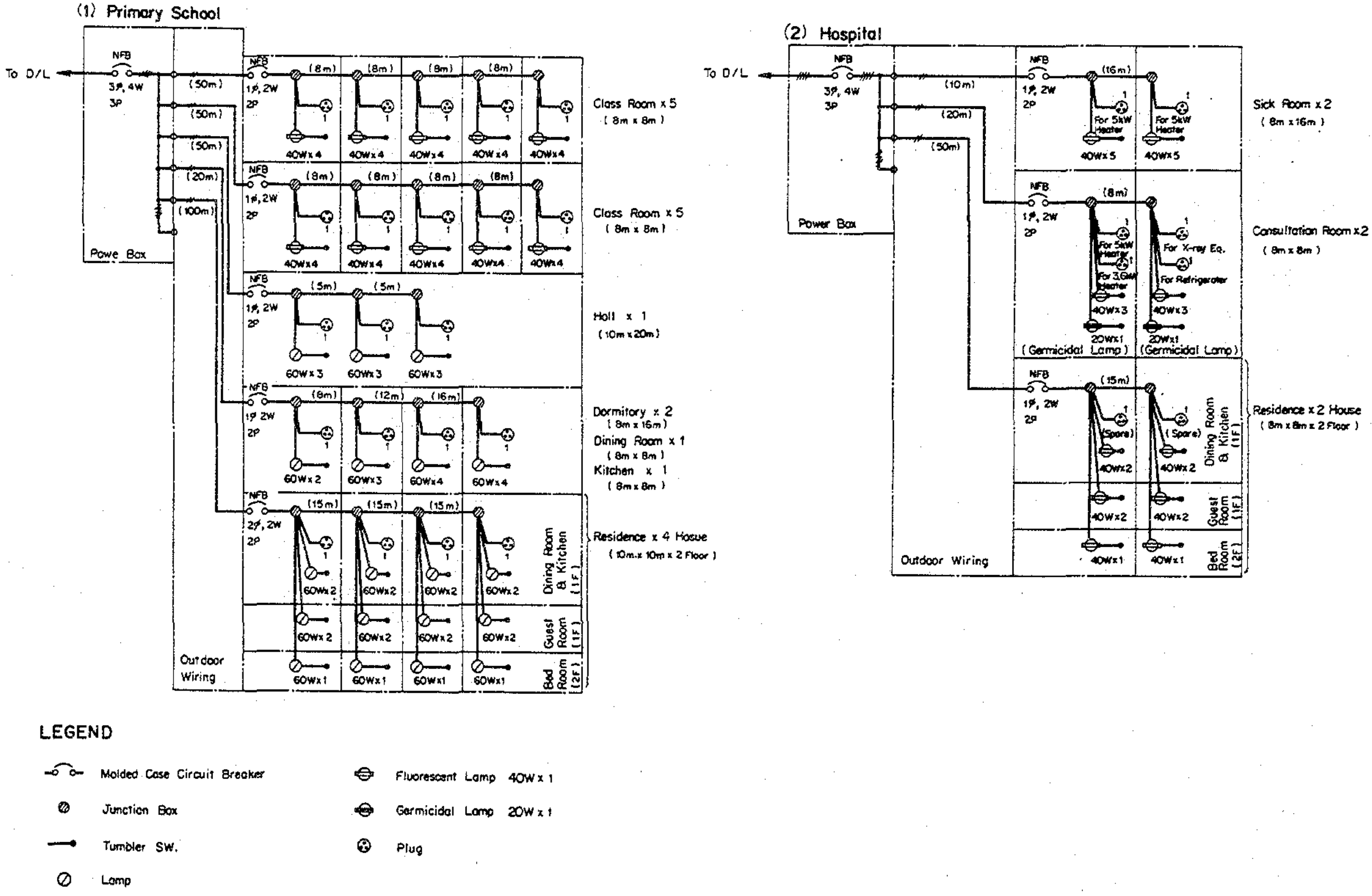
Trapezoid Section with one right angled side	Trapezoid Section
$b = 1.781\ h$ $= 0.005901\ (\frac{1}{I})^{3/4}$ $(\frac{1}{I}) = (\frac{b}{0.005901})^{4/3}$ $h = \frac{b}{1.781}$	$b = 1.562\ h$ $= 0.005175\ (\frac{1}{I})^{3/4}$ $(\frac{1}{I}) = (\frac{6}{0.005175})^{4/3}$ $h = \frac{b}{1.562}$

$n = 0.017$

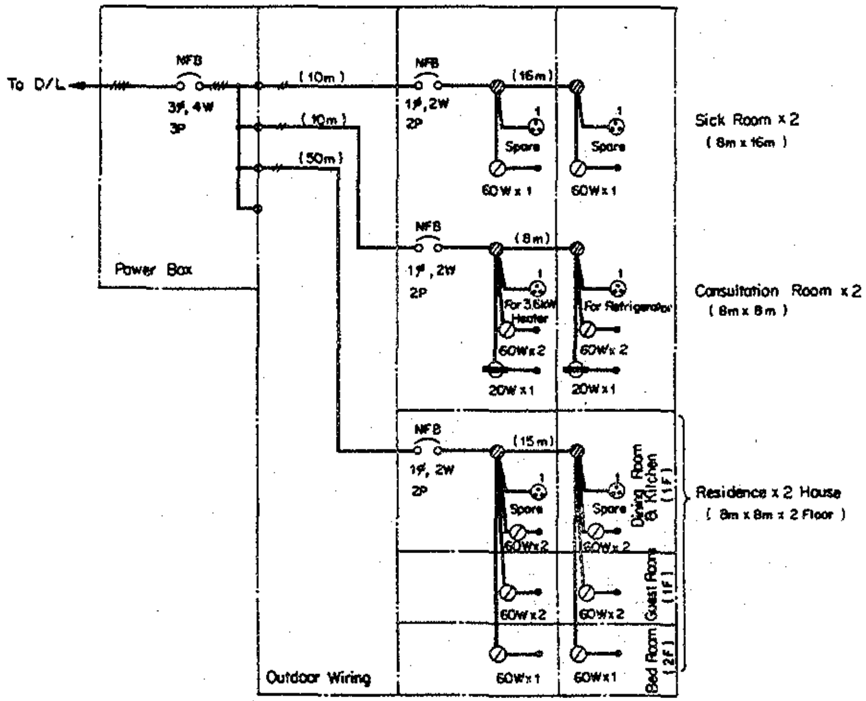
Trapezoid Section with one right angled side	Trapezoid Section
$b = 1.781\ h$ $= 0.007895\ (\frac{1}{I})^{3/4}$ $(\frac{1}{I}) = (\frac{b}{0.007895})^{4/3}$ $h = \frac{b}{1.781}$	$b = 1.562\ h$ $= 0.006925\ (\frac{1}{I})^{3/4}$ $(\frac{1}{I}) = (\frac{6}{0.006925})^{4/3}$ $h = \frac{b}{1.562}$

ANNEX-12 BASIC DESIGN DRAWINGS

Fig. 4.5-4 TYPICAL DESIGN OF INDOOR WIRING FOR PUBLIC FACILITIES

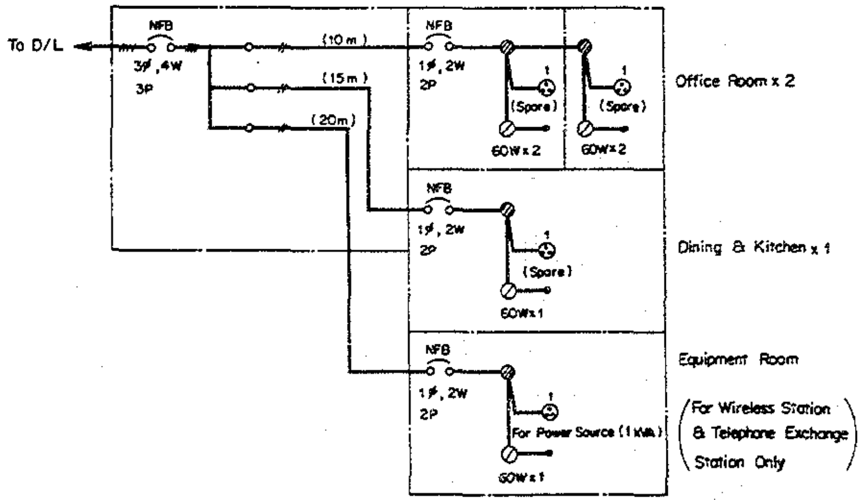


(3) Vet. Hospital



(4) Other Office

(Village Office, Food Corporation, Post Office, Wireless Station, Agriculture Office, Telephone Exchange Station, etc.)



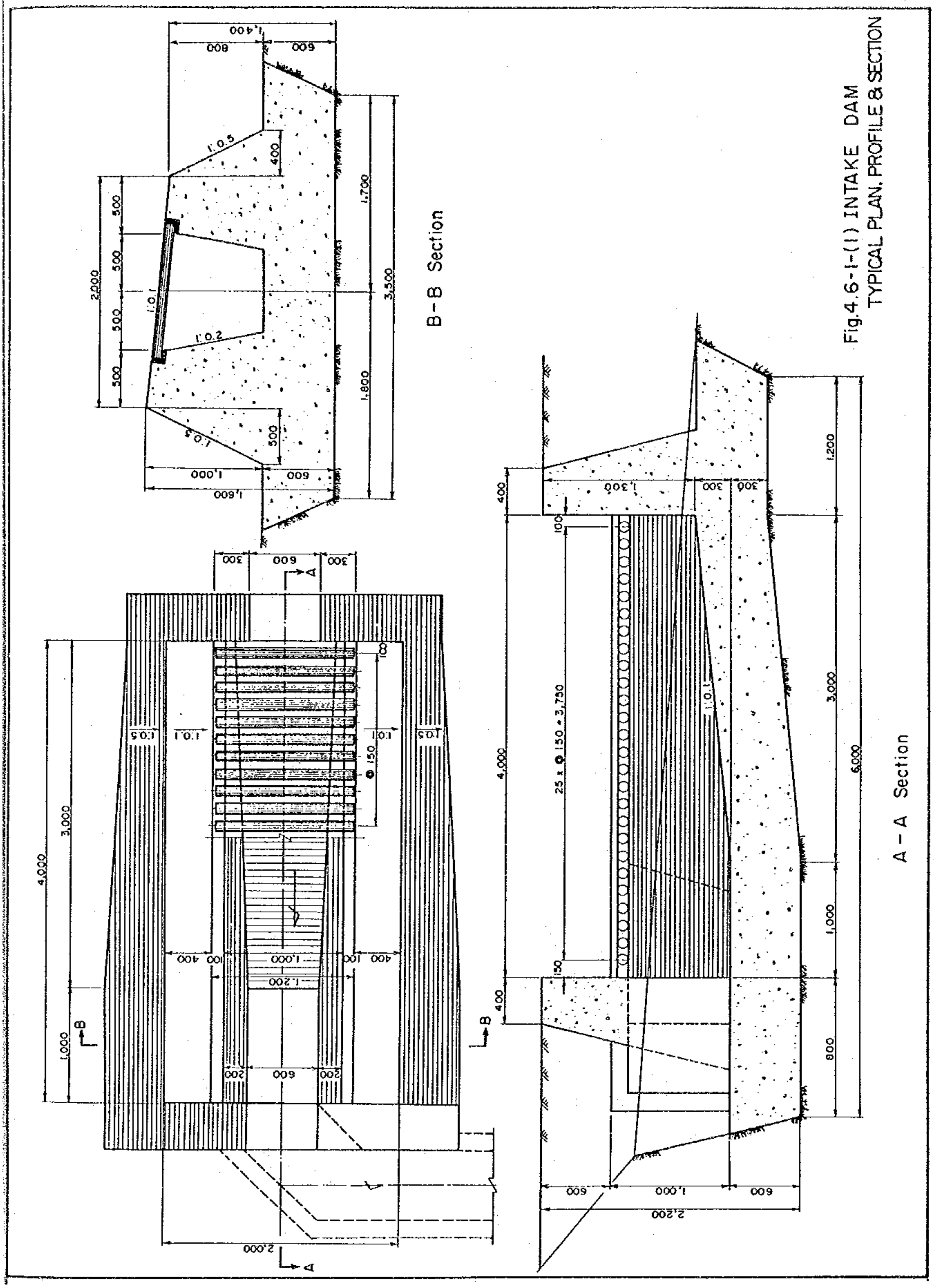


Fig.4.6-1-(1) INTAKE DAM
TYPICAL PLAN, PROFILE & SECTION

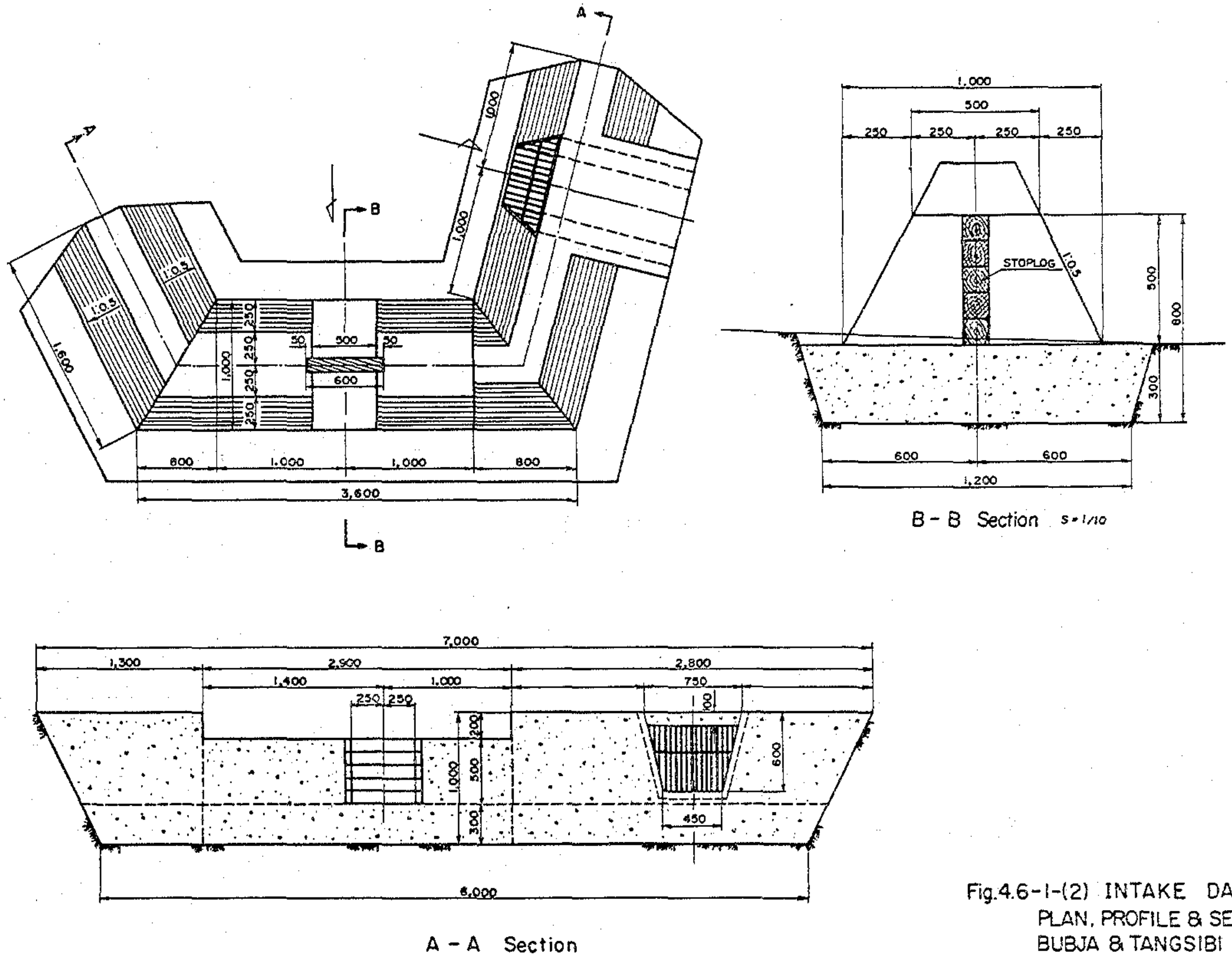


Fig.4.6-1-(2) INTAKE DAM
PLAN, PROFILE & SECTION
BUBJA & TANGSIBI SITE

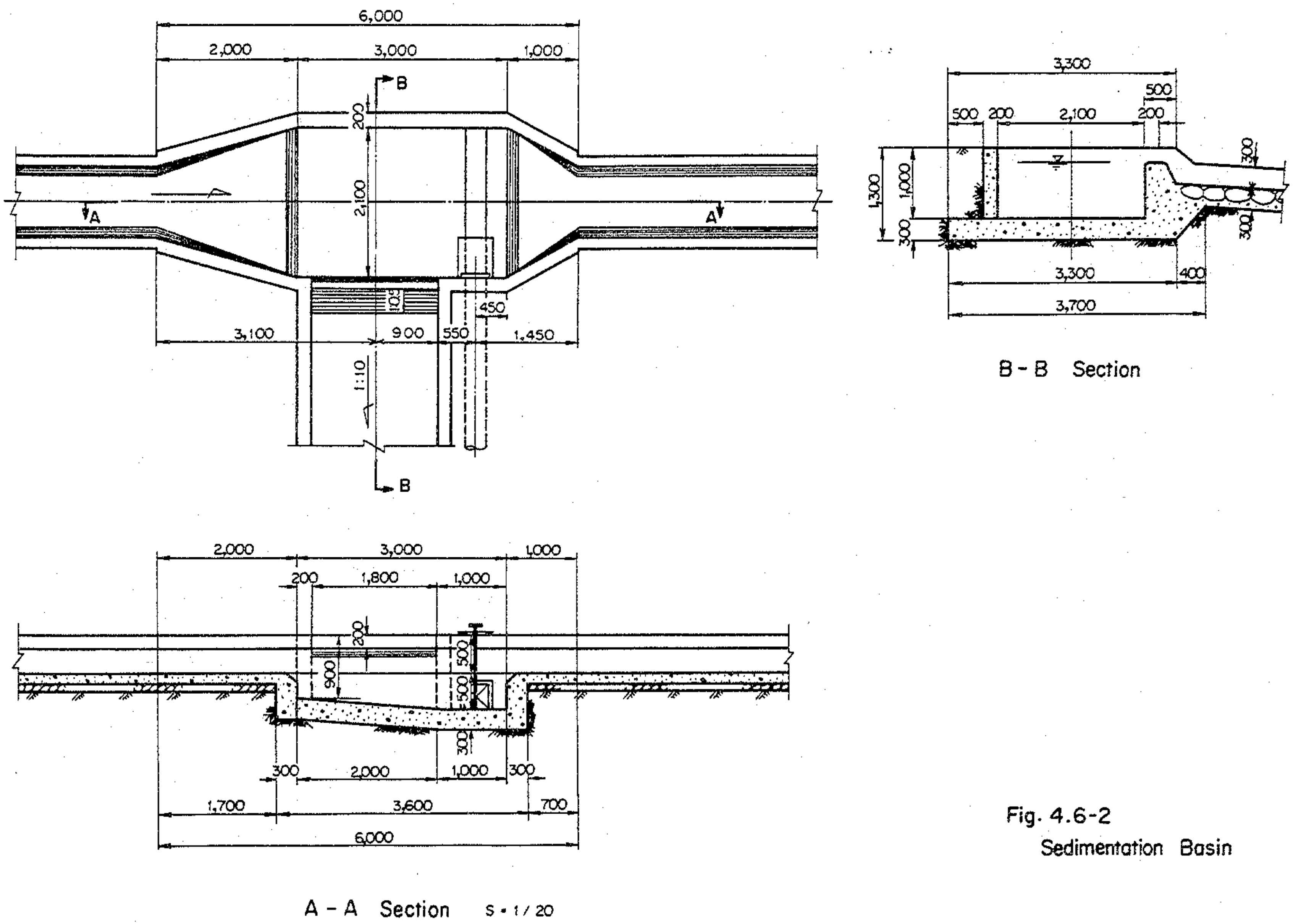


Fig. 4.6-2
Sedimentation Basin

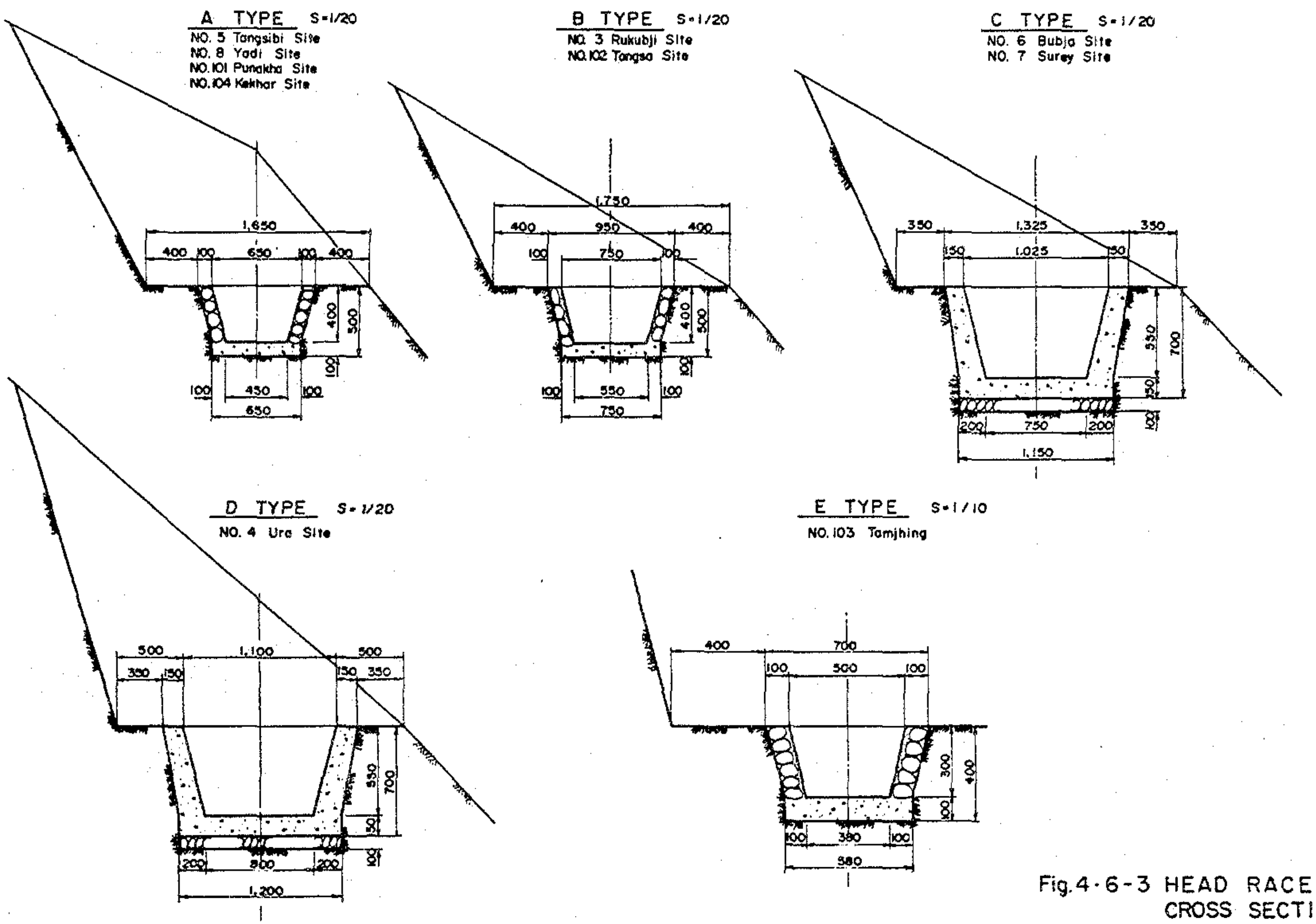


Fig. 4-6-3 HEAD RACE CROSS SECTION

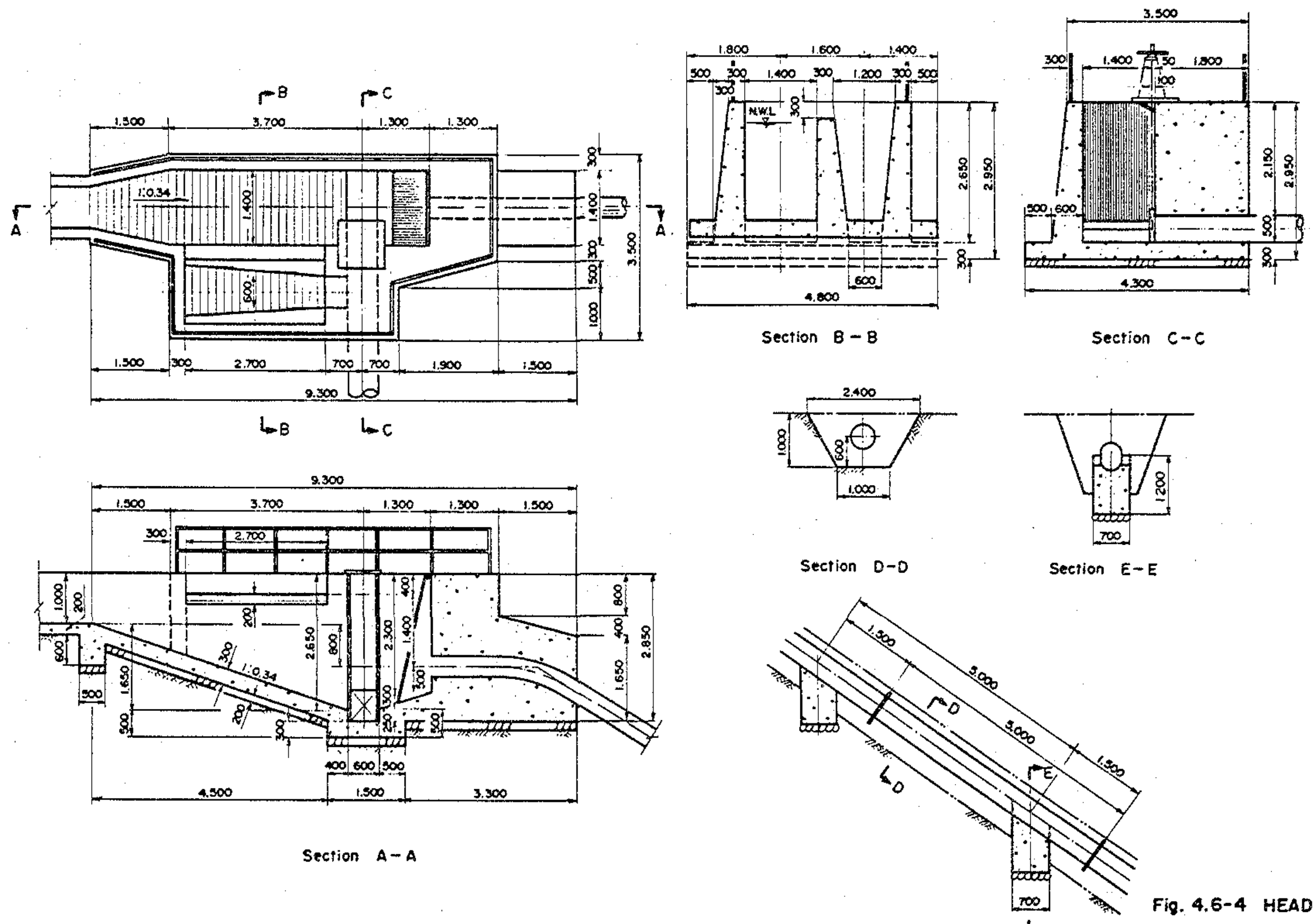


Fig. 4.6-4 HEAD TANK
PLAN AND CROSS SECTION

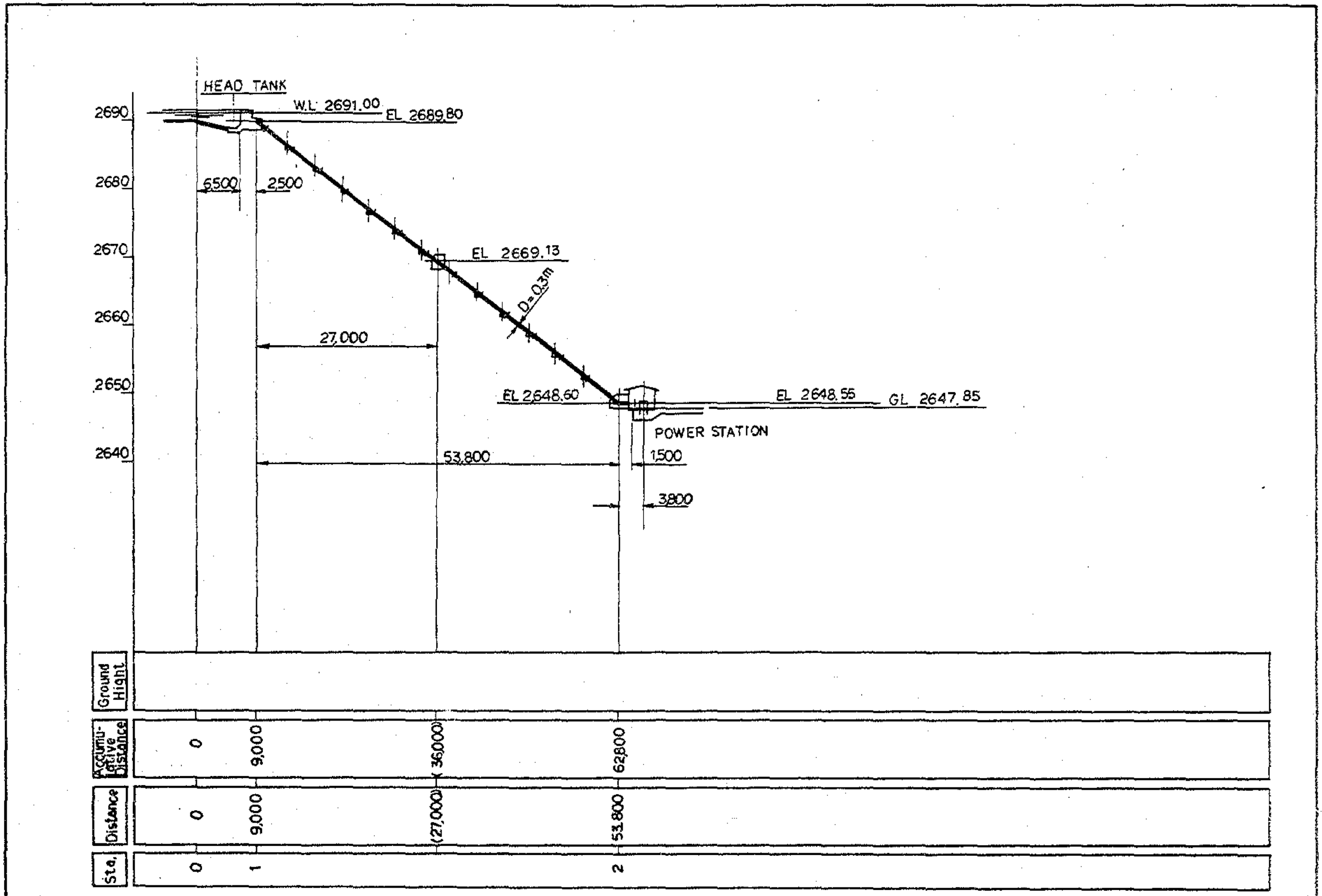


Fig. 4-6-5-(1)
PENSTOCK PROFILE
No. 3 RUKUBJI SITE
SCALE 1/500

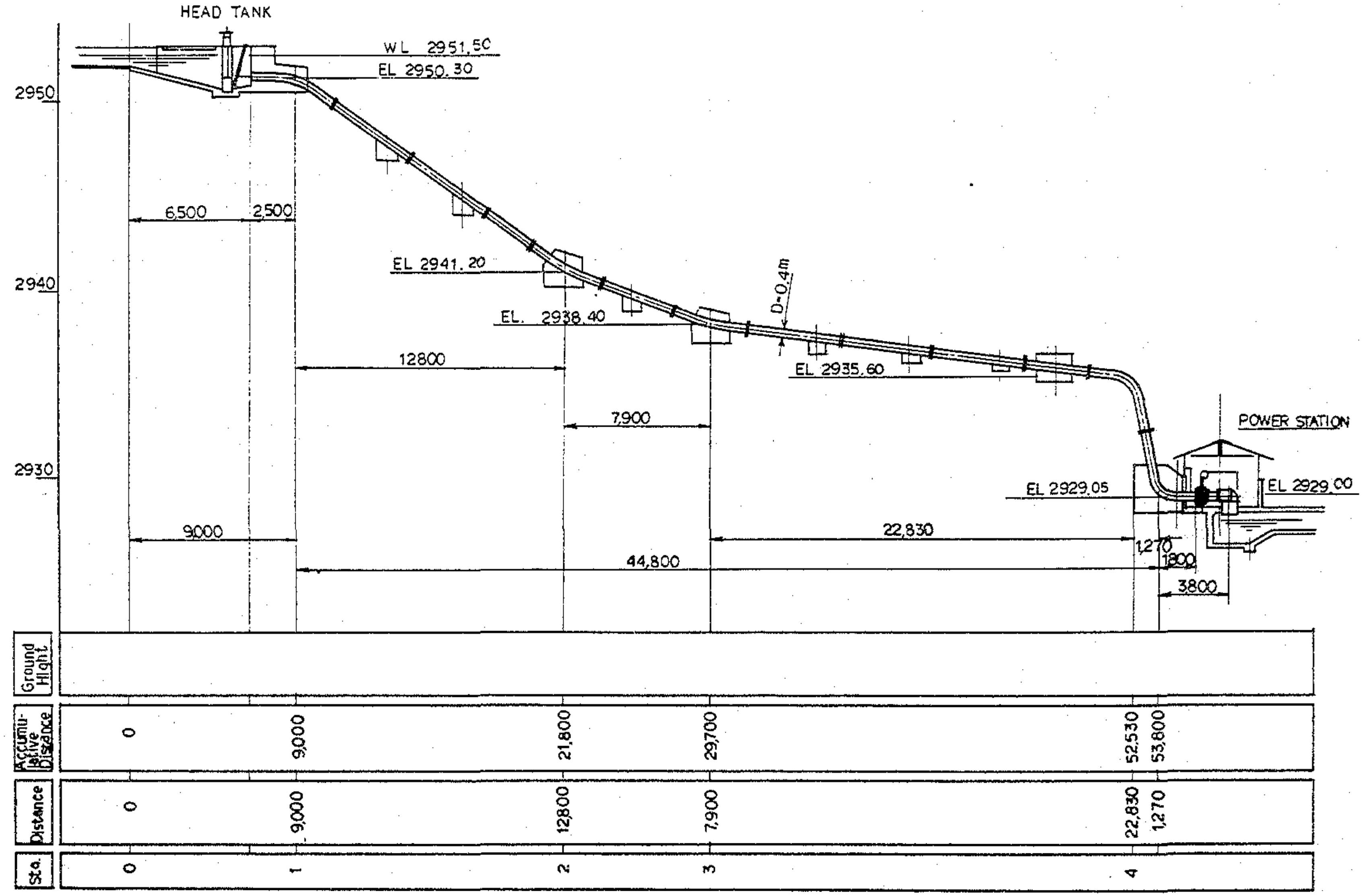


Fig. 4-6-5-(2)
PENSTOCK PROFILE
No. 4 URA SITE
SCALE 1/200

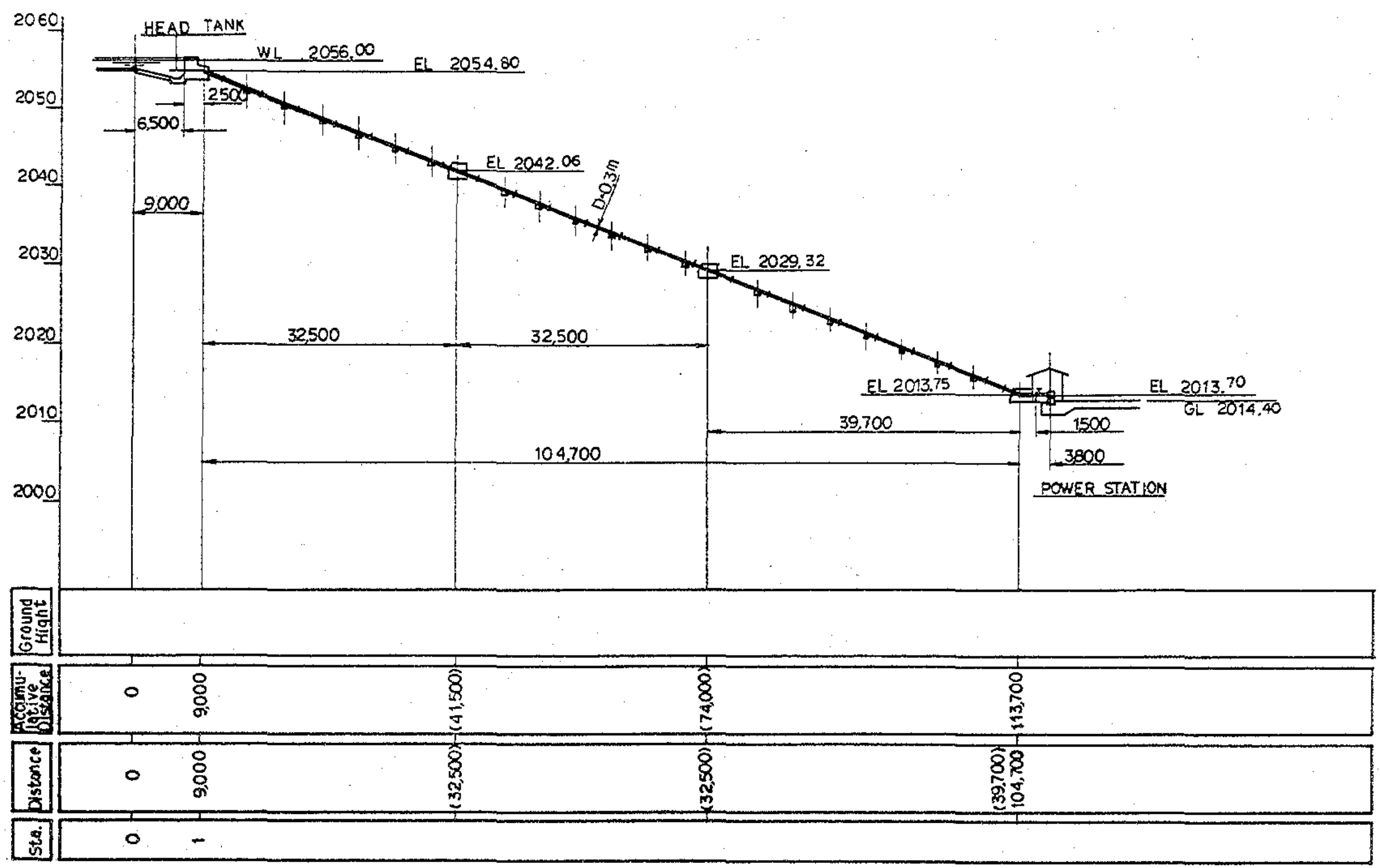
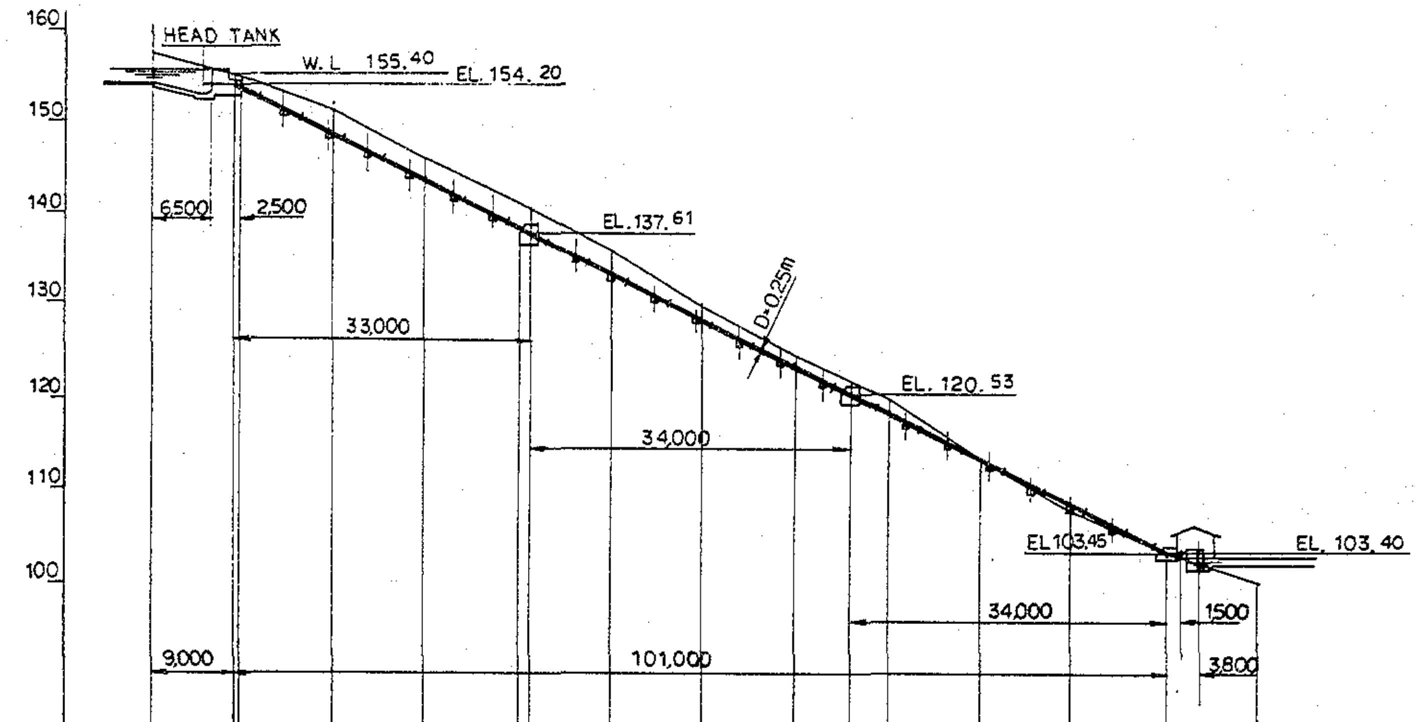
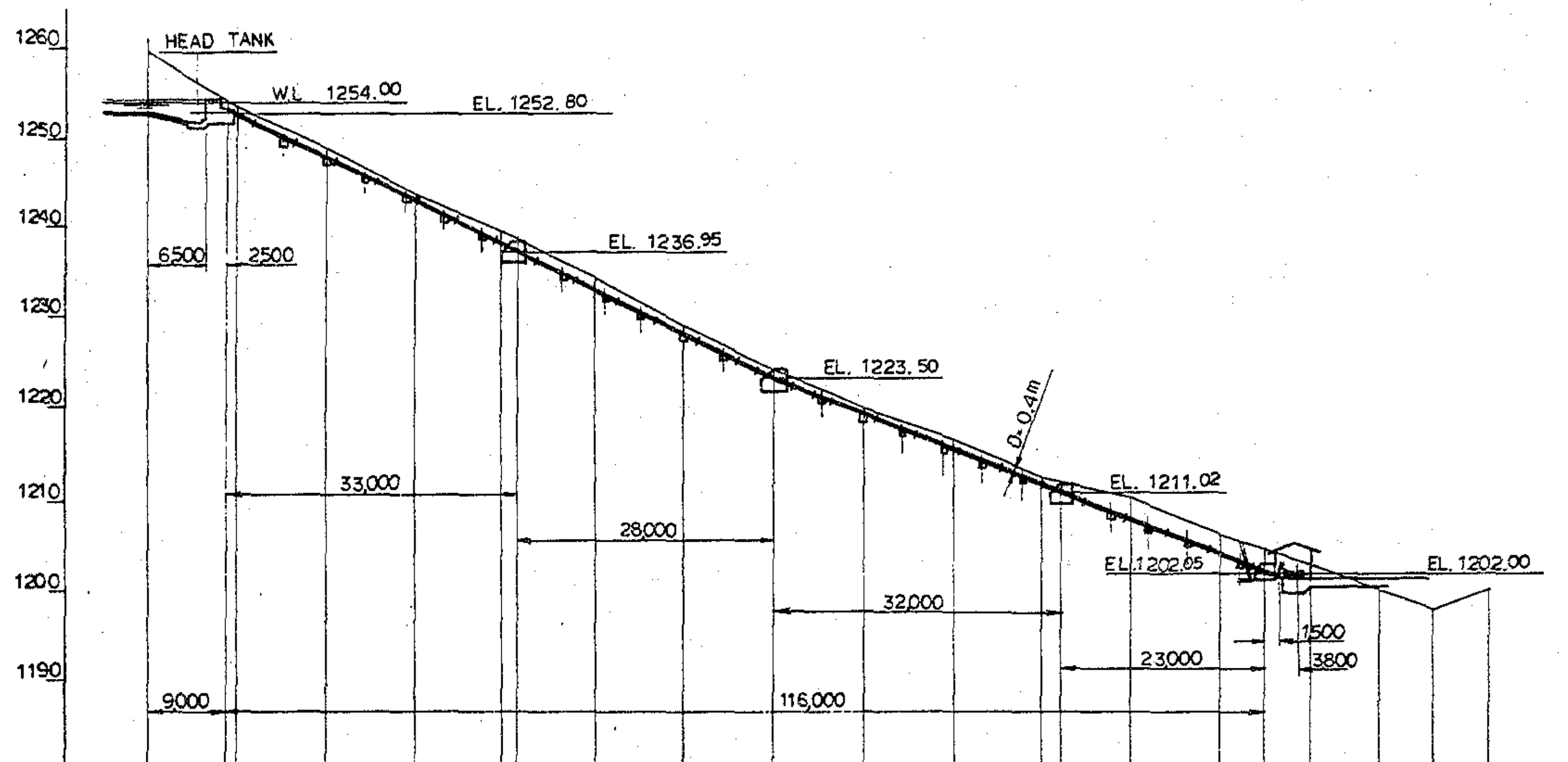


Fig. 4·6-5-(3)
PENSTOCK PROFILE
No. 5 TANGSIBI SITE
SCALE 1/500



Sta.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ground Hight	157.95	154.40	151.63	146.09	141.44	136.06	130.97	124.43	119.46	113.68	107.59	103.38	100.00		
Accumulative Distance	0	(9,000) 10,000	20,000	30,000	40,000	50,000	60,000	70,000	80,000	90,000	100,000	110,000	120,000	130,000	140,000
Distance	0	(9,000) 10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000

Fig. 4·6-5-(4)
PENSTOCK PROFILE
No.6 BUBJA SITE
SCALE 1/500



Sta.	Distance	Accumulative Distance	Ground Hight
0	0	0	1259.97
1	(9,000) 10,000	(9000) 10,000	1253.68
2	10,000	20,000	1249.18
3	10,000	30,000	1244.18
4	10,000 (2,000)	40,000 (42,000)	1239.90
5	10,000	50,000	1235.12
6	10,000	60,000	1229.86
7	10,000	70,000	1224.56
8	10,000	80,000	1220.00
9	10,000	90,000	1216.75
10	10,000	100,000	1214.64
11	10,000	110,000	1210.30
12	10,000	120,000	1206.80
	(5,000)	(125,000)	
13	10,000	130,000	1202.89
14	7,500	137,500	1200.57
15	6,000	143,500	1198.00
16	6,500	150,000	1200.00

Fig. 4-6-5-(5)
PENSTOCK PROFILE
No.7 SUREY SITE
SCALE 1/500

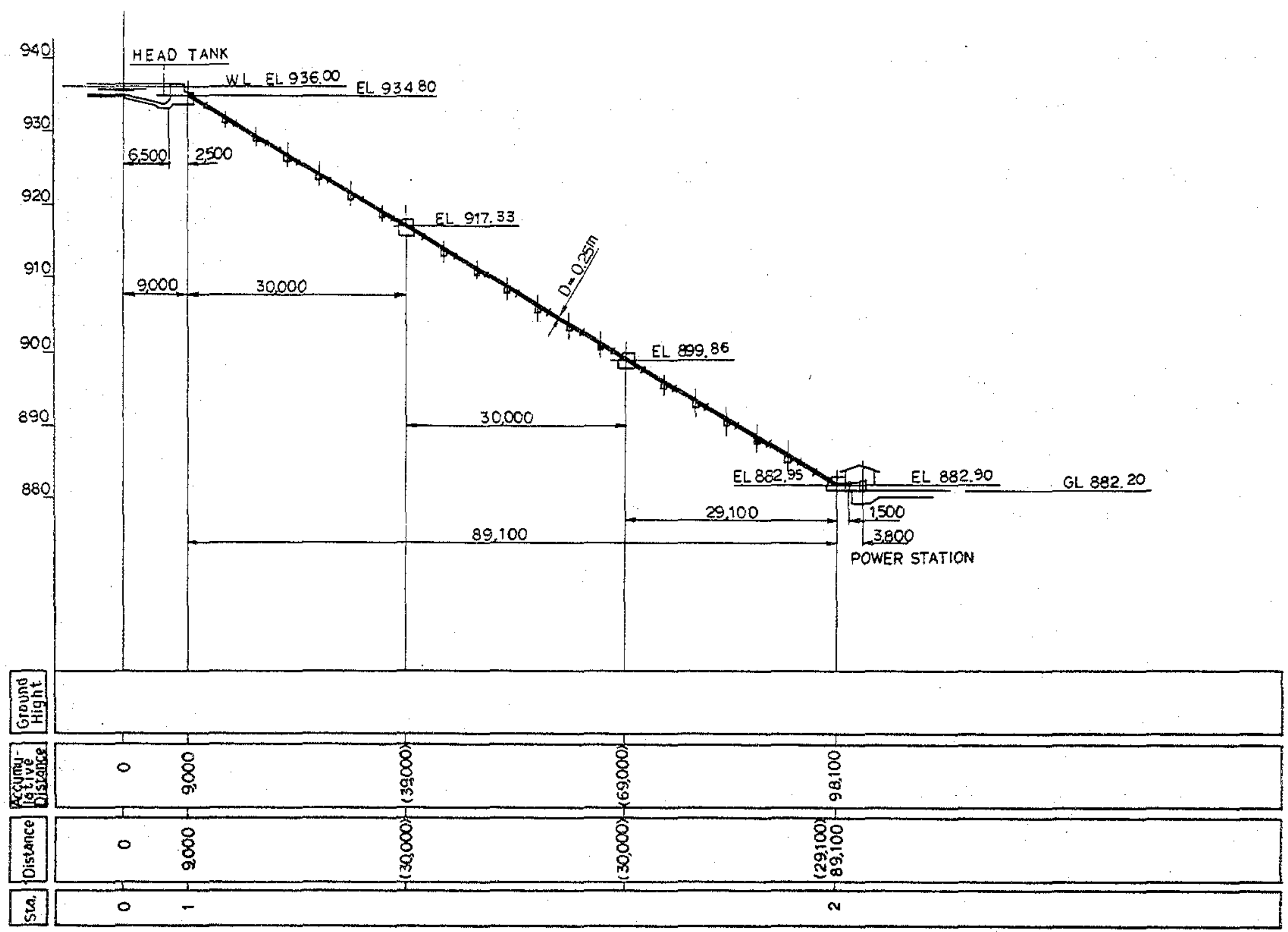


Fig. 4·6-5-(6)
PENSTOCK PROFILE
No.8 YADI SITE
SCALE 1/500

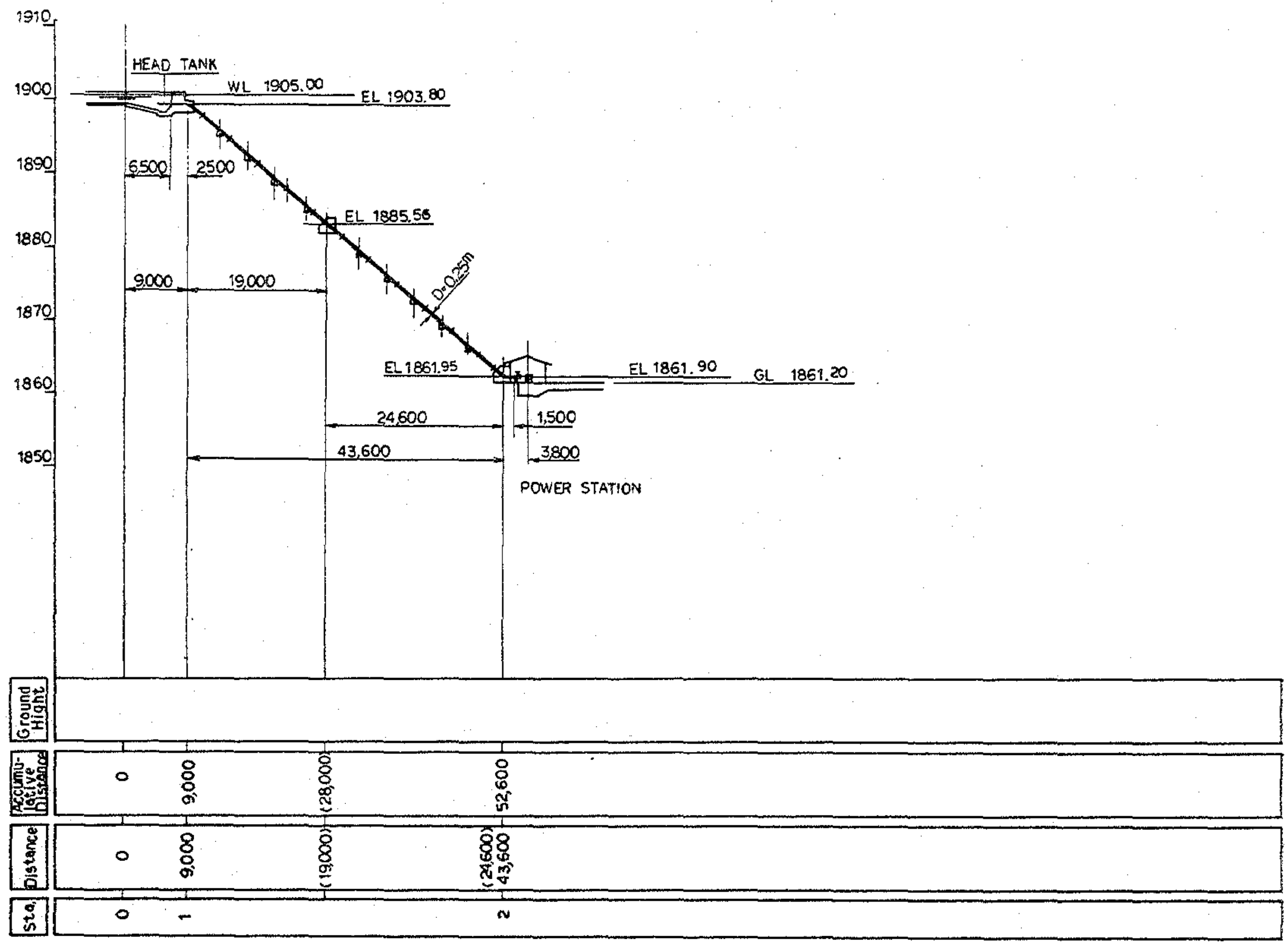


Fig. 4·6 - 5 - (7)
PENSTOCK PROFILE
No.101 PUNAKHA SITE
SCALE 1/500

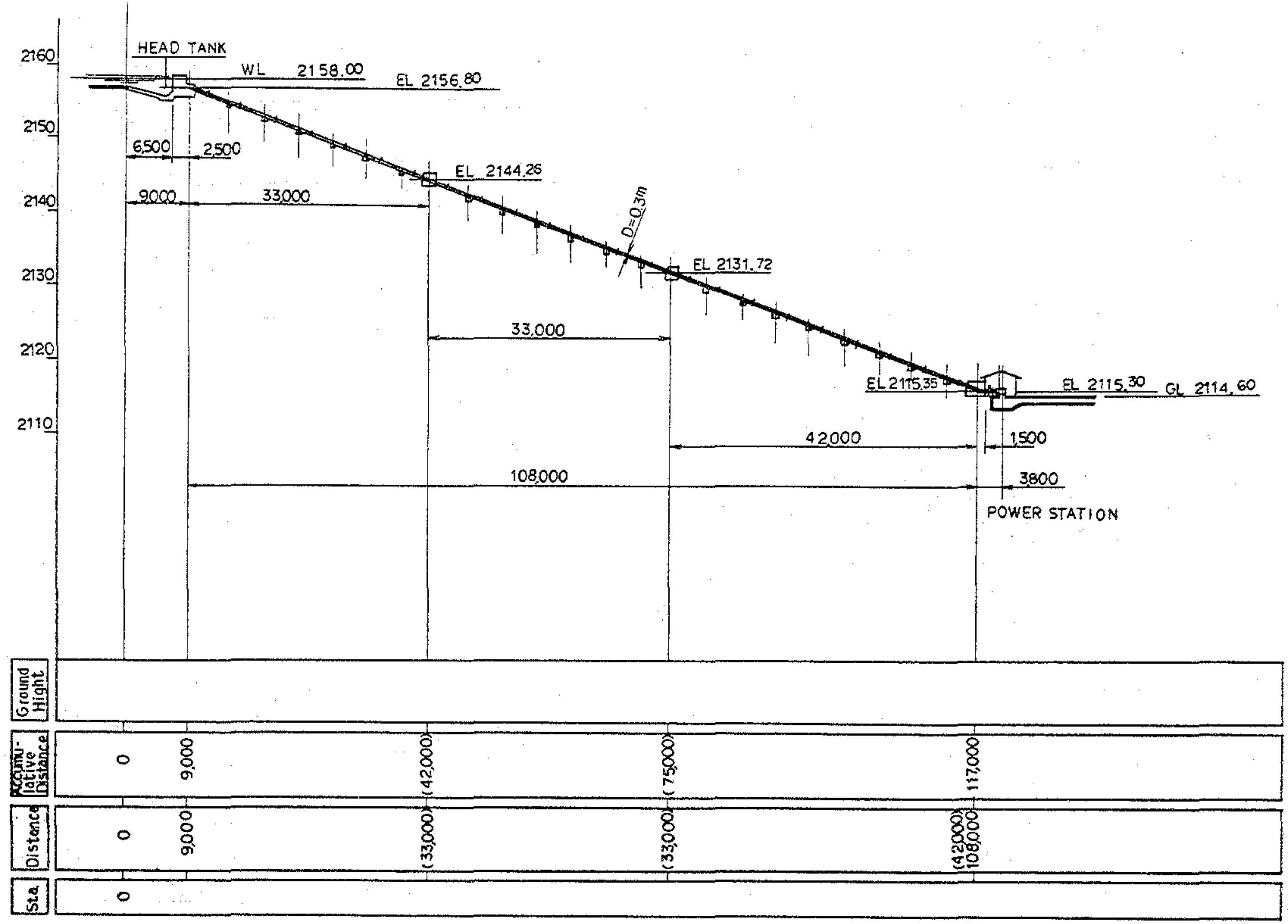


Fig. 4·6-5-(8)
PENSTOCK PROFILE
No. 102 TONGSA SITE
SCALE 1/500

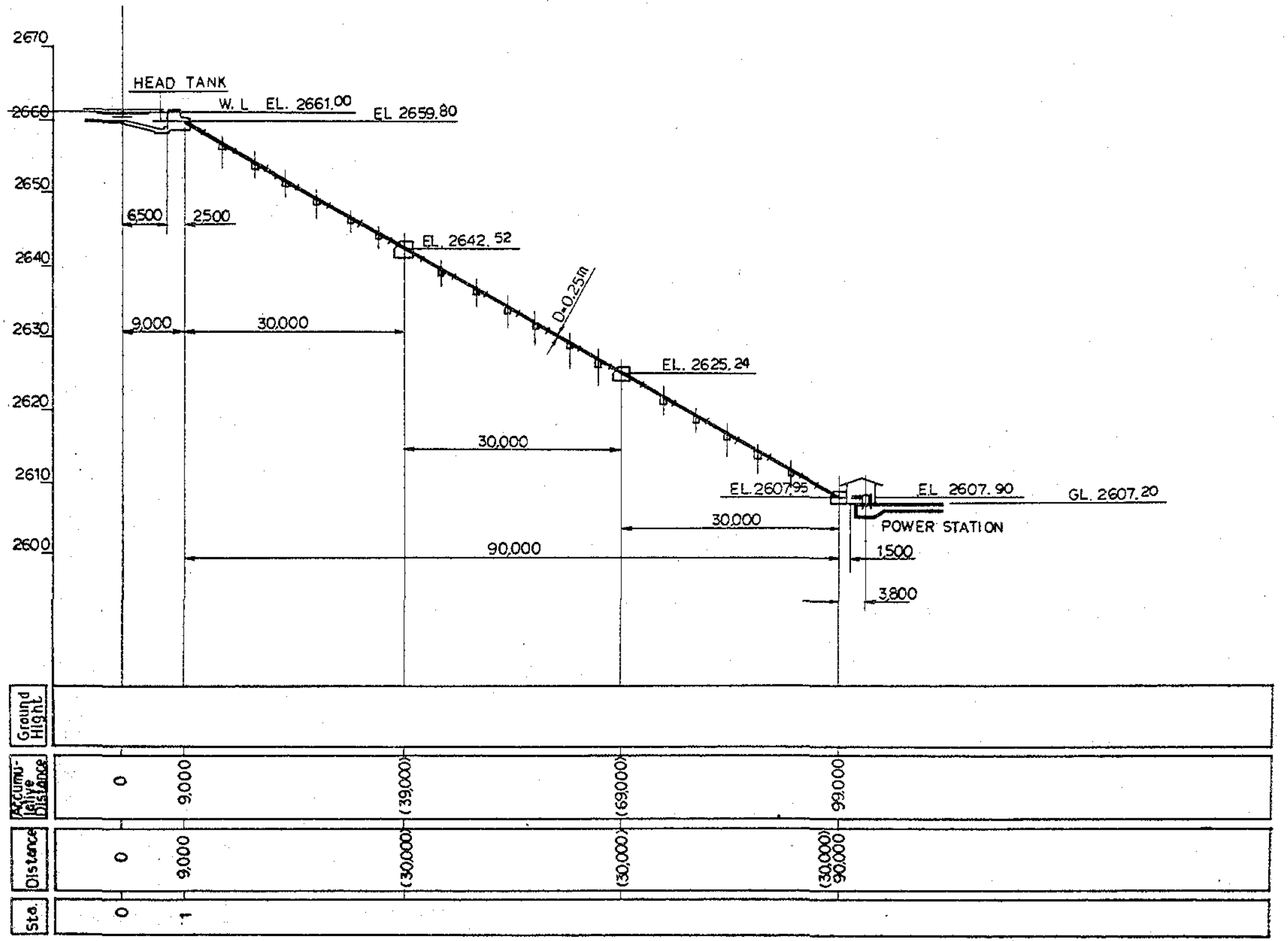
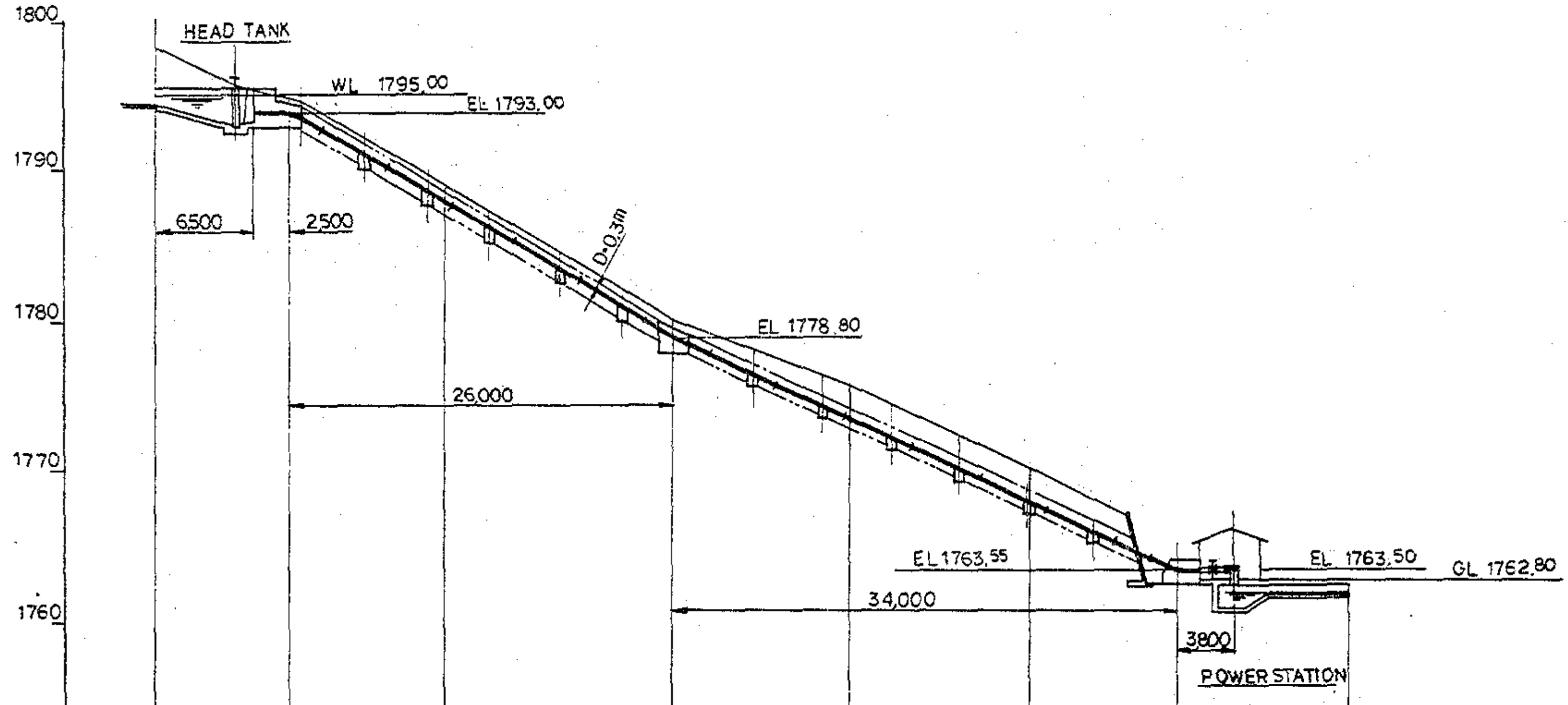


Fig. 4-6-5-(9)
PENSTOCK PROFILE
No.103 TAMJHING SITE
SCALE 1/500



Sta.	0	0+9	1	2	3	4	4+98	5
Distance	0	(9,000)	19,500	15,500	12,000	12,200	(9,800)	21,500
Accumu-lative Distance	0	(9,000)	19,500	35,000	47,000	59,200	(69,000)	80,700
Ground Hight	1,798,524	(1,794,227)	1,789,215	1,780,240	1,775,940	1,770,400	(1,775,140)	1,760,000

Fig. 4-6-5-(10)
PENSTOCK PROFILE
No. 10 KEKHAR SITE
SCALE 1/500

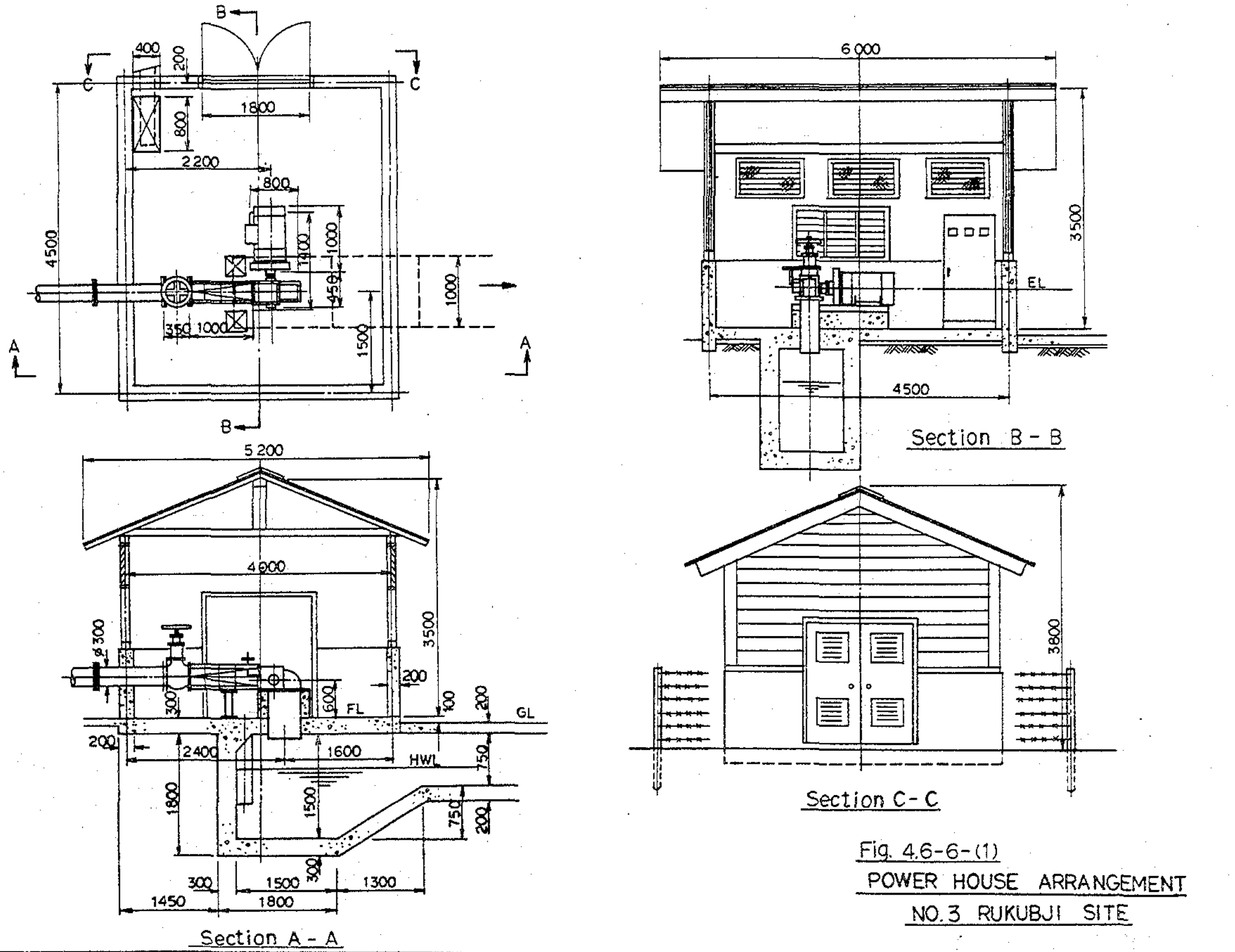


Fig. 4.6-6-(1)
POWER HOUSE ARRANGEMENT
NO.3 RUKUBJI SITE

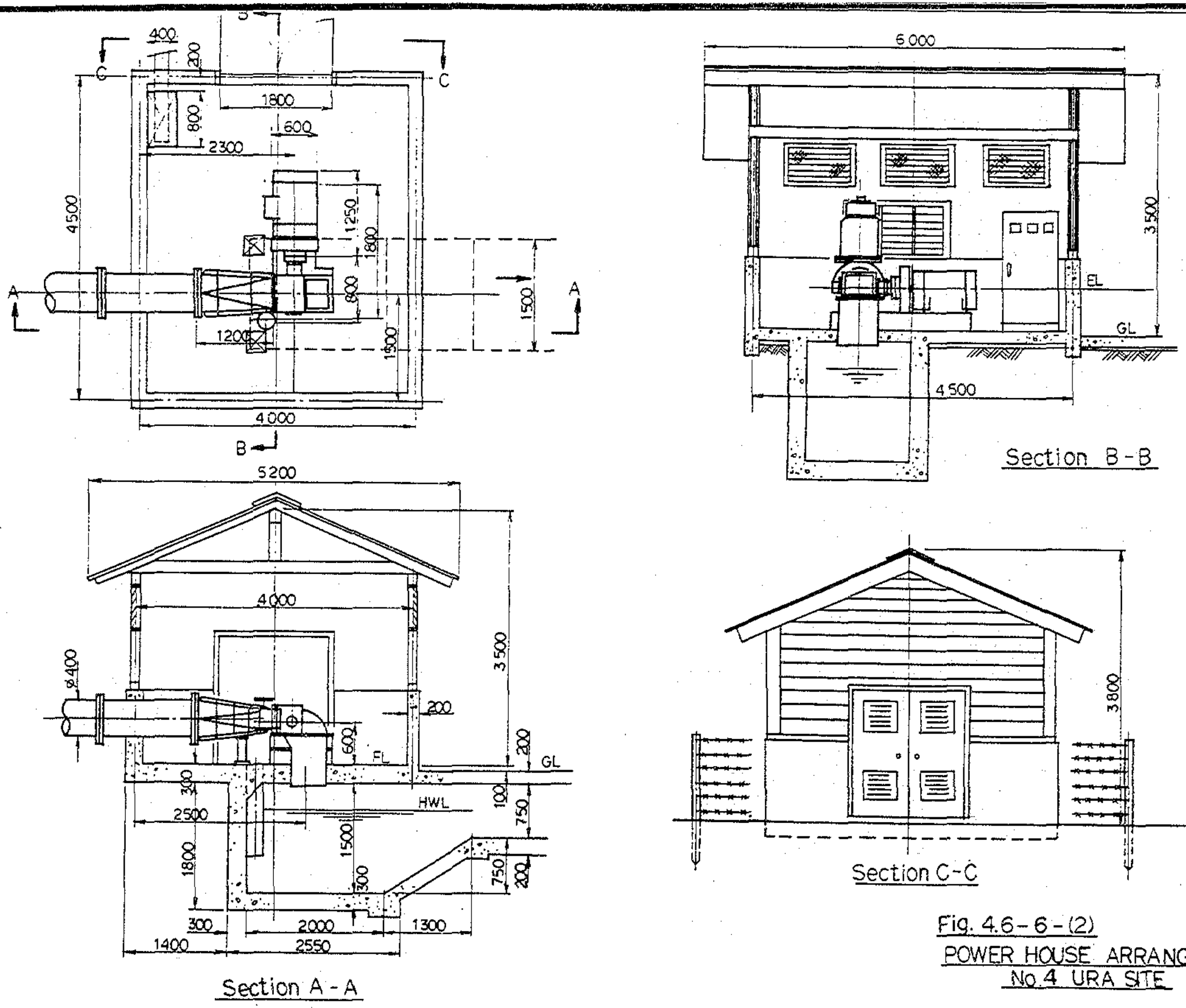


Fig. 4.6-6-(2)
POWER HOUSE ARRANGEMENT
No.4 URA SITE

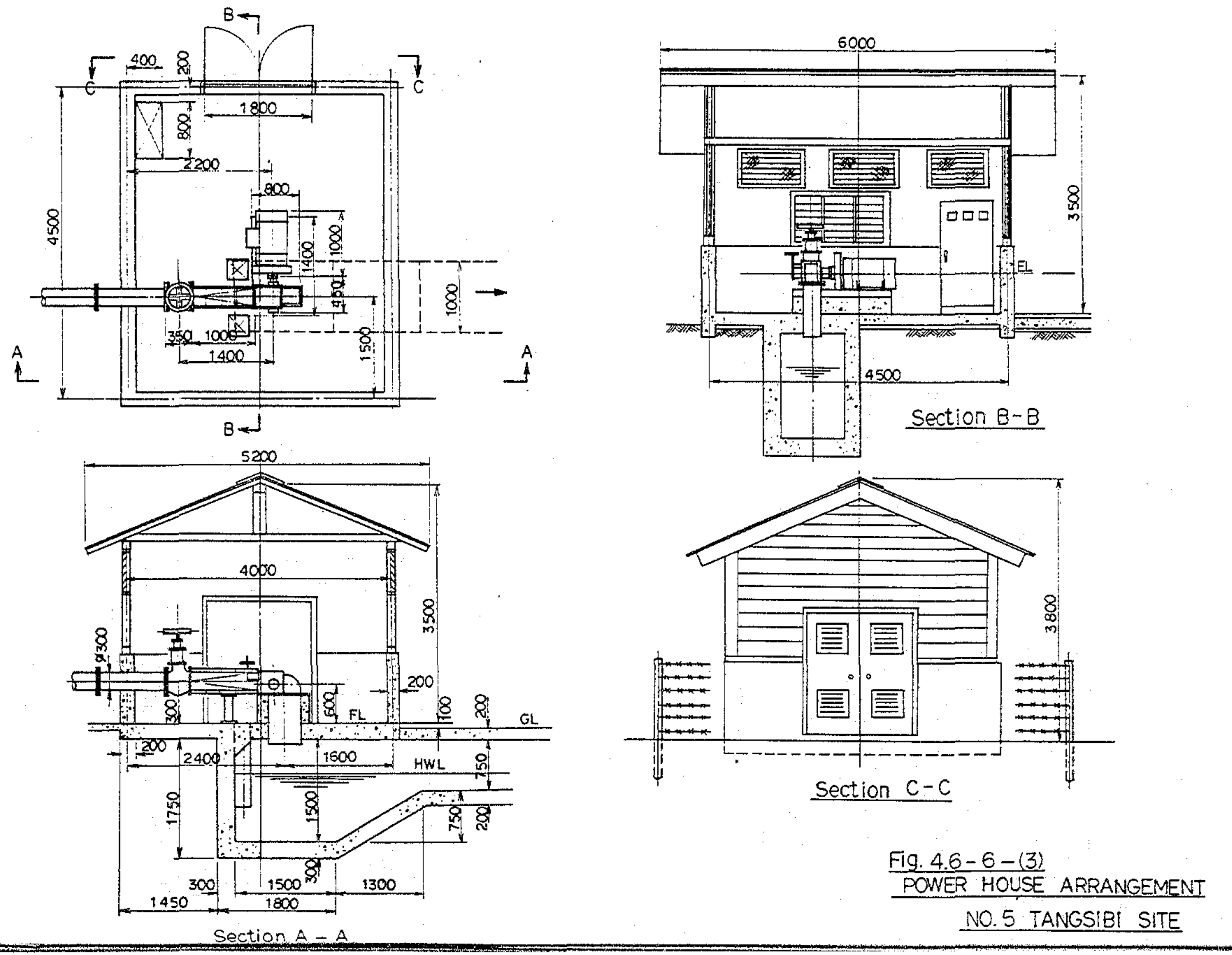


Fig. 4.6-6-(3)
POWER HOUSE ARRANGEMENT
NO. 5 TANGSIBI SITE

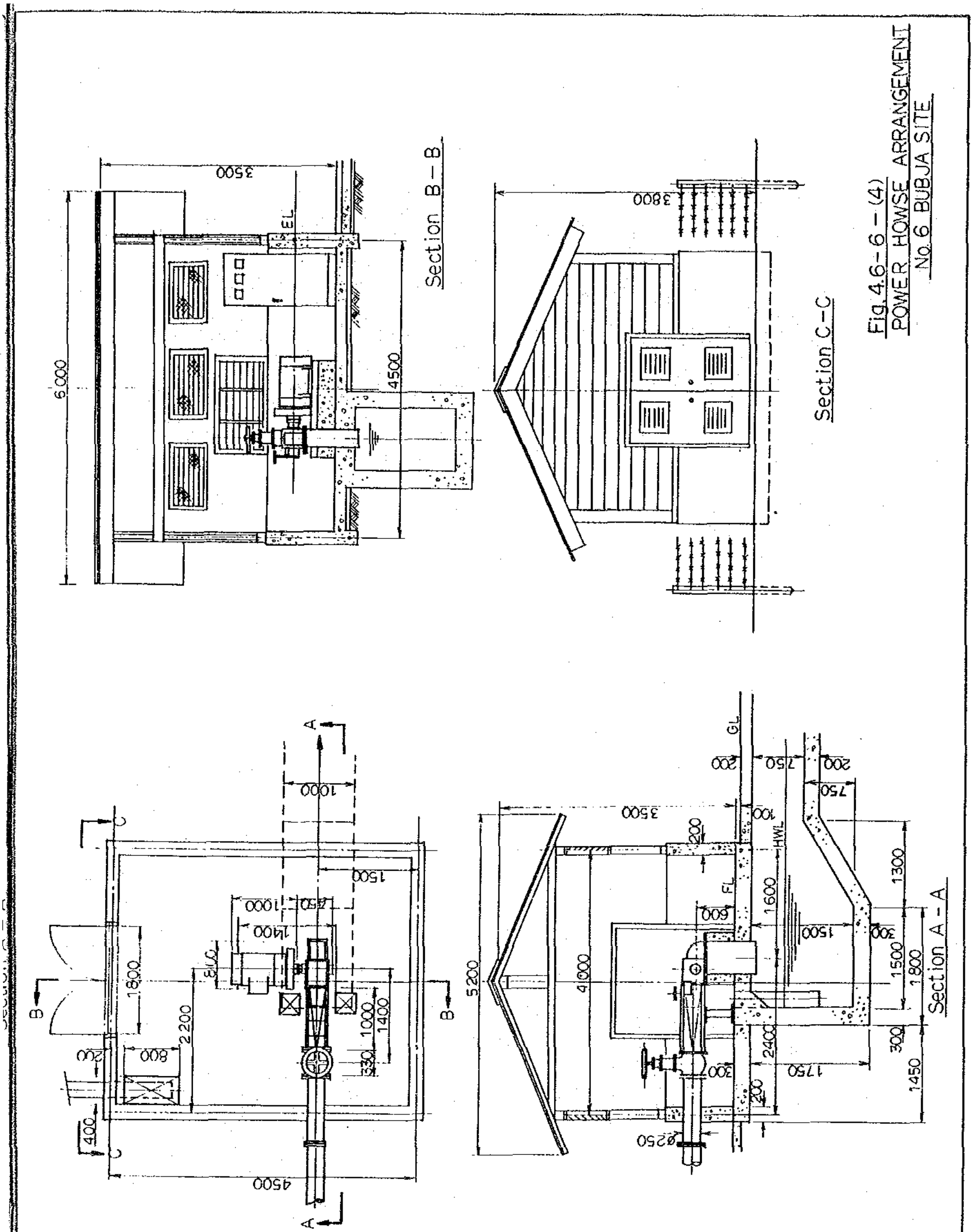


Fig.4.6-6-(4)
POWER HOWSE ARRANGEMENT
No.6 BUBJA SITE

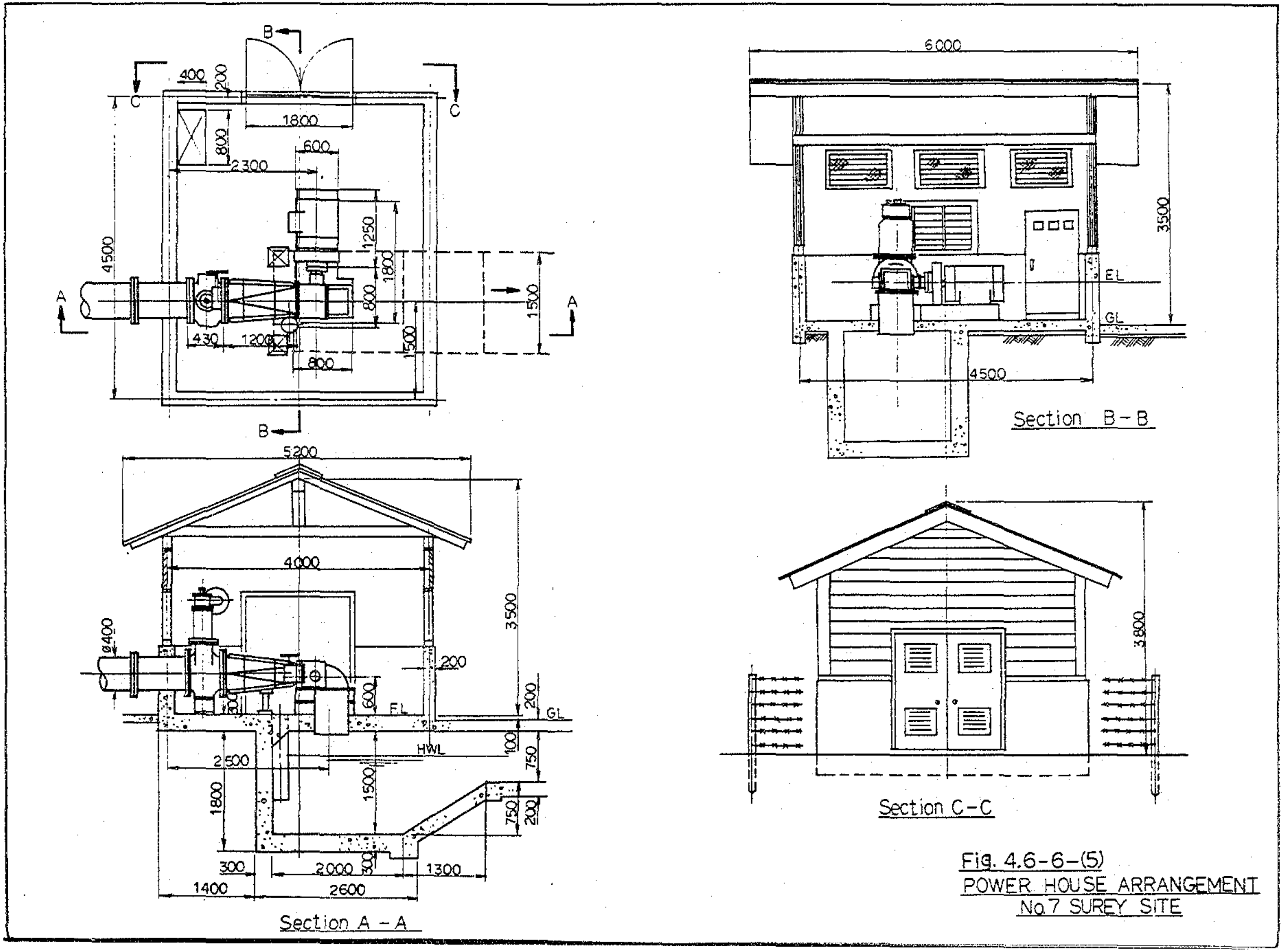


Fig. 4.6-6-(5)
POWER HOUSE ARRANGEMENT
No.7 SUREY SITE

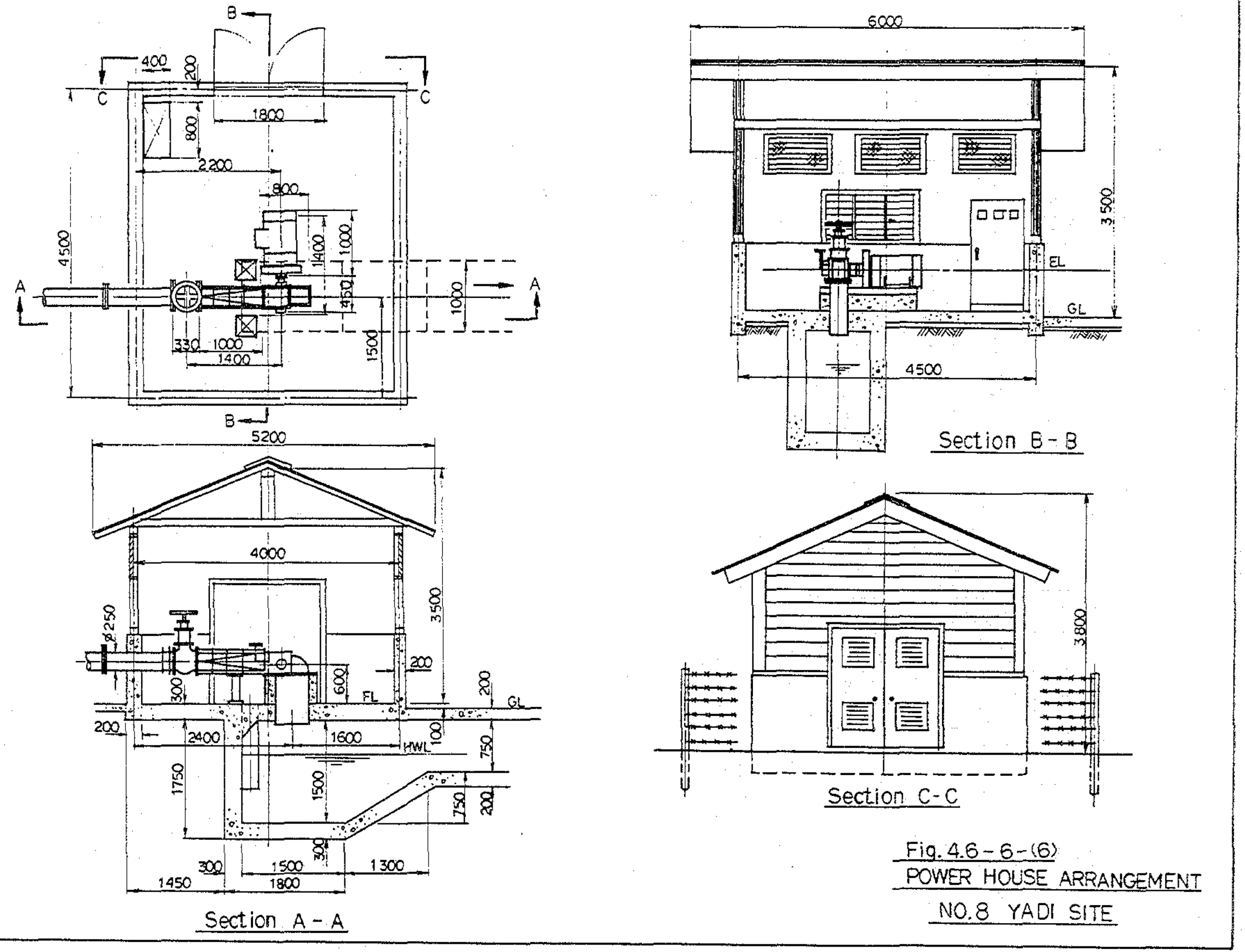


Fig. 4.6-6-(6)
POWER HOUSE ARRANGEMENT
NO.8 YADI SITE

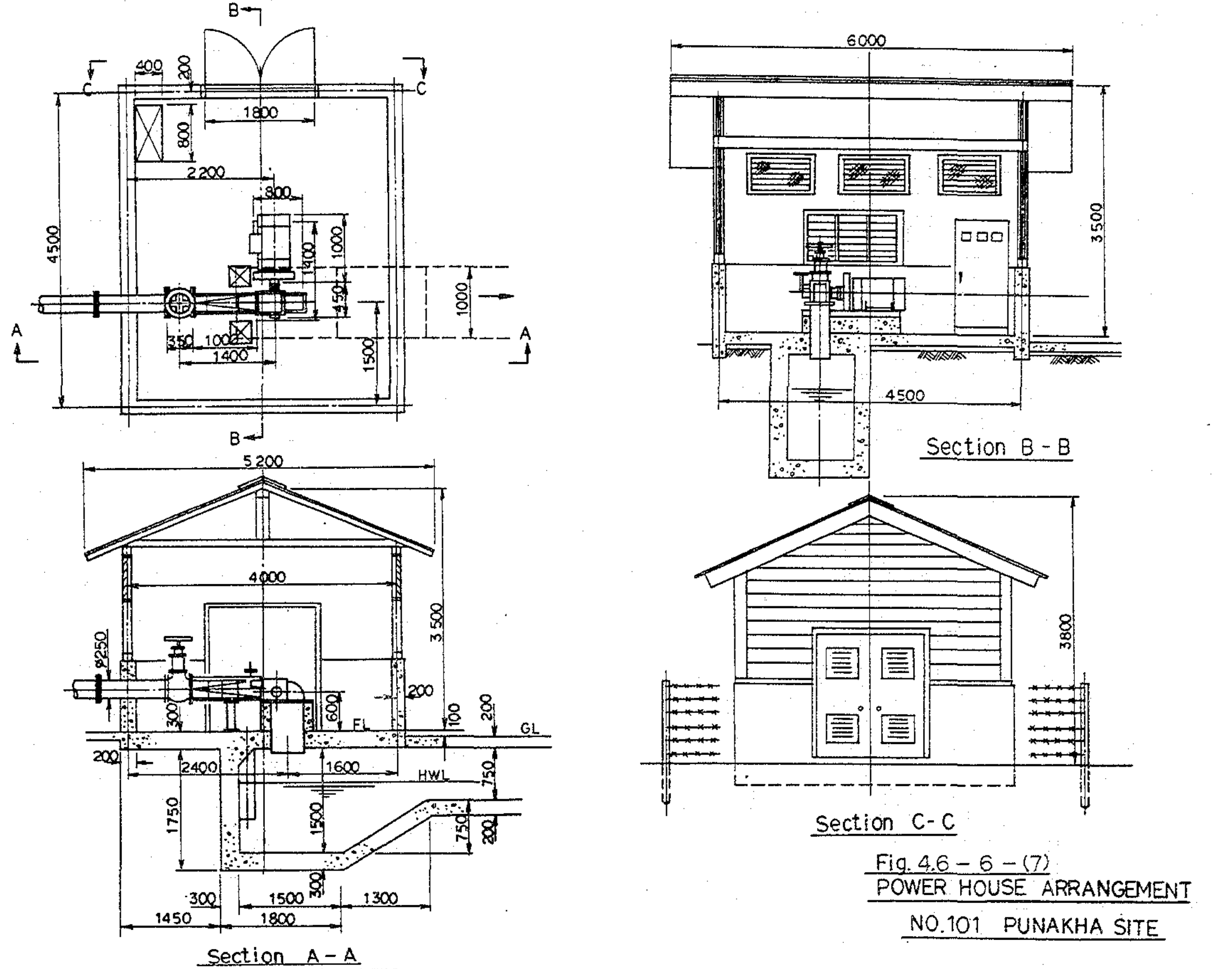


Fig. 4.6 – 6 – (7)
POWER HOUSE ARRANGEMENT
NO.101 PUNAKHA SITE

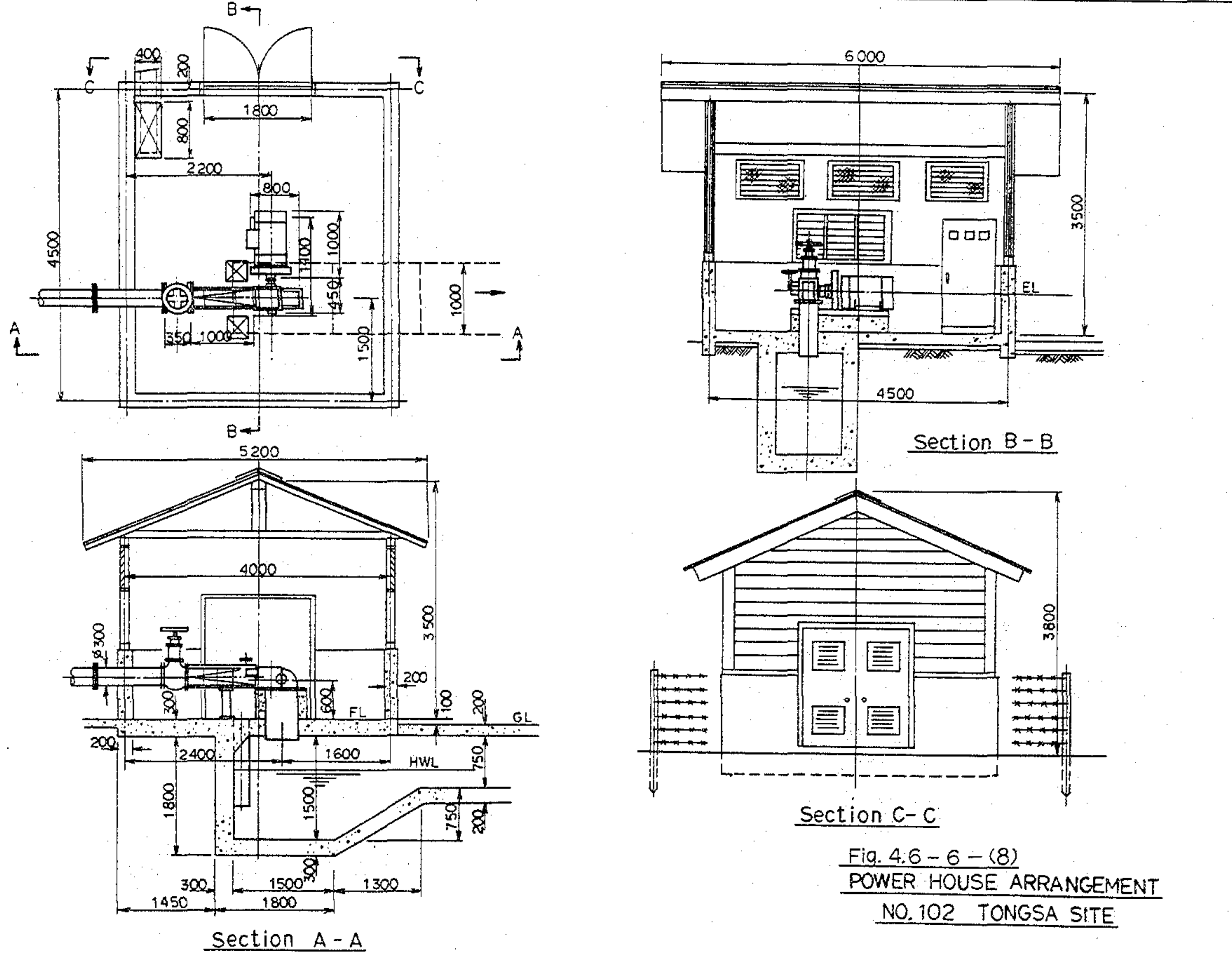


Fig. 4.6 – 6 – (8)
POWER HOUSE ARRANGEMENT
NO. 102 TONGSA SITE

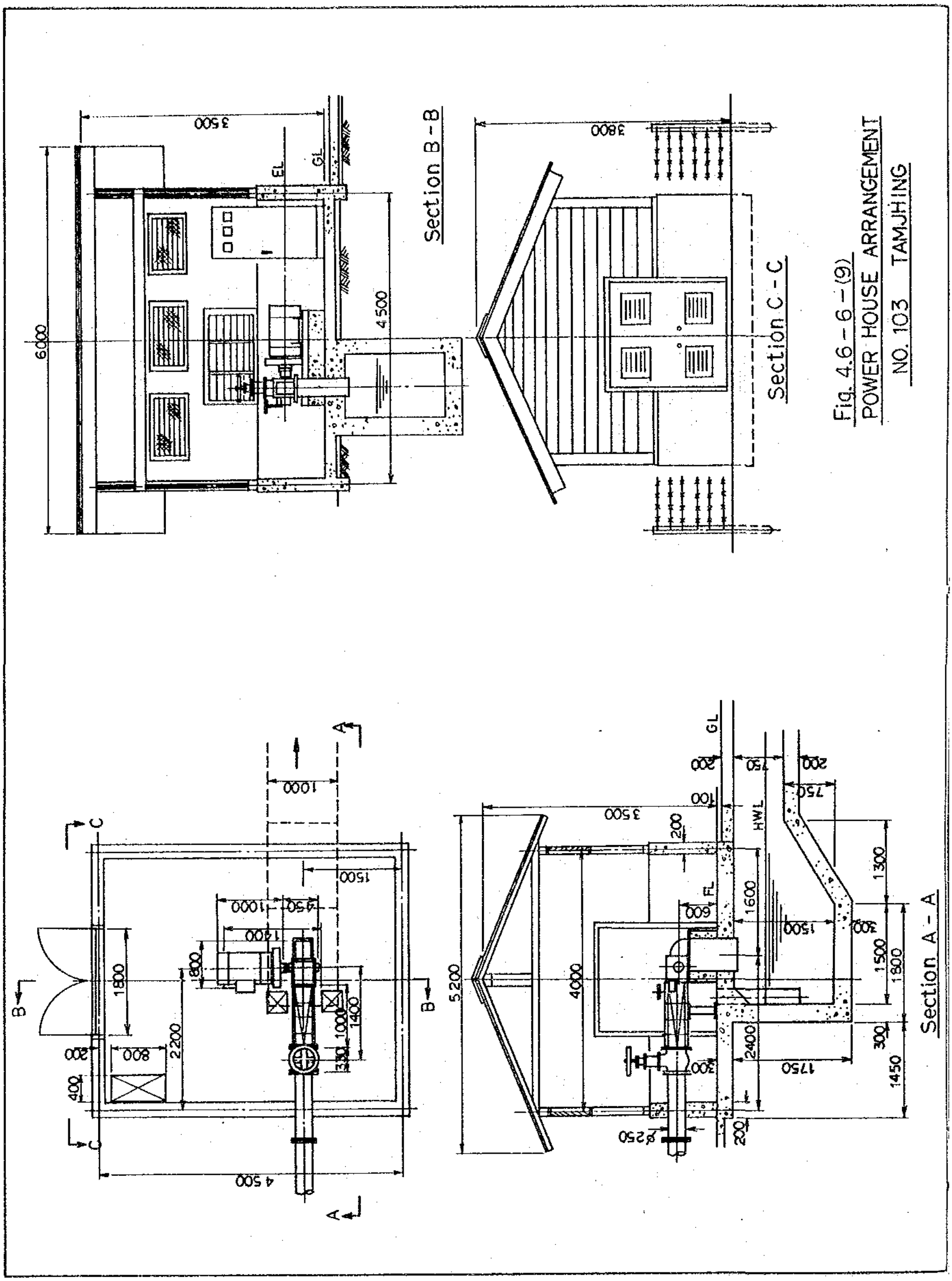


Fig. 4.6 - 6 - (9)
POWER HOUSE ARRANGEMENT
NO. 103 TAMJHING

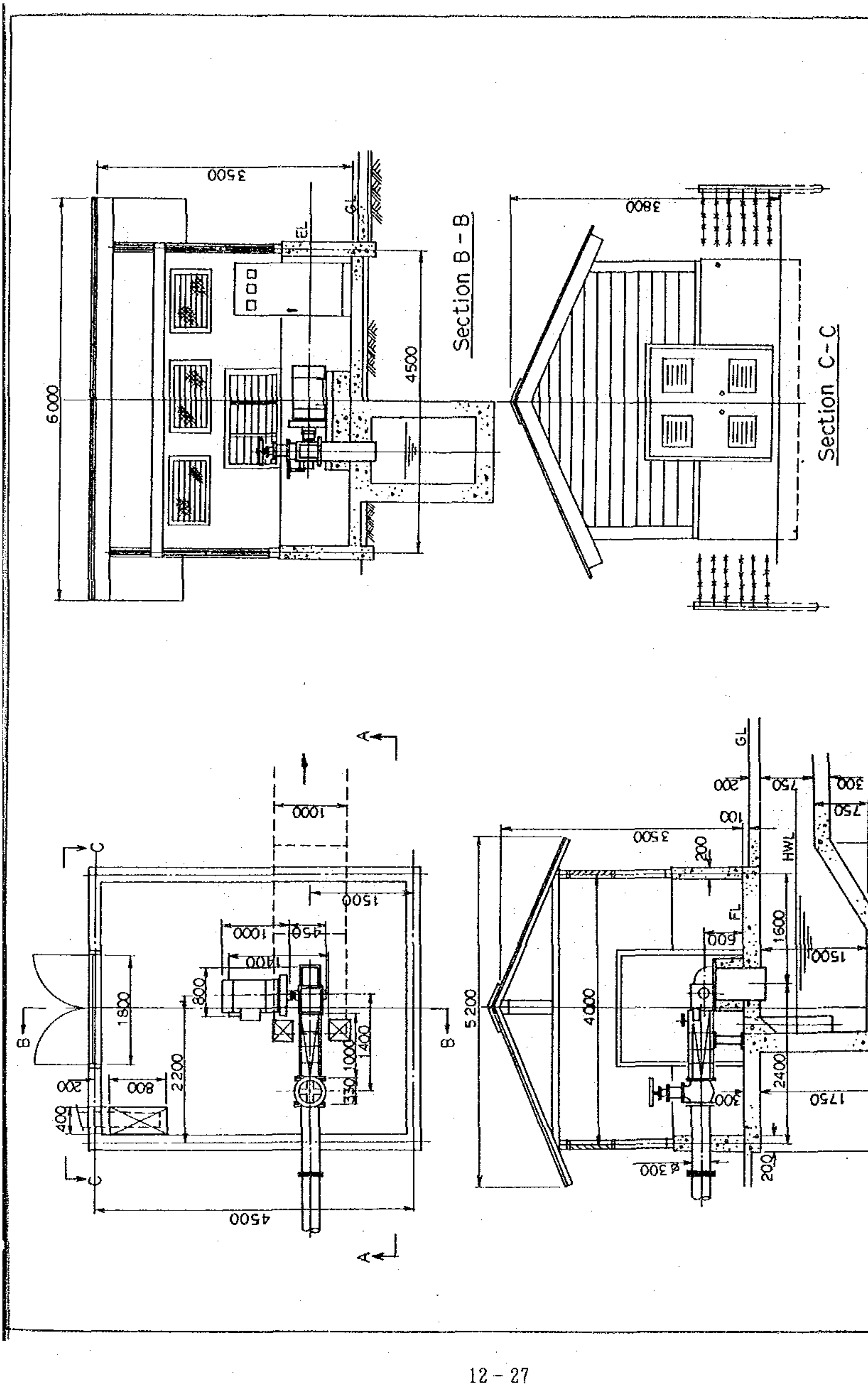
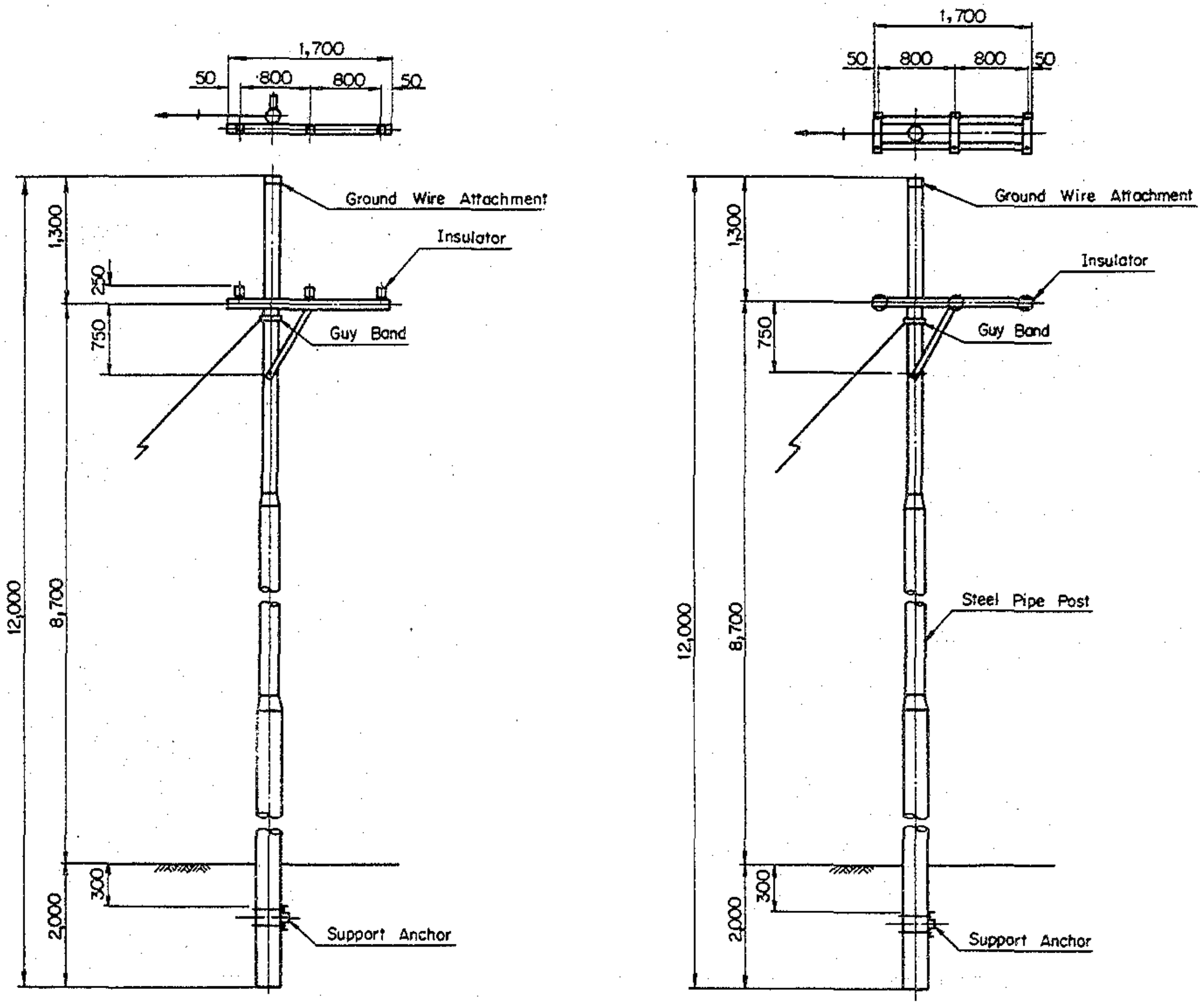


Fig.4.6-6-(10)
POWER HOUSE ARRANGEMENT
NO.104 KEKHAR SITE

Fig. 4.6-7 (1) 6.6kV T/L Post Arrangment



for Struight Line

for Dead End Type

Fig. 4. 6-7(2) 6.6kV T/L Post Arrangment

For Sending end and Reciving end

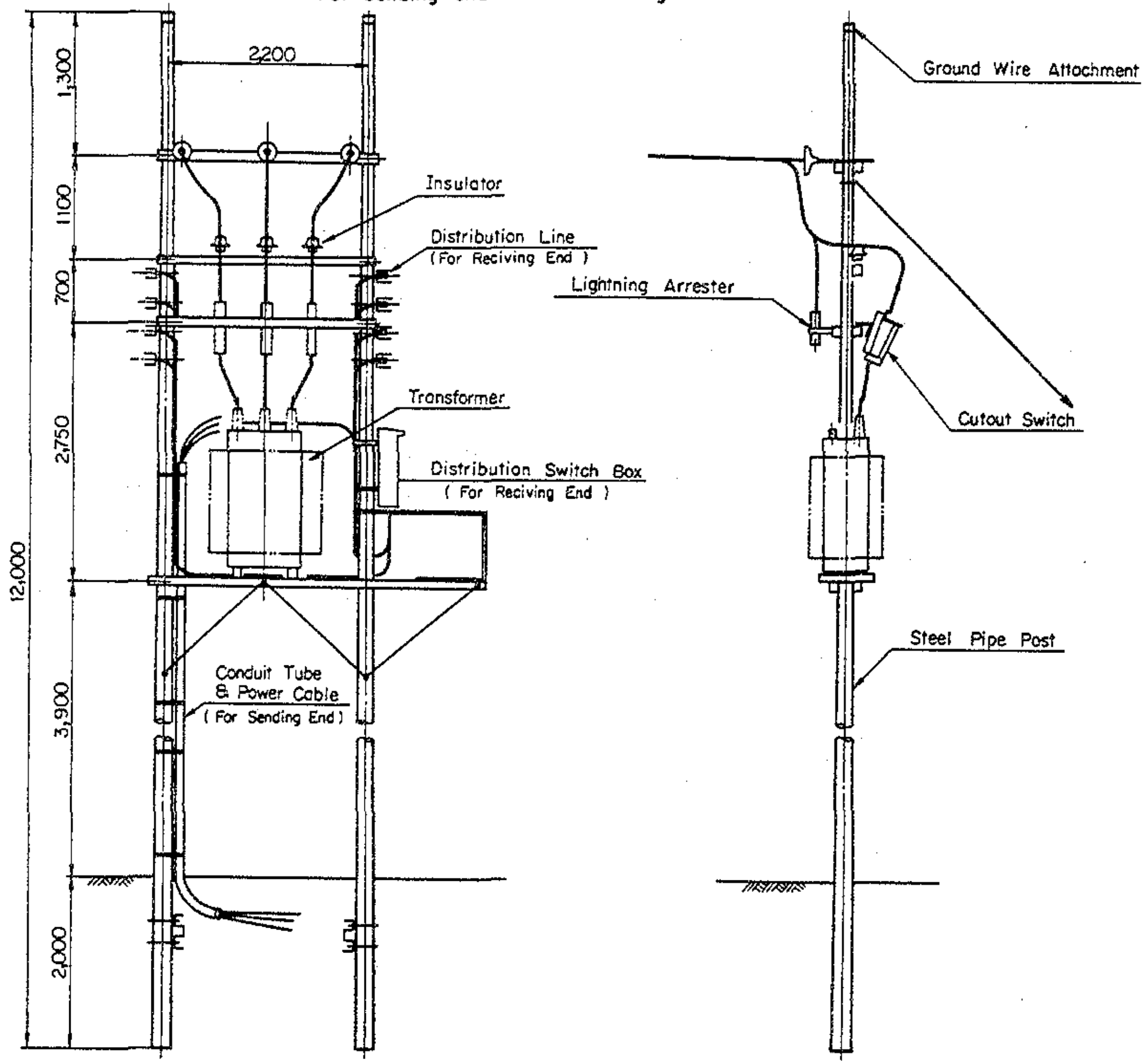
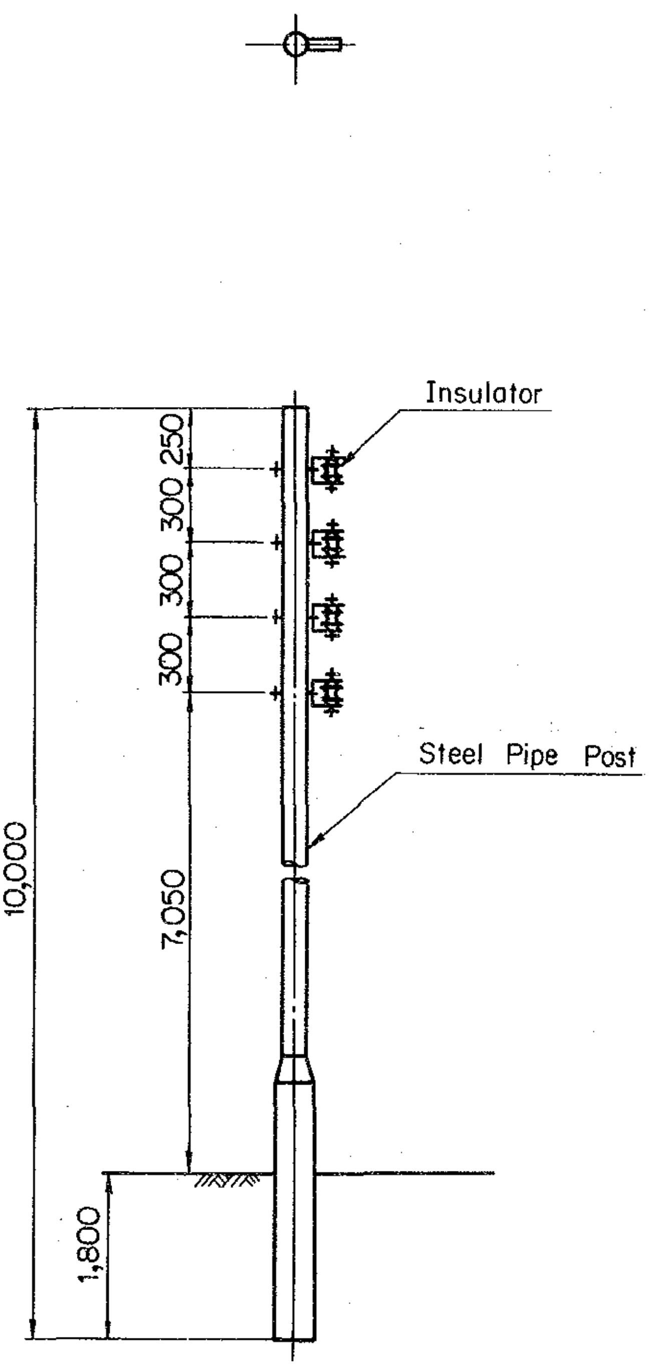


Fig. 4.6-8 400V D/L Post Arrangement



JICA