11.	Stability Ana	lysis of Sabo	Dam Struct	ure	

* Facilit	ty name	e Pawa-Burabod Rv. Sab	o Dam	
* H=	6.00	(m) Damhight	Density of depsit	2.6 t/m³
*B2'=	5.00	(m) Crown widh	Internal friction angle	30.0°
*he=	2.20	(m) Water depth	Concentration of debris	0.6
*n=	1.20	Downstream slope	Gravity	9.8
*m=	1.20	Upstream slope	Roughness coeffcient	0.10
* Ce=	0.30	Coefficient of earth pressure	Factor	1.00
* v	0.40	Pecentage of void		
* f	0.60	Friction factor	Discharge	214.0 m³/s
* T =	0.00	t/m <sup>2</sup> Shearing force	Design flood discharge	321.0 m³/s
*	30.00	t/m <sup>2</sup> Bearing capcity	Width of waterway	55.0 m
*Wc=	2.00	t/m³ Concrete Density	Slope of river bed	1/37.5
*Ws≂	1.10	t/m³ Depsit Density in water		
*W <sub>0</sub> =	1.20	t/m³ Water Density	Safe factor against Sliding	1.2

●Analysis (flood case)		Pawa-Bura	ibod Rv. Sabo Dam	crown width	
(1)Condition				<b> ←→</b>	
Dam hight	H=	6.00 m			
Water depth	h3=	2.20 m		water de	epth
Crown width	B≖	5.00 m	<b>1</b>	/i	T
Width of bottom	B2=	19.40 m		/: \	
Downstream slope	n=	1:1.20			
Upperstream slope	m=	1:1.20		1:1.20	:1.20
Water density Concrete density Coefficient of friction Shearing force	W0= Wc≠ f = τ =	1.20 t/m3 2.00 t/m3 0.60 0.00 t/m2	hight	C <sub>v2</sub> C <sub>v3</sub> C <sub>v3</sub> density of concrete	dam hight

(2) Ext	ernal for	ce (flood	case)						·				
	V€	ertical for	rce / Ho	rizontal fo	orce				Resisting/Disturbing				
load													moment
			(t/m)						(m)				(tm/m)
C <sub>v1</sub>	1/2×	1.20×	6.00 <sup>2</sup>	×2.00=	43.200				2/3×	1.20×	6.00 =	4.800	207.360
C <sub>v2</sub>		5.00×	6.00	×2.00=	60.000			1/2×	5.00+	1.20×	6.00 =	9.700	582.000
C <sub>v3</sub>	1/2×	1.20×	6.00 <sup>2</sup>	×2.00=	43.200	1/3×	1.20 ×	6.00+	5.00+	1.20×	6.00 =	14.600	630.720
									· · · · · · · · · · · · · · · · · · ·	******			
$W_{v1}$	1/2×	1.20×	6.00 z	×1.20=	25.920				1/3×	1.20×	6.00 =	2.400	62.208
W <sub>v2</sub>	1.20×	6.00×	2.20	×1.20=	19.008				1/2×	1.20×	6.00 =	3.600	68.429
$W_{v3}$		5.00×	2.20	×1.20=	13.200			1/2×	5.00+	1.20×	6.00 =	9.700	128.040
W <sub>h1</sub>		1/2×	6.00 z	×1.20=	21.600					1/3×	6.00 =	2.000	43.200
W <sub>h2</sub>		6.00×	2.20	×1.20=	15.840					1/2×	6.00 ≃	3.000	47.520
			Vertica	al force=	204.528						Resisting n	noment=	1,678.757
		<u></u>	lorizonta	al force=	37.440						Disturbing n	noment=	90.720

# (3) Stability of structure

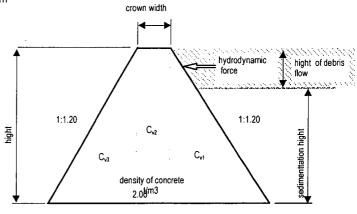
1) Sliding  $F_{s} = \frac{f \times \sum V + \tau \times \ell}{\sum H} = \frac{0.60 \times 204.53 + 0.00 \times 19.40}{37.44} = 3.278 \text{ >=Fs} = 1.20 \text{ O.K}$ 2) Overturning  $e = \frac{M_{r} + M_{0}}{\sum V} - \frac{B}{2} = \frac{1.678.76 + 90.72}{204.53} - \frac{19.40}{2} = 1.05 \text{ <=B0/6} = 3.23 \text{ O.K}$ 3) Subgrage reaction  $\sigma = \frac{\sum V}{B_{0}} \cdot \left(1 \pm \frac{6e}{B_{0}}\right) = \frac{204.53}{19.40} \left(1 \pm \frac{6 \times 3.233}{19.40}\right) \begin{cases} \sigma \, d = 13.96 \text{ t/m2(downstreem)} \\ \sigma \, u = 7.13 \text{ t/m2(upperstreem)} \end{cases}$ 

#### Analysis(debris flow case)

#### Pawa-Burabod Rv. Sabo Dam

#### (1)Condition

Dam hight	H=	6.00 m
Crown width	B≃	5.00 m
Bottom width	B2=	19.40 m
Downstream slope	n=	1:1.20
Upperstream slope	m=	1:1.20
Water density	W0=	1.20 t/m³
Concrete density	Wc=	$2.00 \text{ t/m}^3$
Density of deposit	Ws=	1.10 t/m³
Hight of deposit	Hs =	3.45 m
Void of deposit	ν =	0.40
Coefficient of earth press	ure Ce=	0.30
Coefficient of friction	f =	0.60
Shearing force	τ =	$0.00 \text{ t/m}^2$



 $1.62 \text{ t/m}^3$ 9.8 m/s<sup>2</sup> 1.0 3.45 m

#### (2) Debris flow Discharge and Fluid force

#### 1) Debris flow Discharge: Qsp

Q <sub>sp</sub> =	$\frac{C.}{CC_d} \times Q_p =$	428.00 m <sup>3</sup> /s	hight of debris Hd=	$\frac{n}{R} \frac{O_{eq}}{\sqrt{\sin \theta}} =$	2.55	m
	Qp: discarge	214.00 m <sup>3</sup> /s		n : roughness factor	0.10	
	C*:condensy of deposit	0.60		B: Debris width	55.00	m
	Cd:debris flow concentration	1		Qsp:debris flow quantity	428.00	m3/s
	0.3<=Cd<=0.9Cd(=0.54)	0.3	Verosity	$Ud = 1/n \times R^{2/3} \times \sqrt{\sin \theta}$	3.049	m/s
Cd=	$\frac{\rho \tan \theta}{(\sigma - \rho) (\tan \phi - \tan \theta)}$	0.042	Fluid force	$F_d = \alpha \frac{\rho}{d} H_d \times U_d^2 =$	3.922	tf/m
	σ:densty of gravel	$2.60 \text{ t/m}^3$		R: radius debris flow		
	ρ:densty of water	$1.20 \text{ t/m}^3$		$\rho$ d: densty ofdebris flow		1.6
	$\phi$ :in-angle of deposit	30.0 °		g : gravity		9.
	$\theta$ :Bed slope	1.53 °		$\alpha$ : factor		1.
				debris flow max case sedimentetion high	nt Hs=	3.4

# (3) External force(debris flow case)

		V	ertical fo	rce / Horiz	ontal force	е	Arm length	Resisting/Disturbing
load								moment
				(t/m)			(m)	(tm/m)
dam weight	Cv1	1/2×	1.20×	6.00	×2.00=	43.20	$2/3 \times 1.20 \times 6.00 = 4.80$	207.36
	Cv2		5.00×	6.00	×2.00=	60.00	$1/2 \times 5.00 + 1.20 \times 6.00 = 9.70$	582.00
	Cv3	1/2×	1.20×	6.00	×2.00=	43.20	1/3× 1.20 × 6.00+ 5.00+ 1.20× 6.00 = 14.60	630.72
depsit presure	Sv	1/2X	1.20×	3.45	×1.10=	7.85	1/3× 1.20× 3.45 = 1.38	10.82
water presure	Wv	1/2×	1.20X	3.45	×1.20=	8.56	$1/3 \times 1.20 \times 3.45 = 1.38$	11.80
debris flow weight	Dv1	1.20×	2.55×	3.45	×1.62=	17.11	$1/2 \times 1.20 \times 3.45 = 2.07$	35.39
	Dv2	1/2×	1.20×	3.45	×1.62=	6.33	$1/3 \times 1.20 \times 2.55 +$ $1.20 \times 3.45 =$ 5.16	32.65
depsit presure	Sh1	0.30×	1/2×	3.448	×1.10=	1.96	1/3× 3.45 ≈ 1.15	2.25
	Sh2	0.30×	2.55×	3.448	×1.62=	4.28	$1/2 \times 3.45 = 1.72$	7.37
water presure	Wh1		1/2×	3.448	×1.20=	7.13	$1/3 \times 3.45 = 1.15$	8.20
	Wh2		2.55×	3.448	×1.20=	10.56	$1/2 \times 3.45 = 1.72$	18.20
fluid force	Fd					3.92	$1/2 \times 2.55 + 3.45 = 4.72$	18.53
		·		Vertic	al force=	186.24	Resisting moment=	1,510.75
_				Horizont	al force=	27.85	Disturbing moment=	54.55

2)Debris flow Hight, Velocity, Hydorodynamic force

## (4) Stability of structure

1) Sliding

$$F_s = \frac{f \times \sum V + \tau \times \ell}{\sum H} = \frac{0.60 \times 186.24 + 0.00 \times 19.40}{27.85} = 4.012 > = Fs = 1.20 \text{ O.K}$$

2) Overturning 
$$e = \frac{M_r + M_0}{\sum V} - \frac{B}{2} = \begin{vmatrix} 1.510.75 + 54.55 \\ 186.24 \end{vmatrix} = \begin{vmatrix} 1.9.40 \\ 2 \end{vmatrix} = 1.30 < B0/6$$
: 3.23 O.K

3) Subgrage reaction 
$$\sigma = \frac{\sum V}{B_0} \bullet \left(1 \pm \frac{6e}{B_0}\right) = \frac{186.24}{19.40} \left(1 \pm \frac{6 \times 3.233}{19.40}\right) \begin{cases} \sigma \, d = 13.45 \, \text{t/m2(downstreem)} \\ \sigma \, u = 5.76 \, \text{t/m2(upperstreem)} \end{cases}$$

* Facili	ty nam	e Budiao Rv. Sabo Dam		
* H=	6.00	(m) Damhight	Density of depsit	2.6 t/m³
*B2'=	5.00	(m) Crown widh	Internal friction angle	30.0 *
*he=	2.20	(m) Water depth	Concentration of debris	0.6
*n=	1.20	Downstream slope	Gravity	9.8
*m=	1.20	Upstream slope	Roughness coeffcient	0.10
* Ce=	0.30	Coefficient of earth pressure	Factor	1.00
* v	0.40	Pecentage of void		
* f	0.60	Friction factor	Discharge	189.0 m³/s
* T =	0.00	t/m <sup>2</sup> Shearing force	Design flood discharge	284.0 m³/s
*	30.00	t/m <sup>2</sup> Bearing capcity	Width of waterway	50.0 m
*Wc=	2.00	t/m³ Concrete Density	Slope of river bed	1/20.0
*Ws=	1.10	t/m³ Depsit Density in water		
*W <sub>0</sub> =	1.20	t/m³ Water Density	Safe factor against Sliding	1.2

#### ● Analysis (flood case) Budiao Rv. Sabo Dam crown width (1)Condition 6.00 m Dam hight H= water depth Water depth h3= 2.20 m 5.00 m B= Crown width Width of bottom B2= 19.40 m Downstream slope n= 1:1.20 Upperstream slope m= 1:1.20 1:1.20 1:1.20 dam hight $C_{v2}$ Water density W0= 1.20 t/m3 Concrete density Wc= 2.00 t/m3 $C_{v1}$ Coefficient of friction 0.60 f = density of concrete Shearing force 0.00 t/m2 2.00 t/m3

(2) External force (flood case)

load	Ve	ertical fo	rce / Hor	rizontal f	orce				Arm leng	gth			Resisting/Disturbing moment
			(t/m)						(m)				(tm/m)
C <sub>v1</sub>	1/2×	1.20×	6.00 2	×2.00=	43.200				2/3×	1.20×	6.00 =	4.800	207.360
C <sub>v2</sub>		5.00×	6.00	×2.00=	60.000			1/2×	5.00+	1.20×	6.00 =	9.700	582.000
C <sub>v3</sub>	1/2×	1.20×	6.00 <sup>2</sup>	×2.00=	43.200	1/3×	1.20 ×	6.00+	5.00+	1.20×	6.00 =	14.600	630.720
W <sub>v1</sub>	1/2×	1.20×	6.00 z	×1.20=	25.920				1/3×	1.20×	6.00 =	2.400	62.208
W <sub>v2</sub>	1.20×	6.00×	2.20	×1.20=	19.008				1/2×	1.20×	6.00 =	3.600	68.429
W <sub>v3</sub>		5.00×	2.20	×1.20=	13.200			1/2×	5.00+	1.20×	6.00 =	9.700	128.040
W <sub>h1</sub>		1/2×	6.00 <sub>2</sub>	×1.20=	21.600					1/3×	6.00 =	2.000	43.200
W <sub>h2</sub>		6.00×	2.20	×1.20=	15.840					1/2×	6.00 =	3.000	47.520
			Vertica	I force=	204.528						Resisting n	noment=	1,678.757
		<u> </u>	lorizonta	I force=	37.440						Disturbing n	noment=	90.720

# (3) Stability of structure

$$F_s = \frac{f \times \sum V + \tau \times \ell}{\sum H} = \frac{0.60 \times 204.53 + 0.00 \times 19.40}{37.44} = 3.278 > \text{Fs} = 1.20 \text{ O.K}$$

2) Overturning 
$$e = \frac{M_r + M_0}{\sum V} - \frac{B}{2} = \frac{1.678.76 + 90.72}{204.53} - \frac{19.40}{2} = 1.05 <= B0/6 = 3.23 \text{ O.K}$$

3) Subgrage reaction  $\sigma = \frac{\sum V}{B_0} \bullet \left(1 \pm \frac{6e}{B_0}\right) = \frac{204.53}{19.40} \left(1 \pm \frac{6 \times 3.233}{19.40}\right) \left\{\begin{array}{ll} \sigma \, \mathrm{d} = & 13.96 \, \, \mathrm{t/m2(downstreem)} \\ \sigma \, \mathrm{u} = & 7.13 \, \, \mathrm{t/m2(upperstreem)} \end{array}\right\}$ 

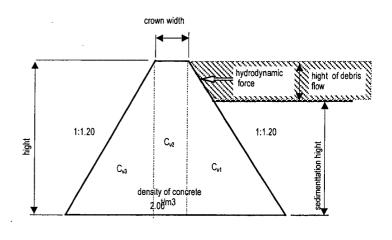
#### Analysis(debris flow case)

#### Budiao Rv. Sabo Dam

 $0.00 \text{ t/m}^2$ 

#### (1)Condition

Dam hight	H=	6.00 m	
Crown width	B=	5.00 m	
Bottom width	B2=	19.40 m	
Downstream slope	n=	1:1.20	
Upperstream slope	m=	1:1.20	
Water density	W0=	1.20 t/m³	3
Concrete density	Wc=	2.00 t/m³	3
Density of deposit	Ws≖	1.10 t/m³	3
Hight of deposit	Hs =	3.92 m	
Void of deposit	ν =	0.40	
Coefficient of earth press	sure Ce=	0.30	
Coefficient of friction	f =	0.60	



## (2)Debris flow Discharge and Fluid force

Shearing force

## 1)Debris flow Discharge:Qsp

$Q_{sp} = \frac{C.}{CC_d} \times Q_p =$	378.00 m³/s	hight of debris Hd=	$\frac{n}{R} \frac{O_{sp}}{\sqrt{\sin A}} =$	2.08	m
Qp: discarge	189.00 m³/s		n : roughness factor	0.10	
C*:condensy of deposit	0.60		B: Debris width	50.00	m
Cd:debris flow concentration	ı		Qsp:debris flow quantity	378.00	m3/s
0.3<=Cd<=0.9Cd(=0.54)	0.3	Verosity	$Ud = 1/n \times R^{2/3} \times \sin \theta$	3.639	m/s
$Cd = \frac{\rho \tan \theta}{(\sigma - \rho) (\tan \phi - \tan \theta)}$	0.081	Fluid force	$F_d = \alpha \frac{\rho}{d} H_d \times U_d^2 =$	4.549	tf/m
σ:densty of gravel	$2.60 \text{ t/m}^3$		R: radius debris flow		
$\rho$ :densty of water	1.20 t/m³		$\rho$ d: densty ofdebris flow		1.62 t/m³
$\phi$ :in-angle of deposit	30.0°		g : gravity		9.8 m/s <sup>2</sup>
heta :Bed slope	2.86 °		$\alpha$ : factor		1.0
			debris flow max case sedimentetion hig	int Hs=	3.92 m

2)Debris flow Hight, Velocity, Hydorodynamic force

# (3) External force(debris flow case)

load		V	ertical fo	rce / Horiz	ontal force	9			A	rm lengt	h			Resisting/Disturbing moment
1044				(t/m)						(m)				(tm/m)
dam weight	Cv1	1/2X	1.20×	6.00	×2.00=	43.20				2/3×	1.20×	6.00 =	4.80	207.36
	Cv2		5.00×	6.00	×2.00=	60.00			1/2×	5.00+	1.20×	6.00 =	9.70	582.00
	Cv3	1/2X	1.20×	6.00	×2.00=	43.20	1/3×	1.20 ×	6.00+	5.00+	1.20×	6.00 =	14.60	630.72
depsit presure	Sv	1/2X	1.20×	3.92	×1.10=	10.15				1/3×	1.20×	3.92 =	1.57	15.93
water presure	Wv	1/2X	1.20×	3.92	×1.20=	11.08				1/3×	1.20X	3.92 =	1.57	17.38
debris flow weight	Dv1	1.20×	2.08×	3.92	X1.62=	15.84				1/2×	1.20×	3.92 =	2.35	37.28
	Dv2	1/2X	1.20×	3.92	×1.62=	4.20	1/3×	1.20 X	2.08+		1.20×	3.92 =	5.54	23.24
depsit presure	Sh1	0.30×	1/2×	3.922	×1.10=	2.54		,	-		1/3×	3.92 =	1.31	3.32
	Sh2	0.30×	2.08×	3.922	×1.62=	3.96					1/2×	3.92 =	1.96	7.77
water presure	Wh1		1/2×	3.922	×1.20=	9.23					1/3×	3.92 =	1.31	12.06
	Wh2		2.08×	3.922	×1.20=	9.78					1/2×	3.92 =	1.96	19.18
fluid force	Fd					4.55				1/2×	2.08+	3.92 =	4.96	22.57
			•	Vertic	al force=	187.67					Re	sisting m	oment=	1,513.91
				Horizont	al force=	30.06					Dist	urbing m	oment=	64.89

## (4) Stability of structure

1) Sliding

$$F_{s} = \frac{f \times \sum V + \tau \times \ell}{\sum H} = \frac{0.60 \times 187.67 + 0.00 \times 19.40}{30.06} = 3.746 > = Fs = 1.20 \text{ O.K}$$

$$M_{s} + M_{s} = R_{s} + R_{s} = R_{s} = 1.20 \text{ O.K}$$

2) Overturning 
$$e = \frac{M_r + M_0}{\sum V} - \frac{B}{2} = \begin{vmatrix} 1.513.91 + 64.89 \\ 187.67 \end{vmatrix} = \begin{vmatrix} 19.40 \\ 2 \end{vmatrix} = 1.29 < 80/6$$
 3.23 O.K

3) Subgrage reaction 
$$\sigma = \frac{\sum V}{B_0} \cdot \left(1 \pm \frac{6e}{B_0}\right) = \frac{187.67}{19.40} \left(1 \pm \frac{6 \times 3.233}{19.40}\right) \begin{cases} \sigma d = 13.52 \text{ t/m2(downstreem)} \\ \sigma u = 5.82 \text{ t/m2(upperstreem)} \end{cases}$$

* Facilit	ty name	e Anoling Rv. Sabo Dar	n	
* H=	6.00	(m) Damhight	Density of depsit	2.6 t/m³
*B2'=	5.00	(m) Crown widh	Internal friction angle	30.0 °
*he=	2.20	(m) Water depth	Concentration of debris	0.6
*n=	1.20	Downstream slope	Gravity	9.8
*m=	1.20	Upstream slope	Roughness coeffcient	0.10
* Ce=	0.30	Coefficient of earth pressure	Factor	1.00
* v	0.40	Pecentage of void		
* f	0.60	Friction factor	Discharge	257.0 m³/s
* T =	0.00	t/m² Shearing force	Design flood discharge	386.0 m³/s
*	30.00	t/m <sup>2</sup> Bearing capcity	Width of waterway	68.0 m
*Wc=	2.00	t/m³ Concrete Density	Slope of river bed	1/20.0
*Ws=	1.10	t/m³ Depsit Density in water		
*Wo=	1.20	t/m³ Water Density	Safe factor against Sliding	1.2

#### Analysis (flood case) Anoling R Rv. Sabo Dam crown width (1)Condition 6.00 m Dam hight H= water depth Water depth 2.20 m 5.00 m B= Crown width B2= 19.40 m Width of bottom Downstream slope n= 1:1.20 Upperstream slope m= 1:1.20 1:1.20 1:1.20 dam hight Water density W0= 1.20 t/m3 2.00 t/m3 Wc= Concrete density Coefficient of friction 0.60 f = density of concrete Shearing force 0.00 t/m2 2.00 t/m3

(2) Ext	ernal for	e (flood	case)										
	V€	rtical for	rce / Hoi	rizontal fo	rce			Resisting/Disturbing					
load													moment
			(t/m)						(m)				(tm/m)
C <sub>v1</sub>	1/2×	1.20×	6.00 <sup>2</sup>	×2.00=	43.200				2/3×	1.20×	6.00 =	4.800	207.360
Cvz		5.00×	6.00	×2.00=	60.000			1/2×	5.00+	1.20×	6.00 =	9.700	582.000
C <sub>v3</sub>	1/2×	1.20×	6.00 <sup>2</sup>	×2.00=	43.200	1/3×	1.20 ×	6.00+	5.00+	1.20×	6.00 =	14.600	630.720
W <sub>v1</sub>	1/2×	1.20×	6.00 z	×1.20=	25.920				1/3×	1.20×	6.00 =	2.400	62.208
W <sub>v2</sub>	1.20×	6.00×	2.20	×1.20=	19.008				1/2×	1.20×	6.00 =	3.600	68.429
W <sub>v3</sub>		5.00×	2.20	×1.20=	13.200			1/2×	5.00+	1.20×	6.00 =	9.700	128.040
W <sub>h1</sub>		1/2×	6.00 z	×1.20=	21.600					1/3×	6.00 =	2.000	43.200
W <sub>h2</sub>		6.00×	2.20	×1.20=	15.840					1/2×	6.00 =	3.000	47.520
Vertical force= 204.528											Resisting n	noment=	1,678.757
Horizontal force= 37.440											Disturbing n	noment=	90.720

# (3) Stability of structure

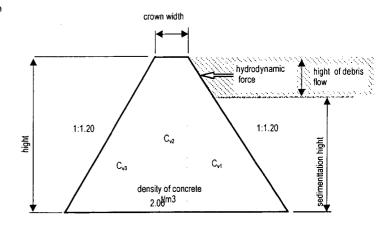
1) Sliding  $F_{s} = \frac{f \times \sum V + \tau \times \ell}{\sum H} = \frac{0.60 \times 204.53 + 0.00 \times 19.40}{37.44} = 3.278 \text{ >=Fs} = 1.20 \text{ O.K}$ 2) Overturning  $e = \frac{M_{r} + M_{0}}{\sum V} - \frac{B}{2} = \frac{1.678.76 + 90.72}{204.53} - \frac{19.40}{2} = 1.05 \text{ <=B0/6} = 3.23 \text{ O.K}$ 3) Subgrage reaction  $\sigma = \frac{\sum V}{B_{0}} \cdot \left(1 \pm \frac{6e}{B_{0}}\right) = \frac{204.53}{19.40} \left(1 \pm \frac{6 \times 3.233}{19.40}\right) \begin{cases} \sigma \text{ d} = 13.96 \text{ t/m2(downstreem)} \\ \sigma \text{ u} = 7.13 \text{ t/m2(upperstreem)} \end{cases}$ 

#### Analysis(debris flow case)

Anoling Rv. Sabo Dam

## (1)Condition

Dam hight	H=	6.00 m
Crown width	B=	5.00 m
Bottom width	B2=	19.40 m
Downstream slope	n≖	1:1.20
Upperstream slope	m=	1:1.20
Water density	W0=	1.20 t/m³
Concrete density	Wc=	$2.00 \text{ t/m}^3$
Density of deposit	Ws=	1.10 t/m³
Hight of deposit	Hs =	3.92 m
Void of deposit	ν ==	0.40
Coefficient of earth pres	sure Ce=	0.30
Coefficient of friction	f =	0.60
Shearing force	τ =	$0.00 \text{ t/m}^2$



# (2)Debris flow Discharge and Fluid force

# 1)Debris flow Discharge:Qsp

$Q_{sp} = \frac{C}{C \cdot - C_d} \times Q_p =$	514.00	m³/s
Qp: discarge	257.00	m³/s
C*:condensy of deposit	0.60	
Cd:debris flow concentration	ı	
0.3<=Cd<=0.9Cd(=0.54)	0.3	
$Cd = \frac{\rho \tan \theta}{(\sigma - \rho) (\tan \phi - \tan \theta)}$	0.081	
σ:densty of gravel	2.60	t/m³
$\rho$ :densty of water	1.20	t/m³
$\phi$ :in-angle of deposit	30.0	•
$\theta$ :Bed slope	2.86	•

# 2)Debris flow Hight, Velocity, Hydorodynamic force

hight of debris Hd=	$\frac{n}{R}\sqrt{\sin \theta}$ =	2.08	m	
	n : roughness factor	0.10		
	B: Debris width	68.00	m	
	Qsp:debris flow quantity	514.00	m3/s	
Verosity	$Ud = 1/n \times R^{2/3} \times \sqrt{\sin \theta}$	3.639	m/s	
Fluid force	$F_d = \alpha \frac{\rho}{d} H_d \times U_d^2 =$	4.549	tf/m	
	R: radius debris flow			
	$\rho$ d: densty ofdebris flow		1.62	t/
	a e accuitu		0.0	_

/m³  $9.8 \text{ m/s}^2$ g: gravity  $\alpha$ : factor 1.0

3.92 m debris flow max case sedimentation hight Hs=

# (3) External force(debris flow case)

		V	ertical fo	rce / Horiz	ontal force	9	Arm length						Resisting/Disturbing	
load														moment
				(t/m)						(m)				(tm/m)
dam weight	Cv1	1/2×	1.20×	6.00	×2.00=	43.20				2/3×	1.20×	6.00 =	4.80	207.36
-	Cv2		5.00×	6.00	×2.00=	60.00			1/2×	5.00+	1.20×	6.00 =	9.70	582.00
	Cv3	1/2×	1.20×	6.00	×2.00=	43.20	1/3×	1.20 X	6.00+	5.00+	1.20×	6.00 =	14.60	630.72
depsit presure	Sv	1/2×	1.20×	3.92	×1.10=	10.15				1/3×	1.20×	3.92 =	1.57	15.93
water presure	W∨	1/2×	1.20×	3.92	×1.20=	11.08				1/3×	1.20×	3.92 =	1.57	17.38
debris flow weight	Dv1	1.20×	2.08×	3.92	×1.62=	15.84				1/2×	1.20×	3.92 =	2.35	37.28
	Dv2	1/2×	1.20×	3.92	×1.62=	4.20	1/3×	1.20 ×	2.08+		1.20×	3.92 =	5.54	23.24
depsit presure	Sh1	0.30×	1/2×	3.922	X1.10=	2.54					1/3×	3.92 =	1.31	3.32
	Sh2	0.30×	2.08×	3.922	×1.62=	3.96					1/2×	3.92 =	1.96	7.77
water presure	Wh1		1/2×	3.922	×1.20=	9.23					1/3×	3.92 =	1.31	12.06
	Wh2		2.08×	3.922	×1.20=	9.78					1/2X	3.92 =	1.96	19.18
fluid force	Fd		_			4.55				1/2×	2.08+	3.92 =	4.96	22.57
				Vertic	al force=	187.67		-			Re	sisting m	oment=	1,513.91
				Horizont	al force=	30.06					Dist	turbing m	oment=	64.89

## (4) Stability of structure

1) Sliding

$$F_s = \frac{f \times \sum V + \tau \times \ell}{\sum H} = \frac{0.60 \times 187.67 + 0.00 \times 19.40}{30.06} = 3.746 > = Fs = 1.20 \text{ O.K}$$

2) Overturning 
$$e = \frac{M_r + M_0}{\sum V} - \frac{B}{2} = \begin{vmatrix} 1.513.91 + 64.89 \\ 187.67 \end{vmatrix} - \frac{19.40}{2} = 1.29 <= B0/6: 3.23 \text{ O.K}$$

3) Subgrage reaction 
$$\sigma = \frac{\sum V}{B_0} \cdot \left(1 \pm \frac{6e}{B_0}\right) = \frac{187.67}{19.40} \left(1 \pm \frac{6 \times 3.233}{19.40}\right) \cdot \left\{\begin{array}{ccc} \sigma \ d = & 13.52 \ \text{t/m2(downstreem)} \\ \sigma \ u = & 5.82 \ \text{t/m2(upperstreem)} \end{array}\right.$$