

THE PREPARATORY SURVEY  
ON  
EXPANSION OF NAM NGUM 1 HYDROPOWER STATION  
IN  
LAO PEOPLE'S DEMOCRATIC REPUBLIC  
**FINAL REPORT**

Appendices

Appendix F Dam Stability Analysis

Appendix F-1 Dam Stability Analysis

Appendix F-2 Figures of Load Condition

Appendix F-3 Calculations of Load

THE PREPARATORY SURVEY  
ON  
EXPANSION OF NAM NGUM 1 HYDROPOWER STATION  
IN  
LAO PEOPLE'S DEMOCRATIC REPUBLIC  
**DRAFT FINAL REPORT**

Appendices

Appendix F-1 Dam Stability Analysis

## 1. Analysis case and load conditions

The stress and stability analysis of the dam was made for NO.20 and NO.11 section, assuming the following three different stages and four different load conditions. In case of “StageB during construction”, stability analysis was not made for load condition “Case II Unusual\_Flood” and “CaseIV Extreme\_Earthquake” .

The load condition case for each analysis is shown in **Table C.1.1**. The study case and condition is shown in **Table C.1.2**.

[Stage]

- Stage A current condition
- Stage B during construction
- Stage C after completion

[Load condition]

- Case I Usual\_
- Case II Unusual Flood
- CaseIII Unusual Earthquake(k=0.061 for OBE)
- CaseIV Extreme Earthquake(k=0.215 for MCE)

**Table C.1.1 Case of Load Condition for each analysis**

Load Condition			Stage A	Stage B	Stage C
			Current Condition	During Construction	After Completion
Case I	Usual		Load A- I	Load B- I	Load C- I
Case II	Unusual	Flood	Load A- II	—	Load C- II
CaseIII		Earthquake (k=0.061) OBE	Load A-III	Load B-III	Load C-III
CaseIV	Extreme	Earthquake (k=0.215) MCE	Load A-IV	—	Load C-IV

**Table C.1.2 Analysis Case and Condition**

Items	Alternatives				Optimum Plan
	Case1.1	Case1.2	Case1.3	Case1.4	Case2
Section	NO.11	NO.20	NO.11	NO.20	NO.20
Additional Unit Capacity	40 MW	40MW	60 MW	60MW	40MW
Support of Enclosure	Pedestal concrete				Steel girder
Restriction of Upper Limit Water Level	No restriction				EL.207m 3.5 months

## 2. Principal feature of NO.11 and NO.20 section

The dimensions of NO.11 and NO.20 section, surrounding water and silt conditions are shown in **Table C.2.1**. Principal feature of the steel enclosure is shown in **Table C.2.2**.

**Table C.2.1 Principal Feature of NO.11 and NO.20 Section**

Items	Dimensions	
	No.11	No.20
Dam crest elevation	EL.215.0m	
Bedrock elevation	EL.166.0 m	EL.161.0 m
Height of dam	49 m	54 m
Base Length	37.03 m	41.38 m
Upstream slope of dam	Vertical above EL.175.0 m 1 to 0.2 below EL.175.0 m	
Downstream slope of dam	1 to 0.67	
Normal high water level	EL.212.0 m	
Flood water level	EL.215.0 m	
Silt surface level	EL.180.0 m	
Normal tail water level	EL.166.9 m	
Flood tail water level	EL.176.4 m	

**Table C.2.2 Principal Feature of Steel Enclosure**

Items		Alternatives				Optimum Plan
		Case1.1 40MW NO.11	Case1.2 40MW NO.20	Case1.3 60MW NO.11	Case1.4 60MW NO.20	Case2 40MW NO.20
Shape		Square type				
Support		Pedestal concrete			Steel girder	
Inside Dimensions	Width	12m		13m		11.5m
	Length	4m		4m		4m
	Height	32m		32.7m		29m
Weight of Steel Enclosure		820t	870t	930t	980t	580t
Volume of Pedestal Concrete		1,050m <sup>3</sup>	1,300 m <sup>3</sup>	1,250 m <sup>3</sup>	1,630 m <sup>3</sup>	—

※Restriction of upper limit water level EL.207m is needed in Case2

### 3. Load combination

Load combination in each load condition case is shown in **Table C.3.1~C.3.3**.

**Table C.3.1 Load Combination (Stage A : Current condition)**

Load condition		Loads to be considered									
		Self-weight of dam	Water pressure	Silt pressure	Uplift pressure	Inertia force	Hydro-dynamic pressure	Self-weight decrease due to piercing	Weight of enclosure	Buoyancy of dewatered enclosure	Weight of pedestal concrete
Load A-I	Usual	X	X	X	X						
Load A-II	Unusual	Flood	X	X	X	X					
Load A-III		Earthquake (k=0.061)	X	X	X	X	X	X			
Load A-IV	Extreme	Earthquake (k=0.215)	X	X	X	X	X	X			

※1 Considered load is checked by mark "X"

**Table C.3.2 Load Combination (Stage B : Current condition)**

Load condition		Loads to be considered									
		Self-weight of dam	Water pressure	Silt pressure	Uplift pressure	Inertia force	Hydro-dynamic pressure	Self-weight decrease due to piercing	Weight of enclosure	Buoyancy of dewatered enclosure	Weight of pedestal concrete
Load B-I	Usual	X	X		X			X	X	X	X
—	Unusual	Flood									
Load B-III		Earthquake (k=0.061)	X	X		X	X	X	X	X	X
—	Extreme	Earthquake (k=0.215)									

※1 Considered load is checked by mark "X"

**Table C.3.3 Load Combination (Stage C : Current condition)**

Load condition		Loads to be considered									
		Self-weight of dam	Water pressure	Silt pressure	Uplift pressure	Inertia force	Hydro-dynamic pressure	Self-weight decrease due to piercing	Weight of enclosure	Buoyancy of dewatered enclosure	Weight of pedestal concrete
Load C-I	Usual	X	X	X	X			X			X
Load C-II	Unusual	Flood	X	X	X	X		X			X
Load C-III		Earthquake (k=0.061)	X	X	X	X	X	X	X		X
Load C-IV	Extreme	Earthquake (k=0.215)	X	X	X	X	X	X			X

※1 Considered load is checked by mark "X"

#### 4. Formulas for calculation of the loads

The loads for each case are calculated by the following formulas.

- 1) Hydrostatic pressure :  $P_w$

$$P_w = \frac{1}{2} \times w_0 \times h^2$$

where  $w_0$  : unit weight of water, 1.0t/m<sup>3</sup>  
 $h$  : water depth in meters

In load condition Case I and Case II, half height of possible maximum wave of 0.9m is added to the water depth.

- 2) Silt pressure :  $P_e$

$$P_w = \frac{1}{2} \times C_e \times W_e \times d^2$$

where  $C_e$  : coefficient of silt pressure, 0.5  
 $d$  : depth of silt deposit in meters  
 $W_e$  : unit weight of silt in water, 0.6t/m<sup>3</sup>

Silt pressure is neglected in Stage B “during construction” of Case1.1~1.4. And silt surface level is EL.170m in Stage B “during construction” of Case2.

- 3) Hydrodynamic pressure :  $P_d$

$$P_d = \frac{7}{12} \times k \times h^2$$

where  $h$  : water depth in meters  
 $k$  : seismic coefficient, 0.061 for OBE  
 0.215 for MCE

The hydrodynamic pressure due to the seismic action is considered only in CaseIII and CaseIV. It is considered on the upstream and downstream side of dam.

- 4) Weight of dam :  $W$

$$W = w_c \times V + W_E$$

where  $w_c$  : unit weight of concrete, 2.33t/m<sup>3</sup>  
 $V$  : Volume of concrete  
 $W_E$  : Weight of steel enclosure etc

Change in weight due to gate work is not considered in Stage C in this analysis.

- 5) Inertia force of dam due to seismic action :  $W_s$

$$W_s = k \times W$$

where  $W$  : weight of dam

k : seismic coefficient, 0.061 for OBE  
0.215 for MCE

Inertia force of dam is considered only in Case III and Case IV.

6) Uplift pressure : U

$$\begin{aligned}
 U &= w_0 \times h_1 && \text{at upstream heel} \\
 &w_0 \times \left( h_2 + \frac{1}{3} (h_1 - h_2) \right) && \text{at drain hole} \\
 &w_0 \times h_2 && \text{at downstream toe}
 \end{aligned}$$

where  $w_0$  : unit weight of water, 1.0t/m<sup>3</sup>  
 $h_1$  : water depth of upstream side  
 $h_2$  : water depth of downstream side

Uplift pressure is not subject to wave action on the reservoir water surface.

## 5. Criteria

Criteria for dam stability is based on Lao Electric Power Technical Standards(2004). In case of Extreme condition, the manual of US Army Corps of Engineers is referred. Criteria for dam stability analysis is shown in **Table C.5.1**.

Overturning, Sliding and stress in the foundation rock are calculated by the following formulas.

(1) Overturning

Resultant location " $x_0$ " and distance of eccentricity " $e$ " are calculated by the following formulas.

$$\begin{aligned}
 x_0 &= \frac{M}{V} \\
 e &= \left| x_0 - \frac{L}{2} \right|
 \end{aligned}$$

where  $x_0$  : resultant location  
 $e$  : distance of eccentricity  
 $M$  : total moment acting on the shear plane per unit width  
 $V$  : total vertical force acting on the shear plane per unit width  
 $L$  : base length

(2) Sliding

Shear friction safety factor " $n$ " is calculated by the following formulas.



$$n = \frac{\tau \times L + f \times V}{H}$$

where

- n : shear friction safety factor
- $\tau$  : sum of the moments
- L : base length
- f : internal friction factor
- V : total vertical force acting on the shear plane per unit width
- H : total horizontal force acting on the shear plane per unit width

### (3) Stress in the foundation rock

Compressive stress in the foundation rock at downstream end “ $P_d$ ” is calculated by the following formulas.

$$P_d = \frac{V}{L} \left( 1 + \frac{6 \cdot e}{L} \right)$$

where

- $P_d$  : sum of the moments
- e : distance of eccentricity
- L : base length
- V : total vertical force acting on the shear plane per unit width

**Table C.5.1 Criteria for Dam Stability Analysis**

Load Condition		Overturning	Sliding	Stress in the Foundation
Usual		Within middle 1/3 ( $e \leq L/6$ )	$n \geq 3.0$	$P_d \leq$ allowable compression stress
Unusual	Flood	Within Middle 1/2 ( $e \leq L/4$ )	$n \geq 2.0$	$P_d \leq$ allowable compression stress
	Earthquake ( $k=0.061$ )			
Extreme	Earthquake ( $k=0.215$ )	Within base <sup>※1</sup> ( $e \leq L/2$ )	$n \geq 1.3$ <sup>※1</sup>	$P_d \leq 1.33 \times$ allowable compression stress <sup>※1</sup>

※1 Based on the manual of US Army Corps of Engineers

## 6. Seismic coefficient

In this dam stability analysis, seismic coefficient k is assumed from PGA of design earthquakes for Nam Ngum 2 Dam<sup>※1</sup>.

$$\begin{aligned} \cdot \text{OBE} & : k = 0.092 \times 2/3 = \underline{0.061} \\ \cdot \text{MCE} & : k = 0.322 \times 2/3 = \underline{0.215} \end{aligned}$$

Where

OBE (Operating Basis Earthquake)	:	Return period 145 years
MCE (Maximum Credible Earthquake)	:	Return period 10000 years
PGA (Peak Ground Acceleration)	:	0.092 for OBE in the study of NN2 0.322 for MCE in the study of NN2

※1 Source : Probabilistic Seismic Hazard Assessment of Nam Ngum 2 Dam Site

## 7. Analysis Cases and Results

Models for analysis are shown in Figure C.7.1. Results of the dam stability analysis made for Cases 1.2 to 1.4 (Block No.11 and 20 for alternative plans) are shown in Table C.7.2.1 and C.7.2.2. Results of the same analysis for Case 2 (Block No.20 for optimum plan) are shown in Table C.7.3

Figures of load condition are shown in Appendix F-2, and calculation results of load are shown in Appendix F-3.

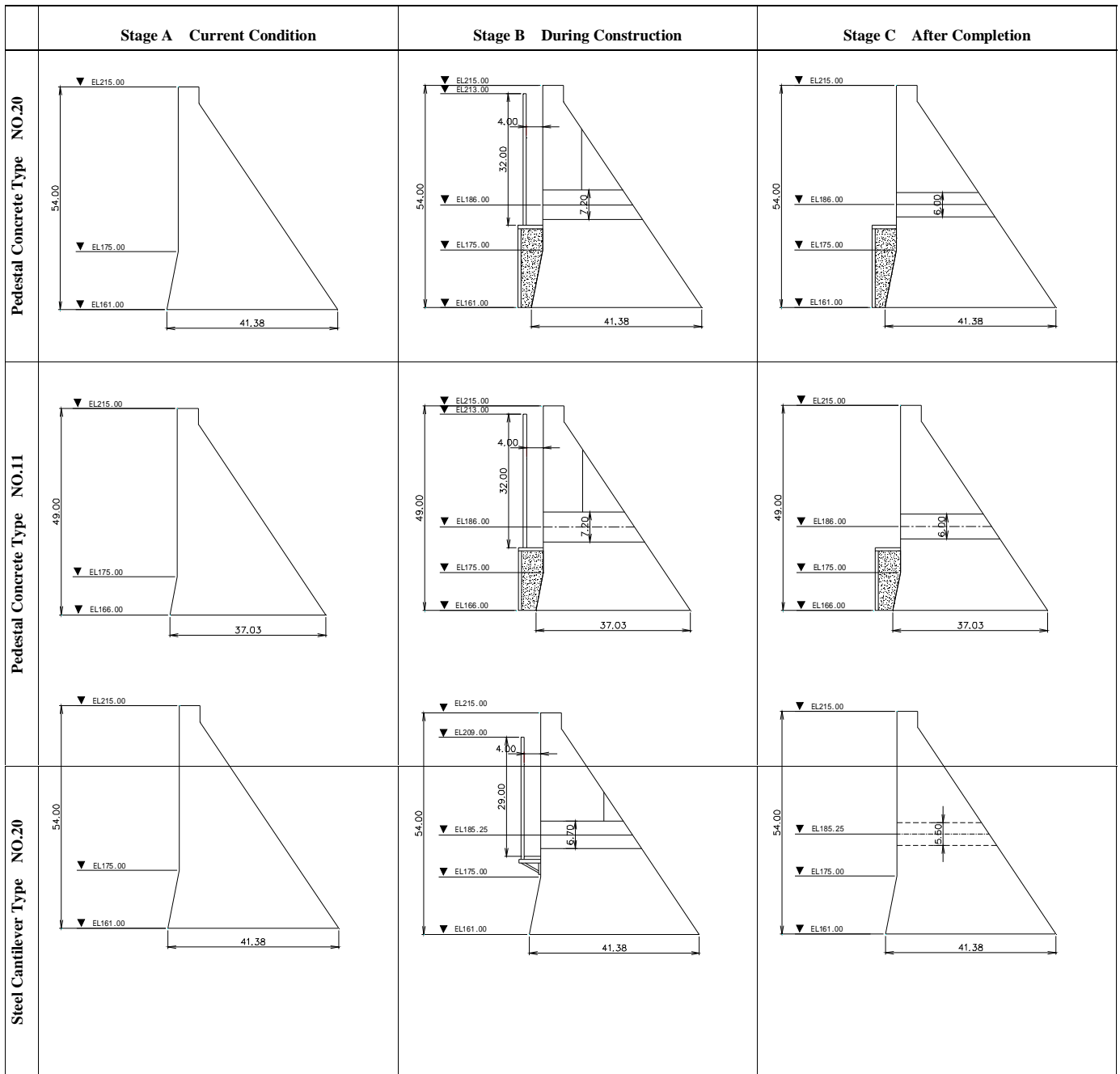


Figure C.7.1 Models for analysis

Table C.7.2.1 Result of Dam Stability Analysis (Case1.1, Case1.2)

Load condition		Criteria		Case1.1 No.11_40MW Evaluation					
				Current condition		During construction		After completion	
Usual	Overturning	$e \leq B/6$	$ e  = 3.73 \leq B/6 = 6.17$	$ e  = 5.22 \leq B/6 = 6.17$	$ e  = 3.45 \leq B/6 = 6.17$	OK	OK	OK	
			$n = 8.36 \geq 3$	$n = 8.41 \geq 3$	$n = 8.33 \geq 3$	OK	OK	OK	
			$\sigma = 78.55 \leq 400$	$\sigma = 77.52 \leq 400$	$\sigma = 74.40 \leq 400$	OK	OK	OK	
Usual	Sliding	$n \geq 3$	$n = 8.36 \geq 3$	$n = 8.41 \geq 3$	$n = 8.33 \geq 3$	OK	OK	OK	
			$\sigma = 78.55 \leq 400$	$\sigma = 77.52 \leq 400$	$\sigma = 74.40 \leq 400$	OK	OK	OK	
			$\sigma = 78.55 \leq 400$	$\sigma = 77.52 \leq 400$	$\sigma = 74.40 \leq 400$	OK	OK	OK	
Unusual	Flood	Overturning	$ e  = 5.65 \leq B/4 = 9.26$	$ e  = 5.60 \leq B/4 = 9.26$	$ e  = 5.60 \leq B/4 = 9.26$	OK	OK	OK	
			Sliding	$n = 7.9 \geq 2$	$n = 7.87 \geq 2$	$n = 7.87 \geq 2$	OK	OK	OK
				Max. Stress in foundation	$\sigma = 80.65 \leq 400$	$\sigma = 77.74 \leq 400$	$\sigma = 77.74 \leq 400$	OK	OK
	Earthquake (k=0.061) OBE	Overturning	$ e  = 5.74 \leq B/4 = 9.26$		$ e  = 7.53 \leq B/4 = 9.26$	$ e  = 5.59 \leq B/4 = 9.26$	OK	OK	OK
			Sliding	$n = 6.97 \geq 2$	$n = 7.00 \geq 2$	$n = 6.94 \geq 2$	OK	OK	OK
				Max. Stress in foundation	$\sigma = 94.49 \leq 400$	$\sigma = 94.34 \leq 400$	$\sigma = 90.95 \leq 400$	OK	OK
Extreme	Earthquake (k=0.215) MCE	Overturning	$ e  = 10.83 \leq B/2 = 18.52$		$ e  = 10.96 \leq B/2 = 18.52$	$ e  = 10.96 \leq B/2 = 18.52$	OK	OK	
			Sliding	$n = 4.91 \geq 1.3$	$n = 4.82 \geq 1.3$	$n = 4.82 \geq 1.3$	OK	OK	
				Max. Stress in foundation	$\sigma = 157.17 \leq 532$	$\sigma = 156.01 \leq 532$	$\sigma = 156.01 \leq 532$	OK	OK
Extreme	Earthquake (k=0.215) MCE	Max. Stress in foundation	$\sigma = 157.17 \leq 532$		$\sigma = 156.01 \leq 532$	$\sigma = 156.01 \leq 532$	OK	OK	
			$\sigma = 157.17 \leq 532$	$\sigma = 156.01 \leq 532$	$\sigma = 156.01 \leq 532$	OK	OK		
Load condition		Criteria		Case1.2 No.20_40MW Evaluation					
				Current condition		During construction		After completion	
Usual	Overturning	$e \leq B/6$	$ e  = 5.58 \leq B/6 = 6.9$	$ e  = 6.55 \leq B/6 = 6.90$	$ e  = 5.06 \leq B/6 = 6.90$	OK	OK	OK	
			Sliding	$n = 6.96 \geq 3$	$n = 7.14 \geq 3$	$n = 6.95 \geq 3$	OK	OK	OK
				Max. Stress in foundation	$\sigma = 90.79 \leq 400$	$\sigma = 88.36 \leq 400$	$\sigma = 86.47 \leq 400$	OK	OK
Unusual	Flood	Overturning	$ e  = 7.88 \leq B/4 = 10.35$		$ e  = 7.34 \leq B/4 = 10.35$	$ e  = 7.34 \leq B/4 = 10.35$	OK	OK	OK
			Sliding	$n = 6.79 \geq 2$	$n = 6.78 \geq 2$	$n = 6.78 \geq 2$	OK	OK	OK
				Max. Stress in foundation	$\sigma = 94.43 \leq 400$	$\sigma = 90.24 \leq 400$	$\sigma = 90.24 \leq 400$	OK	OK
	Earthquake (k=0.061) OBE	Overturning	$ e  = 8 \leq B/4 = 10.35$		$ e  = 9.15 \leq B/4 = 10.35$	$ e  = 7.48 \leq B/4 = 10.35$	OK	OK	OK
			Sliding	$n = 5.86 \geq 2$	$n = 5.98 \geq 2$	$n = 5.85 \geq 2$	OK	OK	OK
				Max. Stress in foundation	$\sigma = 109.1 \leq 400$	$\sigma = 108.33 \leq 400$	$\sigma = 104.16 \leq 400$	OK	OK
Extreme	Earthquake (k=0.215) MCE	Overturning	$ e  = 14.13 \leq B/2 = 20.69$		$ e  = 13.87 \leq B/2 = 20.69$	$ e  = 13.87 \leq B/2 = 20.69$	OK	OK	
			Sliding	$n = 4.2 \geq 1.3$	$n = 4.13 \geq 1.3$	$n = 4.13 \geq 1.3$	OK	OK	
				Max. Stress in foundation	$\sigma = 211.04 \leq 532$	$\sigma = 201.95 \leq 532$	$\sigma = 201.95 \leq 532$	OK	OK
Extreme	Earthquake (k=0.215) MCE	Max. Stress in foundation	$\sigma = 211.04 \leq 532$		$\sigma = 201.95 \leq 532$	$\sigma = 201.95 \leq 532$	OK	OK	
			$\sigma = 211.04 \leq 532$	$\sigma = 201.95 \leq 532$	$\sigma = 201.95 \leq 532$	OK	OK		

**Table C.7.2.2 Result of Dam Stability Analysis (Case1.3, Case1.4)**

Load condition		Criteria		Case1.3 No.11_60MW Evaluation					
				Current condition		During construction		After completion	
Usual	Overturning	$e \leq B/6$	$ e  = 3.73 \leq B/6 = 6.17$	$ e  = 5.74 \leq B/6 = 6.17$	$ e  = 3.58 \leq B/6 = 6.17$	OK	OK	OK	
			$n = 8.36 \geq 3$	$n = 8.35 \geq 3$	$n = 8.29 \geq 3$	OK	OK	OK	
			$\sigma = 78.55 \leq 400$	$\sigma = 76.29 \leq 400$	$\sigma = 73.00 \leq 400$	OK	OK	OK	
Unusual	Flood	Overturning	$ e  = 5.65 \leq B/4 = 9.26$		$ e  = 6.05 \leq B/4 = 9.26$	OK		OK	
			$n = 7.9 \geq 2$		$n = 7.84 \geq 2$	OK		OK	
			$\sigma = 80.65 \leq 400$		$\sigma = 77.59 \leq 400$	OK		OK	
	Earthquake (k=0.061) OBE	Overturning	$e \leq B/4$	$ e  = 5.74 \leq B/4 = 9.26$	$ e  = 8.30 \leq B/4 = 9.26$	$ e  = 5.90 \leq B/4 = 9.26$	OK	OK	OK
				$n = 6.97 \geq 2$	$n = 6.97 \geq 2$	$n = 6.92 \geq 2$	OK	OK	OK
				$\sigma = 94.49 \leq 400$	$\sigma = 95.48 \leq 400$	$\sigma = 90.37 \leq 400$	OK	OK	OK
Extreme	Earthquake (k=0.215) MCE	Overturning	$ e  = 10.83 \leq B/2 = 18.52$		$ e  = 10.00 \leq B/2 = 18.52$	OK		OK	
			$n = 4.91 \geq 1.3$		$n = 4.85 \geq 1.3$	OK		OK	
			$\sigma = 157.17 \leq 532$		$\sigma = 139.42 \leq 532$	OK		OK	

Load condition		Criteria		Case1.4 No.20_60MW Evaluation					
				Current condition		During construction		After completion	
Usual	Overturning	$e \leq B/6$	$ e  = 5.58 \leq B/6 = 6.9$	$ e  = 6.78 \leq B/6 = 6.90$	$ e  = 5.17 \leq B/6 = 6.90$	OK	OK	OK	
			$n = 6.96 \geq 3$	$n = 7.11 \geq 3$	$n = 6.92 \geq 3$	OK	OK	OK	
			$\sigma = 90.79 \leq 400$	$\sigma = 86.56 \leq 400$	$\sigma = 84.68 \leq 400$	OK	OK	OK	
Unusual	Flood	Overturning	$ e  = 7.88 \leq B/4 = 10.35$		$ e  = 7.57 \leq B/4 = 10.35$	OK		OK	
			$n = 6.79 \geq 2$		$n = 6.75 \geq 2$	OK		OK	
			$\sigma = 94.43 \leq 400$		$\sigma = 88.53 \leq 400$	OK		OK	
	Earthquake (k=0.061) OBE	Overturning	$e \leq B/4$	$ e  = 8 \leq B/4 = 10.35$	$ e  = 9.43 \leq B/4 = 10.35$	$ e  = 7.61 \leq B/4 = 10.35$	OK	OK	OK
				$n = 5.86 \geq 2$	$n = 5.96 \geq 2$	$n = 5.83 \geq 2$	OK	OK	OK
				$\sigma = 109.1 \leq 400$	$\sigma = 106.94 \leq 400$	$\sigma = 102.08 \leq 400$	OK	OK	OK
Extreme	Earthquake (k=0.215) MCE	Overturning	$ e  = 14.13 \leq B/2 = 20.69$		$ e  = 14.07 \leq B/2 = 20.69$	OK		OK	
			$n = 4.2 \geq 1.3$		$n = 4.12 \geq 1.3$	OK		OK	
			$\sigma = 211.04 \leq 532$		$\sigma = 201.95 \leq 532$	OK		OK	

Table C.7.3 Result of Dam Stability Analysis (Case2)

Load condition		Criteria		Case2 No.20_40MW Evaluation						
				Current Condition		During Construction (Upper Limit of Water Level EL.207m)		After Completion		
Usual	Overturning	$e \leq B/6$	$ e  = 5.58 \leq B/6 = 6.9$	$ e  = 3.94 \leq B/6 = 6.90$	$ e  = 6.12 \leq B/6 = 6.90$	OK		OK		
	Sliding	$n \geq 3$	$n = 6.96 \geq 3$	$n = 8.67 \geq 3$	$n = 6.92 \geq 3$	OK		OK		
	Max. Stress in foundation	$\sigma \leq 400$ tf/m <sup>2</sup>	$\sigma = 90.79 \leq 400$	$\sigma = 71.13 \leq 400$	$\sigma = 90.67 \leq 400$	OK		OK		
Unusual	Flood	Overturning	$e \leq B/4$	$ e  = 7.88 \leq B/4 = 10.35$		$ e  = 8.62 \leq B/4 = 10.35$	OK		OK	
		Sliding	$n \geq 2$	$n = 6.79 \geq 2$		$n = 6.75 \geq 2$	OK		OK	
		Max. Stress in foundation	$\sigma \leq 400$ tf/m <sup>2</sup>	$\sigma = 94.43 \leq 400$		$\sigma = 94.34 \leq 400$	OK		OK	
	Earthquake (k=0.061) OBE	Overturning	$e \leq B/4$	$ e  = 8 \leq B/4 = 10.35$	$ e  = 6.26 \leq B/4 = 10.35$	$ e  = 8.59 \leq B/4 = 10.35$	OK		OK	
		Sliding	$n \geq 2$	$n = 5.86 \geq 2$	$n = 7.15 \geq 2$	$n = 5.85 \geq 2$	OK		OK	
		Max. Stress in foundation	$\sigma \leq 400$ tf/m <sup>2</sup>	$\sigma = 109.1 \leq 400$	$\sigma = 86.36 \leq 400$	$\sigma = 109.53 \leq 400$	OK		OK	
Extreme	Earthquake (k=0.215) MCE	Overturning	$e \leq B/2$	$ e  = 14.13 \leq B/2 = 20.69$		$ e  = 15.15 \leq B/2 = 20.69$	OK		OK	
		Sliding	$n \geq 1.3$	$n = 4.2 \geq 1.3$		$n = 4.16 \geq 1.3$	OK		OK	
		Max. Stress in foundation	$\sigma \leq 532$ tf/m <sup>2</sup>	$\sigma = 211.04 \leq 532$		$\sigma = 239.35 \leq 532$	OK		OK	

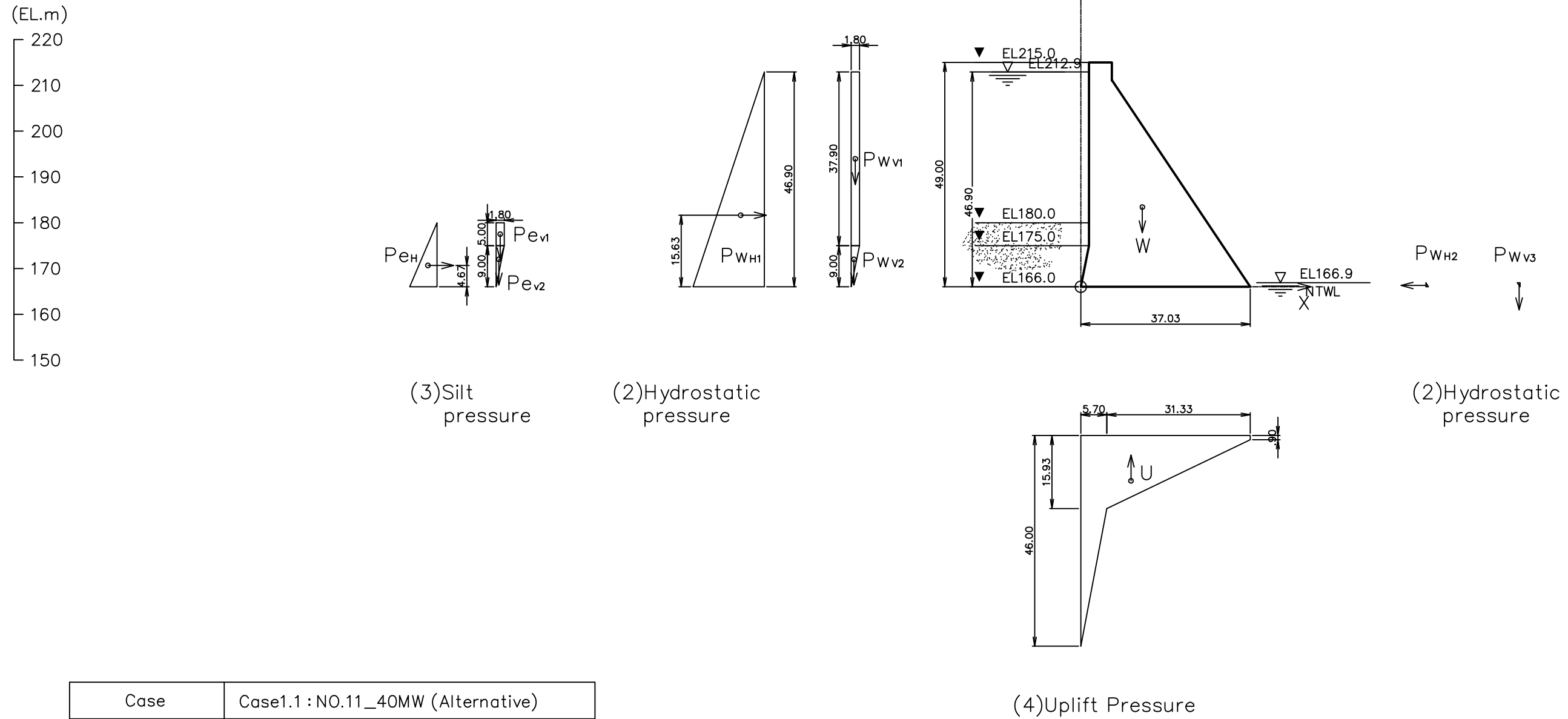
THE PREPARATORY SURVEY  
ON  
EXPANSION OF NAM NGUM 1 HYDROPOWER STATION  
IN  
LAO PEOPLE'S DEMOCRATIC REPUBLIC  
**DRAFT FINAL REPORT**

Appendices

Appendix F-2 Figures of Load Condition

(Upstream Side)

(Downstream Side)



Case	Case1.1 : NO.11_40MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- I : Usual

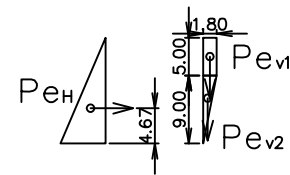
Figure Load Condition (Case1.1\_A- I )



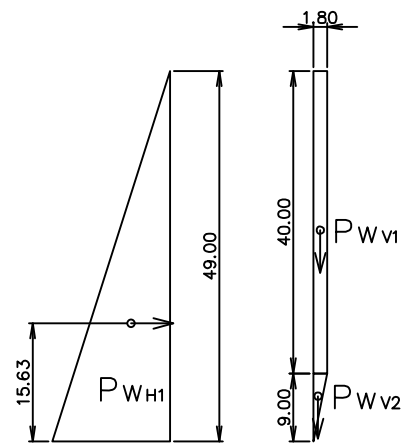
(Upstream Side)

(Downstream Side)

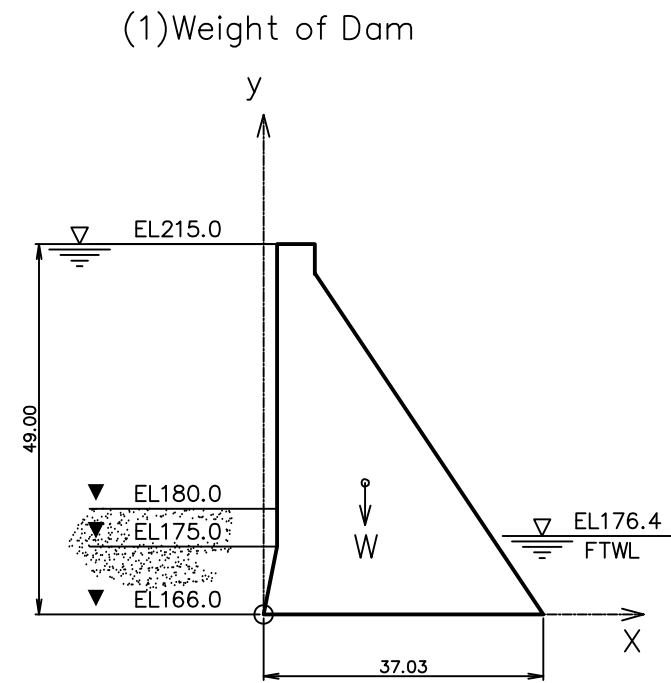
(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



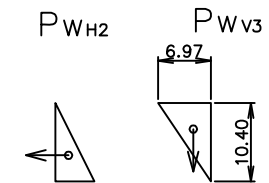
(3) Silt pressure



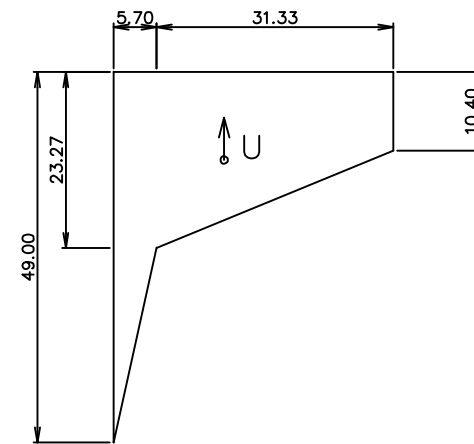
(2) Hydrostatic pressure



(1) Weight of Dam



(2) Hydrostatic pressure



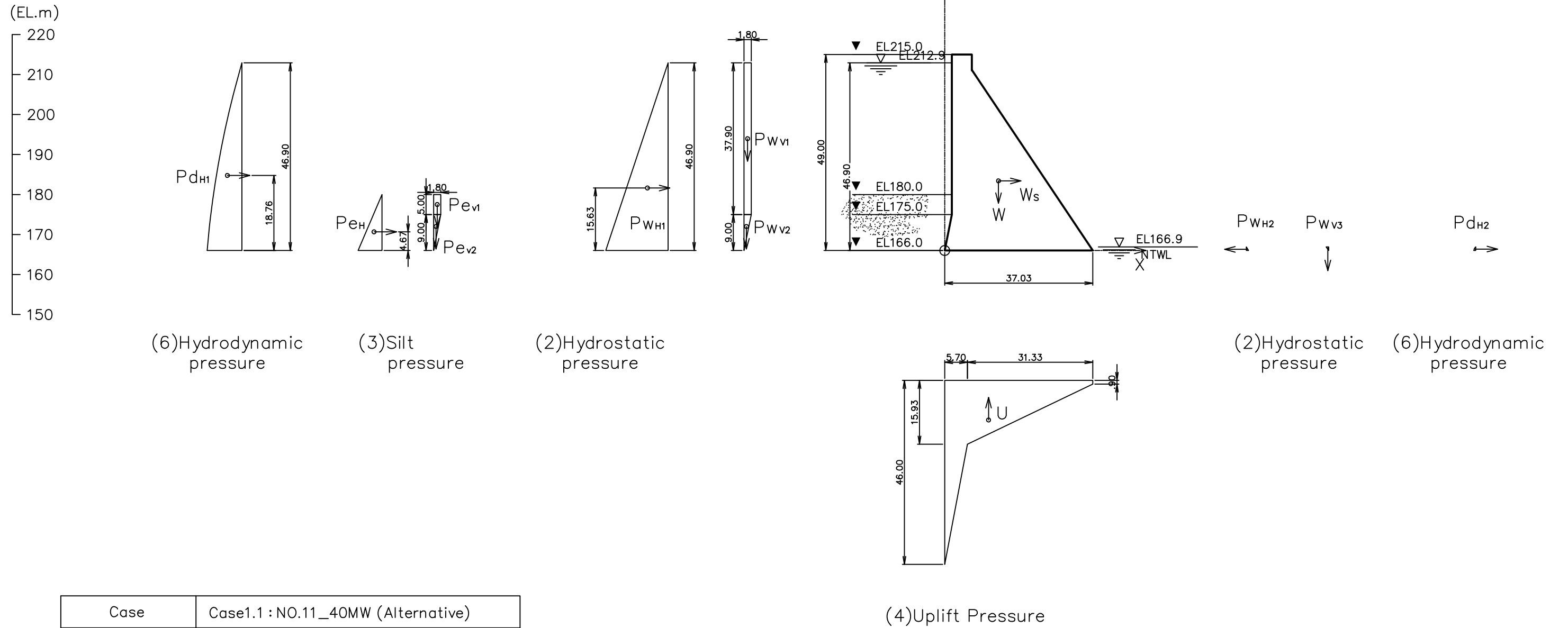
(4) Uplift Pressure

Case	Case1.1 : NO.11_40MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- II : Flood

Figure Load Condition (Case1.1\_A- II)

(Upstream Side)

(Downstream Side)

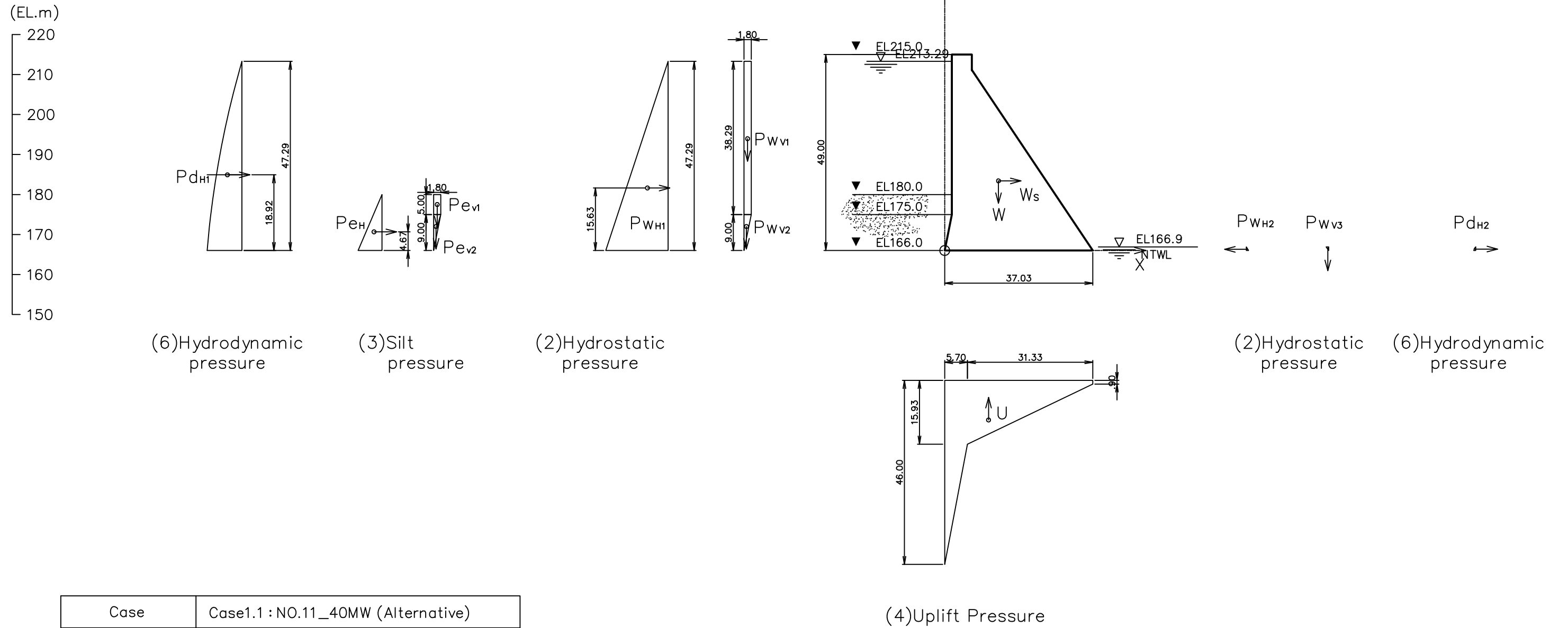


Case	Case1.1 : NO.11_40MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- III : Earthquake (k=0.061)

Figure Load Condition (Case1.1\_A-III)

(Upstream Side)

(Downstream Side)

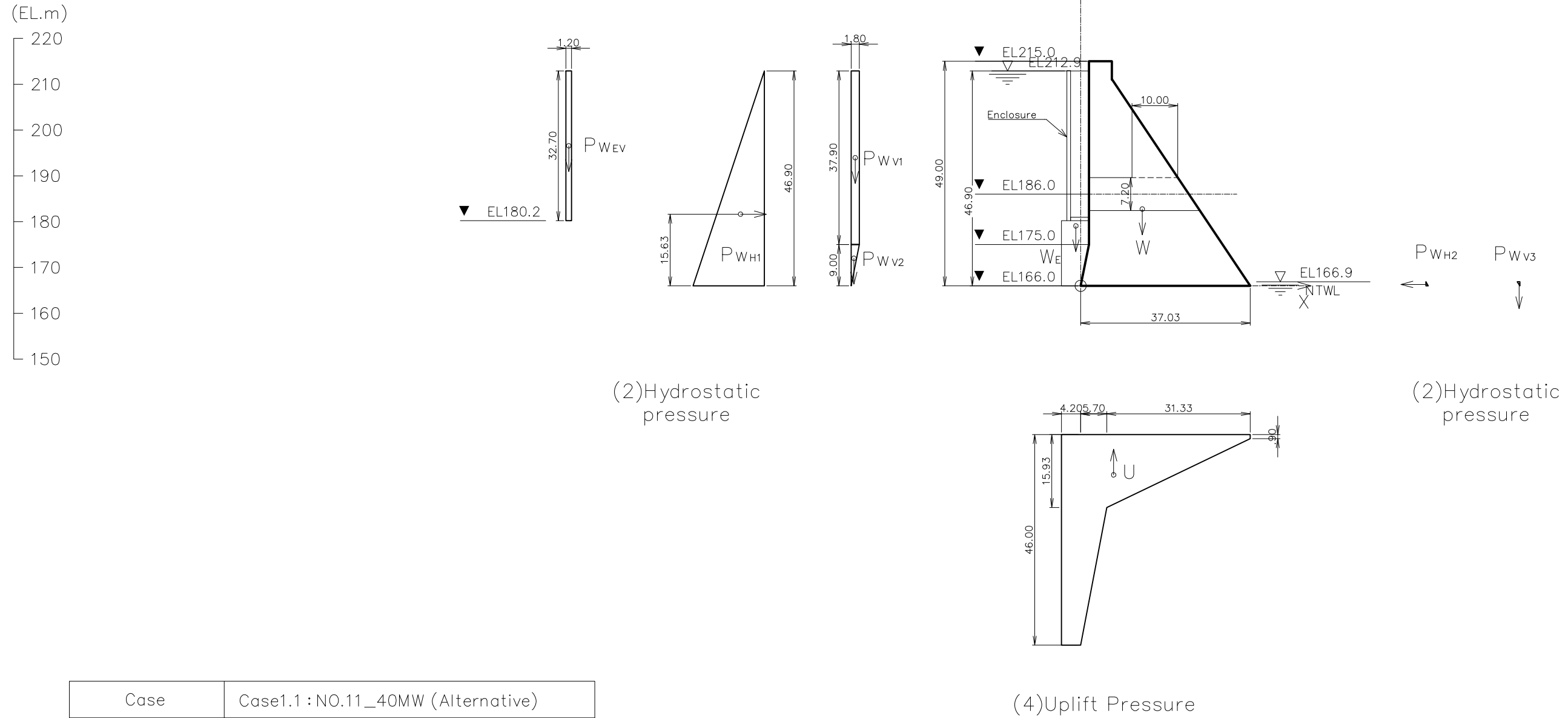


Case	Case1.1 : NO.11_40MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A-IV : Earthquake (k=0.215)

Figure Load Condition (Case1.1\_A-IV)

(Upstream Side)

(Downstream Side)



Case	Case1.1 : NO.11_40MW (Alternative)
Stage	Stage B : During Construction
Load Condition	Load B- I : Usual

Figure Load Condition (Case1.1\_B- I)

(Upstream Side)

(Downstream Side)

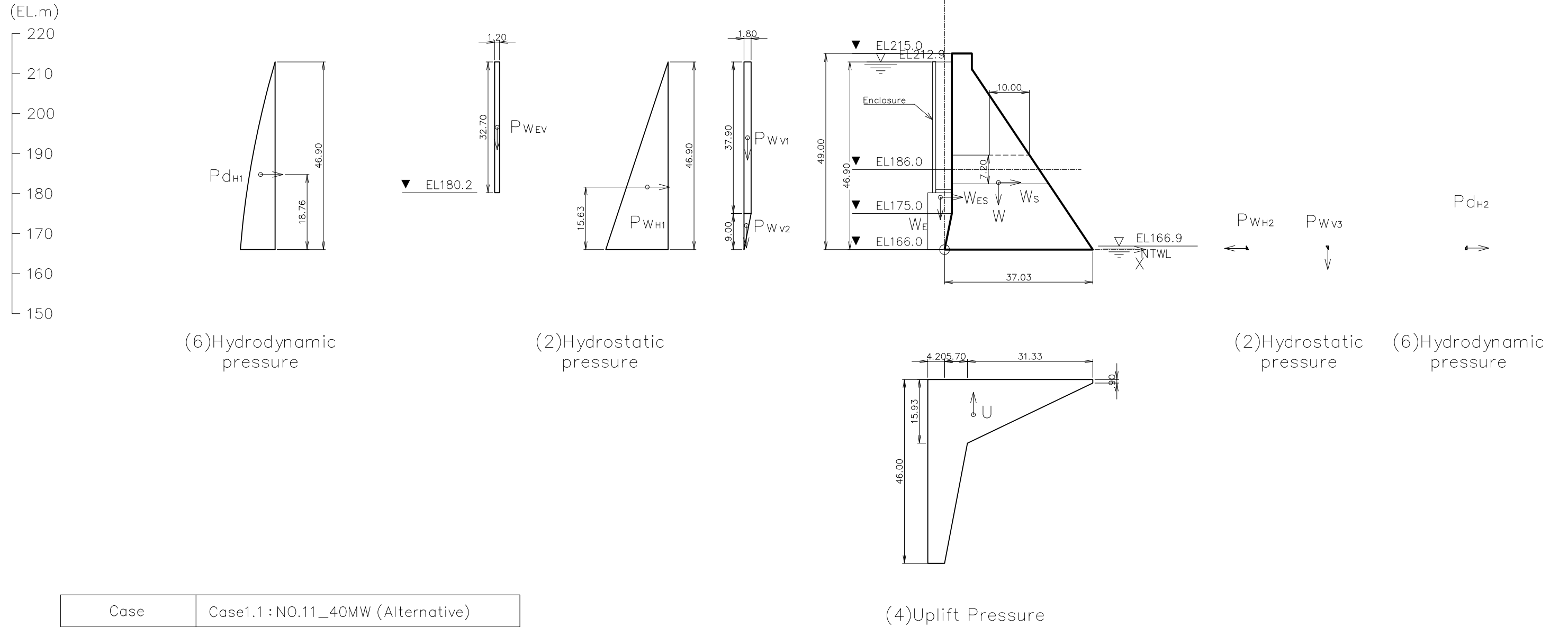
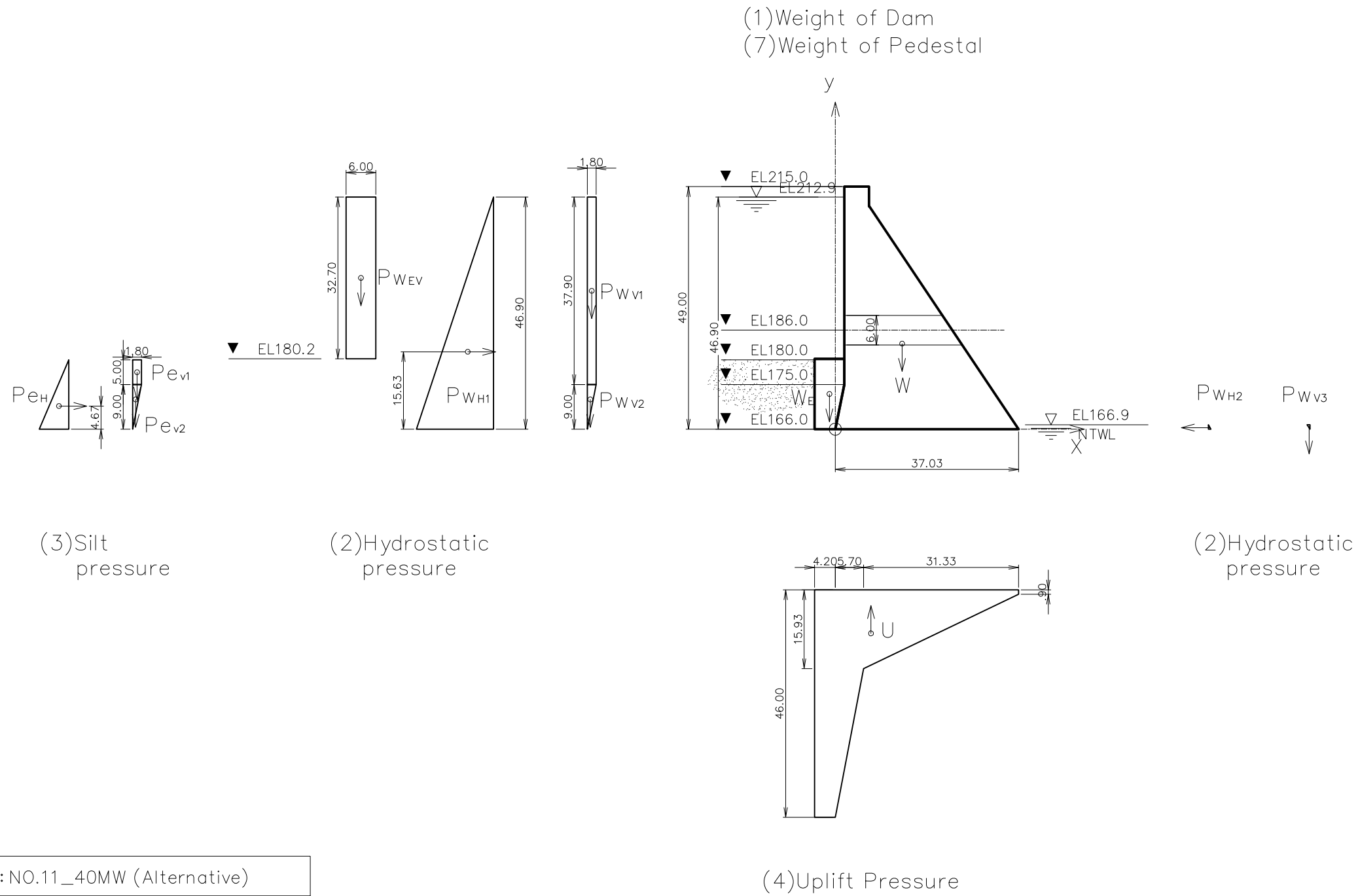


Figure Load Condition (Case1.1\_B-III)

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



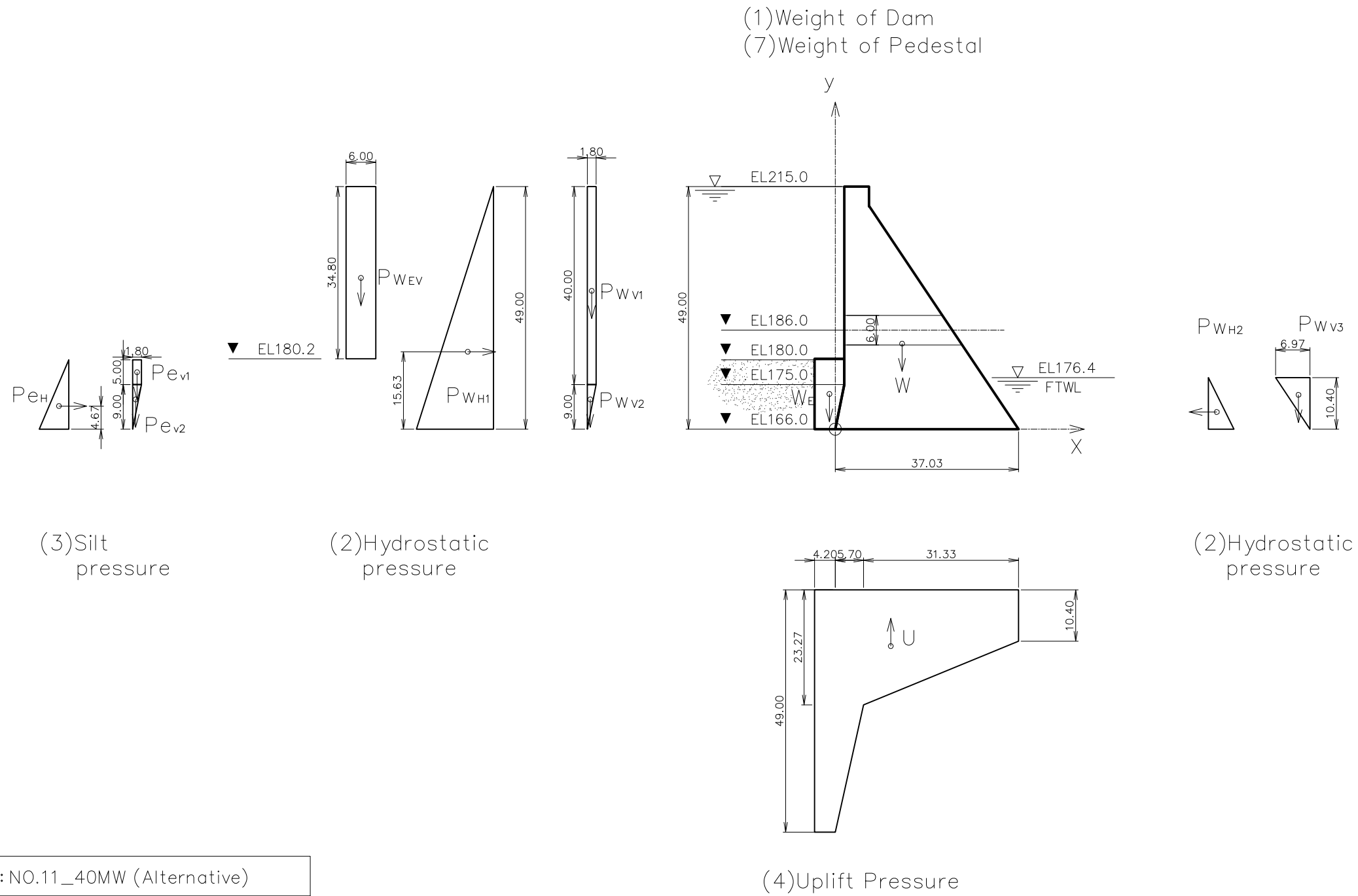
Case	Case1.1 : NO.11_40MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C- I : Usual

Figure Load Condition (Case1.1\_C- I)

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150

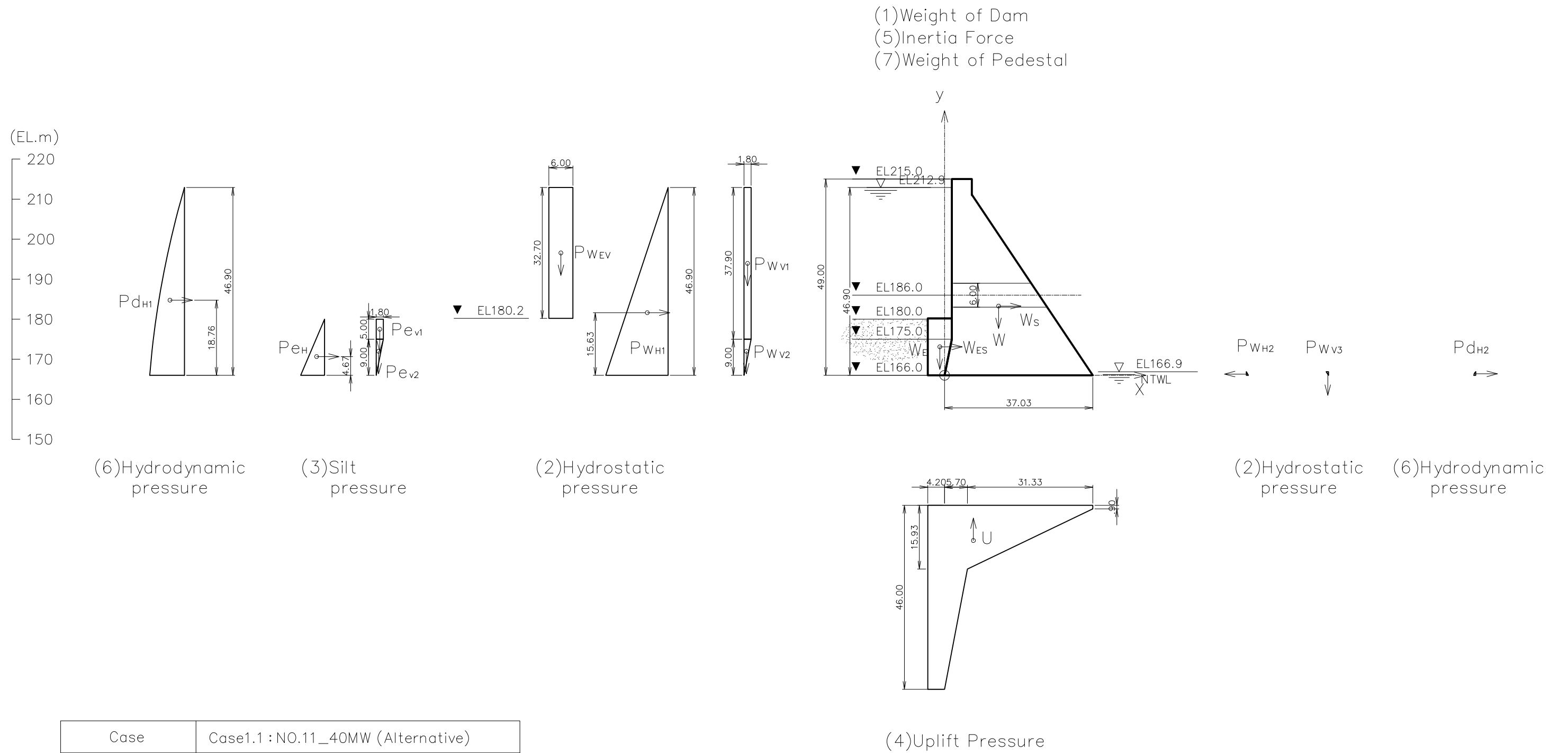


Case	Case1.1 : NO.11_40MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C- II : Flood

Figure Load Condition (Case1.1\_C- II)

(Upstream Side)

(Downstream Side)



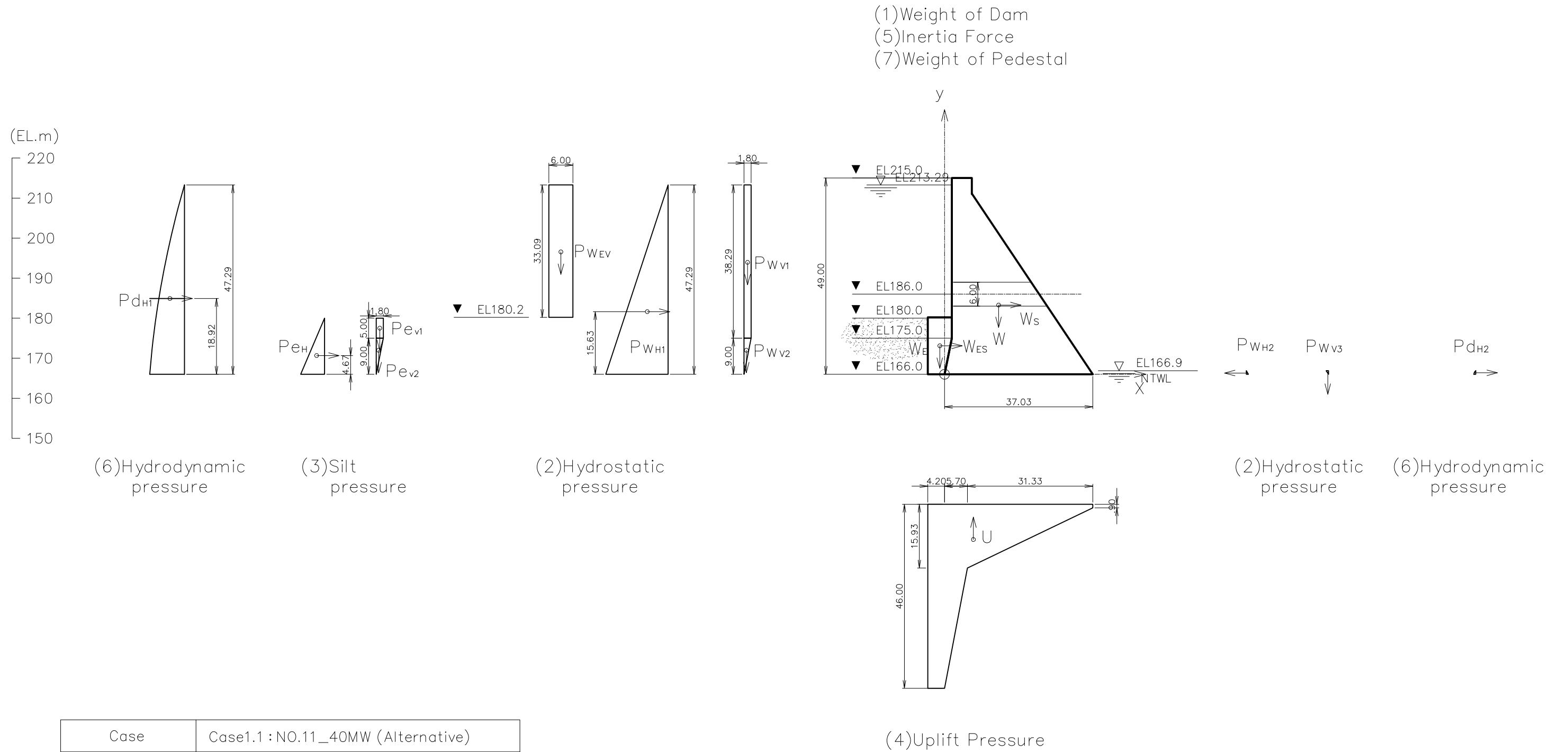
Case	Case1.1 : NO.11_40MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C-III : Earthquake (k=0.061)

Figure Load Condition (Case1.1\_C-III)



(Upstream Side)

(Downstream Side)



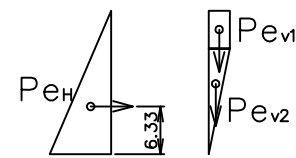
Case	Case1.1 : NO.11_40MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C-IV : Earthquake (k=0.215)

Figure Load Condition (Case1.1\_C-IV)

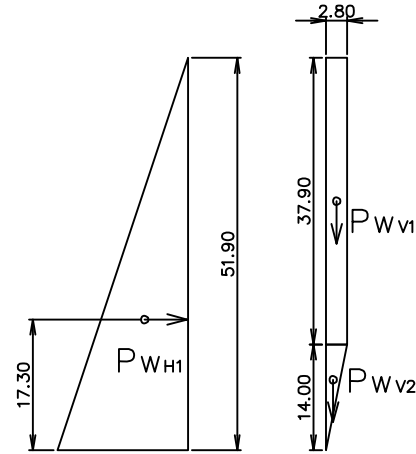
(Upstream Side)

(Downstream Side)

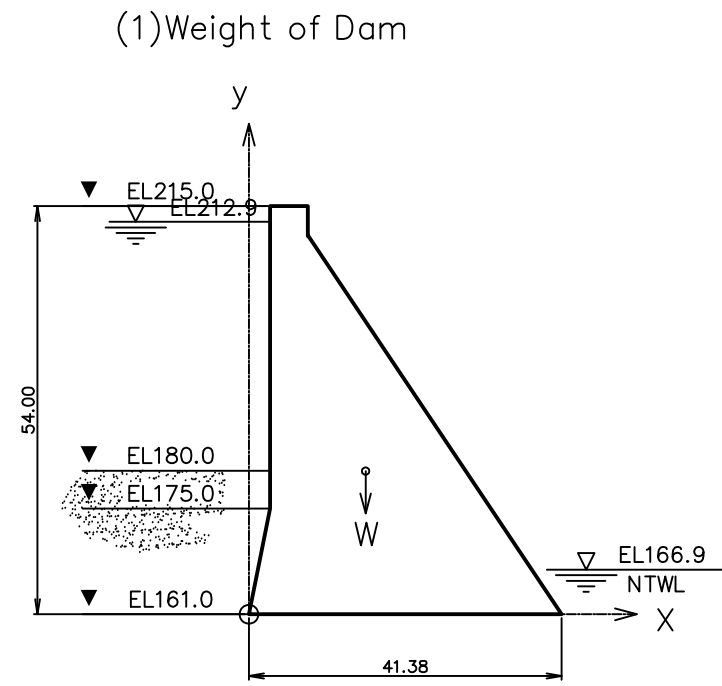
(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



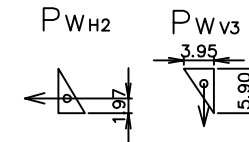
(3) Silt pressure



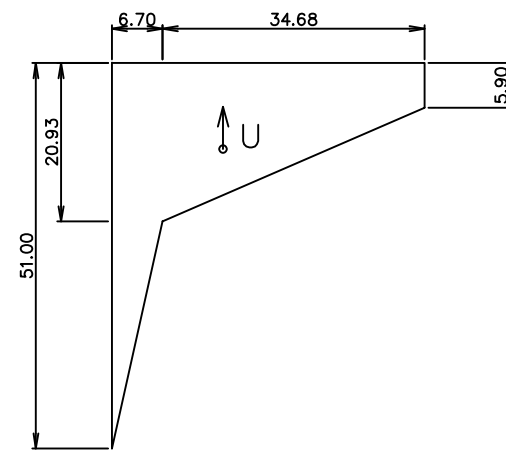
(2) Hydrostatic pressure



(1) Weight of Dam



(2) Hydrostatic pressure



(4) Uplift Pressure

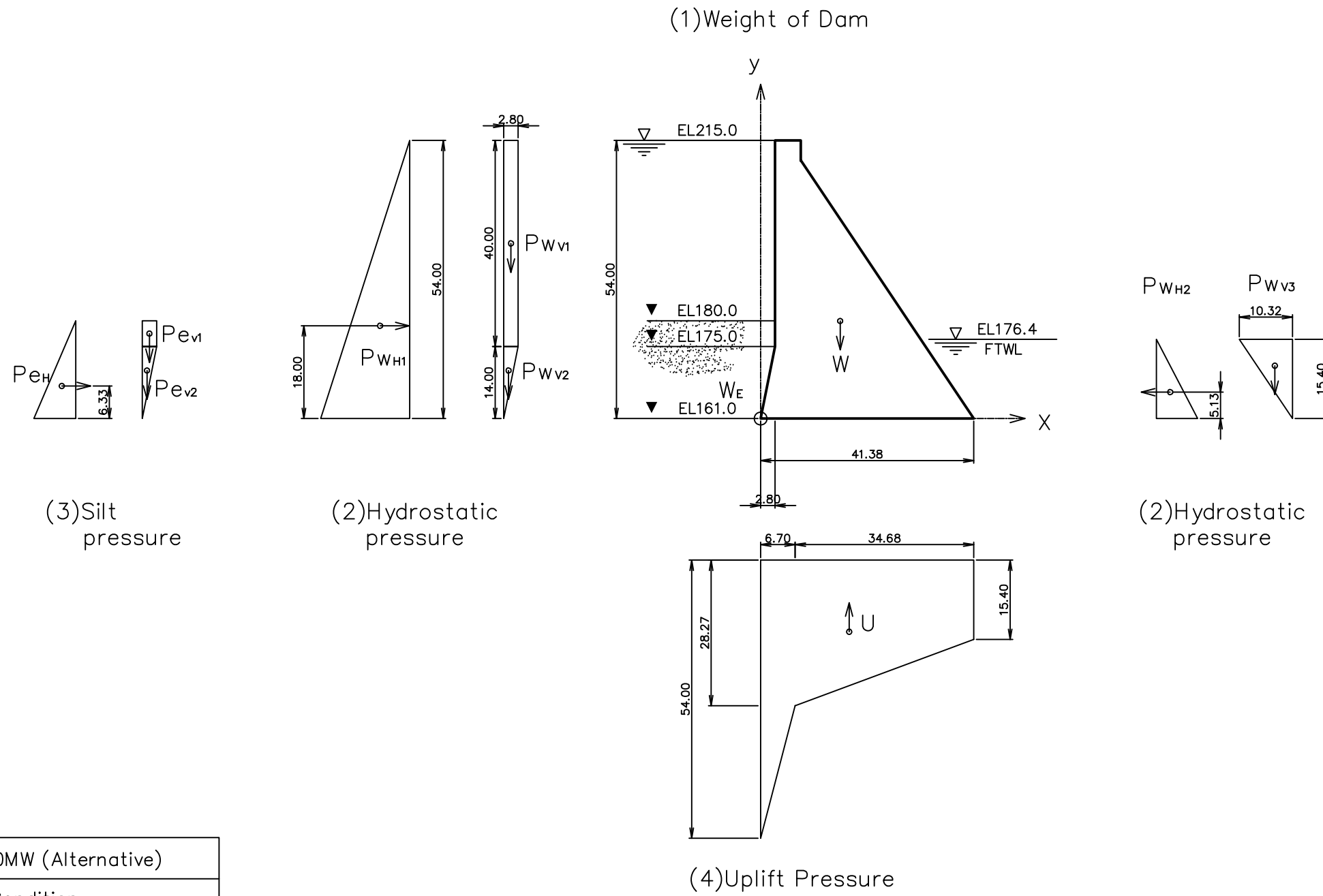
Case	Case1.2 : NO.20_40MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- I : Usual

Figure Load Condition (Case1.2\_A- I )

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150

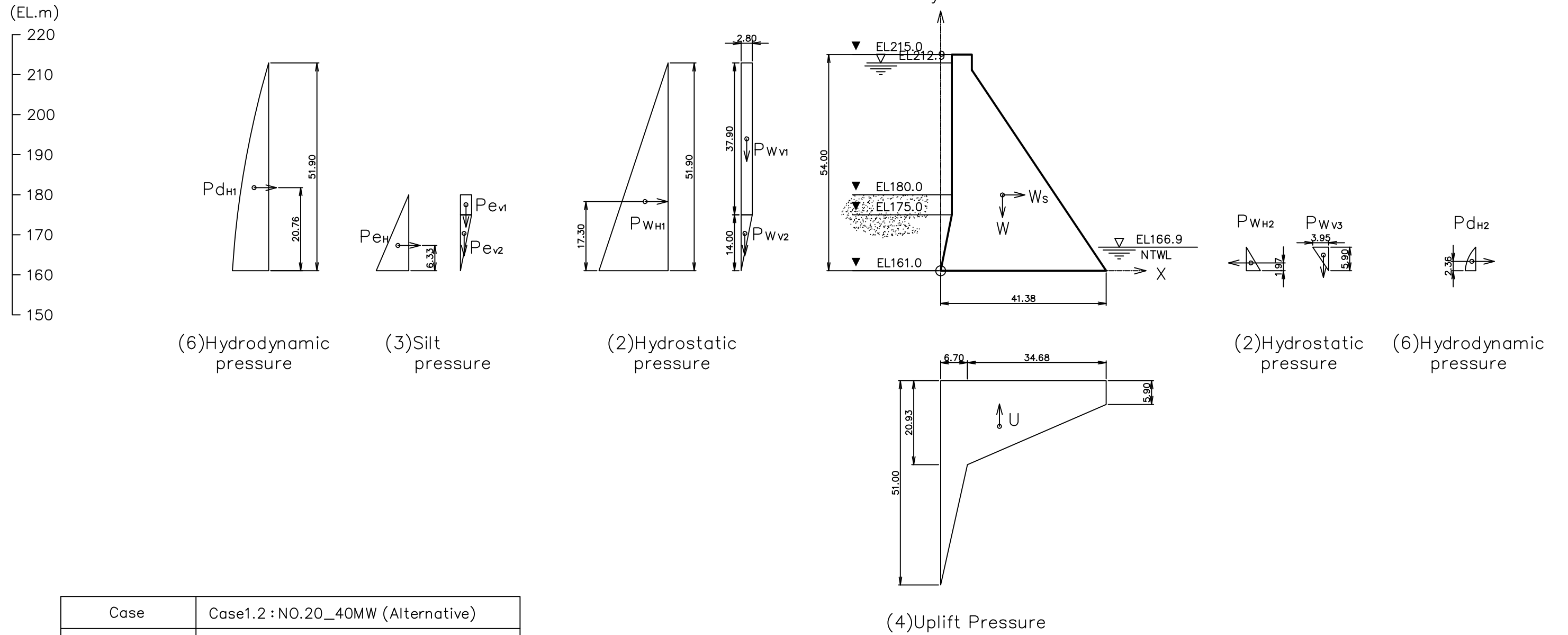


Case	Case1.2 : NO.20_40MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- II : Flood

Figure Load Condition (Case1.2\_A- II)

(Upstream Side)

(Downstream Side)

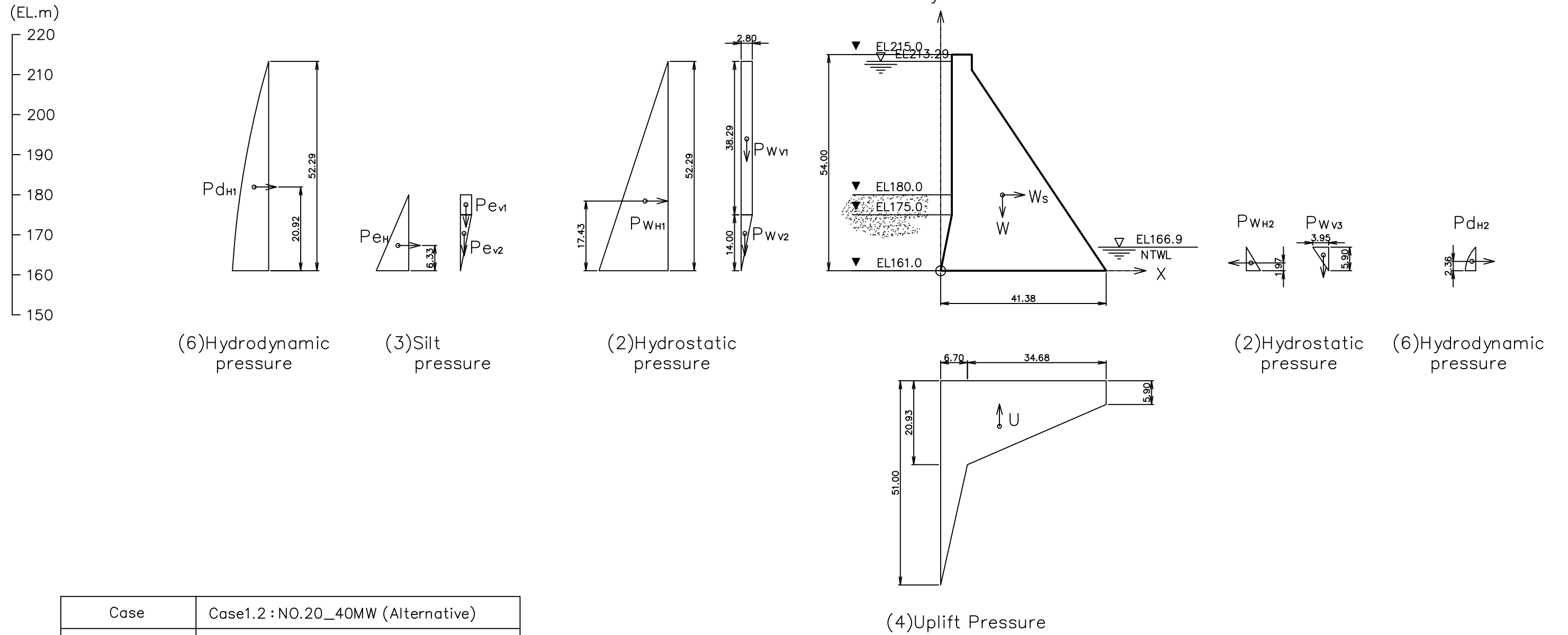


Case	Case1.2 : NO.20_40MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A-III : Earthquake (k=0.061)

Figure Load Condition (Case1.2\_A-III)

(Upstream Side)

(Downstream Side)



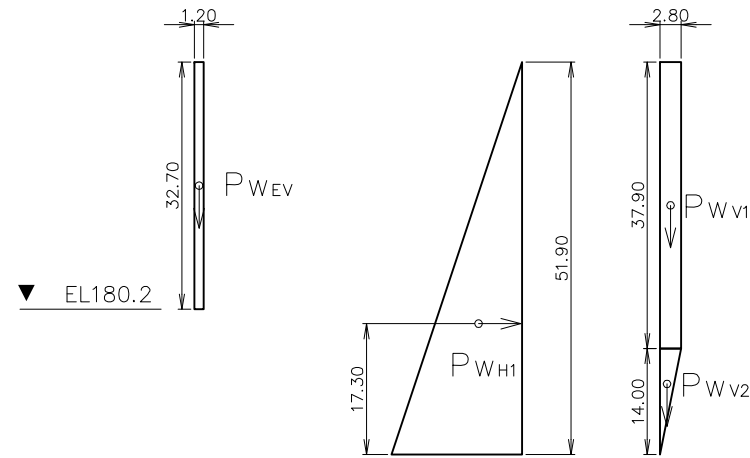
Case	Case1.2 : NO.20_40MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A-IV : Earthquake (k=0.215)

Figure Load Condition (Case1.2\_A-IV)

(Upstream Side)

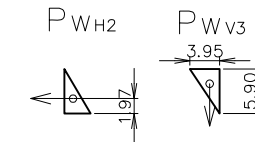
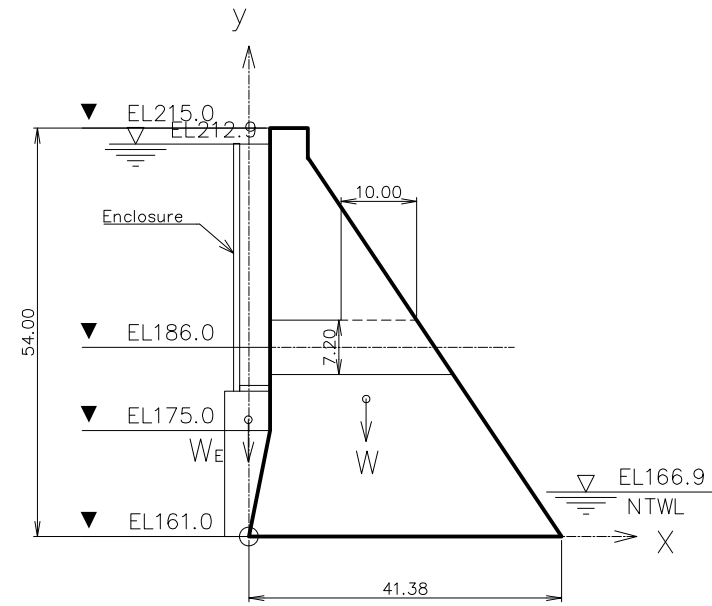
(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150

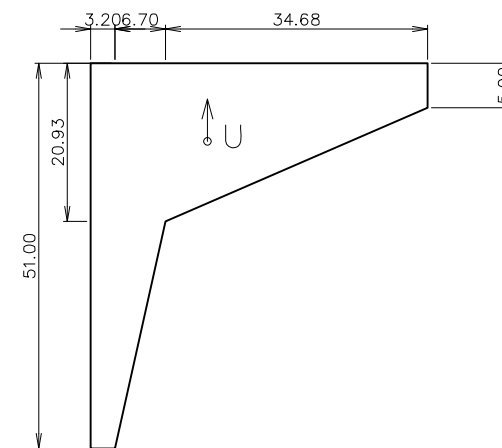


(2)Hydrostatic pressure

(1)Weight of Dam  
(7)Weight of Enclosure



(2)Hydrostatic pressure



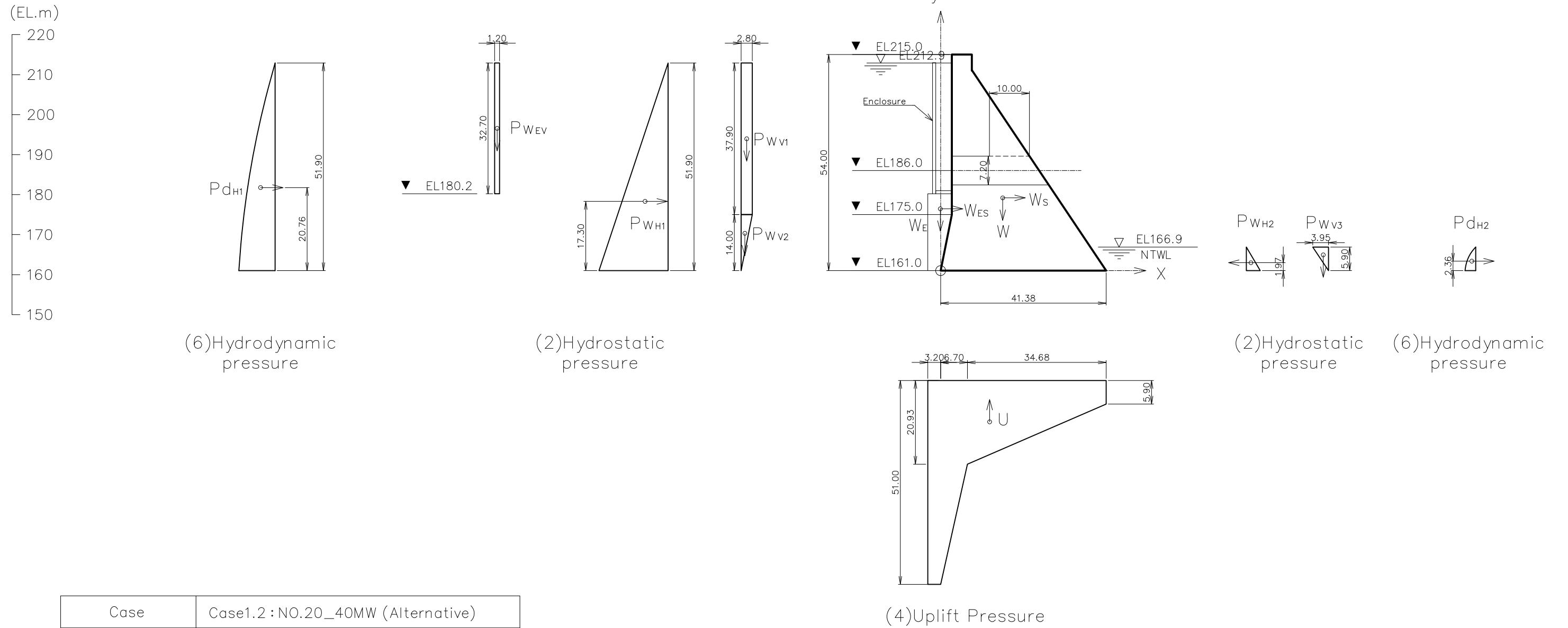
(4)Uplift Pressure

Case	Case1.2 : NO.20_40MW (Alternative)
Stage	Stage B : During Construction
Load Condition	Load B- I : Usual

Figure Load Condition (Case1.2\_B- I)

(Upstream Side)

(Downstream Side)

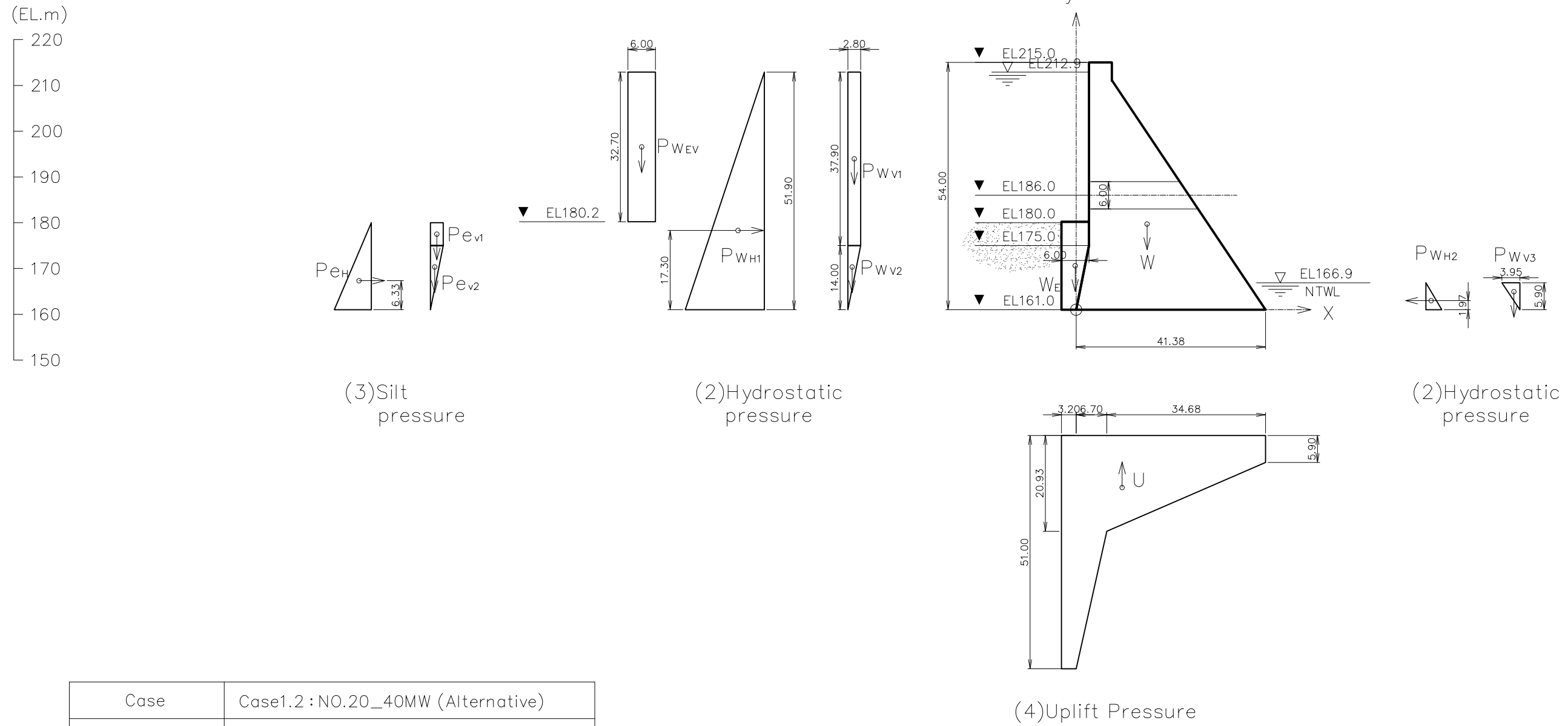


Case	Case1.2 : NO.20_40MW (Alternative)
Stage	Stage B : During Construction
Load Condition	Load B-III : Earthquake (k=0.061)

Figure Load Condition (Case1.2\_B-III)

(Upstream Side)

(Downstream Side)



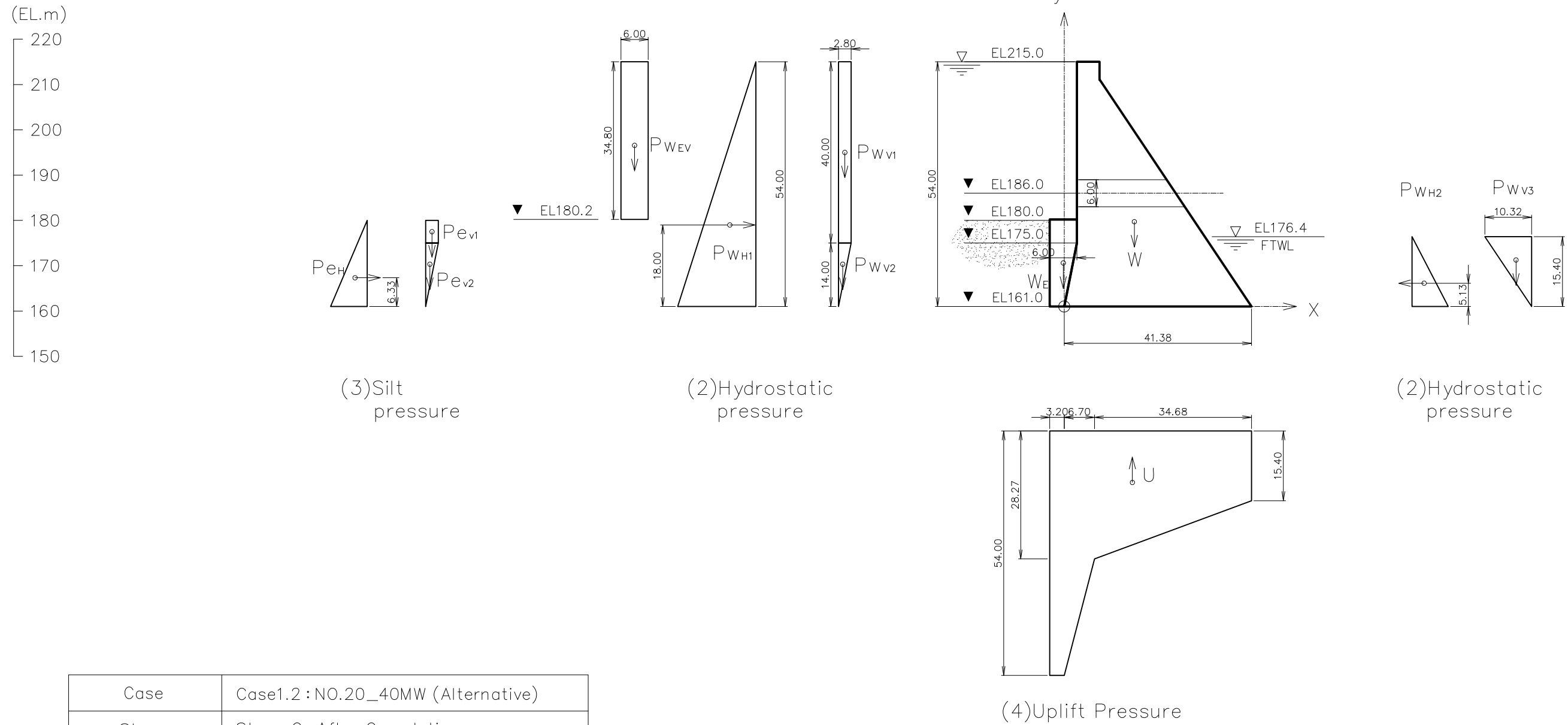
Case	Case1.2 : NO.20_40MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C- I : Usual

Figure Load Condition (Case1.2\_C- I)



(Upstream Side)

(Downstream Side)



Case	Case1.2 : NO.20_40MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C- II : Flood

Figure Load Condition (Case1.2\_C- II)

(Upstream Side)

(Downstream Side)

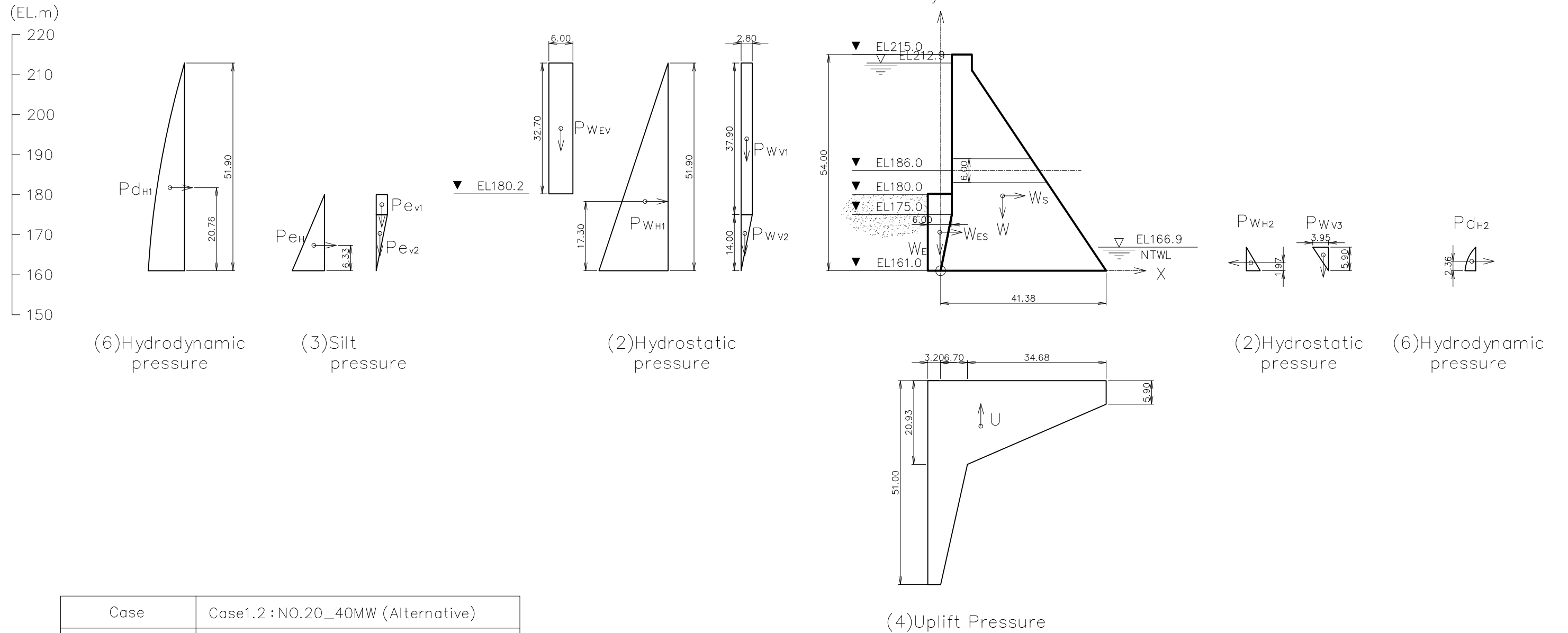
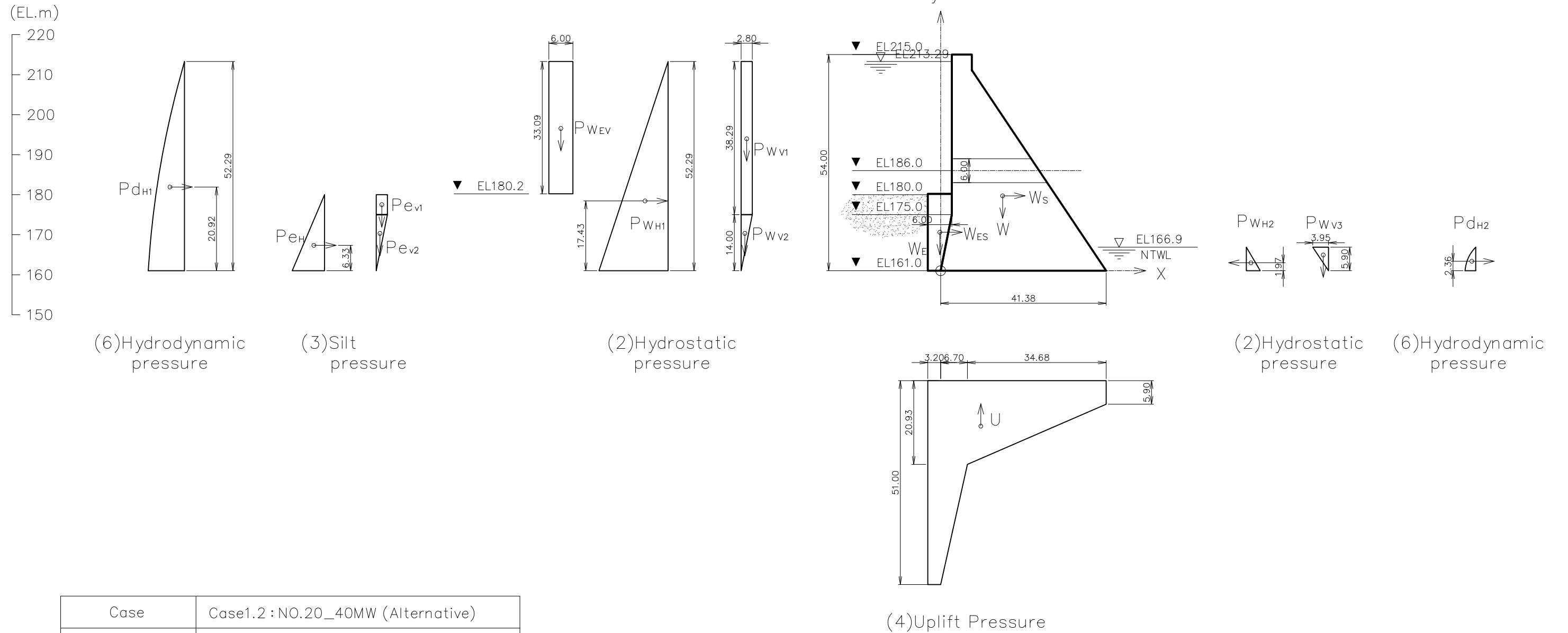


Figure Load Condition (Case1.2\_C-III)

(Upstream Side)

(Downstream Side)



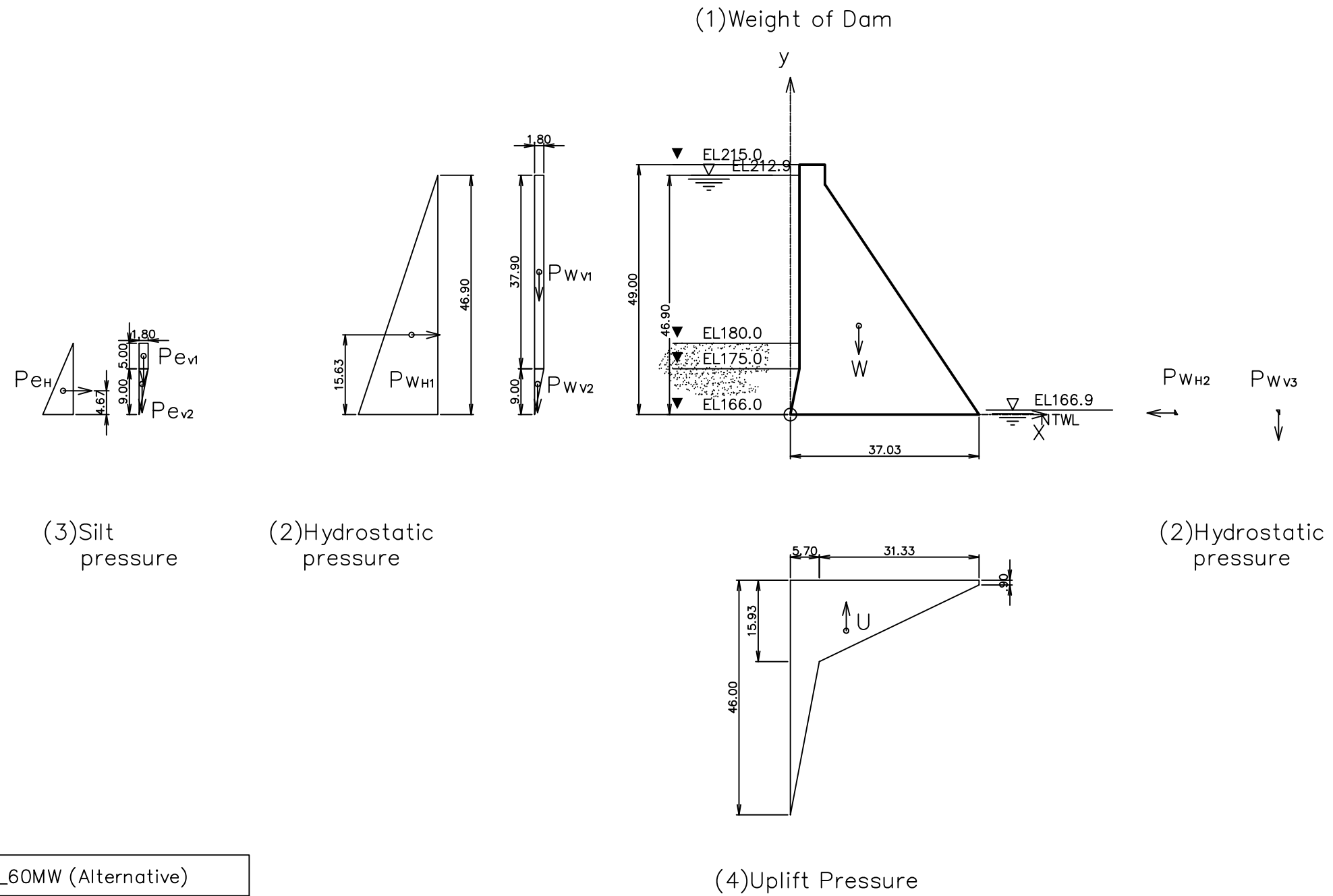
Case	Case1.2 : NO.20_40MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C-IV : Earthquake (k=0.215)

Figure Load Condition (Case1.2\_C-IV)

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



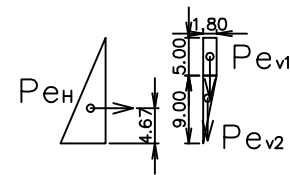
Case	Case1.3 : NO.11_60MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- I : Usual

Figure Load Condition (Case1.3\_A- I )

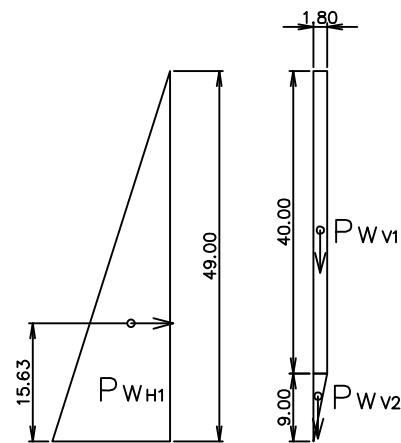
(Upstream Side)

(Downstream Side)

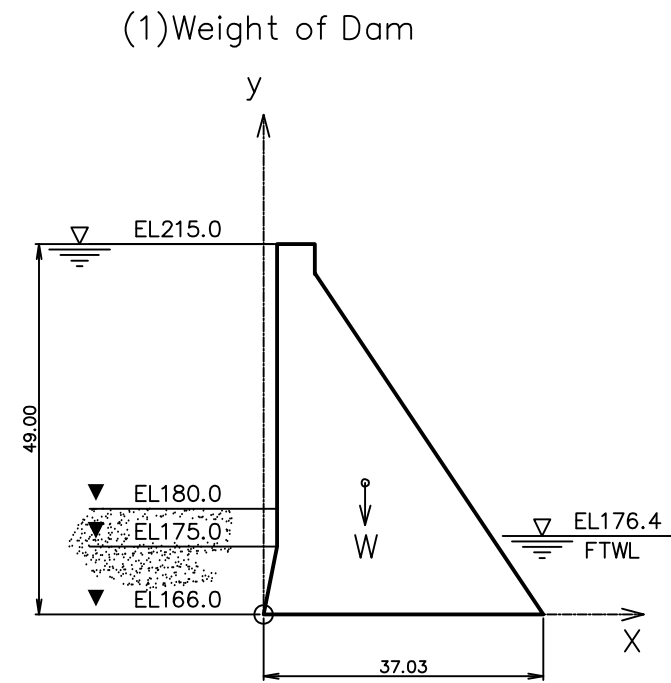
(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



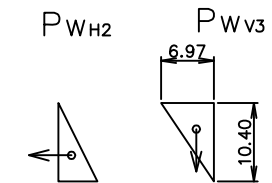
(3) Silt pressure



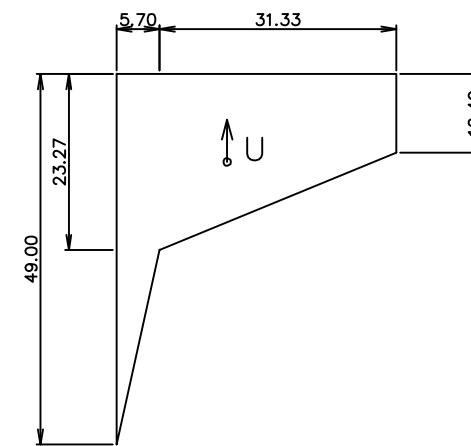
(2) Hydrostatic pressure



(1) Weight of Dam



(2) Hydrostatic pressure



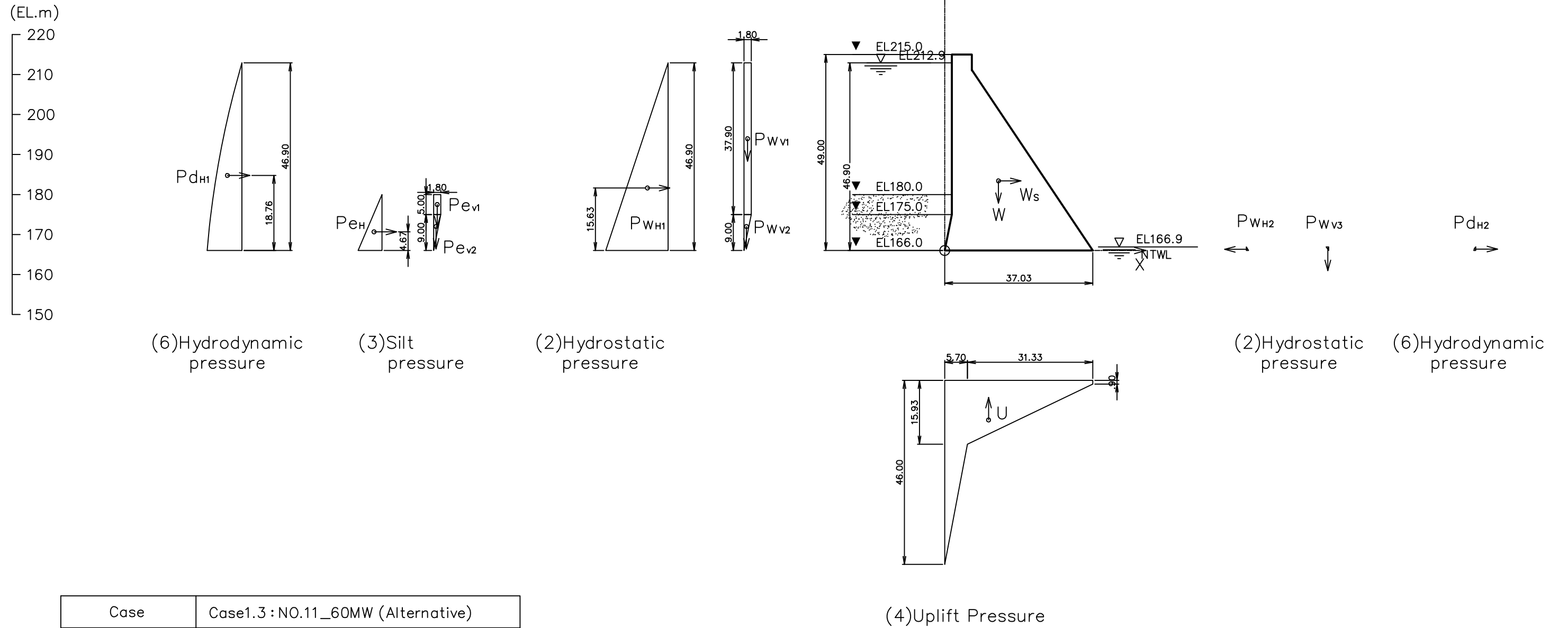
(4) Uplift Pressure

Case	Case1.3 : NO.11_60MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- II : Flood

Figure Load Condition (Case1.3\_A- II)

(Upstream Side)

(Downstream Side)

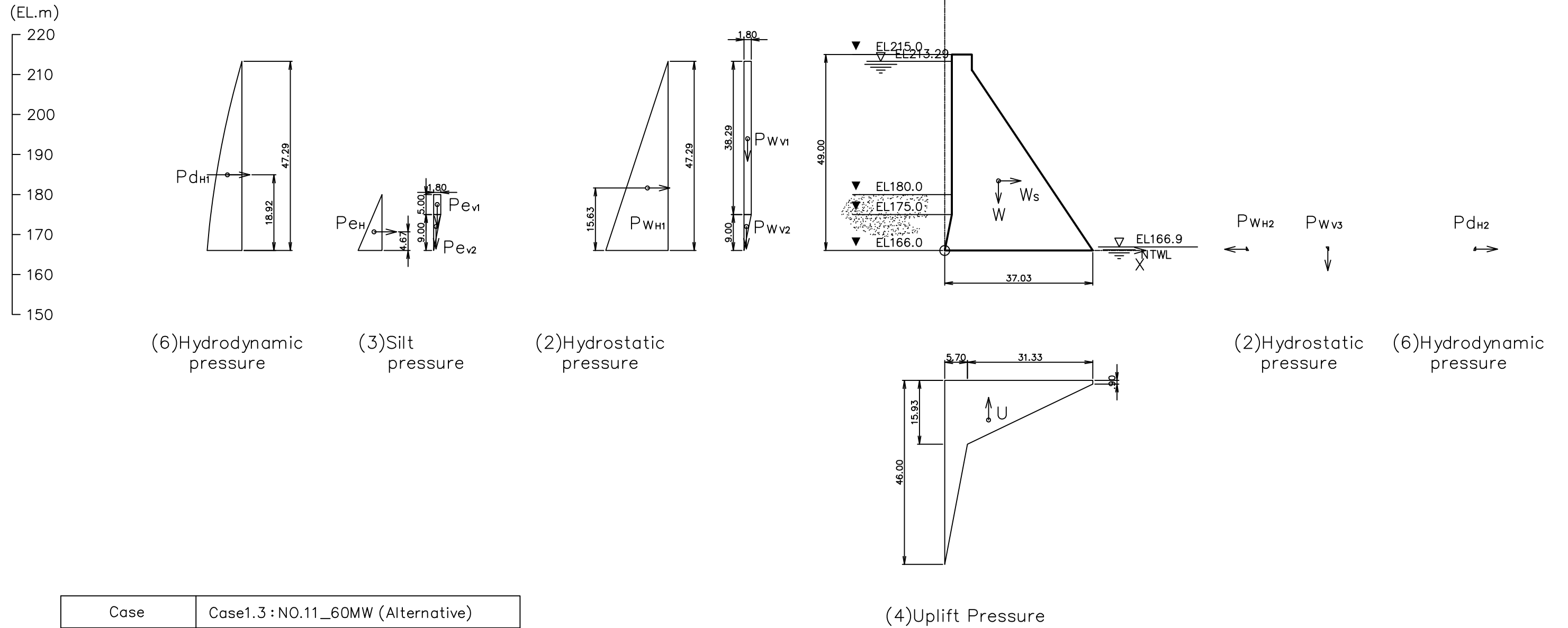


Case	Case1.3 : NO.11_60MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- III : Earthquake (k=0.061)

Figure Load Condition (Case1.3\_A-III)

(Upstream Side)

(Downstream Side)



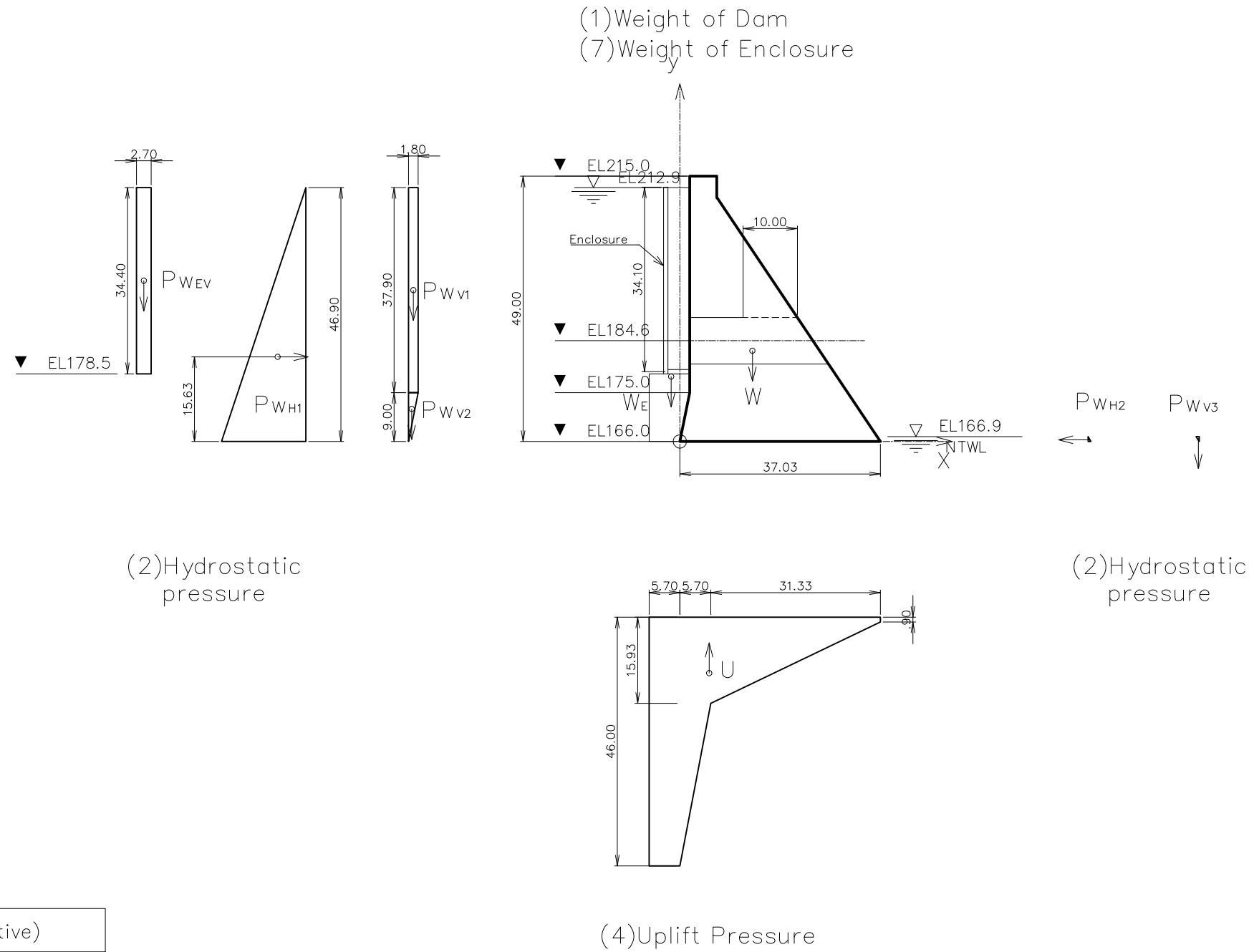
Case	Case1.3 : NO.11_60MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A-IV : Earthquake (k=0.215)

Figure Load Condition (Case1.3\_A-IV)

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



Case	Case1.3 : NO.11_60MW (Alternative)
Stage	Stage B : During Construction
Load Condition	Load B- I : Usual

Figure Load Condition (Case1.3\_B- I)



(Upstream Side)

(Downstream Side)

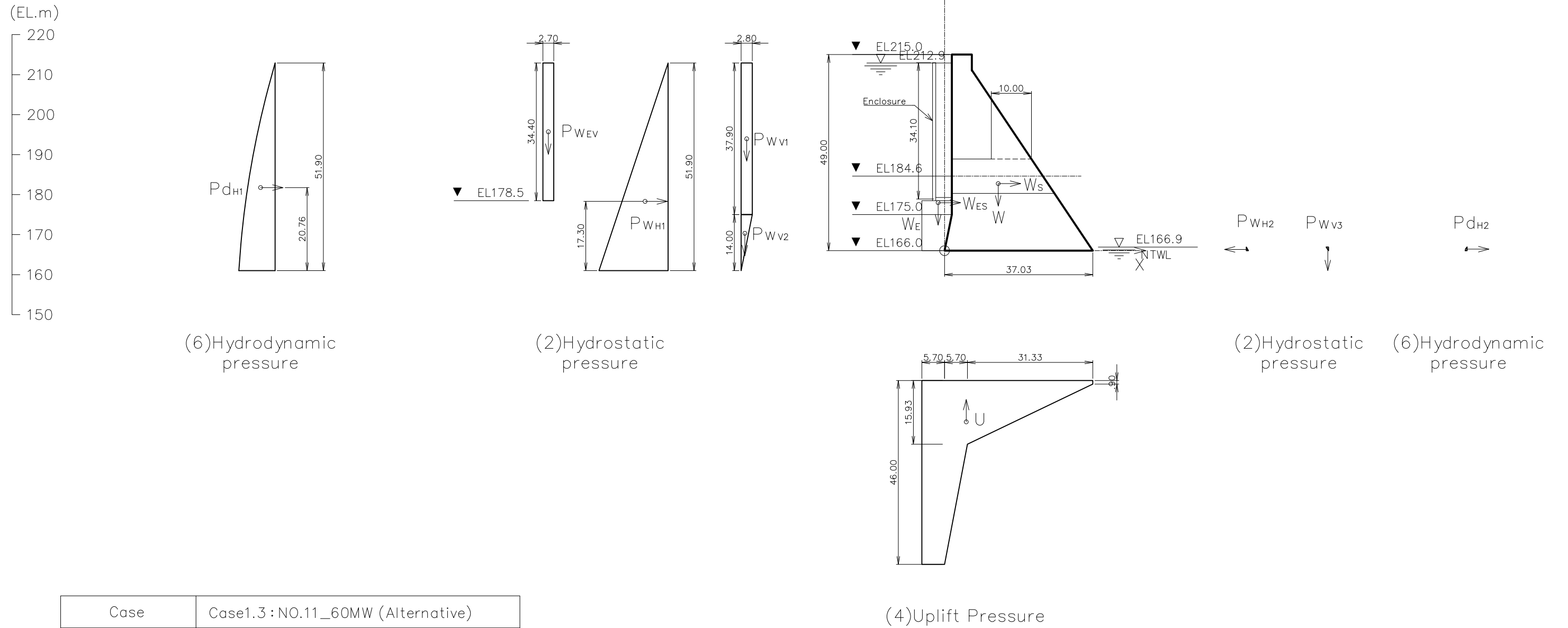
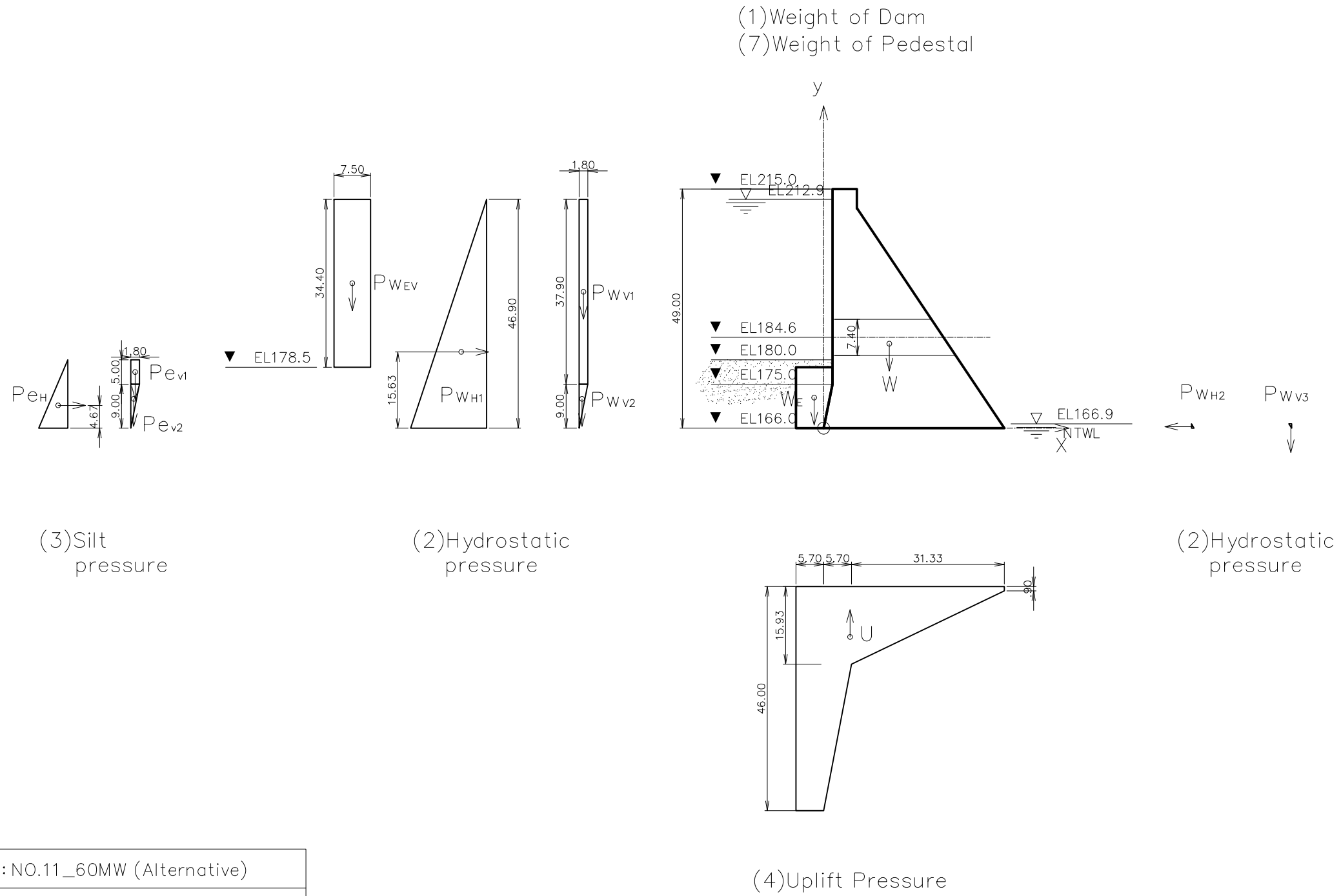


Figure Load Condition (Case1.3\_B-III)

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



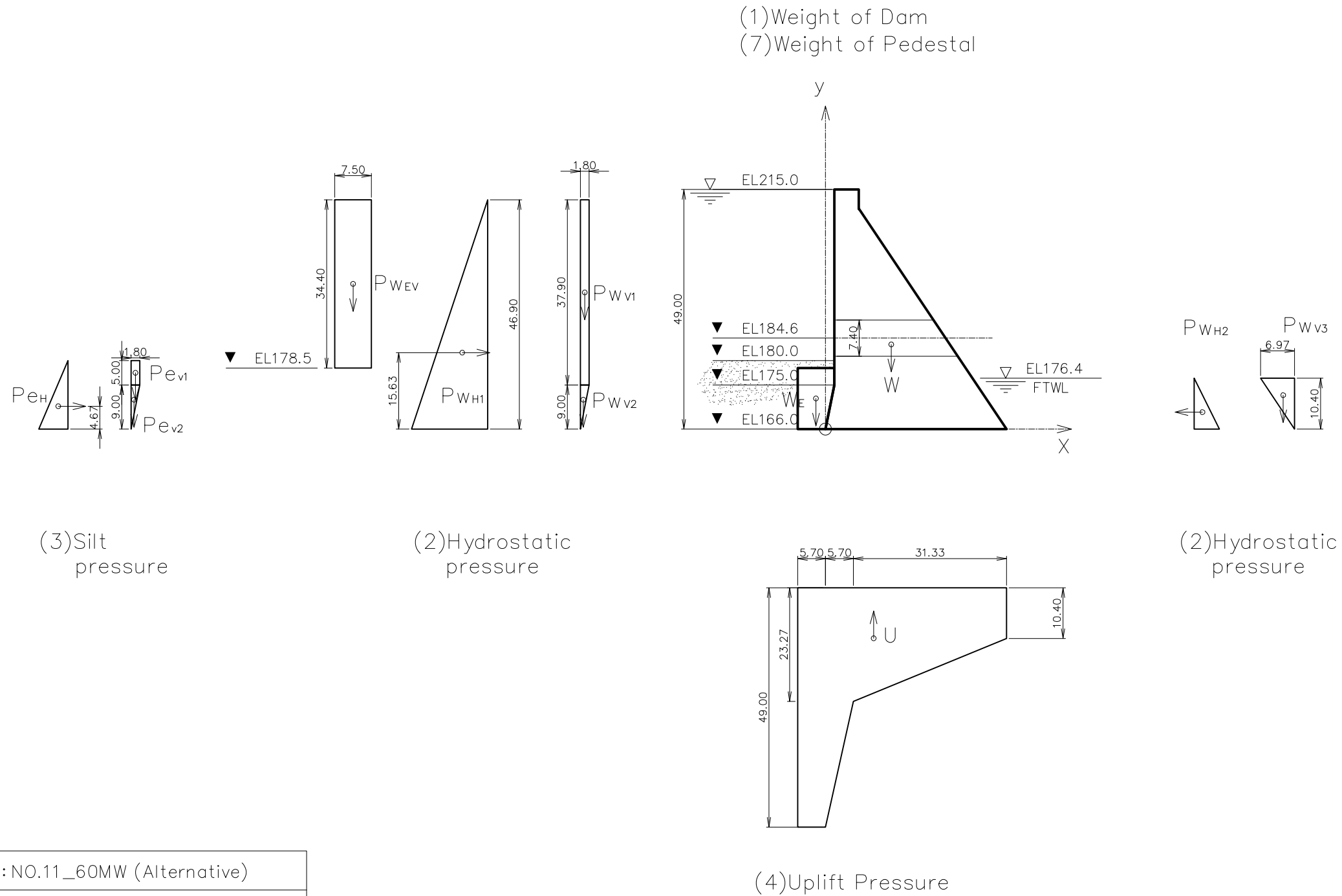
Case	Case1.3 : NO.11_60MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C- I : Usual

Figure Load Condition (Case1.3\_C- I)

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



Case	Case1.3 : NO.11_60MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C- II : Flood

Figure Load Condition (Case1.3\_C- II)

(Upstream Side)

(Downstream Side)

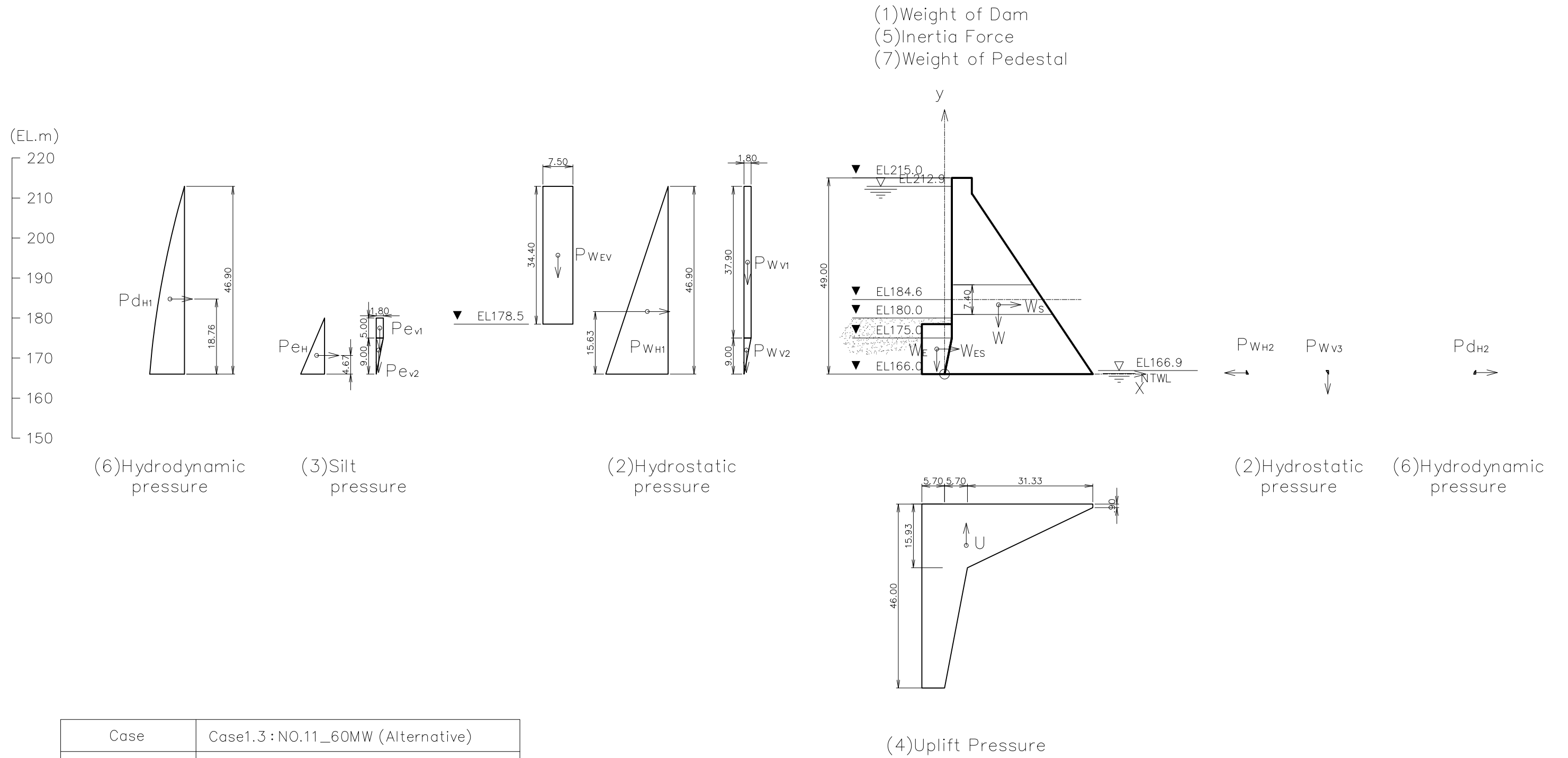
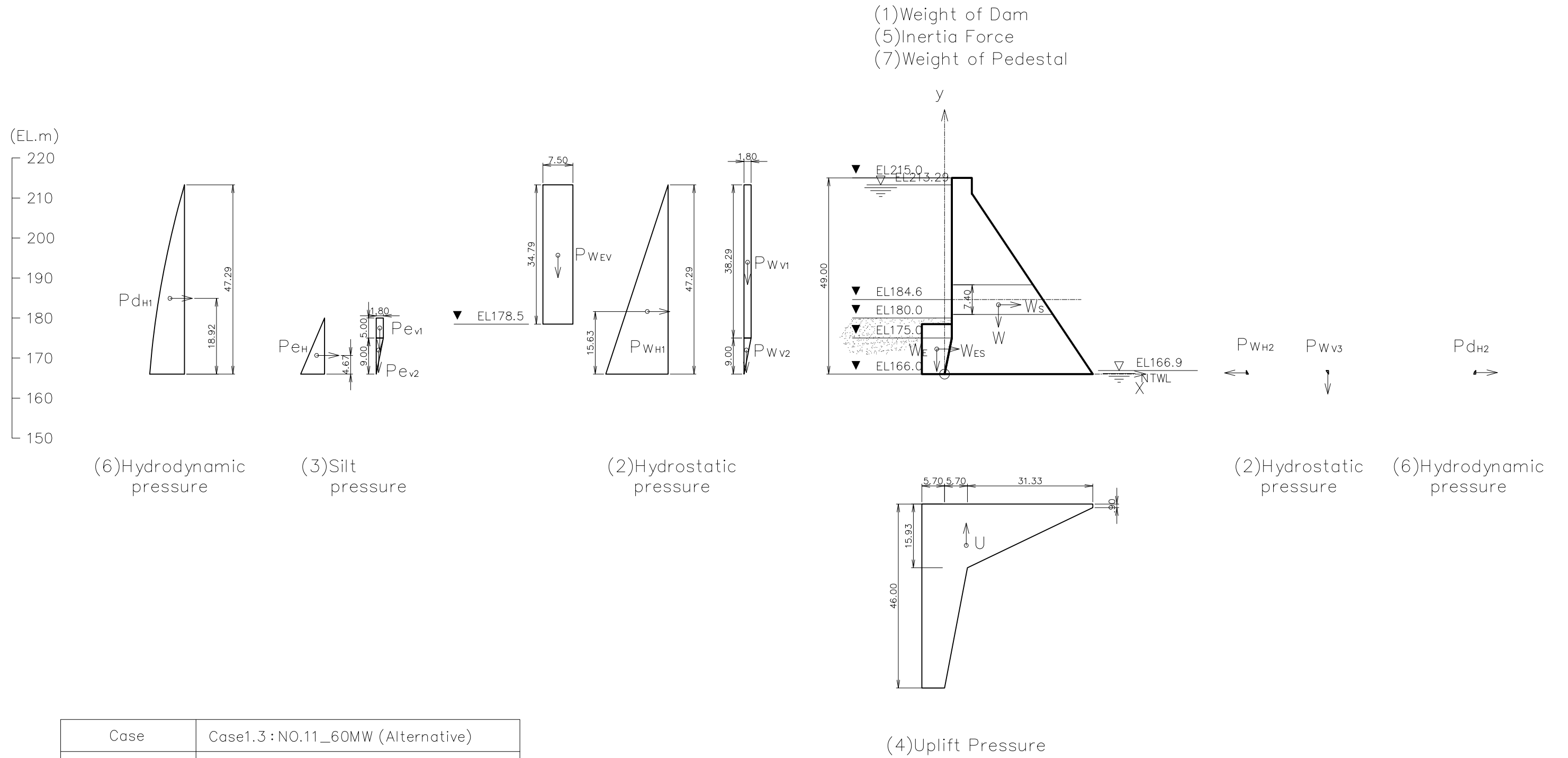


Figure Load Condition (Case1.3\_C-III)

(Upstream Side)

(Downstream Side)



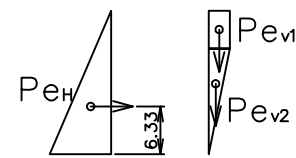
Case	Case1.3 : NO.11_60MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C-IV : Earthquake (k=0.215)

Figure Load Condition (Case1.3\_C-IV)

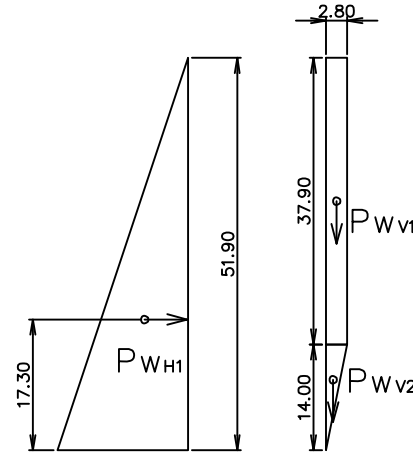
(Upstream Side)

(Downstream Side)

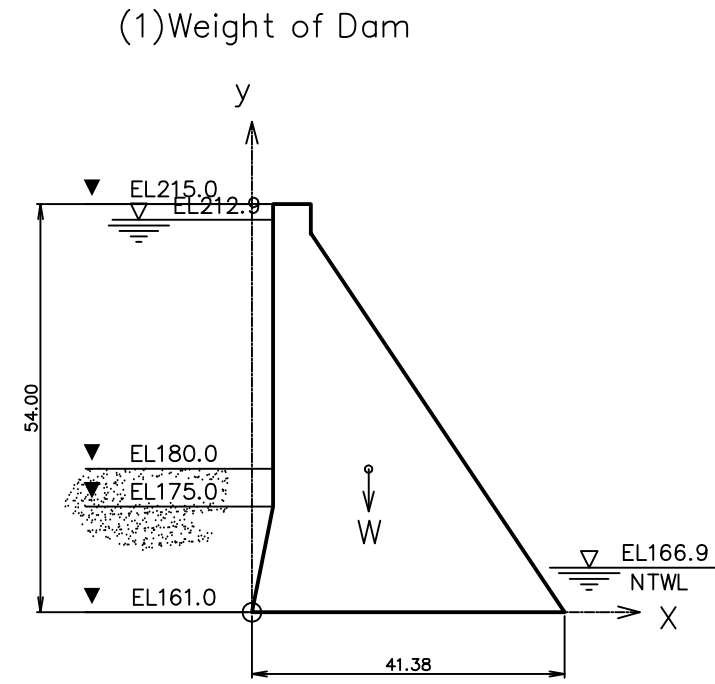
(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



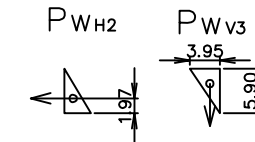
(3) Silt pressure



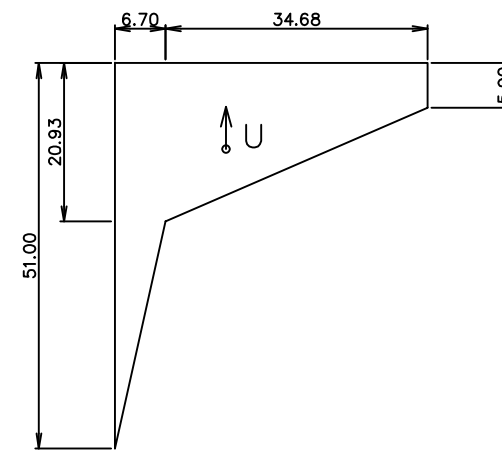
(2) Hydrostatic pressure



(1) Weight of Dam



(2) Hydrostatic pressure



(4) Uplift Pressure

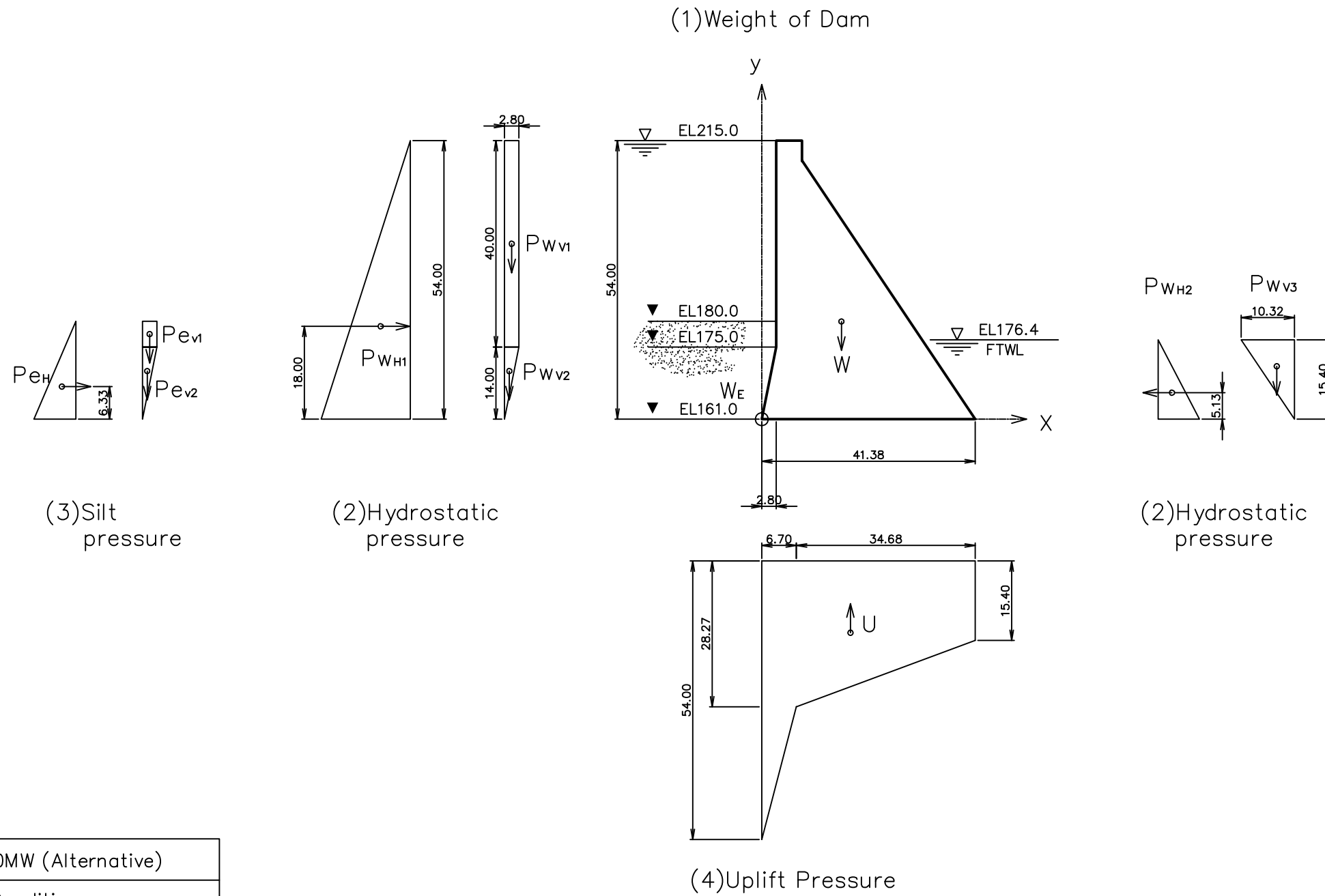
Case	Case1.4 : NO.20_60MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- I : Usual

Figure Load Condition (Case1.4\_A- I )

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150

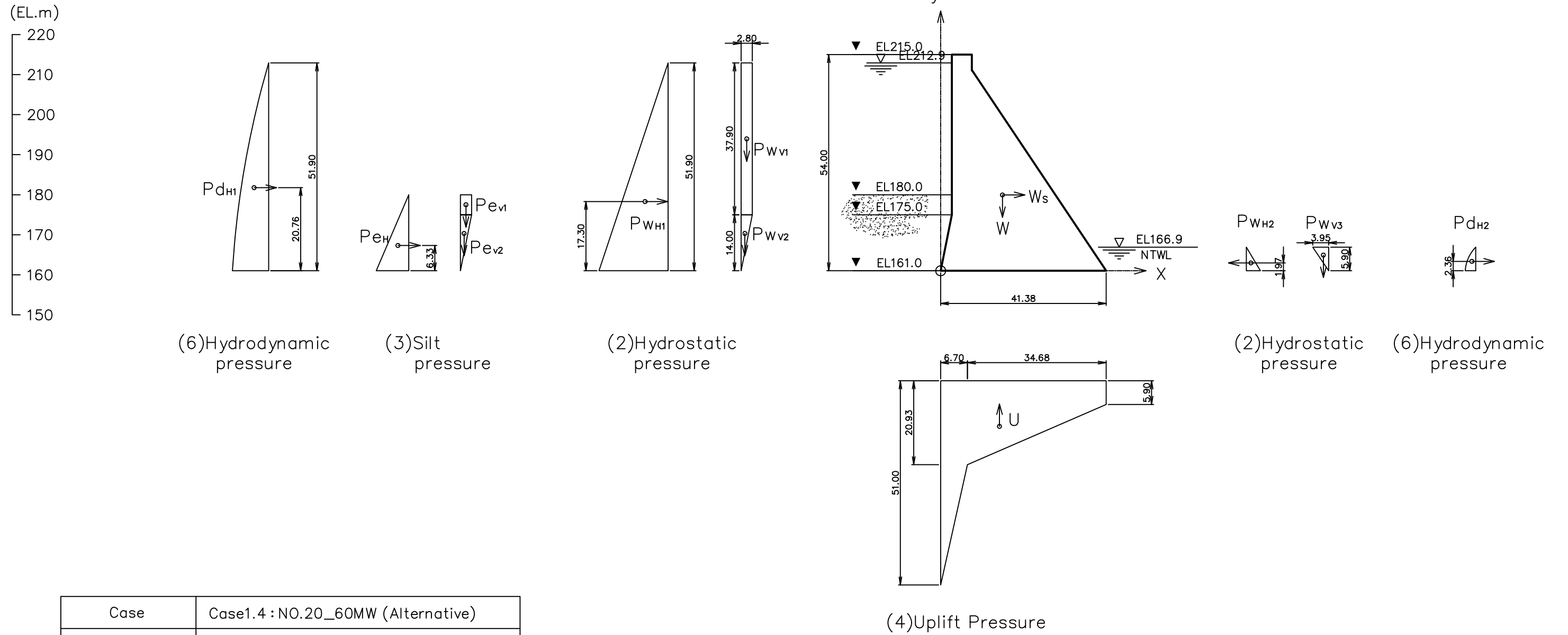


Case	Case1.4 : NO.20_60MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A- II : Flood

Figure Load Condition (Case1.4\_A- II)

(Upstream Side)

(Downstream Side)



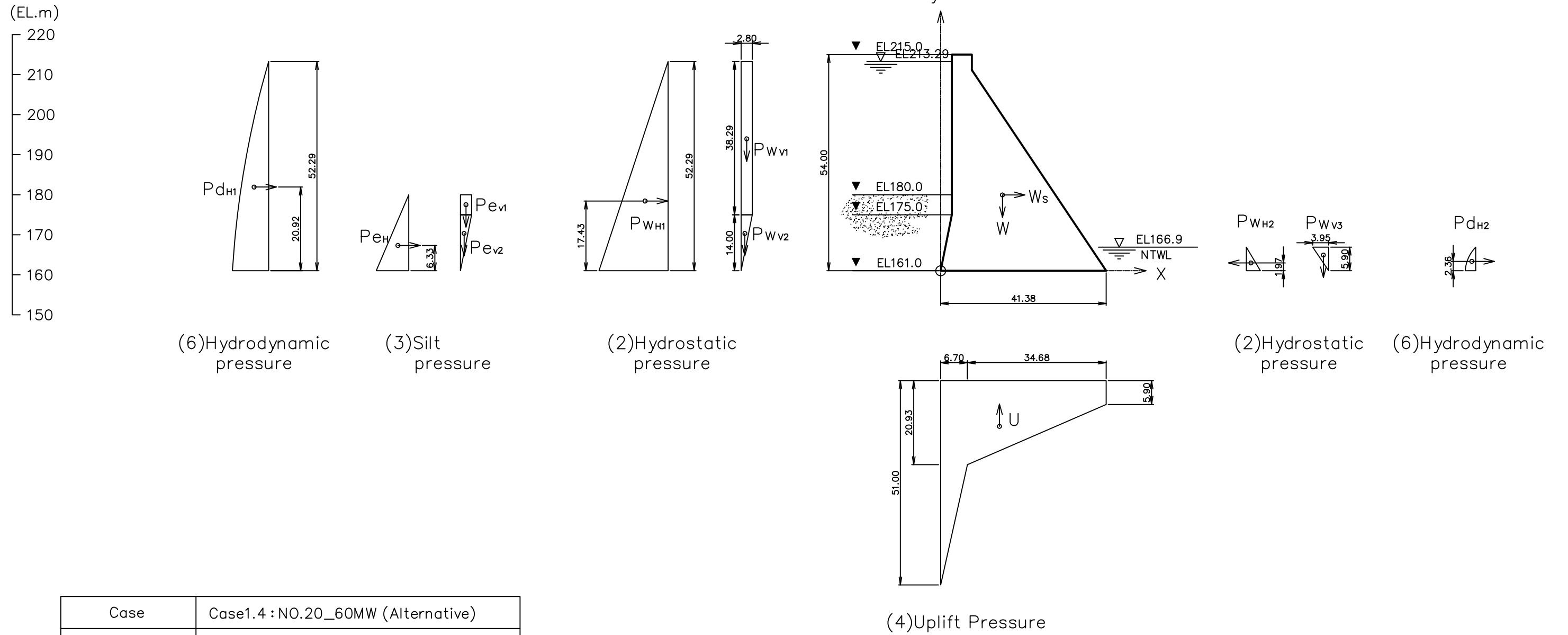
Case	Case1.4 : NO.20_60MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A-III : Earthquake (k=0.061)

Figure Load Condition (Case1.4\_A-III)



(Upstream Side)

(Downstream Side)



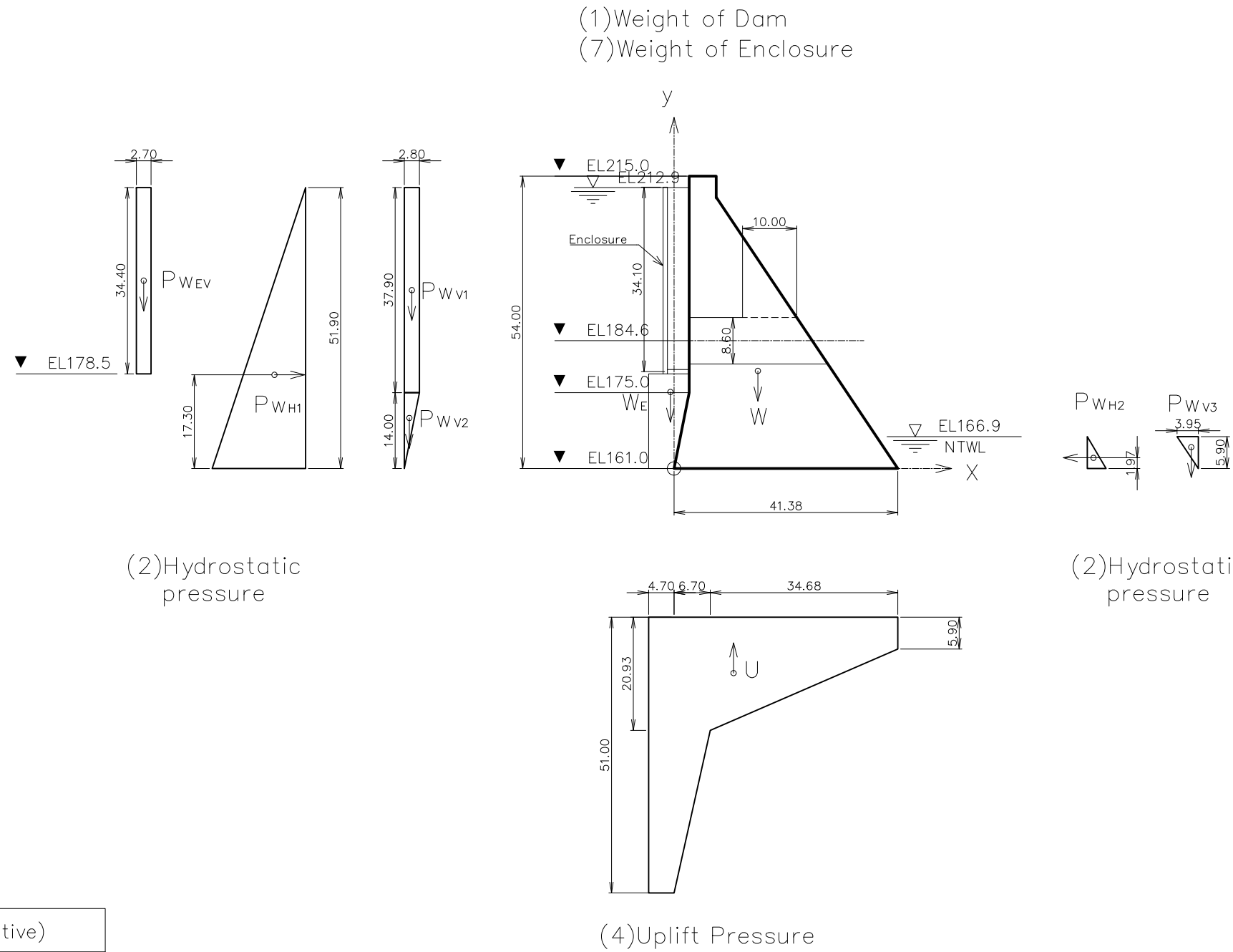
Case	Case1.4 : NO.20_60MW (Alternative)
Stage	Stage A : Current Condition
Load Condition	Load A-IV : Earthquake (k=0.215)

Figure Load Condition (Case1.4\_A-IV)

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



Case	Case1.4 : NO.20_60MW (Alternative)
Stage	Stage B : During Construction
Load Condition	Load B- I : Usual

Figure Load Condition (Case1.4\_B- I)

(Upstream Side)

(Downstream Side)

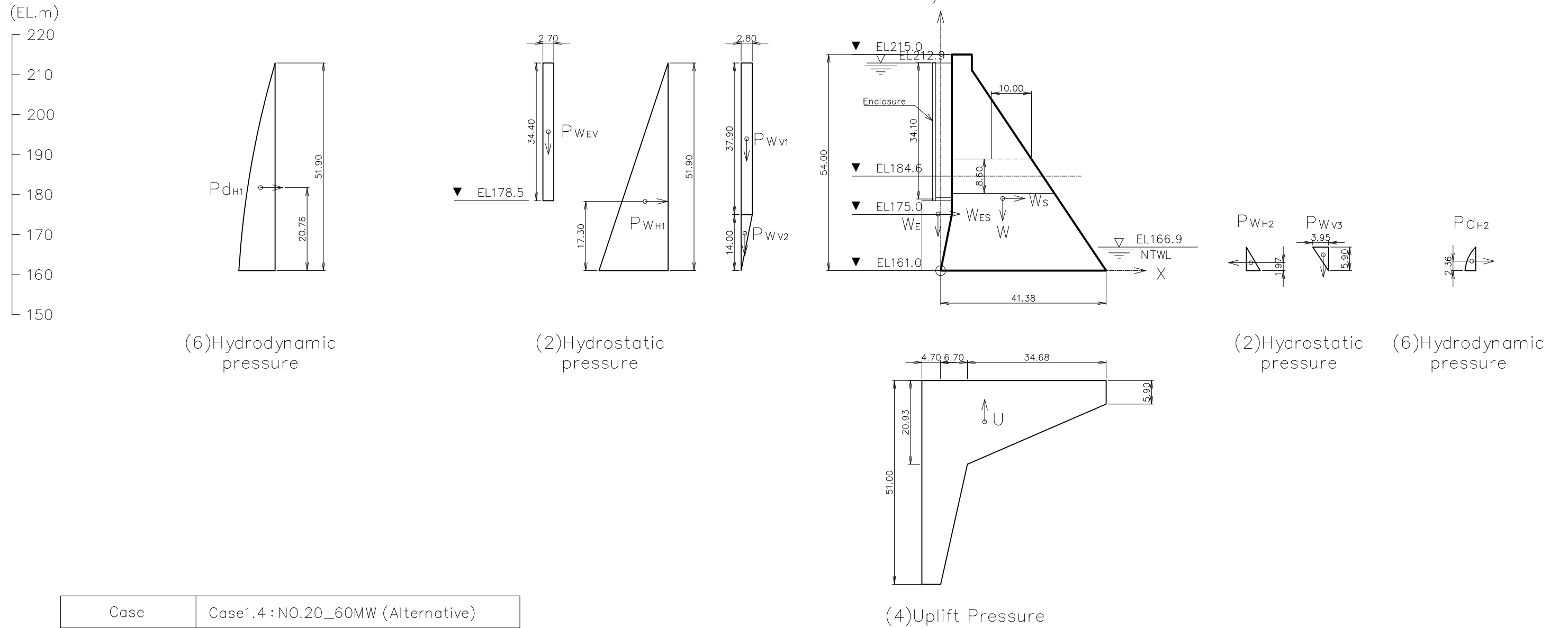


Figure Load Condition (Case1.4\_B-III)

(Upstream Side)

(Downstream Side)

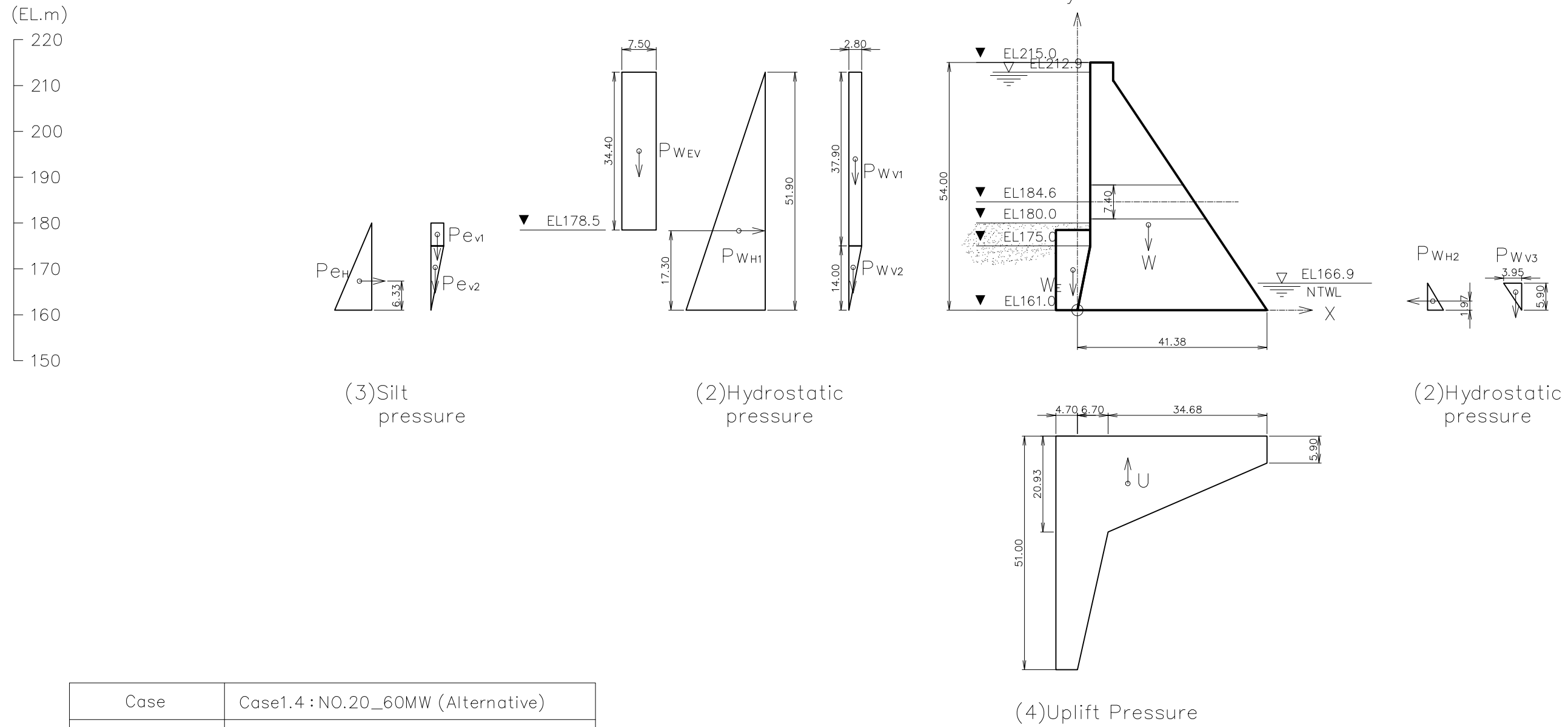
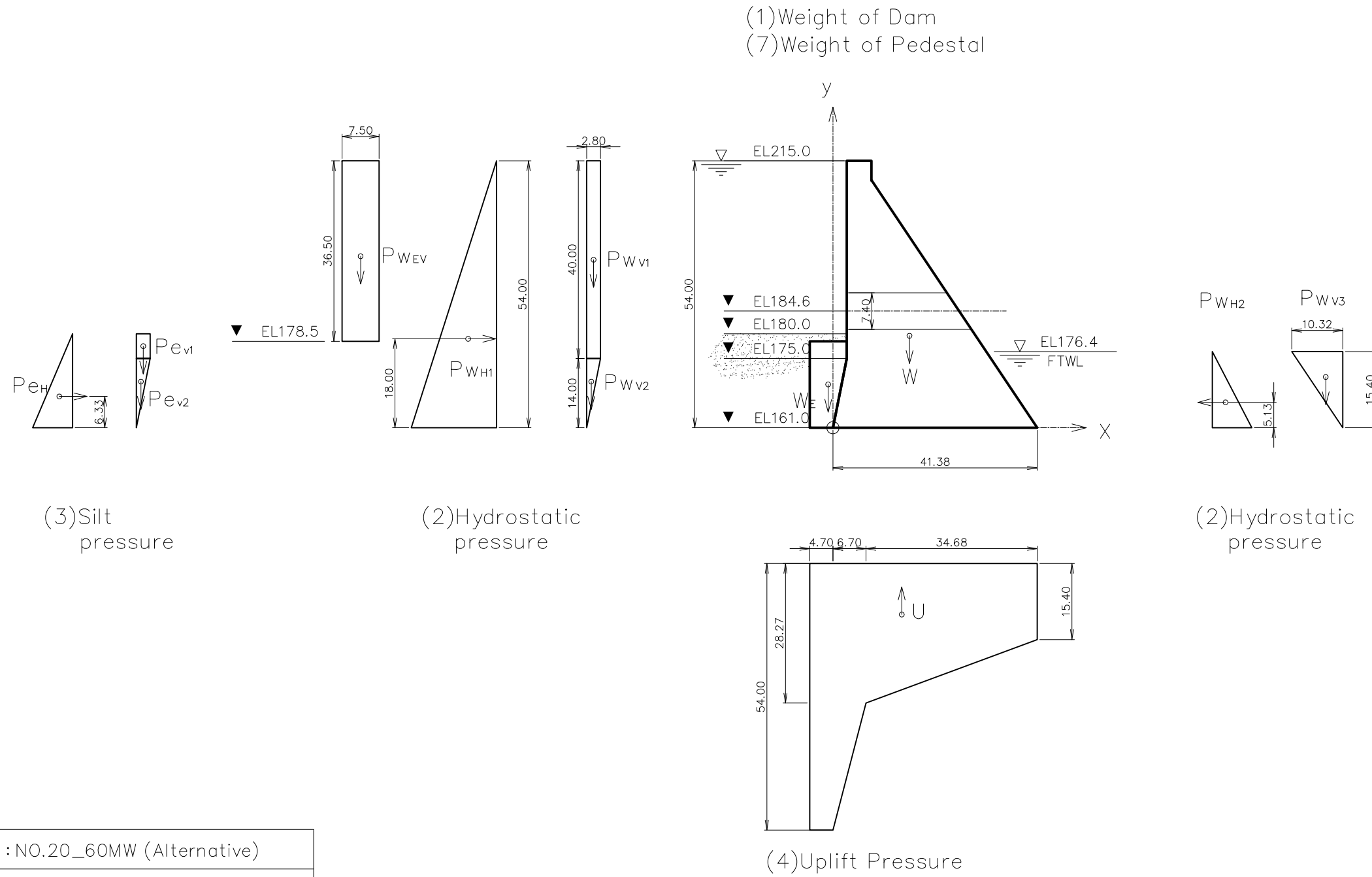


Figure Load Condition (Case1.4\_C- I)

(Upstream Side)

(Downstream Side)

(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



Case	Case1.4 : NO.20_60MW (Alternative)
Stage	Stage C : After Completion
Load Condition	Load C- II : Flood

Figure Load Condition (Case1.4\_C-II)

(Upstream Side)

(Downstream Side)

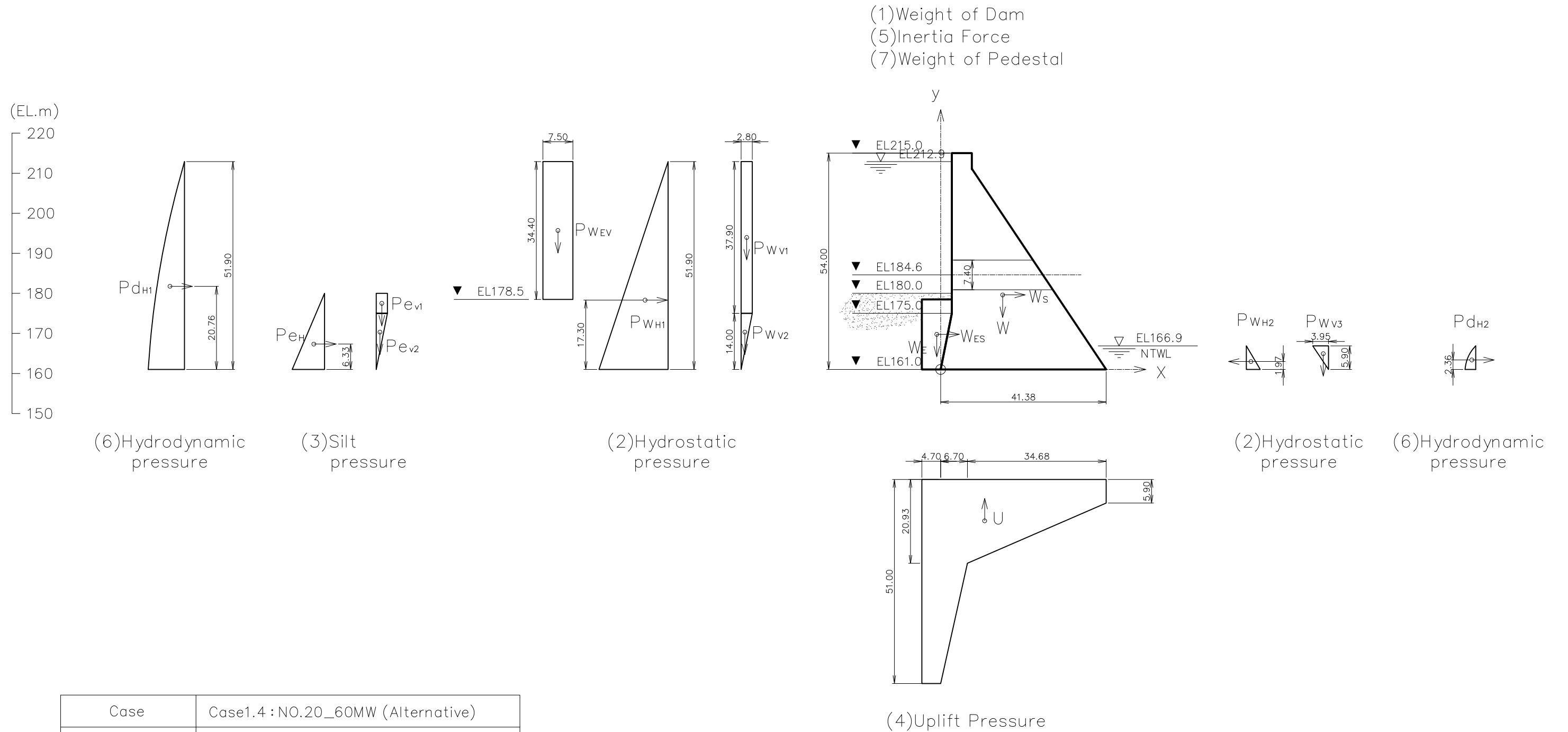


Figure Load Condition (Case1.4\_C-III)

(Upstream Side)

(Downstream Side)

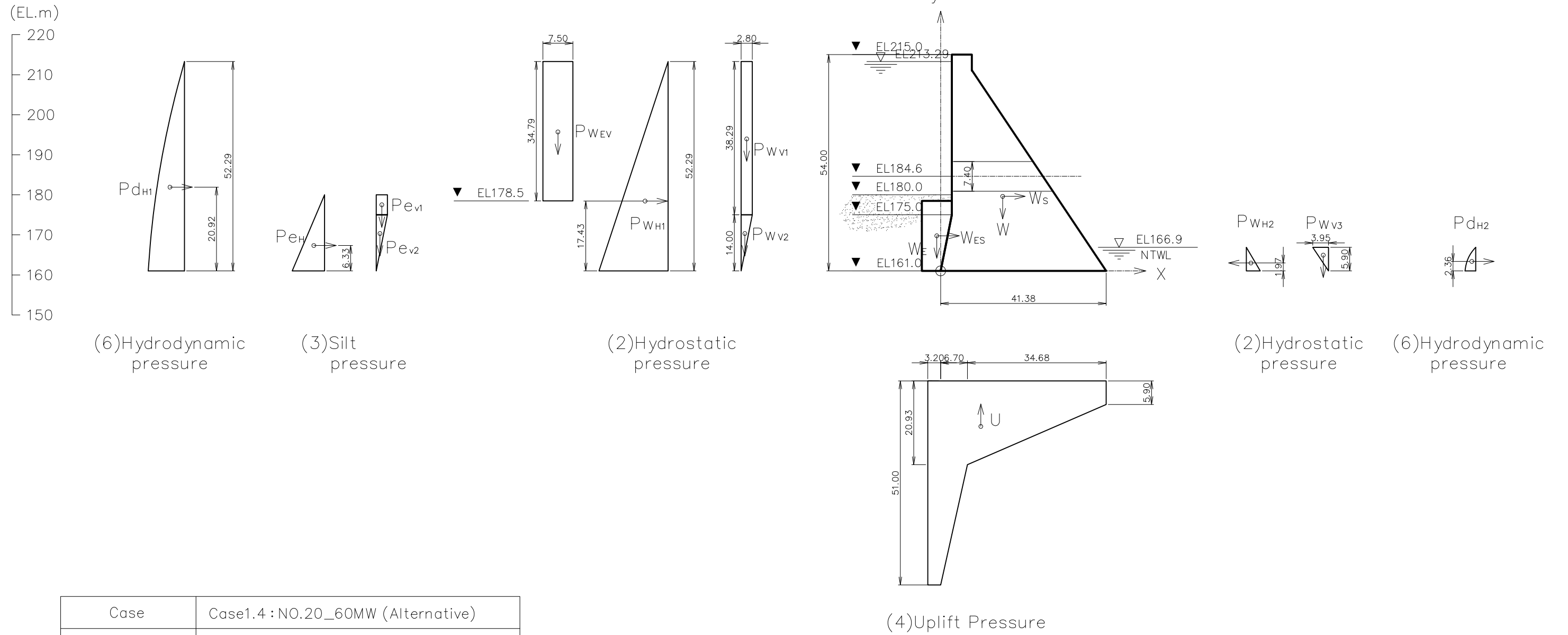
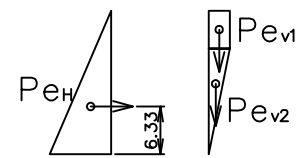


Figure Load Condition (Case1.4\_C-IV)

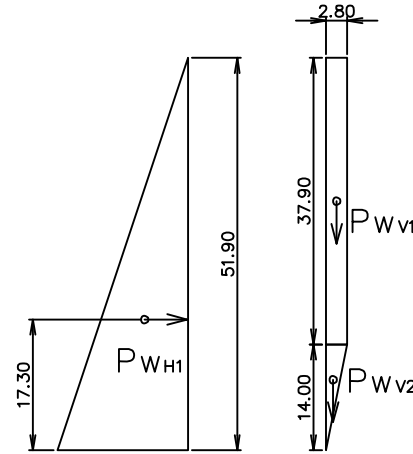
(Upstream Side)

(Downstream Side)

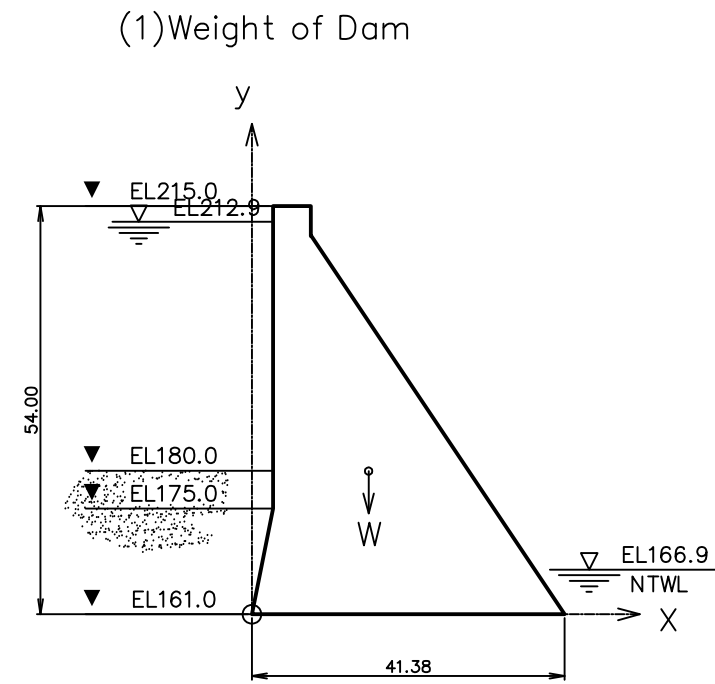
(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



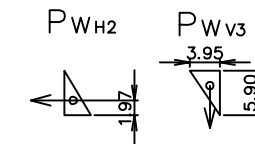
(3) Silt pressure



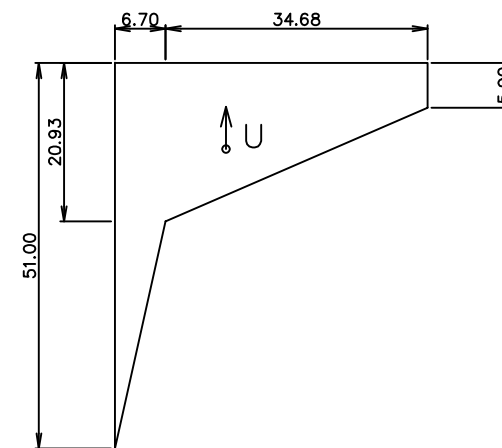
(2) Hydrostatic pressure



(1) Weight of Dam



(2) Hydrostatic pressure



(4) Uplift Pressure

Case	Case2 : NO.20_40MW (Optimum Plan)
Stage	Stage A : Current Condition
Load Condition	Load A- I : Usual

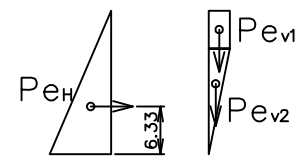
Figure Load Condition (Case2\_A- I )



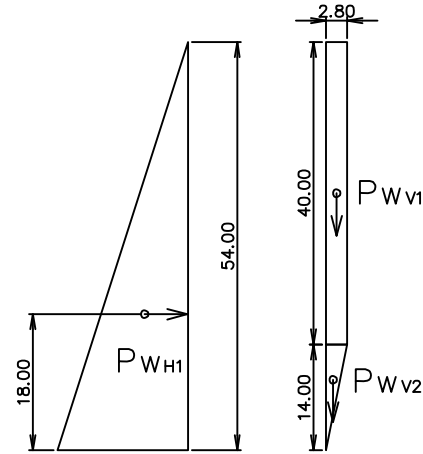
(Upstream Side)

(Downstream Side)

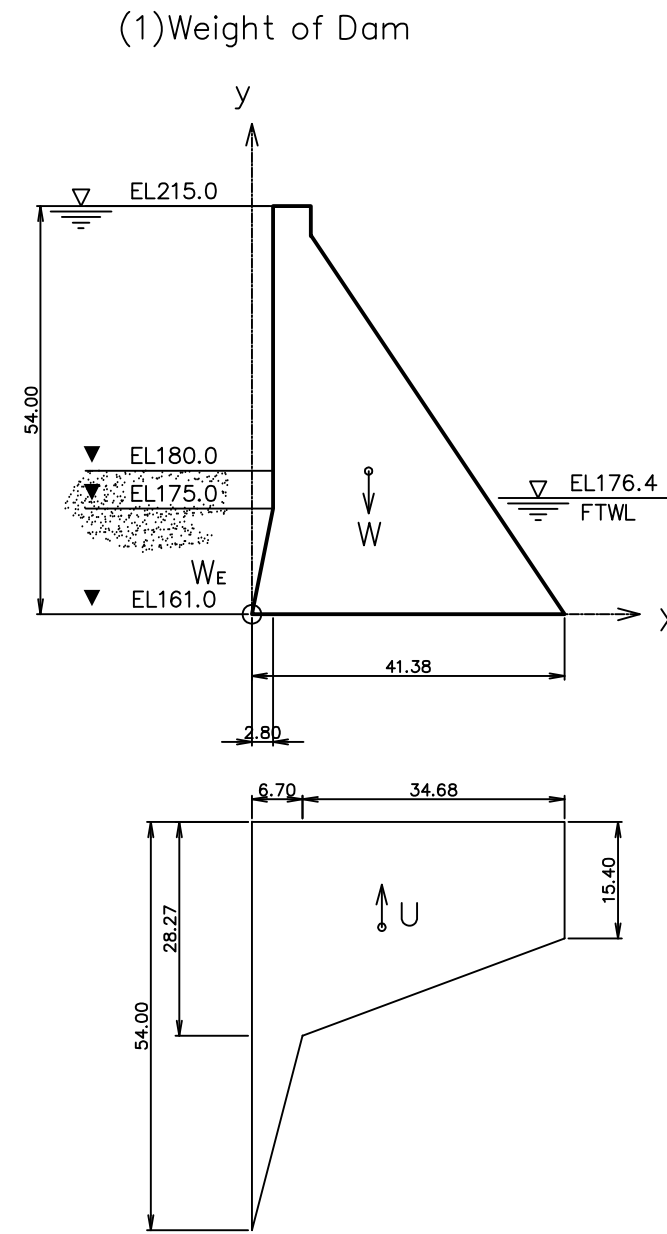
(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



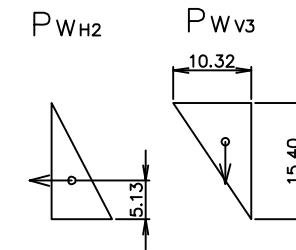
(3) Silt pressure



(2) Hydrostatic pressure



(1) Weight of Dam



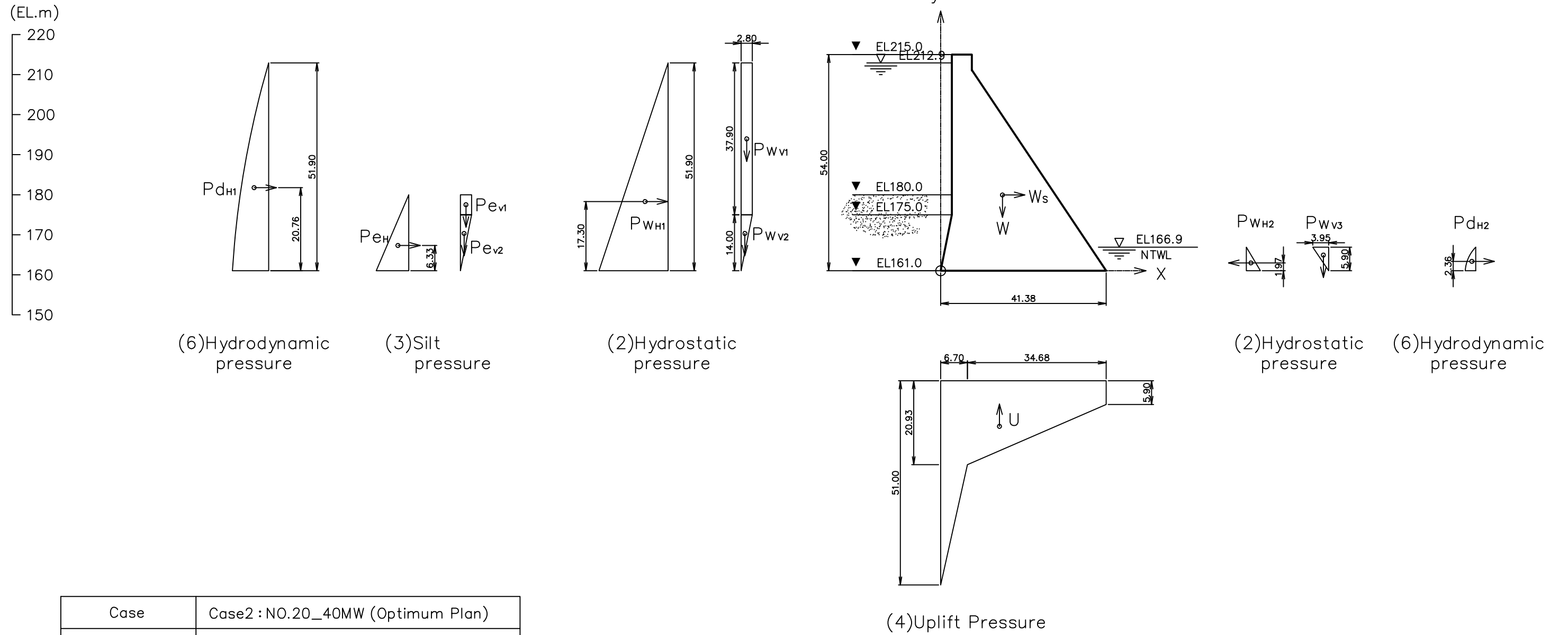
(2) Hydrostatic pressure

Case	Case2 : NO.20_40MW (Optimum Plan)
Stage	Stage A : Current Condition
Load Condition	Load A- II : Flood

Figure Load Condition (Case2\_A- II)

(Upstream Side)

(Downstream Side)



Case	Case2 : NO.20_40MW (Optimum Plan)
Stage	Stage A : Current Condition
Load Condition	Load A-III : Earthquake (k=0.061)

Figure Load Condition (Case2\_A-III)

(Upstream Side)

(Downstream Side)

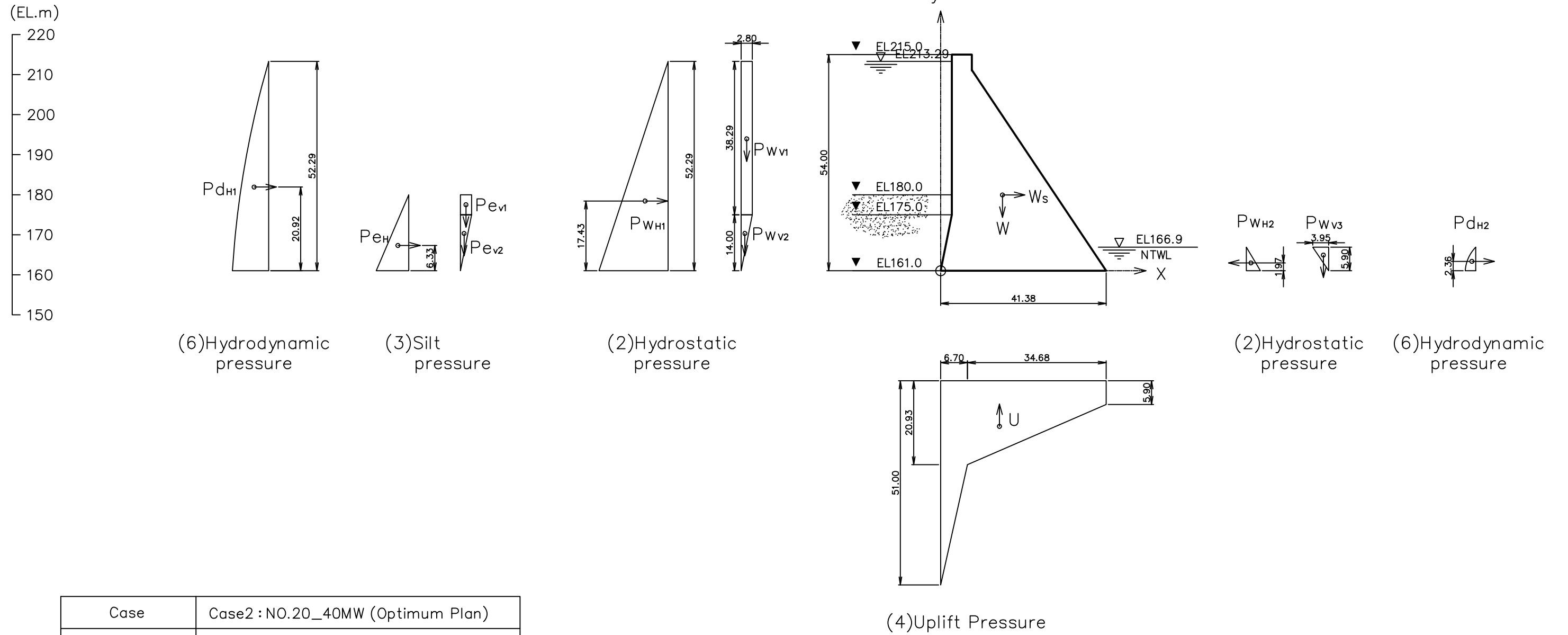
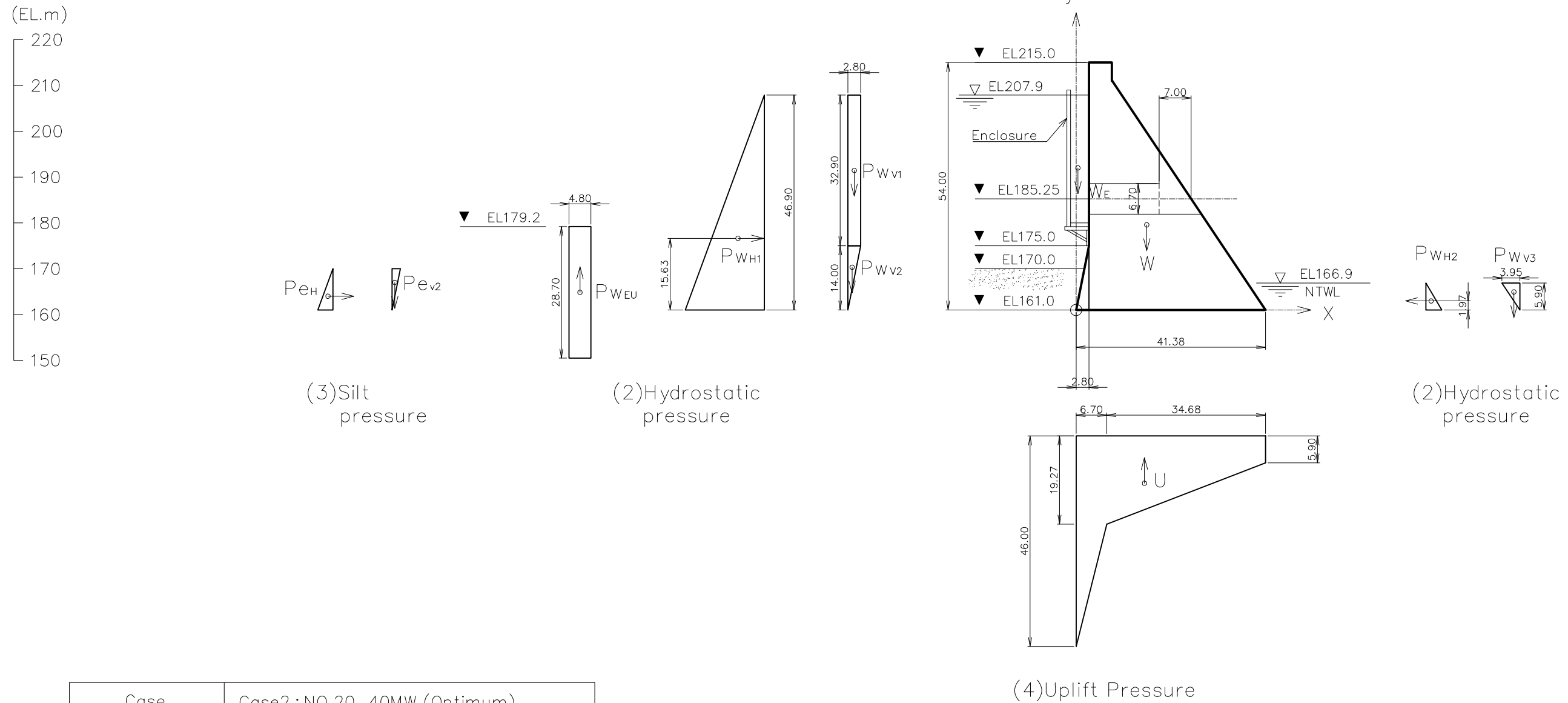


Figure Load Condition (Case2\_A-IV)

(Upstream Side)

(Downstream Side)



Case	Case2 : NO.20_40MW (Optimum)
Stage	Stage B : During Construction
Load Condition	Load B- I : Usual

Figure Load Condition (Case2\_B- I)

(Upstream Side)

(Downstream Side)

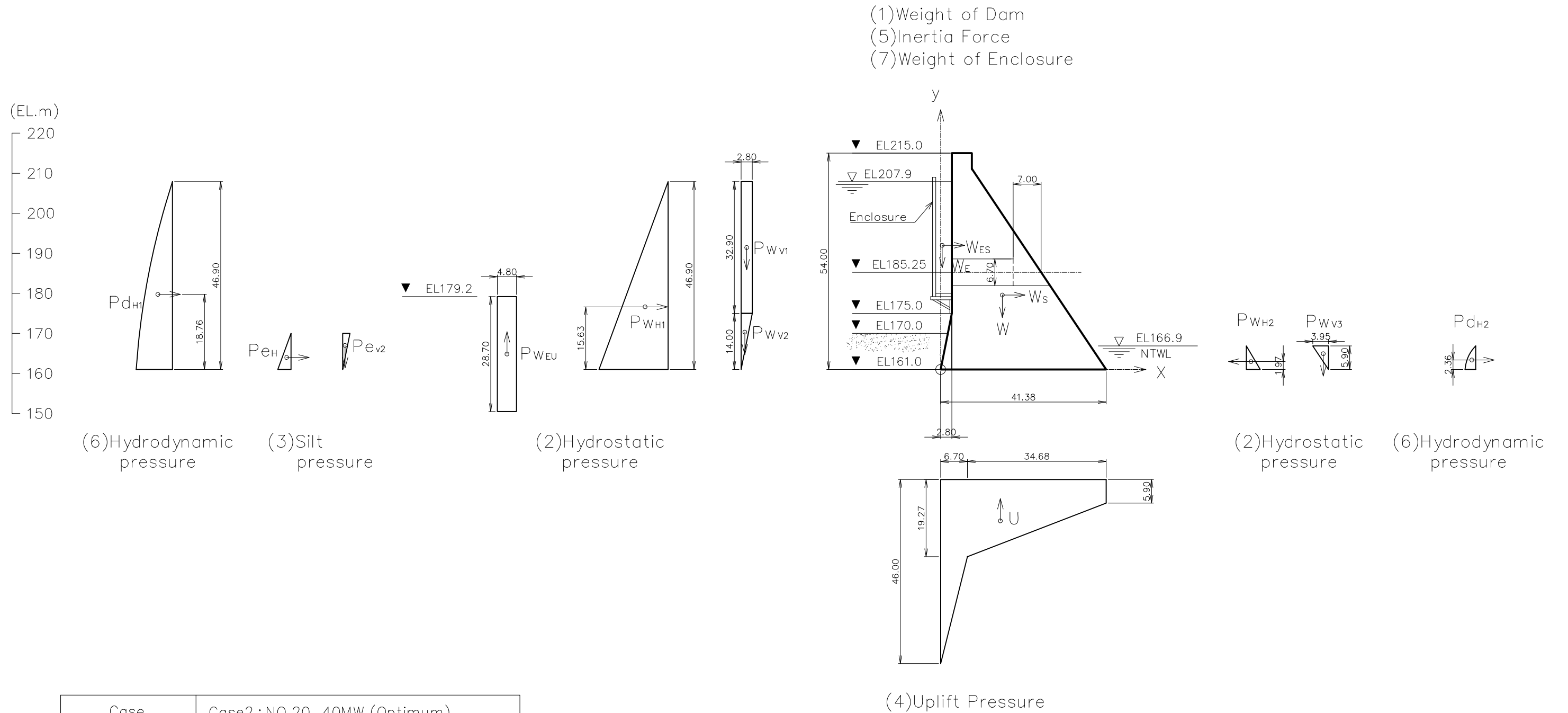
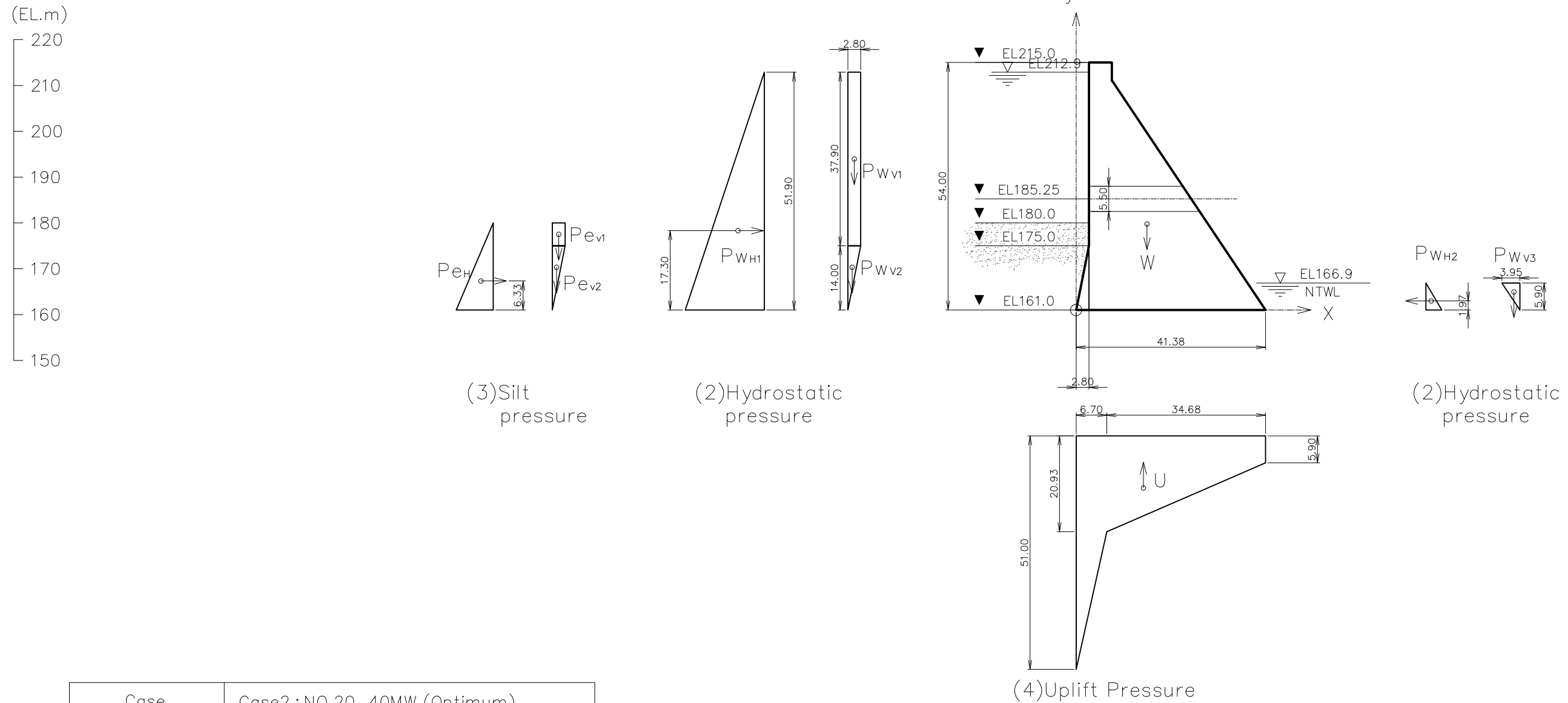


Figure Load Condition (Case2\_B-III)

(Upstream Side)

(Downstream Side)



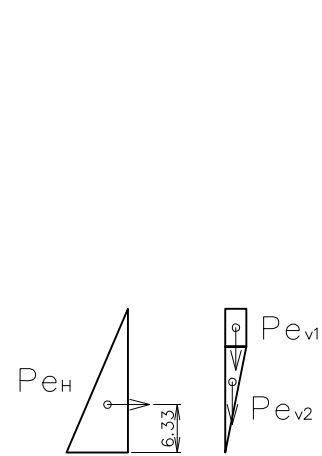
Case	Case2 : NO.20_40MW (Optimum)
Stage	Stage C : After Completion
Load Condition	Load C- I : Usual

Figure Load Condition (Case2\_C- I)

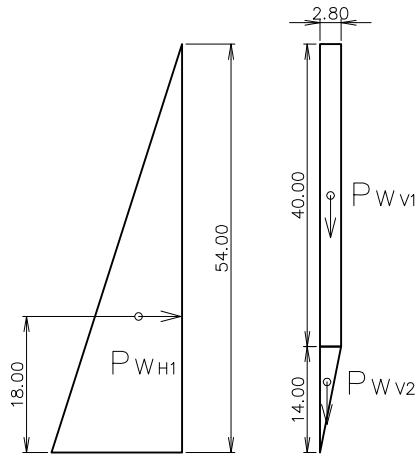
(Upstream Side)

(Downstream Side)

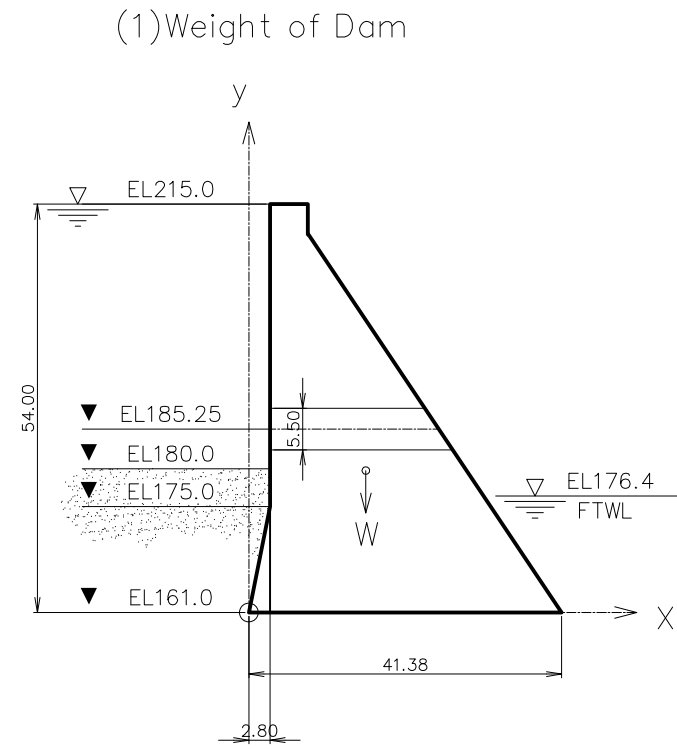
(EL.m)  
220  
210  
200  
190  
180  
170  
160  
150



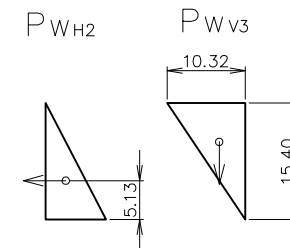
(3) Silt pressure



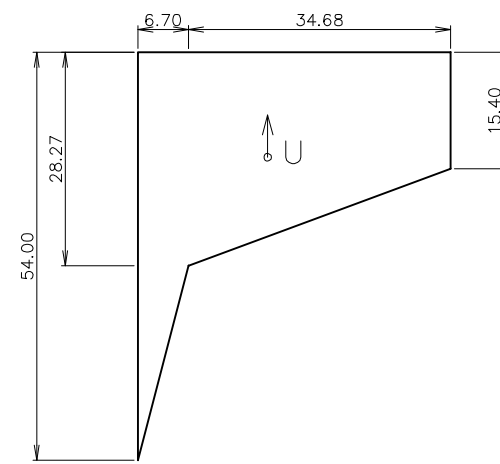
(2) Hydrostatic pressure



(1) Weight of Dam



(2) Hydrostatic pressure



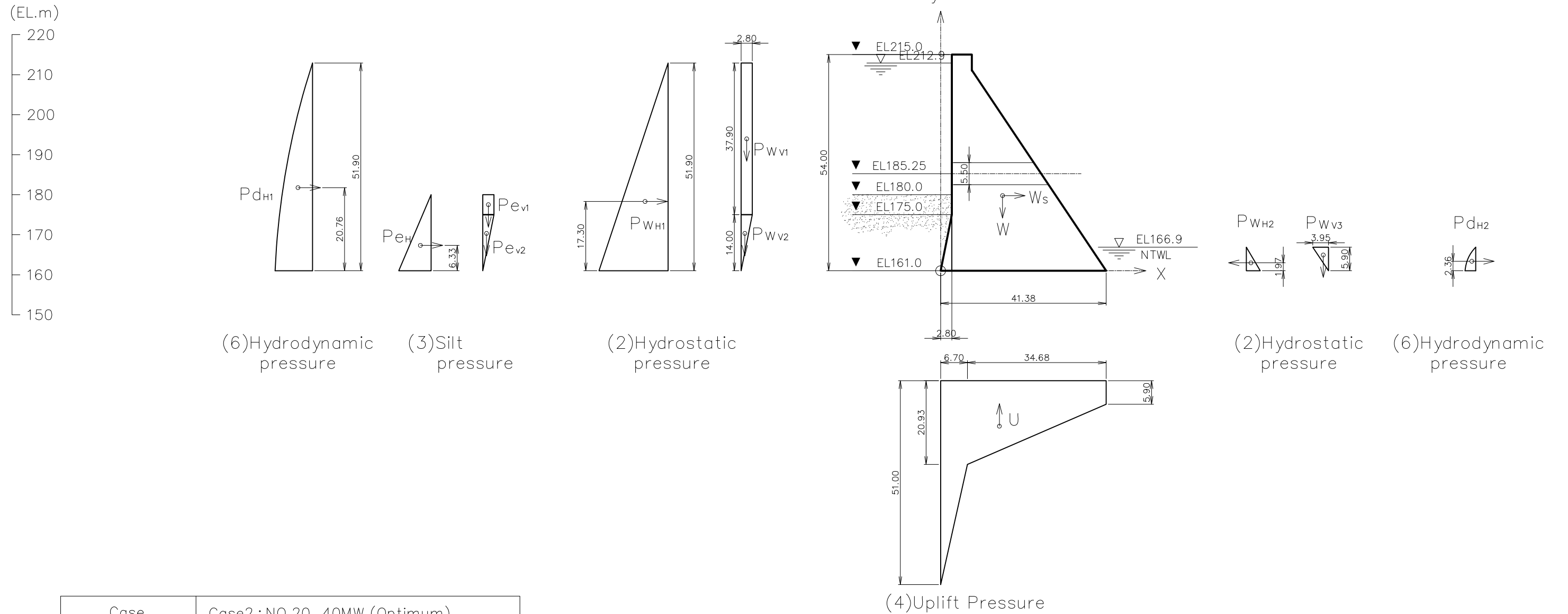
(4) Uplift Pressure

Case	Case2 : NO.20_40MW (Optimum)
Stage	Stage C : After Completion
Load Condition	Load C- II : Flood

Figure Load Condition (Case2\_C-II)

(Upstream Side)

(Downstream Side)



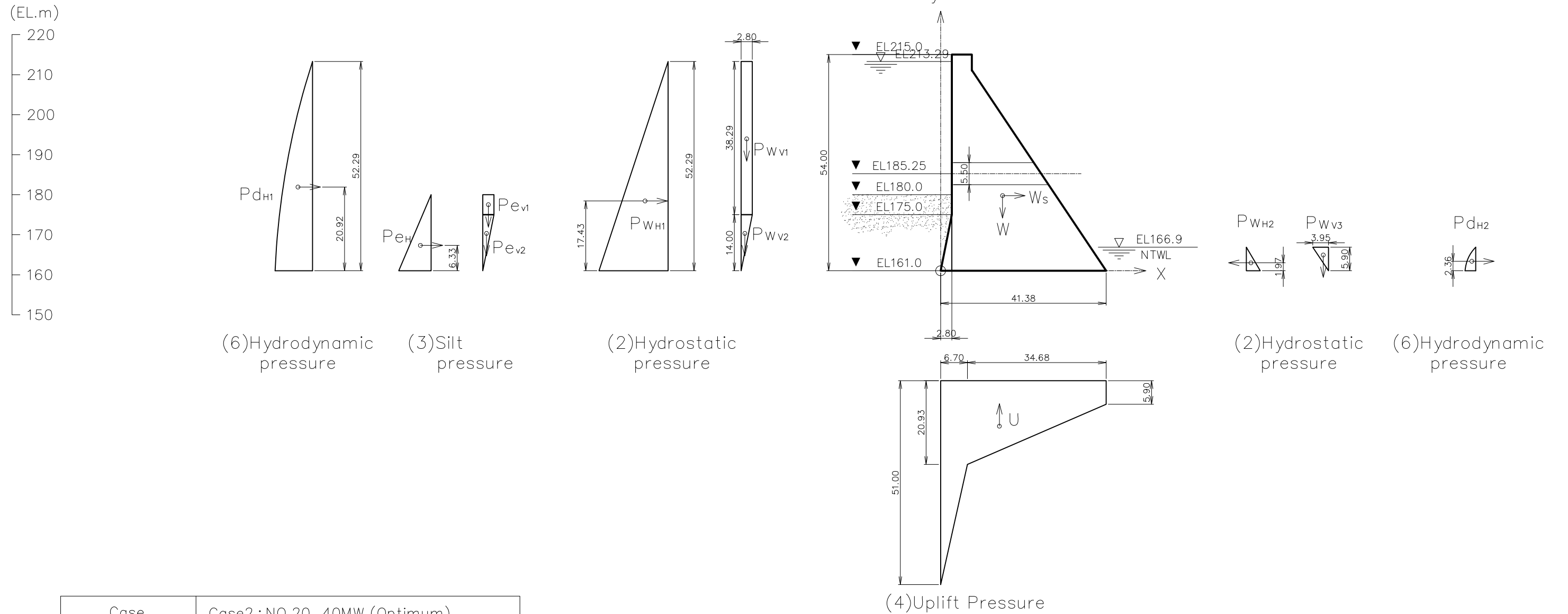
Case	Case2 : NO.20_40MW (Optimum)
Stage	Stage C : After Completion
Load Condition	Load C-III : Earthquake (k=0.061)

Figure Load Condition (Case2\_C-III)



(Upstream Side)

(Downstream Side)



Case	Case2 : NO.20_40MW (Optimum)
Stage	Stage C : After Completion
Load Condition	Load C-IV : Earthquake (k=0.215)

Figure Load Condition (Case2\_C-IV)

THE PREPARATORY SURVEY  
ON  
EXPANSION OF NAM NGUM 1 HYDROPOWER STATION  
IN  
LAO PEOPLE'S DEMOCRATIC REPUBLIC  
**DRAFT FINAL REPORT**

Appendices

Appendix F-3 Calculations of Load

## Calculation of Load ( Case1.1\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,178.74		13.45		29,304.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,000.82		15.63	15,642.8
Upstream Vertical Load $P_{WV1}$	62.08		0.90		55.9
Upstream Vertical Load $P_{WV2}$	7.37		0.60		4.4
Uplift for Enclosure --					
Downstream Horizontal Load $P_{WH2}$		-0.41		0.30	-0.1
Downstream Vertical Load $P_{WV3}$	0.27		36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		26.75		4.67	124.9
Upstream Vertical Load $P_{eV1}$	2.46		0.90		2.2
Upstream Vertical Load $P_{eV2}$	2.21		0.60		1.3
(4)Uplift Pressure U	-440.21		10.96		-4,824.7
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	1,812.9	1,027.2			40,320.7
$x_o = M/ V$					22.24

## Calculation of Load ( Case1.1\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,178.74		13.45		29,304.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,092.46		16.33	17,839.9
Upstream Vertical Load $P_{WV1}$	65.52		0.90		59.0
Upstream Vertical Load $P_{WV2}$	7.37		0.60		4.4
Uplift for Enclosure --					
Downstream Horizontal Load $P_{WH2}$		-54.08		3.47	-187.7
Downstream Vertical Load $P_{WV3}$	36.23		34.71		1,257.5
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		26.75		4.67	124.9
Upstream Vertical Load $P_{eV1}$	2.46		0.90		2.2
Upstream Vertical Load $P_{eV2}$	2.21		0.60		1.3
(4)Uplift Pressure U	-733.35		14.64		-10,736.2
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	1,559.2	1,065.1			37,669.4
$x_o = M/ V$					24.16

## Calculation of Load ( Case1.1\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,178.74	13.45		29,304.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>W<sub>H1</sub></sub>	1,000.82		15.63	15,642.8
Upstream Vertical Load	P <sub>W<sub>V1</sub></sub>	62.08	0.90		55.9
Upstream Vertical Load	P <sub>W<sub>V2</sub></sub>	7.37	0.60		4.4
Uplift for Enclosure	--				0.0
Downstream Horizontal Load	P <sub>W<sub>H2</sub></sub>	-0.41		0.30	-0.1
Downstream Vertical Load	P <sub>W<sub>V3</sub></sub>	0.27	36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>e<sub>H</sub></sub>	26.75		4.67	124.9
Upstream Vertical Load	P <sub>e<sub>V1</sub></sub>	2.46	0.90		2.2
Upstream Vertical Load	P <sub>e<sub>V2</sub></sub>	2.21	0.60		1.3
(4)Uplift Pressure	U	-440.21	10.96		-4,824.7
(5)Inertia Force					
Dam	W <sub>s</sub>	132.90		17.41	2,313.8
Enclosure	--	0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>d<sub>H1</sub></sub>	71.23		18.76	1,336.3
Downstream Horizontal Load	P <sub>d<sub>H2</sub></sub>	0.03		0.36	0.0
(7)Weight of Enclosure	--				0.0
Total		1,812.92	1,231.32		43,970.8
xo = M/ V					24.25

## Calculation of Load ( Case1.1\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,178.74	13.45		29,304.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>W<sub>H1</sub></sub>	1,000.82		15.63	15,642.8
Upstream Vertical Load	P <sub>W<sub>V1</sub></sub>	62.08	0.90		55.9
Upstream Vertical Load	P <sub>W<sub>V2</sub></sub>	7.37	0.60		4.4
Uplift for Enclosure	--				0.0
Downstream Horizontal Load	P <sub>W<sub>H2</sub></sub>	-0.41		0.30	-0.1
Downstream Vertical Load	P <sub>W<sub>V3</sub></sub>	0.27	36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>e<sub>H</sub></sub>	26.75		4.67	124.9
Upstream Vertical Load	P <sub>e<sub>V1</sub></sub>	2.46	0.90		2.2
Upstream Vertical Load	P <sub>e<sub>V2</sub></sub>	2.21	0.60		1.3
(4)Uplift Pressure	U	-440.21	10.96		-4,824.7
(5)Inertia Force					
Dam	W <sub>s</sub>	468.43		17.41	8,155.4
Enclosure	--	0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>d<sub>H1</sub></sub>	251.04		18.76	4,709.5
Downstream Horizontal Load	P <sub>d<sub>H2</sub></sub>	0.10		0.36	0.0
(7)Weight of Enclosure	--				0.0
Total		1,812.92	1,746.73		53,185.7
xo = M/ V					29.34

## Calculation of Load ( Case1.1\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	1,933.99	13.46		26,031.5
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,000.82		15.63	15,642.8
Upstream Vertical Load	P <sub>WV1</sub>	4.97	0.90		4.5
Upstream Vertical Load	P <sub>WV2</sub>	0.59	0.60		0.4
Uplift for Enclosure	P <sub>WEU</sub>	32.85	-3.60		-118.3
Downstream Horizontal Load	P <sub>WH2</sub>	-0.41		0.30	-0.1
Downstream Vertical Load	P <sub>WV3</sub>	0.27	36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>EH</sub>	0.00		0.00	0.0
Upstream Vertical Load	P <sub>EV1</sub>	0.00	0.00		0.0
Upstream Vertical Load	P <sub>EV2</sub>	0.00	0.00		0.0
(4)Uplift Pressure	U	-617.95	7.20		-4,449.2
(5)Inertia Force	--				
(6)Hydrodynamic Pressure	--				
(7)Weight of Enclosure	W <sub>E</sub>	200.50	-1.05		-210.5
Total		1,555.2	1,000.4		36,910.9
xo = M/ V					23.73

## Calculation of Load ( Case1.1\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	1,933.99	13.46		26,031.5
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,000.82		15.63	15,642.8
Upstream Vertical Load	P <sub>WV1</sub>	4.97	0.90		4.5
Upstream Vertical Load	P <sub>WV2</sub>	0.59	0.60		0.4
Vertical load for Enclosure	P <sub>WEU</sub>	32.85	-3.60		-118.3
Downstream Horizontal Load	P <sub>WH2</sub>	-0.41		0.30	-0.1
Downstream Vertical Load	P <sub>WV3</sub>	0.27	36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>EH</sub>	0.00		0.00	0.0
Upstream Vertical Load	P <sub>EV1</sub>	0.00	0.00		0.0
Upstream Vertical Load	P <sub>EV2</sub>	0.00	0.00		0.0
(4)Uplift Pressure	U	-617.95	7.20		-4,449.2
(5)Inertia Force					
Dam	W <sub>s</sub>	117.97		16.75	1,976.0
Enclosure	W <sub>s</sub>	12.23		13.07	159.9
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>dH1</sub>	71.23		18.76	1,336.3
Downstream Horizontal Load	P <sub>dH2</sub>	0.03		0.36	0.0
(7)Weight of Enclosure	W <sub>E</sub>	200.50	-1.05		-210.5
Total		1,555.22	1,201.87		40,383.1
xo = M/ V					25.97

## Calculation of Load ( Case1.1\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,065.08		13.49		27,857.9
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,000.82		15.63	15,642.8
Upstream Vertical Load $P_{WV1}$	4.97		0.90		4.5
Upstream Vertical Load $P_{WV2}$	0.59		0.60		0.4
Vertical load for Enclosure $P_{WEU}$	164.26		-1.20		-197.1
Downstream Horizontal Load $P_{WH2}$		-0.41		0.30	-0.1
Downstream Vertical Load $P_{WV3}$	0.27		36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		26.75		4.67	124.9
Upstream Vertical Load $P_{eV1}$	0.20		0.90		0.2
Upstream Vertical Load $P_{eV2}$	0.18		0.60		0.1
(4)Uplift Pressure U	-617.95		7.20		-4,449.2
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure $W_E$	149.60		-1.20		-179.5
Total	1,767.2	1,027.2			38,814.7
$x_o = M/ V$					21.96

## Calculation of Load ( Case1.1\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,065.08		13.49		27,857.9
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,092.46		16.33	17,839.9
Upstream Vertical Load $P_{WV1}$	5.24		0.90		4.7
Upstream Vertical Load $P_{WV2}$	0.59		0.60		0.4
Vertical load for Enclosure $P_{WEU}$	174.81		-1.20		-209.8
Downstream Horizontal Load $P_{WH2}$		-54.08		3.47	-187.7
Downstream Vertical Load $P_{WV3}$	36.23		34.71		1,257.5
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		26.75		4.67	124.9
Upstream Vertical Load $P_{eV1}$	0.20		0.90		0.2
Upstream Vertical Load $P_{eV2}$	0.18		0.60		0.1
(4)Uplift Pressure U	-922.69		11.20		-10,334.1
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --	149.60		-1.20		-179.5
Total	1,509.2	1,065.1			36,174.5
$x_o = M/ V$					23.97

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,065.08	13.49		27,857.9
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,000.82		15.63	15,642.8
Upstream Vertical Load	P <sub>WV1</sub>	4.97	0.90		4.5
Upstream Vertical Load	P <sub>WV2</sub>	0.59	0.60		0.4
Vertical load for Enclosure	P <sub>WEU</sub>	164.26	-1.20		-197.1
Downstream Horizontal Load	P <sub>WH2</sub>	-0.41		0.30	-0.1
Downstream Vertical Load	P <sub>WV3</sub>	0.27	36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load	Pe <sub>H</sub>	26.75		4.67	124.9
Upstream Vertical Load	Pe <sub>V1</sub>	0.20	0.90		0.2
Upstream Vertical Load	Pe <sub>V2</sub>	0.18	0.60		0.1
(4)Uplift Pressure	U	-617.95	7.20		-4,449.2
(5)Inertia Force					
Dam	Ws	125.97		17.28	2,176.8
Enclosure	We <sub>S</sub>	9.13		7.10	64.8
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	Pd <sub>H1</sub>	71.23		18.76	1,336.3
Downstream Horizontal Load	Pd <sub>H2</sub>	0.03		0.36	0.0
(7)Weight of Enclosure	W <sub>E</sub>	149.60	-1.20		-179.5
Total		1,767.20	1,233.52		42,392.6
xo = M/ V					23.99

## Calculation of Load ( Case1.1\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,065.08	13.49		27,857.9
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,017.54		15.76	16,036.4
Upstream Vertical Load	P <sub>WV1</sub>	5.02	0.90		4.5
Upstream Vertical Load	P <sub>WV2</sub>	0.59	0.60		0.4
Vertical load for Enclosure	P <sub>WEU</sub>	166.22	-1.20		-199.5
Downstream Horizontal Load	P <sub>WH2</sub>	-0.41		0.30	-0.1
Downstream Vertical Load	P <sub>WV3</sub>	0.27	36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load	Pe <sub>H</sub>	26.75		4.67	124.9
Upstream Vertical Load	Pe <sub>V1</sub>	0.20	0.90		0.2
Upstream Vertical Load	Pe <sub>V2</sub>	0.18	0.60		0.1
(4)Uplift Pressure	U	-617.95	7.20		-4,449.2
(5)Inertia Force					
Dam	Ws	443.99		17.28	7,672.2
Enclosure	We <sub>S</sub>	32.16		7.10	228.3
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	Pd <sub>H1</sub>	255.23		18.92	4,829.0
Downstream Horizontal Load	Pd <sub>H2</sub>	0.10		0.36	0.0
(7)Weight of Enclosure	W <sub>E</sub>	149.60	-1.20		-179.5
Total		1,769.21	1,775.36		51,935.5
xo = M/ V					29.36

## Calculation of Load ( Case1.2\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{W_{V1}}$	106.12		1.40		148.6
Upstream Vertical Load $P_{W_{V2}}$	19.60		0.93		18.2
Uplift for Enclosure --					
Downstream Horizontal Load $P_{W_{H2}}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{W_{V3}}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{E_H}$		54.15		6.33	342.8
Upstream Vertical Load $P_{E_{V1}}$	4.20		1.40		5.9
Upstream Vertical Load $P_{E_{V2}}$	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	2,076.6	1,383.6			54,543.4
$x_o = M / V$					26.27

## Calculation of Load ( Case1.2\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,458.00		18.00	26,244.0
Upstream Vertical Load $P_{W_{V1}}$	112.00		1.40		156.8
Upstream Vertical Load $P_{W_{V2}}$	19.60		0.93		18.2
Uplift for Enclosure --					
Downstream Horizontal Load $P_{W_{H2}}$		-118.58		5.13	-608.3
Downstream Vertical Load $P_{W_{V3}}$	79.45		37.94		3,014.3
(3)Silt Pressure					
Upstream Horizontal Load $P_{E_H}$		54.15		6.33	342.8
Upstream Vertical Load $P_{E_{V1}}$	4.20		1.40		5.9
Upstream Vertical Load $P_{E_{V2}}$	5.88		0.93		5.5
(4)Uplift Pressure U	-1,032.78		17.18		-17,743.2
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	1,823.8	1,393.6			52,100.8
$x_o = M / V$					28.57



## Calculation of Load ( Case1.2\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{WV1}$	106.12		1.40		148.6
Upstream Vertical Load $P_{WV2}$	19.60		0.93		18.2
Uplift for Enclosure --					0.0
Downstream Horizontal Load $P_{WH2}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{WV3}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		54.15		6.33	342.8
Upstream Vertical Load $P_{eV1}$	4.20		1.40		5.9
Upstream Vertical Load $P_{eV2}$	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force					
Dam $W_s$		160.76		18.95	3,046.4
Enclosure --		0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load $P_{dH1}$		95.85		20.76	1,989.9
Downstream Horizontal Load $P_{dH2}$		1.24		2.36	2.9
(7)Weight of Enclosure --					0.0
Total	2,076.64	1,641.40			59,582.6
$x_o = M / V$					28.69

## Calculation of Load ( Case1.2\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{WV1}$	106.12		1.40		148.6
Upstream Vertical Load $P_{WV2}$	19.60		0.93		18.2
Uplift for Enclosure --					0.0
Downstream Horizontal Load $P_{WH2}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{WV3}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		54.15		6.33	342.8
Upstream Vertical Load $P_{eV1}$	4.20		1.40		5.9
Upstream Vertical Load $P_{eV2}$	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force					
Dam $W_s$		566.62		18.95	10,737.5
Enclosure --		0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load $P_{dH1}$		337.82		20.76	7,013.1
Downstream Horizontal Load $P_{dH2}$		4.37		2.36	10.3
(7)Weight of Enclosure --					0.0
Total	2,076.64	2,292.36			72,304.3
$x_o = M / V$					34.82

## Calculation of Load ( Case1.2\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,419.45		15.53		37,574.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load P <sub>WH1</sub>		1,346.81		17.30	23,299.8
Upstream Vertical Load P <sub>WV1</sub>	25.47		1.40		35.7
Upstream Vertical Load P <sub>WV2</sub>	4.70		0.93		4.4
Uplift for Enclosure P <sub>WEU</sub>	29.82		-2.60		-77.5
Downstream Horizontal Load P <sub>WH2</sub>		-17.41		1.97	-34.3
Downstream Vertical Load P <sub>WV3</sub>	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load P <sub>eH</sub>		0.00		0.00	0.0
Upstream Vertical Load P <sub>eV1</sub>	0.00		0.00		0.0
Upstream Vertical Load P <sub>eV2</sub>	0.00		0.00		0.0
(4)Uplift Pressure U	-830.29		12.25		-10,171.1
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure W <sub>E</sub>	214.44		-0.06		-12.9
Total	1,875.3	1,329.4			51,085.3
x <sub>o</sub> = M/ V					27.24

## Calculation of Load ( Case1.2\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,419.45		15.53		37,574.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load P <sub>WH1</sub>		1,346.81		17.30	23,299.8
Upstream Vertical Load P <sub>WV1</sub>	25.47		1.40		35.7
Upstream Vertical Load P <sub>WV2</sub>	4.70		0.93		4.4
Vertical load for Enclosure P <sub>WEU</sub>	29.82		-2.60		-77.5
Downstream Horizontal Load P <sub>WH2</sub>		-17.41		1.97	-34.3
Downstream Vertical Load P <sub>WV3</sub>	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load P <sub>eH</sub>		0.00		0.00	0.0
Upstream Vertical Load P <sub>eV1</sub>	0.00		0.00		0.0
Upstream Vertical Load P <sub>eV2</sub>	0.00		0.00		0.0
(4)Uplift Pressure U	-830.29		12.25		-10,171.1
(5)Inertia Force					
Dam W <sub>s</sub>		147.59		18.18	2,683.2
Enclosure W <sub>eS</sub>		13.08		15.46	202.2
(6)Hydrodynamic Pressure					
Upstream Horizontal Load P <sub>dH1</sub>		95.85		20.76	1,989.9
Downstream Horizontal Load P <sub>dH2</sub>		1.24		2.36	2.9
(7)Weight of Enclosure W <sub>E</sub>	214.44		-0.06		-12.9
Total	1,875.25	1,587.16			55,963.4
x <sub>o</sub> = M/ V					29.84

## Calculation of Load (Case1.2\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,534.74		15.49		39,263.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{W_{V1}}$	25.47		1.40		35.7
Upstream Vertical Load $P_{W_{V2}}$	4.70		0.93		4.4
Vertical load for Enclosure $P_{W_{EU}}$	149.11		-0.20		-29.8
Downstream Horizontal Load $P_{W_{H2}}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{W_{V3}}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{E_H}$		54.15		6.33	342.8
Upstream Vertical Load $P_{E_{V1}}$	1.01		1.40		1.4
Upstream Vertical Load $P_{E_{V2}}$	1.41		0.93		1.3
(4)Uplift Pressure U	-830.29		12.25		-10,171.1
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure $W_E$	166.11		-0.20		-33.2
Total	2,063.9	1,383.6			53,147.2
$x_o = M / V$					25.75

## Calculation of Load (Case1.2\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,534.74		15.49		39,263.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,458.00		18.00	26,244.0
Upstream Vertical Load $P_{W_{V1}}$	26.88		1.40		37.6
Upstream Vertical Load $P_{W_{V2}}$	4.70		0.93		4.4
Vertical load for Enclosure $P_{W_{EU}}$	158.69		-0.20		-31.7
Downstream Horizontal Load $P_{W_{H2}}$		-118.58		5.13	-608.3
Downstream Vertical Load $P_{W_{V3}}$	79.45		37.94		3,014.3
(3)Silt Pressure					
Upstream Horizontal Load $P_{E_H}$		54.15		6.33	342.8
Upstream Vertical Load $P_{E_{V1}}$	1.01		1.40		1.4
Upstream Vertical Load $P_{E_{V2}}$	1.41		0.93		1.3
(4)Uplift Pressure U	-1,164.11		15.06		-17,531.5
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure $W_E$	166.11		-0.20		-33.2
Total	1,808.9	1,393.6			50,704.2
$x_o = M / V$					28.03

## Calculation of Load ( Case1.2\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,534.74	15.49		39,263.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,346.81		17.30	23,299.8
Upstream Vertical Load	P <sub>WV1</sub>	25.47	1.40		35.7
Upstream Vertical Load	P <sub>WV2</sub>	4.70	0.93		4.4
Vertical load for Enclosure	P <sub>WEU</sub>	149.11	-0.20		-29.8
Downstream Horizontal Load	P <sub>WH2</sub>	-17.41		1.97	-34.3
Downstream Vertical Load	P <sub>WV3</sub>	11.66	40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>EH</sub>	54.15		6.33	342.8
Upstream Vertical Load	P <sub>EV1</sub>	1.01	1.40		1.4
Upstream Vertical Load	P <sub>EV2</sub>	1.41	0.93		1.3
(4)Uplift Pressure	U	-830.29	12.25		-10,171.1
(5)Inertia Force					
Dam	W <sub>S</sub>		154.62	18.72	2,894.5
Enclosure	W <sub>ES</sub>		10.13	9.60	97.3
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>DH1</sub>	95.85		20.76	1,989.9
Downstream Horizontal Load	P <sub>DH2</sub>	1.24		2.36	2.9
(7)Weight of Enclosure	W <sub>E</sub>	166.11	-0.20		-33.2
Total		2,063.92	1,645.39		58,131.7
xo = M/ V					28.17

## Calculation of Load ( Case1.2\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,534.74	15.49		39,263.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,367.12		17.43	23,828.9
Upstream Vertical Load	P <sub>WV1</sub>	25.73	1.40		36.0
Upstream Vertical Load	P <sub>WV2</sub>	4.70	0.93		4.4
Vertical load for Enclosure	P <sub>WEU</sub>	150.89	-0.20		-30.2
Downstream Horizontal Load	P <sub>WH2</sub>	-17.41		1.97	-34.3
Downstream Vertical Load	P <sub>WV3</sub>	11.66	40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>EH</sub>	54.15		6.33	342.8
Upstream Vertical Load	P <sub>EV1</sub>	1.01	1.40		1.4
Upstream Vertical Load	P <sub>EV2</sub>	1.41	0.93		1.3
(4)Uplift Pressure	U	-830.29	12.25		-10,171.1
(5)Inertia Force					
Dam	W <sub>S</sub>		544.97	18.72	10,201.8
Enclosure	W <sub>ES</sub>		35.71	9.60	342.8
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>DH1</sub>	342.92		20.92	7,173.9
Downstream Horizontal Load	P <sub>DH2</sub>	4.37		2.36	10.3
(7)Weight of Enclosure	W <sub>E</sub>	166.11	-0.20		-33.2
Total		2,065.96	2,331.83		71,405.1
xo = M/ V					34.56

## Calculation of Load ( Case1.3\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,178.74		13.45		29,304.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,000.82		15.63	15,642.8
Upstream Vertical Load $P_{WV1}$	62.08		0.90		55.9
Upstream Vertical Load $P_{WV2}$	7.37		0.60		4.4
Uplift for Enclosure --					
Downstream Horizontal Load $P_{WH2}$		-0.41		0.30	-0.1
Downstream Vertical Load $P_{WV3}$	0.27		36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		26.75		4.67	124.9
Upstream Vertical Load $P_{eV1}$	2.46		0.90		2.2
Upstream Vertical Load $P_{eV2}$	2.21		0.60		1.3
(4)Uplift Pressure U	-440.21		10.96		-4,824.7
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	1,812.9	1,027.2			40,320.7
$x_o = M / V$					22.24

## Calculation of Load ( Case1.3\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,178.74		13.45		29,304.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,092.46		16.33	17,839.9
Upstream Vertical Load $P_{WV1}$	65.52		0.90		59.0
Upstream Vertical Load $P_{WV2}$	7.37		0.60		4.4
Uplift for Enclosure --					
Downstream Horizontal Load $P_{WH2}$		-54.08		3.47	-187.7
Downstream Vertical Load $P_{WV3}$	36.23		34.71		1,257.5
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		26.75		4.67	124.9
Upstream Vertical Load $P_{eV1}$	2.46		0.90		2.2
Upstream Vertical Load $P_{eV2}$	2.21		0.60		1.3
(4)Uplift Pressure U	-733.35		14.64		-10,736.2
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	1,559.2	1,065.1			37,669.4
$x_o = M / V$					24.16

## Calculation of Load ( Case1.3\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,178.74		13.45		29,304.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,000.82		15.63	15,642.8
Upstream Vertical Load $P_{WV1}$	62.08		0.90		55.9
Upstream Vertical Load $P_{WV2}$	7.37		0.60		4.4
Uplift for Enclosure --					0.0
Downstream Horizontal Load $P_{WH2}$		-0.41		0.30	-0.1
Downstream Vertical Load $P_{WV3}$	0.27		36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		26.75		4.67	124.9
Upstream Vertical Load $P_{eV1}$	2.46		0.90		2.2
Upstream Vertical Load $P_{eV2}$	2.21		0.60		1.3
(4)Uplift Pressure U	-440.21		10.96		-4,824.7
(5)Inertia Force					
Dam $W_s$		132.90		17.41	2,313.8
Enclosure --		0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load $P_{dH1}$		71.23		18.76	1,336.3
Downstream Horizontal Load $P_{dH2}$		0.03		0.36	0.0
(7)Weight of Enclosure --					0.0
Total	1,812.92	1,231.32			43,970.8
$x_o = M / V$					24.25

## Calculation of Load ( Case1.3\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,178.74		13.45		29,304.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,000.82		15.63	15,642.8
Upstream Vertical Load $P_{WV1}$	62.08		0.90		55.9
Upstream Vertical Load $P_{WV2}$	7.37		0.60		4.4
Uplift for Enclosure --					0.0
Downstream Horizontal Load $P_{WH2}$		-0.41		0.30	-0.1
Downstream Vertical Load $P_{WV3}$	0.27		36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		26.75		4.67	124.9
Upstream Vertical Load $P_{eV1}$	2.46		0.90		2.2
Upstream Vertical Load $P_{eV2}$	2.21		0.60		1.3
(4)Uplift Pressure U	-440.21		10.96		-4,824.7
(5)Inertia Force					
Dam $W_s$		468.43		17.41	8,155.4
Enclosure --		0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load $P_{dH1}$		251.04		18.76	4,709.5
Downstream Horizontal Load $P_{dH2}$		0.10		0.36	0.0
(7)Weight of Enclosure --					0.0
Total	1,812.92	1,746.73			53,185.7
$x_o = M / V$					29.34

## Calculation of Load ( Case1.3\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	1,842.35		13.39		24,669.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,000.82		15.63	15,642.8
Upstream Vertical Load $P_{WV1}$	0.62		0.90		0.6
Upstream Vertical Load $P_{WV2}$	0.07		0.60		0.0
Uplift for Enclosure $P_{WEU}$	83.68		-4.35		-364.0
Downstream Horizontal Load $P_{WH2}$		-0.41		0.30	-0.1
Downstream Vertical Load $P_{WV3}$	0.27		36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load $P_{EH}$		0.00		0.00	0.0
Upstream Vertical Load $P_{EV1}$	0.00		0.00		0.0
Upstream Vertical Load $P_{EV2}$	0.00		0.00		0.0
(4)Uplift Pressure U	-699.79		5.84		-4,086.8
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure $W_E$	236.50		-1.62		-383.1
Total	1,463.7	1,000.4			35,488.4
$x_o = M / V$					24.25

## Calculation of Load ( Case1.3\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	1,842.35		13.39		24,669.1
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,000.82		15.63	15,642.8
Upstream Vertical Load $P_{WV1}$	0.62		0.90		0.6
Upstream Vertical Load $P_{WV2}$	0.07		0.60		0.0
Vertical load for Enclosure $P_{WEU}$	83.68		-4.35		-364.0
Downstream Horizontal Load $P_{WH2}$		-0.41		0.30	-0.1
Downstream Vertical Load $P_{WV3}$	0.27		36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load $P_{EH}$		0.00		0.00	0.0
Upstream Vertical Load $P_{EV1}$	0.00		0.00		0.0
Upstream Vertical Load $P_{EV2}$	0.00		0.00		0.0
(4)Uplift Pressure U	-699.79		5.84		-4,086.8
(5)Inertia Force					
Dam $W_s$		112.38		16.75	1,882.4
Enclosure $W_{Es}$		14.43		11.99	173.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load $P_{dH1}$		71.23		18.76	1,336.3
Downstream Horizontal Load $P_{dH2}$		0.03		0.36	0.0
(7)Weight of Enclosure $W_E$	236.50		-1.62		-383.1
Total	1,463.70	1,198.48			38,880.1
$x_o = M / V$					26.56

## Calculation of Load (Case1.3\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	1,998.39		13.46		26,898.3
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,000.82		15.63	15,642.8
Upstream Vertical Load $P_{W_{V1}}$	0.62		0.90		0.6
Upstream Vertical Load $P_{W_{V2}}$	0.07		0.60		0.0
Vertical load for Enclosure $P_{W_{EU}}$	232.43		-1.95		-453.2
Downstream Horizontal Load $P_{W_{H2}}$		-0.41		0.30	-0.1
Downstream Vertical Load $P_{W_{V3}}$	0.27		36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load $P_{e_H}$		26.75		4.67	124.9
Upstream Vertical Load $P_{e_{V1}}$	0.02		0.90		0.0
Upstream Vertical Load $P_{e_{V2}}$	0.02		0.60		0.0
(4)Uplift Pressure U	-699.79		5.84		-4,086.8
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure $W_E$	178.77		-1.95		-348.6
Total	1,710.8	1,027.2			37,787.9
$x_o = M / V$					22.09

## Calculation of Load (Case1.3\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	1,998.39		13.46		26,898.3
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,092.46		16.33	17,839.9
Upstream Vertical Load $P_{W_{V1}}$	0.66		0.90		0.6
Upstream Vertical Load $P_{W_{V2}}$	0.07		0.60		0.0
Vertical load for Enclosure $P_{W_{EU}}$	246.62		-1.95		-480.9
Downstream Horizontal Load $P_{W_{H2}}$		-54.08		3.47	-187.7
Downstream Vertical Load $P_{W_{V3}}$	36.23		34.71		1,257.5
(3)Silt Pressure					
Upstream Horizontal Load $P_{e_H}$		26.75		4.67	124.9
Upstream Vertical Load $P_{e_{V1}}$	0.02		0.90		0.0
Upstream Vertical Load $P_{e_{V2}}$	0.02		0.60		0.0
(4)Uplift Pressure U	-1,009.86		9.85		-9,947.1
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure $W_E$	178.77		-1.95		-348.6
Total	1,450.9	1,065.1			35,157.0
$x_o = M / V$					24.23



## Calculation of Load ( Case1.3\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	1,998.39	13.46		26,898.3
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,000.82		15.63	15,642.8
Upstream Vertical Load	P <sub>WV1</sub>	0.62	0.90		0.6
Upstream Vertical Load	P <sub>WV2</sub>	0.07	0.60		0.0
Vertical load for Enclosure	P <sub>WEU</sub>	232.43	-1.95		-453.2
Downstream Horizontal Load	P <sub>WH2</sub>	-0.41		0.30	-0.1
Downstream Vertical Load	P <sub>WV3</sub>	0.27	36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>eH</sub>	26.75		4.67	124.9
Upstream Vertical Load	P <sub>eV1</sub>	0.02	0.90		0.0
Upstream Vertical Load	P <sub>eV2</sub>	0.02	0.60		0.0
(4)Uplift Pressure	U	-699.79	5.84		-4,086.8
(5)Inertia Force					
Dam	W <sub>s</sub>	121.90		17.32	2,111.3
Enclosure	W <sub>Es</sub>	10.90		6.25	68.1
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>dH1</sub>	71.23		18.76	1,336.3
Downstream Horizontal Load	P <sub>dH2</sub>	0.03		0.36	0.0
(7)Weight of Enclosure	W <sub>E</sub>	178.77	-1.95		-348.6
Total		1,710.80	1,231.22		41,303.6
xo = M/ V					24.14

## Calculation of Load ( Case1.3\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	1,998.39	13.46		26,898.3
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,017.54		15.76	16,036.4
Upstream Vertical Load	P <sub>WV1</sub>	0.63	0.90		0.6
Upstream Vertical Load	P <sub>WV2</sub>	0.07	0.60		0.0
Vertical load for Enclosure	P <sub>WEU</sub>	235.07	-1.20		-282.1
Downstream Horizontal Load	P <sub>WH2</sub>	-0.41		0.30	-0.1
Downstream Vertical Load	P <sub>WV3</sub>	0.27	36.83		9.9
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>eH</sub>	26.75		4.67	124.9
Upstream Vertical Load	P <sub>eV1</sub>	0.02	0.90		0.0
Upstream Vertical Load	P <sub>eV2</sub>	0.02	0.60		0.0
(4)Uplift Pressure	U	-631.48	7.01		-4,426.7
(5)Inertia Force					
Dam	W <sub>s</sub>	429.65		17.32	7,441.5
Enclosure	W <sub>Es</sub>	38.44		6.25	240.3
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>dH1</sub>	255.23		18.92	4,829.0
Downstream Horizontal Load	P <sub>dH2</sub>	0.10		0.36	0.0
(7)Weight of Enclosure	W <sub>E</sub>	178.77	-1.95		-348.6
Total		1,781.76	1,767.30		50,523.6
xo = M/ V					28.36

## Calculation of Load ( Case1.4\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{W_{V1}}$	106.12		1.40		148.6
Upstream Vertical Load $P_{W_{V2}}$	19.60		0.93		18.2
Uplift for Enclosure --					
Downstream Horizontal Load $P_{W_{H2}}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{W_{V3}}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{e_H}$		54.15		6.33	342.8
Upstream Vertical Load $P_{e_{V1}}$	4.20		1.40		5.9
Upstream Vertical Load $P_{e_{V2}}$	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	2,076.6	1,383.6			54,543.4
$x_o = M / V$					26.27

## Calculation of Load ( Case1.4\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,458.00		18.00	26,244.0
Upstream Vertical Load $P_{W_{V1}}$	112.00		1.40		156.8
Upstream Vertical Load $P_{W_{V2}}$	19.60		0.93		18.2
Uplift for Enclosure --					
Downstream Horizontal Load $P_{W_{H2}}$		-118.58		5.13	-608.3
Downstream Vertical Load $P_{W_{V3}}$	79.45		37.94		3,014.3
(3)Silt Pressure					
Upstream Horizontal Load $P_{e_H}$		54.15		6.33	342.8
Upstream Vertical Load $P_{e_{V1}}$	4.20		1.40		5.9
Upstream Vertical Load $P_{e_{V2}}$	5.88		0.93		5.5
(4)Uplift Pressure U	-1,032.78		17.18		-17,743.2
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	1,823.8	1,393.6			52,100.8
$x_o = M / V$					28.57

## Calculation of Load ( Case1.4\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{WV1}$	106.12		1.40		148.6
Upstream Vertical Load $P_{WV2}$	19.60		0.93		18.2
Uplift for Enclosure --					0.0
Downstream Horizontal Load $P_{WH2}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{WV3}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		54.15		6.33	342.8
Upstream Vertical Load $P_{eV1}$	4.20		1.40		5.9
Upstream Vertical Load $P_{eV2}$	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force					
Dam $W_s$		160.76		18.95	3,046.4
Enclosure --		0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load $P_{dH1}$		95.85		20.76	1,989.9
Downstream Horizontal Load $P_{dH2}$		1.24		2.36	2.9
(7)Weight of Enclosure --					0.0
Total	2,076.64	1,641.40			59,582.6
$x_o = M / V$					28.69

## Calculation of Load ( Case1.4\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{WV1}$	106.12		1.40		148.6
Upstream Vertical Load $P_{WV2}$	19.60		0.93		18.2
Uplift for Enclosure --					0.0
Downstream Horizontal Load $P_{WH2}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{WV3}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		54.15		6.33	342.8
Upstream Vertical Load $P_{eV1}$	4.20		1.40		5.9
Upstream Vertical Load $P_{eV2}$	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force					
Dam $W_s$		566.62		18.95	10,737.5
Enclosure --		0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load $P_{dH1}$		337.82		20.76	7,013.1
Downstream Horizontal Load $P_{dH2}$		4.37		2.36	10.3
(7)Weight of Enclosure --					0.0
Total	2,076.64	2,292.36			72,304.3
$x_o = M / V$					34.82

## Calculation of Load (Case1.4\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,333.05		15.51		36,185.6
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{WV1}$	20.16		1.40		28.2
Upstream Vertical Load $P_{WV2}$	3.72		0.93		3.5
Uplift for Enclosure $P_{WEU}$	75.23		-3.35		-252.0
Downstream Horizontal Load $P_{WH2}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{WV3}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		0.00		0.00	0.0
Upstream Vertical Load $P_{eV1}$	0.00		0.00		0.0
Upstream Vertical Load $P_{eV2}$	0.00		0.00		0.0
(4)Uplift Pressure U	-900.42		11.01		-9,913.6
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure $W_E$	262.78		-0.67		-176.1
Total	1,806.2	1,329.4			49,608.2
$x_o = M / V$					27.47

## Calculation of Load (Case1.4\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,333.05		15.51		36,185.6
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{WH1}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{WV1}$	20.16		1.40		28.2
Upstream Vertical Load $P_{WV2}$	3.72		0.93		3.5
Vertical load for Enclosure $P_{WEU}$	75.23		-3.35		-252.0
Downstream Horizontal Load $P_{WH2}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{WV3}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		0.00		0.00	0.0
Upstream Vertical Load $P_{eV1}$	0.00		0.00		0.0
Upstream Vertical Load $P_{eV2}$	0.00		0.00		0.0
(4)Uplift Pressure U	-900.42		11.01		-9,913.6
(5)Inertia Force					
Dam $W_s$		142.32		18.04	2,567.5
Enclosure $W_{eS}$		16.03		14.14	226.7
(6)Hydrodynamic Pressure					
Upstream Horizontal Load $P_{dH1}$		95.85		20.76	1,989.9
Downstream Horizontal Load $P_{dH2}$		1.24		2.36	2.9
(7)Weight of Enclosure $W_E$	262.78		-0.67		-176.1
Total	1,806.18	1,584.84			54,395.1
$x_o = M / V$					30.12

## Calculation of Load (Case1.4\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,448.43		15.52		37,999.6
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{W_{V1}}$	20.16		1.40		28.2
Upstream Vertical Load $P_{W_{V2}}$	3.72		0.93		3.5
Vertical load for Enclosure $P_{W_{EU}}$	208.98		-0.95		-198.5
Downstream Horizontal Load $P_{W_{H2}}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{W_{V3}}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		54.15		6.33	342.8
Upstream Vertical Load $P_{eV1}$	0.80		1.40		1.1
Upstream Vertical Load $P_{eV2}$	1.12		0.93		1.0
(4)Uplift Pressure U	-900.42		11.01		-9,913.6
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure $W_E$	208.33		-0.95		-197.9
Total	2,002.8	1,383.6			51,798.8
$x_o = M / V$					25.86

## Calculation of Load (Case1.4\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,448.43		15.52		37,999.6
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,458.00		18.00	26,244.0
Upstream Vertical Load $P_{W_{V1}}$	21.28		1.40		29.8
Upstream Vertical Load $P_{W_{V2}}$	3.72		0.93		3.5
Vertical load for Enclosure $P_{W_{EU}}$	221.74		-0.95		-210.7
Downstream Horizontal Load $P_{W_{H2}}$		-118.58		5.13	-608.3
Downstream Vertical Load $P_{W_{V3}}$	79.45		37.94		3,014.3
(3)Silt Pressure					
Upstream Horizontal Load $P_{eH}$		54.15		6.33	342.8
Upstream Vertical Load $P_{eV1}$	0.80		1.40		1.1
Upstream Vertical Load $P_{eV2}$	1.12		0.93		1.0
(4)Uplift Pressure U	-1,238.36		13.94		-17,262.7
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure $W_E$	208.33		-0.95		-197.9
Total	1,746.5	1,393.6			49,356.5
$x_o = M / V$					28.26

## Calculation of Load ( Case1.4\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,448.43	15.52		37,999.6
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,346.81		17.30	23,299.8
Upstream Vertical Load	P <sub>WV1</sub>	20.16	1.40		28.2
Upstream Vertical Load	P <sub>WV2</sub>	3.72	0.93		3.5
Vertical load for Enclosure	P <sub>WEU</sub>	208.98	-0.95		-198.5
Downstream Horizontal Load	P <sub>WH2</sub>	-17.41		1.97	-34.3
Downstream Vertical Load	P <sub>WV3</sub>	11.66	40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load	Pe <sub>H</sub>	54.15		6.33	342.8
Upstream Vertical Load	Pe <sub>V1</sub>	0.80	1.40		1.1
Upstream Vertical Load	Pe <sub>V2</sub>	1.12	0.93		1.0
(4)Uplift Pressure	U	-900.42	11.01		-9,913.6
(5)Inertia Force					
Dam	Ws			18.61	2,779.4
Enclosure	We <sub>s</sub>			8.75	111.2
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	Pd <sub>H1</sub>	95.85		20.76	1,989.9
Downstream Horizontal Load	Pd <sub>H2</sub>	1.24		2.36	2.9
(7)Weight of Enclosure	W <sub>E</sub>	208.33	-0.95		-197.9
Total		2,002.78	1,642.70		56,682.2
xo = M/ V					28.30

## Calculation of Load ( Case1.4\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,448.43	15.52		37,999.6
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>WH1</sub>	1,367.12		17.43	23,828.9
Upstream Vertical Load	P <sub>WV1</sub>	20.37	1.40		28.5
Upstream Vertical Load	P <sub>WV2</sub>	3.72	0.93		3.5
Vertical load for Enclosure	P <sub>WEU</sub>	211.35	-0.95		-200.8
Downstream Horizontal Load	P <sub>WH2</sub>	-17.41		1.97	-34.3
Downstream Vertical Load	P <sub>WV3</sub>	11.66	40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load	Pe <sub>H</sub>	54.15		6.33	342.8
Upstream Vertical Load	Pe <sub>V1</sub>	0.80	1.40		1.1
Upstream Vertical Load	Pe <sub>V2</sub>	1.12	0.93		1.0
(4)Uplift Pressure	U	-900.42	11.01		-9,913.6
(5)Inertia Force					
Dam	Ws			18.61	9,796.5
Enclosure	We <sub>s</sub>			8.75	391.9
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	Pd <sub>H1</sub>	342.92		20.92	7,173.9
Downstream Horizontal Load	Pd <sub>H2</sub>	4.37		2.36	10.3
(7)Weight of Enclosure	W <sub>E</sub>	208.33	-0.95		-197.9
Total		2,005.36	2,322.35		69,698.5
xo = M/ V					34.76

## Calculation of Load ( Case2\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load P <sub>WH1</sub>		1,346.81		17.30	23,299.8
Upstream Vertical Load P <sub>WV1</sub>	106.12		1.40		148.6
Upstream Vertical Load P <sub>WV2</sub>	19.60		0.93		18.2
Uplift for Enclosure --					
Downstream Horizontal Load P <sub>WH2</sub>		-17.41		1.97	-34.3
Downstream Vertical Load P <sub>WV3</sub>	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load Pe <sub>H</sub>		54.15		6.33	342.8
Upstream Vertical Load Pe <sub>V1</sub>	4.20		1.40		5.9
Upstream Vertical Load Pe <sub>V2</sub>	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	2,076.6	1,383.6			54,543.4
xo = M/ V					26.27

## Calculation of Load ( Case2\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,635.44		15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load P <sub>WH1</sub>		1,458.00		18.00	26,244.0
Upstream Vertical Load P <sub>WV1</sub>	112.00		1.40		156.8
Upstream Vertical Load P <sub>WV2</sub>	19.60		0.93		18.2
Uplift for Enclosure --					
Downstream Horizontal Load P <sub>WH2</sub>		-118.58		5.13	-608.3
Downstream Vertical Load P <sub>WV3</sub>	79.45		37.94		3,014.3
(3)Silt Pressure					
Upstream Horizontal Load Pe <sub>H</sub>		54.15		6.33	342.8
Upstream Vertical Load Pe <sub>V1</sub>	4.20		1.40		5.9
Upstream Vertical Load Pe <sub>V2</sub>	5.88		0.93		5.5
(4)Uplift Pressure U	-1,032.78		17.18		-17,743.2
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	1,823.8	1,393.6			52,100.8
xo = M/ V					28.57

## Calculation of Load ( Case2\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,635.44	15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>W<sub>H1</sub></sub>	1,346.81		17.30	23,299.8
Upstream Vertical Load	P <sub>W<sub>V1</sub></sub>	106.12	1.40		148.6
Upstream Vertical Load	P <sub>W<sub>V2</sub></sub>	19.60	0.93		18.2
Uplift for Enclosure	--				0.0
Downstream Horizontal Load	P <sub>W<sub>H2</sub></sub>	-17.41		1.97	-34.3
Downstream Vertical Load	P <sub>W<sub>V3</sub></sub>	11.66	40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>e<sub>H</sub></sub>	54.15		6.33	342.8
Upstream Vertical Load	P <sub>e<sub>V1</sub></sub>	4.20	1.40		5.9
Upstream Vertical Load	P <sub>e<sub>V2</sub></sub>	5.88	0.93		5.5
(4)Uplift Pressure	U	-706.26	14.69		-10,375.0
(5)Inertia Force					
Dam	W <sub>s</sub>	160.76		18.95	3,046.4
Enclosure	--	0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>d<sub>H1</sub></sub>	95.85		20.76	1,989.9
Downstream Horizontal Load	P <sub>d<sub>H2</sub></sub>	1.24		2.36	2.9
(7)Weight of Enclosure	--				0.0
Total		2,076.64	1,641.40		59,582.6
xo = M/ V					28.69

## Calculation of Load ( Case2\_A- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,635.44	15.43		40,664.8
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>W<sub>H1</sub></sub>	1,346.81		17.30	23,299.8
Upstream Vertical Load	P <sub>W<sub>V1</sub></sub>	106.12	1.40		148.6
Upstream Vertical Load	P <sub>W<sub>V2</sub></sub>	19.60	0.93		18.2
Uplift for Enclosure	--				0.0
Downstream Horizontal Load	P <sub>W<sub>H2</sub></sub>	-17.41		1.97	-34.3
Downstream Vertical Load	P <sub>W<sub>V3</sub></sub>	11.66	40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>e<sub>H</sub></sub>	54.15		6.33	342.8
Upstream Vertical Load	P <sub>e<sub>V1</sub></sub>	4.20	1.40		5.9
Upstream Vertical Load	P <sub>e<sub>V2</sub></sub>	5.88	0.93		5.5
(4)Uplift Pressure	U	-706.26	14.69		-10,375.0
(5)Inertia Force					
Dam	W <sub>s</sub>	566.62		18.95	10,737.5
Enclosure	--	0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>d<sub>H1</sub></sub>	337.82		20.76	7,013.1
Downstream Horizontal Load	P <sub>d<sub>H2</sub></sub>	4.37		2.36	10.3
(7)Weight of Enclosure	--				0.0
Total		2,076.64	2,292.36		72,304.3
xo = M/ V					34.82



## Calculation of Load ( Case2\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,472.62	15.43		38,152.5
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>W<sub>H1</sub></sub>	1,099.81		15.63	17,190.0
Upstream Vertical Load	P <sub>W<sub>V1</sub></sub>	92.12	1.40		129.0
Upstream Vertical Load	P <sub>W<sub>V2</sub></sub>	19.60	0.93		18.2
Uplift for Enclosure	P <sub>W<sub>EU</sub></sub>	-100.56	0.40		-40.2
Downstream Horizontal Load	P <sub>W<sub>H2</sub></sub>	-17.41		1.97	-34.3
Downstream Vertical Load	P <sub>W<sub>V3</sub></sub>	11.66	40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>E<sub>H</sub></sub>	12.15		3.00	36.5
Upstream Vertical Load	P <sub>E<sub>V1</sub></sub>	0.00	0.00		0.0
Upstream Vertical Load	P <sub>E<sub>V2</sub></sub>	0.66	0.60		0.4
(4)Uplift Pressure	U	-655.04	14.94		-9,786.3
(5)Inertia Force	--				
(6)Hydrodynamic Pressure	--				
(7)Weight of Enclosure	W <sub>E</sub>	32.22	0.40		12.9
Total		1,873.3	1,094.6		46,145.8
xo = M/ V					24.63

## Calculation of Load ( Case2\_B- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam	W	2,472.62	15.43		38,152.5
(2)Hydrostatic Pressure					
Upstream Horizontal Load	P <sub>W<sub>H1</sub></sub>	1,099.81		15.63	17,190.0
Upstream Vertical Load	P <sub>W<sub>V1</sub></sub>	92.12	1.40		129.0
Upstream Vertical Load	P <sub>W<sub>V2</sub></sub>	19.60	0.93		18.2
Uplift for Enclosure	P <sub>W<sub>EU</sub></sub>	-100.56	0.40		-40.2
Downstream Horizontal Load	P <sub>W<sub>H2</sub></sub>	-17.41		1.97	-34.3
Downstream Vertical Load	P <sub>W<sub>V3</sub></sub>	11.66	40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load	P <sub>E<sub>H</sub></sub>	12.15		3.00	36.5
Upstream Vertical Load	P <sub>E<sub>V1</sub></sub>	0.00	0.00		0.0
Upstream Vertical Load	P <sub>E<sub>V2</sub></sub>	0.66	0.60		0.4
(4)Uplift Pressure	U	-655.04	14.94		-9,786.3
(5)Inertia Force					
Dam	W <sub>s</sub>	150.83		18.57	2,800.9
Enclosure	W <sub>e<sub>s</sub></sub>	1.97		31.00	61.1
(6)Hydrodynamic Pressure					
Upstream Horizontal Load	P <sub>d<sub>H1</sub></sub>	78.27		18.76	1,468.4
Downstream Horizontal Load	P <sub>d<sub>H2</sub></sub>	1.24		2.36	2.9
(7)Weight of Enclosure	W <sub>E</sub>	32.22	0.40		12.9
Total		1,873.28	1,326.86		50,479.0
xo = M/ V					26.95

## Calculation of Load ( Case2\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,546.74		15.48		39,423.5
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,346.81		17.30	23,299.8
Upstream Vertical Load $P_{W_{V1}}$	106.12		1.40		148.6
Upstream Vertical Load $P_{W_{V2}}$	19.60		0.93		18.2
Uplift for Enclosure --					
Downstream Horizontal Load $P_{W_{H2}}$		-17.41		1.97	-34.3
Downstream Vertical Load $P_{W_{V3}}$	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load $P_{e_H}$		54.15		6.33	342.8
Upstream Vertical Load $P_{e_{V1}}$	4.20		1.40		5.9
Upstream Vertical Load $P_{e_{V2}}$	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					
Total	1,987.9	1,383.6			53,302.1
$x_o = M/ V$					26.81

## Calculation of Load ( Case2\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,546.74		15.48		39,423.5
(2)Hydrostatic Pressure					
Upstream Horizontal Load $P_{W_{H1}}$		1,458.00		18.00	26,244.0
Upstream Vertical Load $P_{W_{V1}}$	112.00		1.40		156.8
Upstream Vertical Load $P_{W_{V2}}$	19.60		0.93		18.2
Uplift for Enclosure --					0.0
Downstream Horizontal Load $P_{W_{H2}}$		-118.58		5.13	-608.3
Downstream Vertical Load $P_{W_{V3}}$	79.45		37.94		3,014.3
(3)Silt Pressure					
Upstream Horizontal Load $P_{e_H}$		54.15		6.33	342.8
Upstream Vertical Load $P_{e_{V1}}$	4.20		1.40		5.9
Upstream Vertical Load $P_{e_{V2}}$	5.88		0.93		5.5
(4)Uplift Pressure U	-1,032.78		17.18		-17,743.2
(5)Inertia Force --					
(6)Hydrodynamic Pressure --					
(7)Weight of Enclosure --					0.0
Total	1,735.1	1,393.6			50,859.5
$x_o = M/ V$					29.31

## Calculation of Load ( Case2\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,546.74		15.48		39,423.5
(2)Hydrostatic Pressure					
Upstream Horizontal Load P <sub>WH1</sub>		1,346.81		17.30	23,299.8
Upstream Vertical Load P <sub>WV1</sub>	106.12		1.40		148.6
Upstream Vertical Load P <sub>WV2</sub>	19.60		0.93		18.2
Uplift for Enclosure --					0.0
Downstream Horizontal Load P <sub>WH2</sub>		-17.41		1.97	-34.3
Downstream Vertical Load P <sub>WV3</sub>	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load P <sub>eH</sub>		54.15		6.33	342.8
Upstream Vertical Load P <sub>eV1</sub>	4.20		1.40		5.9
Upstream Vertical Load P <sub>eV2</sub>	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force					
Dam W <sub>s</sub>		155.35		18.77	2,915.9
Enclosure --		0.00		0.00	0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load P <sub>dH1</sub>		95.85		20.76	1,989.9
Downstream Horizontal Load P <sub>dH2</sub>		1.24		2.36	2.9
(7)Weight of Enclosure --					0.0
Total	1,987.94	1,635.99			58,210.8
xo = M/ V					29.28

## Calculation of Load ( Case2\_C- )

Loads	Vertical Load V (tf/m)	Horizontal Load H (tf/m)	Moment Arm Length		Moment M (tf/m*m)
			Lx (m)	Ly (m)	
(1)Weight of Dam W	2,546.74		15.48		39,423.5
(2)Hydrostatic Pressure					
Upstream Horizontal Load P <sub>WH1</sub>		1,367.12		17.43	23,828.9
Upstream Vertical Load P <sub>WV1</sub>	107.21		1.40		150.1
Upstream Vertical Load P <sub>WV2</sub>	19.60		0.93		18.2
Uplift for Enclosure --					0.0
Downstream Horizontal Load P <sub>WH2</sub>		-17.41		1.97	-34.3
Downstream Vertical Load P <sub>WV3</sub>	11.66		40.06		467.1
(3)Silt Pressure					
Upstream Horizontal Load P <sub>eH</sub>		54.15		6.33	342.8
Upstream Vertical Load P <sub>eV1</sub>	4.20		1.40		5.9
Upstream Vertical Load P <sub>eV2</sub>	5.88		0.93		5.5
(4)Uplift Pressure U	-706.26		14.69		-10,375.0
(5)Inertia Force					
Dam W <sub>s</sub>		547.55		18.77	10,277.5
Enclosure --					0.0
(6)Hydrodynamic Pressure					
Upstream Horizontal Load P <sub>dH1</sub>		342.92		20.92	7,173.9
Downstream Horizontal Load P <sub>dH2</sub>		4.37		2.36	10.3
(7)Weight of Enclosure --					0.0
Total	1,989.03	2,298.70			71,294.4
xo = M/ V					35.84