Appendix 12.3.2

Civil Works

725
(726)

(1) Care of River

a) Upstream Cofferdam

Type of Works | Calculation | Quantity

<Excavation>

First Coffering

Common Excavation and Rock Excavation

Survey Station	Section Length(m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume(m^3)	Notes
No.0		0.0				
No.1	0.3	1.5	0.75	0.2	0.2	
No.2	5.0	32.5	17.00	85.0	85.2	
No.3	20.0	10.6	21.55	431.0	516.2	
No.4	15.0	42.3	26.45	396.8	913.0	
No.5	5.0	3.6	22.95	114.8	1,027.7	
No.6	0.6	0.0	1.80	1.1	1,028.8	

Second Coffering

Common Excavation and Rock Excavation

Survey Station	Section Length(m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume(m^3)	Notes
No.0		0.0				
No.1	2.8	33.0	16.50	46.2	46.2	
No.2	5.5	75.1	54.05	297.3	343.5	
No.3	10.4	10.8	42.95	446.7	790.2	
No.4	20.0	85.8	48.30	966.0	1,756.2	
No.5	12.0	78.6	82.20	986.4	2,742.6	
No.6	20.0	48.4	63.50	1,270.0	4,012.6	
No.7	9.0	6.0	27.20	244.8	4,257.4	
No.8	4.1	0.0	3.00	12.3	4,269.7	

Estimated Ratio··(Common Excavation):(Rock Excavation)= 7 : 3

(1) Common Excavation

First Coffering

$V_1 = 1,028.8 \times 0.7 = 720.2\ m^3$

Second Coffering

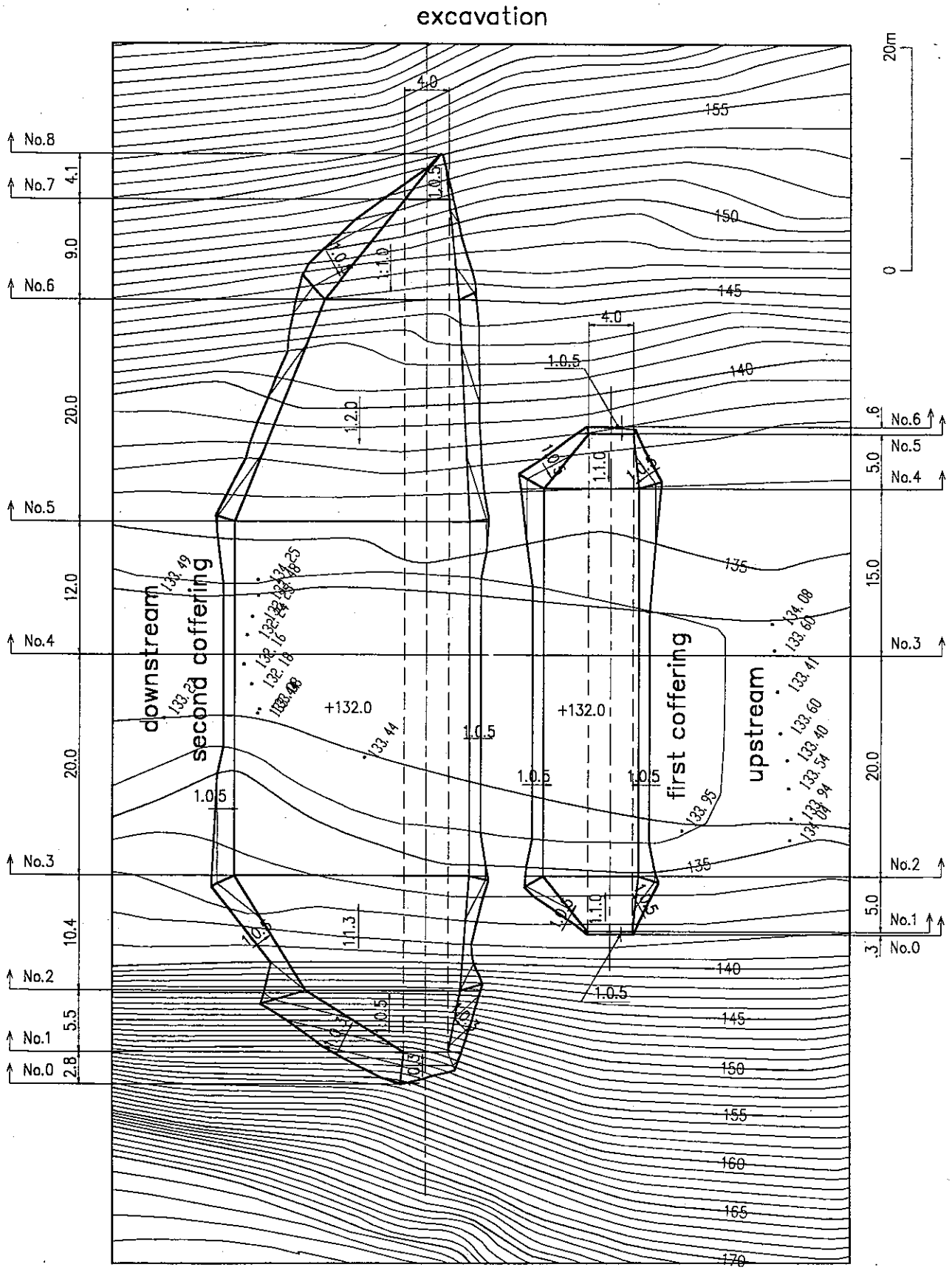
$V_2 = 4,269.7 \times 0.7 = 2,988.8\ m^3$

Total

$\Sigma V = V_1 + V_2 = 3,709.0\ m^3$ → 3,709 m^3

727

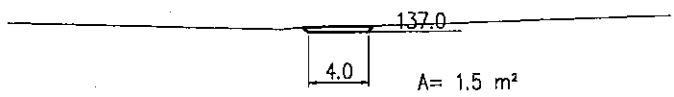
Upstream Cofferdam—Plan



Upstream Cofferdam—Section

first coffering (excavation)

No.1



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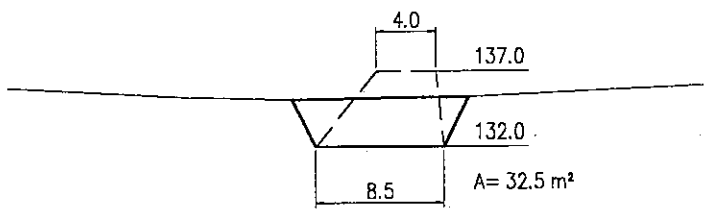

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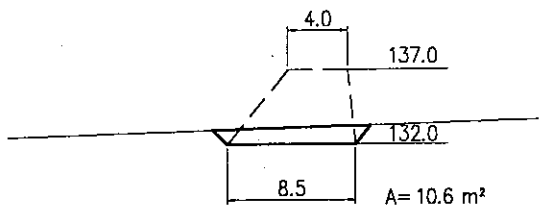

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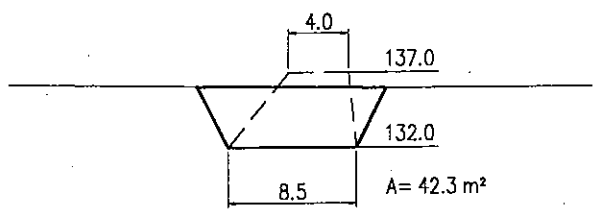

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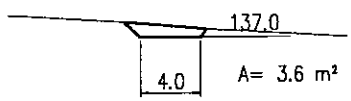
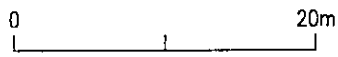
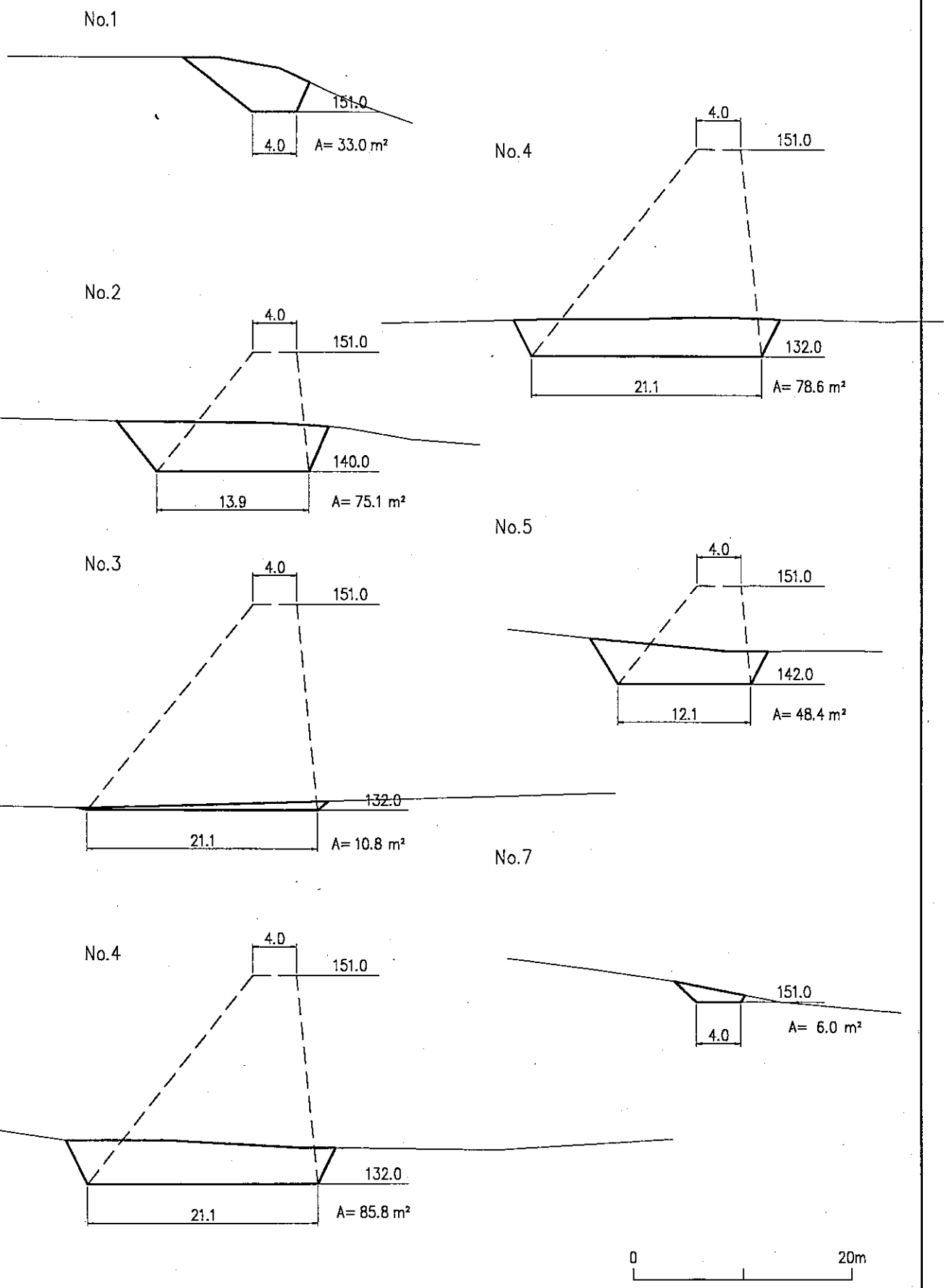




Upstream Cofferdam—Section

second coffering (excavation)



730

Type of Works	Calculation	Quantity

(2) Rock Excavation

First Coffering

$V_1 = 1,028.8 \times 0.3$ = 308.6 m^3

Second Coffering

$V_2 = 4,269.7 \times 0.3$ = 1,280.9 m^3

Total

$\Sigma V = V_1 + V_2$ = 1,589.5 m^3 → 1,590 m^3

< Dam Concrete (RCC) >

First Coffering

Survey Station	Section Length(m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
No. 0		0.0				
No. 1	0.3	0.0	0.00	0.0	0.0	
No. 2	5.0	31.3	15.65	78.3	78.3	
No. 3	20.0	31.3	31.30	626.0	704.3	
No. 4	15.0	31.3	31.30	469.5	1,173.8	
No. 5	5.0	0.0	15.65	78.3	1,252.0	
No. 6	0.6	0.0	0.00	0.0	1,252.0	

V_1 = 1,252.0 m^3

Second Coffering

Survey Station	Section Length(m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
No. 0		0.0				
No. 1	2.8	0.0	0.00	0.0	0.0	
No. 2	5.5	98.5	49.25	270.9	270.9	
No. 3	10.4	238.5	168.50	1,752.4	2,023.3	
No. 4	20.0	238.5	238.50	4,770.0	6,793.3	
No. 5	12.0	238.5	238.50	2,862.0	9,655.3	
No. 6	20.0	72.5	155.50	3,110.0	12,765.3	
No. 7	9.0	0.0	36.25	326.3	13,091.5	
No. 8	4.1	0.0	0.00	0.0	13,091.5	

V_2= 13,091.5 m^3

Total

$\Sigma V = V_1 + V_2$ = 14,343.5 m^3 → 14,344 m^3

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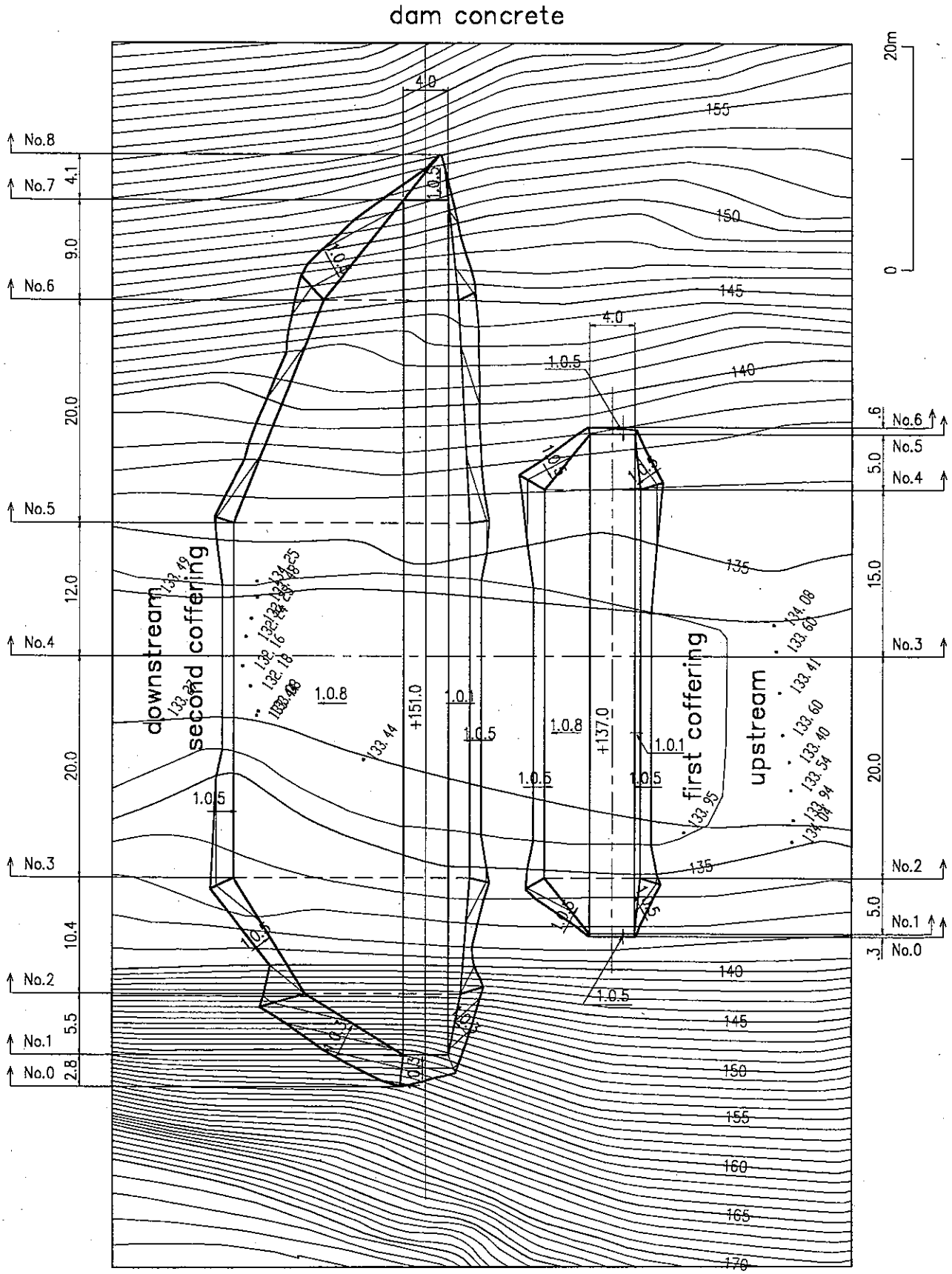
Upstream Cofferdam—Plan

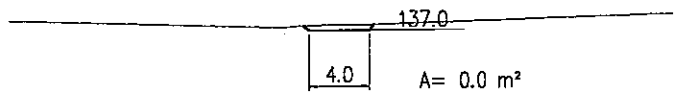


732.

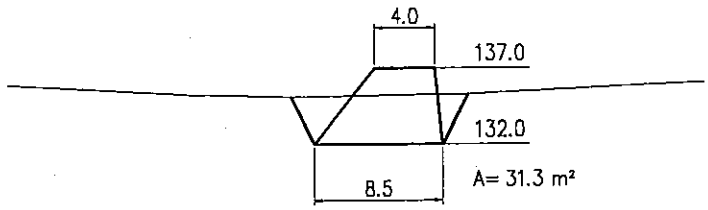
Upstream Cofferdam—Section

first coffering (dam concrete)

No.1



No.2



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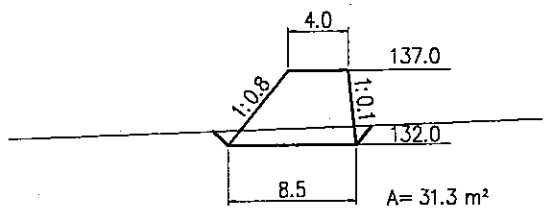

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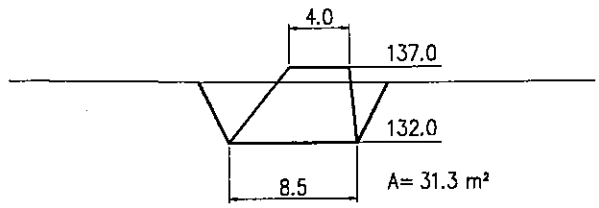

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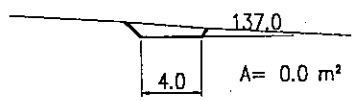
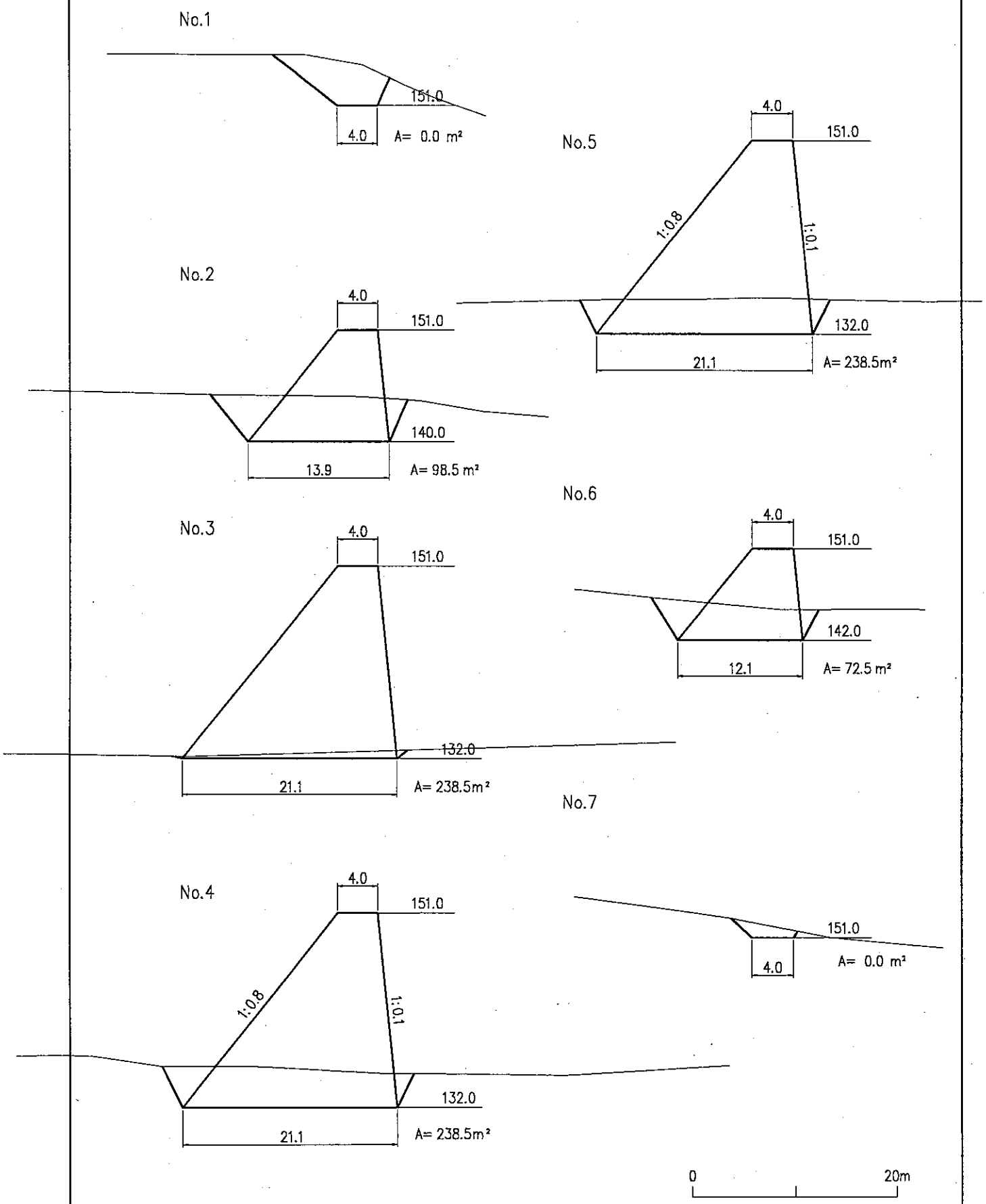


733

Upstream Cofferdam—Section

second coffering (dam concrete)



b) Downstream Cofferdam

Type of Works	Calculation	Quantity

< Excavation >

Common Excavation and Rock Excavation

Survey Station	Section Length(m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
No.0		0.0				
No.1	0.5	11.5	5.75	2.9	2.9	
No.2	2.5	106.8	59.15	147.9	150.8	
No.3	1.5	237.4	172.10	258.2	408.9	
No.4	22.0	50.8	144.10	3,170.2	3,579.1	
No.5	12.0	95.9	73.35	880.2	4,459.3	
No.6	8.0	7.9	51.90	415.2	4,874.5	
No.7	1.9	0.0	3.95	7.5	4,882.0	

Estimated Ratio‥(Common Excavation):(Rock Excavation)= 7 : 3

(1) Common Excavation

V = 4,882.0×0.7 = 3,417.4 m^3

(2) Rock Excavation

V = 4,882.0×0.3 = 1,464.6 m^3

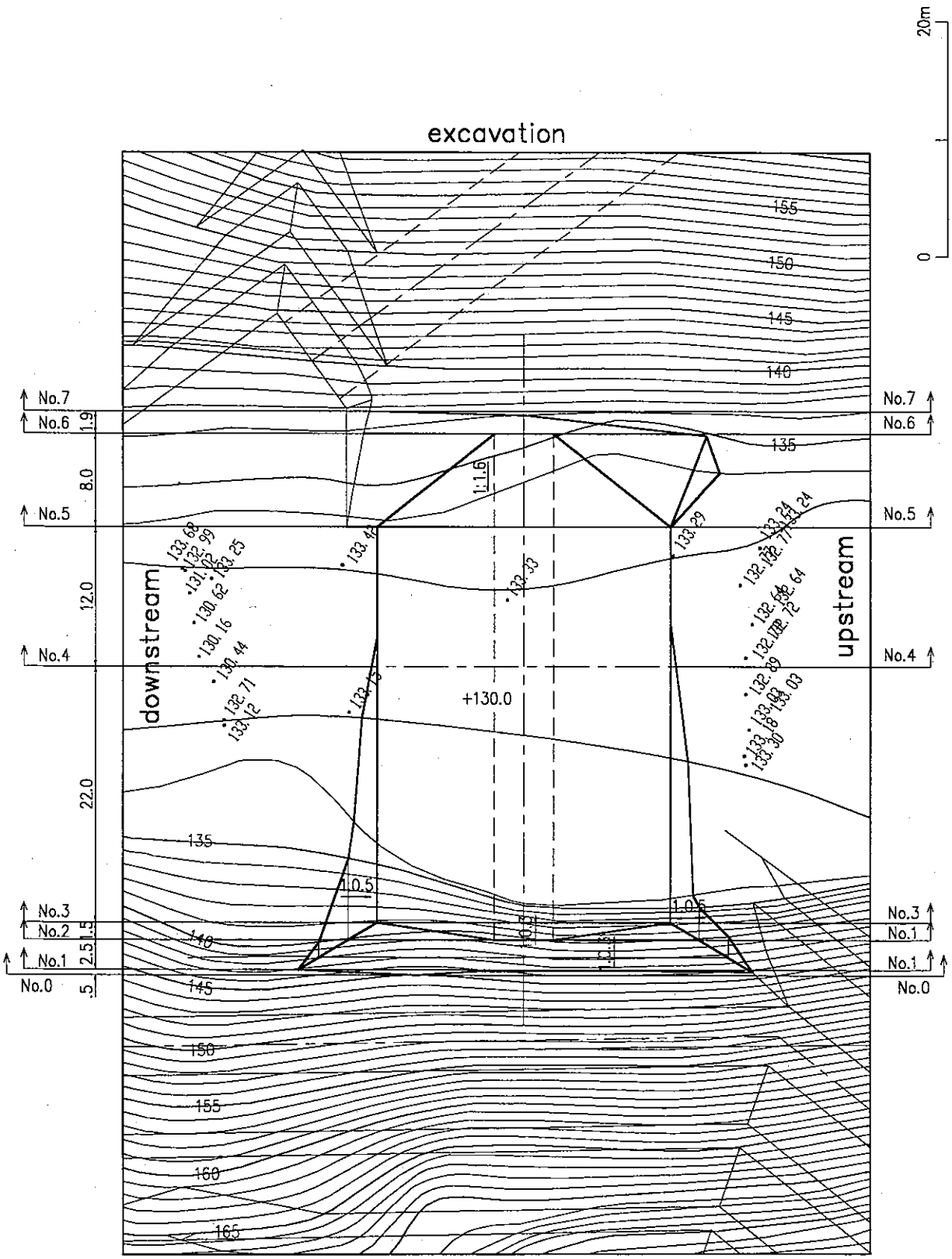
< Embankment >

Survey Station	Section Length(m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
No.0		0.0				
No.1	0.5	0.0	0.00	0.0	0.0	
No.2	2.5	0.0	0.00	0.0	0.0	
No.3	1.5	75.0	37.50	56.3	56.3	
No.4	22.0	75.0	75.00	1,650.0	1,706.3	
No.5	12.0	75.0	75.00	900.0	2,606.3	
No.6	8.0	0.0	37.50	300.0	2,906.3	
No.7	1.9	0.0	0.00	0.0	2,906.3	

V = 2,906.3 m^3

725

Downstream Cofferdam—Plan



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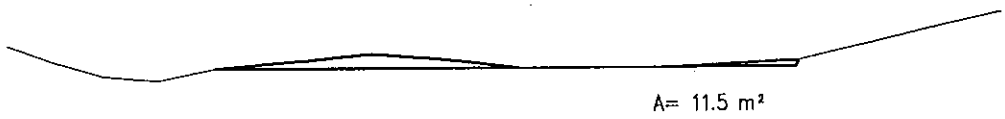
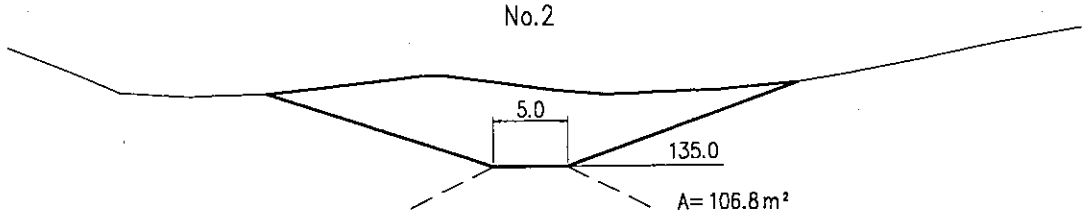
Downstream Cofferdam—Section

(excavation)

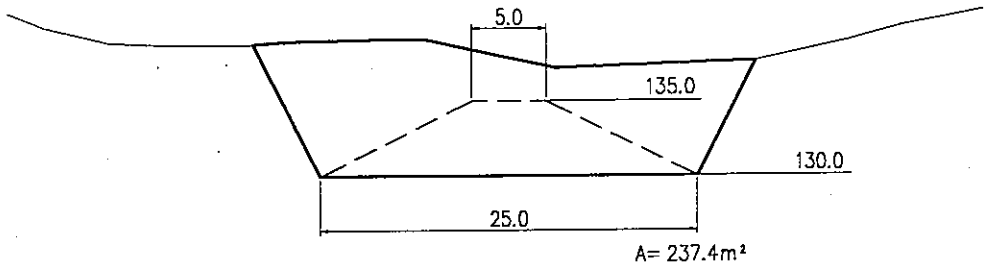
No.1



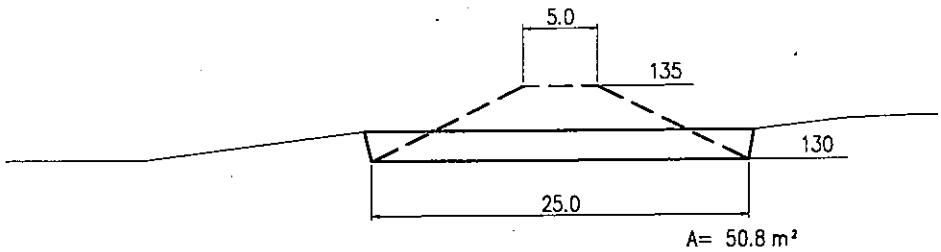
No.2



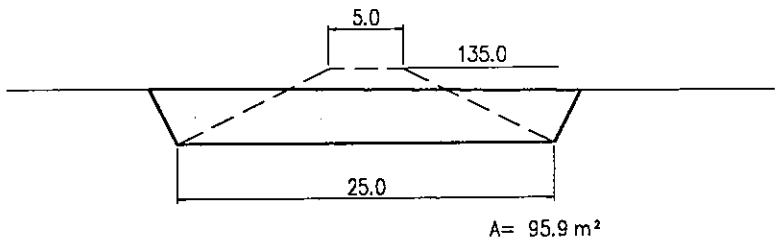
No.3



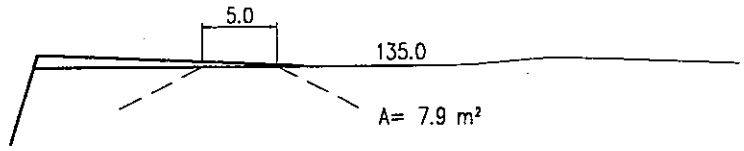
No.4

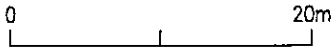


No.5

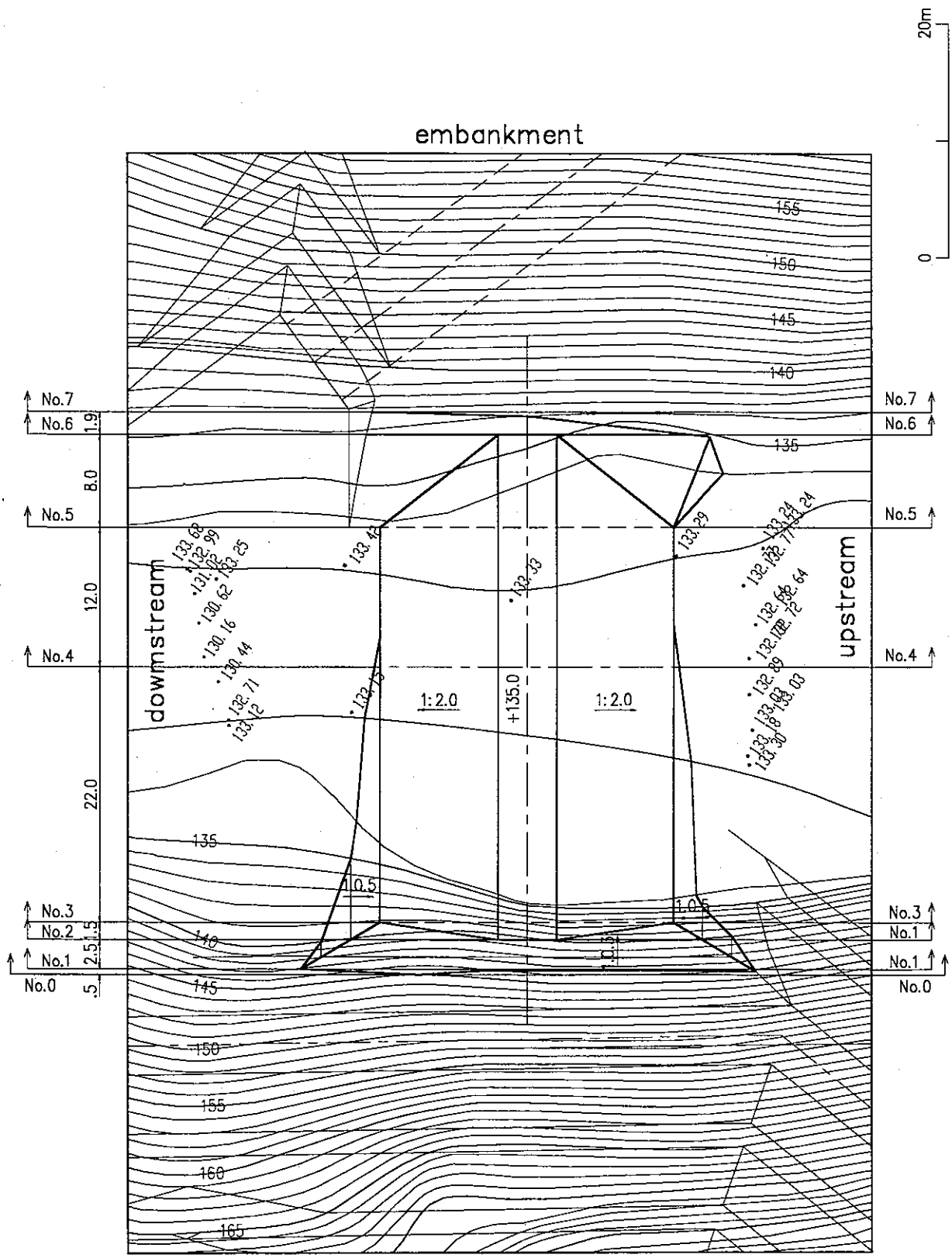


No.6





Downstream Cofferdam—Plan



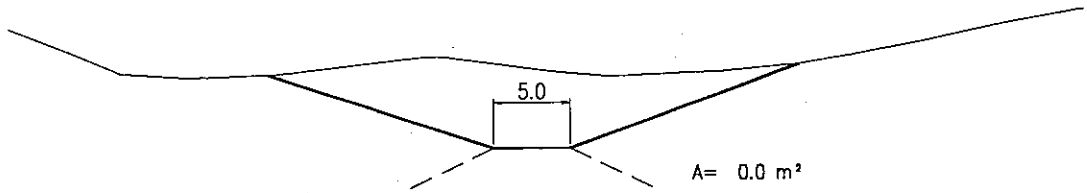
Downstream Cofferdam—Section

(embankment)

No.1

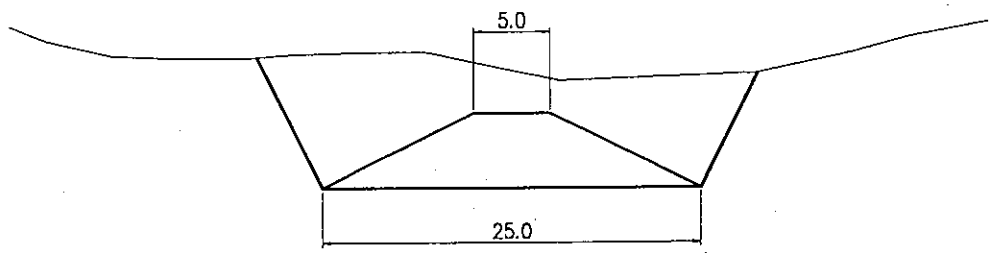
A= 0.0 m²

No.2



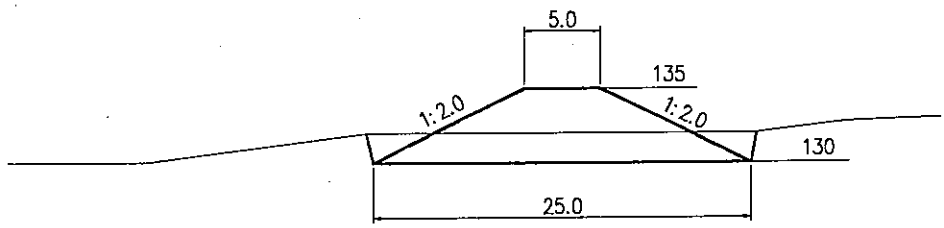
A= 0.0 m²

No.3



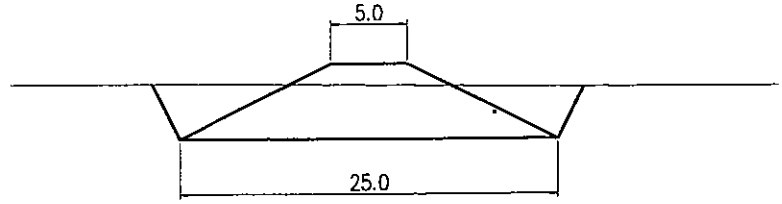
A= 75.0 m²

No.4



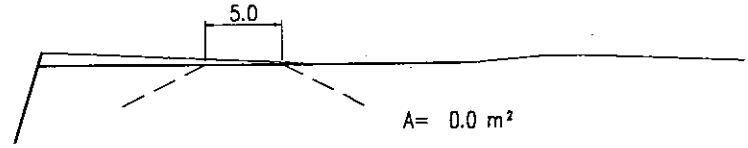
A= 75.0 m²

No.5

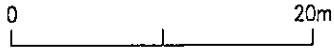


A= 75.0 m²

No.6



A= 0.0 m²



c) Diversion Tunnel

Type of Works	Calculation	Quantity

< Common Excavation >

(1) Intake

Elevation (m)	Head (m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
EL132.0		667.4				
EL142.0	10.0	85.0	376.2	3,762.0	3,762.0	
EL142.0	0.0	150.5	117.8	0.0	3,762.0	
EL152.0	10.0	0.0	75.3	752.5	4,514.5	

$V = 4,514.5 m^3$

(2) Outlet

Elevation (m)	Head (m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
EL130.0		415.7				
EL140.0	10.0	64.5	240.1	2,401.0	2,401.0	
EL140.0	0.0	117.8	91.2	0.0	2,401.0	
EL150.0	10.0	30.1	74.0	739.5	3,140.5	
EL150.0	0.0	66.8	48.5	0.0	3,140.5	
EL160.0	10.0	4.5	35.7	356.5	3,497.0	
EL160.0	0.0	24.3	14.4	0.0	3,497.0	
EL170.0	10.0	0.9	12.6	126.0	3,623.0	
EL170.0	0.0	14.4	7.7	0.0	3,623.0	
EL176.0	6.0	0.0	7.2	43.2	3,666.2	

$V = 3,666.2 m^3$

Total $V = 4,514.5 + 3,666.2 = 8,180.7 m^3$ — Quantity: $8,180.7\ m^3$

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Type of Works	Calculation	Quantity
< Tunnel Excavation >		
Tunnel of Concrete Lining		
	$A1 = \pi \times 4.3^2 / 2 + 8.6 \times 4.5 = 67.7\ m^2$	
	$L1 = 40.0 + 40.0 = 80.0\ m$	
	$V1 = A1 \times L1 = 5,416.0\ m^3$	
Tunnel of No-concrete Lining		
	$A2 = \pi \times 4.0^2 / 2 + 8.0 \times 4.5 = 61.1\ m^2$	
	$L2 = 303.5 = 303.5\ m$	
	$V2 = A2 \times L2 = 18,543.9\ m^3$	
Total		
	$\Sigma V = V1 + V2 =$	$23,959.9\ m^3$
< Lining Concrete >		
Invert Concrete		
Part of Concrete Lining		
	$A1 = 8.6 \times 0.5 = 4.3\ m^2$	
	$L1 = 40.0 + 40.0 = 80.0\ m$	
	$V1 = A1 \times L1 = 344.0\ m^3$	
Part of No-concrete Lining		
	$A2 = 8.0 \times 0.5 = 4.0\ m^2$	
	$L2 = 303.5 = 303.5\ m$	
	$V2 = A2 \times L2 = 1,214.0\ m^3$	
Total		
	$\Sigma V = V1 + V2 =$	$1,558.0\ m^3$
Lining Concrete		
	$A = \pi \times (4.3^2 - 4.0^2) / 2 + 4.0 \times 0.3 \times 2 = 6.3\ m^2$	
	$L = 40.0 + 40.0 = 80.0\ m$	
	$V = A \times L =$	$504.0\ m^3$
Total	$V = 1,558.0 + 504.0 = 2,062.0\ m^3$	$2,062.0\ m^3$
< Reinforced Bar >		
The amount of reinforced bar is calculated by the next formula.		
	$W =$ (concrete volume) $\times$ (the amount of reinforced bar per $1m^3$ concrete)	
The concrete volume of reinforced bar is calculated by the next formula.		
The part of concrete lining of invert concrete and the lining concrete need the reinforced bar.		
	$V = 344.0 + 504.0 = 848.0\ m^3$	
The amount of reinforced bar per 1 m^3 concrete $= 64.8\ kg/m^3$ (See the next page)		
	$W = 848.0 \times 64.8 / 1,000 =$	$55.0\ t$

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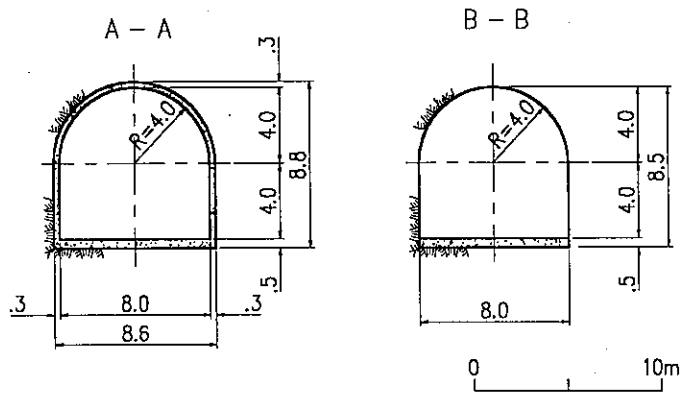
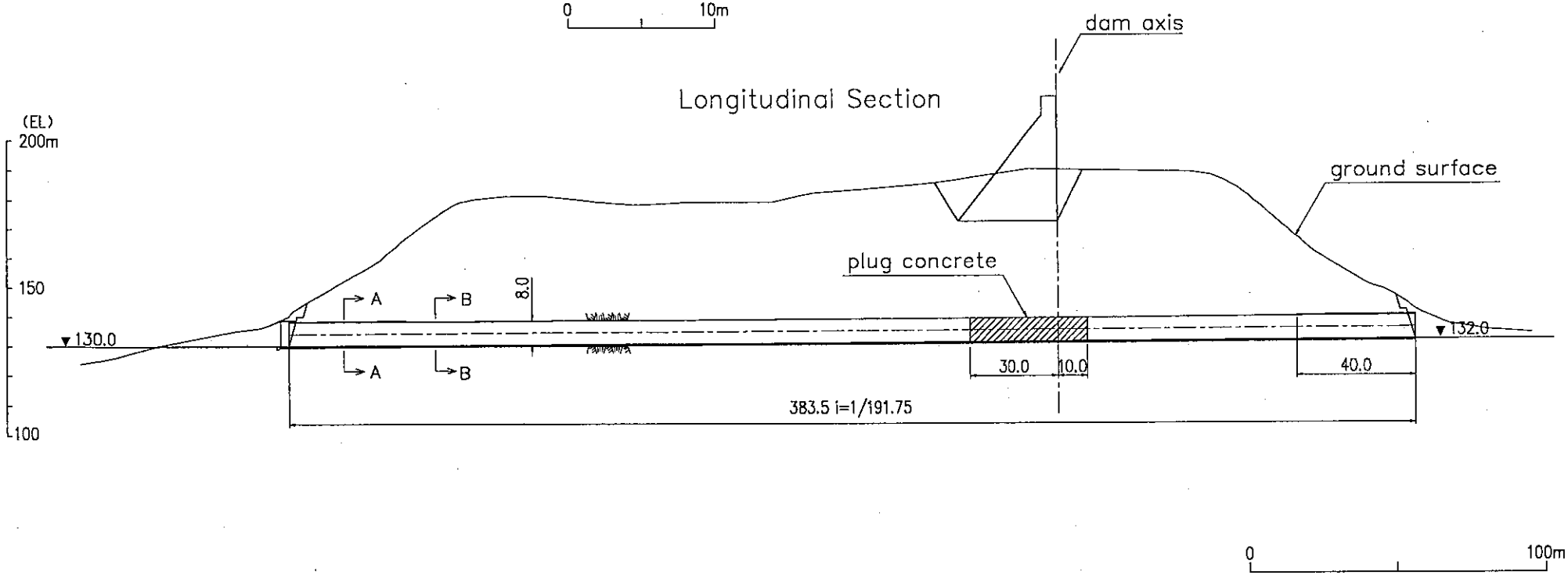
Type of Works	Calculation	Quantity
	(The amount of reinforced bar per 1 m^3 concrete)	
	The condition of computation Reinforced bar of circuit direction : D22@20 Reinforced bar of horizontal direction D16@30 The protective covering is 10cm inside of the lining concrete.	
	The calculation of quantity (The direction of extension per 1m) The reinforced bar of the circumference direction L1 = (2π × 4.1/2 + 4.1 × 2+8.2) ×5 numbers = 146.4 m w1 = 3.04 kg/m (D22) W1 = 146.4 × 3.04 = 445.1kg/m	
	The reinforced bar of the horizontal direction L2 = (2π × 4.1/2 + 4.1 × 2 + 8.2) ／ 0.3 × 1.0m = 97.6 m w2 = 1.56 kg/m (D16) W2 = 97.6 × 1.56 = 152.3kg/m	
	The total volume of the reinforced bar ΣW = (W1 + W2) × 1.15 = 687.0kg/m ※ Increase propotionally of 15% considering the joint length etc.	
	(The amount of reinforced bar per 1 m^3 concrete) The lining concrete volume of the 1m tunnel length V' = V ／ L = 848.0 ／ 80.0 = 10.6m^3/m The amount of reinforced bar per 1 m^3 concrete W' = W ／ V' = 687.0kg/m／10.6m^3/m = 64.8kg/m^3	
< Plug Concrete >	A = π × 4.0^2 ／ 2 + 8.0 × 4.0 = 57.1 m^2 L = 40.0 = 40.0 m V = A × L =	2,284.0m^3

Diversion Tunnel Cross Section

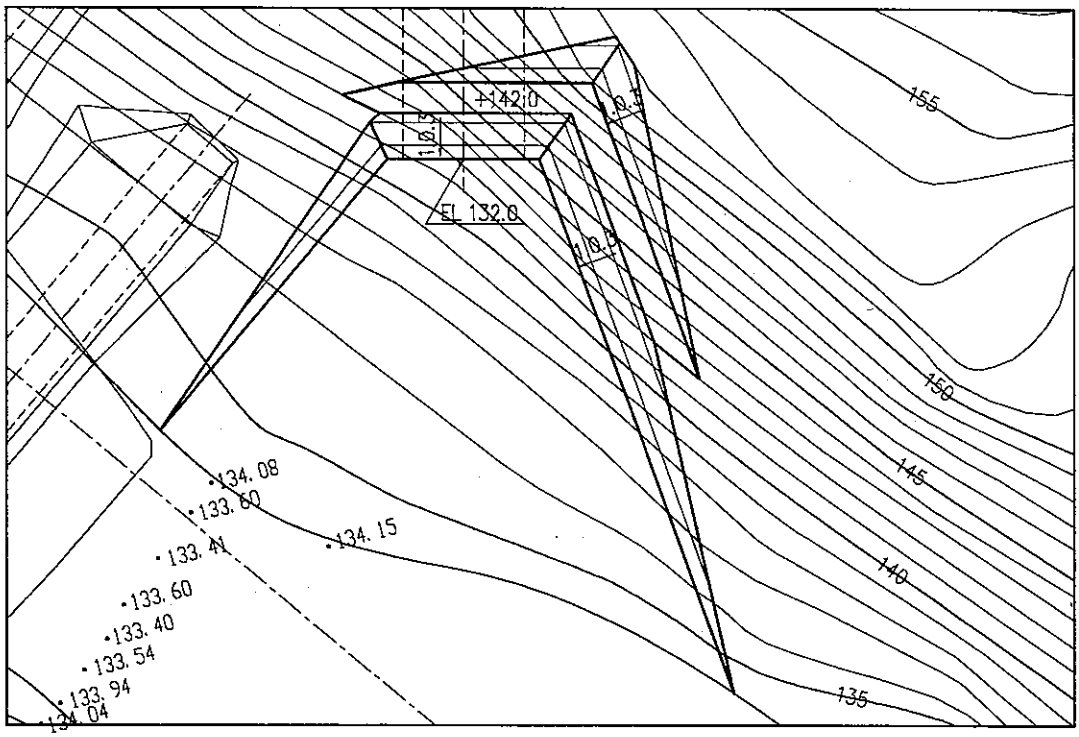


Longitudinal Section

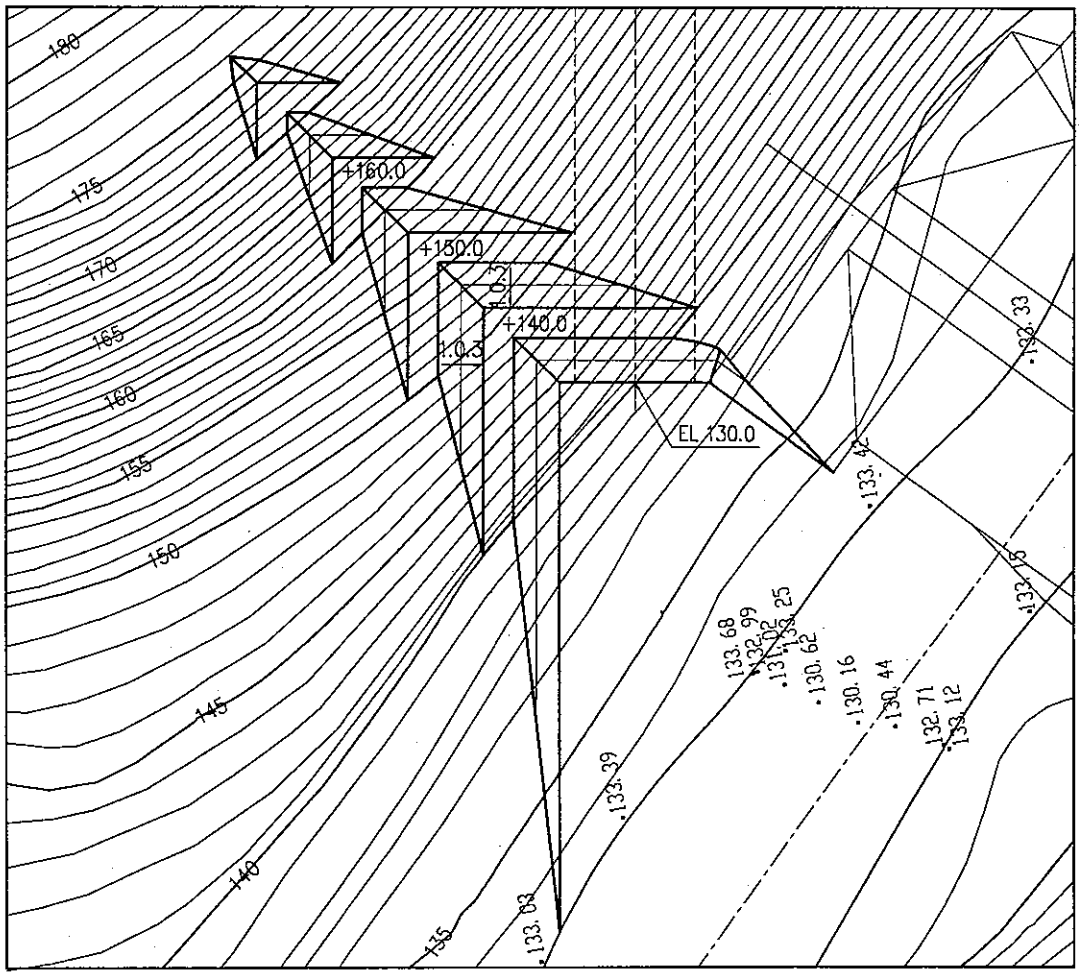


Diversion Tunnel—Common Excavaton

Intake—Plan



Outlet—Plan

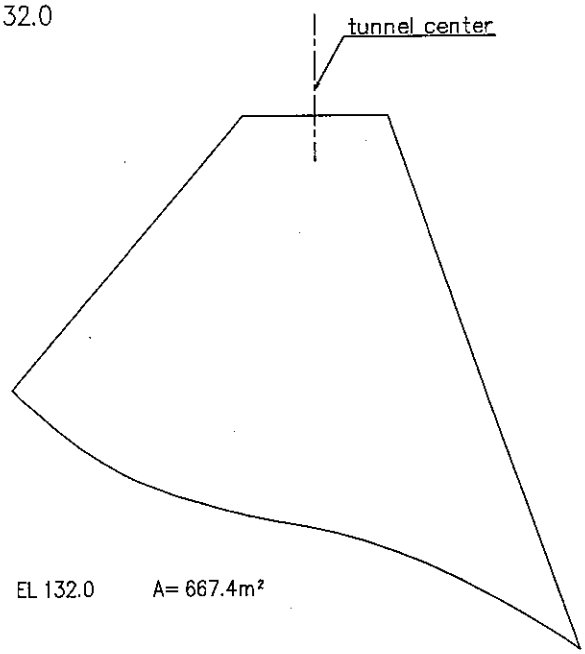


0 20m

Diversion Tunnel—Common Excavation

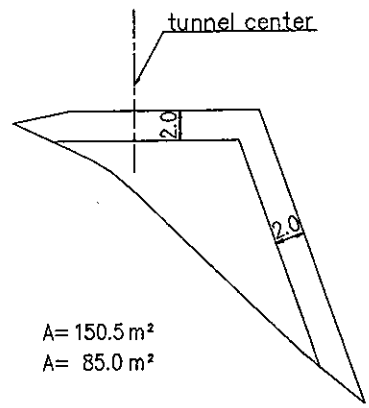
common excavation (intake)

EL 132.0



EL 132.0 A= 667.4m²

EL 142.0



EL 142.0 A= 150.5 m²
EL 142.0 A= 85.0 m²

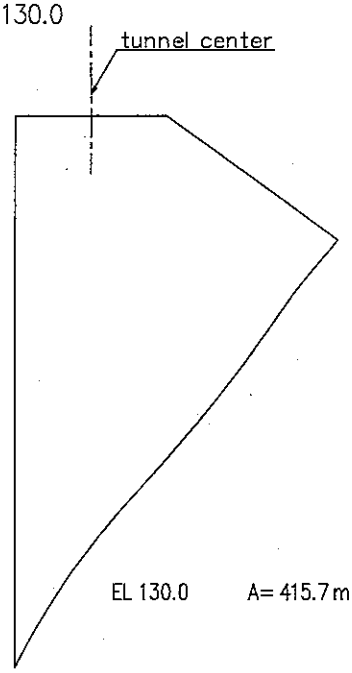
0 20m

745

Diversion Tunnel—Common Excavation

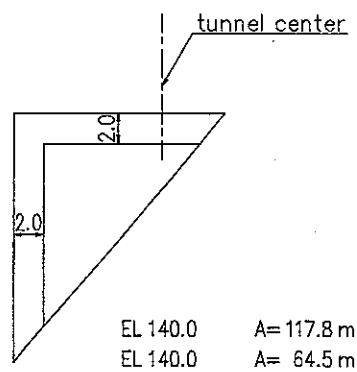
common excavation (outlet)

EL 130.0



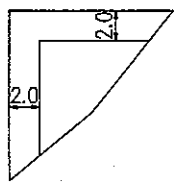
EL 130.0 A= 415.7 m²

EL 140.0



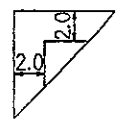
EL 140.0 A= 117.8 m²
EL 140.0 A= 64.5 m²

EL 150.0



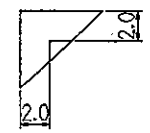
EL 150.0 A= 66.8 m²
EL 150.0 A= 30.1 m²

EL 160.0

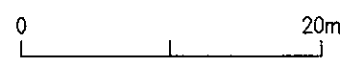


EL 160.0 A= 24.3 m²
EL 160.0 A= 4.5 m²

EL 170.0



EL 170.0 A= 14.4 m²
EL 170.0 A= 0.9 m²



746

(2) Dam

a) Dam

Type of Works	Calculation	Quantity

<Common Excavation and Rock Excavation>

The left bank of dam center line [Dam]

Elevation (m)	Head (m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
242.0		0.0				
240.0	2.0	118.4	59.2	118.4	118.4	
235.0	5.0	374.7	246.6	1,232.8	1,351.2	
234.5	0.5	399.6	387.2	193.6	1,544.8	
234.5	0.0	291.4	345.5	0.0	1,544.8	
230.0	4.5	558.0	424.7	1,911.2	3,456.0	
225.0	5.0	913.7	735.9	3,679.3	7,135.3	
224.5	0.5	947.7	930.7	465.4	7,600.7	
224.5	0.0	759.6	853.7	0.0	7,600.7	
220.0	4.5	999.5	879.6	3,958.0	11,558.7	
215.0	5.0	1,458.2	1,228.9	6,144.3	17,703.0	
214.5	0.5	1,530.8	1,494.5	747.3	18,450.3	
214.5	0.0	414.1	972.5	0.0	18,450.3	
210.0	4.5	485.0	449.6	2,023.0	20,473.3	
209.5	0.5	500.1	492.6	246.3	20,719.6	
209.5	0.0	305.8	403.0	0.0	20,719.6	
205.0	4.5	461.9	383.9	1,727.3	22,446.9	
200.0	5.0	650.7	556.3	2,781.5	25,228.4	
195.0	5.0	1,119.2	885.0	4,424.8	29,653.2	
190.0	5.0	1,668.7	1,394.0	6,969.8	36,623.0	
185.0	5.0	2,079.5	1,874.1	9,370.5	45,993.5	
180.0	5.0	2,315.3	2,197.4	10,987.0	56,980.5	
175.0	5.0	1,838.1	2,076.7	10,383.5	67,364.0	
170.0	5.0	1,080.1	1,459.1	7,295.5	74,659.5	
165.0	5.0	1,026.0	1,053.1	5,265.3	79,924.8	
160.0	5.0	967.8	996.9	4,984.5	84,909.3	
155.0	5.0	916.8	942.3	4,711.5	89,620.8	
150.0	5.0	826.0	871.4	4,357.0	93,977.8	
145.0	5.0	745.3	785.7	3,928.3	97,906.1	
140.0	5.0	665.4	705.4	3,526.8	101,432.9	
135.0	5.0	1,141.8	903.6	4,518.0	105,950.9	
130.0	5.0	1,726.1	1,434.0	7,169.8	113,120.7	
127.0	3.0	1,450.8	1,588.5	4,765.4	117,886.1	
Total				117,886.1		

Type of Works	Calculation	Quantity

The right bank of dam center line [Dam]

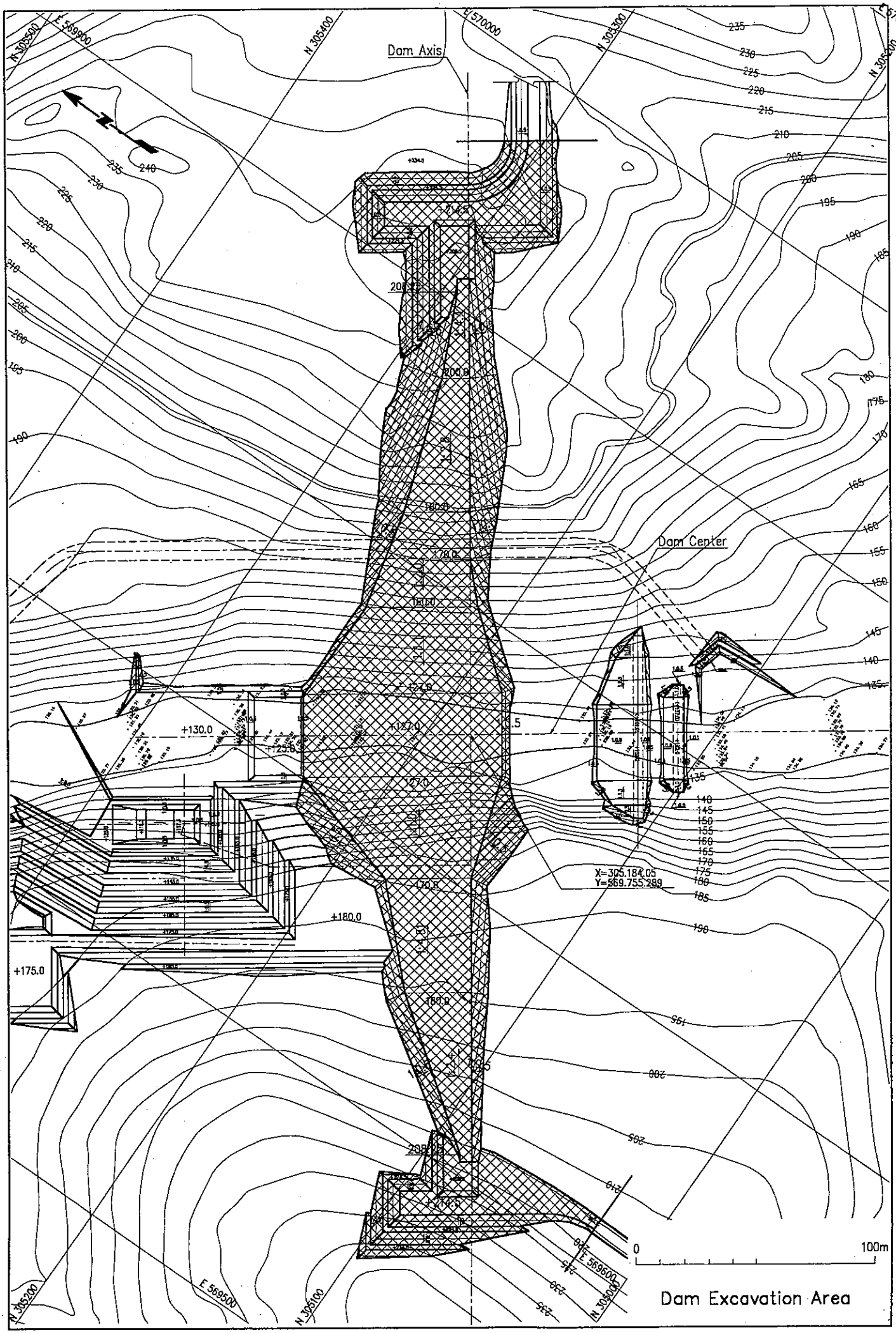
Elevation (m)	Head (m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
237.5		0.0				
235.0	2.5	1,158.0	579.0	1,447.5	1,447.5	
230.0	5.0	2,907.6	2,032.8	10,164.0	11,611.5	
225.0	5.0	4,823.1	3,865.4	19,326.8	30,938.3	
224.5	0.5	4,950.2	4,886.7	2,443.3	33,381.6	
224.5	0.0	4,496.0	4,723.1	0.0	33,381.6	
220.0	4.5	4,308.1	4,402.1	19,809.2	53,190.8	
215.0	5.0	3,809.0	4,058.6	20,292.8	73,483.6	
214.5	0.5	3,744.0	3,776.5	1,888.3	75,371.9	
214.5	0.0	4,496.0	4,120.0	0.0	75,371.9	
210.0	4.5	2,571.6	3,533.8	15,902.1	91,274.0	
209.5	0.5	2,544.2	2,557.9	1,279.0	92,553.0	
209.5	0.0	2,192.7	2,368.5	0.0	92,553.0	
205.0	4.5	2,055.9	2,124.3	9,559.4	102,112.4	
200.0	5.0	1,815.3	1,935.6	9,678.0	111,790.4	
195.0	5.0	1,624.7	1,720.0	8,600.0	120,390.4	
190.0	5.0	1,419.2	1,522.0	7,609.8	128,000.2	
185.0	5.0	1,207.7	1,313.5	6,567.3	134,567.5	
180.0	5.0	974.8	1,091.3	5,456.3	140,023.8	
175.0	5.0	843.5	909.2	4,545.8	144,569.6	
170.0	5.0	696.5	770.0	3,850.0	148,419.6	
165.0	5.0	530.5	613.5	3,067.5	151,487.1	
160.0	5.0	341.9	436.2	2,181.0	153,668.1	
155.0	5.0	371.4	356.7	1,783.3	155,451.4	
150.0	5.0	396.0	383.7	1,918.5	157,369.9	
145.0	5.0	415.4	405.7	2,028.5	159,398.4	
140.0	5.0	437.6	426.5	2,132.5	161,530.9	
135.0	5.0	528.6	483.1	2,415.5	163,946.4	
130.0	5.0	1,750.8	1,139.7	5,698.5	169,644.9	
127.0	3.0	1,450.8	1,600.8	4,802.4	174,447.3	
Total				174,447.3		

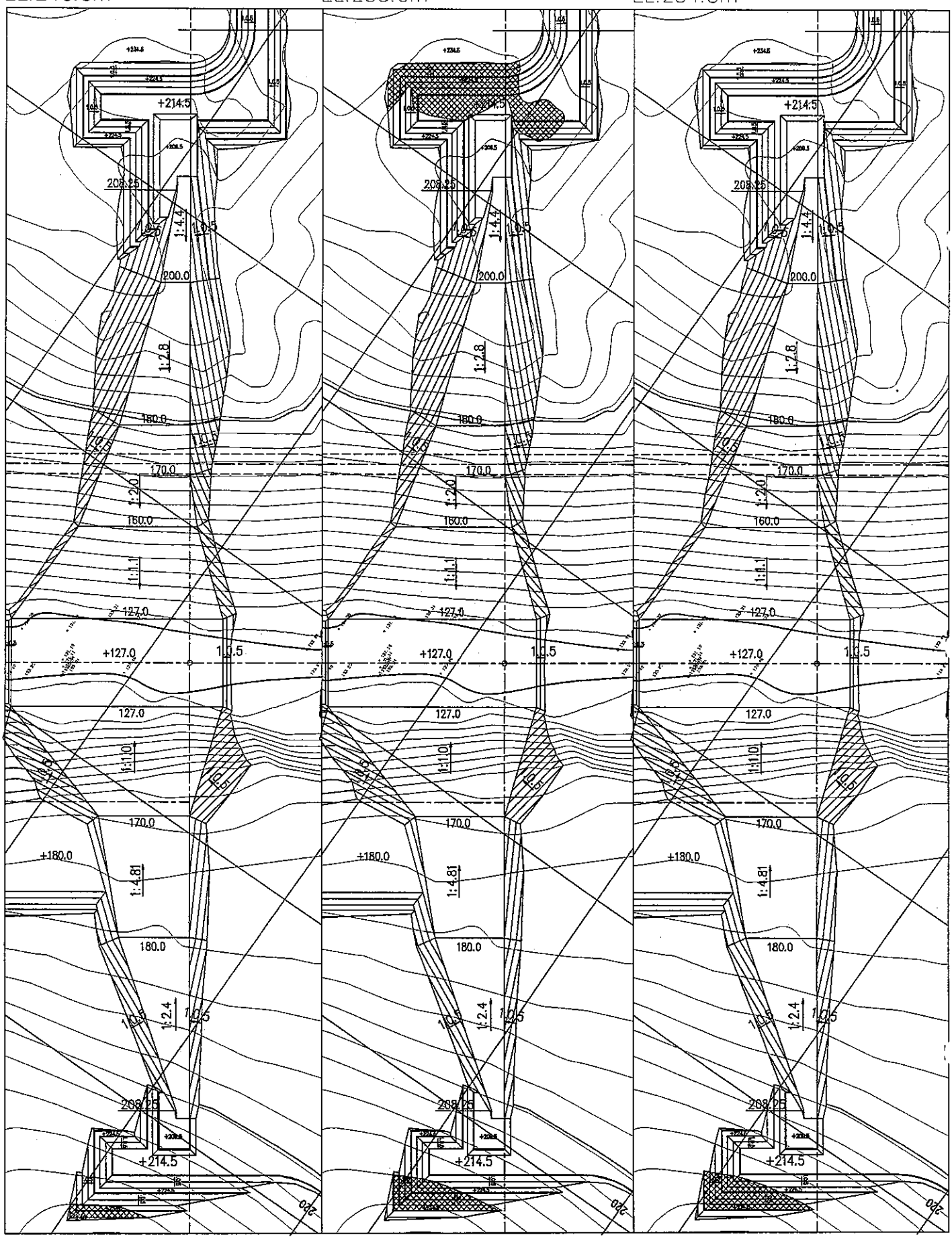
Total excavation volume＝117,886.1(Left Bank)＋174,447.3(Right Bank)＝292,3 m^3

Estimated Ratio‥(Common Excavation) : (Rock Excavation)＝ 4 : 6

V 1 (Common Excavation)＝ 116,933.4 m^3

V a (Rock Excavation)＝ 175,400.0 m^3

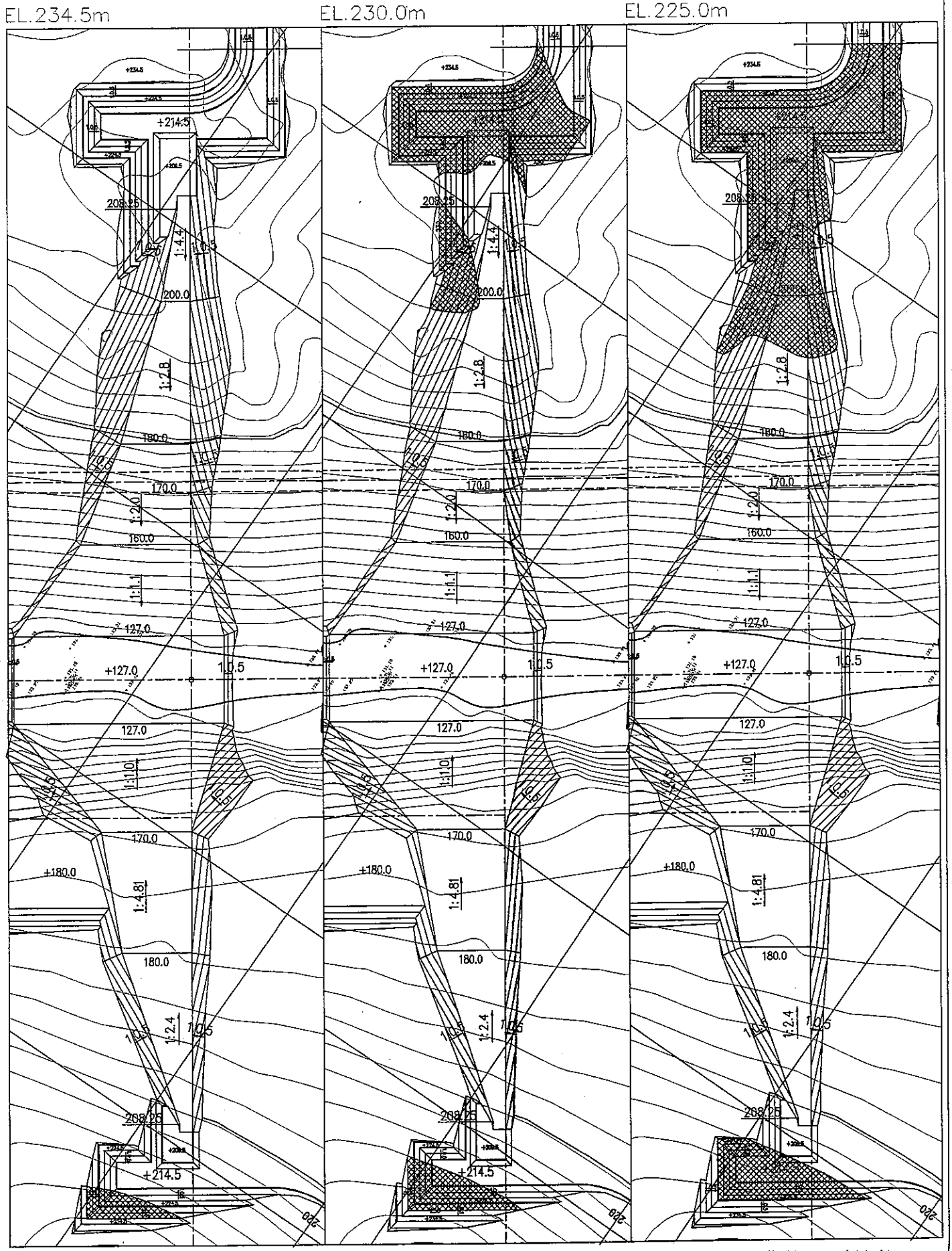

Dam Axis
Dam Center
N 305500
E 569900
N 305400
E 570000
N 305300
E 570100
N 305200
E 569500
N 305100
E 569600
N 305000
+214.5
200.0
180.0
160.0
140.0
127.0
+130.0
+120.0
+180.0
+175.0
X=305,184.05
Y=569,755.289
0
100m
Dam Excavation Area



	left side	right side
EL.240.0m	118.4 m2	0 m2
EL.235.0m	374.7 m2	1,158.0 m2
EL.234.5m	399.6 m2	

0 100m

Dam Excavation (1)



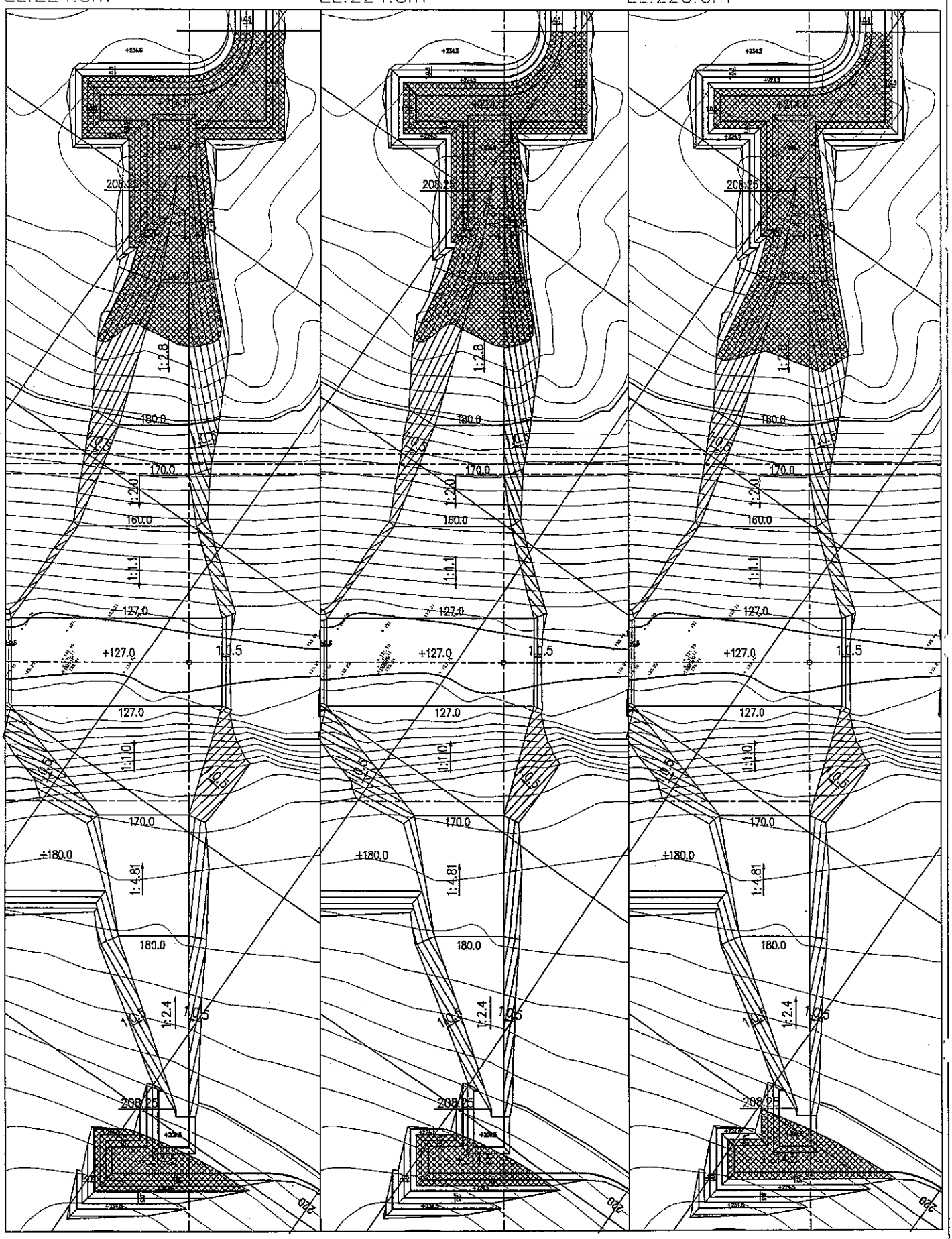
EL.234.5m left side 291.4 m2

EL.230.0m left side 558.0 m2 right side 2,907.6 m2 (2,391.7+515.9)

EL.225.0m left side 913.7 m2 right side 4,823.1 m2

0 100m

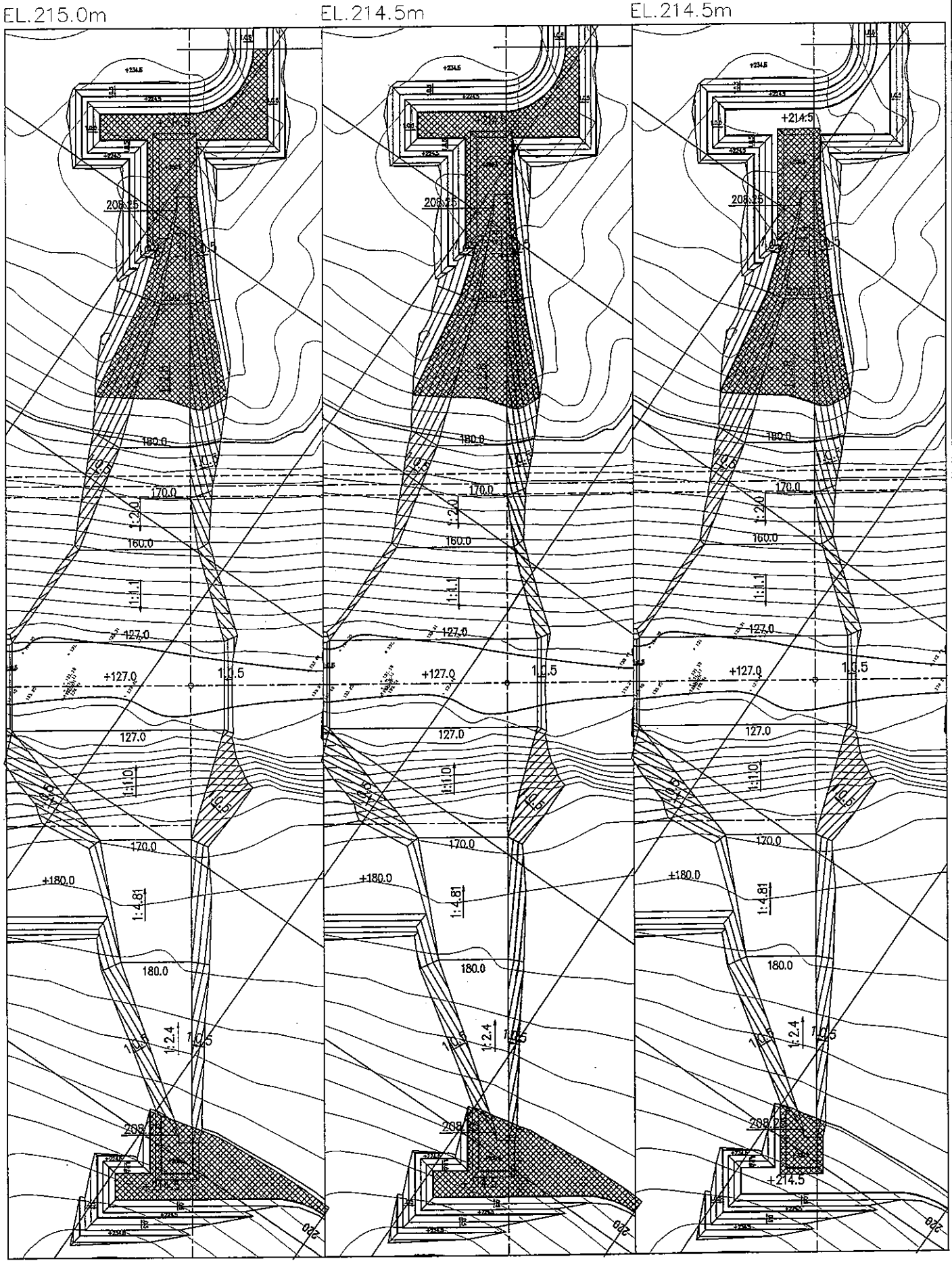
Dam Excavation (2)



	left side	right side
EL.224.5m	947.7 m2	4,950.2 m2
EL.224.5m	759.6 m2	4,496.0 m2
EL.220.0m	999.5 m2	4,308.1 m2

0 100m

Dam Excavation (3)

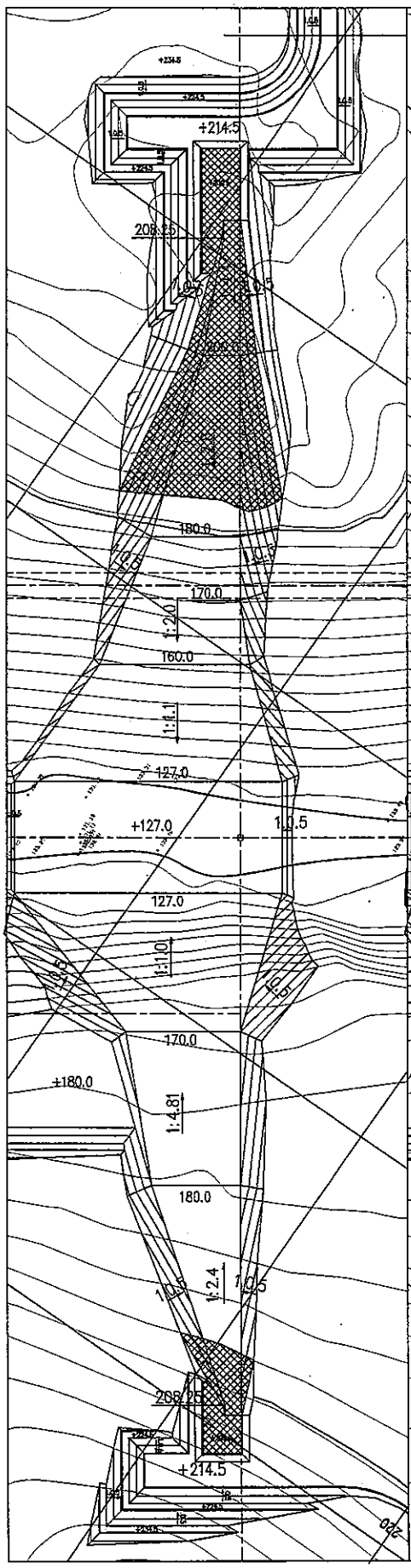


	left side	right side
EL.215.0m	1,458.2 m2	3,809.0 m2
EL.214.5m	1,530.8 m2	3,744.0 m2
EL.214.5m	414.1 m2	4,496.0 m2

0 100m

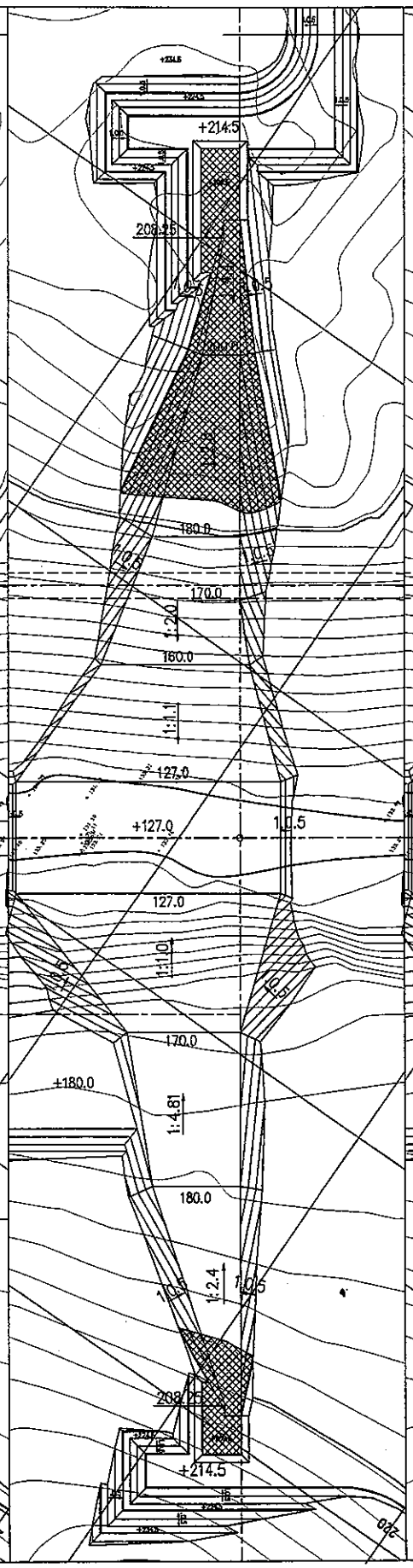
Dam Excavation (4)

EL.210.0m



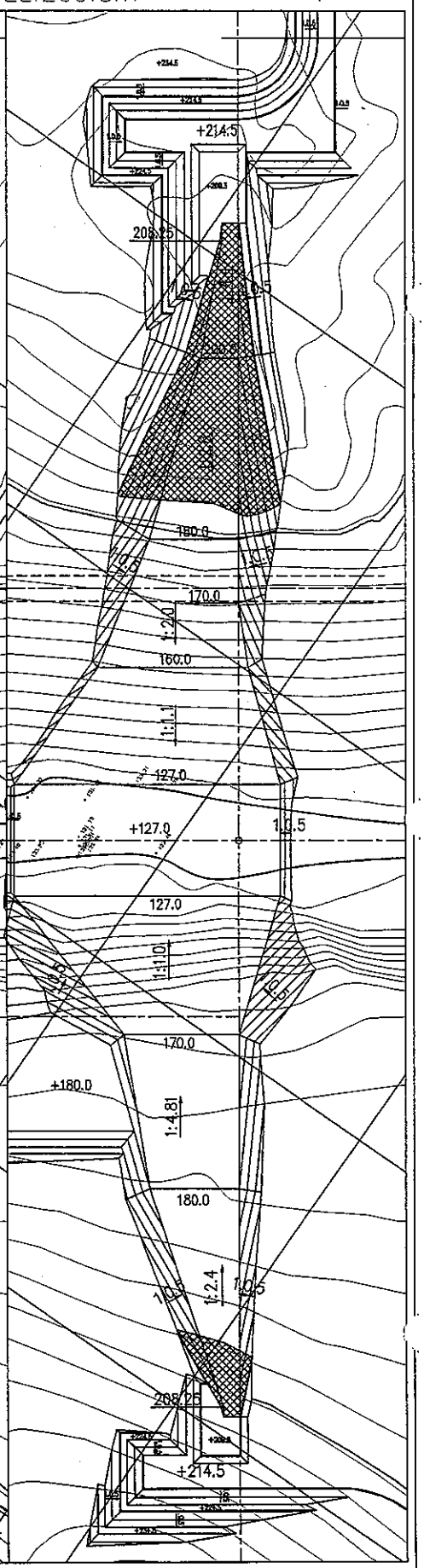
	left side	right side
EL.210.0m	485.0 m2	2,571.6 m2

EL.209.5m



	left side	right side
EL.209.5m	500.1 m2	2,544.2 m2

EL.209.5m

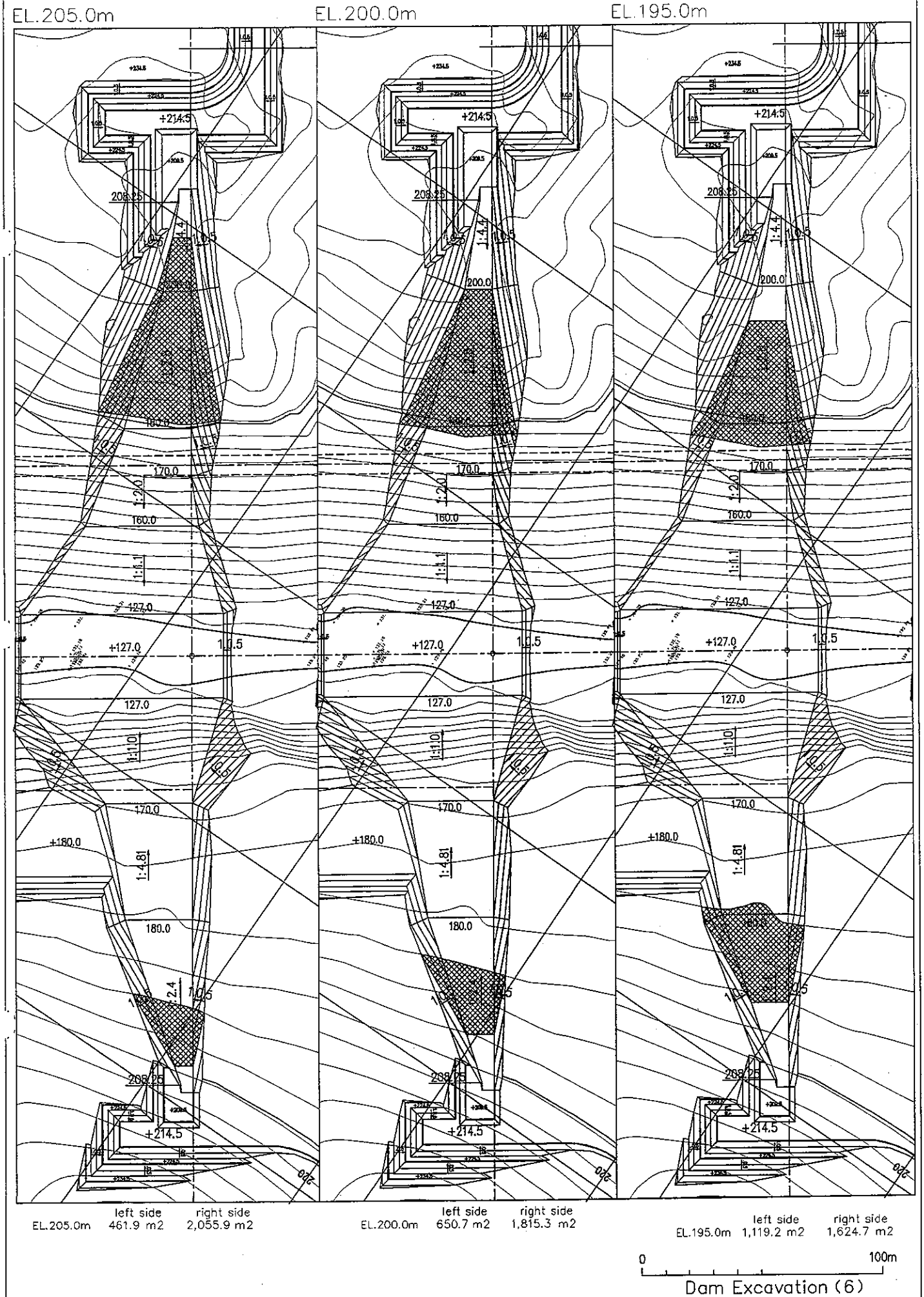


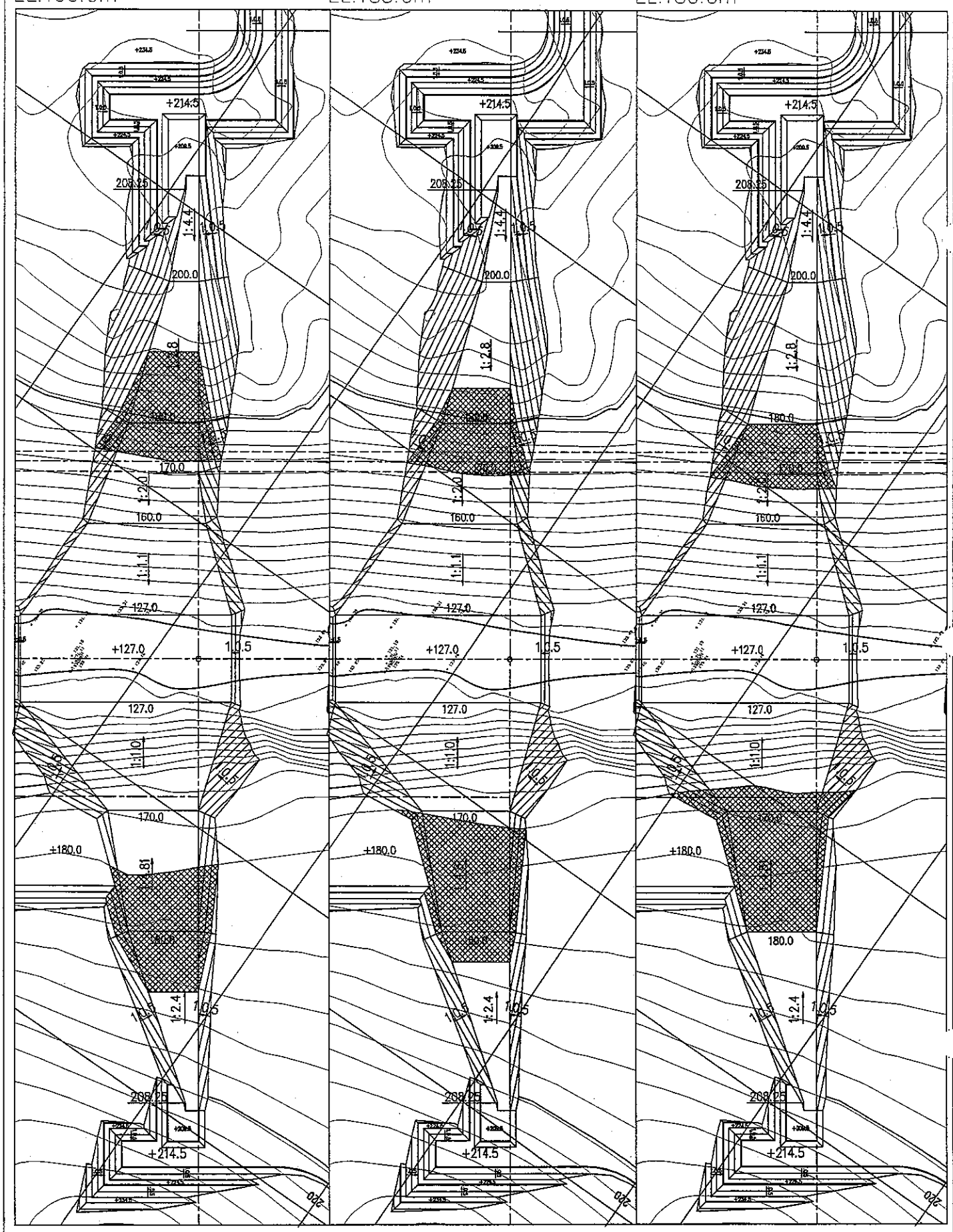
	left side	right side
EL.209.5m	305.8 m2	2,192.7

0

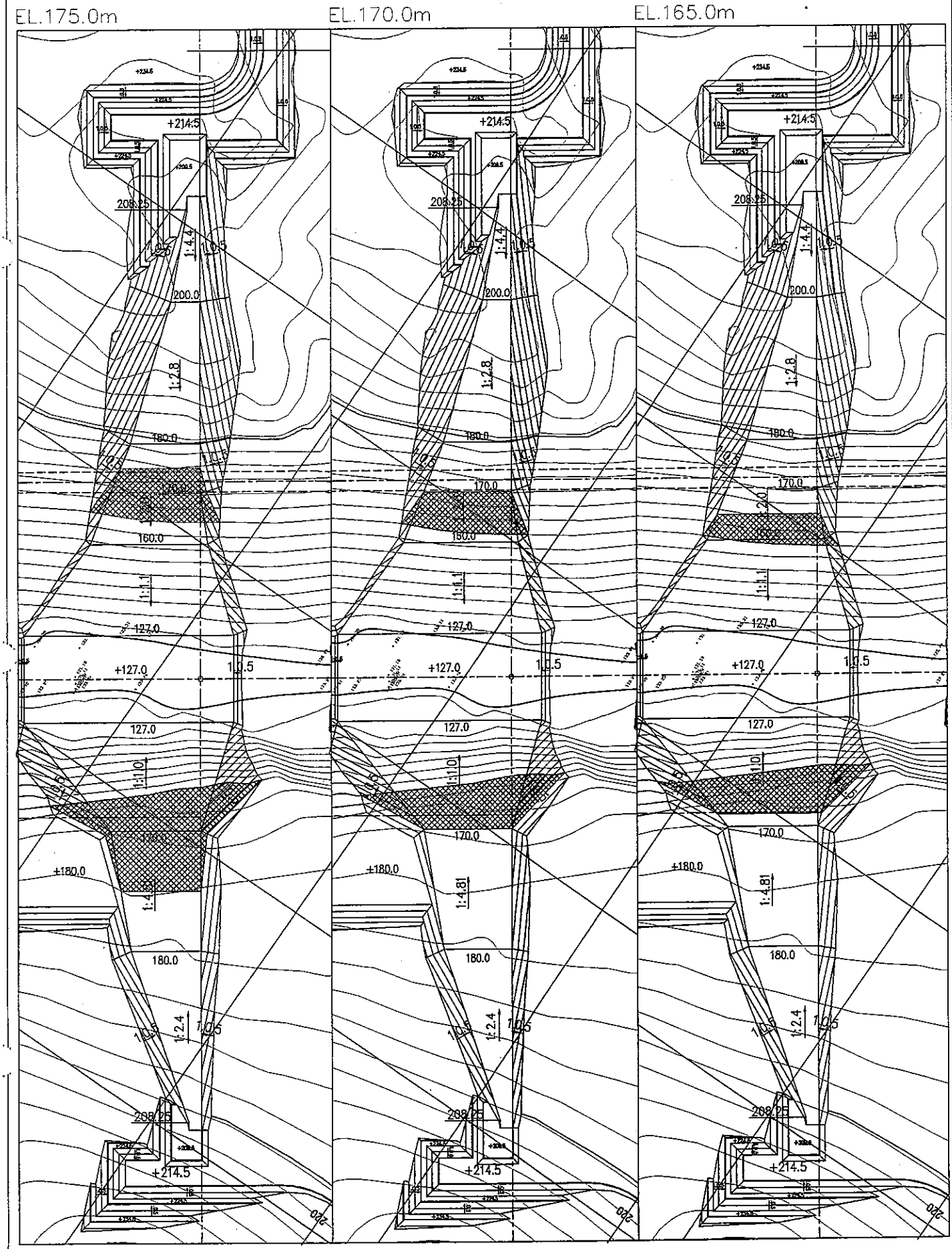
Dam Excavation (5)

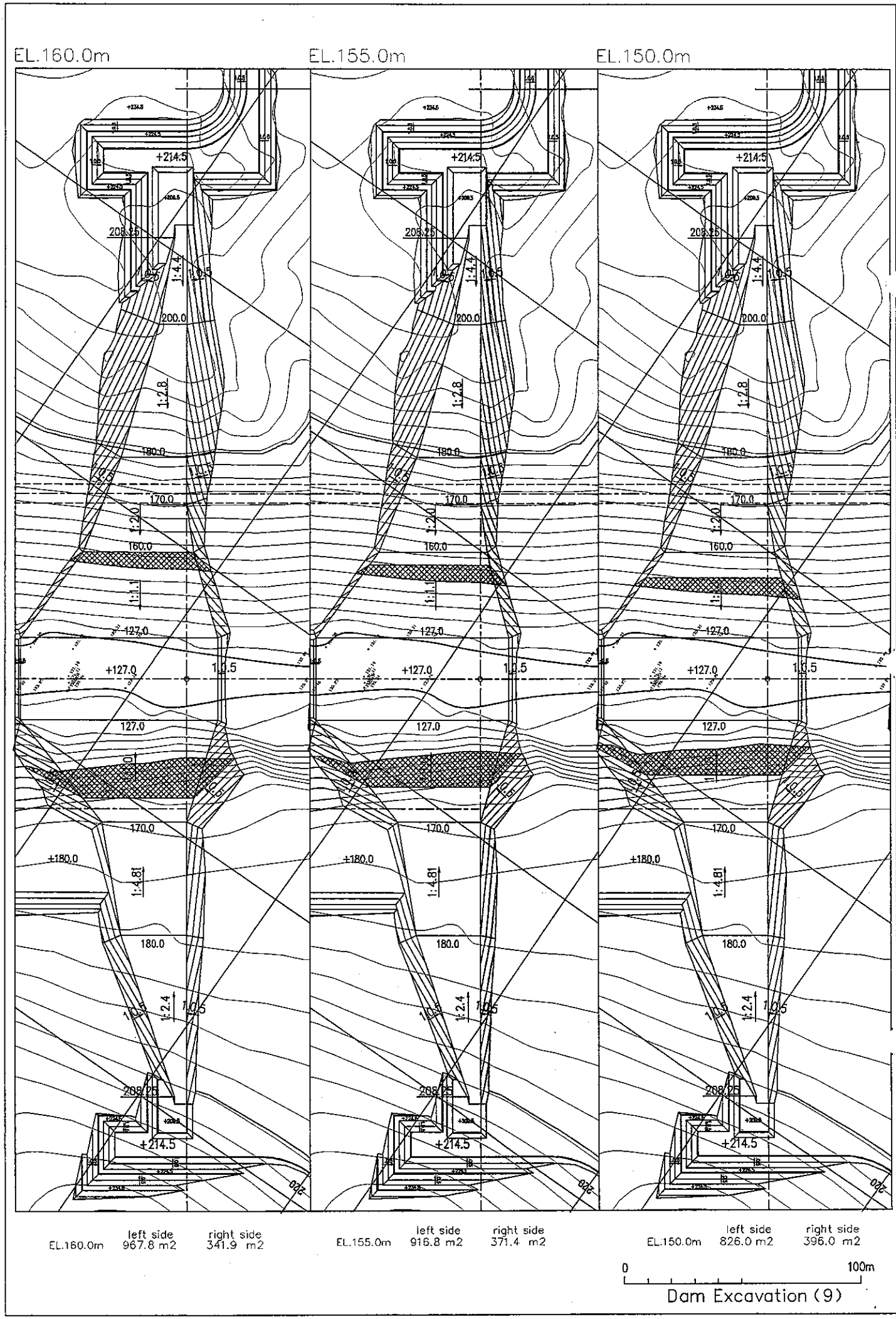
754

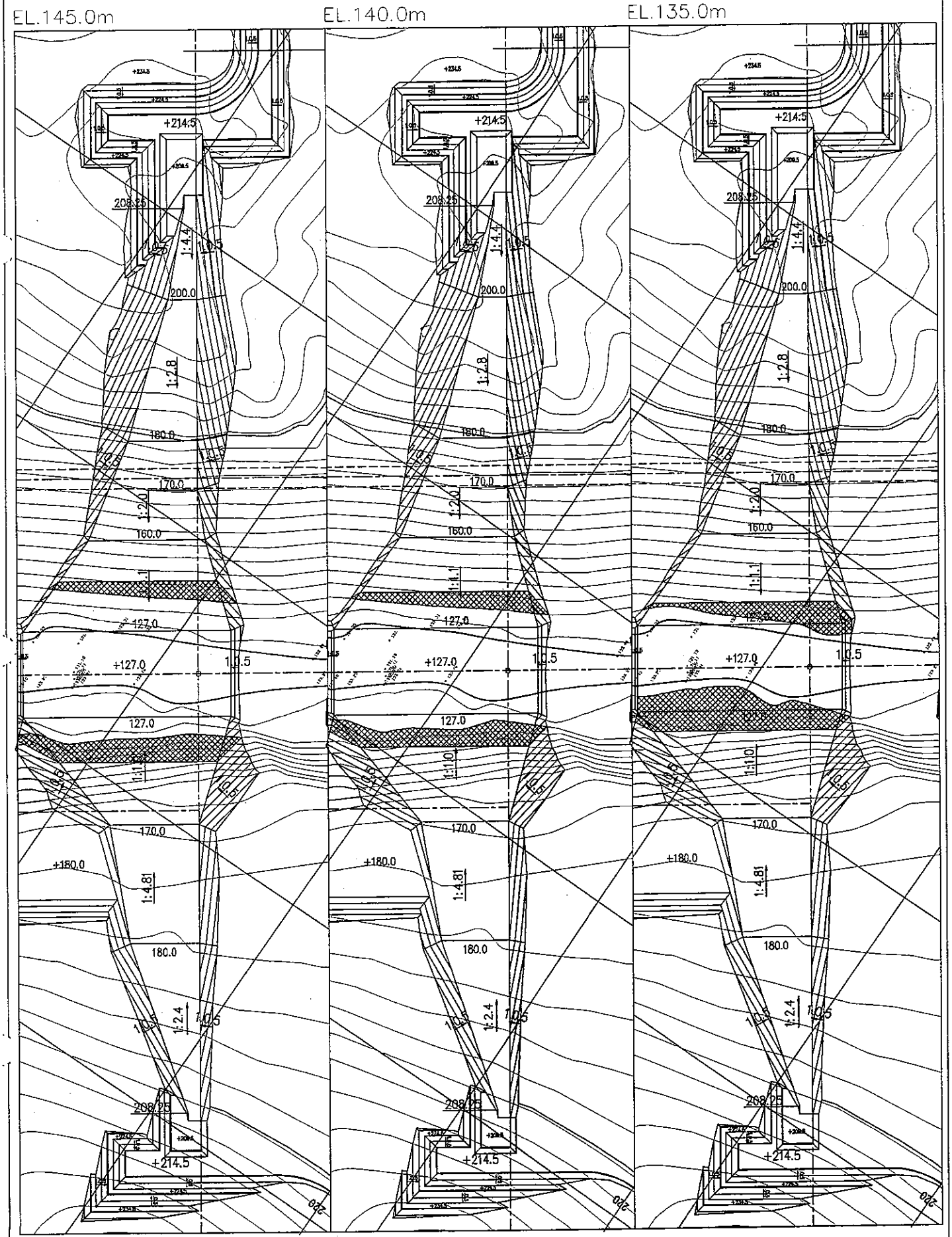

EL.205.0m
EL.200.0m
EL.195.0m
+214.5
208.25
200.0
170.0
160.0
127.0
+127.0
180.0
+180.0
1:4.4
1:2.0
1:1.1
1:1.0
1:4.81
2.4
1.0.5
left side
right side
EL.205.0m 461.9 m2 2,055.9 m2
EL.200.0m 650.7 m2 1,815.3 m2
EL.195.0m 1,119.2 m2 1,624.7 m2
0
100m
Dam Excavation (6)

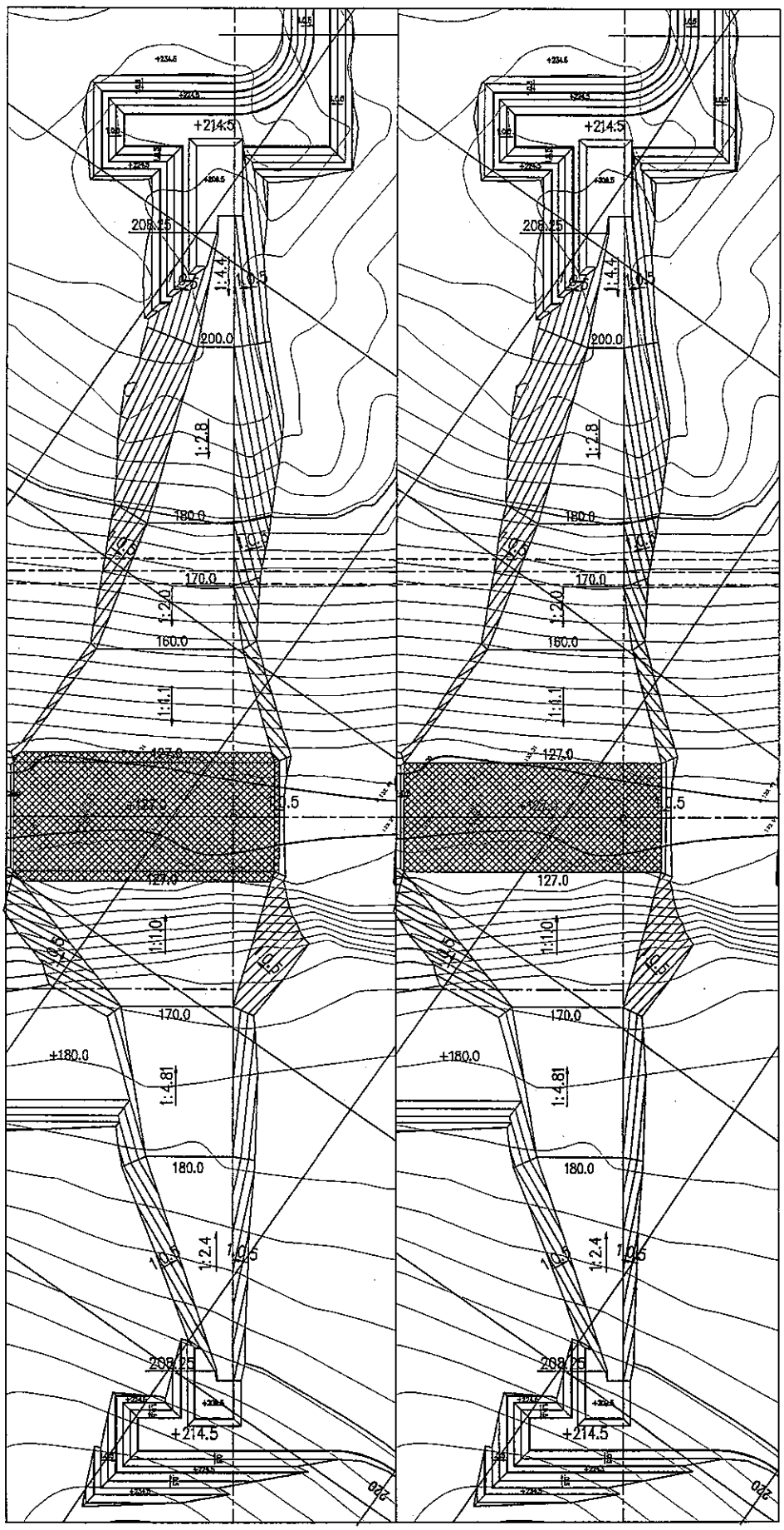

EL.190.0m
EL.185.0m
EL.180.0m
+214.5
208.25
200.0
170.0
160.0
127.0
+127.0
+180.0
1:4.4
1:2.8
1:2.0
1:1.1
1:1.10
1:2.4
1.0:5
180.0
left side
right side
EL.190.0m 1,668.7 m2 1,419.2 m2
EL.185.0m 2,079.5m2 1,207.7 m2
EL.180.0m 2,315.3 m2 974.8 m2
0
100m
Dam Excavation (7)

756


EL.175.0m
EL.170.0m
EL.165.0m
+214.5
208.25
200.0
180.0
160.0
170.0
127.0
+127.0
+180.0
1:4.4
1:2.8
1:1.1
1:1.0
1:4.81
1:2.4
1:0.5
left side
right side
EL.175.0m 1,838.1 m2 843.5 m2
EL.170.0m 1,080.1 m2 696.5 m2
EL.165.0m 1,026.0 m2 530.5 m2
0
100m
Dam Excavation (8)


EL.160.0m
EL.155.0m
EL.150.0m
+214.5
208.25
200.0
180.0
170.0
160.0
127.0
+127.0
1:4.4
1:2.8
1:2.0
1:1.1
1:0.5
1:4.81
1:2.4
EL.160.0m left side 967.8 m2 right side 341.9 m2
EL.155.0m left side 916.8 m2 right side 371.4 m2
EL.150.0m left side 826.0 m2 right side 396.0 m2
0
100m
Dam Excavation (9)


EL.145.0m
EL.140.0m
EL.135.0m
+214.5
208.25
200.0
180.0
170.0
160.0
127.0
+180.0
1:4.4
1:2.8
1:2.0
1:1.1
1:1.5
1:1.10
1:4.81
1:2.4
1:0.5
EL.145.0m left side 745.3 m2 right side 415.4 m2
EL.140.0m left side 665.4 m2 right side 437.6 m2
EL.135.0m left side 1,141.8 m2 right side 528.6 m2
0
100m
Dam Excavation (10)


EL.130.0m
EL.127.0m
+214.5
208.25
200.0
180.0
170.0
160.0
127.0
1:4.4
1:2.8
1:2.0
1:1.1
1:11.0
1:4.81
1:2.4
10.5
left side
right side
EL.130.0m 1,726.1 m2 1,750.8 m2
EL.127.0m 1,450.8 m2 1,450.8 m2
0
100m
Dam Excavation (11)

Type of Works	Calculation	Quantity

The left bank of dam center line (Flood-control Waterway)

Elevation (m)	Head (m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
151.8		0.0				
150.0	1.8	3.4	1.7	3.1	3.1	
145.0	5.0	38.8	21.1	105.5	108.6	
140.0	5.0	218.5	128.7	643.3	751.9	
135.0	5.0	933.9	576.2	2,881.0	3,632.9	
130.0	5.0	1,889.6	1,411.8	7,058.8	10,691.7	
130.0	0.0	446.2	1,167.9	0.0	10,691.7	
127.0	3.0	385.0	415.6	1,246.8	11,938.5	
125.0	2.0	330.0	357.5	715.0	12,653.5	
Total				12,653.5		

The right bank of dam center line (Flood-control Waterway)

Elevation (m)	Head (m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
151.8		0.0				
150.0	1.8	1.4	0.7	1.3	1.3	
145.0	5.0	3.9	2.7	13.3	14.6	
140.0	5.0	7.2	5.6	27.8	42.4	
135.0	5.0	27.6	17.4	87.0	129.4	
130.0	5.0	1,560.1	793.9	3,969.3	4,098.7	
130.0	0.0	446.2	1,003.2	0.0	4,098.7	
127.0	3.0	385.0	415.6	1,246.8	5,345.5	
125.0	2.0	330.0	357.5	715.0	6,060.5	
Total				6,060.5		

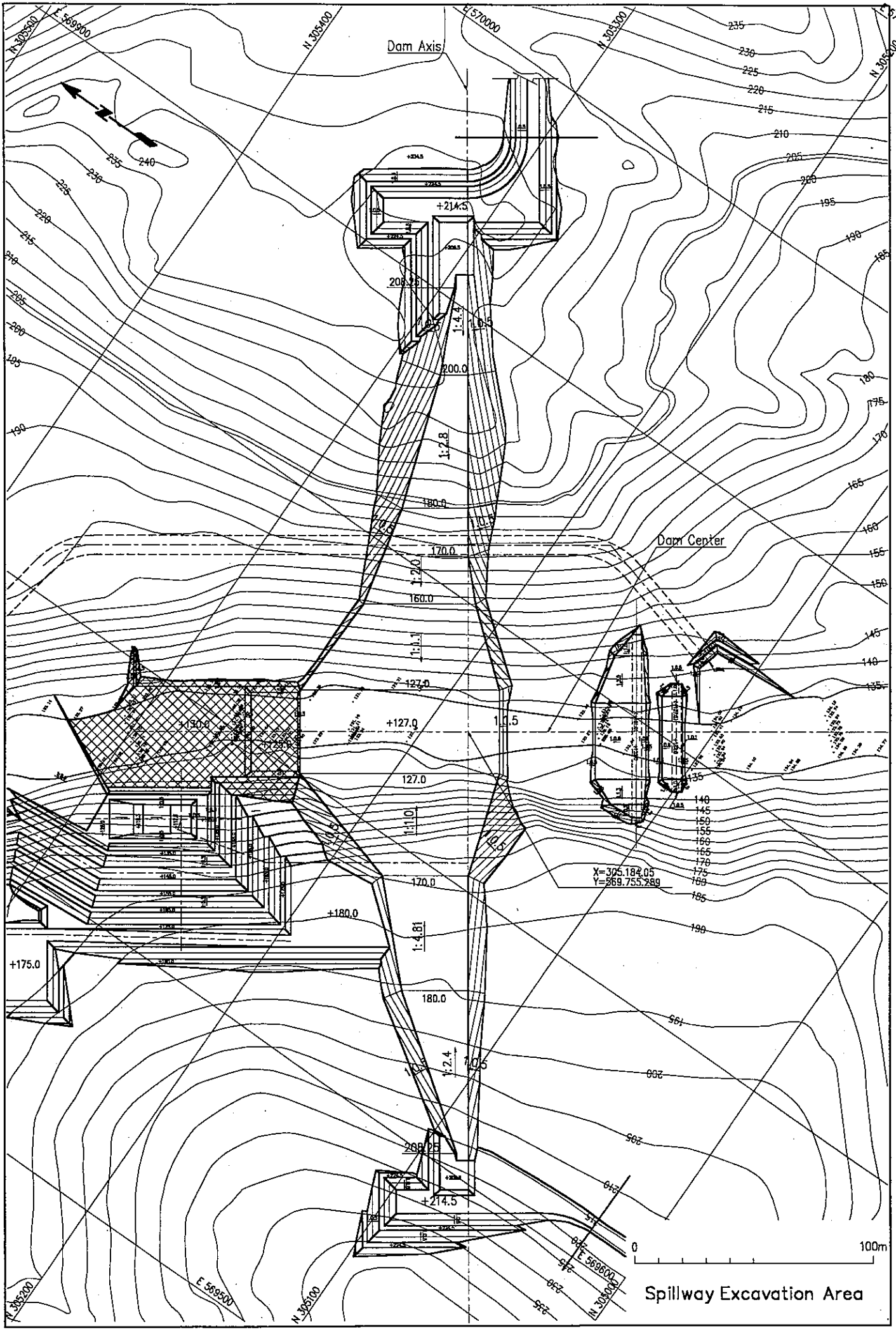
Total excavation volume= 12,653.5(Left Bank)+ 6,060.5(Right Bank)=18,714.m^3

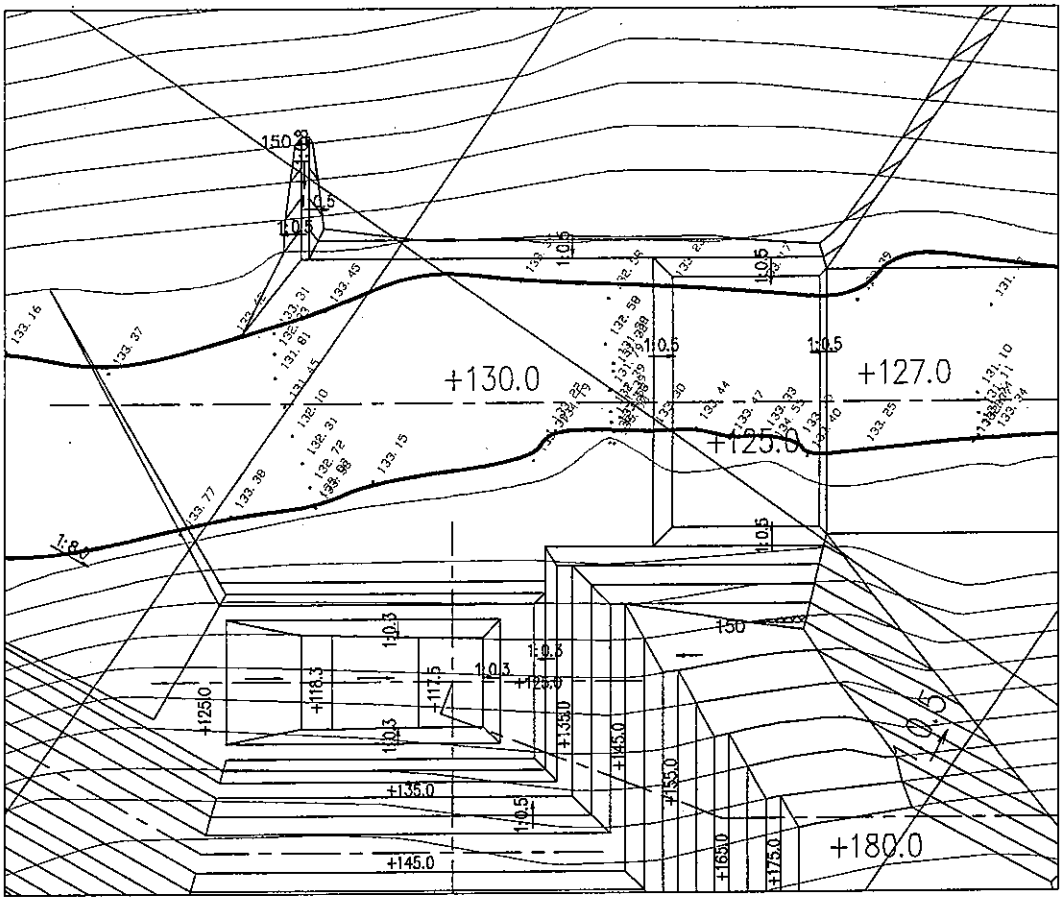
Estimated Ratio··(Common Excavation) : (Rock Excavation) = 4 : 6

V 2 (Common Excavation) = 7,485.6 m^3

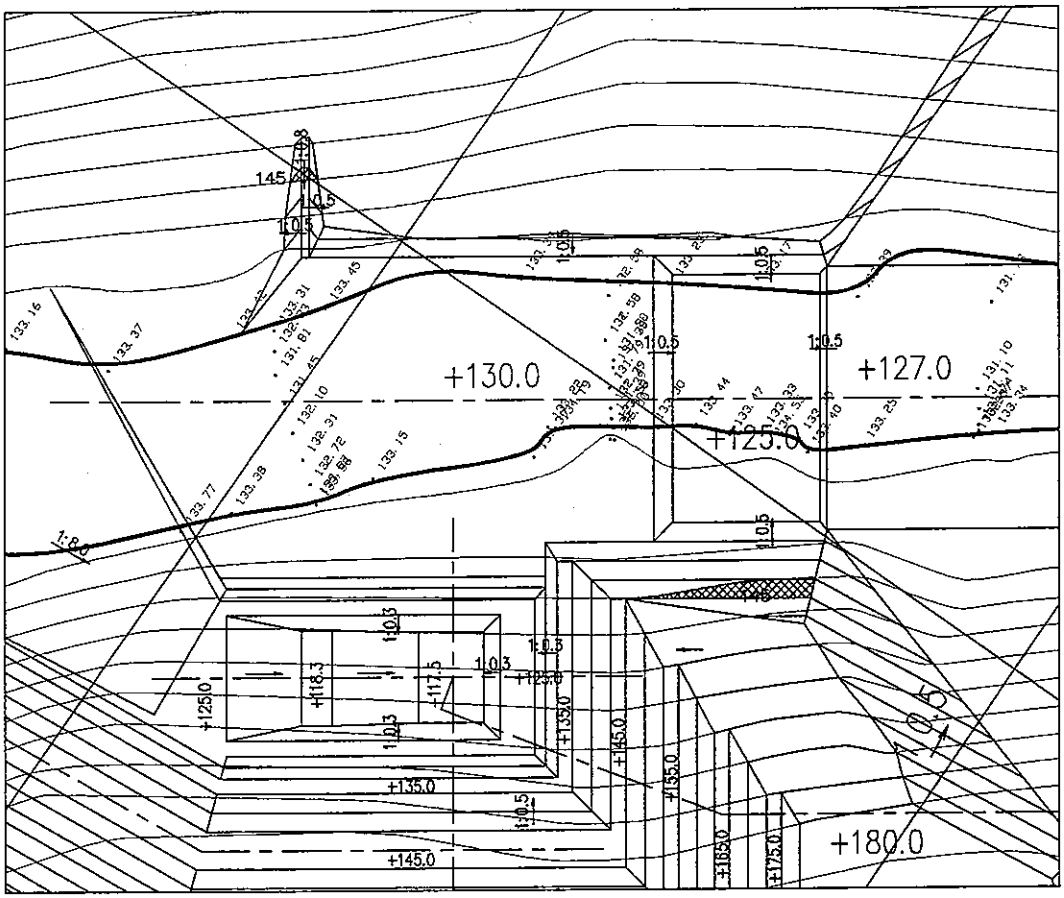
V b (Rock Excavation) = 11,228.4 m^3

(1) Common Excavation	V1+V2=116,933.4+ 7,485.6	=	124,419.0 m^3
(2) Rock Excavation	Va+Vb=175,400.0+11,228.4	=	186,628.4 m^3


Dam Axis
Dam Center
+214.5
208.25
200.0
180.0
170.0
160.0
127.0
+130.0
+127.0
+180.0
+175.0
1:4.4
1:2.8
1:2.0
1:1.1
1:1.10
1:4.81
1:2.4
1:0.5
X=305,184.05
Y=569,755.289
0
100m
Spillway Excavation Area
N 305500
E 569900
N 305400
E 570000
N 305300
N 305200
E 569500
N 305100
E 569600
N 305000



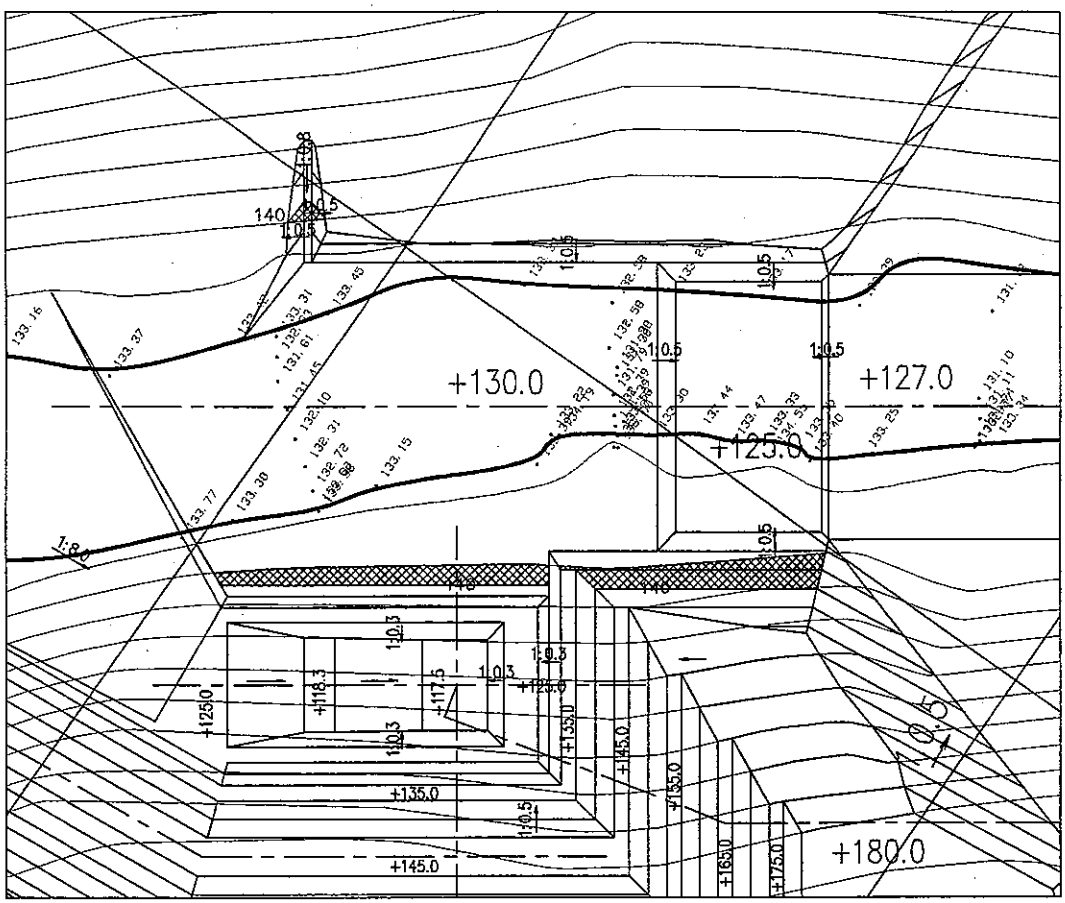
	left side	right side
EL150.0m	3.4 m2	1.4 m2



	left side	right side
EL145.0m	38.8 m2	3.9 m2

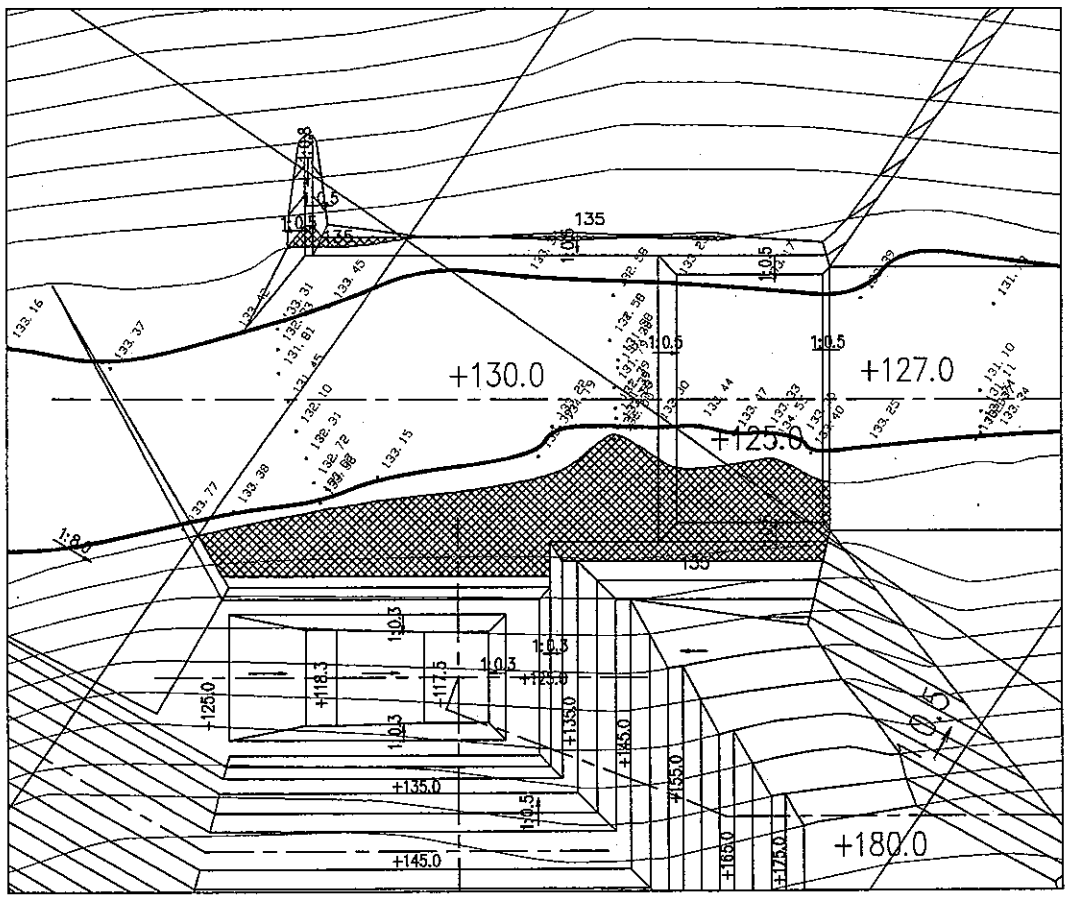
0 100m

Spillway Excavation (1)



	left side	right side
EL140.0m	218.5 m2	7.2 m2

(104.7+113.8=218.5)



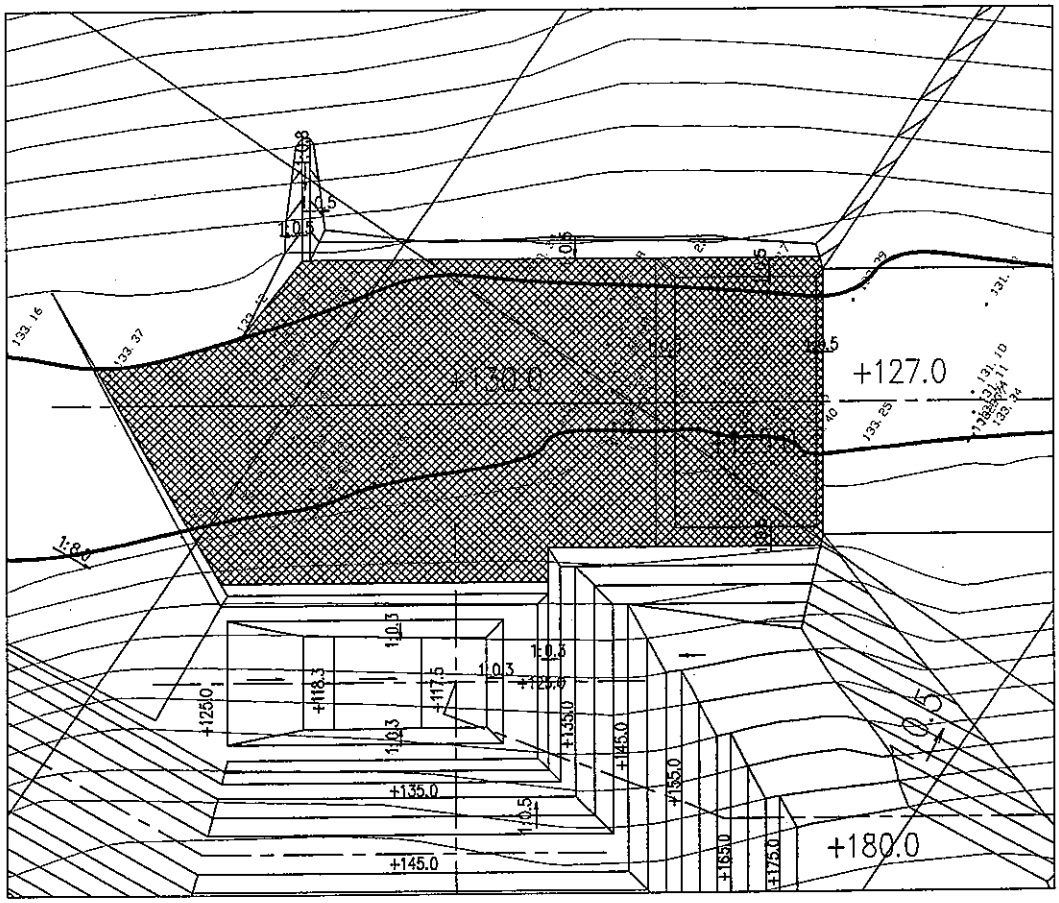
	left side	right side
EL135.0m	933.9 m2	27.6 m2

(19.5+
+8.1=27.6)

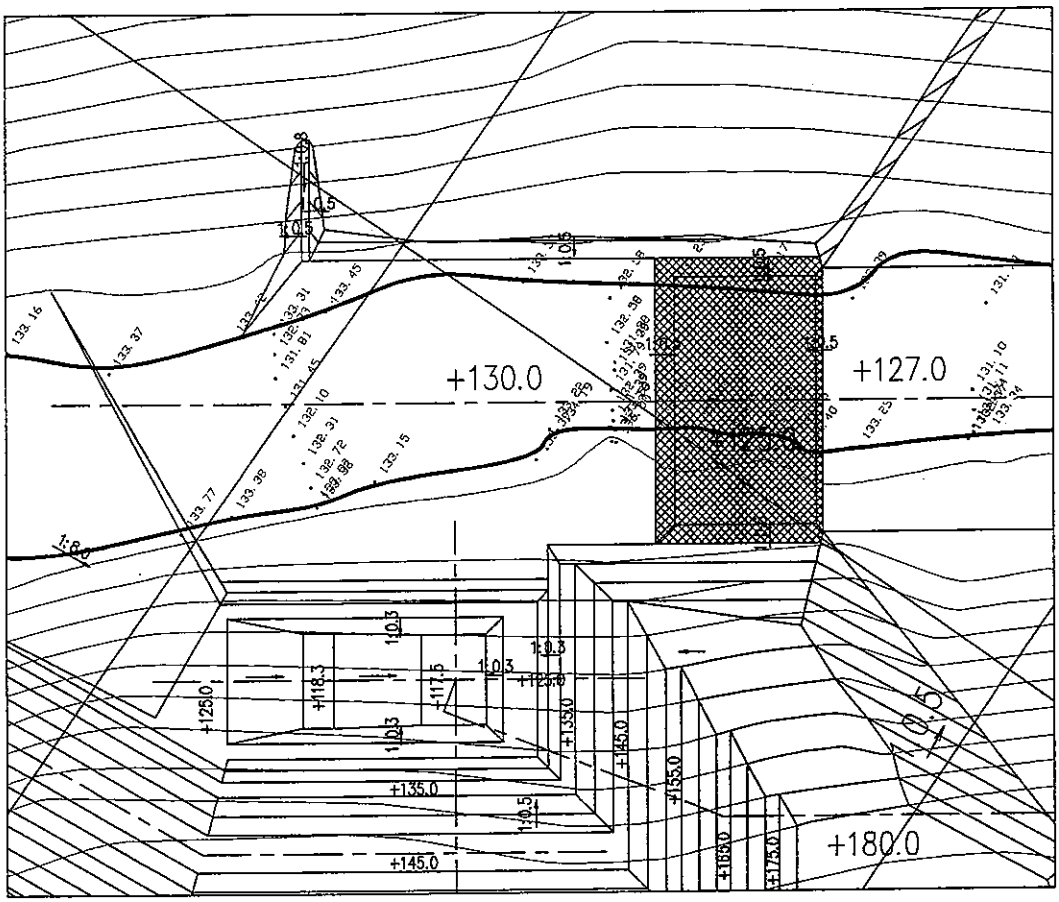
0 100m

Spillway Excavation (2)

764



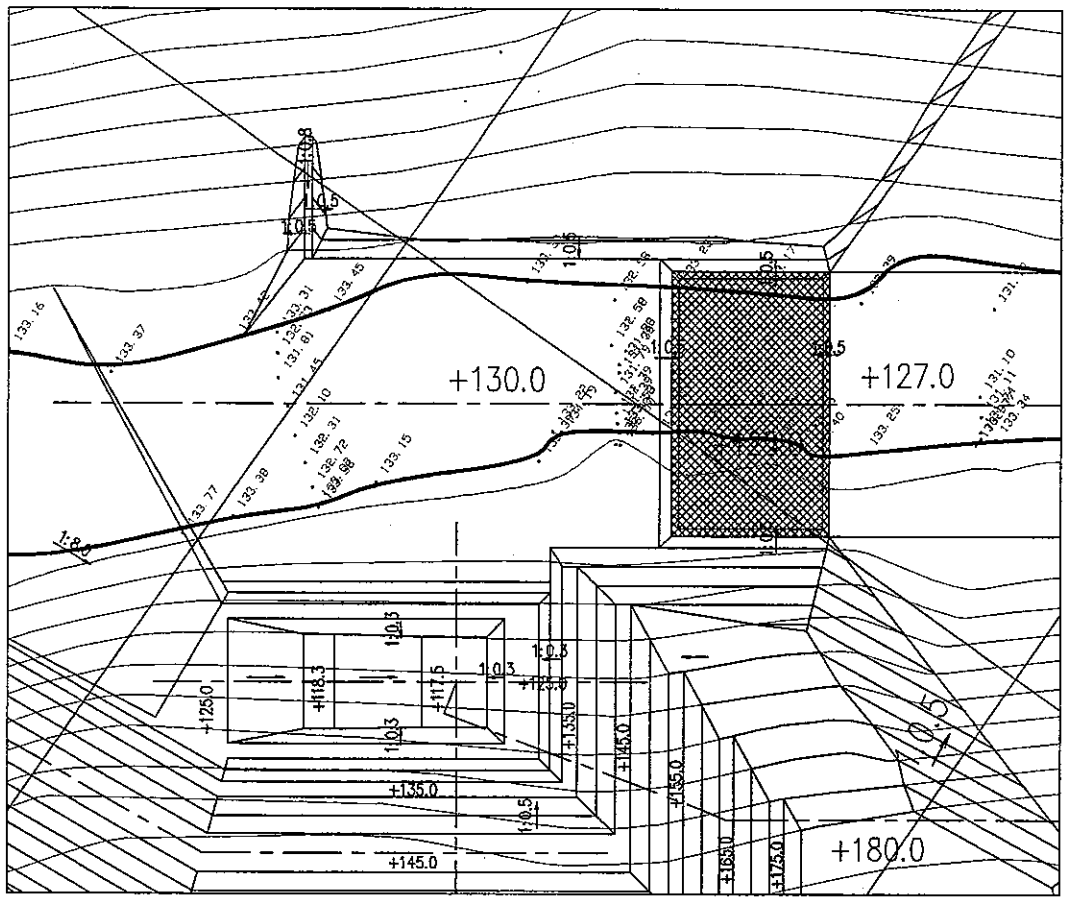
	left side	right side
EL130.0m	1889.6 m2	1560.1 m2



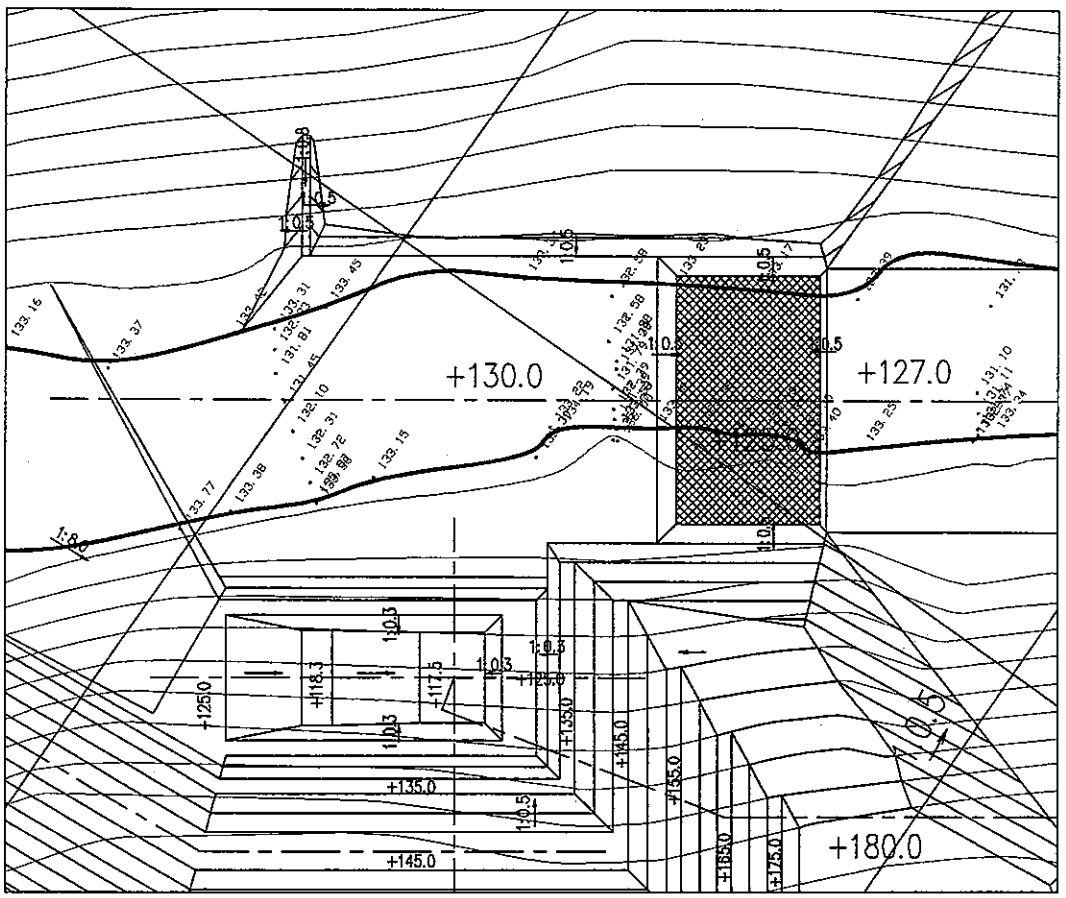
	left side	right side
EL130..0m	446.2 m2	446.2 m2

0 100m

Spillway Excavation (3)



	left side	right side
EL127.0m	385.0 m2	385.0 m2



	left side	right side
EL125.0m	330.0 m2	330.0 m2

0 100m

Spillway Excavation (4)

766

Type of Works	Calculation	Quantity

< Dam Concrete (RCC) , Inner concrete >

1)Whole volume [Reference drawing] Situation of section, Calculation of concrete volume(1)～(6)

Survey Station	Section Length(m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume(m^3)	Notes
No. 3		8.4				
No. 4	40.3	225.1	116.75	4,705.0	4,705.0	
No. 5	48.1	461.3	343.20	16,507.9	21,212.9	
No. 6-1	19.5	1,190.6	825.95	16,106.0	37,319.0	
No. 6-2	0.0	1,137.5	1,164.05	0.0	37,319.0	
No. 7	23.5	2,570.6	1,854.05	43,570.2	80,889.1	
No. 8	35.0	2,570.6	2,570.60	89,971.0	170,860.1	
No. 9-1	23.5	1,242.7	1,906.65	44,806.3	215,666.4	
No. 9-2	0.0	1,295.1	1,268.90	0.0	215,666.4	
No. 10	12.8	784.1	1,039.60	13,306.9	228,973.3	
No. 11	20.0	461.3	622.70	12,454.0	241,427.3	
No. 12	20.0	225.1	343.20	6,864.0	248,291.3	
No. 13	47.0	8.4	116.75	5,487.3	253,778.6	

Total Volume V1= 253,778.6 m^3

2)Subtract volume

①Penstock [Reference drawing] Calculation of concrete volume(10)

Subtract area

$A21 = \pi/4 \times 5.0^2 = 19.6\ m^2$

Subtract length

$L21 = 15.2\ m$

Subtract volume

$V21 = A21 \times L21 = 19.6 \times 15.2 = 297.9\ m^3$

②Gallery [Reference drawing] Calculation of concrete volume(7), (9)

Subtract area

$A22 = 18.0\ m^2$

Subtract length

$L22 = 331.9\ m$

Subtract volume

$V22 = A22 \times L22 = 18.0 \times 331.9 = 5,974.2\ m^3$

③Total of subtract volume

$V2 = V21 + V22 = 6,272.1\ m^3$

3)Dam Concrete (RCC)

$V = V1 - V2 = 253,778.6 - 6,272.1 = 247,506.\ m^3$

Type of Works	Calculation	Quantity

< Dam Concrete (Conventional) , Outer concrete >

(1) Crest of dam

1) Whole volume [Reference drawing] Situation of section, Calculation of concrete volume (1) ~ (6)

Survey Station	Section Length (m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
No. 1		25.0				
No. 2	12.0	25.0	25.00	300.0	300.0	
No. 2+19.7	19.7	85.6	55.30	1,089.4	1,389.4	
No. 3	10.8	85.6	85.60	924.5	2,313.9	
No. 4	40.3	85.6	85.60	3,449.7	5,763.6	
No. 5	48.1	85.6	85.60	4,117.4	9,880.9	
No. 6-1	19.5	85.6	85.60	1,669.2	11,550.1	
No. 6-2	0.0	0.0	42.80	0.0	11,550.1	
No. 7	23.5	0.0	0.00	0.0	11,550.1	
No. 8	35.0	0.0	0.00	0.0	11,550.1	
No. 9-1	23.5	0.0	0.00	0.0	11,550.1	
No. 9-2	0.0	85.6	42.80	0.0	11,550.1	
No. 10	12.8	85.6	85.60	1,095.7	12,645.8	
No. 11	20.0	85.6	85.60	1,712.0	14,357.8	
No. 12	20.0	85.6	85.60	1,712.0	16,069.8	
No. 13	47.0	85.6	85.60	4,023.2	20,093.0	
No. 14	9.0	85.6	85.60	770.4	20,863.4	
No. 14+5.7	5.7	85.6	85.60	487.9	21,351.3	
No. 15	36.1	25.0	55.30	1,996.3	23,347.7	
No. 16	22.0	25.0	25.00	550.0	23,897.7	

Total Volume V1 = 23,897.7 m^3

2) Subtract volume

Gallery [Reference drawing] Calculation of concrete volume (7), (9)

Subtract area

$A2 = 4.7 \ m^2$

Subtract length

$L2 = 25.5 + 42.1 = 67.6 \ m$

Subtract volume

$V2 = A2 \times L2 = 4.7 \times 67.6 = 317.7 \ m^3$

3) Dam Concrete (Conventional) : Crest of dam

$Vc = V1 - V2 = 23,897.7 - 317.7 = 23,580. \ m^3$

Type of Works	Calculation	Quantity

(2) Surface of dam

1) Whole volume [Reference drawing] Situation of section, Calculation of concrete

Survey Station	Section Length(m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume(m^3)	Notes
No. 2+19.7		0.0				
No. 3	10.8	47.4	23.70	256.0	256.0	
No. 4	40.3	181.7	114.55	4,616.4	4,872.3	
No. 5	48.1	261.7	221.70	10,663.8	15,536.1	
No. 6-1	19.5	435.7	348.70	6,799.7	22,335.7	
No. 6-2	0.0	407.5	421.60	0.0	22,335.7	
No. 7	23.5	619.2	513.35	12,063.7	34,399.5	
No. 8	35.0	619.2	619.20	21,672.0	56,071.5	
No. 9-1	23.5	426.8	523.00	12,290.5	68,362.0	
No. 9-2	0.0	454.7	440.75	0.0	68,362.0	
No. 10	12.8	350.1	402.40	5,150.7	73,512.7	
No. 11	20.0	261.7	305.90	6,118.0	79,630.7	
No. 12	20.0	181.7	221.70	4,434.0	84,064.7	
No. 13	47.0	47.4	114.55	5,383.9	89,448.5	
No. 14	9.0	14.4	30.90	278.1	89,726.6	
No. 14+5.7	5.7	0.0	7.20	41.0	89,767.7	

Total Volume V1= 89,767.7 m^3

2) Subtract volume

Penstock [Reference drawing] Calculation of concrete volume(10)

Subtract area

$A21 = \pi/4 \times 5.0^2 = 19.6\ m^2$

$A22 = \pi/4 \times (5.0^2 + 5.5^2) / 2 = 21.7\ m^2$

Subtract length

$L21 = 2.6 + 1.5 = 4.1\ m$

$L22 = 1.5\ m$

Subtract volume

$V21 = A21 \times L21 = 19.6 \times 4.1 = 80.4\ m^3$

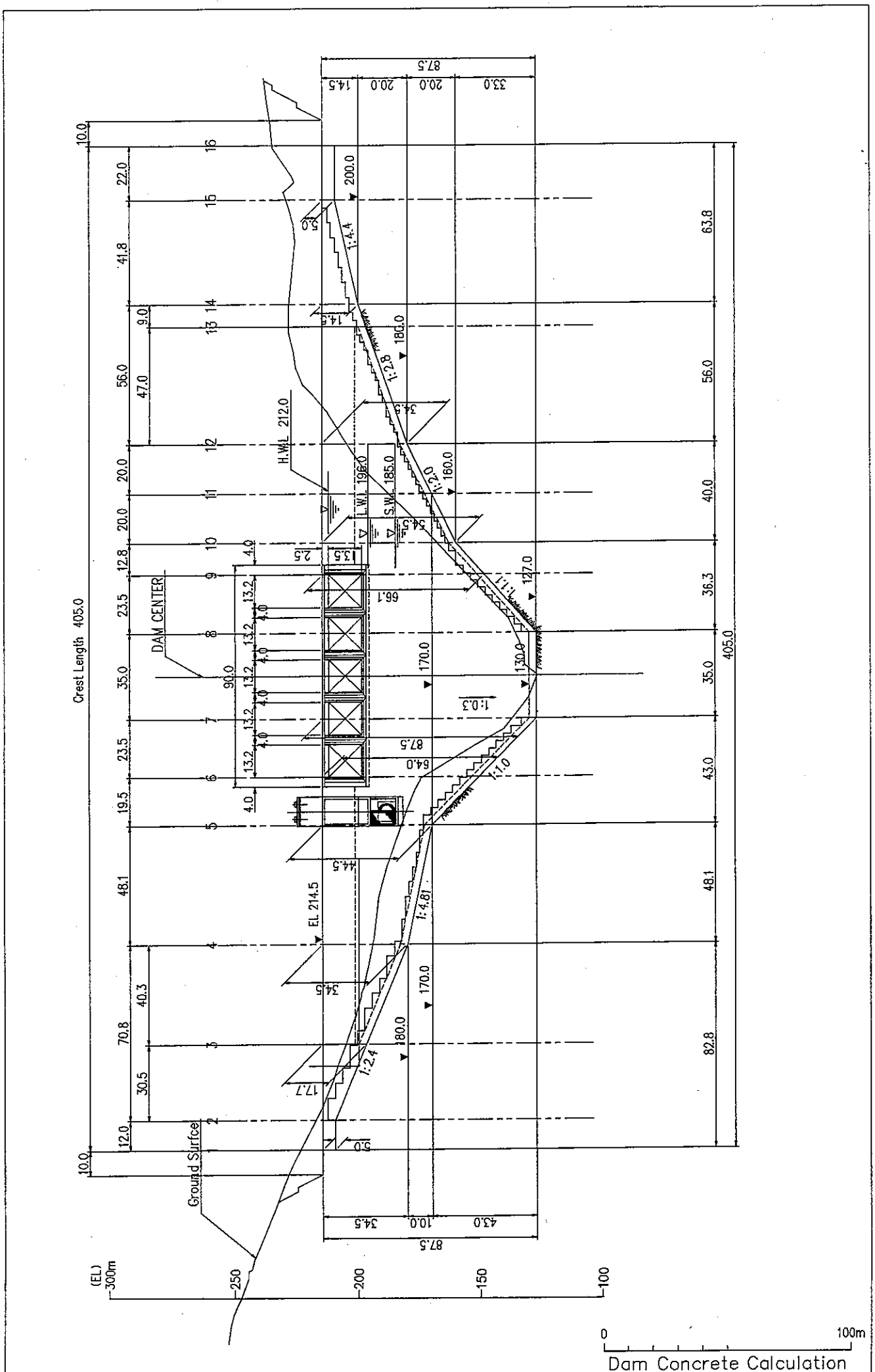
$V22 = A22 \times L22 = 21.7 \times 1.5 = 32.6\ m^3$

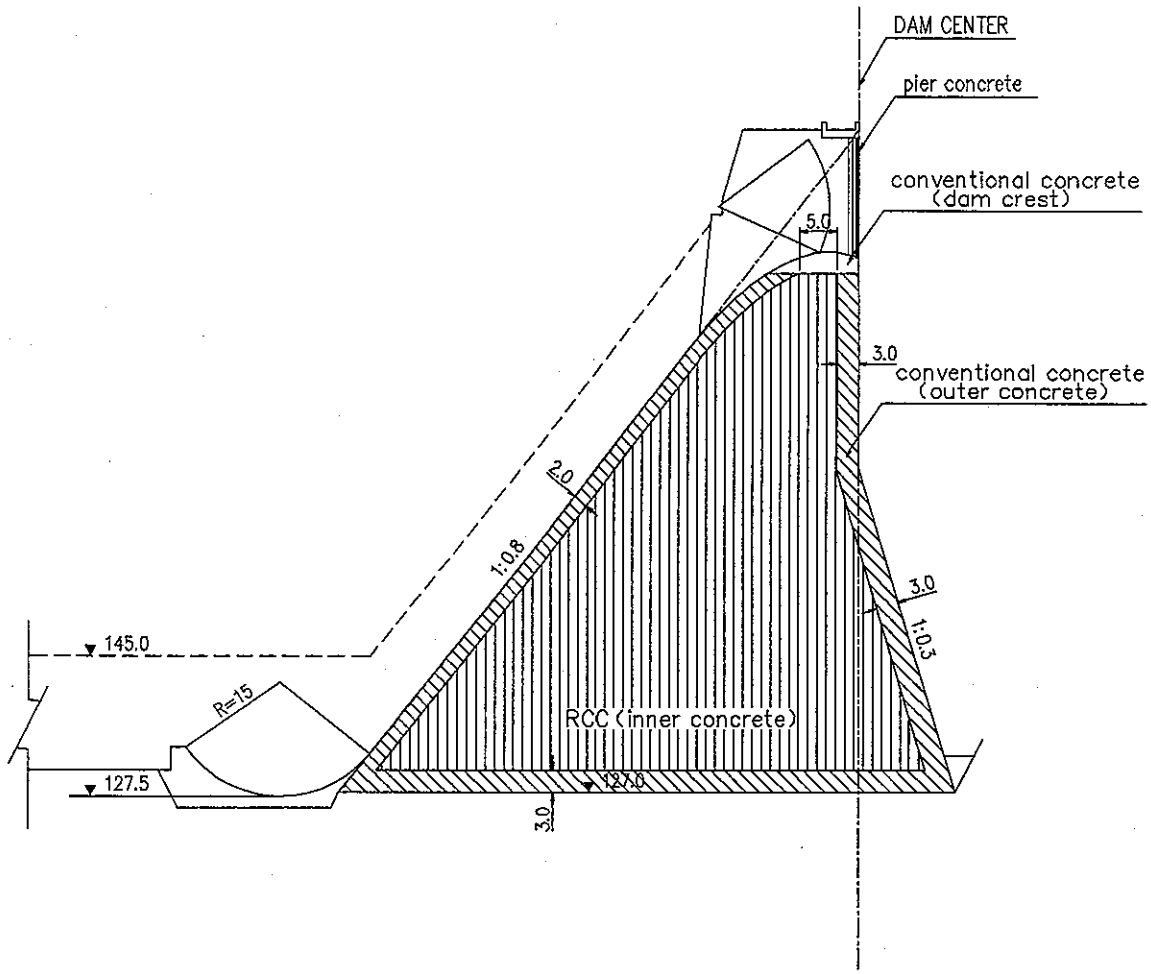
Subtract volume

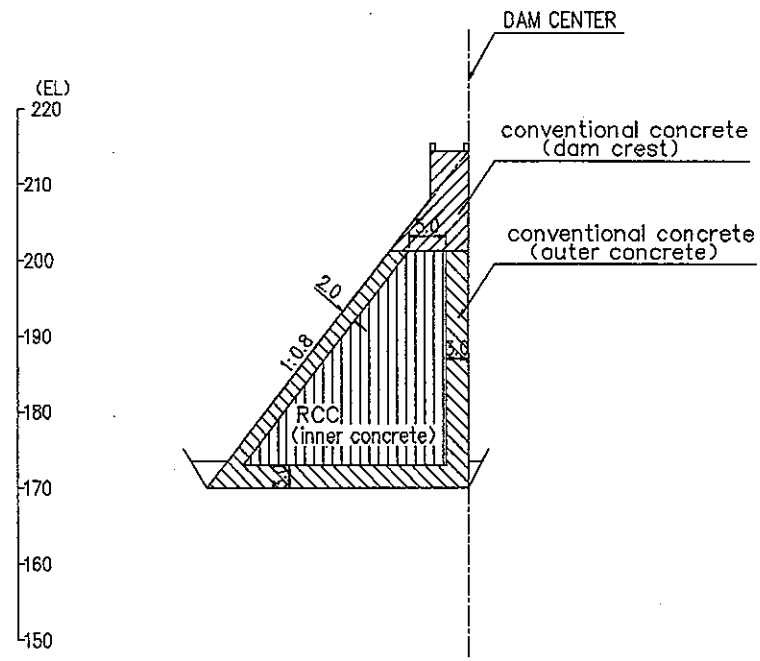
$V2 = V21 + V22 = 113.0\ m^3$

Type of Works	Calculation	Quantity
	3)Additional concrete volume	
	①Environ of gallery [Reference drawing] Calculation of concrete volume(7), (9)	
	Additional area	
	$A31 = 13.3 \ m^2$	
	Additional length	
	$L31 = 25.5 + 42.1 = 67.6 \ m$	
	Additional volume	
	$V31 = A31 \times L31 = 13.3 \times 67.6 = 899.1 \ m^3$	
	②Footing [Reference drawing] Calculation of concrete volume(7), (8)	
	Standard section area of footing	
	$A321 = 6.3 \ m^2$ (Upper stream;Vertical part)	
	$A322 = 10.0 \ m^2$ (Upper stream;Part of fillet)	
	$A323 = 16.3 \ m^2$ (Lower stream)	
	Established length of footing	
	$L321 = 119.0 + 114.7 = 233.7 \ m$ (Upper stream;Vertical part)	
	$L322 = 43.0 + 56.3 = 99.3 \ m$ (Upper stream;Part of fillet)	
	$L323 = 150.0 + 156 = 306.0 \ m$ (Lower stream)	
	Volume of footing	
	$V321 = A321 \times L321 = 6.3 \times 233.7 = 1,472.3 \ m^3$	
	$V322 = A322 \times L322 = 10.0 \times 99.3 = 993.0 \ m^3$	
	$V323 = A323 \times L323 = 16.3 \times 306.0 = 4,987.8 \ m^3$	
	$\Sigma V32 = V321 + V322 + V323 = 7,453.1 \ m^3$	
	③Total volume of additional concrete	
	$V3 = V31 + V32 = 8,352.2 \ m^3$	
	4)Total concrete volume : Surface of dam	
	$V = V1 - V2 + V3$	
	$= 89,767.7 - 113.0 + 8,352.2 = 98,006. \ m^3$	
(3)	Total volume of dam concrete (conventional) , outer concrete surface of dam	
	$V = 23,580.0 \ m^3 + 98,006.9 \ m^3 = 121,586. \ m^3$	

770

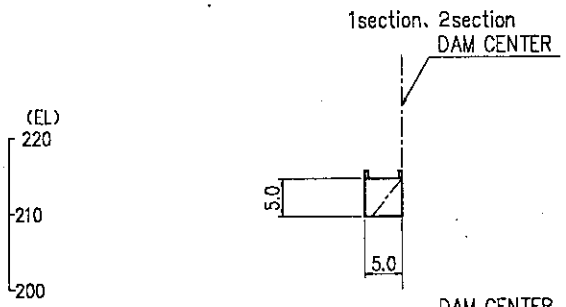

Crest Length 405.0
DAM CENTER
Ground Surface
H.W.L 212.0
L.W.L 196.0
S.W.L 185.0
EL. 214.5
200.0
180.0
170.0
160.0
130.0
127.0
87.5
64.0
66.1
1:0.3
1:1.0
1:1.1
1:2.0
1:2.8
1:4.4
1:4.81
1:2.4
405.0
63.8
56.0
40.0
36.3
35.0
43.0
48.1
82.8
87.5
33.0
20.0
14.5
43.0
10.0
34.5
(EL) 300m
250
200
150
100
0
100m
Dam Concrete Calculation



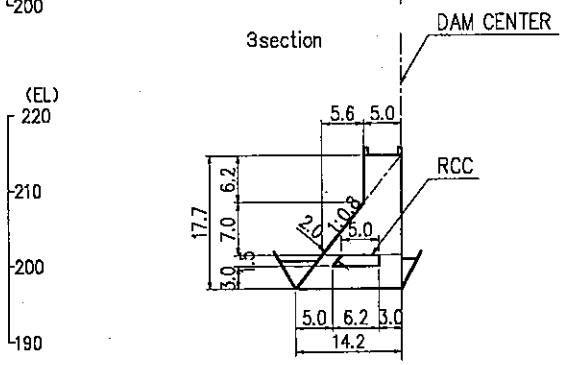


Dam Concrete Calculation

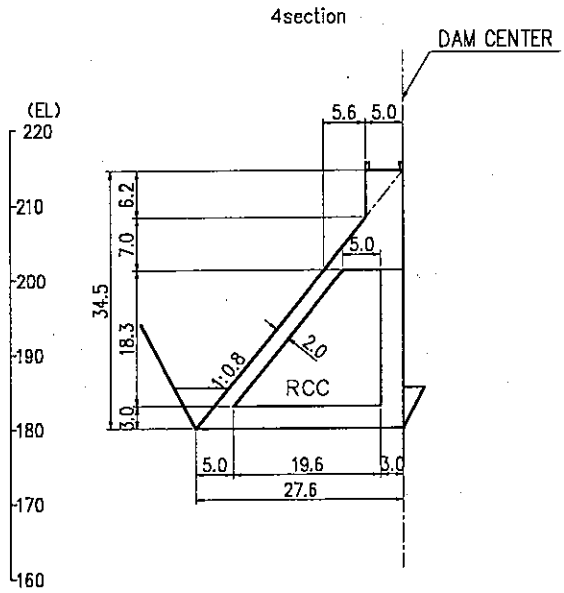
772



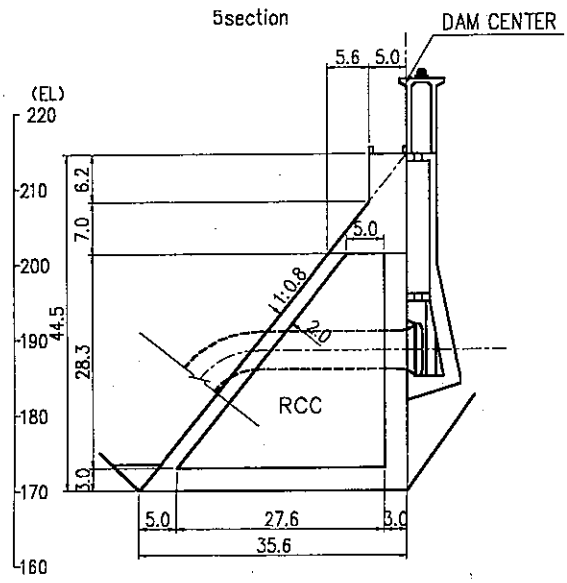
RCC : 0.0m2
dam crest : 25.0m2
outer : 0.0m2



RCC : 8.4m2
dam crest : 85.6m2
outer : 47.4m2



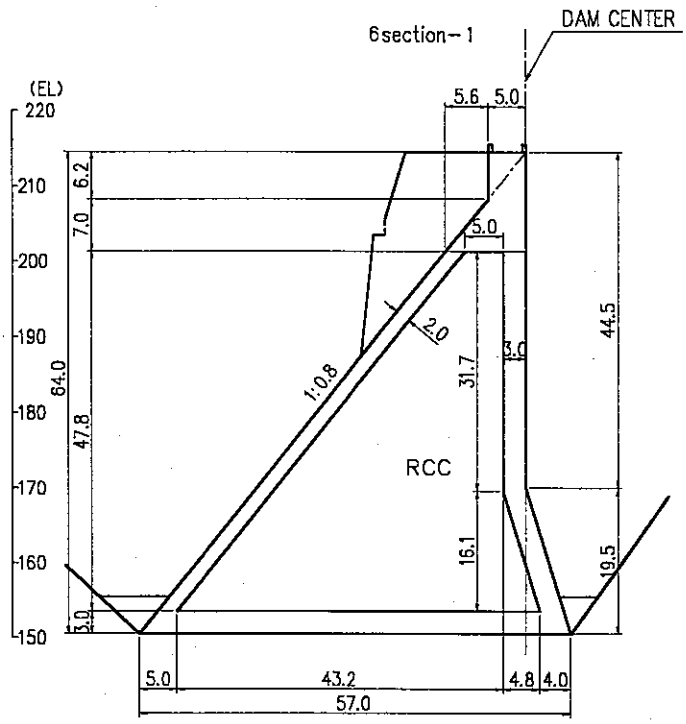
RCC : 225.1m2
dam crest : 85.6m2
outer : 181.7m2



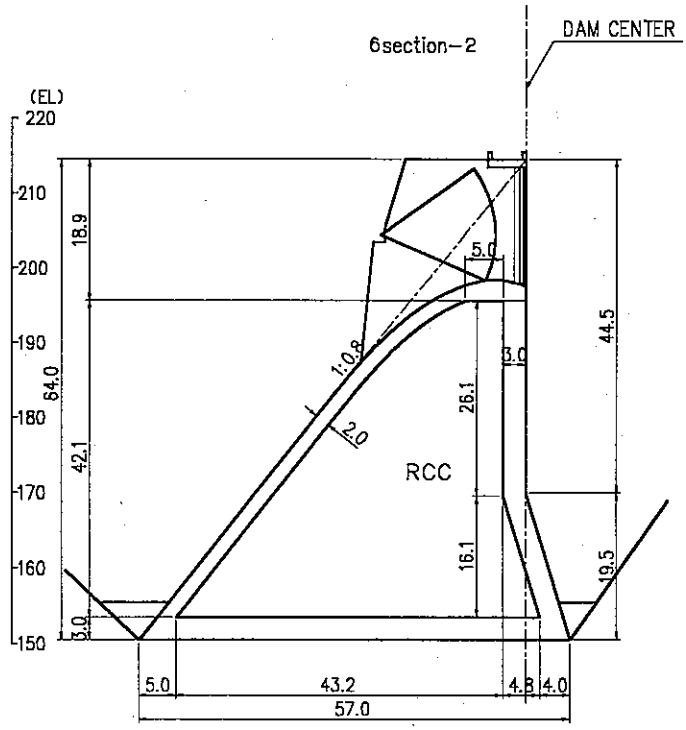
RCC : 461.3m2
dam crest : 85.6m2
outer : 261.7m2

0 50m

Dam Concrete (1)



RCC : 1190.6m2
dam crest : 85.6m2
outer : 435.7m2

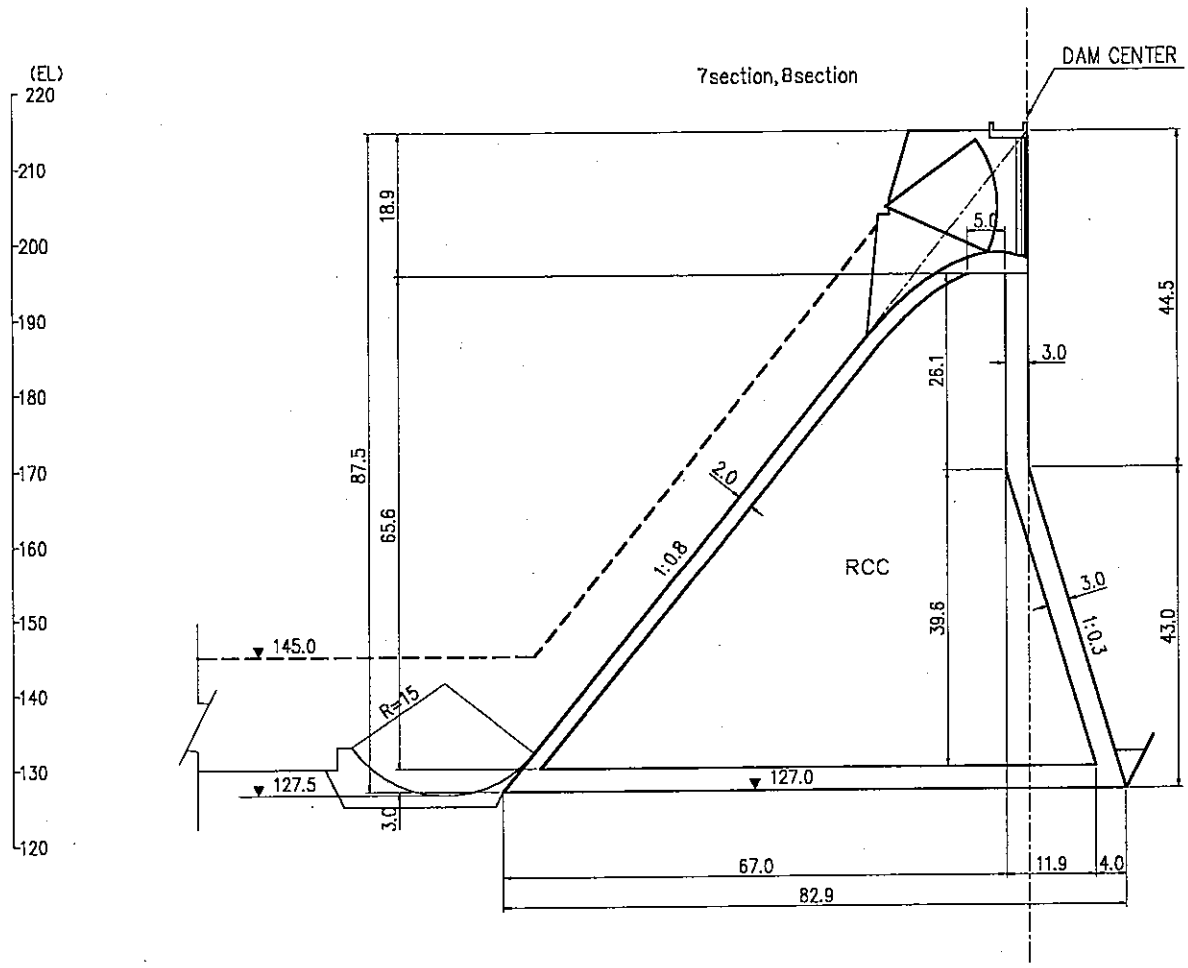


RCC : 1137.5m2
dam crest : 0.0m2
outer : 407.5m2

0 50m

Dam Concrete (2)

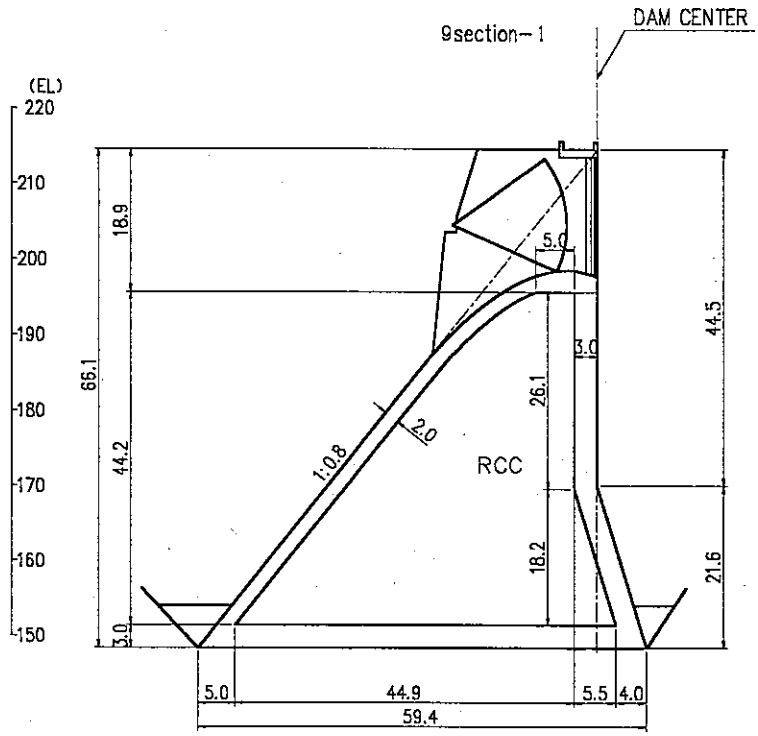
774



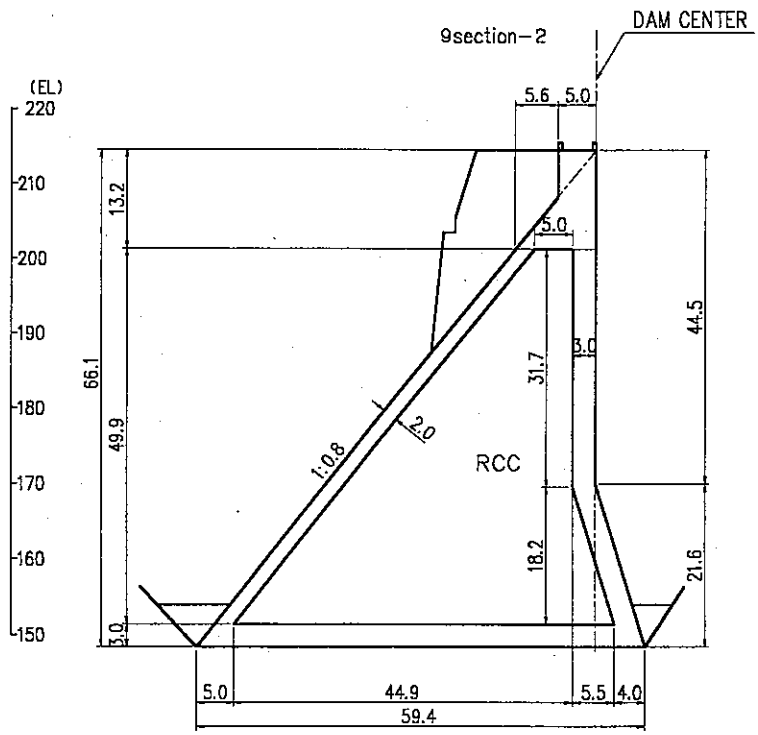
RCC : 2570.6m2
dam crest : 0.0m2
outer : 619.2m2

0 50m

Dam Concrete (3)



RCC : 1242.7m2
dam crest : 0.0m2
outer : 426.8m2

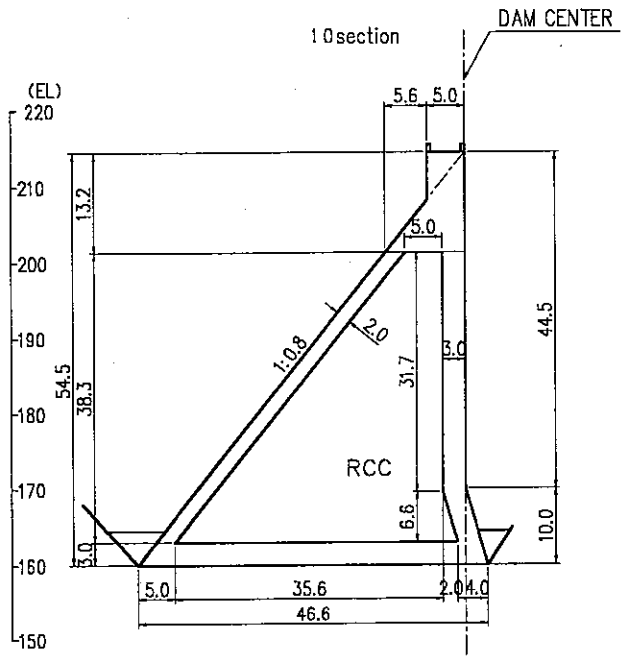


RCC : 1295.1m2
dam crest : 85.6m2
outer : 454.7m2

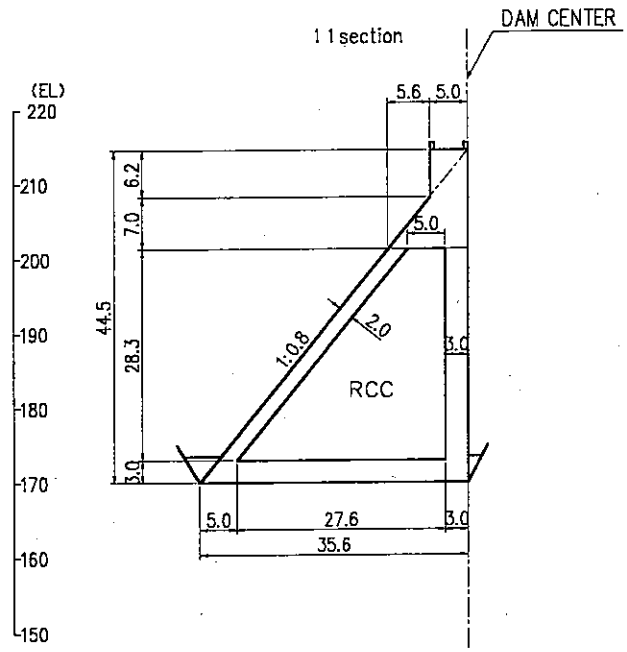
0 50m

Dam Concrete (4)

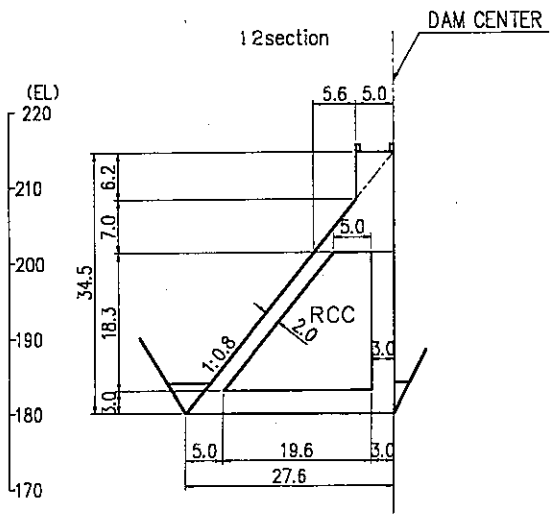
776



RCC : 784.1m2
dam crest : 85.6m2
outer : 350.1m2



RCC : 461.3m2
dam crest : 85.6m2
outer : 261.7m2

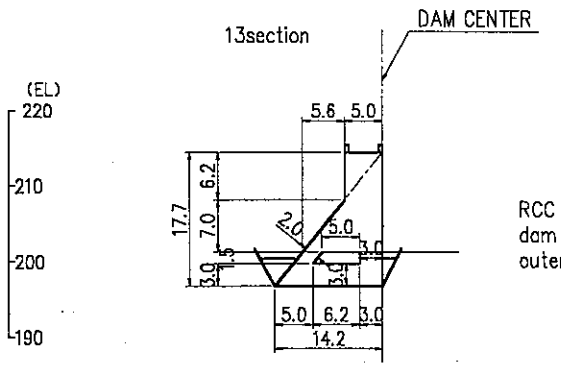


RCC : 225.1m2
dam crest : 85.6m2
outer : 181.7m2

0 50m

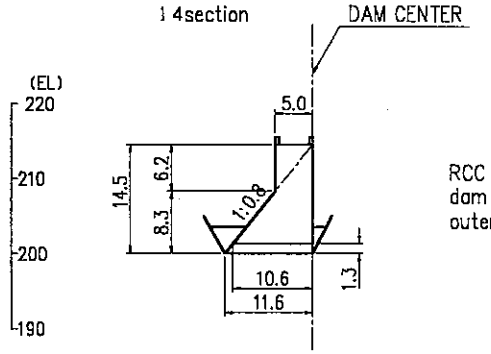
Dam Concrete (5)

13section



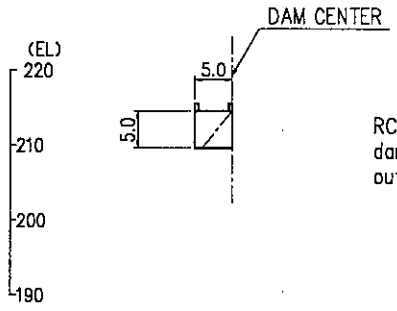
RCC : 8.4m2
dam crest : 85.6m2
outer : 47.4m2

14section



RCC : 0.0m2
dam crest : 85.6m2
outer : 14.4m2

15section、16section



RCC : 0.0m2
dam crest : 25.0m2
outer : 0.0m2

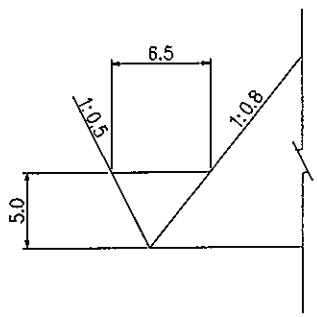
0 50m

Dam Concrete (6)

778

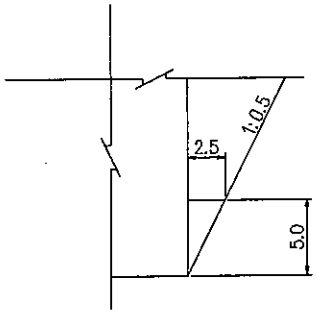
Footing Cross Section

downstream

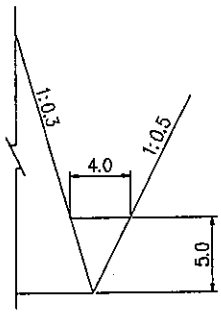


A=16.3m2

upstream



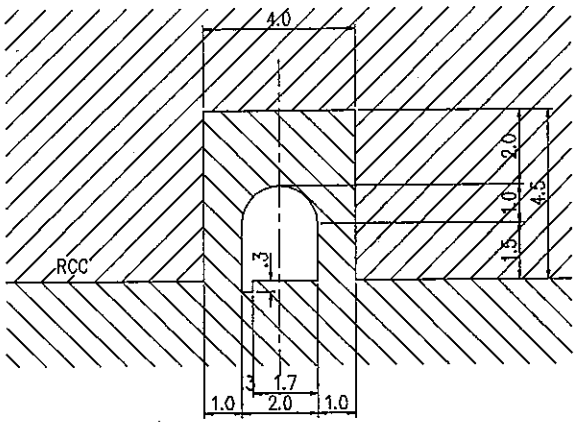
A= 6.3m2



A=10.0m2

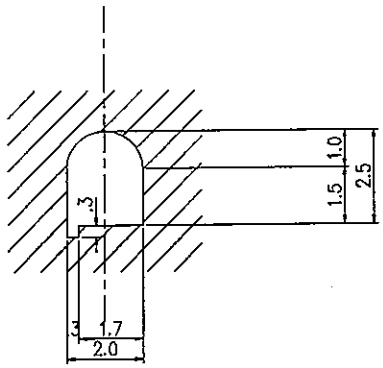
Gallery Cross Section

RCC concrete

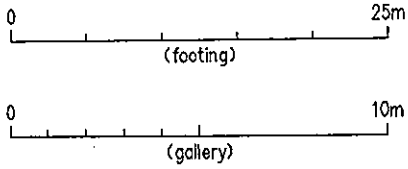


- subtract concrete at RCC
  A=4.0×4.5=18.0m2
- additional concrete for conventional concrete (outer)
  A=4.0×4.5−2.0×1.5−$\pi \times 1^2$ /2−0.3×0.3=13.3m2

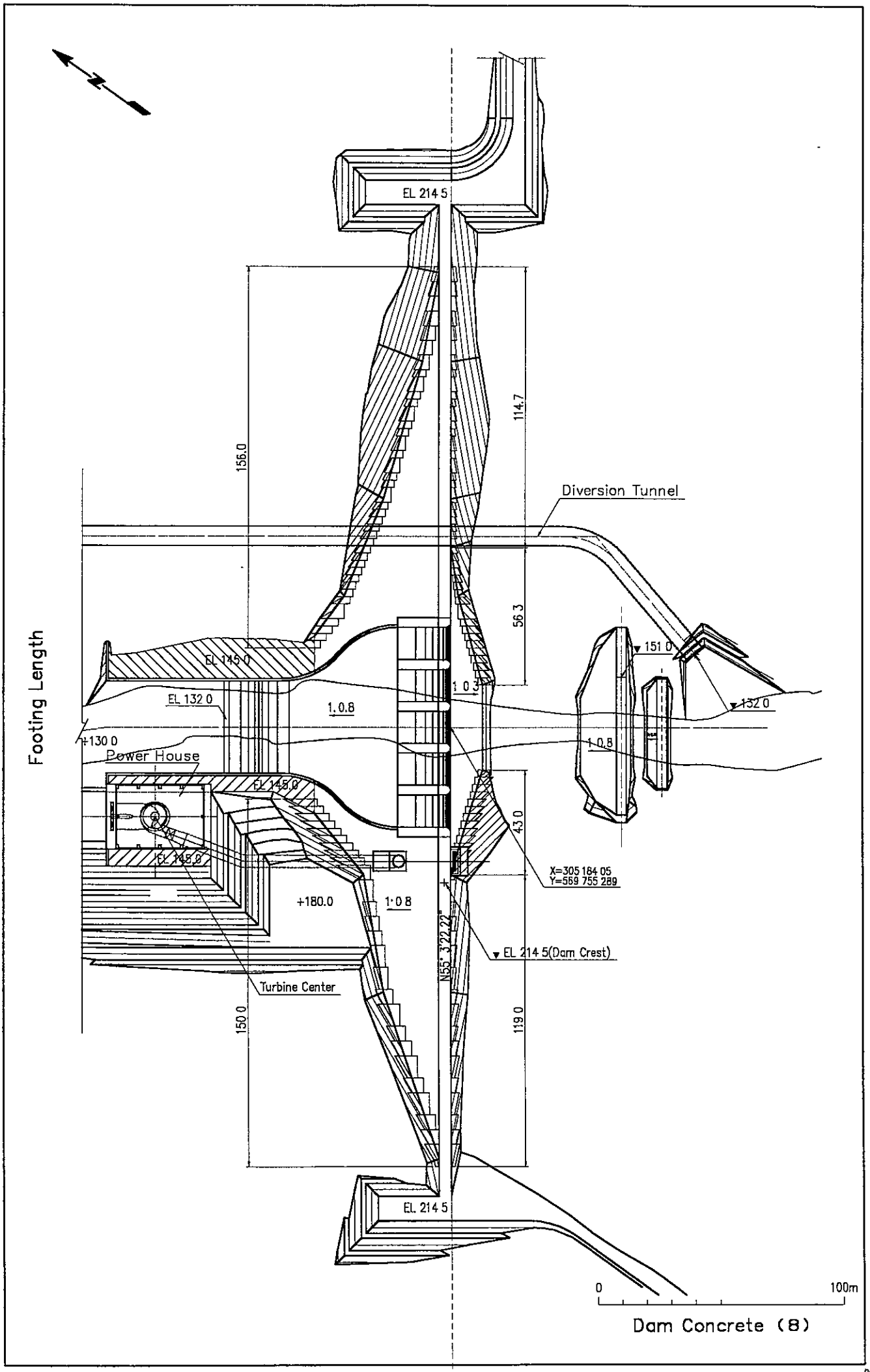
dam crest concrete

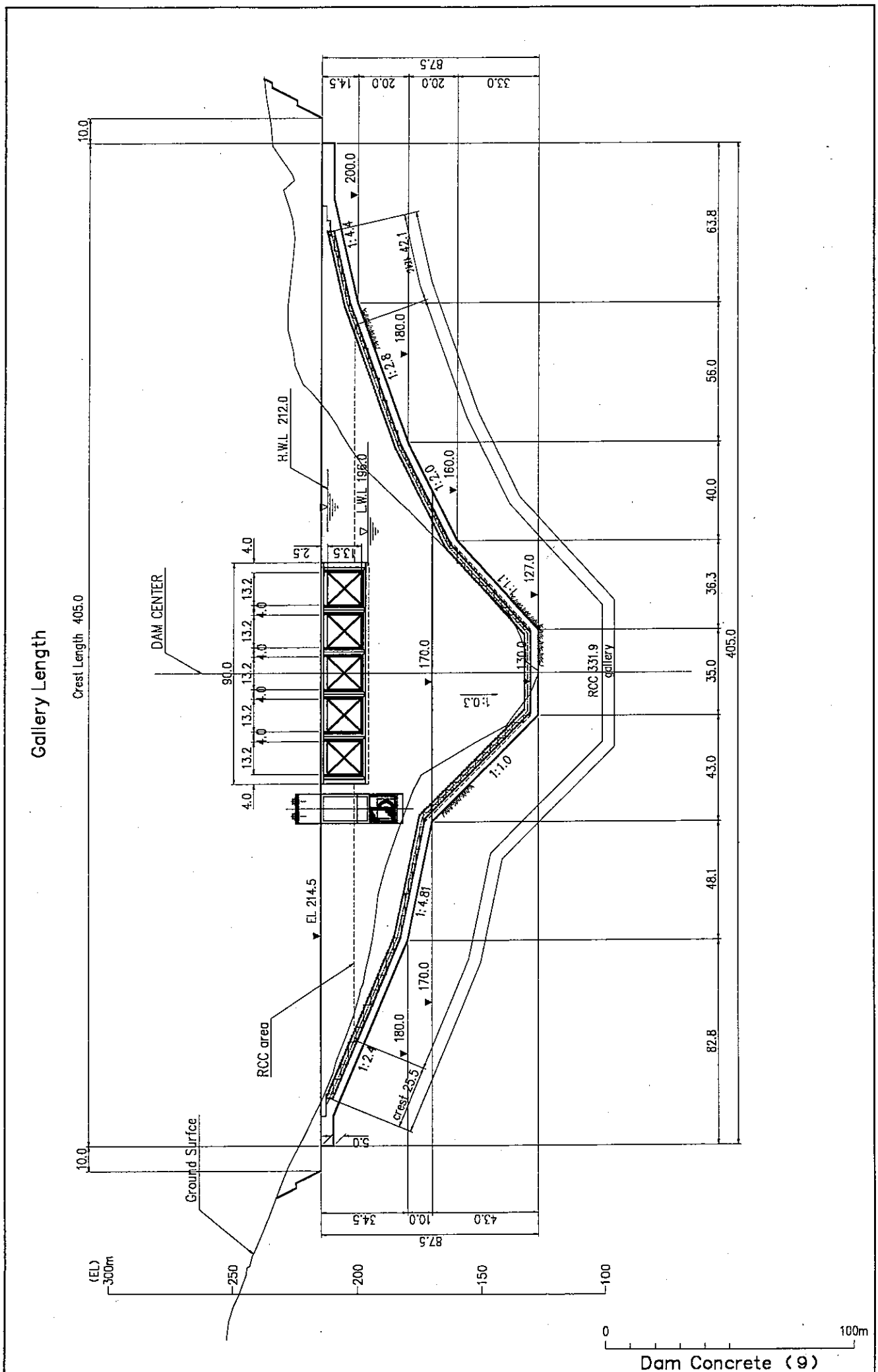


- subtract concrete at dam crest
  A=2.0×1.5+$\pi \times 1^2$ /2+0.3×0.3=4.7m2

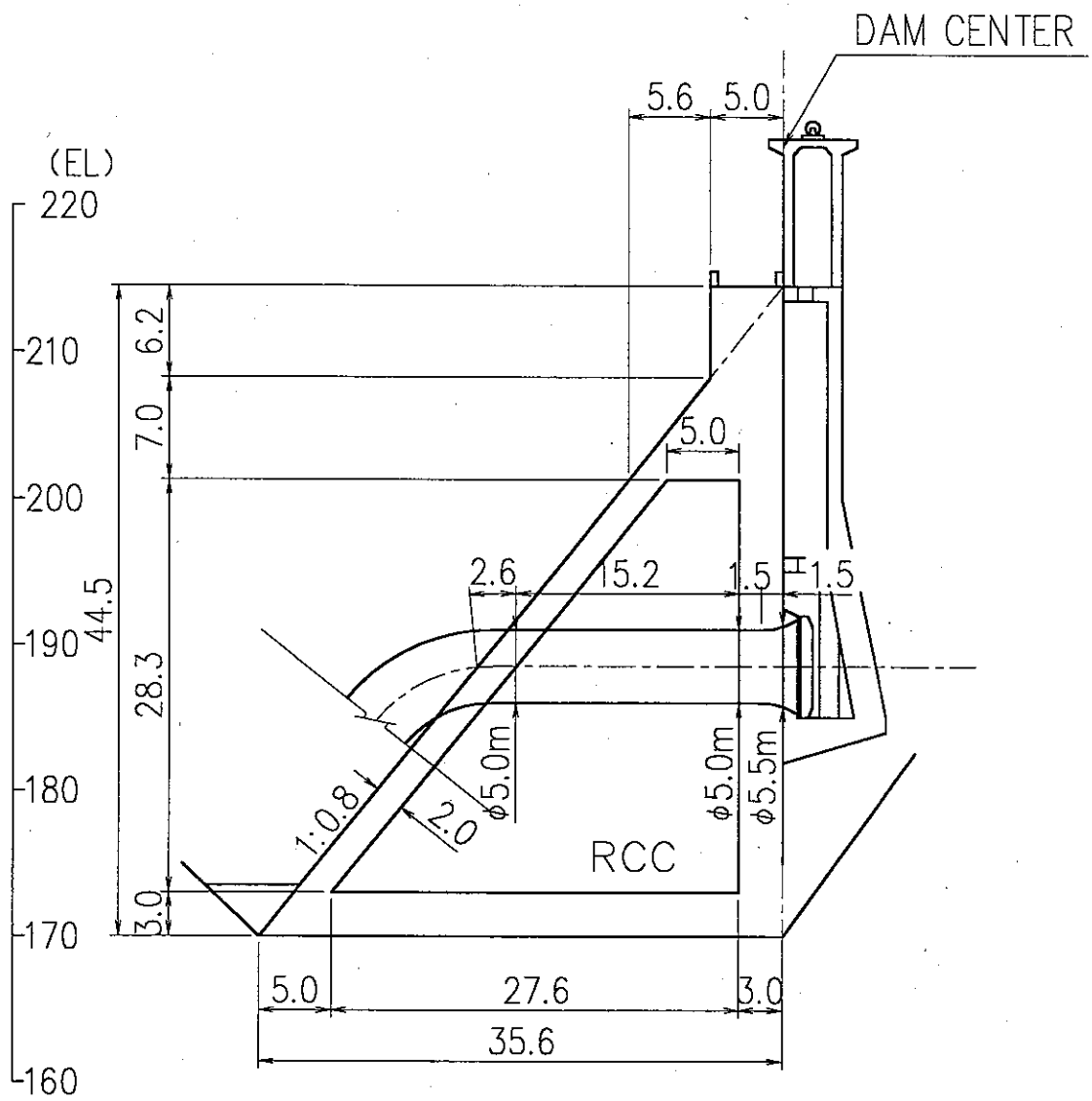


Dam Concrete (7)


EL 214 5
156.0
114.7
Diversion Tunnel
56 3
EL 145 0
1 0 3
EL 132 0
1:0.8
+130 0
Power House
151 0
132 0
1 0.8
EL 145.0
43 0
EL 145.0
X=305 184 05
Y=569 755 289
+180.0
1:0 8
EL 214 5(Dam Crest)
N55° 3'22.22"
Turbine Center
150 0
119 0
EL 214 5
0
100m
Dam Concrete (8)
Footing Length


Gallery Length
Crest Length 405.0
DAM CENTER
RCC area
RCC 331.9
gallery
H.W.L 212.0
L.W.L 198.0
EL. 214.5
Ground Surface
Crest 25.5
87.5
33.0
20.0
14.5
43.0
10.0
34.5
405.0
63.8
56.0
40.0
36.3
35.0
43.0
48.1
82.8
200.0
180.0
160.0
127.0
170.0
130.0
90.0
1:4.4
1:2.8
1:2.0
1:1.1
1:1.0
1:0.3
1:4.8
1:2.4
1:3.5
2.5
5.0
4.0
13.2
(EL) 300m
250
200
150
100
0
100m
Dam Concrete (9)

Penstock



0 25m

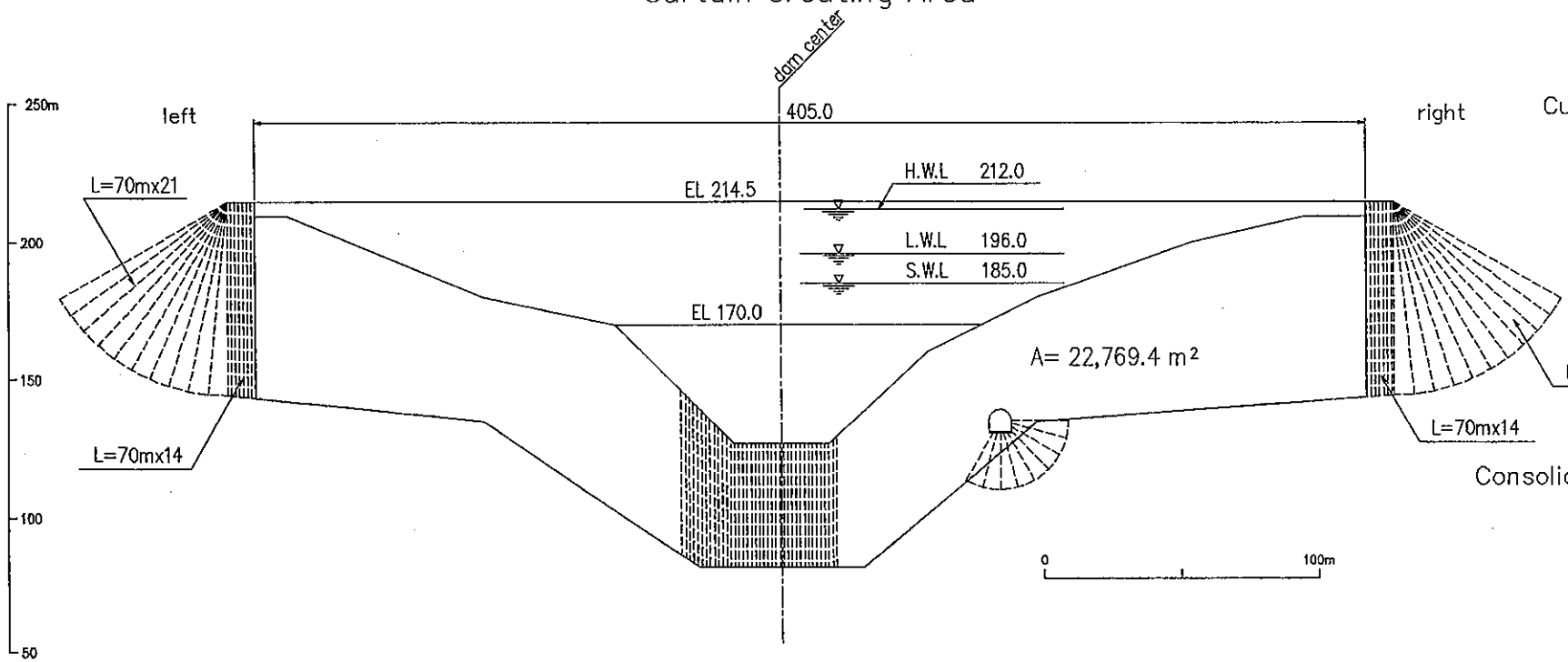
Dam Concrete (10)

782

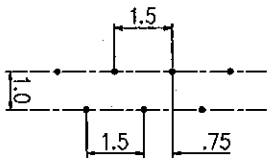
Type of Works	Calculation	Quantity
<Consolidation Grouting Drilling>		
	Area of dam foundation A = 13,490 m^2 Useful Area of 1 grouting a = 5.0 × 5.0 = 25.0 m^2 Number of grouting N = A / a ≒ 540 Numbers Length of consolidation grouting drilling The part of rock L1 = N × 5.0 = 540 × 5.0 = 2,700.0 m ※Length of grouting:L=5.0m The part of concrete L2 = N × 3.0 = 540 × 3.0 = 1,620.0 m ※Thickness of lift:t=3.0m Total length of consolidation grouting drilling ΣL = L1 + L2 =	4,320.0 m
<Consolidation Grouting Cement>		
	Impregnation quantity of cement per 1 m length : 30 kg/m Total length of consolidation grouting L = L1 = 2,700.0 m Volume of consolidation Grouting Cement W = 2,700.0 m × 30 kg/m = 81,000 kg =	81.0 t
<Curtain Grouting Drilling>		
	Curtain Grouting Part of dam body Part of rock : (extent of execution)／(pitch of grouting) Extent of execution A1 = 22,769 m^2 (Computed by planimeter) Length of excavation L1 = A1 / 0.75 = 22,769／0.75 =30,358.'m ※Pitch of grouting b=0.75m Part of concrete : (number of execution) × (length) Number of execution N2 = 405.0 / 0.75 = 540 Numbers ※Length of dam's top L=405.0m, pitch 0.75m Length of excavation L2 = N2 × 3.0 = 540 × 3.0 = 1,620.0 m ※Thickness of lift t=3.0m	

Type of Works	Calculation	Quantity
	Part of rim	
	Part of rock : (number of execution) × (length)	
	Number of execution	
	N31 = 21 + 14 = 35 Numbers (left bank)	
	N32 = 21 + 14 = 35 Numbers (right bank)	
	ΣN3 = N31 + N32 = 70 Numbers	
	Length of excavation	
	L3 = N × 70.0 = 70 × 70.0 = 4,900.0 m	
	※length of grouting L=70.0m	
	Total length of curtain grouting excavation	
	ΣLa = L1 + L2 + L3 = 36,878.7m	
	Support Curtain Grouting	
	Part of dam body	
	Part of rock : (extent of execution) / (pitch of grouting)	
	Extent of execution (1/2 of curtain grouting)	
	A2 = 22,769 / 2 ≒ 11,385 m^2	
	(Computed by planimeter)	
	Length of excavation	
	L4 = A2 / 1.5 × α	
	= 11,385 / 1.5 × 1.10 = 8,349.0 m	
	※pitch of grouting b=1.5m , Modulus of transformation about inclined length α=24.8/22.5=1.10 (reference of drawin	
	Part of concrete : (number of execution) × (length)	
	Number of execution	
	N5 = 405.0 / 1.5 = 270 Numbers	
	※Length of dam's top L=405.0m, pitch 1.5m	
	Length of excavation	
	L5 = N5 × 5.5 = 270 × 5.5 = 1,485.0 m	
	※Thickness of lift t=3.0m, Inclined length (reference of drawing)	
	Total length of support curtain grouting	
	ΣLb = L4 + L5 = 9,834.0 m	
	Total length of support curtain grouting excavation	
	ΣL = La + Lb =	46,712.7 m
<Curtain Grouting Cement>		
	Impregnation quantity of cement per 1 m length : 50 kg/m	
	Total length of curtain grouting	
	L = L1 + L3 + L4 = 43,607.7 m	
	(See the "Curtain Grouting Drilling")	
	Impregnation of grouting	
	W = 43,607.7 × 50 = 2,180,385 kg =	2,180 t

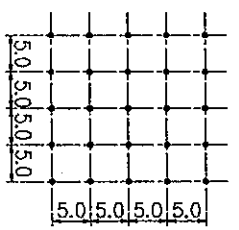
Curtain Grouting Area



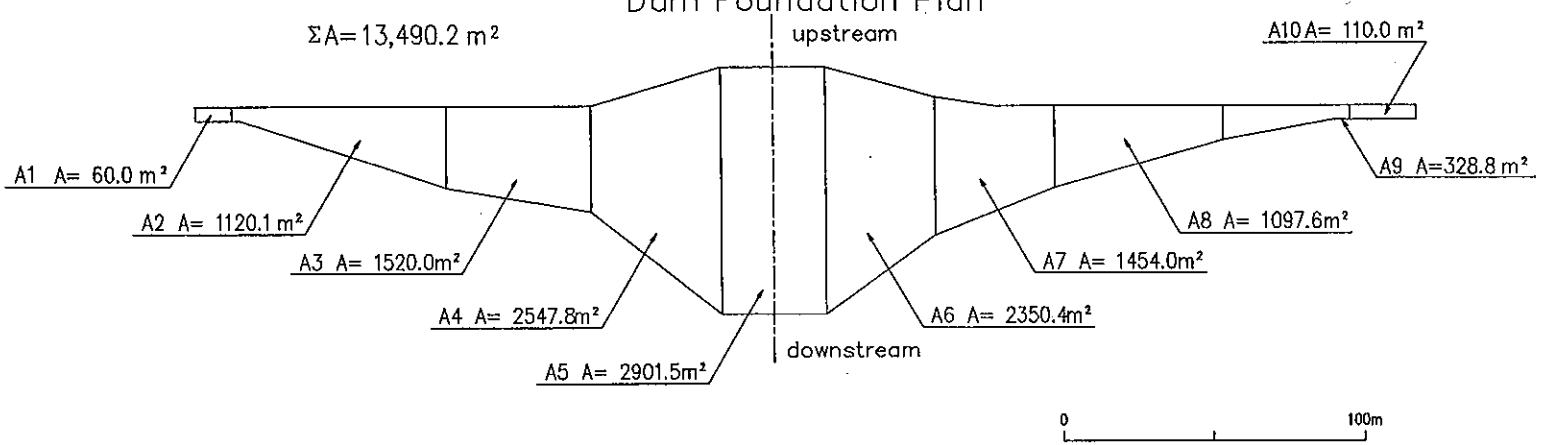
Curtain Grouting Pattern



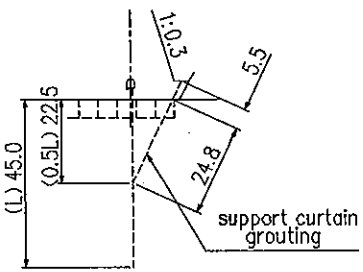
Consolidation Grouting Pattern



Dam Foundation Plan



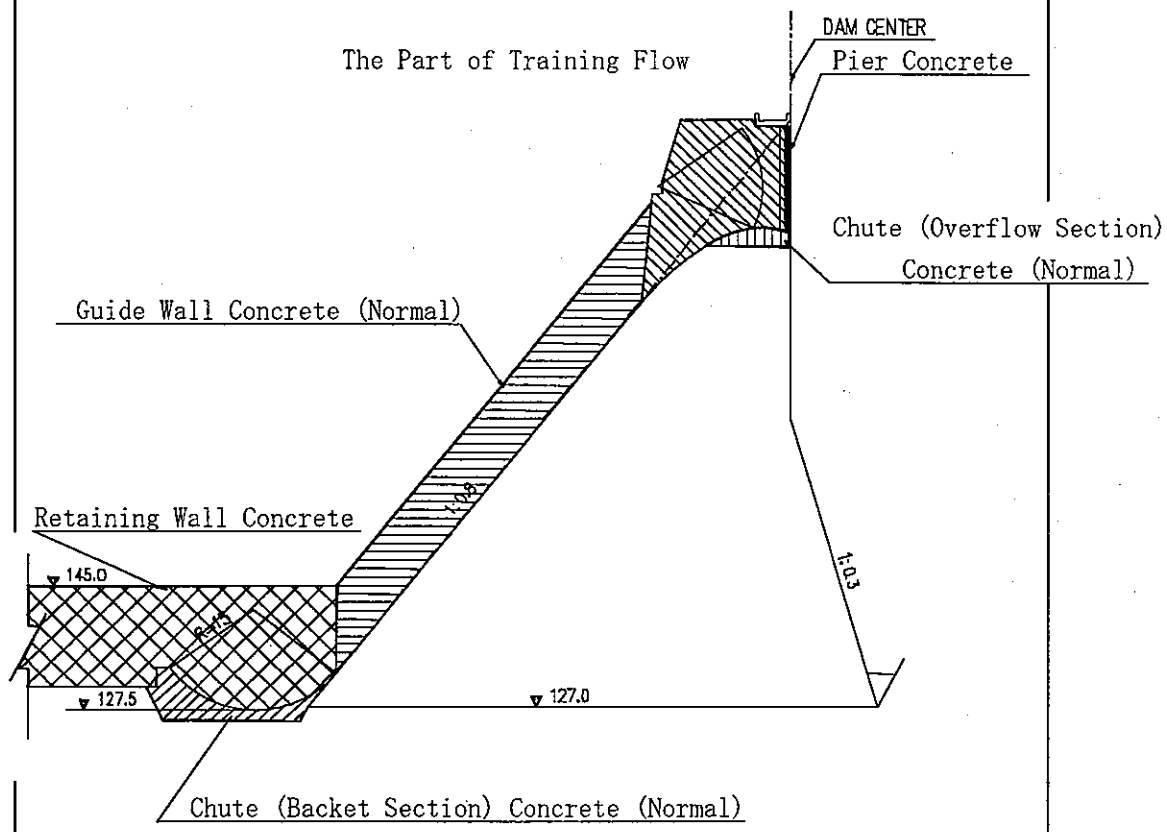
Support Curtain Grouting



b) Spillway

Type of works	Calculation	Quantity

[The Section of Quantity]



<Structural Concrete>

(1) Pier Concrete (Normal)

[Reference Drawing] Spillway, Calculation of pier concrete volume (1), (2)

1)Pier 1, Pier 6

Sectional area $a1 = 216.9\ m^2$

Thickness $t1 = 4.0\ m$

$V1 = 216.9 \times 4.0 = 867.6\ m^3$

2)Pier 2～5

Sectional area $a2 = 352.2\ m^2$

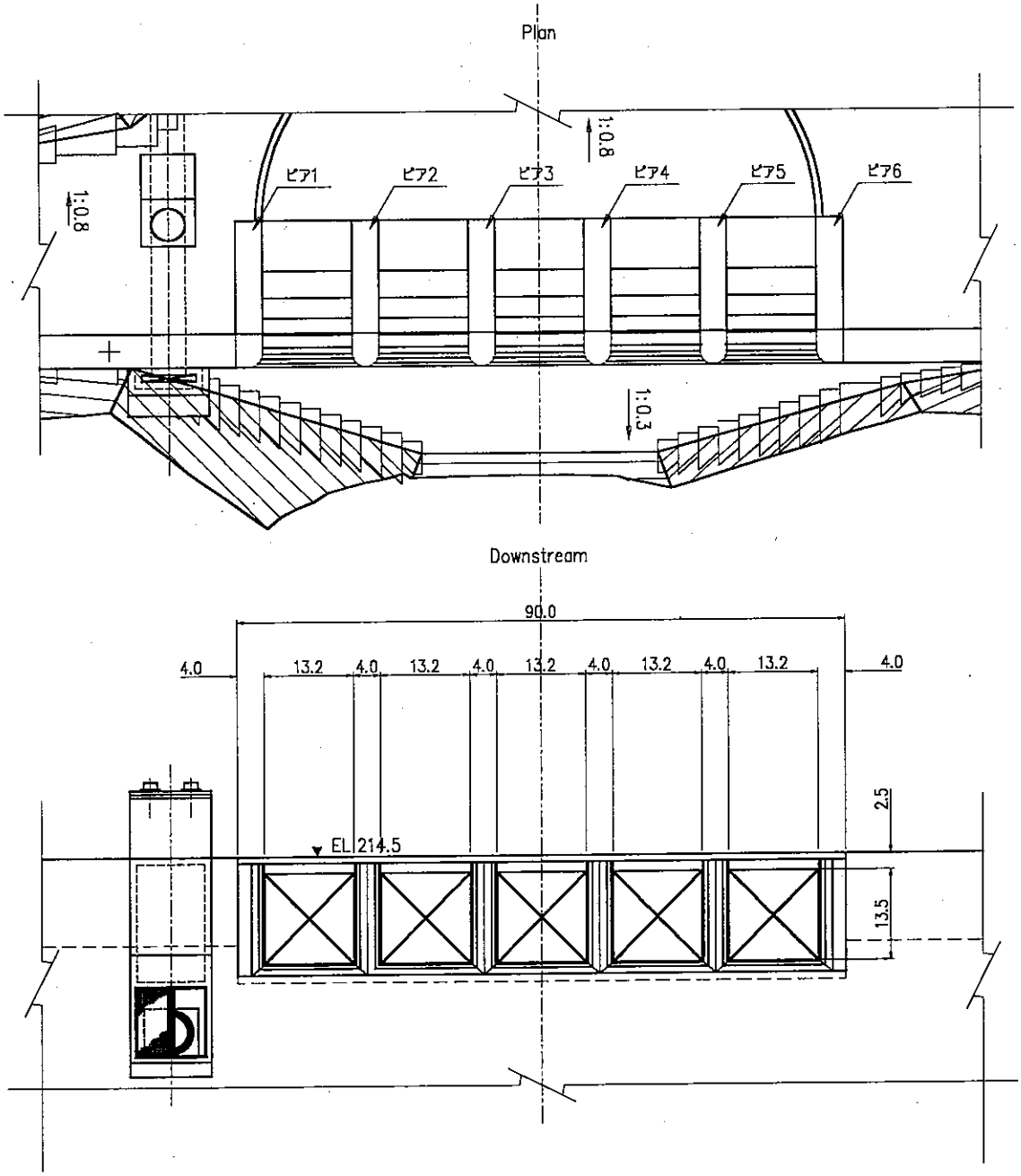
Thickness $t2 = 4.0\ m$

$V2 = 352.2 \times 4.0 = 1,408.8\ m^3$

$\therefore \Sigma V = V1 \times 2 + V2 \times 4$

$867.6 \times 2 + 1,408.8 \times 4 = 7,370.4\ m^3$ — $7,370.4\ m^3$

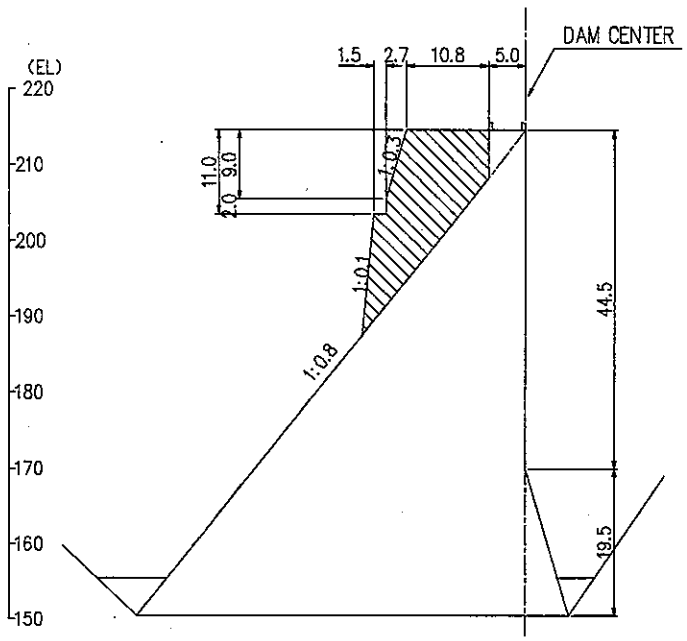
786



0 50m

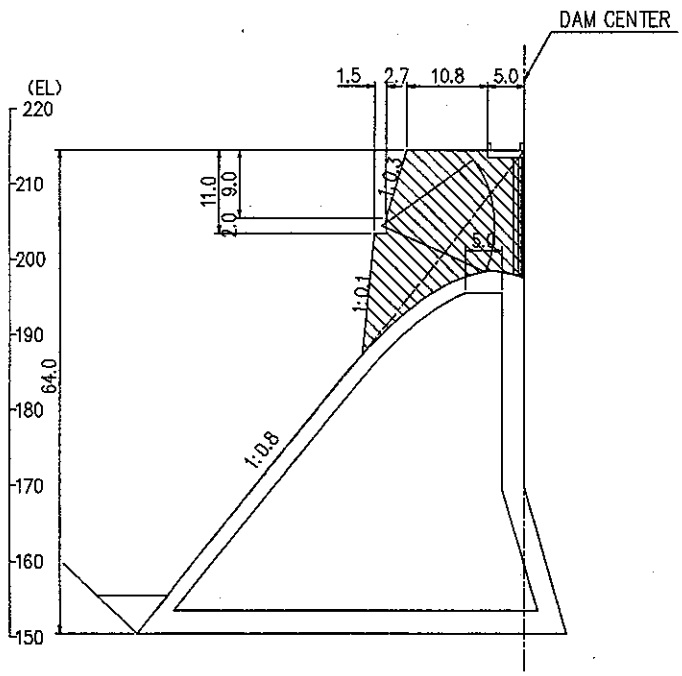
Spillway Pier Concrete (1)

Pier1、Pier6 Section



A=216.9m2

Pier2~5 Section



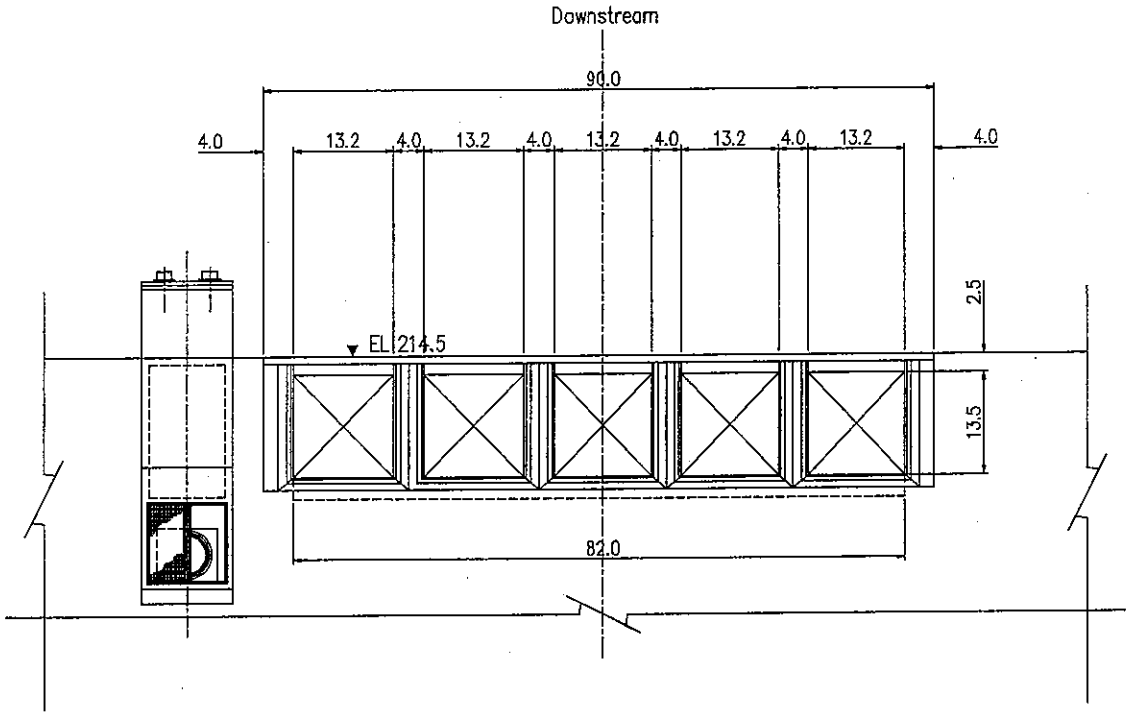
A=352.2m2

0 50m

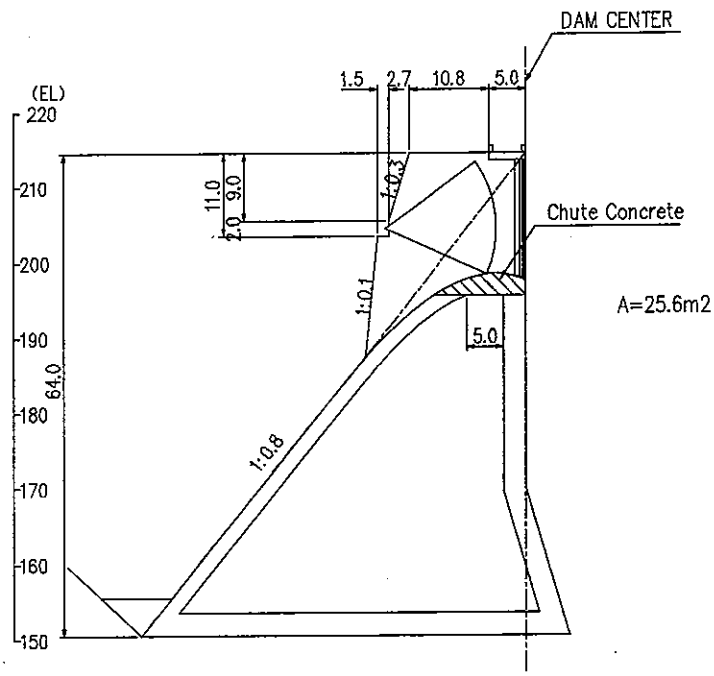
Spillway Pier Concrete (2)

Type of works	Calculation	Quantity
(2) Chute (overflow section) concrete (normal)	[Reference Drawing] Spillway, Calculation of chute (overflow section) concrete (normal) volume Sectional area a = 25.6 m^2 Length l = 82.0 m V= 25.6 × 82.0 = 2,099.2 m^3	2,099.2 m^3
(3) Chute (bucket section) concrete (normal)	[Reference Drawing] Spillway, Calculation of chute (bucket section) concrete (normal) volume Sectional area a = 77.7 m^2 Length l = 38.0 m V= 77.7 × 38.0 = 2,952.6 m^3	2,952.6 m^3
(4) Guide wall concrete	[Reference Drawing] Spillway, Calculation of guide wall concrete volume (1), (2) 1)Guide wall concrete of overflow spillway Sectional area a2= 25.6m^2 (Retaining wall concrete of overflow, section B- Length(left bank side) l1 = 50.8 m (plane length) Length(right bank side) l2 = 50.8 m (plane length) V1 = 25.6 × 50.8 + 25.6 × 50.8 = 2,601.0 m^3 2)Retaining wall concrete (standard position) Sectional area(standard position) a2= 53.0m^2 (Retaining wall concrete, standard position) Length(left bank side) l3 = 31.4 m Length(right bank side) l4 = 73.7 m Length(right bank side) l5 = 15.5 m V2 =53.0×31.4 + 53.0×73.7 + (53.0+0.0)／2×15.5= 5,981.1 m^3	

Type of works	Calculation		Quantity
	3) Retaining wall concrete (powerhouse position)		
	Sectional area (powerhouse position) a3 = 42.5 m^2		
	(Retaining wall concrete, standard position)		
	Length (left bank side) l6 = 46.3 m		
	V3 = 42.5 × 46.3	= 1,967.8 m^3	
	$\Sigma V_{1\sim3}$ =		10,549.9 m^3
(5)	Total of structural concrete		
	V = 7,370.4 + 2,099.2 + 2,952.6 + 10,549.9		22,972.1 m^3
<Reinforced Bar>			
	1) Reinforced bar of pier concrete		
	W1 = 7,370.4 × 30 kg/m^3	= 221.1 t	
	2) Reinforced bar of chute (overflow section) concrete		
	W2 = 2,099.2 × 20 kg/m^3	= 42.0 t	
	3) Reinforced bar of chute (bucket section) concrete		
	W3 = 2,952.6 × 20 kg/m^3	= 59.1 t	
	4) Reinforced bar of guide wall concrete		
	W4 = 10,549.9 × 30 kg/m^3	= 316.5 t	
	$\Sigma W_{1\sim4}$ =		638.7 t

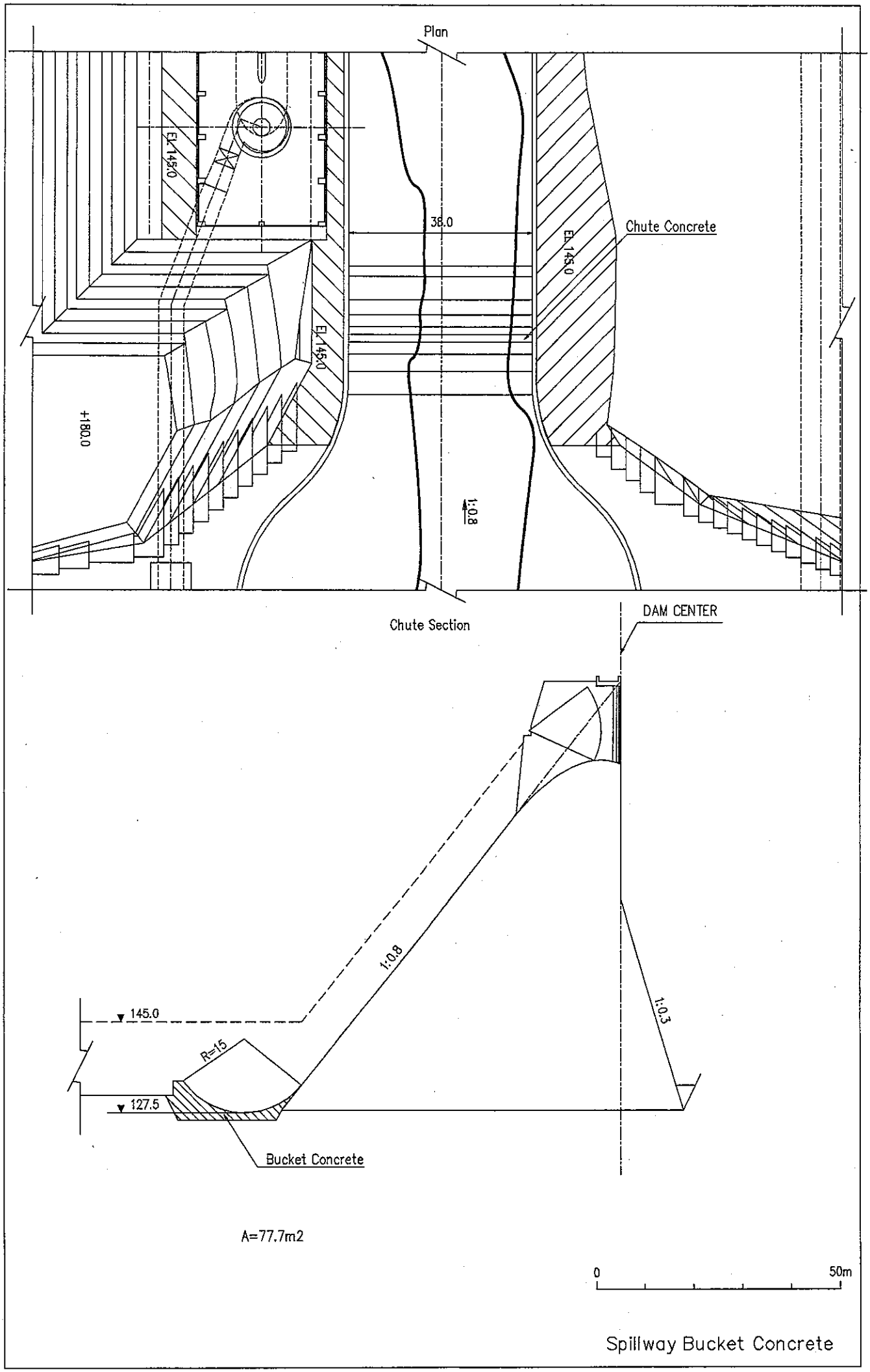


Chute Section



0 50m

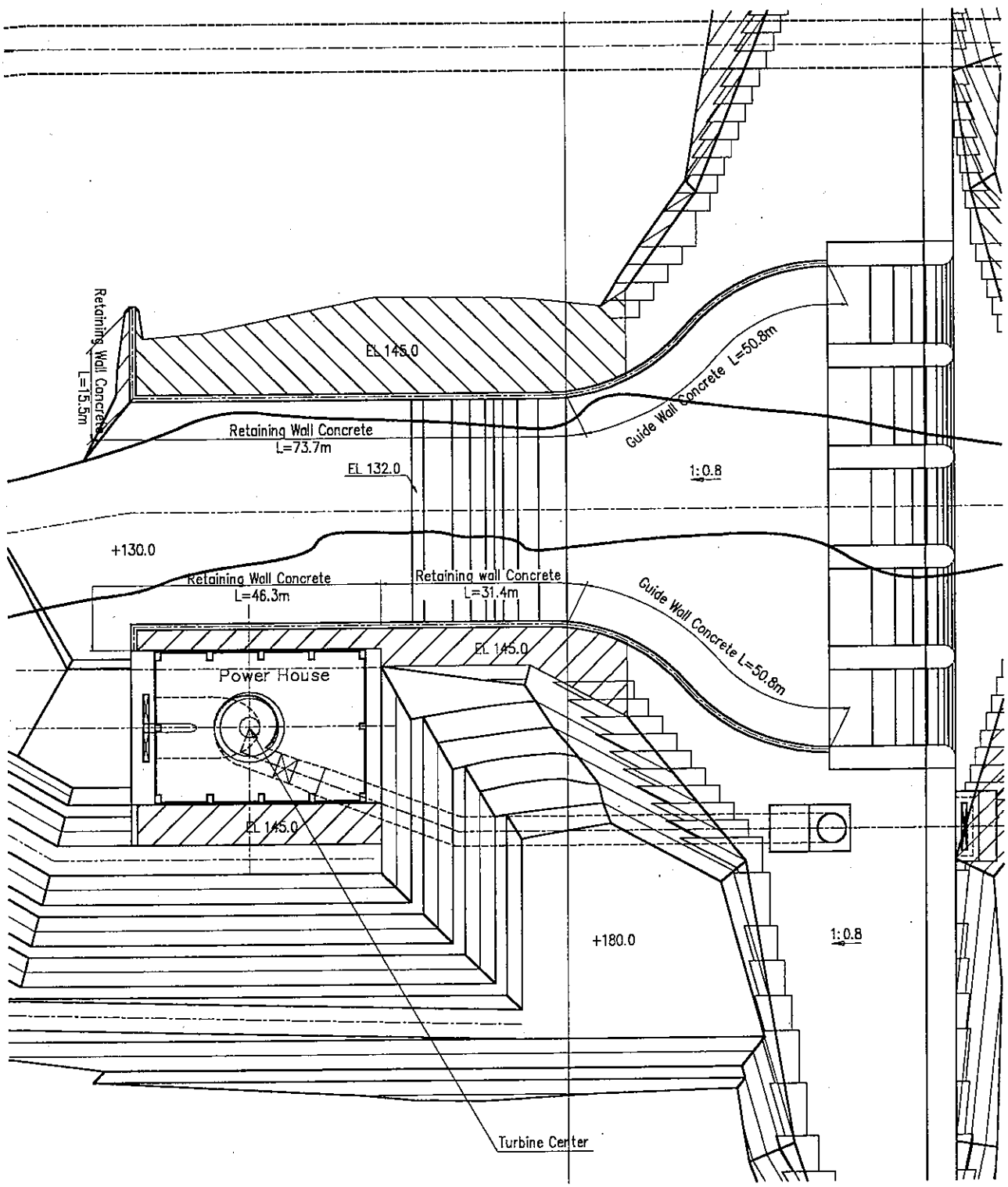
Spillway Chute Concrete



Spillway Bucket Concrete

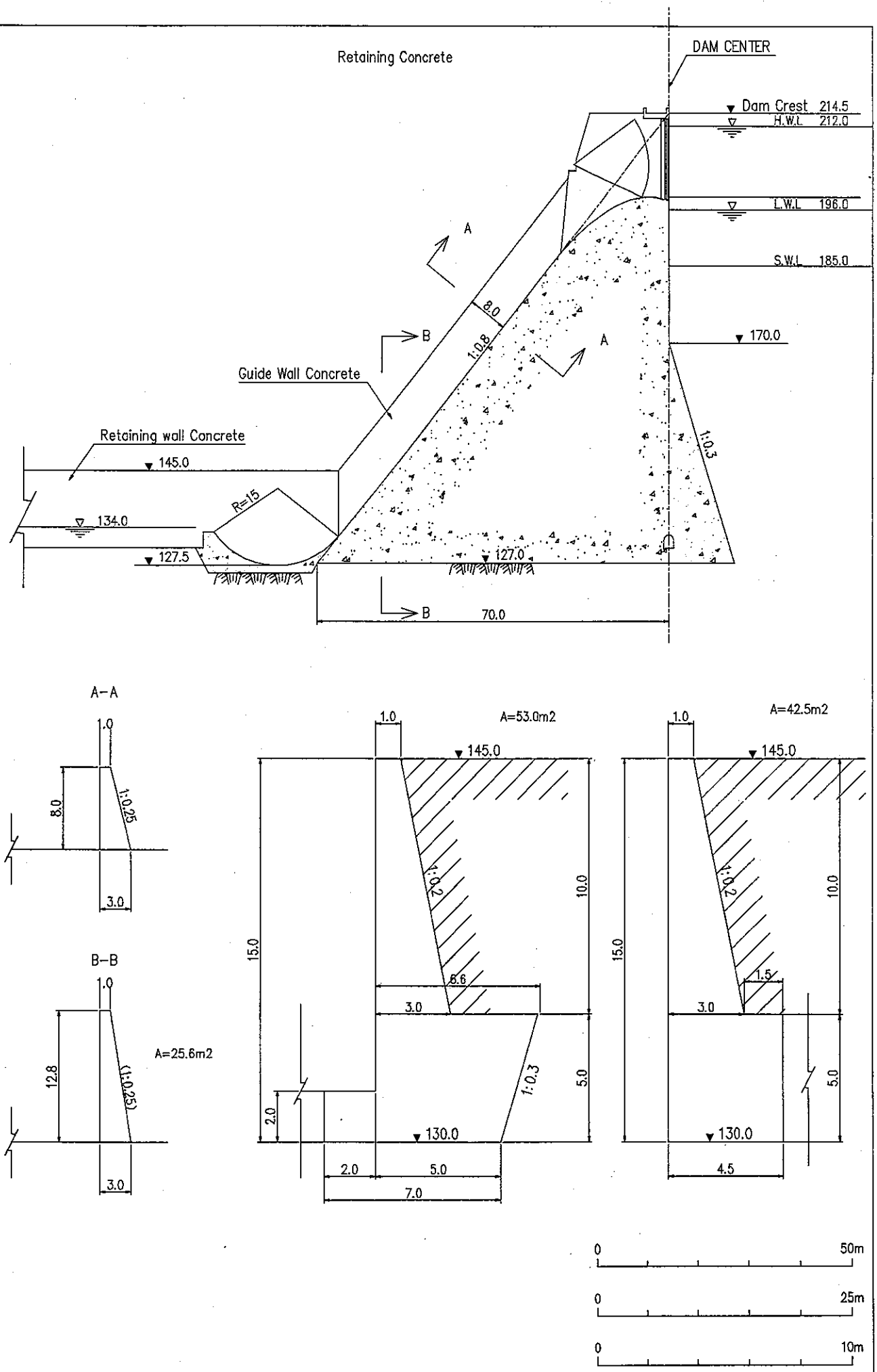
792

Spillway Stilling Basin



0 50m

Spillway Retaining Concrete (1)



Spillway Retaining Concrete (2)

794

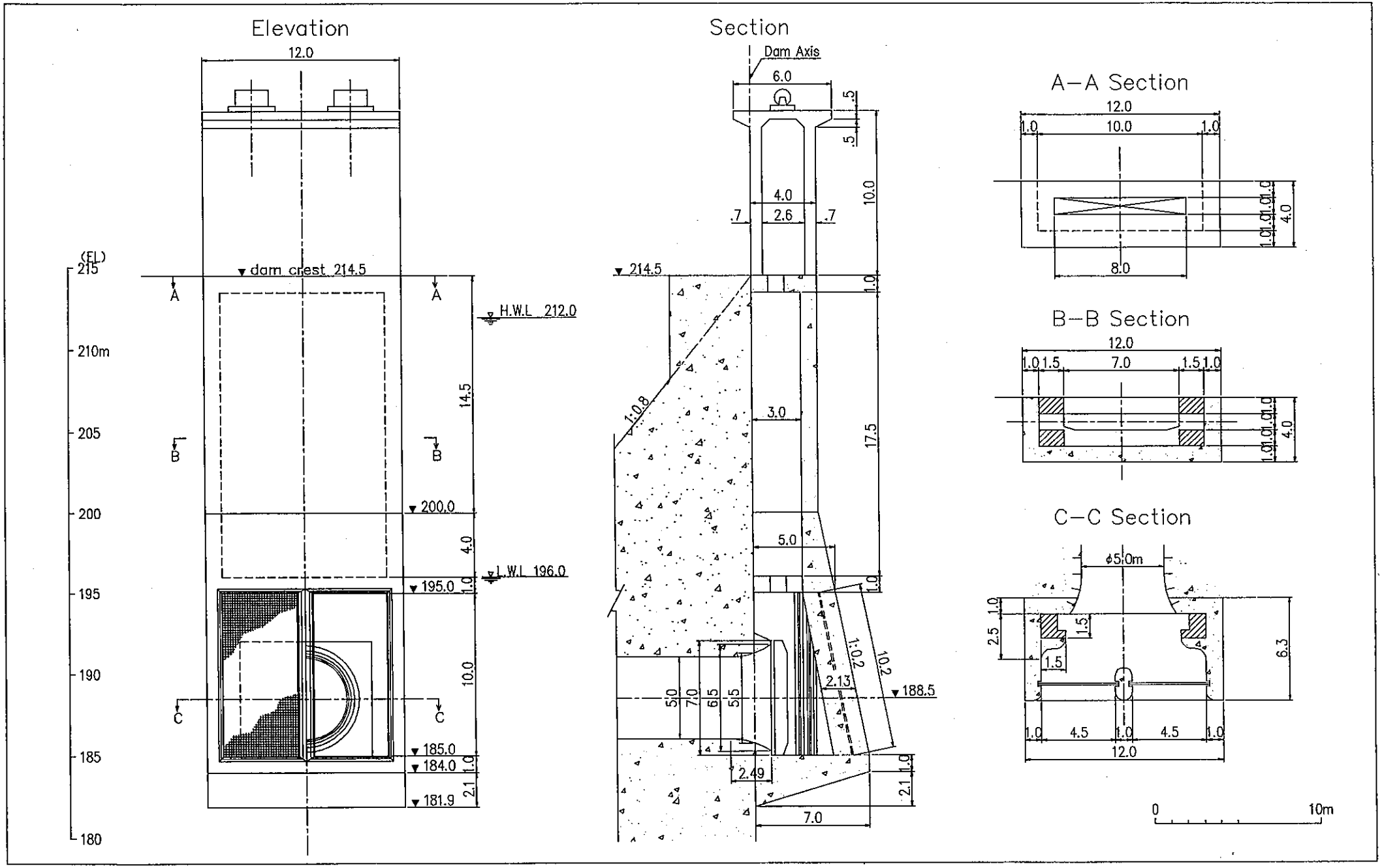
(3) Water Way

a) Intake

Type of Works	Calculation	Quantity
<Structural Concrete>		
1) True form of intake (under EL214.5m)		
All volume		
	$A = 4.0 \times 14.5 + (4.0 + 7.0) \times 1/2 \times 15.0$	
	$+ 7.0 \times 1.0 + 7.0 \times 2.1 \times 1/2$	
	$= 154.9\ m^2$	
	$V = 154.9 \times 12.0 = 1,858.8\ m^3$	
Subtraction part		
	$V_① = 1.0 \times 1.0 \times 8.0 = 8.0\ m^3$	
	$V_② = 3.0 \times 10.0 \times 17.5 = 525.0\ m^3$	
	$V_③ = 1.0 \times 1.0 \times 8.0 = 8.0\ m^3$	
	$V_④ = (5.0 \times 10.0 + 7.0 \times 10.0) \times 1/2 \times 10.0 = 600.0\ m^3$	
	$\Sigma V = V_① \sim V_④ = 1,141.0\ m^3$	
Additional part		
Pier of screen		
	$V_① = 2.13 \times 1.00 \times 10.0 = 21.3\ m^3$	
Seconddary concrete		
	$V_② = 1.5 \times 1.00 \times 4ヶ \times 17.5 = 105.0\ m^3$	
	$V_③ = (1.5 + 2.5) \times 1/2 \times 1.5 \times 2ヶ \times 10.0 = 60.0\ m^3$	
Entrance of penstock		
	$V_④ = 7.0 \times 10.0 \times 1.0 - \pi/4 \times (6.5^2+5.5^2) \times 1/2 \times 1.0 = 41.5\ m^3$	
	$\Sigma V = V_① \sim V_④ = 227.8\ m^3$	
Total volume of true form of intake		
	$V_C = 1858.8 - 1141.0 + 227.8 = 945.6\ m^3$	

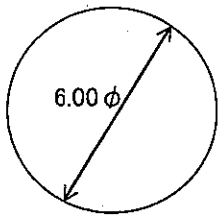
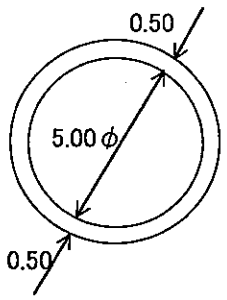
795

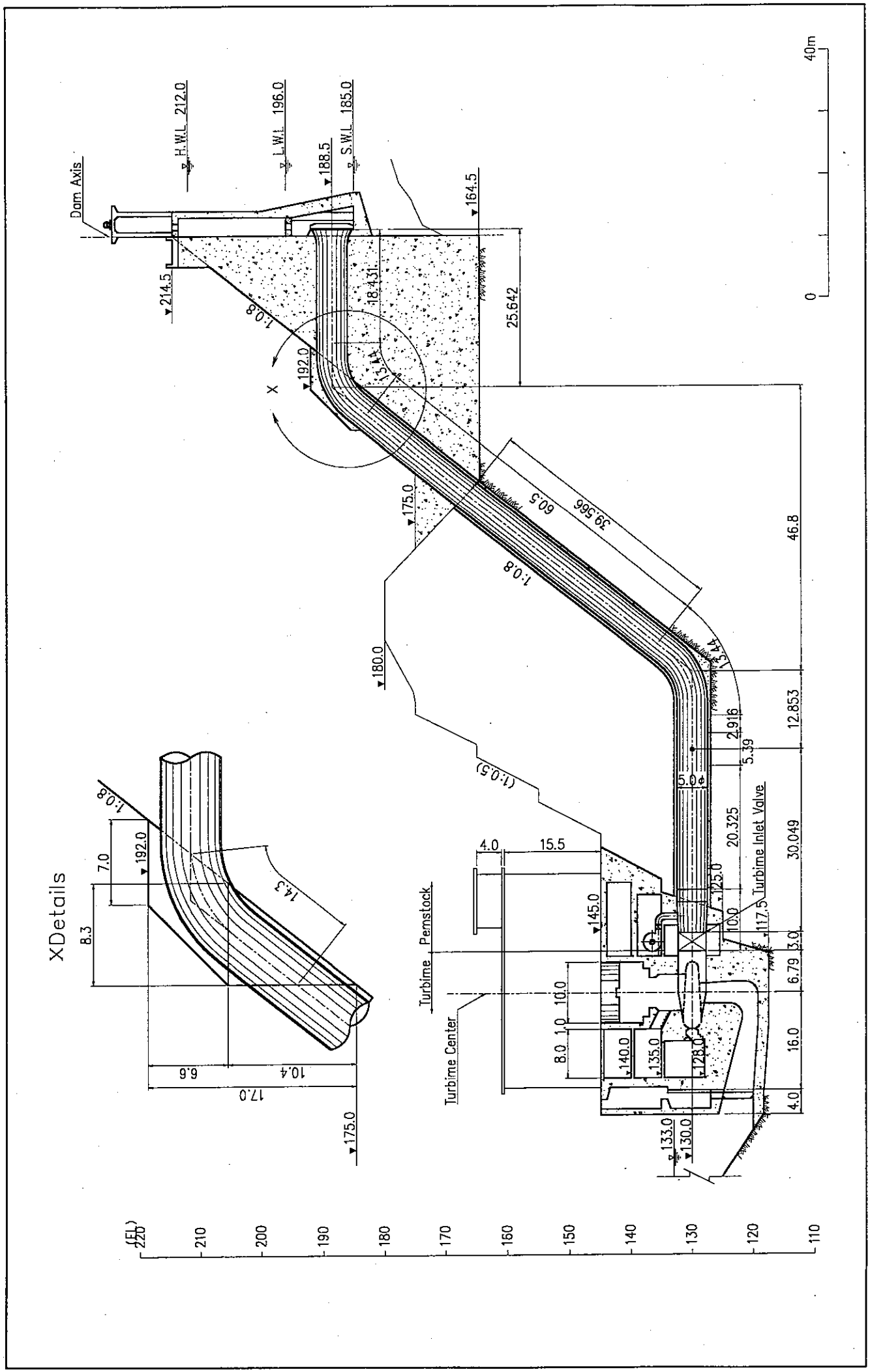
Type of Works	Calculation	Quantity
	2)Pier concrete	
	$A = 6.0 \times 0.5 + (2.2 + 0.7) / 2 \times 0.5 \times 2 + 0.7 \times 9.0 \times 2$	
	$= 3.0 + 1.5 + 12.6 = 17.1\ m^2$	
	$V_C = 17.1 \times 12.0 = 205.2\ m^3$	
	3)Total volume of intake concrete	
	$V = 945.6 + 205.2 =$	$1,150.8\ m^3$
<Reinforced Bar>		
	$W = 1,150.8 \times 50.0\ kg/m^3 = 57,540.0\ kg = 57.5\ t$	57.5 t


Elevation
12.0
(EL)
215
210m
205
200
195
190
185
180
dam crest 214.5
H.W.L 212.0
L.W.L 196.0
200.0
195.0
185.0
184.0
181.9
14.5
4.0
1.0
10.0
2.1
A
B
C
Section
Dam Axis
6.0
.5
.5
4.0
2.6
.7
.7
10.0
214.5
1.0
3.0
17.5
1:0.8
5.0
1.0
1:0.2
10.0
2.13
188.5
5.0
7.0
6.5
5.5
2.49
2.1
1.0
7.0
A–A Section
12.0
1.0
10.0
1.0
1.0 1.0 1.0
4.0
8.0
B–B Section
12.0
1.0 1.5
7.0
1.5 1.0
1.0 1.0 1.0
4.0
C–C Section
ϕ5.0m
1.0
2.5
1.5
1.5
6.3
1.0
4.5
1.0
4.5
1.0
12.0
0
10m

12-3-75

b) Penstock

Type of works	Calculation	Quantity
<Tunnel Excavation>		
	L = 39.566 + 13.44 + 2.916 + 5.39 + 20.325 + 2.0 = 83.637 m	
	A = π/4 × 6.00² = 28.274 m²	
	Ve = 83.637 × 28.274 = 2,364.8 m³  =	2,364.8 m³
<Filling Concrete>		
	Ac = π/4 (6.00² − 5.00²) = 8.639 m³ 	
	Vc = 8.639 × 83.637 = 722.5 m³ =	722.5 m³
<Structural Concrete>		
	Total volume	
	A = (7.0 + 8.3) × 1/2 × 6.6 + 8.3 × 1/2 × 10.4 = 93.65 m²	
	V = 93.65 × 8.0 = 749.2 m³	
	Deduction of penstock	
	V = π/4 × 5.00² × 14.3 = 280.8 m³	
	Concrete volume	
	Vc = 749.2 − 280.8 =	468.4 m³
<Reinforced Bar>		
	Structural concrete	
	W = 468.4 × 30 kg/m³ =	14.1 t


Dam Axis
H.W.L 212.0
L.W.L 196.0
S.W.L 185.0
214.5
188.5
164.5
192.0
175.0
180.0
1:0.8
18.431
25.642
39.566
60.5
46.8
12.853
2.916
5.39
5.0ϕ
20.325
30.049
6.79
3.0
16.0
4.0
4.0
15.5
125.0
117.5 Turbime Inlet Valve
10.0
145.0
140.0
135.0
128.0
133.0
130.0
8.0
1.0
10.0
Turbime Pemstock
Turbime Center
(1:0.5)
X
XDetails
1:0.8
192.0
7.0
8.3
14.3
17.0
10.4
6.6
175.0
0
40m
(EL)
220
210
200
190
180
170
160
150
140
130
120
110

(4) Powerhouse

a) Powerhouse

Type of Works	Calculation	Quantity

<Common Excavation and Rock Excavation>

Total excavation volume (power station side)

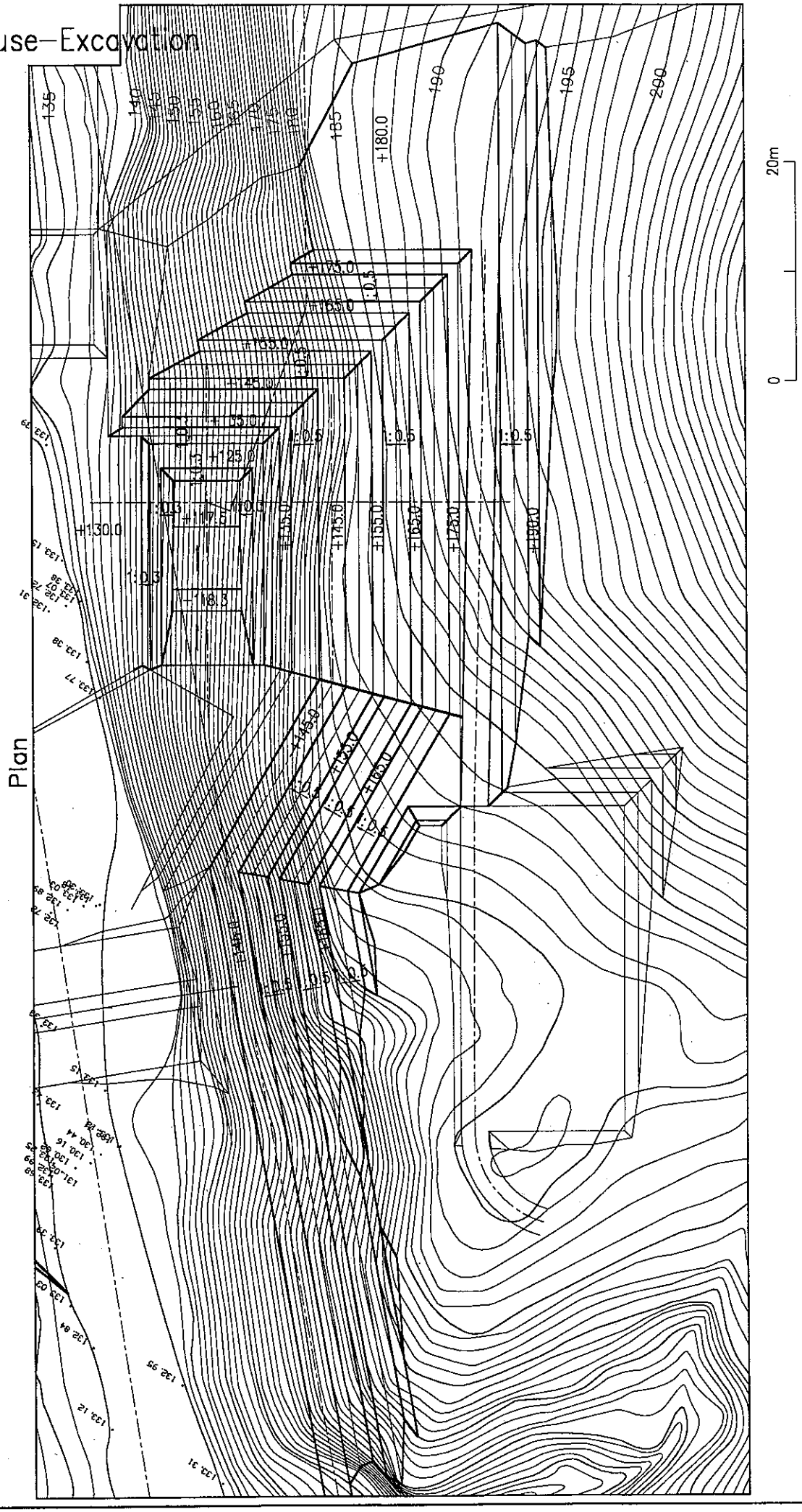
Elevation (m)	Head (m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
EL117.5		102.0				
EL118.3	0.8	250.0	176.0	140.8	140.8	
EL118.3	0.0	300.0	275.0	0.0	140.8	
EL125.0	6.7	597.0	448.5	3,005.0	3,145.8	
EL125.0	0.0	835.6	716.3	0.0	3,145.8	
EL130.0	5.0	994.5	915.1	4,575.3	7,721.0	
EL130.0	0.0	1,058.5	1,026.5	0.0	7,721.0	
EL135.0	5.0	1,166.9	1,112.7	5,563.5	13,284.5	
EL135.0	0.0	1,317.5	1,242.2	0.0	13,284.5	
EL145.0	10.0	1,578.0	1,447.8	14,477.5	27,762.0	
EL145.0	0.0	1,919.6	1,748.8	0.0	27,762.0	
EL155.0	10.0	1,871.7	1,895.7	18,956.5	46,718.5	
EL155.0	0.0	2,065.6	1,968.7	0.0	46,718.5	
EL165.0	10.0	1,974.5	2,020.1	20,200.5	66,919.0	
EL165.0	0.0	2,182.9	2,078.7	0.0	66,919.0	
EL175.0	10.0	2,074.4	2,128.7	21,286.5	88,205.5	
EL175.0	0.0	2,298.0	2,186.2	0.0	88,205.5	
EL180.0	5.0	2,129.1	2,213.6	11,067.8	99,273.3	
EL180.0	0.0	3,869.2	2,999.2	0.0	99,273.3	
EL190.0	10.0	1,473.2	2,671.2	26,712.0	125,985.3	
EL190.0	0.0	1,692.2	1,582.7	0.0	125,985.3	
EL196.0	6.0	0.0	1,032.8	6,196.8	132,182.1	

Total excavation volume (outlet side, over EL145.0 m)

Elevation	Head (m)	Sectional Area (m^2)	Mean Area (m^2)	Volume (m^3)	Total Volume (m^3)	Notes
EL145.0	0.0	1,981.2				
EL155.0	10.0	1,406.8	1,694.0	16,940.0	16,940.0	
EL155.0	0.0	1,704.7	1,555.8	0.0	16,940.0	
EL165.0	10.0	1,097.6	1,401.2	14,011.5	30,951.5	
EL165.0	0.0	1,353.8	1,225.7	0.0	30,951.5	
EL175.0	10.0	768.1	1,061.0	10,609.5	41,561.0	
EL175.0	0.0	963.3	865.7	0.0	41,561.0	
EL180.0	5.0	629.5	796.4	3,982.0	45,543.0	
EL185.0	5.0	0.0	314.8	1,573.8	47,116.8	

Type of Works	Calculation	Quantity
	Total excavation volume Total excavation volume (power station side) V1 = 132,182.1 m^3 Total excavation volume (outlet side, over EL145.0 m) V2 = 47,116.8 m^3 Total excavation volume ΣV = 179,298.8 m^3 Estimated Ratio··(Common Excavation) : (Rock Excavation) = 2 : 8	
(1) Common Excavation	V = 179,298.8 × 0.2 =	35,859.8 m^3
(2) Rock Excavation	V = 179,298.8 × 0.8 =	143,439.0 m^3

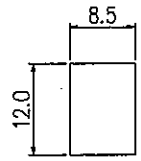
Powerhouse–Excavation



Powerhouse—Excavation

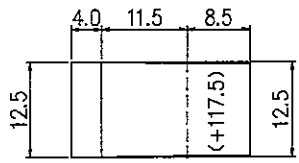
Slice

EL 117.5



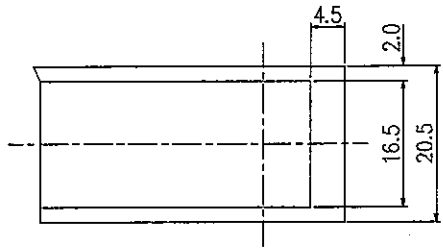
EL 117.5 A= 102.0 m²

EL 118.3



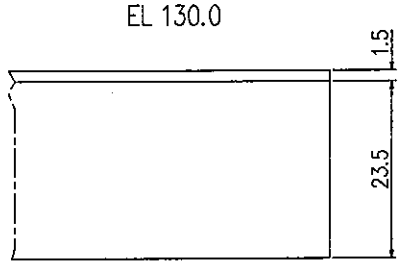
EL 118.3 A= 300.0m²
EL 118.3 A= 250.0m²

EL 125.0



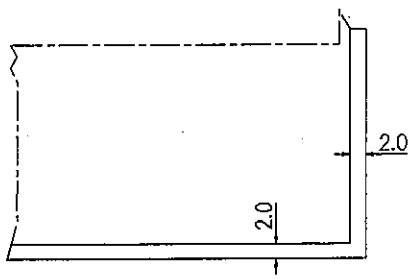
EL 125.0 A= 835.6m²
EL 125.0 A= 597.0m²

EL 130.0



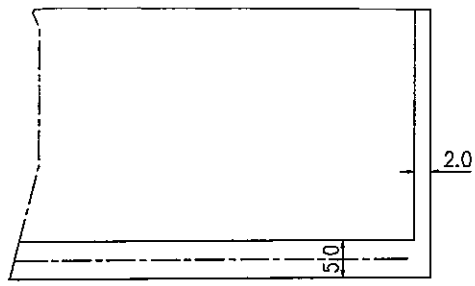
EL 130.0 A= 1,058.5 m²
EL 130.0 A= 994.5 m²

EL 135.0



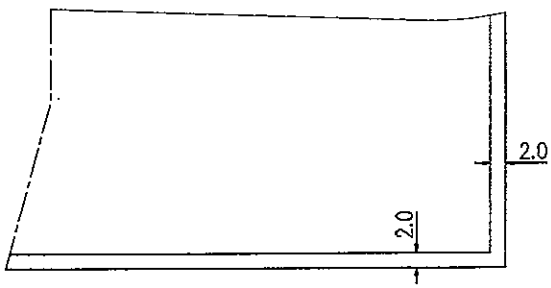
EL 135.0 A= 1,317.5 m²
EL 135.0 A= 1,166.9 m²

EL 145.0



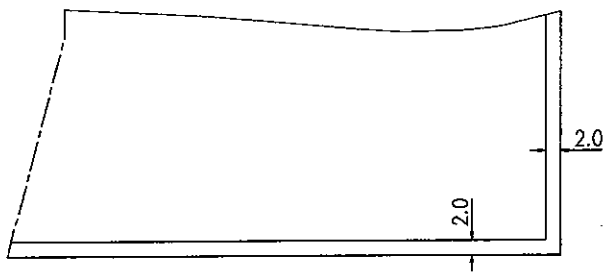
EL 145.0 A= 1,919.6 m²
EL 145.0 A= 1,578.0m²

EL 155.0



EL 155.0 A= 2,065.6m²
EL 155.0 A= 1,871.7 m²

EL 165.0



EL 165.0 A= 2,182.9m²
EL 165.0 A= 1,974.5m²

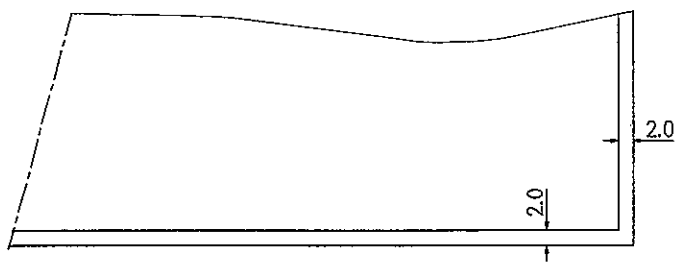
0 40m

803

Powerhouse—Excavation

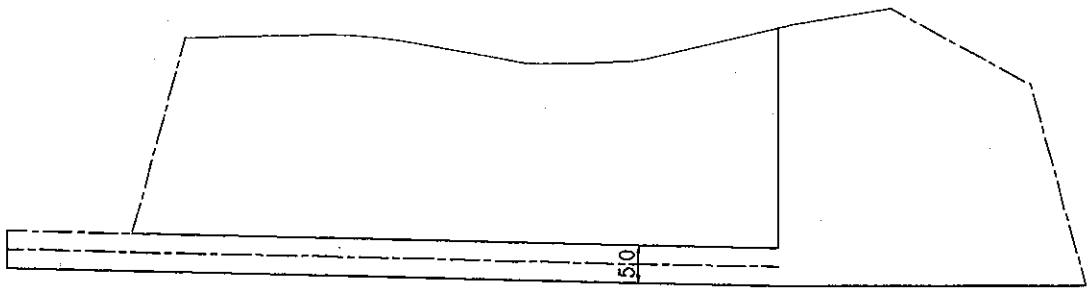
Slice

EL 175.0



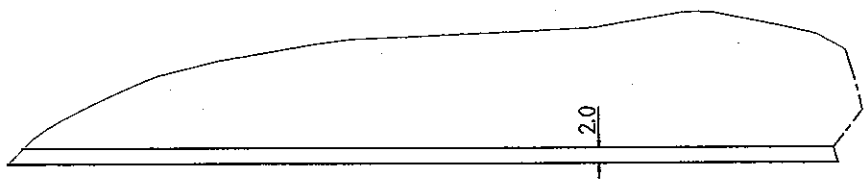
EL 175.0 A= 2,298.0 m²
EL 175.0 A= 2,074.4 m²

EL 180.0



EL 180.0 A= 3,869.2m²
EL 180.0 A= 2,129.1 m²

EL 190.0



EL 190.0 A= 1,692.2m²
EL 190.0 A= 1,473.2m²

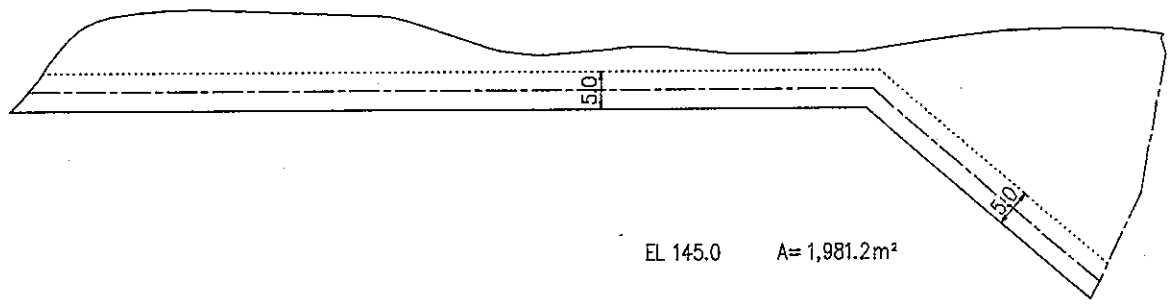
0 40m

E04.

Powerhouse—Excavation

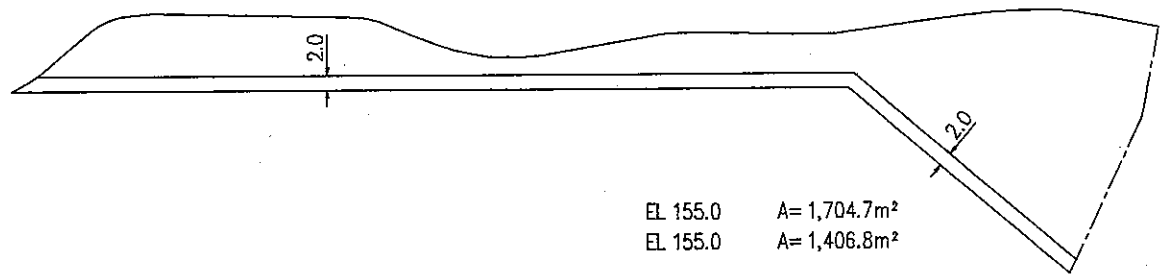
Slice

EL 145.0



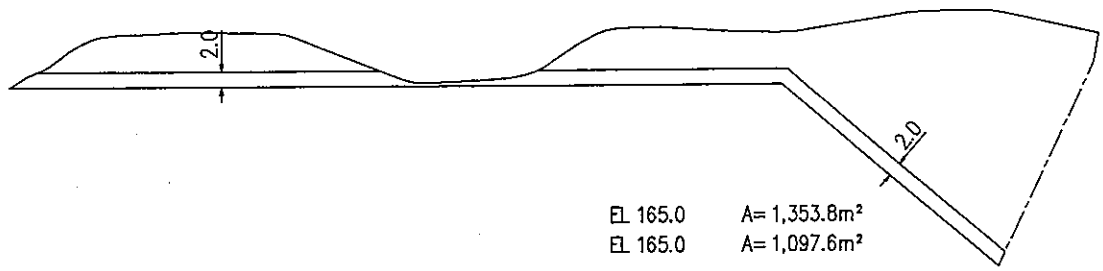
EL 145.0 A= 1,981.2m²

EL 155.0



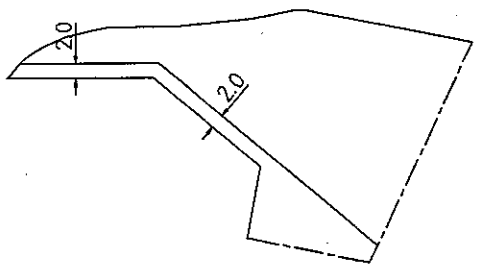
EL 155.0 A= 1,704.7m²
EL 155.0 A= 1,406.8m²

EL 165.0



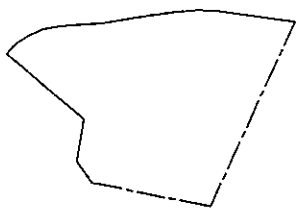
EL 165.0 A= 1,353.8m²
EL 165.0 A= 1,097.6m²

EL 175.0

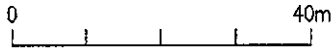


EL 175.0 A= 963.3m²
EL 175.0 A= 768.1m²

EL 180.0



EL 180.0 A= 629.5m²



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