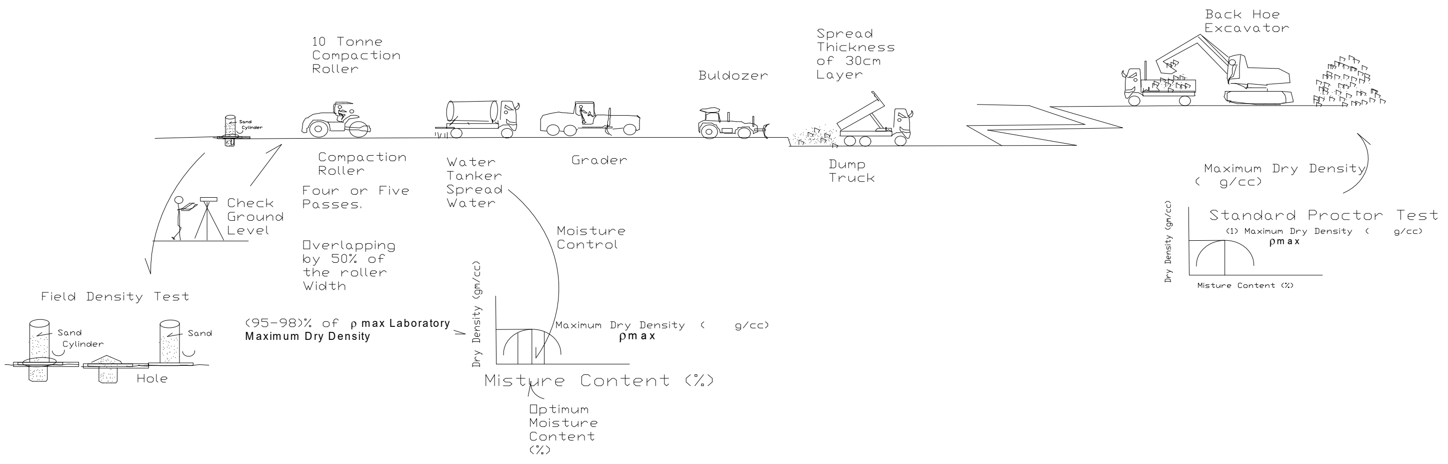
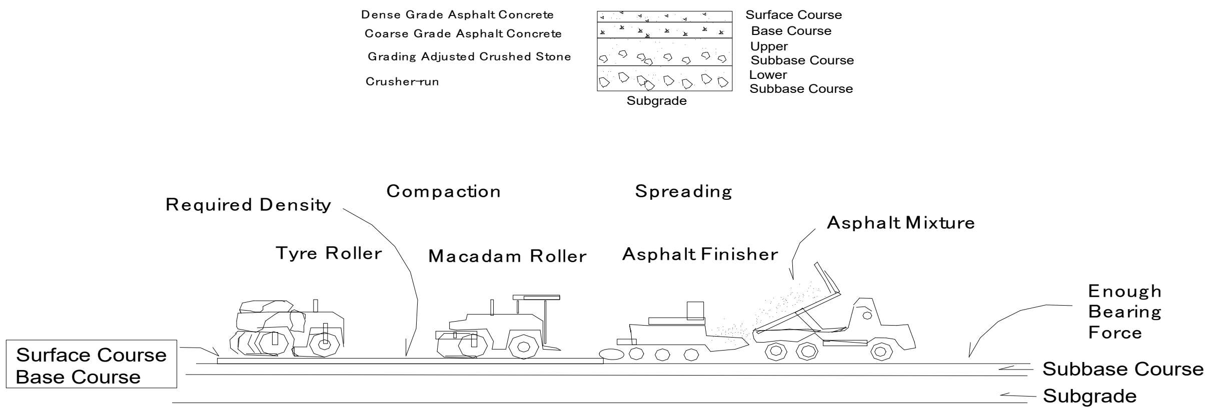
Asphalt Pavement in Africa (1-23)

(2) Earth Works



(16) Asphalt Pavement

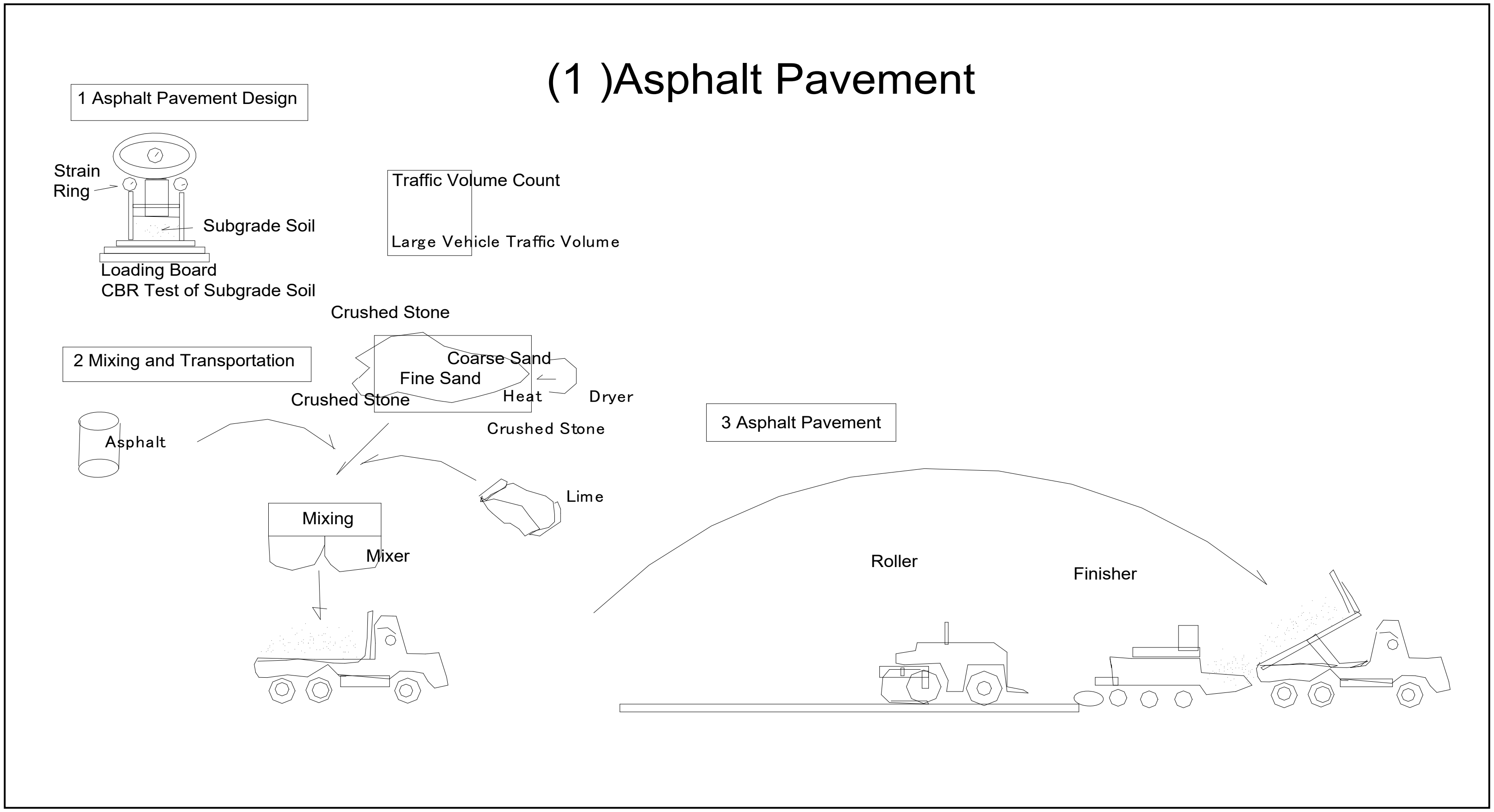


只野　敏夫
TADANO TOSHIO

Asphalt Pavement

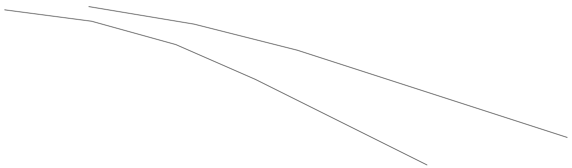
Contents

(1)Asphalt Pavement



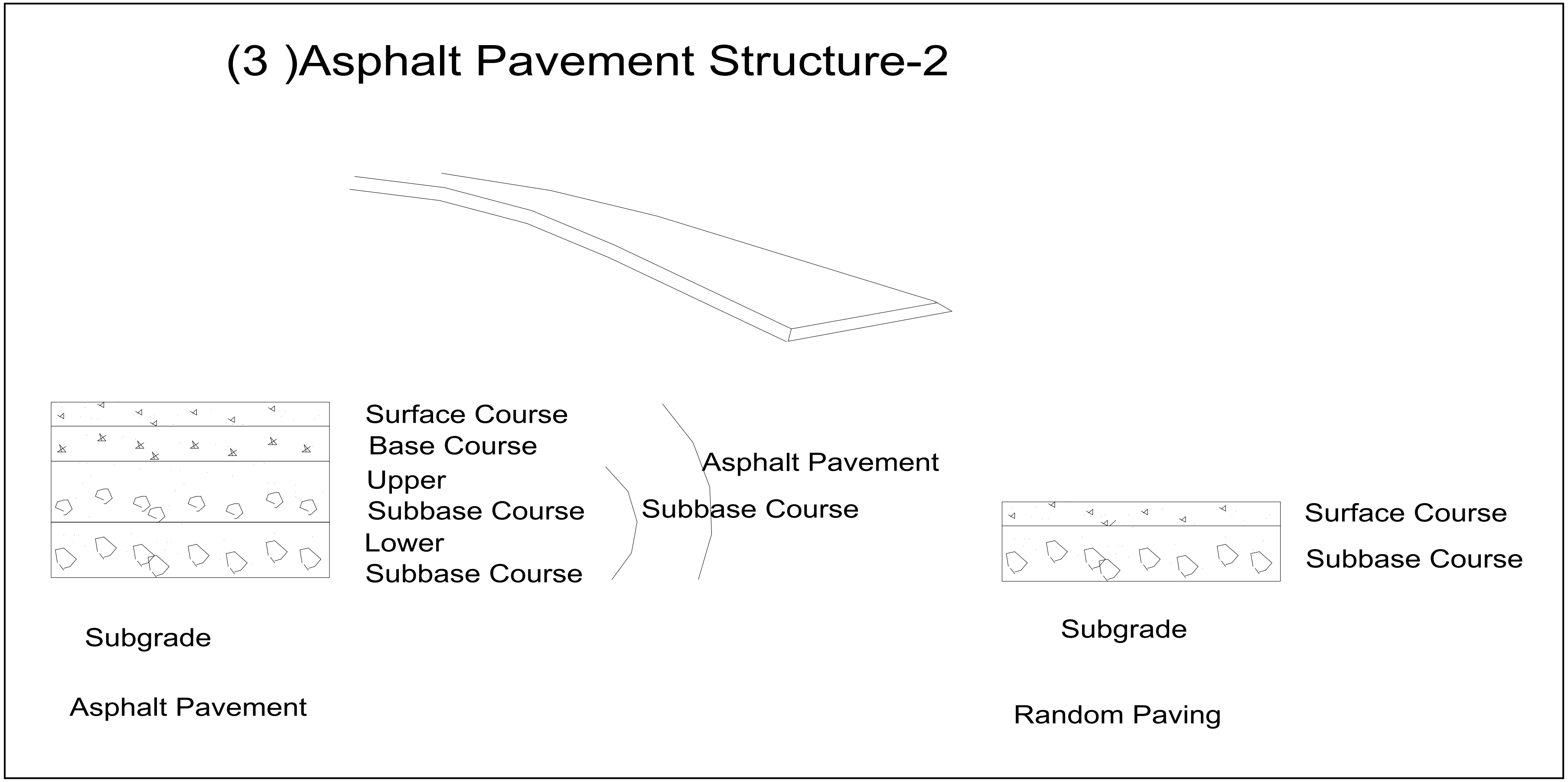
(2)Asphalt Pavement Structure-1

(2)Asphalt Pavement Structure-1



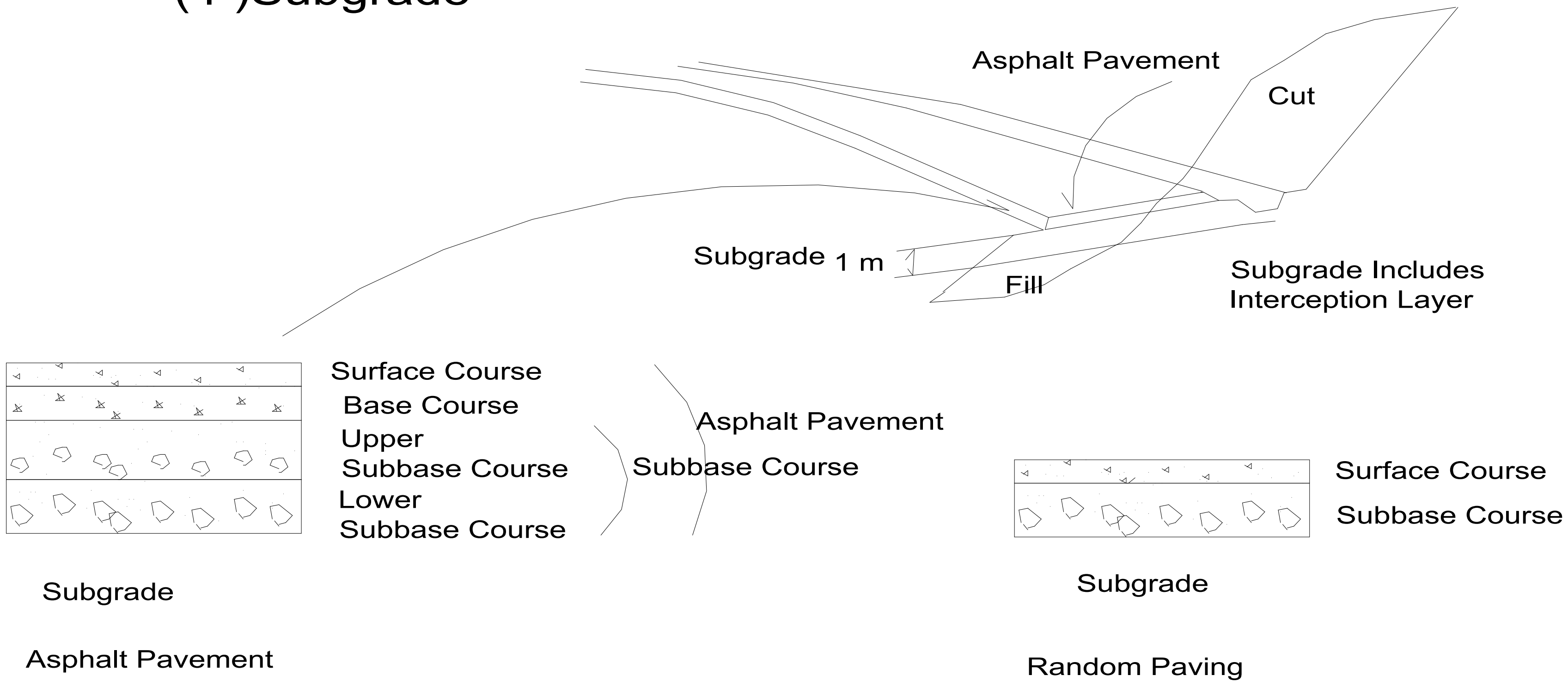
	Asphalt Pavement	Cement Concrete Pavement
Flexible	Flexible Pavement Big	Rigid Pavement Small
Curing	Short	Long
Construction Period	Short	Long
Joint	No	Many
Surface Roughness	Smooth	Not Smooth
Maintenance	Easy	Difficult

(3)Asphalt Pavement Structure-2

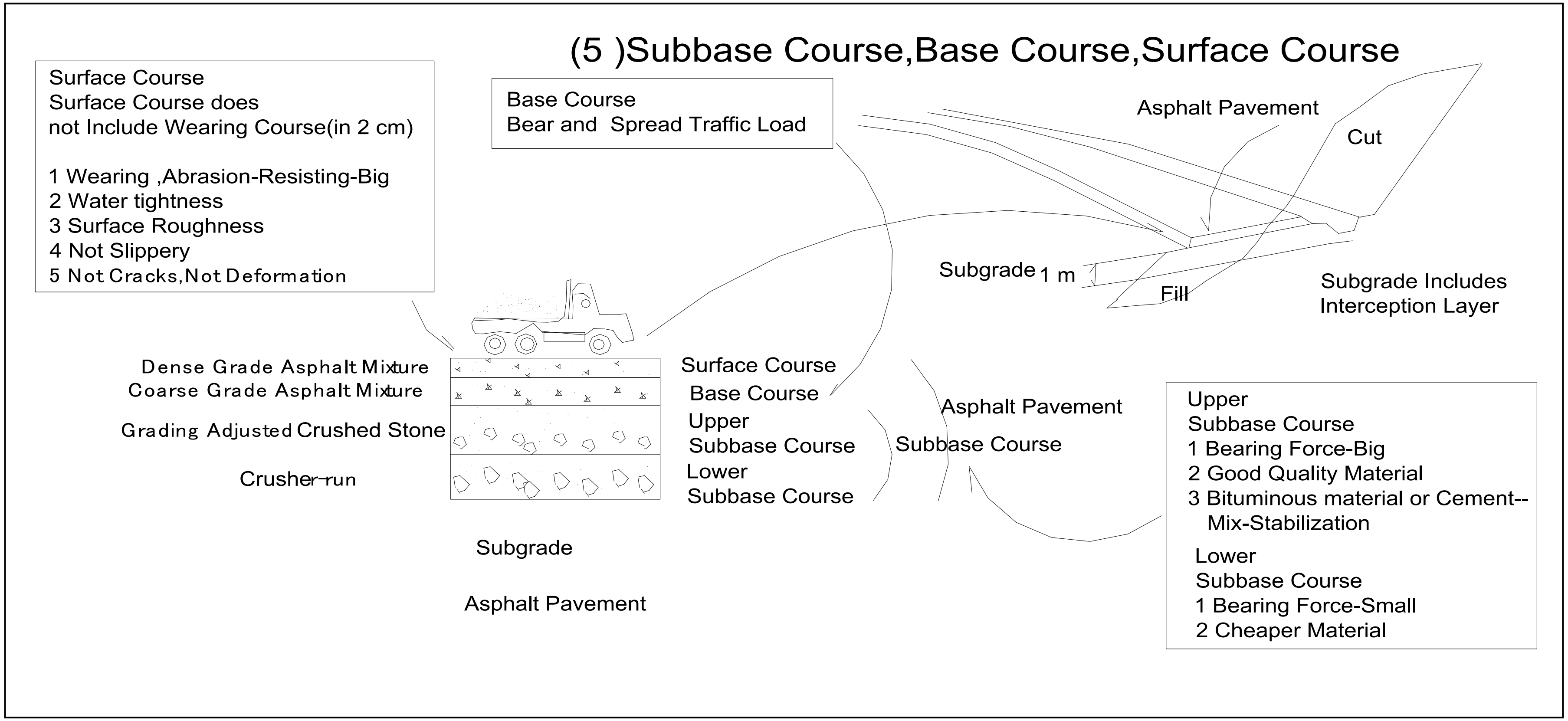


(4)Subgrade

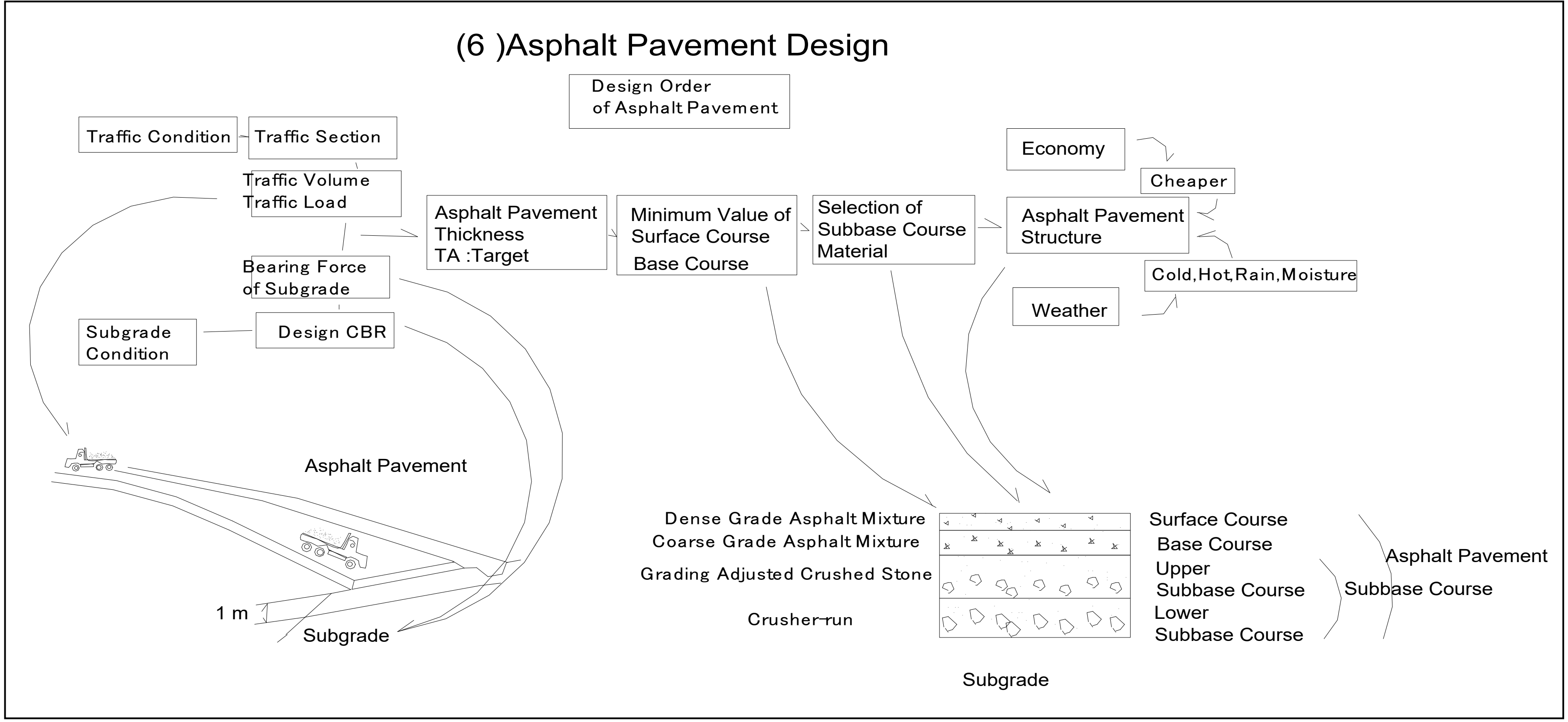
(4)Subgrade



(5) Subbase Course,Base Course,Surface Course

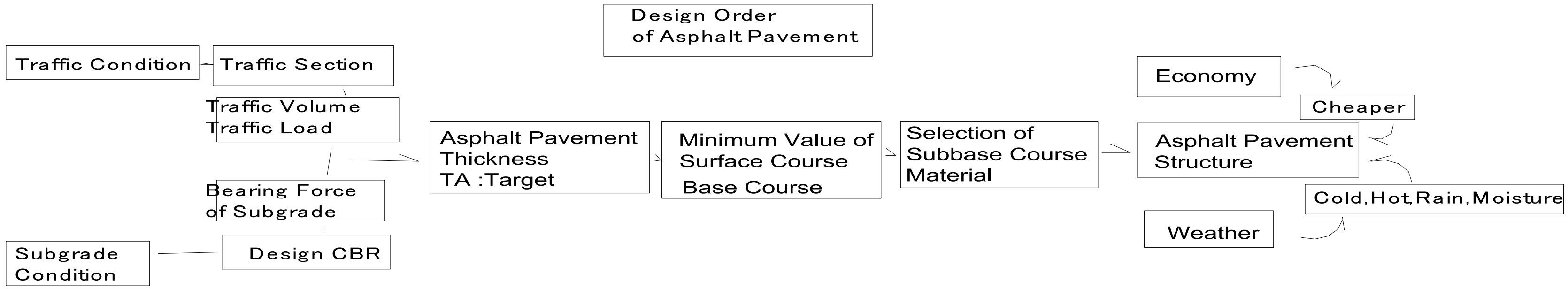


(6)Asphalt Pavement Design

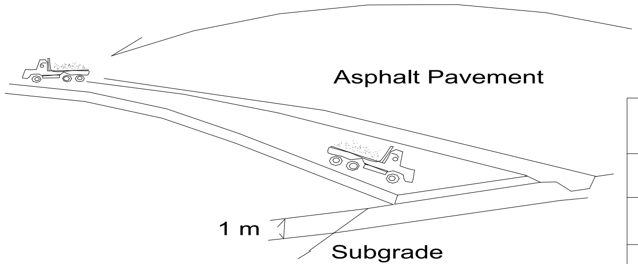


(7) 1-Traffic Condition

(7) 1-Traffic Condition



1-Traffic Condition



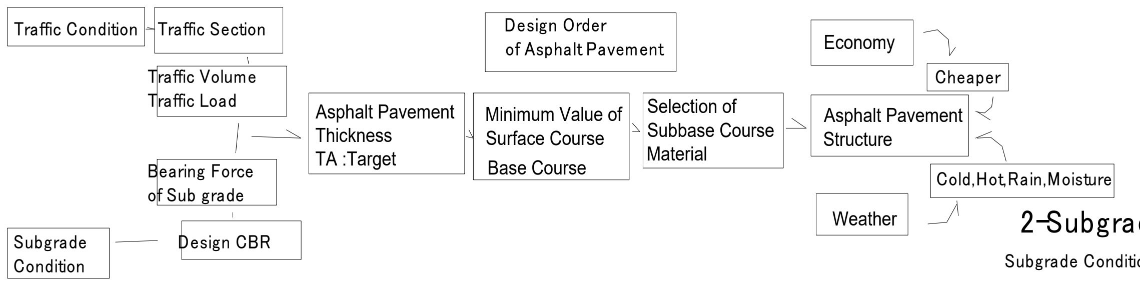
Traffic Volume of Large Vehicle
(per One Day,per One Way,after 5 Years)

Traffic Section

Traffic Section	Traffic Volume of Large Vehicle (per One Day,per One Way,after 5 Years)
L Traffic	below 100
A Traffic	100-250
B Traffic	250-1000
C Traffic	1000-3000
D Traffic	over 3000

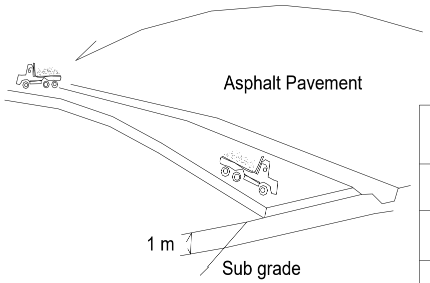
(8) 2-Subgrade Condition and Weather Condition

(8) 2-Subgrade Condition and Weather Condition



1-Traffic Condition

Traffic Volume of Large Vehicle
(per One Day,per One Way,after 5 Years)



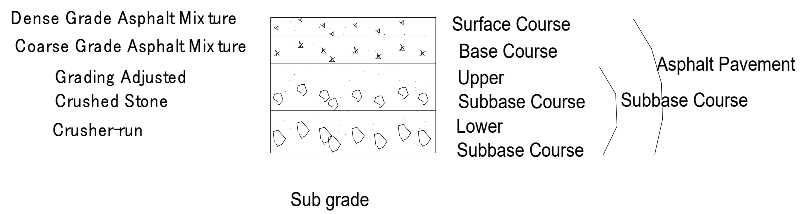
Traffic Section

Traffic Section	Traffic Volume of Large Vehicle (per One Day,per One Way,after 5 Years)
L Traffic	below 100
A Traffic	100-250
B Traffic	250-1000
C Traffic	1000-3000
D Traffic	over 3000

2-Subgrade Condition and Weather Condition

Subgrade Condition

Decision of Asphalt Pavement Thickness



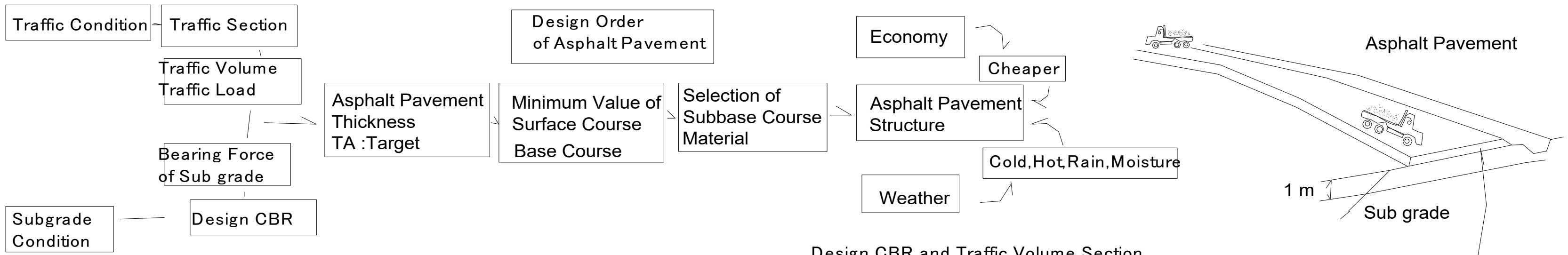
Weather Condition

Asphalt Pavement Structure

Freezing Depth

(9) Design of Asphalt Pavement Thickness

(9) Design of Asphalt Pavement Thickness



Design CBR and Traffic Volume Section

Design CBR and Traffic Volume Section

Asphalt Pavement Thickness
TA :Target
and Total Thickness
Target Value

1-Traffic Condition

Traffic Volume of Large Vehicle
(per One Day,per One Way,after 5 Years)

Traffic Section

Traffic Section	Traffic Volume of Large Vehicle (per One Day,per One Way,after 5 Years)
L Traffic	below 100
A Traffic	100-250
B Traffic	250-1000
C Traffic	1000-3000
D Traffic	over 3000

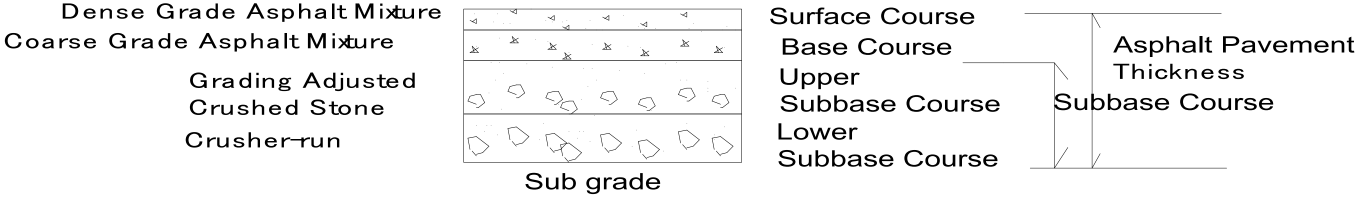
TA and Target Value of Total Thickness (H)

Design CBR	Target Value (cm)									
	L Traffic		A Traffic		B Traffic		C Traffic		D Traffic	
	TA	Total Thickness	TA	Total Thickness	TA	Total Thickness	TA	Total Thickness	TA	Total Thickness
2	17	52	21	61	29	74	39	90	51	105
3	15	41	19	48	26	58	35	70	45	83
4	14	35	18	41	24	49	32	59	41	70
6	12	27	16	32	21	38	28	47	37	55
8	11	23	14	27	19	32	26	39	34	46
12	–	–	13	21	17	26	23	31	30	36
over 20	–	–	–	–	–	–	20	23	26	27

(10) Asphalt Pavement Structure

Subgrade Condition

Decision of Asphalt Pavement Thickness ← Design CBR of Subgrade



Minimum Thickness of
Surface Course + Base Course

Traffic Section	Minimum Thickness (cm) of Surface Course + Base Course
L Traffic	5
A Traffic	5
B Traffic	10(5)
C Traffic	15(10)
D Traffic	20(15)

( ) — Minimum Thickness of
Surface Course + Base Course
Use Bituminous stabilization
on Upper Subbase Course

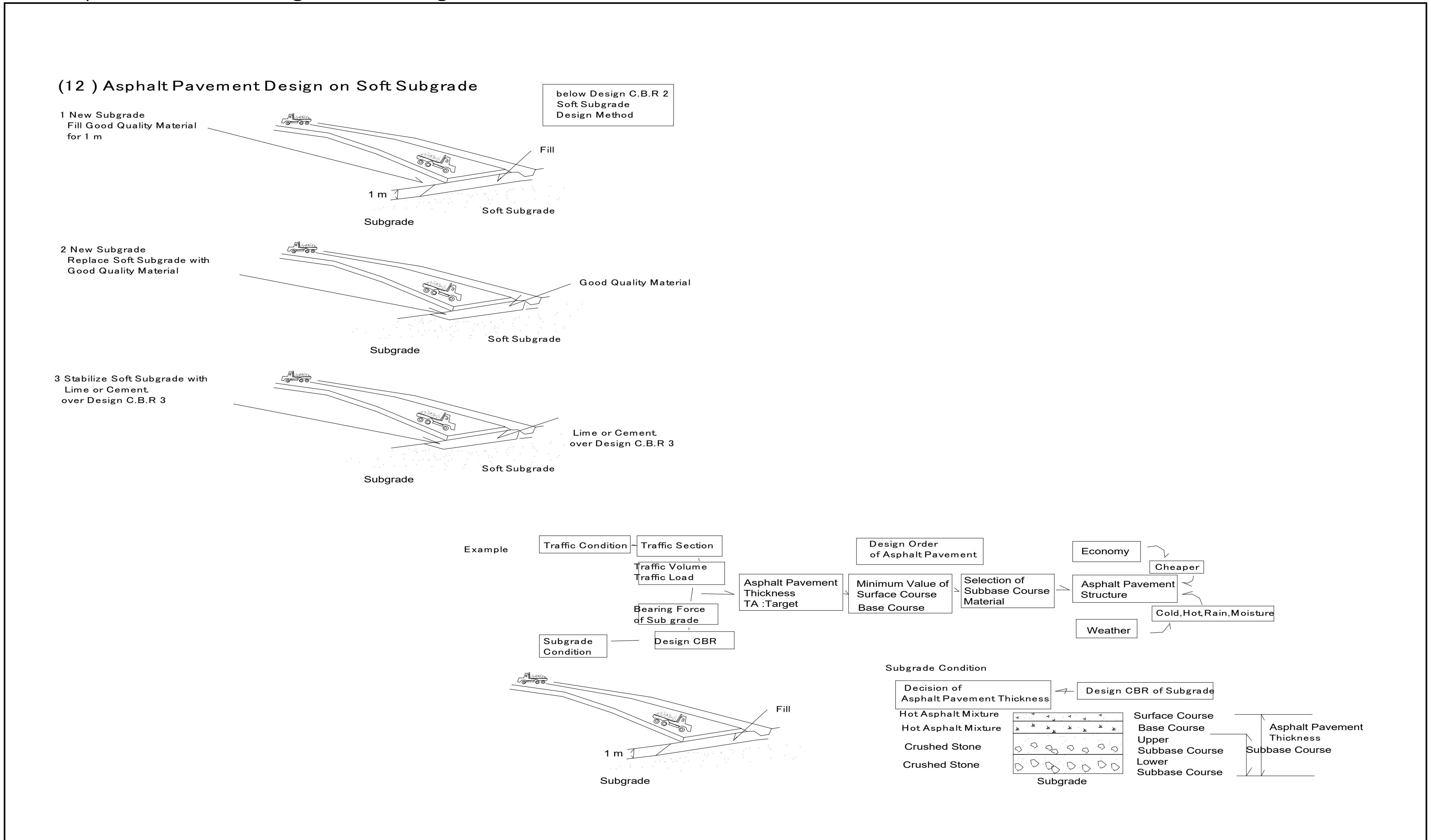
(11) Equal Value Conversion Coefficient

(11) Equal Value Conversion Coefficient

Equal Value Conversion Coefficient
:Thickness (1 cm) of Hot Asphalt Mixture of
Surface Course ,Base Course=Thickness
by Subbase Course Method or Material
TA Calculation
TA=a1T1+a2T2+ +anTn
a1 a2 an :Equal Value Conversion Coefficient
T1,T2, ,Tn:Each Thickness

Location	Method or Material	Summary	Equal Conversion Coefficient an
Surface Course Base Course	Hot Asphalt Mixture of Surface Course ,Base Course		1.0
Upper Subbase Course	Bituminous stabilization	Hot Asphalt Mixture :Stability over 350kg	0.8
	Bituminous stabilization	Cold-Laid Mixture :Stability over 250kg	0.55
	Cement stabilization	Unconfined Compression Test (7 Days) 30kg/cm2	0.55
	Lime stabilization	Unconfined Compression Test (10 Days) 30kg/cm2	0.45
	Grading Adjusted Crushed Stone Grading Adjusted Slag	Adjusted CBR :over 80	0.35
Lower Subbase Course	Crusher-run,Slag,Sand	Corrected C.B.R :over 30 Corrected C.B.R :over 20 below 30	0.25 0.20
	Cement stabilization	Unconfined Compression Test (7 Days) 10kg/cm2	0.25
	Lime stabilization	Unconfined Compression Test (10 Days) 7kg/cm2	0.25

(12) Asphalt Pavement Design on Soft Subgrade



(13) Example of Asphalt Pavement Design-1

Example-1

Traffic Condition
Traffic Section:B
Design C.B.R 4

Subbase Material
Grading Adjusted Crushed Stone
(Corrected C.B.R>80)
Crusher-run
(Corrected C.B.R>30)

1 Target Value of TA and H
accoring to Table-3
TA and Target Value of
Total Thickness

TA:24cm
H:49cm

Table-3 TA and Target Value of Total Thickness (H)

Design CBR	Target Value (cm)									
	L Traffic		A Traffic		B Traffic		C Traffic		D Traffic	
	TA	Total Thickness	TA	Total Thickness	TA	Total Thickness	TA	Total Thickness	TA	Total Thickness
2	17	52	21	61	29	74	39	90	51	105
3	15	41	19	48	26	58	35	70	45	83
4	14	35	18	41	24	49	32	59	41	70
6	12	27	16	32	21	38	28	47	37	55
8	11	23	14	27	19	32	26	39	34	46
12	−	−	13	21	17	26	23	31	30	36
over 20	−	−	−	−	−	−	20	23	26	27

(14) Example of Asphalt Pavement Design -2

(14) Example of Asphalt Pavement Design-2

3 Selection of Subbase Course Material according to Table-5

Grading Adjusted Crushed Stone (Corrected C.B.R>80) :0.35
Crusher-run (Corrected C.B.R>30) :0.25

Table-5 Equal Value Conversion Coefficient for TA Calculation

Location	Method or Material	Summary	Equal Conversion Coefficient an
Surface Course Base Course	Hot Asphalt Mixture of Surface Course, Base Course		1.0
Upper Subbase Course	Bituminous stabilization	Hot Asphalt Mixture :Stability over 350kg	0.8
	Bituminous stabilization	Cold-Laid Mixture :Stability over 250kg	0.55
	Cement stabilization	Unconfined Compression Test (7 Days) 30kg/cm2	0.55
	Lime stabilization	Unconfined Compression Test (10 Days) 30kg/cm2	0.45
	Grading Adjusted Crushed Stone Grading Adjusted Slag	Corrected CBR :over 80	0.35
Lower Subbase Course	Crusher-run , Slag, Sand	Corrected CBR :over 30 Corrected CBR :over 20 below 30	0.25 0.20
	Cement stabilization	Unconfined Compression Test (7 Days) 10kg/cm2	0.25
	Lime stabilization	Unconfined Compression Test (10 Days) 7kg/cm2	0.25

(15) Example of Asphalt Pavement Design -3

(15) Example of Asphalt Pavement Design-3

4 Design Each Subbase Course Thickness according to Economy

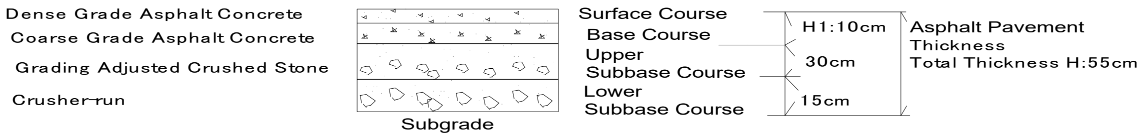
0.35*Upper Subbase Thickness+
0.25*Lower Subbase Thickness>=TA2
Upper Subbase Thickness+Lower
Subbase Thickness>=H2

Example
Upper Subbase Course
Grading Adjusted Crushed Stone 30cm

Lower Subbase Course
(Crusher-run) 15cm

TA2=0.35*30+0.25*15=14.25>TA2(=14cn)
H2 = 30+15=45>H2 (=39cm)

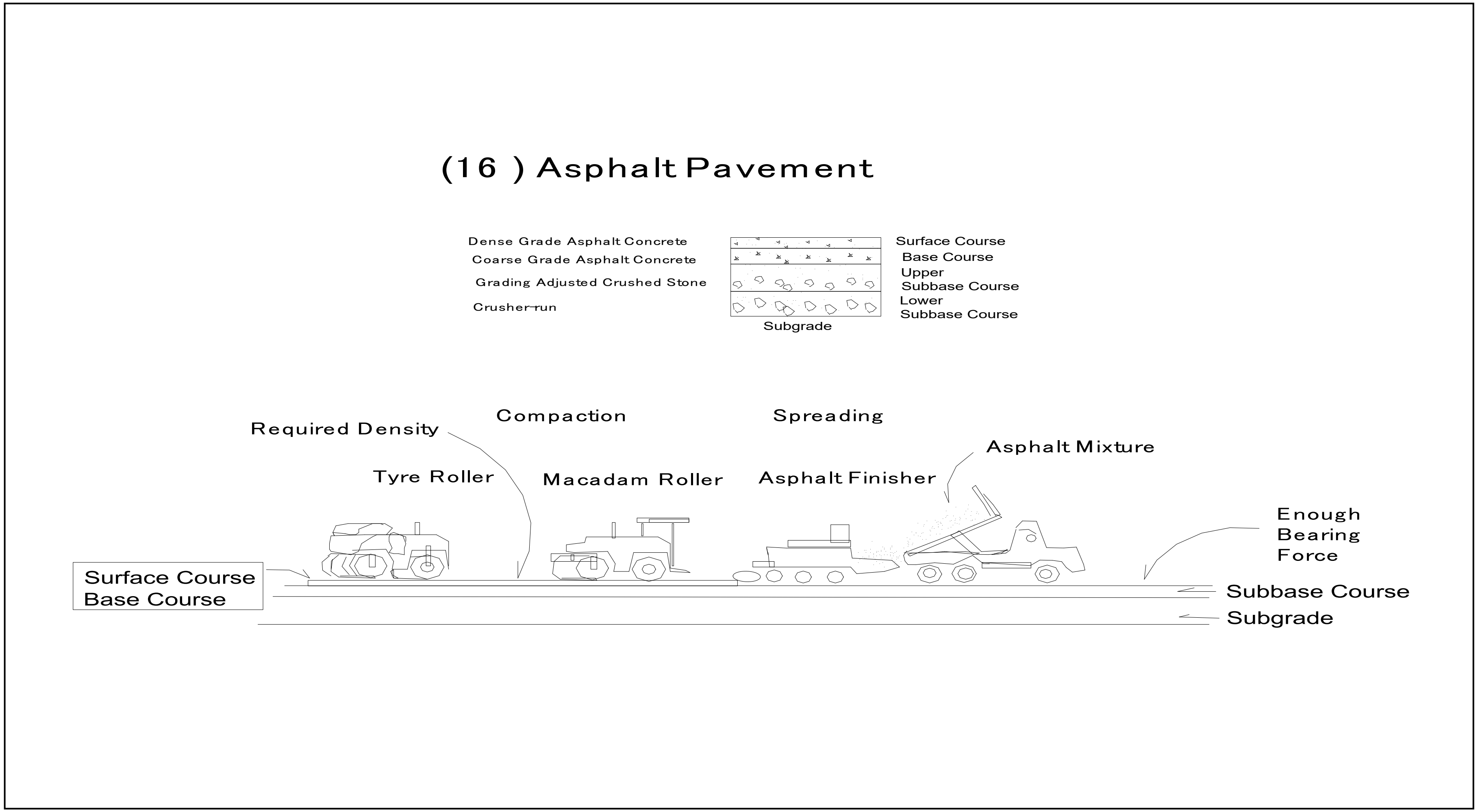
5 Decision of Asphalt Pavement Thickness and Structure



TA=TA1+TA2=24.25cm>TA(=24)
H=H1+H2=55cm>H(=49)

Surface Course and Base Course are Decided by Construction Easiness

(16) Asphalt Pavement



(17) Preparation of Asphalt Pavement

(1) Asphalt Pavement Planning

Plant Capacity Planning
Transportation Planning

Construction Volume / Construction Period / Construction Easiness → Schedule → Construction Volume per One Day

(2) Preparation of Construction Machine and Equipment

according to Construction Volume per One Day | Type of Construction Machine | Combination | Number of Construction Machine

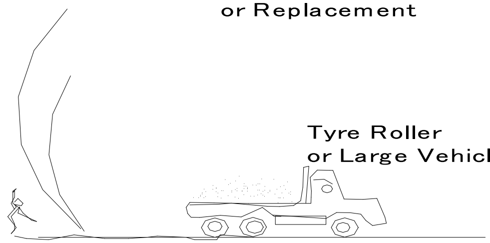
Selection of Construction Machine
Balance each Construction Machine Capacity

Mixing Capacity → Transportation Capacity → Spreading Capacity → Compaction Capacity

(3) Inspection of Subbase /Base Course

Inspection
Surface Roughness ,Bearing Force of Subbase and Base Course

Bad Points—Exchange or Replacement

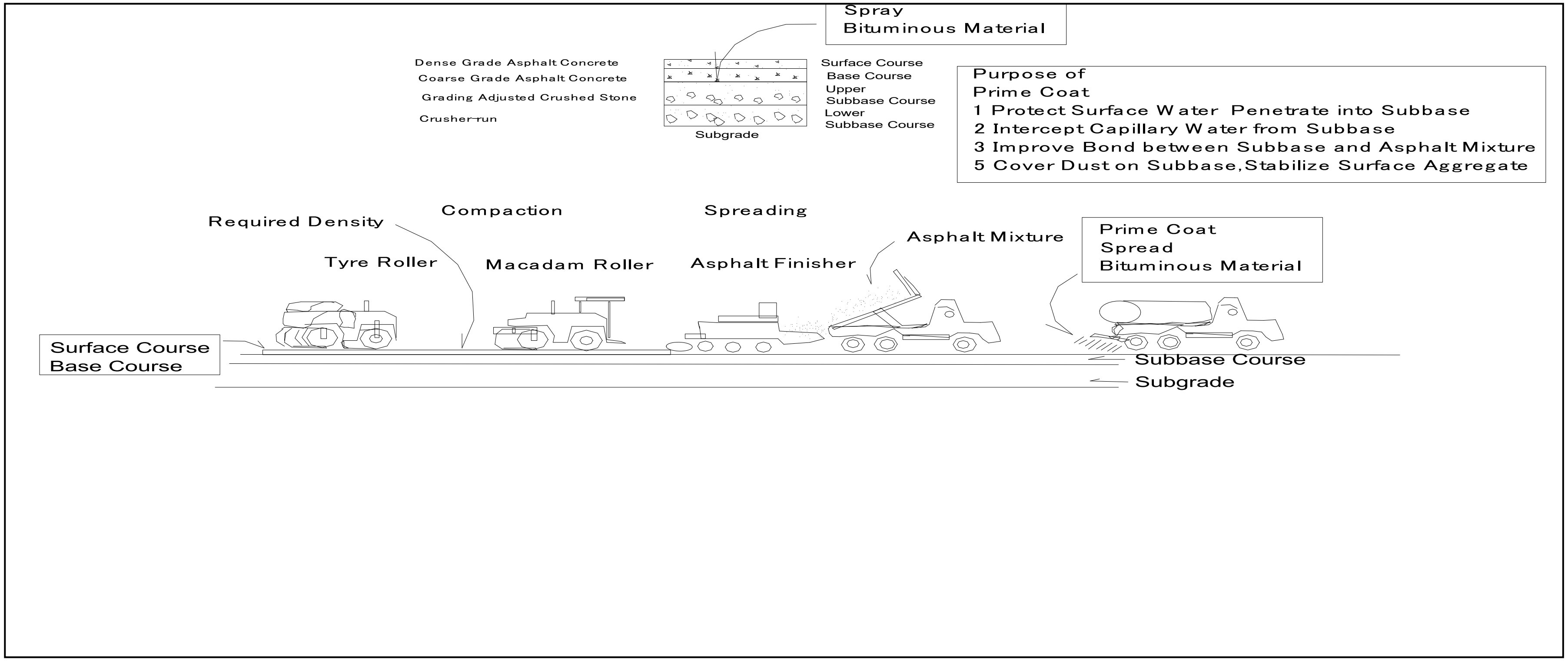


Tyre Roller or Large Vehicle

(4) Cleaning of Subbase,Base Course

Take out Dust,Mud,Floating Stone
Wet Surface—Dry—Asphalt Pavement

(18) Prime Coat-1



(19) Prime Coat-2

(19) Prime Coat-2

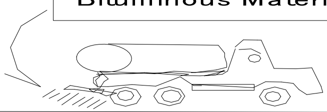
(1) Material

Cut-back Asphalt
Road Tar

Asphalt Emulsion

Popular

Prime Coat
Spread
Bituminous Material



Selection of
Bituminous Material

Subbase Course

Prime Coat Bituminous Material	Subbase Condition
1 Asphalt Emulsion (PK-3)	Bad Weather Condition,Wet Subbase
2 Cut-back Asphalt (RC-70,MC-70)	Good Weather Condition,Absorption-Big
3 Road Tar (A-1-3,B-1-3)	Good Weather Condition,Absorption-Small

(2) Spreading Amount

1.0-2.0 Liter/m2

(3) Spreading and Curing

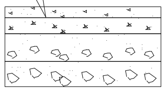
a Spreading
1 Cleaning
2 Fine Day
3 Proper Spreader
Uniformity Quantity

b Curing
1 Stop Traffic
2 Start Paving after Dry

(20) Tack Coat

(20) Tack Coat

Tack Coat
Spred
Bituminous Material



(2) Spreading Amount

1.0-2.0 Liter/m2

(3) Spreading and Curing

a Spreading
1 Cleaning
2 Fine Day
3 Proper Spreader
Uniformity Quantity

b Curing
1 Stop Traffic
2 Start Paving after Dry

Tack Coat
Improve Adhesion between
Base Course and Asphalt Mixture

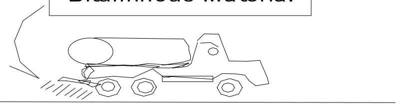
Spread Bituminos Material on
Base Course

Cut-back Asphalt
Road Tar

Asphalt Emulsion

Popular

Prime Coat
Spread
Bituminous Material



Subbase Course

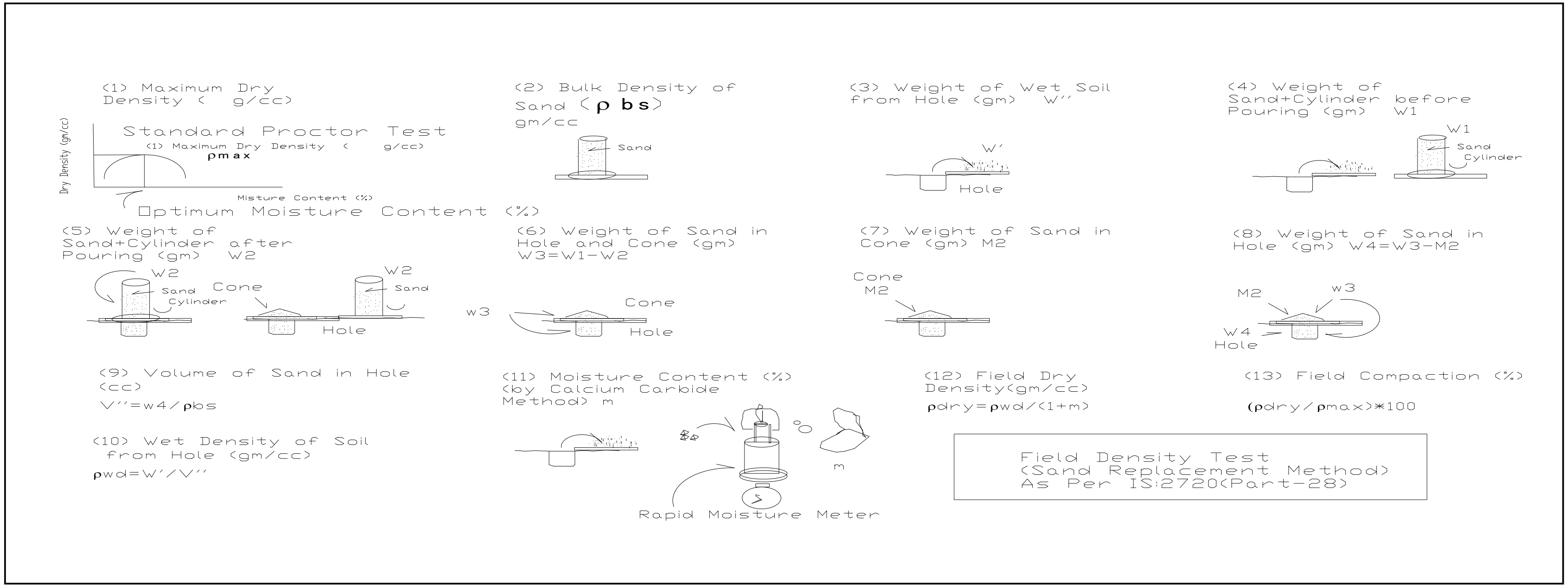
Selection of
Bituminous Material

Prime Coat
Bituminous Material

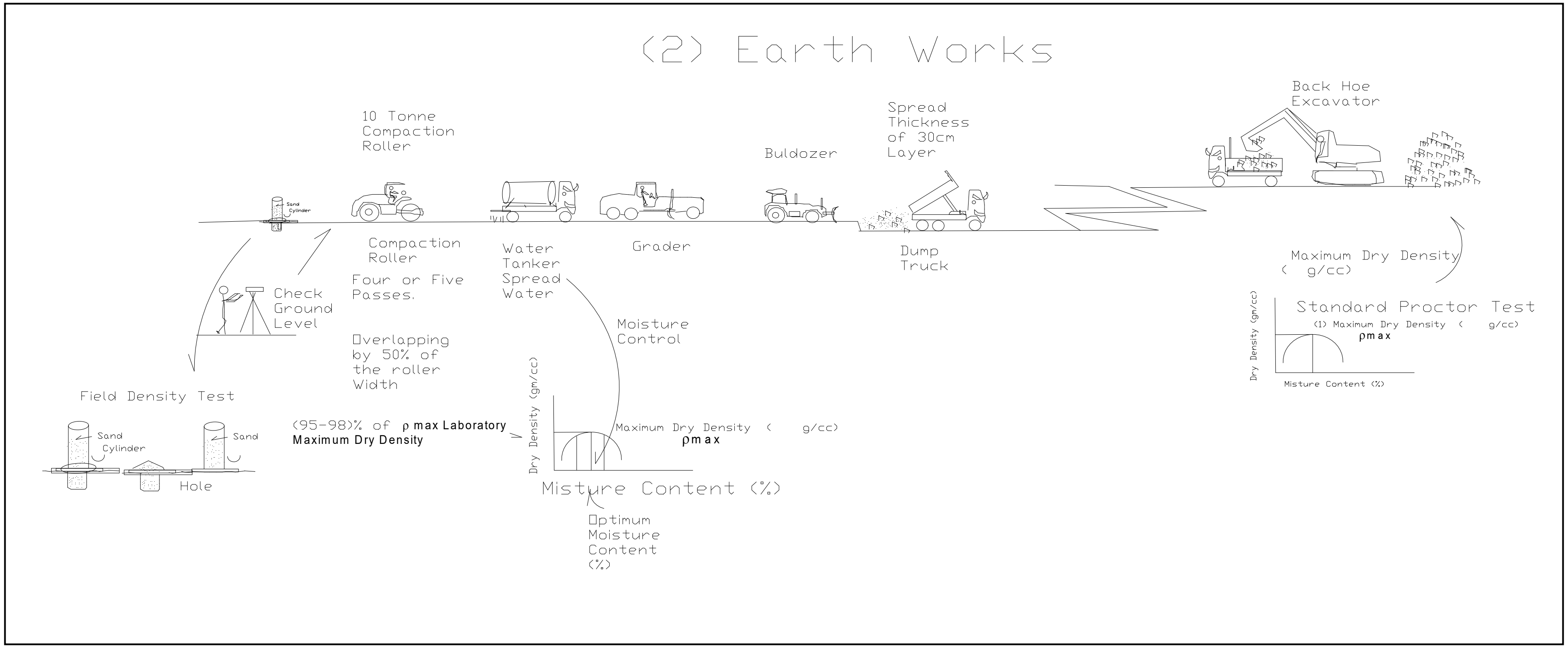
Subbase Condition

1 Asphalt Emulsion (PK-3) —— Bad Weather Condition,Wet Subbase
2 Cut-back Asphalt (RC-70,MC-70) - Good Weather Condition,Absorption-Big
3 Road Tar (A-1-3,B-1-3) —— Good Weather Condition,Absorption-Small

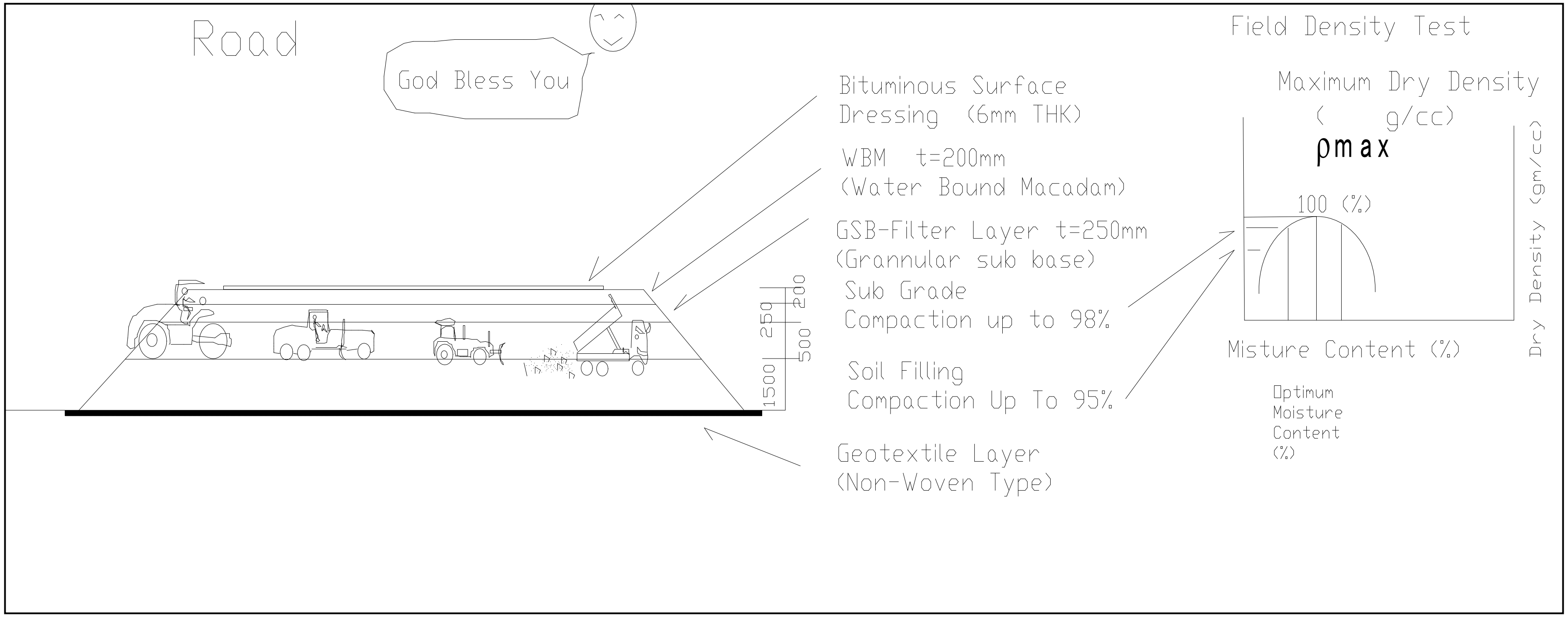
(21) Field Density Test



(22) Earth Works



(23) Access Road



Civil Engineering Calculation in Africa(1-11)

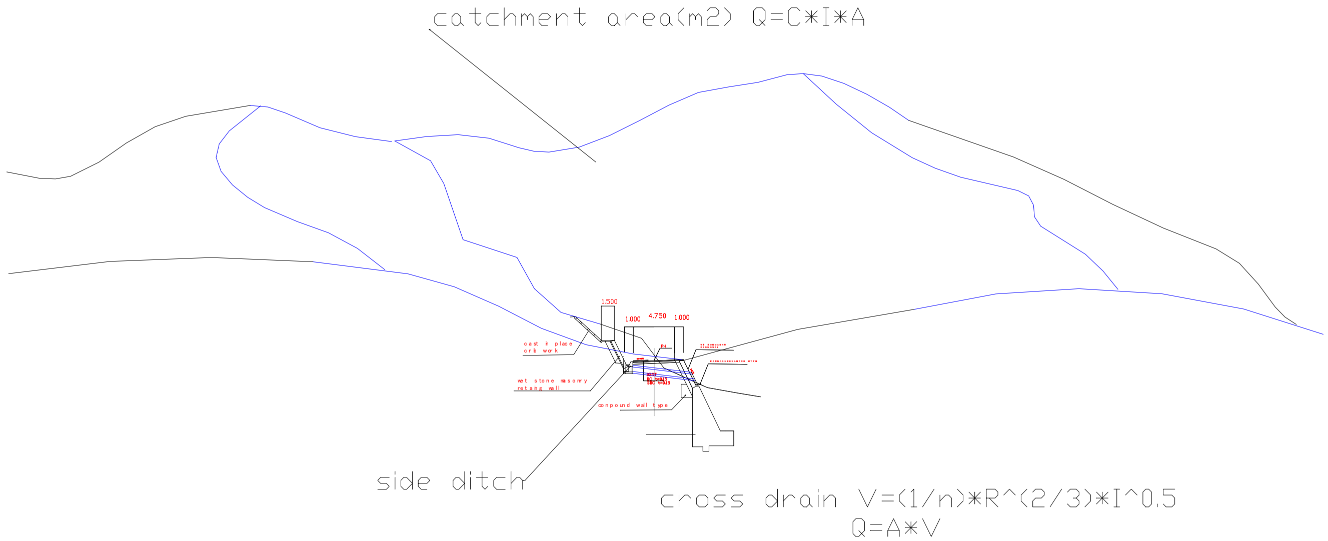


figure-1 drain cross-2

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TADANO TOSHIO

Civil Engineering Calculation in Africa

1	(1)channel section
2	(2)clothoide-1
3	(3)compound wall
4	(4)Pipe and Box Culvert
5	(5)culvert section
6	(6)gravity wall-10-new
7	(7)leveling
8	(8)retaing wall stability calculation
9	(9)side ditch
10	(10)vertical drain interval length
11	(11)vertical drainage

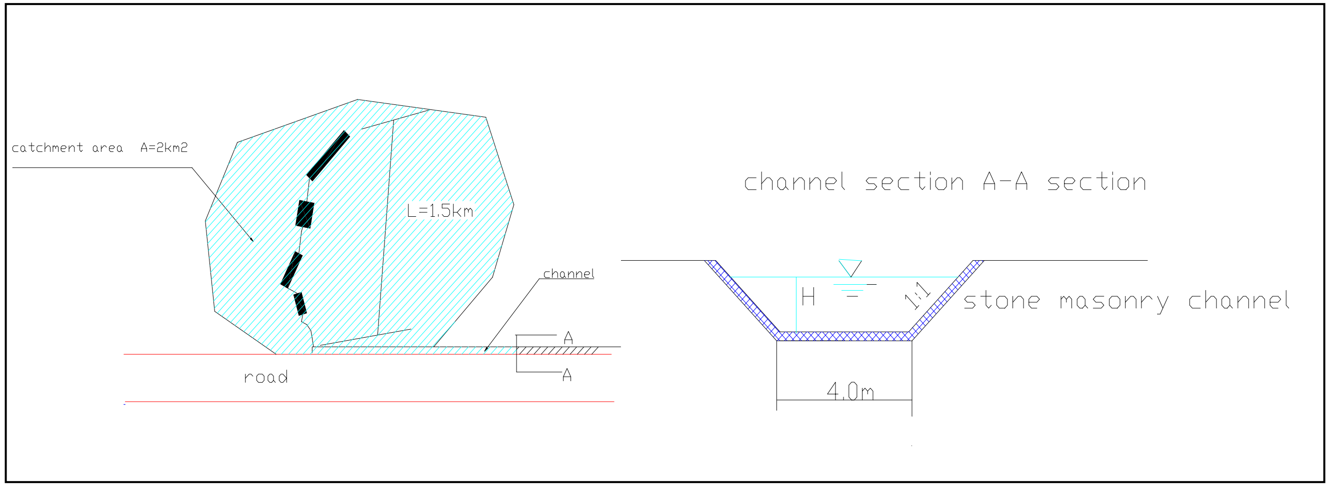
Unit symbols and unit conversion figures

conversion	conversion table		conversion standard		
N = kgf * 9.8	N	kgf	1N	≒	0.1kgf
	1	0.102	10N	≒	1kgf
	9.8	1	100N	≒	10kgf
			1kN = 1000N	≒	100kgf
			10kN = 10000N	≒	1000kgf = 1tf

formula

conversion	conversion table					conversion standard		
N/m2 = kgf/cm2 * 98000	N/m2	N/cm2	N/mm2	kgf/cm2	kgf/mm2	1N/mm2	≒	10kgf/cm2
N/m2 = kgf/mm2 * 980000	1	0.0001	0.000001	0.0000102	0.000000102	10N/mm2	≒	100kgf/cm2
N/mm2 = kgf/cm2 * 0.098	10000	1	0.01	0.102	0.00102	100N/mm2	≒	1000kgf/cm2 = 1tf/cm2
N/mm2 = kgf/mm2 * 9.8	1000000	100	1	10.2	0.102	1kN/mm2 = 1000N/mm2	≒	10000kgf/cm2 = 10tf/cm2
	98000	9.8	0.098	1	0.01	1N/cm2	≒	0.1kgf/cm2
	9800000	980	9.8	100	1	10N/cm2	≒	1kgf/cm2
						100N/cm2	≒	10kgf/cm2
						1kN/cm2 = 1000N/cm2	≒	100kgf/cm2

(1)channel section

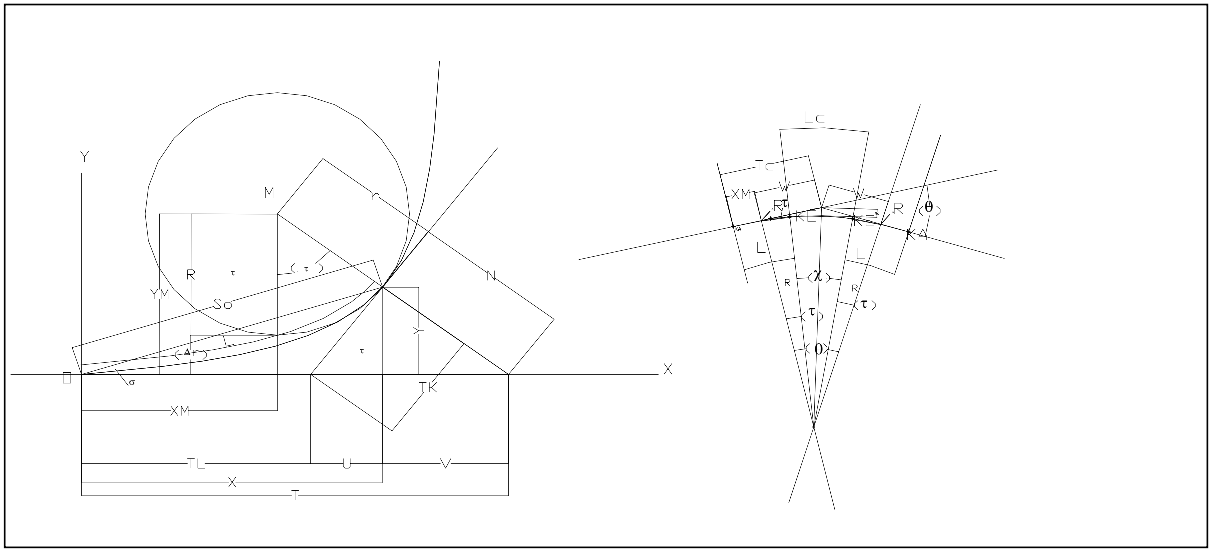


channel section ?

no		item	unit	quantity	remarks
1	A	catchment area	km^2	2	A=a1+a2+a3
2	a1	catchment area on mountain	km^2	1	
3	a2	catchment area in town	km^2	0.6	
4	a3	catchment area in park	km^2	0.4	
5	c1	co-efficient discharge on mountain		0.75	
6	c2	co-efficient discharge in town		0.75	
7	c3	co-efficient discharge in park		0.6	
8	I3	intensity of rainfall	mm/h	105.4	I3=8625/(tc+55)
9	tc	time of concentration	min	26.8	tc=t1+t2
10	t1	time of concentration	min	20.0	
11	t2	time of concentration	min	6.8	t2=L/(v*60)
12	L	Length	m	1500	
13	C	coefficient of discharge		0.72	C=(a1*c1+a2*c2+a3*c3)/(a1+a2+a3)
14	Q	discharge of storm sewage	m3/sec	42.15829558	Q=C*I*A/3.6

15						
16		(B-4,H-2.5)				
17	n	coefficient of roughness		0.0250		
18	I	vertical gradient on drain	%	0.0050		200
19	n	coefficient of roughness		0.0160		
20	R	hydraulic mean depth		1.4679	R=A/P	
21	P	Wetted perimeter of the channel		11.07	P=B+2*1.414*H	
22	A	drain section area	m2	16.25	A=(2B+2H)*0.5*H	
23	B	drain width	m	4.0000		
24	H	drain height	m	2.5000		
25	I	drain slope gradient	%	0.0050		200
26	v	flowing velocity	m/sec	3.657950652	v=(1/n)*(R^0.67)*(I)^0.5	
27	Qc	drain discharge capacity	m3/sec	59.44169809	Qc=A*v	
28				Qc should be over Q		
29						
30		(B-4,H-2.1)				
31	n	coefficient of roughness		0.0250		
32	I	vertical gradient on drain	%	0.0050		200
33	n	coefficient of roughness		0.0160		
34	R	hydraulic mean depth		1.2889	R=A/P	
35	P	Wetted perimeter of the channel		9.9388	P=B+2*1.414*H	
36	A	drain section area	m2	12.81	A=(2B+2H)*0.5*H	
37	B	drain width	m	4.0000		
38	H	drain height	m	2.1000		
39	I	drain slope gradient	%	0.0050		200
40	v	flowing velocity	m/sec	3.352657299	v=(1/n)*(R^0.67)*(I)^0.5	
41	Qc	drain discharge capacity	m3/sec	42.94753999	Qc=A*v	
				Qc should be over Q		
	h1	20% increase height=	m	2.52	h1=1.2*H	

(2)clothoide-1



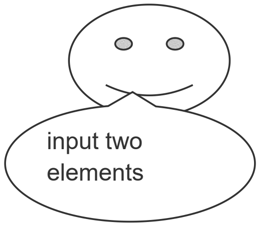
condition

1		R*L=A^2
2		A=1(single curbe)
3		R*L=1
4		r*(l)=1
5	curve radius	R=A*r
6	curve length	L=A*(l)

according to
japan civil engineering learned society
(survey practice text book)
japan road cooperation
(road strucure law,explanation and adaptation)
(clothoide pocket book)

1	tangent	τ	τ	τ=(L/2R)*180/3.1416 L^2/2*A^2 A^2/2*R^2
2	angle	σ	σ	σ=atan(y/x)
3	parameter	1	A	
4	clothoide length	l	L=A*(l)	L=A^2/R=2*(τ)*R=A(2τ)^0.5
5	radius of curvature	r	R=A*r	R=A^2/L=L/2(τ)=A/(2*τ)^0.5
6	shifting amount	Δ(r)	(Δ)R=A*(Δ)r	Δ(r)=y+r*cos(τ)-r
7	X coordinate at M	xM	XM=A*xM	xM=x-r*sin(τ)
8	X coordinate at P	x	X=A*x	x=l*(1-l^2/40r^2+l^4/3456*r^4-l^6/599040*r^6+l^8/175472640*r^8-l^10/78033715200*r^10+l^12/4904976384000*r^12)
9	Y coordinate at P	y	Y=A*y	y=(l^2/6*r)(1-l^2/56*r^2+l^4/7040*r^4-l^6/1612800*r^6+l^8/588349440*r^8-l^10/313373491200*r^10+l^12/229552894771200*r^12)
10	short tangent	tK	TK=A*tK	tK=ycosec(τ)
11	long tangent	tL	TL=A*tL	tL=x-y*cot(τ)
12	X coordinate at intersection	t	T=A*t	t=x+y*tan(τ)
13	alignment length	n	N=A*n	n=y*sec(τ)
14	(shifting) diameter	s	S=A*s	s=y*cosec(σ)
15	(shifting amount)/curvature radi	Δ(r)/r	ΔR/R=Δ(r)/r	Δ(r)/r=(y/r)+cos(τ)−1
16	curve length/curvature radius	l/r=l^2	L/R=l^2	l/r=l^2

1 x=l*(1-l^2/40r^2+l^4/3456*r^4-l^6/599040*r^6+l^8/175472640*r^8-l^10/78033715200*r^10+l^12/4904976384000*r^12)
2 y=(l^2/6*r)(1-l^2/56*r^2+l^4/7040*r^4-l^6/1612800*r^6+l^8/588349440*r^8-l^10/313373491200*r^10+l^12/229552894771200*r^12)



			unit	remarks		
1	R	100	R=A^2/L		100	(firstly decide R ,L and A)
2	L	100	L=A^2/R		100	(according to R*L=A^2)
3	A	100	A=(R*L)^0.5		100	

		(1)	A (2)	(3)	(4)=(1)*(2)	
1	(l)=L/A	1	100	L	100	
2	(τ)=(L/2R)*180/3.1416	28.648	100	(τ)	28.6478	
3	σ=atan(y/x)	**9.5290**	100	σ	9.52896	
4	x	0.9753	100	X	97.529	
5	y	0.1637	100	Y	16.371	
6	r=R/A	1	100	R	100.000	
7	Δ(r)=((y/r)+cos(τ)−1)∗r	0.0413	100	Δ(R)	4.130	
8	xM=x-r*sin(τ)	0.4959	100	XM	49.586	
9	tK=ycosec(τ)	0.3415	100	TK	34.148	
10	tL=x-y*cot(τ)	0.6756	100	TL	67.561	
11	t=x+y*tan(τ)	1.0647	100	T	106.472	
12	n=y*sec(τ)	0.1866	100	N	18.655	
13	s=y*cosec(σ)	0.9889	100	S	98.893	
14	Δ(r)/r=(y/r)+cos(τ)−1	0.0413	100	Δ(R)/R	4.130	
15	(l)/r=(l)^2	1	100	L/R	100.000	
16	θ=χ+2∗τ				30	(θ is deflection angle
17	χ=2∗τ−θ			χ=2∗τ−θ	27.2956	,is given fastly.(IA))
18	Lc=R*π∗χ/180			Lc=R*π∗χ/180	47.64	
19	CL=L1+L2+Lc			CL	CL=L1+L2+Lc	
20	W=(R+ΔR)*tan(θ/2)			W	27.9015	
21	Tc=W+XM			Tc	77.488	
22	Nc=(R+ΔR)(1/cos(θ/2))-R			Nc	7.80302	

(3)compound wall (3-1)

A-1
allowable stress
σ28
concrete design basic strength
σca
concrete allowable bending copressive stress
τa
concrete allowable shearing stress
σta
concrete allowable bending tensile stress
σsa
reinforced bar allowable bending tensile stress

A-2
seismic coefficient
K
horizontal seismic coeff
Kv
vertical seismic coeffici

A-3
unit weight
u
concrete unit weight
r
Unit weight of soil behir

A-4
soil condition
φ
behind soil internal friction angle
φ
bearing ground internal friction angle
qa
ultimate bearing capacity
earth pressure formula is Coulomb's earth-pressure theory

α
angle between slope surface and horizontal
θ
internal angle between estimated behind surface and vertical line
δ
behind soil internal friction angle

A-5
allowable ground bearing force
q
ultimate bearing capacity
qa1=(1/3)*qa
allowable ground bearing force(nor
qa2=(1/2)*qa
allowable ground bearing force(ear

A-6
stability calculation
sl
confirmation to sliding
safety ratio to sliding
normal time over 1.5
earthquake time over 1.2
confirmation to falling
resultant working position is (following length from center)
normal time
within 1/6 of B
earthquake time
within 1/4 of B
B
Foundation bottom width

B: section shape dimension

C-1
C:stability calculation in normal time
eartpressure calculation

compound wall new

	A-1				A-2		A-3		A-4				A-5			A-6				C-1						
																				ka=(cos^2(φ-θ))/(((cos^2*θ*cos(θ+φ)*(1+((sin(φ+δ)*sin(φ-χ)/(cos(θ+φ)*cos(θ-χ))^0.5						
																		e/B<1/6	e/B<1/4							
H	σ28	σca	τa	σta	kh	kv	u	r	φ	α	θ	δ	qa	qa1	qa2	f to slide	f to slide	f to slide	f to slide	KA	cos^2(φ-θ)	cos^2(θ)	cos(θ+φ)	sin(δ+φ)	sin(δ-χ)	cos(θ+φ)
	kg/cm2	kg/cm2	kg/cm2	kg/cm2			t/m3	t/m3	degree	degree	degree	degree	t/m2	t/m2	t/m2											
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
A	B	C	D	E	F	G	H	I	j	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
2	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	=(1/3)*N43	=(1/2)*N43	>1.5	>1.2			=(V43)/(((W43*X43)*(1+((Y43*Z43)/(AA43*AB43))^0.5)^2))	=(COS((J43-L43)*PI()/180))^2	=(COS(L43*PI()/180))^2	=COS((L43+J43)*PI()/180)	=SIN((M43+J43)*PI()/180)	=ABS(SIN((M43-K43)*PI()/180))	=COS((L43+J43)*PI()/180)
2	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	10	15	>1.5	>1.2			0.194525	0.75	1	0.8660254	0.8660254	0.5509892	0.8660254
3	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	10	15	>1.5	>1.2			0.194525	0.75	1	0.8660254	0.8660254	0.5509892	0.8660254
4	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	10	15	>1.5	>1.2			0.194525	0.75	1	0.8660254	0.8660254	0.5509892	0.8660254
5	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	10	15	>1.5	>1.2			0.194525	0.75	1	0.8660254	0.8660254	0.5509892	0.8660254
6	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	10	15	>1.5	>1.2			0.194525	0.75	1	0.8660254	0.8660254	0.5509892	0.8660254
7	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	10	15	>1.5	>1.2			0.194525	0.75	1	0.8660254	0.8660254	0.5509892	0.8660254
8	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	10	15	>1.5	>1.2			0.194525	0.75	1	0.8660254	0.8660254	0.5509892	0.8660254
9	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	10	15	>1.5	>1.2			0.194525	0.75	1	0.8660254	0.8660254	0.5509892	0.8660254
10	180	60	8	3	0.15	0	2.35	2	30	63.4349	0	30	30	10	15	>1.5	>1.2			0.194525	0.75	1	0.8660254	0.8660254	0.5509892	0.8660254

(3-2)

Pa

(2) total earth pressure to estimated behind surface

Pa=(1/2)*r*Ka*H^2+(KA*q-2*C*(Ka)^0.5)*H

q

loading on ground surface in normal time

c

soil adhesion(sand)

r

soil unit weight

H

wall height or estimated behind surface

PH

horizontal earthpressure(PH)=P*cos(δ)

PV

horizontal earthpressure(PV)=P*sin(δ)

y

working point of total pressure y=H/3

C-2

weight and gravity center

1 compound wall -new				
2 design order				
3 compound wall -new				
4 A	design condition		figure	table
5	A-1	allowable stress		
6	A-2	sesimic		
7	A-3	unit weight		table-1
8	A-4	soil condition		table-1
9	A-5	allowable groud bearing force		
10	A-6	stability calculation		
11 B	section dimension		figure-1	
12 C	normal time stability calculation			
13	C-1	eartpressure calculation	figure-2	table-2,5
14	C-2	weight and gravity center	figure-3	table-1
15	C-3	resultant force working point		table-3
16	C-4	confirmation to falling		table-4
17	C-5	confirmation to sliding	figure-5	table-4
18	C-6	confirmation to ground reaction force	figure-4	
19 D	eartquke time stability calculation			
20	D-1	eartpressure calculation	figure-2	table-2,5
21	D-2	weight and gravity center	figure-3	table-1
22	D-3	resultant force working point		table-3
23	D-4	confirmation to falling		table-4
24	D-5	confirmation to sliding	figure-5	table-4
25	D-6	confirmation to ground reaction force	figure-4	

Pa C-2

;)^2																							type classificatio h5	rectangle concrete a1=b1*h1	triangle concrete a2=0.5*b2*l	rectangle concrete a3=b3*h3
cos(θ-χ)	Pa	q	c	r	H	PH	PV	Y	H	b1	b2	b3	b4	b5	b6	b7	b8	B	h1	h2	h3	h4	h5	a1=b1*h1	a2=0.5*b2*l	a3=b3*h3
	t	t/m2		t/m3	m	t	t	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m2	m2	m2
28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB
=COS((L43-K43)*PI()/180)	=(1/2)*AF43*U43*AG43^2+(U43*AD43-2*AE43*(U43)^0.5)*AG43	1	0	2	=AK43+1.1	=AC43*COS(M43*PI()/180)	=AC43*SIN(M43*PI()/180)	=AG43/3	2	0.85	0.5	1.9	0.4	0.55	0.95	0.55	0.55	=AQ43+AO43+AR43	1	1	1	0.4	1.1	=AL43*AU43	=0.5*AM43*AV43	=AN43*AW43
0.4472144	2.4724133	1	0	2	3.1	2.1411728	1.2362067	1.0333333	2	0.85	0.5	1.9	0.4	0.55	0.95	0.55	0.55	1.9	1	1	1	0.4	1.1	0.85	0.25	1.9
0.4472144	4.0675187	1	0	2	4.1	3.5225745	2.0337594	1.3666667	3	0.85	1	2.4	0.4	0.55	1.3	0.7	0.55	2.4	2	2	1	0.4	1.1	1.7	1	2.4
0.4472144	6.0516742	1	0	2	5.1	5.2409036	3.0258371	1.7	4	0.85	1.5	2.9	0.5	0.55	1.6	0.8	0.55	2.9	3	3	1	0.5	1.1	2.55	2.25	2.9
0.4472144	8.4248798	1	0	2	6.1	7.2961599	4.2124399	2.0333333	5	0.85	2	3.4	0.5	0.55	1.8	1.1	0.55	3.4	4	4	1	0.5	1.1	3.4	4	3.4
0.4472144	11.187135	1	0	2	7.1	9.6883435	5.5935677	2.3666667	6	0.85	2.5	3.9	0.7	0.55	2	1.2	0.55	3.9	5	5	1	0.6	1.1	4.25	6.25	3.9
0.4472144	14.338441	1	0	2	8.1	12.417454	7.1692206	2.7	7	0.85	3	4.4	0.7	0.55	2.2	1.5	0.55	4.4	6	6	1	0.7	1.1	5.1	9	4.4
0.4472144	17.878797	1	0	2	9.1	15.483492	8.9393985	3.0333333	8	0.85	3.5	5	0.8	0.55	2.4	1.8	0.65	5	7	7	1	0.8	1.1	5.95	12.25	5
0.4472144	21.808203	1	0	2	10.1	18.886458	10.904101	3.3666667	9	0.85	4	5.5	0.9	0.55	2.6	2	0.65	5.5	8	8	1	0.9	1.1	6.8	16	5.5
0.4472144	26.126659	1	0	2	11.1	22.62635	13.063329	3.7	10	0.85	4.5	6.1	1	0.55	2.8	2.3	0.75	6.1	9	9	1	1	1.1	7.65	20.25	6.1

(3-3)

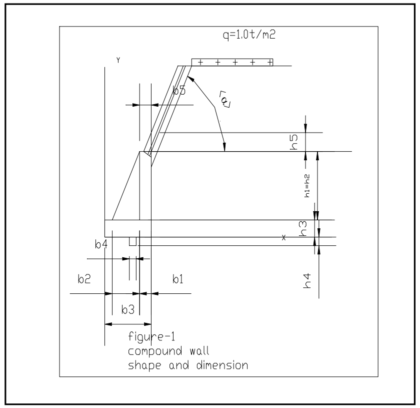


figure-1
compound wall
shape and dimension

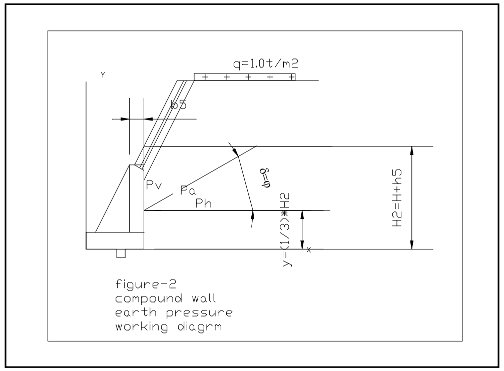


figure-2
compound wall
earth pressure
working diagrm

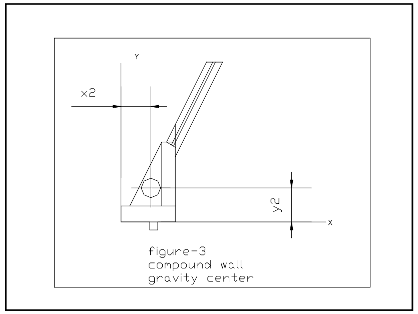


figure-3
compound wall
gravity center

rectangle	triangle	w=a1*(u,r)						x-direction	gravity center length				y-direction													
concrete	soil	concrete	concrete	concrete	concrete	soil	total weight	=b2+0.5*b1	=b8+(2/3)*b	=(1/2)*b3	=B6+0.5*B4	=b2+b8+0.3	=h3+0.5*h2	=h3+(1/3)*h	=0.5*h3	=-(0.5*h4)	=H1+H3+(1/3)*H5						total momen	Pa=(1/2)*r*Ka*H^2+(KA*q-2*C*(Ka)		
a4=b4*h4	a5=0.5*b5*I	w1	w2	w3	w4	w5	Σw	x1	x2	x3	x4	x5	y1	y2	y3	y4	y5	m1=w1*x1	m2=w2*x2	m3=w3*x3	m4=w4*x4	m5=w5*x5	Mw	Pa	KA	r
m2	m2	t	t	t	t	t	t	m	m	m	m	m	m	m	m	m	m	t.m	t.m	t.m	t.m	t.m	t.m	t		t/m3
55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC
=AO43*AX43	=0.5*AP43*AY43	=AZ43*2.35	=BA43*2.35	=BB43*2.35	=BC43*2.35	=BD43*2	=SUM(BE43:BI43)	=AM43+0.5*AL43	=AS43+(2/3)*AM43	=(1/2)*AN43	=AQ43+0.5*AO43	=AM43+AS43+0.3+(2/3)*AP43	=AW43+0.5*AV43	=116+(1/3)*AV43	=0.5*AW43	=-(0.5*AX43)	=AU43+AW43+(1/3)*AY43	=BE43*BK43	=BF43*BL43	=BG43*BM43	=BH43*BN43	=BI43*BO43	=SUM(BU43:BY43)	=ABS((1/2)*CC43*CB43*CD43^2+(CB43*CF43-2*CE43*(CB43)^0.5)*	=U43	=AF43
0.16	0.3025	1.9975	0.5875	4.465	0.376	0.605	8.031	0.925	0.8833333	0.95	1.15	1.7166667	1.5	116.33333	0.5	-0.2	2.3666667	1.8476875	0.5189583	4.24175	0.4324	1.0385833	8.0793792	2.4724133	0.194525	2
0.16	0.3025	3.995	2.35	5.64	0.376	0.605	12.966	1.425	1.2166667	1.2	1.5	2.2166667	2	116.66667	0.5	-0.2	3.3666667	5.692875	2.8591667	6.768	0.564	1.3410833	17.225125	4.0675187	0.194525	2
0.25	0.3025	5.9925	5.2875	6.815	0.5875	0.605	19.2875	1.925	1.55	1.45	1.85	2.7166667	2.5	117	0.5	-0.25	4.3666667	11.535563	8.195625	9.88175	1.086875	1.6435833	32.343396	6.0516742	0.194525	2
0.25	0.3025	7.99	9.4	7.99	0.5875	0.605	26.5725	2.425	1.8833333	1.7	2.05	3.2166667	3	117.33333	0.5	-0.25	5.3666667	19.37575	17.703333	13.583	1.204375	1.9460833	53.812542	8.4248798	0.194525	2
0.42	0.3025	9.9875	14.6875	9.165	0.987	0.605	35.432	2.925	2.2166667	1.95	2.35	3.7166667	3.5	117.66667	0.5	-0.3	6.3666667	29.213438	32.557292	17.87175	2.31945	2.2485833	84.210513	11.187135	0.194525	2
0.49	0.3025	11.985	21.15	10.34	1.1515	0.605	45.2315	3.425	2.55	2.2	2.55	4.2166667	4	118	0.5	-0.35	7.3666667	41.048625	53.9325	22.748	2.936325	2.5510833	123.21653	14.338441	0.194525	2
0.64	0.3025	13.9825	28.7875	11.75	1.504	0.605	56.629	3.925	2.9833333	2.5	2.8	4.8166667	4.5	118.33333	0.5	-0.4	8.3666667	54.881313	85.882708	29.375	4.2112	2.9140833	177.2643	17.878797	0.194525	2
0.81	0.3025	15.98	37.6	12.925	1.9035	0.605	69.0135	4.425	3.3166667	2.75	3.05	5.3166667	5	118.66667	0.5	-0.45	9.3666667	70.7115	124.70667	35.54375	5.805675	3.2165833	239.98418	21.808203	0.194525	2
1	0.3025	17.9775	47.5875	14.335	2.35	0.605	82.855	4.925	3.75	3.05	3.3	5.9166667	5.5	119	0.5	-0.5	10.366667	88.539188	178.45313	43.72175	7.755	3.5795833	322.04865	26.126659	0.194525	2

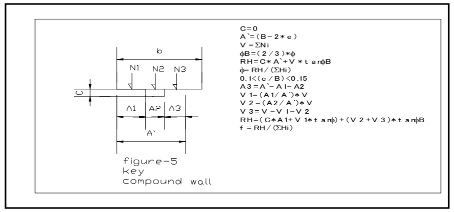
(3-4)

horizontal earthpressure(PH)=P*cos(δ)
verticakal earthpressure(PV)=P*sin(δ)

C-3
resultant working position
resultant working position is e' from A

C-4
confirmation to falling
e'=(ΣumM)/(ΣsumN)
eccentric length
e=B/2-e'
e/B=0.134/2.6
safety ratio
f=Mr/Mo

C-5
confirmation to sliding
RH
sliding resist
RH=c*A'+V*tan(φB)
c
adhesion between bearing ground and foundation bottom surface
A'
effective loading area
v
total vertical load
(φB)
=(2/3)*(φ)
friction angle between bearing ground and foundation bottom surface
f
safety ratio
f=RH/PH



									C-3				C-4									C-5				
^0.5)*H			horizontal earthpressure(PH)=P*cos(δ)								ΣN															
H=H+1.1	c	q	PH	PV=P*sin(δ	(δ)	=xv=B	Mv	ΣMr=Mw+M	ΣM	Mo=-PH*(H/3)		e'=(ΣM)/(ΣN	e=B/2-e'	=e/B			judgement	f=Mr/Mo		f	judgement	RH	c	A'	ΣN=V	(φB)
m		1/m2	t	t	degree	m	t	t.m	t.m	t.m	t	m	m									t		m	t	degree
82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
CD	CE	CF	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX	CY	CZ	DA	DB	DC	DD
=AK43+1.1	=AE43	=AD43	=CA43*COS(CI43*PI()/180)	=CA43*SIN(M43*PI()/180)	=M43	=AT43	=CH43*CJ43	=BZ43+XK43	=BZ43+XK43−XN43	=CG43*(CD43/3)	=B943+XH43	=CM43/CO43	=ABS(CJ43/2-CP43)	=ABS(CQ43/CJ43)	<	0.25	ok	=CL43/CN43	>	1.5	ok	=DA43*DB43+DC43*TAN(DD43*PI()/180)	0	=CJ43-2*CQ43	=BJ43+CH43	20
3.1	0	1	2.1411728	1.2362067	30	1.9	2.3487927	10.428172	8.2156267	2.2125452	9.2672067	0.8865268	0.0634732	0.033407	<	0.25	ok	4.7132018	>	1.5	ok	3.3729874	0	1.7730535	9.2672067	20
4.1	0	1	3.5225745	2.0337594	30	2.4	4.8810225	22.106147	17.291962	4.8141852	14.999759	1.152816	0.047184	0.01966	<	0.25	ok	4.5918772	>	1.5	ok	5.4594659	0	2.305632	14.999759	20
5.1	0	1	5.2409036	3.0258371	30	2.9	8.7749276	41.118323	32.208787	8.9095361	22.313337	1.4434769	0.0065231	0.0022493	<	0.25	ok	4.6150914	>	1.5	ok	8.1213905	0	2.8869539	22.313337	20
6.1	0	1	7.2961599	4.2124399	30	3.4	14.322296	68.134837	53.299312	14.835525	30.78494	1.7313437	0.0313437	0.0092187	<	0.25	ok	4.5926812	>	1.5	ok	11.204802	0	3.3373126	30.78494	20
7.1	0	1	9.6883435	5.5935677	30	3.9	21.814914	106.02543	83.096347	22.92908	41.025568	2.0254771	0.0754771	0.0193531	<	0.25	ok	4.6240594	>	1.5	ok	14.932085	0	3.7490458	41.025568	20
8.1	0	1	12.417454	7.1692206	30	4.4	31.544571	154.7611	121.23398	33.527127	52.400721	2.3135937	0.1135937	0.0258168	<	0.25	ok	4.6159966	>	1.5	ok	19.072303	0	4.1728126	52.400721	20
9.1	0	1	15.483492	8.9393985	30	5	44.696992	221.9613	174.9947	46.966594	65.568398	2.6688879	0.1688879	0.0337776	<	0.25	ok	4.7259399	>	1.5	ok	23.864945	0	4.6622243	65.568398	20
10.1	0	1	18.886458	10.904101	30	5.5	59.972558	299.95673	236.37233	63.584408	79.917601	2.9577004	0.2077004	0.0377637	<	0.25	ok	4.7174574	>	1.5	ok	29.087628	0	5.0845991	79.917601	20
11.1	0	1	22.62635	13.063329	30	6.1	79.68631	401.73496	318.01746	83.717496	95.918329	3.3155025	0.2655025	0.043525	<	0.25	ok	4.7986977	>	1.5	ok	34.911417	0	5.568995	95.918329	20

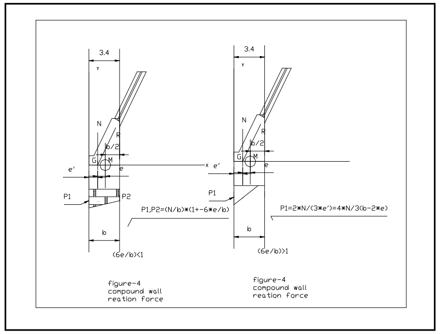
(3-5)

C-6

confirmation to ground reaction

p1=(@sum(N)/B)*(1+6*e/B)

p2=(@sum(N)/B)*(1-6*e/B)



D-1

earth pressure calculation(earthquake time)

φ

Internal friction angle of soil

χ

internal angle betwenn ground surface and horizontal line

δ φ/2

behind soil internal friction angle

θ

internal angle between estimated behind surface and vertical line

θo =ATAN(Kh)

kEA

kEA=(cos^2(φ-θo-θ))/(((cosθocos^2*θ*cos(θo+φ+θ)*(1+(sin(φ+δ)*sin(φ-χ-θo)/(cos(θ+φ+θ)*cos(θ-χ))^0.5)^2

C-6 D-1

f	judgement f		p1	p2	e/B		B/6		qa1	judgement	φ	χ	δ	θo	θ	kEA	=(φ-θo-θ)	=(θo)	=(θ)	(δ+θo+θ)	=(δ+φ)	=(φ-χ-θo)	=(δ+θo+θ)	=(θ-χ)	cos^2(φ-θo-θ)	cos(θo)
			t/m2	t/m2					t/m2		degree	degree	degree	degree	degree											
109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135
DE	DF	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB	EC	ED	EE
=CZ43/CG43	>	1.5	=(DC43/CJ43)*(1+6*CQ43/CJ43)	=(DC43/CJ43)*(1-6*CQ43/CJ43)	=CQ43/CJ43	<	=CJ43/6	<	=O43	ok	=J43	=K43	=(1/2)*DP43	=ATAN(F43)	=L43	=(ED43)/((EE43*EF43*EG43)*(1+((EH43*EI43)/(EJ43*EK43))^0.5)^2)	=(DP43-DS43-DT43)	=(DS43)	=DT43	=(DR43+DS43+DT43)	=(DR43+DP43)	=ABS((DP43-DQ43-DS43))	=(DR43+DS43+DT43)	=ABS(DT43-DQ43)	=(COS(DV43*PI()/180))^2	=COS(DW43*PI()/180)
1.575299	>	1.5	5.8551276	3.8998268	0.033407	<	0.3166667	<	10	ok	30	63.4349	15	0.1488899	0	0.2045549	29.85111	0.1488899	0	15.14889	45	33.58379	15.14889	63.4349	0.7522471	0.9999966
1.5498511	>	1.5	6.9871382	5.5126612	0.01966	<	0.4	<	10	ok	30	63.4349	15	0.1488899	0	0.2045549	29.85111	0.1488899	0	15.14889	45	33.58379	15.14889	63.4349	0.7522471	0.9999966
1.5496165	>	1.5	7.7980959	7.5904125	0.0022493	<	0.4833333	<	10	ok	30	63.4349	15	0.1488899	0	0.2045549	29.85111	0.1488899	0	15.14889	45	33.58379	15.14889	63.4349	0.7522471	0.9999966
1.5357122	>	1.5	9.5552147	8.5535735	0.0092187	<	0.5666667	<	10	ok	30	63.4349	15	0.1488899	0	0.2045549	29.85111	0.1488899	0	15.14889	45	33.58379	15.14889	63.4349	0.7522471	0.9999966
1.5412424	>	1.5	11.740871	9.2978813	0.0193531	<	0.65	<	10	ok	30	63.4349	15	0.1488899	0	0.2045549	29.85111	0.1488899	0	15.14889	45	33.58379	15.14889	63.4349	0.7522471	0.9999966
1.5359269	>	1.5	13.754004	10.064505	0.0258168	<	0.7333333	<	10	ok	30	63.4349	15	0.1488899	0	0.2045549	29.85111	0.1488899	0	15.14889	45	33.58379	15.14889	63.4349	0.7522471	0.9999966
1.5413154	>	1.5	15.771369	10.45599	0.0337776	<	0.8333333	<	10	ok	30	63.4349	15	0.1488899	0	0.2045549	29.85111	0.1488899	0	15.14889	45	33.58379	15.14889	63.4349	0.7522471	0.9999966
1.5401315	>	1.5	17.822821	11.238125	0.0377637	<	0.9166667	<	10	ok	30	63.4349	15	0.1488899	0	0.2045549	29.85111	0.1488899	0	15.14889	45	33.58379	15.14889	63.4349	0.7522471	0.9999966
1.542954	>	1.5	19.830721	11.617911	0.043525	<	1.0166667	<	10	ok	30	63.4349	15	0.1488899	0	0.2045549	29.85111	0.1488899	0	15.14889	45	33.58379	15.14889	63.4349	0.7522471	0.9999966

(3-6)

Pa
total earth pressure to estimated behind surface
P=(1/2)*eb117*KEA*ec117^2
q
loading on ground surface in normal time
c
soil adhesion(sand)
r
soil unit weight
H
wall height or estimated behind surface
PH
horizontal earthpressure(PH)=P*cos(δ)
PV
vertical earthpressure(PV)=P*sin(δ)
y

D-2
horizontal prssure and working height
H1-H6
H=w*Kh

table-1 unit weight of material

material	unit weight	internal friction angle	remarks
unit	(t/m3)	degree	
signal	u,r	φ	
concrete	2.35		
reinforced concrete	2.5		
good compacted gravel or sand(A)	1.9	35	
good compacted sandy soil or sand(B)	1.8	30	
good compacted clay soil(C)	1.7	25	

table-2 live load

back fill soil
signal
unit
good compacted gravel or sand(A)
good compacted sandy soil or sand
good compacted clay soil(C)

Pa

D-2

cos^2(θ)	cos(δ+θo+θ)	sin(δ+φ)	sin(φ−χ−θo)	cos(δ+θo+θ)	cos(θ-χ)	P	q	c
						t	t/m2	
136	137	138	139	140	141	142	143	144
EF	EG	EH	EI	EJ	EK	EL	EM	EN
=(COS(DX43*PI()/180))^2	=COS(DY43*PI()/180)	=SIN(DZ43*PI()/180)	=SIN(EA43*PI()/180)	=COS(EB43*PI()/180)	=COS(EC43*PI()/180)	=(1/2)*EO43*DU43*EP43^2	=AD43	=AE43
1	0.96525	0.7071068	0.5531559	0.96525	0.4472144	1.9657722	1	0
1	0.96525	0.7071068	0.5531559	0.96525	0.4472144	3.4385672	1	0
1	0.96525	0.7071068	0.5531559	0.96525	0.4472144	5.320472	1	0
1	0.96525	0.7071068	0.5531559	0.96525	0.4472144	7.6114864	1	0
1	0.96525	0.7071068	0.5531559	0.96525	0.4472144	10.311611	1	0
1	0.96525	0.7071068	0.5531559	0.96525	0.4472144	13.420844	1	0
1	0.96525	0.7071068	0.5531559	0.96525	0.4472144	16.939188	1	0
1	0.96525	0.7071068	0.5531559	0.96525	0.4472144	20.866641	1	0
1	0.96525	0.7071068	0.5531559	0.96525	0.4472144	25.203205	1	0

r	H	Ph	Pv	y	horizontal force H1=w1*kh	H2=w2*kh	H3=w3*kh	H4=w4*kh
t/m3	m	t	t	m	t	t	t	t
145	146	147	148	149	150	151	152	153
EO	EP	EQ	ER	ES	ET	EU	EV	EW
=AF43	=AG43	=EL43*COS(M43*PI()/180)	=EL43*SIN(M43*PI()/180)	=EP43/3	=BE43*F43	=BF43*F43	=BG43*F43	=BH43*F43
2	3.1	1.7024087	0.9828861	1.0333333	0.299625	0.088125	0.66975	0.0564
2	4.1	2.9778866	1.7192836	1.3666667	0.59925	0.3525	0.846	0.0564
2	5.1	4.6076639	2.660236	1.7	0.898875	0.793125	1.02225	0.088125
2	6.1	6.5917406	3.8057432	2.0333333	1.1985	1.41	1.1985	0.088125
2	7.1	8.9301167	5.1558053	2.3666667	1.498125	2.203125	1.37475	0.14805
2	8.1	11.622792	6.7104222	2.7	1.79775	3.1725	1.551	0.172725
2	9.1	14.669767	8.4695941	3.0333333	2.097375	4.318125	1.7625	0.2256
2	10.1	18.071042	10.433321	3.3666667	2.397	5.64	1.93875	0.285525
2	11.1	21.826615	12.601602	3.7	2.696625	7.138125	2.15025	0.3525

H5=w5*kh	Σ(H)	Σ(pH)	horizontal force MH	y1	y2	y3	y4	y5
t	t	t	t	m	m	m	m	m
154	155	156	157	158	159	160	161	162
EX	EY	EZ	FA	FB	FC	FD	FE	FF
=BI43*F43	=SUM(ET43:EX43)	=EQ43	=EY43+EZ43	=AW43+AU43/2	=AW43+AV43/3	=AW43/2	=-AX43/2	=AU43+AV43+1.1/3
0.09075	1.20465	1.7024087	2.9070587	1.5	1.3333333	0.5	-0.2	2.3666667
0.09075	1.9449	2.9778866	4.9227866	2	1.6666667	0.5	-0.2	4.3666667
0.09075	2.893125	4.6076639	7.5007889	2.5	2	0.5	-0.25	6.3666667
0.09075	3.985875	6.5917406	10.577616	3	2.3333333	0.5	-0.25	8.3666667
0.09075	5.3148	8.9301167	14.244917	3.5	2.6666667	0.5	-0.3	10.366667
0.09075	6.784725	11.622792	18.407517	4	3	0.5	-0.35	12.366667
0.09075	8.49435	14.669767	23.164117	4.5	3.3333333	0.5	-0.4	14.366667
0.09075	10.352025	18.071042	28.423067	5	3.6666667	0.5	-0.45	16.366667
0.09075	12.42825	21.826615	34.254865	5.5	4	0.5	-0.5	18.366667

(3-7)

D-3

resultant force working point

D-4

confirmation to falling

e:eccentric length

e=B/2-e'

e'=ΣM/ΣN

e'

f:safety ratio

f=Mr/Mo

D-5

confirmation to sliding

sliding resist

c=0

(φB)=(2/3)*Φ

RH=c*A'+V*tan(φB)=tanΣN*tan27=18.056*0.510=9.2t

safety ratio

f=RH/ΣH=9.2/11.767=0.78<1.2

to set key, due to shortage of sliding resist

key height=b

0.1<b/B<0.15

effective loading area

A'=B-2e=2.6-2*0.512=1.576

sliding resist by key

Hu=V*tanφ

Hu=ΣN*tanφ

safety ratio

f=Hu/ΣH

(φB)=(2/3)*Φ

	live load(1.0t/m2)	live load(0.7t/m2)	remarks
	q	qa	
	t/m2	t/m2	
	0.25	0.18	
l(B)	0.3	0.21	
	0.4	0.2	

table 4 safety ratio of falling,sliding

load	safety ratio(Fs)	remarks
long period load	1.5	
short period load	1.2	

table 5 internal friction angle(foundation bottom and ground)

condition	angle	adhesion(C)	remarks
soil and concrete	φB=(2/3)*ϕ	C=0	
sand and concrete	tanφB=0.5	C=0	
rock and concrete	tanφB=0.6	C=0	
rock	φB=ϕ	C=Co	

Co:adhesion of bearing ground (t/m2)

ϕ:internal friction angle of bearing ground(degree)

table-3 e/B<following`s value

load	long period load	short period load	remarks
rock	`1/4	`1/3	
sandy soil	`1/6	`1/4	
clay +sand ground	`1/10	`1/6	

e:eccentric length

B:foundation width

D-3 D-4

mo-1	mo-2	mo-3	mo-4	mo-5	Σ(mo)	=PH*y	Σ(mo)+PH*y	vertical force Σ(W)	arm	moment Mr-1	PV	Σ(N)	arm B	Mr-2	Σ(Mr)	ΣM=Mr-Mo	e'=ΣM/ΣN	e	e/B		1/4=0.25	judgement	f			
t.m	t.m	t.m	t.m	t.m	t.m	t.m	t.m	t		t.m	t	t	m				m									
163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189
FG	FH	FI	FJ	FK	FL	FM	FN	FO	FP	FQ	FR	FS	FT	FU	FV	FW	FX	FY	FZ	GA	GB	GC	GD	GE	GF	GG
=ET43*FB43	=EU43*FC43	=EV43*FD43	=EW43*FE43	=EX43*FF43	=SUM(FG43:FK43)	=EQ43*ES43	=FL43+FM43	=BJ43		=BZ43	=ER43	=FO43+FR43	=AT43	=FR43*FT43	=FQ43+FU43	=FV43-FN43	=FW43/FS43	=FT43/2-FX43	=FY43/FT43	<	1/4=0.25	ok	=FV43/FN43	>	1.2	ok
0.4494375	0.1175	0.334875	-0.01128	0.214775	1.1053075	1.7591556	2.8644631	8.031		8.0793792	0.9828861	9.0138861	1.9	1.8674836	9.9468628	7.0823996	0.785721	0.164279	0.0864626	<	1/4=0.25	ok	3.4725051	>	1.2	ok
1.1985	0.5875	0.423	-0.01128	0.396275	2.593995	4.0697783	6.6637733	12.966		17.225125	1.7192836	14.685284	2.4	4.1262807	21.351406	14.687632	1.0001599	0.1998401	0.0832667	<	1/4=0.25	ok	3.2041014	>	1.2	ok
2.2471875	1.58625	0.511125	-0.022031	0.577775	4.9003063	7.8330286	12.733335	19.2875		32.343396	2.660236	21.947736	2.9	7.7146843	40.05808	27.324745	1.2449915	0.2050085	0.0706926	<	1/4=0.25	ok	3.1459222	>	1.2	ok
3.5955	3.29	0.59925	-0.022031	0.759275	8.2219938	13.403206	21.6252	26.5725		53.812542	3.8057432	30.378243	3.4	12.939527	66.752069	45.126869	1.4854996	0.2145004	0.0630883	<	1/4=0.25	ok	3.0867724	>	1.2	ok
5.2434375	5.875	0.687375	-0.044415	0.940775	12.702173	21.13461	33.836782	35.432		84.210513	5.1558053	40.587805	3.9	20.107641	104.31815	70.481371	1.7365159	0.2134841	0.0547395	<	1/4=0.25	ok	3.0829809	>	1.2	ok
7.191	9.5175	0.7755	-0.060454	1.122275	18.545821	31.381539	49.92736	45.2315		123.21653	6.7104222	51.941922	4.4	29.525858	152.74239	102.81503	1.9794229	0.2205771	0.0501312	<	1/4=0.25	ok	3.0592923	>	1.2	ok
9.4381875	14.39375	0.88125	-0.09024	1.303775	25.926723	44.498294	70.425016	56.629		177.2643	8.4695941	65.098594	5	42.34797	219.61227	149.18726	2.2917124	0.2082876	0.0416575	<	1/4=0.25	ok	3.1183844	>	1.2	ok
11.985	20.68	0.969375	-0.128486	1.485275	34.991164	60.839173	95.830337	69.0135		239.98418	10.433321	79.446821	5.5	57.383264	297.36744	201.5371	2.5367548	0.2132452	0.0387719	<	1/4=0.25	ok	3.1030616	>	1.2	ok
14.831438	28.5525	1.075125	-0.17625	1.666775	45.949588	80.758477	126.70806	82.855		322.04865	12.601602	95.456602	6.1	76.869774	398.91842	272.21036	2.8516661	0.1983339	0.0325138	<	1/4=0.25	ok	3.148327	>	1.2	ok

(3-8)

to set key, due to shortage of sliding resist
key height=b
0.1<b/B<0.15
A'=B-2e
effective loading area

Hu=V*tanφ
sliding resist by key

D-6
confirmation to ground reaction
ground reaction
e/B>1/6
q=2*Σ*N/3*e'
ground reaction is triangle destibution
e/B<1/6
p1=(N/B)(1+6e/B)
p2=(N/B)(1-6e/B)

according to
(japan road cooperation)
(road eartworks)
(retainging wall)

D-5

D-6

RH	V=ΣN	(φB)=(2/3)*φc		f			judgement	0.1<b/B<0.15 B	b=0.15*B	A'	Hu	φ	f=Hu/ΣH		f	judgement	e/B		1	P1	P2		qa2	judgement
t	t	degree						m	m	m	t	degree								t/m2	t/m2		t/m2	
190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214
GH	GI	GJ	GK	GL	GM	GN	GO	GP	GQ	GR	GS	GT	GU	GV	GW	GX	GY	GZ	HA	HB	HC	HD	HE	HF
=FS43*TAN(GJ43*PI()/180)	=FS43	=(2/3)*DP43	=EN43	=GH43/FA43	<	1.2	no	=FT43	=0.15*FT43	=GP43-2*FY43	=GI43*TAN(DP43*PI()/180)	=DP43	=GS43/FA43	>	1.2	ok	=FY43/FT43	<	1	=(GI43/FT43)*(1+6*FY43/FT43)	=(GI43/FT43)*(1-6*FY43/FT43)	<	=P43	ok
3.2807862	9.0138861	20	0	1.1285587	<	1.2	no	1.9	0.3	1.571442	5.2041696	30	1.7901839	>	1.2	ok	0.0864626	<	1	7.205301	2.2830002	<	15	ok
5.3450061	14.685284	20	0	1.0857684	<	1.2	no	2.4	0.4	2.0003199	8.4785524	30	1.7223075	>	1.2	ok	0.0832667	<	1	9.1758557	3.0618807	<	15	ok
7.9883226	21.947736	20	0	1.0649977	<	1.2	no	2.9	0.4	2.4899831	12.671531	30	1.6893598	>	1.2	ok	0.0706926	<	1	10.778272	4.3580979	<	15	ok
11.056776	30.378243	20	0	1.0452995	<	1.2	no	3.4	0.5	2.9709993	17.538887	30	1.6581135	>	1.2	ok	0.0630883	<	1	12.316859	5.5526955	<	15	ok
14.772753	40.587805	20	0	1.0370544	<	1.2	no	3.9	0.6	3.4730319	23.43338	30	1.6450346	>	1.2	ok	0.0547395	<	1	13.825216	6.9890431	<	15	ok
18.905314	51.941922	20	0	1.0270431	<	1.2	no	4.4	0.7	3.9588458	29.988683	30	1.6291541	>	1.2	ok	0.0501312	<	1	15.355767	8.2541978	<	15	ok
23.693951	65.098594	20	0	1.022873	<	1.2	no	5	0.8	4.5834249	37.584691	30	1.6225393	>	1.2	ok	0.0416575	<	1	16.273933	9.7655043	<	15	ok
28.916278	79.446821	20	0	1.0173525	<	1.2	no	5.5	0.8	5.0735096	45.868643	30	1.6137824	>	1.2	ok	0.0387719	<	1	17.805205	11.084548	<	15	ok
34.743362	95.456602	20	0	1.0142606	<	1.2	no	6.1	0.9	5.7033322	55.111895	30	1.6088779	>	1.2	ok	0.0325138	<	1	18.701397	12.59585	<	15	ok

(4)Pipe and Box Culvert

No.	Station	Catchment area	Runoff coefficien	Rainfall Intensit	Discharge	Structure type	Area	Wetted perimete	Hydraulic Mean	Manning's	Gradient	Flow Velocity	Capacity	Judgement
		Ac	C	I	Q		80%A	P	R	n	i	V	80%Q	
		(m^2)		(mm/hr)	(m^3/s)		(m^2)	(m)	(m)		(%)	(m/s)	(m^3/s)	
		(1)	(2)	(3)	(4)=(1)X(2)X(3)(1000X60X60)	(5)	(6)=0.8A	(7)	(8)=(6)/(7)	(9)	(10)	$(11)=1/(9)X(8)^{2/3}X[(10)/100]^{0.5}$	(12)=(6)X(11)	
S155	24+264.5	37950	0.4	151	0.637	1 - Φ600	0.226	1.508	0.15	0.015	3	3.260	0.737	
L28	24+243.5	402800	0.8	186	16.649	B/C (2X2)	3.2	5.2	0.615	0.02	2.5	5.720	18.303	
I26	23+906.1	30440	0.8	186	1.258	1 - Φ900	0.509	2.262	0.225	0.015	4.5	5.232	2.663	

Q = CIA
Q = Discharge
C = runoff Coefficeint
- C = 0.4 (JRS recommends 0.3~0.55 for turfing area)
- C = 0.4 Small Catchment Area
- C = 0.8 Big Catchment Area

I = Average Runoff Intensity
- I = 151mm/hr (3 Years Rreturn Period)
- I = 151 Small Catchment Area
- I = 186 Big Catchment Area

$V = 1/nXR^{2/3}Xi^{1/2}$
= Flow Velocity (m/s)
n = Manning's Coefficient of roughness
- n = 0.015 below Φ600
- n = 0.02 over Φ600

R = HydraulicMean Depth (m), (Reference to table 1, 2 and 3)
R = A/P
A = Cross sectional area (m^2) of the water flowing through a channel, (Reference to table 1, 2 and 3)
P = Wetted perimeter of the channel, (Reference to table 1, 2 and 3)
i = Gradient (%), (Judged at site)
Q = Capacity (m^3/s)
Q = AV

Calculation:

(1) To measure catchment area (m2) by plan drawing or map. (Col. 1)
(2) To calculate discharge (m3/s), Q = C.I.A (Col. 4)
(3) To judge cross drainage type by comparing figure 8-3 (Col. 5)
(4) To calculate the allowable capacity (m3/s) of culvert

$V = 1/nXR^{2/3}Xi^{1/2}$ (Col. 11)

$Q = AV$ (Col. 12)

(5) If (4) < table (12) OK, If (4) > table (12) not OK
(6) Flowing velocity is =< 6m/s.

Table - 1

ructu	80%A	P	R	R2/3
	m^2	m	m	
	(1)	(2)	(3)=(1)/(2)	
Pipe Culvert				
1 - Φ0.6	0.226	1.508	0.15	0.282
1 - Φ0.9	0.509	2.262	0.225	0.370
1 - Φ1.2	0.905	3.016	0.3	0.448

$\pi = 3.1416$

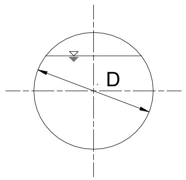


Figure No.

Area = 80%

$A = 0.8\pi D^2/4$ (m^2)
$P = 0.8\pi D$ (m)

Table - 2

Structure	A	P	R	R2/3
	m^2	m	m	
	(1)	(2)	(3)=(1)/(2)	
Pipe Culvert				
1 - Φ0.6	0.242	1.328	0.183	0.322
1 - Φ0.9	0.545	1.992	0.274	0.422
1 - Φ1.2	0.969	2.656	0.365	0.511

$A=D^2(\varphi-\sin\varphi)/8$ $P=(D\varphi)/2$ rad

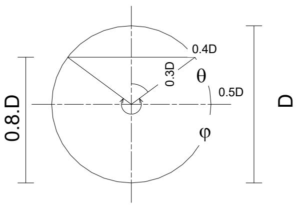


Figure No.

$\cos\theta = 0.3/0.5$
$\theta = 106^\circ$ 15'48.37"
$2\theta = 253^\circ$ 44' 23.2"
$\varphi = 253^\circ$ 44' 23.2"
π rad : $180^\circ = \varphi$: 253° 44'23.2"
$\varphi = 4.426$ rad

Table - 3

Structure	80%A	P	R	R2/3
	m^2	m	m	
	(1)	(2)	(3)=(1)/(2)	
Box Culvert				
1 - 2.0X2.0	3.2	5.2	0.615	0.723
1 - 3.0X3.0	7.2	7.8	0.923	0.948

A=0.8HB P=0.8X2H+B

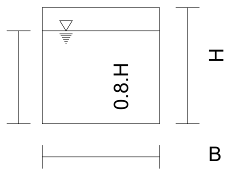
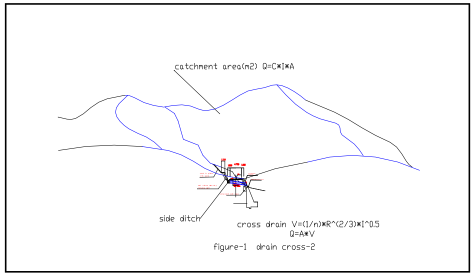
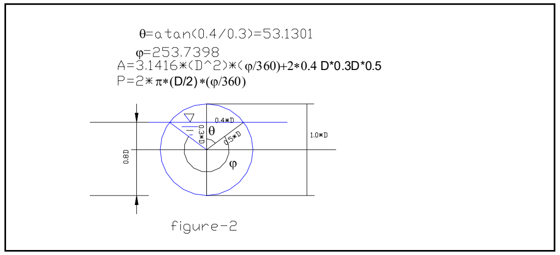
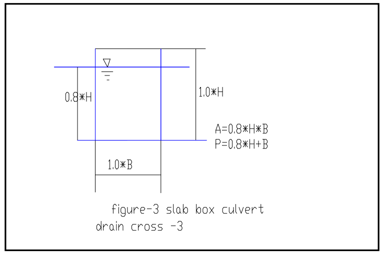


Figure No. 3

(5)culvert section







according to
(Road eartwork drainage)
Japan Road Cooperation

(5)culvert section

(Pipe and Box Culvert)

culvert-pipe box-2

No.	Station	Catchment area	Runoff coefficient	Rainfall Intensity	Discharge	Structure type	pipe diameter	box or slab base	box or slab height	number of pipe slab box			Area	Wetted perimeter	Hydraulic Mean Depth	Manning's coefficient	Gradient	Flow Velocity	Capacity	Judgement
		Ac	C	I	Q		D	B	H		φ	θ	80%A	P	R	n	i	V	80%Q	
		(m^2)		(mm/hr)	(m^3/s)		m	m	m		degree	degree	m2	(m)	(m)		(%)	(m/s)	(m^3/s)	
		(1)	(2)	(3)	(4)=(1)X(2)X(3)/(1000X60X60)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)=0.8A	(13)	(14)=(12)/(13)	(15)	(16)	(17)=1/(15)X(14)$^{2/3}$X[(16)/100]$^{0.5}$	(18)=(12)*(17)*(9)	
		50000	0.8	147	1.633	1 - Φ600	0.6			1	253.7398	53.1301	0.242	1.329	**0.183**	0.015	3	3.713	0.900	1 - Φ600
		75000	0.8	147	2.450	1 - Φ900	0.9			1	253.7398	53.1301	0.546	1.993	**0.274**	0.015	1	2.810	1.533	1 - Φ900
		125000	0.8	147	4.083	2 - Φ900	0.9			2	253.7398	53.1301	0.546	1.993	**0.274**	0.015	1	2.810	3.066	2 - Φ900
		250000	0.8	147	8.167	2 - Φ1200	1.2			2	253.7398	53.1301	0.970	2.657	**0.365**	0.015	0.5	2.407	4.669	2 - Φ1200
		480000	0.8	147	15.680	SC1-B2*H2		2	2	1			3.200	5.200	**0.615**	0.015	0.3	2.641	8.452	SC1-B2*H2
		2000000	0.8	147	65.333	SC1-B4*H3		4	3	1			9.600	8.800	**1.091**	0.015	0.1	2.234	21.448	SC1-B4*H3
		4000000	0.8	147	130.667	SC2-B4*H3		4	3	2			9.600	8.800	**1.091**	0.015	0.1	2.234	42.896	SC2-B4*H3
		485000	0.8	147	15.843	BC1-B2*H2		2	2	1			3.200	5.200	**0.615**	0.015	0.3	2.641	8.452	BC1-B2*H2
		1400000	0.8	147	45.733	BC1-B3*H3		3	3	1			7.200	7.800	**0.923**	0.015	0.2	2.826	20.350	BC1-B3*H3
		2500000	0.8	147	81.667	BC2-B3*H3		3	3	2			7.200	7.800	**0.923**	0.015	0.2	2.826	40.701	BC2-B3*H3
			table-1	table-2 table-3	figure-1 formula-1								figure-2 figure-3 formula-2	formula-3		table-4		table-5 formula-4		

table-1 **Runoff coefficient**

area	C
road surface	0.7~1.0
steep hill	0.75~0.9
smooth hill	0.7~0.8
steep area	0.5~0.75
plain	0.45~0.6
rice field	0.7~0.8
city	0.6~0.9
forest	0.2~0.4
river area in hill	0.75~0.85
small river in plain	0.45~0.75
big river area	0.5~0.75

formula-1

table-2 I = Average Runoff Intensity:(mm/h)

year n	In
2	4725/(t+45)
3	5775/(t+45)
5	7150/(t+50)
7	7700/(t+50)
10	8625/(t+55)
20	10625/(t+65)

t=t1+t2

rainning time(min)

t 10

105

I=1.4*I 147

table-3 **safety ratio**

safety ratio

steep hill(nepal)
(1.2~1.4)

table-4

Manning's coefficient(n)

		n
culvert	cast in concrete	0.015
	concrete pipe	0.013
channel	mortar	0.013
	cocrete	0.015
	stone masonr	0.025
	asphalt	0.013
	soil	0.027
	gravel	0.025
	rock	0.035

table-5

limit of allowable mean velocity (m3/s)

material of drain	v
concrete	0.6~3.0
aspahlat	0.6~1.5
stone masonry,block	0.6~1.8
gravelclay	0.6~1.0
sandy soil	0.3~0.6
clay mixed sandy soil	0.2~0.3
silt	0.1~0.2

v:allowable mean velocity

order

purpose: to decide dimension of side ditch?

1 **calculate discharge(Q) of catchment area, (4)**
2 **propse structure type,(5)**
3 **calculate capacity(Q) of culvert,(18)**
4 **compare (4),(18)**
5 (4) <(18) ok
6 (4) >(18) ,to change structure type

formula-1
Q = CIA
Q = Discharge
C = runoff Coefficeint
I = Average Runoff Intensity:(mm/h)
Q=(1/3600000)*C*I*a(m3/sec)
Q=(1/3.6)*C*I*A(m3/sec)

formula-2 P=(0.8*H*2+B):box
A=3.1416*(D/2)^2*(φ/360) or 0.8*3.1416*(D/2)^2:pip
A=0.8*H*B:box

formula-3
P=(D*π*φ)/360 or 0.8*3.1416*D:pipe

formula-4
V = 1/nXR$^{2/3}$Xi$^{1/2}$
= Flow Velocity (m/s)
n = Manning's Coefficient of roughness
n = 0.015 below Φ600
n = 0.02 over Φ600
R = HydraulicMean Depth (m), (Reference to table 1, 2 and 3)
R = A/P

i = Gradient (%)
Q = Capacity (m^3/s)
Q = AV

compare (18) to (4)
(18)>(4),ok
(18)<(4),not ok

SC:slab culvert
BC:box culvert

(6)gravity wall-10-new (6-1-1)

1 gravity wall-10
2 design order
(6-1-1) 3 gravity wall-10
4 A design condition
5 A-1 allowable stress

6 A-2 sesimic
7 A-3 unit weight
8 A-4 soil condition
9 A-5 allowable groud bearing force
10 A-6 stability calculation
11 B section dimension
12 C normal time stability calculation
13 C-1 eartpressure calculation
14 C-2 weight and gravity center
15 C-3 resultant force working point
16 C-4 confirmation to falling
17 C-5 confirmation to sliding
18 C-6 confirmation to ground reaction force
19 D eartquke time stability calculation
20 D-1 eartpressure calculation
21 D-2 weight and gravity center
22 D-3 resultant force working point
23 D-4 confirmation to falling
24 D-5 confirmation to sliding
25 D-6 confirmation to ground reaction force

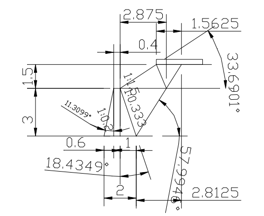


figure-1
gravity wall-11

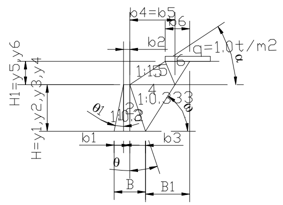


figure-2
gravity wall-11

A:Design condition

B: section shape dimension (figure-1)

C:normal time stability calculation

A-1 allowable stress | A-2 sesimic | A-3 unit weight | A-4 soil condition | A-5 allowable groud bearing force | A-6 stability calculation | C-1 eartpressure calculation | Pa

figure: figure5-4 figure5-5

table: table-1 table-1 table-1 table-5 table-4 table-4 table-2 table-5 table-1

check point: normal e/B<1/6=0.167 earthquake e/B<1/4=0.25

ka=(cos^2(φ-θ))/(((cos^2*θ*cos(θ+φ)*(1+((sin(φ+δ)*sin(φ-α)/(cos(θ+φ)*cos(θ-α))^0.5)^2

H	σ28	σca	τa	σta	kh	kv	u	r	φ	ϕ	θ	δ=(2/3)*φ	qa	qa1	qa2	f to slide	f to slide	f to slide	f to slide		KA	cos^2(φ-θ)	cos^2(θ)	cos(θ+φ)	sin(δ+φ)	sin(δ-α)	cos(θ+φ)	cos(θ-α)	Pa	q	c	r	PH	PV
	kg/cm2	kg/cm2	kg/cm2	kg/cm2			t/m3	t/m3	degree	degree	degree	degree	t/m2	t/m2	t/m2														t	t/m2		t/m3	t	t
A	B	C	D	E	F	G	H	I	j	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI
1.5	180	60	8	3	0.15	0	2.35	2	35		=AR37	=J37*(2/3)	30	=(1/3)*N37	=(1/2)*N37	>1.5	>1.2				=(W37)/(((X37*Y37)*(1+((Z37*AA37)/(AB37*AC37))^0.5)^2))	=(COS((M37-L37)*PI()/180))^2	=(COS(L37*PI()/180))^2	=X37	=SIN((M37+M37)*PI()/180)	=ABS(SIN((M37-AS37)*PI()/180))	=COS((L37+M37)*PI()/180)'	=COS((L37-AS37)*PI()/180)	=(1/2)*AG37*V37*A37^2*(1+2*AE37/(AG37*A37))	1	0	2	=AD37*COS((M37+AR37)*PI()/180)	=AD37*SIN((M37+AR37)*PI()/180)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.167	e/B<1/4=0.25		0.7266256	0.9926576	0.9001799	0.7460447	0.7273736	0.1797764	0.7460447	0.9646848	2.7248459	1	0	2	2.0328568	1.8144636
2	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.168	e/B<1/4=0.26		0.7266256	0.9926576	0.9001799	0.7460447	0.7273736	0.1797764	0.7460447	0.9646848	4.3597534	1	0	2	3.2525708	2.9031418
2.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.169	e/B<1/4=0.27		0.7266256	0.9926576	0.9001799	0.7460447	0.7273736	0.1797764	0.7460447	0.9646848	6.3579737	1	0	2	4.7433325	4.2337485
3	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.170	e/B<1/4=0.28		0.7266256	0.9926576	0.9001799	0.7460447	0.7273736	0.1797764	0.7460447	0.9646848	8.7195067	1	0	2	6.5051417	5.8062836
3.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.171	e/B<1/4=0.29		0.7266256	0.9926576	0.9001799	0.7460447	0.7273736	0.1797764	0.7460447	0.9646848	11.444353	1	0	2	8.5379985	7.6207473
4	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.172	e/B<1/4=0.30		0.7266256	0.9926576	0.9001799	0.7460447	0.7273736	0.1797764	0.7460447	0.9646848	14.532511	1	0	2	10.841903	9.6771394
4.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.173	e/B<1/4=0.31		0.7266256	0.9926576	0.9001799	0.7460447	0.7273736	0.1797764	0.7460447	0.9646848	17.983983	1	0	2	13.416855	11.97546
5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.174	e/B<1/4=0.32		0.7266256	0.9926576	0.9001799	0.7460447	0.7273736	0.1797764	0.7460447	0.9646848	21.798767	1	0	2	16.262854	14.515709
1.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.176	e/B<1/4=0.34		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	2.0659543	1	0	2	1.5412942	1.3757105
2	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.177	e/B<1/4=0.35		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	3.3055269	1	0	2	2.4660708	2.2011367
2.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.178	e/B<1/4=0.36		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	4.82056	1	0	2	3.5963532	3.2099911
3	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.179	e/B<1/4=0.37		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	6.6110538	1	0	2	4.9321415	4.4022735
3.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.180	e/B<1/4=0.38		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	8.6770081	1	0	2	6.4734358	5.7779839
4	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.181	e/B<1/4=0.39		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	11.018423	1	0	2	8.2202359	7.3371225
4.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.182	e/B<1/4=0.40		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	13.635298	1	0	2	10.172542	9.079689
5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.183	e/B<1/4=0.41		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	16.527634	1	0	2	12.330354	11.005684
1.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.185	e/B<1/4=0.43		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	2.0659543	1	0	2	1.5412942	1.3757105
2	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.186	e/B<1/4=0.44		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	3.3055269	1	0	2	2.4660708	2.2011367
2.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.187	e/B<1/4=0.45		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	4.82056	1	0	2	3.5963532	3.2099911
3	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.188	e/B<1/4=0.46		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	6.6110538	1	0	2	4.9321415	4.4022735
3.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.189	e/B<1/4=0.47		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	8.6770081	1	0	2	6.4734358	5.7779839
4	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.190	e/B<1/4=0.48		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	11.018423	1	0	2	8.2202359	7.3371225
4.5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.191	e/B<1/4=0.49		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	13.635298	1	0	2	10.172542	9.079689
5	180	60	8	3	0.15	0	2.35	2	35		18.4178	23.333333	30	10	15	>1.5	>1.2	e/B<1/6=0.192	e/B<1/4=0.50		0.5509211	0.9926576	0.9001799	0.7460447	0.7273736	0.3960798	0.7460447	0.9487781	16.527634	1	0	2	12.330354	11.005684

A-1
allowable stress
σ28
concrete design basic strength
σca
concrete allowable bending copressive stress
τa
concrete allowable shearing stress
σta
concrete allowable bending tensile stress
σsa
reinforced bar allowable bending tensile stress

A-2
seismic coefficient
Kh
horizontal seismic coeff
Kv
vertical seismic coeffici

A-3
unit weight
u
concrete unit weight
r
Unit weight of soil behir

A-4
soil condition
φ
behind soil internal friction angle
ϕ
bearing ground internal friction angle
qa
ultimate bearing capacity
earth pressure formula is Coulomb's earth-pressure theory

α
angle between slope surface and horizontal
θ
internal angle between estimated behind surface and vertical line
δ
behind soil internal friction angle

A-5
allowable ground bearing force

qa
ultimate bearing capacity
qa1=(1/3)*qa
allowable ground bearing force(normal time)
qa2=(1/2)*qa
allowable ground bearing force(earth-quake time)

A-6
stability calculation
sl
confirmation to sliding
safety ratio to sliding
normal time over 1.5
earthquake time over 1.2
confirmation to falling
resultant working position is (following length from center)
normal time
within 1/6 of B
earthquake time
within 1/4 of B
B
Foundation bottom width

C-1
C:stability calculation in normal time
eartpressure calculation

Pa
(2) total earth pressure to estimated behind surface
Pa=(1/2)*r*Ka*H^2*(1+2*q/(r*H))
q
loading on ground surface in normal time
c
soil adhesion(sand)
r
soil unit weight
H
wall height
PH
horizontal earthpressure(PH)=P*cos(δ+θ)
PV
horizontal earthpressure(PV)=P*sin(δ+θ)
y
working point of total pressure y=H/3

(6-1-2)

(6-2-1)

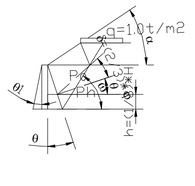
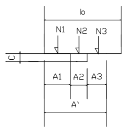
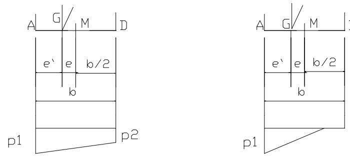


figure-3
gravity wall-11



C=0
A`=(B-2*e)
V=ΣNi
φB=(2/3)*φ
RH=C*A`+V*tan φB
φ=RH/(ΣHi)
0.1<(c/B)<0.15
A3=A`-A1-A2
V1=(A1/A`)*V
V2=(A2/A`)*V
V3=V-V1-V2
RH=(C*A1+V1*tan φ)+(V2+V3)*tan φB
f=RH/(ΣHi)

figure-4
key of foundation



P1,P2=N/b(1+-6*e/b)

(6e/b>1),p1=2*N/3*e`=4*N/(3*(b-2e))

figure-5
ground reaction force

figure-5
ground reaction force

C-2
weight and gravity center
figure5-6

Y	H	H1	H2=H+H1	(f) slope	(b) slope	(g)slope	θ1	θ	α	ω	b1=H*tan(θ1)	b2	b3=H*tan(θ)	b4=H*tan(θ)+H*tan(90-ω)	b5=b4	b6=b5-h6/tan(α)+h6/tan(ω)	B=b1+b2+b3	B1=H2/tan(ω)
m	m	m	m	1:( )	1:( )	1:( )	degree	degree	degree	degree	m	m	m	m	m	m	m	
AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB
=AK37/3	=A37	1.500	=AK37+AL37	0.2	0.333	1.5	**=90-ABS(ATAN((1)/(AN37))/PI()*180)**	**=90-ABS(ATAN((1)/(AO37))/PI()*180)**	**=ABS(ATAN((1)/(AP37))/PI()*180)**	**58.0000**	=AK37*TAN((AQ37)*PI()/180)	0.400	=AK37*TAN((AR37)*PI()/180)	=AK37*TAN(AR37*PI()/180)+AK37*TAN((90-AT37)*PI()/180)	=AK37*TAN(AR37*PI()/180)+AK37*TAN((90-AT37)*PI()/180)	=AY37-BH37/(TAN(AS37*PI()/180))+BH37/(TAN(AT37*PI()/180))	=AU37+AV37+AW37	=AM37/TAN(AT37*PI()/180)
36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
0.5	1.5	1.500	3.000	0.2	0.333	1.5	**11.3099**	**18.4178**	**33.6901**	**58.0000**	0.300	0.400	0.500	1.437	1.437	0.124	1.200	1.8746081
0.6666667	2	1.500	3.500	0.2	0.333	1.5	**11.3099**	**18.4178**	**33.6901**	**58.0000**	0.400	0.400	0.666	1.916	1.916	0.603	1.466	2.1870427
0.8333333	2.5	1.500	4.000	0.2	0.333	1.5	**11.3099**	**18.4178**	**33.6901**	**58.0000**	0.500	0.400	0.833	2.395	2.395	1.082	1.733	2.4994774
1	3	1.500	4.500	0.2	0.333	1.5	**11.3099**	**18.4178**	**33.6901**	**58.0000**	0.600	0.400	0.999	2.874	2.874	1.561	1.999	2.8119121
1.1666667	3.5	1.500	5.000	0.2	0.333	1.5	**11.3099**	**18.4178**	**33.6901**	**58.0000**	0.700	0.400	1.166	3.353	3.353	2.040	2.266	3.1243468
1.3333333	4	1.500	5.500	0.2	0.333	1.5	**11.3099**	**18.4178**	**33.6901**	**58.0000**	0.800	0.400	1.332	3.831	3.831	2.519	2.532	3.4367814
1.5	4.5	1.500	6.000	0.2	0.333	1.5	**11.3099**	**18.4178**	**33.6901**	**58.0000**	0.900	0.400	1.499	4.310	4.310	2.998	2.799	3.7492161
1.6666667	5	1.500	6.500	0.2	0.333	1.5	**11.3099**	**18.4178**	**33.6901**	**58.0000**	1.000	0.400	1.665	4.789	4.789	3.477	3.065	4.0616508
0.5	1.5		1.500	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.300	0.400	0.500				1.200	
0.6666667	2		2.000	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.400	0.400	0.666				1.466	
0.8333333	2.5		2.500	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.500	0.400	0.833				1.733	
1	3		3.000	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.600	0.400	0.999				1.999	
1.1666667	3.5		3.500	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.700	0.400	1.166				2.266	
1.3333333	4		4.000	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.800	0.400	1.332				2.532	
1.5	4.5		4.500	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.900	0.400	1.499				2.799	
1.6666667	5		5.000	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	1.000	0.400	1.665				3.065	
0.5	1.5		1.500	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.300	0.400	0.500	1.437			1.200	0.937304
0.6666667	2		2.000	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.400	0.400	0.666	1.916			1.466	1.2497387
0.8333333	2.5		2.500	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.500	0.400	0.833	2.395			1.733	1.5621734
1	3		3.000	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.600	0.400	0.999	2.874			1.999	1.8746081
1.1666667	3.5		3.500	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.700	0.400	1.166	3.353			2.266	2.1870427
1.3333333	4		4.000	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.800	0.400	1.332	3.831			2.532	2.4994774
1.5	4.5		4.500	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	0.900	0.400	1.499	4.310			2.799	2.8119121
1.6666667	5		5.000	0.2	0.333	1.5	**11.3099**	**18.4178**		**58.0000**	1.000	0.400	1.665	4.789			3.065	3.1243468

Y	h1=H	h2=H	h3=H	h4=H	h5=H1	h6=H1	a1=b1*h1*0.5	a2=b2*h2	a3=b3*h3*0.5	a4=b4*h4*0.5	a5=b5*h5*0.5	a6=b6*h6*0.5	w1=a*u	w2=a2*u	w3=a3*u	w4=a4*r	w5=a5*r
					type classification		area(m2)						w=a1*(u,r)				
							triangle	rectangle	triangle	triangle	triangle						
							concrete	concrete	concrete	soil	soil		concrete	concrete	concrete	soil	soil
m	m	m	m	m	m		m2	m2	m2	m2	m2		t	t	t	t	t
AJ	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS
=AK37/3	=AK37	=AK37	=AK37	=AK37	=AL37	=AL37	=AU37*BC37*0.5	=AV37*BD37	=AW37*BE37*0.5	=AX37*BF37*0.5	=AY37*BG37*0.5	=AZ37*BH37*0.5	=BI37*H37	=BJ37*H37	=BK37*H37	=BL37*AG37	=BM37*AG37
36	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
0.5	1.500	1.500	1.500	1.500	1.500	1.500	0.225	0.600	0.375	1.078	1.078	0.093	0.529	1.410	0.880	2.155	2.155
0.6666667	2.000	2.000	2.000	2.000	1.500	1.500	0.400	0.800	0.666	1.916	1.437	0.452	0.940	1.880	1.565	3.831	2.874
0.8333333	2.500	2.500	2.500	2.500	1.500	1.500	0.625	1.000	1.041	2.993	1.796	0.811	1.469	2.350	2.445	5.987	3.592
1	3.000	3.000	3.000	3.000	1.500	1.500	0.900	1.200	1.499	4.310	2.155	1.171	2.115	2.820	3.521	8.621	4.310
1.1666667	3.500	3.500	3.500	3.500	1.500	1.500	1.225	1.400	2.040	5.867	2.514	1.530	2.879	3.290	4.793	11.734	5.029
1.3333333	4.000	4.000	4.000	4.000	1.500	1.500	1.600	1.600	2.664	7.663	2.874	1.889	3.760	3.760	6.260	15.326	5.747
1.5	4.500	4.500	4.500	4.500	1.500	1.500	2.025	1.800	3.372	9.698	3.233	2.248	4.759	4.230	7.923	19.397	6.466
1.6666667	5.000	5.000	5.000	5.000	1.500	1.500	2.500	2.000	4.163	11.973	3.592	2.607	5.875	4.700	9.782	23.947	7.184
0.5	1.500	1.500	1.500				0.225	0.600	0.375				0.529	1.410	0.880		
0.6666667	2.000	2.000	2.000				0.400	0.800	0.666				0.940	1.880	1.565		
0.8333333	2.500	2.500	2.500				0.625	1.000	1.041				1.469	2.350	2.445		
1	3.000	3.000	3.000				0.900	1.200	1.499				2.115	2.820	3.521		
1.1666667	3.500	3.500	3.500				1.225	1.400	2.040				2.879	3.290	4.793		
1.3333333	4.000	4.000	4.000				1.600	1.600	2.664				3.760	3.760	6.260		
1.5	4.500	4.500	4.500				2.025	1.800	3.372				4.759	4.230	7.923		
1.6666667	5.000	5.000	5.000				2.500	2.000	4.163				5.875	4.700	9.782		
0.5	1.500	1.500	1.500	1.500			0.225	0.600	0.375	1.078			0.529	1.410	0.880	2.155	
0.6666667	2.000	2.000	2.000	2.000			0.400	0.800	0.666	1.916			0.940	1.880	1.565	3.831	
0.8333333	2.500	2.500	2.500	2.500			0.625	1.000	1.041	2.993			1.469	2.350	2.445	5.987	
1	3.000	3.000	3.000	3.000			0.900	1.200	1.499	4.310			2.115	2.820	3.521	8.621	
1.1666667	3.500	3.500	3.500	3.500			1.225	1.400	2.040	5.867			2.879	3.290	4.793	11.734	
1.3333333	4.000	4.000	4.000	4.000			1.600	1.600	2.664	7.663			3.760	3.760	6.260	15.326	
1.5	4.500	4.500	4.500	4.500			2.025	1.800	3.372	9.698			4.759	4.230	7.923	19.397	
1.6666667	5.000	5.000	5.000	5.000			2.500	2.000	4.163	11.973			5.875	4.700	9.782	23.947	

ω C-2
weight and gravity center
on figure

(6-2-2)

(6-3-1)

table-1 unit weight of material

material	unit weight	internal friction angle	remarks
unit	(t/m3)	degree	
signal	u,r	φ	
concrete	2.35		
reinforced concrete	2.5		
good compacted gravel or sand(A)	1.9	35	
good compacted sandy soil or sand(B)	1.8	30	
good compacted clay soil(C)	1.7	25	

table-2 live load

back fill soil	live load(1.0t/m2)	live load(0.7t/m2)	remarks
signal	q	qa	
unit	t/m2	t/m2	
good compacted gravel or sand(A)	0.25	0.18	
good compacted sandy soil or sand(B)	0.3	0.21	
good compacted clay soil(C)	0.4	0.2	

table 4 safety ratio of fa

load
long period load
short period load

table-3 e/B<following`s value

load	ng period load	short period load	remarks
rock	`1/4	`1/3	
sandy soil	`1/6	`1/4	
clay +sand ground	`1/10	`1/6	

e:eccentric length
B:foundation width

C-3
resultant force working point

C-4
confirmation to falling

table-5

table-3

soil	total weight	x-direction gravity center length						y-direction					
w6=a6*r	Σw	x1=(2/3)*b1	x2=b1+(1/2)*b2	x3=b1+b2 +(1/3)*b3	x4=b1+b2 +(1/2)*b4	x5=b1+b2 +(1/2)*b5	x6=B+B1-0.5*b6	y1=(1/3)*h1	y2=(1/2)*h2	y3=(1/3)*h3	y4=(2/3)*h4	y5=h4+(1/3)*h5	y6=h4+(2/3)*h6
t	t	m	m	m	m	m		m	m	m	m	m	
BT	BU	BV	BW	BX	BY	BZ	CA	CB	CC	CD	CE	CF	CG
=BN37*AG37	=SUM(BO37:BT37)	=(2/3)*AU37	=AU37+(1/2)*AV37	=AU37+AV37+(1/3)*AW37	=AU37+AV37+(2/3)*AX37	=AU37+AV37+(2/3)*AY37	=BA37+BB37-0.5*AZ37	=(2/3)*BC37	=(1/2)*BD37	=(1/3)*BE37	=(2/3)*BF37	=BF37+(1/3)*BG37	=BF37+(2/3)*BH37
72	73	74	75	76	77	78	79	80	81	82	83	84	85
0.186	7.316	0.200	0.500	0.867	1.658	1.658	3.012	1.000	0.750	0.500	1	2.000	2.5
0.905	11.995	0.267	0.600	1.022	2.077	2.077	3.352	1.333	1.000	0.667	1.333333333	2.500	3
1.623	17.466	0.333	0.700	1.178	2.496	2.496	3.691	1.667	1.250	0.833	1.666666667	3.000	3.5
2.341	23.729	0.400	0.800	1.333	2.916	2.916	4.030	2.000	1.500	1.000	2	3.500	4
3.060	30.784	0.467	0.900	1.489	3.335	3.335	4.370	2.333	1.750	1.167	2.333333333	4.000	4.5
3.778	38.632	0.533	1.000	1.644	3.754	3.754	4.709	2.667	2.000	1.333	2.666666667	4.500	5
4.497	47.271	0.600	1.100	1.800	4.174	4.174	5.049	3.000	2.250	1.500	3	5.000	5.5
5.215	56.703	0.667	1.200	1.955	4.593	4.593	5.388	3.333	2.500	1.667	3.333333333	5.500	6
	2.819	0.200	0.500	0.867				1.000	0.750	0.500			
	4.385	0.267	0.600	1.022				1.333	1.000	0.667			
	6.264	0.333	0.700	1.178				1.667	1.250	0.833			
	8.456	0.400	0.800	1.333				2.000	1.500	1.000			
	10.962	0.467	0.900	1.489				2.333	1.750	1.167			
	13.780	0.533	1.000	1.644				2.667	2.000	1.333			
	16.912	0.600	1.100	1.800				3.000	2.250	1.500			
	20.357	0.667	1.200	1.955				3.333	2.500	1.667			
	4.974	0.200	0.500	0.867	1.658			1.000	0.750	0.500	1		
	8.217	0.267	0.600	1.022	2.077			1.333	1.000	0.667	1.333333333		
	12.251	0.333	0.700	1.178	2.496			1.667	1.250	0.833	1.666666667		
	17.077	0.400	0.800	1.333	2.916			2.000	1.500	1.000	2		
	22.696	0.467	0.900	1.489	3.335			2.333	1.750	1.167	2.333333333		
	29.106	0.533	1.000	1.644	3.754			2.667	2.000	1.333	2.666666667		
	36.309	0.600	1.100	1.800	4.174			3.000	2.250	1.500	3		
	44.304	0.667	1.200	1.955	4.593			3.333	2.500	1.667	3.333333333		

moment(vertical-direction)						total moment	Pa=(1/2)*r*H^2*Ka(1+2q/(r*H))	horizontal earthpressure(PH)=P*cos(δ)												
m1=w1*x1	m2=w2*x2	m3=w3*x3	m4=w4*x4	m5=w5*x5	m6=w6*x6	Mw	Pa	KA	PH=P*cos(δ+θ)	PV=P*sin(δ+θ)	(δ)=(2/3)*(φ)	=xv=b1+b2 +(2/3)*b3	Mϖ=PV*Xv	ΣMr=Mw+Mv	ΣM=Mw+Mv-Mo	Mo=-PH*(1/3)*(H)	ΣN=Σw+Pv	e'=(ΣM)/(ΣN)	e=ABS(B/2-e')	=e/B
t.m	t.m	t.m	t.m	t.m	t.m	t.m	t		t	t	degree	m	t	t.m	t.m	t.m	t	m	m	
CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU	CV	CW	CX	CY	CZ	DA	DB
=BO37*BV37	=BP37*BW37	=BQ37*BX37	=BR37*BY37	=BS37*BZ37	=BT37*CA37	=SUM(CH37:CM37)	=(1/2)*AG37*A37^2*V37*(1+2*AE37/(AG37*A37))	=V37	=CO37*COS((CS37+AR37)*PI()/180)	=CO37*SIN((M37+AR37)*PI()/180)	=(2/3)*(J37)	=AU37+AV37+(2/3)*AW37	=CR37*CT37	=XN37+XY37	=XY37+XN37−XΞ37	=CQ37*(BC37/3)	=BY37+XP37	=CW37/CY37	=ABS(BA37/2-CZ37)	=DA37/CT37
86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106
0.10575	0.70500	0.76284	3.57305	3.57305	0.56073	9.280	2.7248459	0.7266256	2.0328568	1.8144636	23.333333	1.033	1.8743409	11.154761	10.138	1.0164284	9.1301565	1.1104	0.5106726	0.4943588
0.25067	1.12800	1.59953	7.95859	5.96894	3.03167	19.937	4.3597534	0.7266256	3.2525708	2.9031418	23.333333	1.244	3.6115084	23.548903	21.381	2.1683806	14.897891	1.4351	0.7021375	0.5644192
0.48958	1.64500	2.87954	14.94545	8.96727	5.99035	34.917	6.3579737	0.7266256	4.7433325	4.2337485	23.333333	1.455	6.160104	41.077295	37.125	3.9527771	21.699627	1.7108	0.8445867	0.580472
0.84600	2.25600	4.69413	25.13607	12.56804	9.43678	54.937	8.7195067	0.7266256	6.5051417	5.8062836	23.333333	1.666	9.6732685	64.610282	58.105	6.5051417	29.535363	1.9673	0.9678075	0.5809169
1.34342	2.96100	7.13456	39.13289	16.77124	13.37096	80.714	11.444353	0.7266256	8.5379985	7.6207473	23.333333	1.877	14.304143	95.018205	85.057	9.9609982	38.4051	2.2147	1.0819873	0.576445
2.00533	3.76000	10.29210	57.53834	21.57688	17.79289	112.966	14.532511	0.7266256	10.841903	9.6771394	23.333333	2.088	20.205867	133.17141	118.716	14.45587	48.308837	2.4574	1.191429	0.5706078
2.85525	4.65300	14.25801	80.95487	26.98496	22.70256	152.409	17.983983	0.7266256	13.416855	11.97546	23.333333	2.299	27.531582	179.94023	159.815	20.125282	59.246575	2.6975	1.2982047	0.5646823
3.91667	5.64000	19.12357	109.98490	32.99547	28.09999	199.761	21.798767	0.7266256	16.262854	14.515709	23.333333	2.51	36.43443	236.19502	209.090	27.104757	71.218314	2.9359	1.4034059	0.5591258
0.10575	0.70500	0.76284				1.574	2.0659543	0.5509211	1.5412942	1.3757105	23.333333	1.033	1.4211089	2.9946984	2.224	0.7706471	4.1948292	0.5302	0.0695612	0.067339
0.25067	1.12800	1.59953				2.978	3.3055269	0.5509211	2.4660708	2.2011367	23.333333	1.244	2.7382141	5.716413	4.072	1.6440472	6.5862367	0.6183	0.1146855	0.0921909
0.48958	1.64500	2.87954				5.014	4.82056	0.5509211	3.5963532	3.2099911	23.333333	1.455	4.670537	9.6846598	6.688	2.996961	9.4742098	0.7059	0.1603654	0.1102168
0.84600	2.25600	4.69413				7.796	6.6110538	0.5509211	4.9321415	4.4022735	23.333333	1.666	7.3341876	15.130314	10.198	4.9321415	12.858748	0.7931	0.2064079	0.1238943
1.34342	2.96100	7.13456				11.439	8.6770081	0.5509211	6.4734358	5.7779839	23.333333	1.877	10.845276	22.28425	14.732	7.5523417	16.739853	0.8801	0.2527	0.1346297
2.00533	3.76000	10.29210				16.057	11.018423	0.5509211	8.2202359	7.3371225	23.333333	2.088	15.319912	31.377343	20.417	10.960315	21.117522	0.9668	0.2991712	0.1432812
2.85525	4.65300	14.25801				21.766	13.635298	0.5509211	10.172542	9.079689	23.333333	2.299	20.874205	42.640467	27.382	15.258813	25.991758	1.0535	0.3457755	0.1504026
3.91667	5.64000	19.12357				28.680	16.527634	0.5509211	12.330354	11.005684	23.333333	2.51	27.624266	56.304498	35.754	20.55059	31.362559	1.1400	0.3924811	0.156367
0.10575	0.70500	0.76284	3.57305			5.147	2.0659543	0.5509211	1.5412942	1.3757105	23.333333	1.033	1.4211089	6.5677485	5.797	0.7706471	6.3500353	0.9129	0.3131743	0.3031697
0.25067	1.12800	1.59953	7.95859			10.937	3.3055269	0.5509211	2.4660708	2.2011367	23.333333	1.244	2.7382141	13.675001	12.031	1.6440472	10.417714	1.1549	0.4218555	0.3391121
0.48958	1.64500	2.87954	14.94545			19.960	4.82056	0.5509211	3.5963532	3.2099911	23.333333	1.455	4.670537	24.630109	21.633	2.996961	15.460893	1.3992	0.5329672	0.3663005
0.84600	2.25600	4.69413	25.13607			32.932	6.6110538	0.5509211	4.9321415	4.4022735	23.333333	1.666	7.3341876	40.266384	35.334	4.9321415	21.479573	1.6450	0.6455161	0.3874646
1.34342	2.96100	7.13456	39.13289			50.572	8.6770081	0.5509211	6.4734358	5.7779839	23.333333	1.877	10.845276	61.417139	53.865	7.5523417	28.473752	1.8917	0.7589851	0.4043608
2.00533	3.76000	10.29210	57.53834			73.596	11.018423	0.5509211	8.2202359	7.3371225	23.333333	2.088	15.319912	88.915685	77.955	10.960315	36.443432	2.1391	0.8730787	0.4181412
2.85525	4.65300	14.25801	80.95487			102.721	13.635298	0.5509211	10.172542	9.079689	23.333333	2.299	20.874205	123.59533	108.337	15.258813	45.388612	2.3869	0.9876157	0.4295849
3.91667	5.64000	19.12357	109.98490			138.665	16.527634	0.5509211	12.330354	11.005684	23.333333	2.51	27.624266	166.2894	145.739	20.55059	55.309292	2.6350	1.1024788	0.4392346

horizontal earthpressure(PH)=P*cos(δ+θ)
verticakal earthpressure(PV)=P*sin(δ+θ)

C-3
resultant working position
resultant working position is e' from A

C-4
confirmation to falling
e'=(ΣumM)/(ΣsumN)
eccentric length
e=B/2-e'
e/B=0.134/2.6
safety ratio
f=Mr/Mo

(6-3-2)

(6-4-1)

alling,sliding

safety ratio(Fs)	remarks
1.5	
1.2	

table 5 internal friction angle(foundation bottom and ground)

condition	friction angle jB(friction	adhesion(C)	remarks
soil and concrete	φB=(2/3)*φ	X=0	
sand and concrete	tanjB=0.5	C=0	
rock and concrete	tanjB=0.6	C=0	
soil and soil,rock and rock	φB=φ	X=Xo	

Co:adhesion of bearing ground (t/m2)

ϕ:internal friction angle of bearing ground(degree)

D:eartquke time stability calculation

C-5 confirmation to sliding

C-6 confirmation to ground reaction force

D-1 eartpressure calculation

table-4 table-5 table-4 table-3 table-2

check point check point check point check point

0.1666667

		judgement	f=Mr/Mo		f	judgement	RH	c	A'	ΣN=V	(φB)	f	judgement	f	p1	p2	e/B				qa1	judgement	φ	χ	δ	θo	θ	kEA	=(φ-θo-θ)	=(θo)	=(θ)	(δ+θo+θ)	=(δ+φ)	=(φ-χ-θo)
							t		m	t	degree				t/m2	t/m2					t/m2		degree	degree	degree	degree	degree							
DC	DD	DE	DF	DG	DH	DI	DJ	DK	DL	DM	DN	DO	DP	DQ	DR	DS	DT	DU	DV	DW	DX	DY	DZ	EA	EB	EC	ED	EE	EF	EG	EH	EI	EJ	EK
<	0.25	no	=CV37/CX37	>	1.5	ok	=DK37*DL37+DM37*TAN(DN37*PI()/180)	0	=CT37-2*DA37	=CY37	=(2/3)*J37	=DJ37/CQ37	>	1.5	=(DM37/CT37)*(1+6*DA37/CT37)	=(DM37/CT37)*(1-6*DA37/CT37)	=DA37/CT37	<	=1/6=0.167	<	=O37	ok	=J37	=K37	=(1/2)*DZ37	=ATAN(F37)	=L37	=(EN37)/((EO37*EP37*EQ37)*(1+((ER37*ES37)/(ET37*EU37))^0.5)^2)	=(DZ37-EC37-ED37)	=(EC37)	=ED37	=(EB37+EC37+ED37)	=(EB37+DZ37)	=ABS((DZ37-EA37-EC37))
107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141
>	0.25	no	10.974468	>	1.5	ok	3.9383651	0	0.0116547	9.1301565	23.333333	1.9373549	>	1.5	35.054787	17.377814	0.4943588	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	10.860134	>	1.5	ok	6.426323	0	0.1602749	14.897891	23.333333	1.9757673	>	1.5	52.532014	28.580421	0.5644192	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	10.392009	>	1.5	ok	9.3603053	0	0.2341734	21.699627	23.333333	1.9733606	>	1.5	66.856205	37.028539	0.580472	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	9.9321868	>	1.5	ok	12.740312	0	0.2696149	29.535363	23.333333	1.9584988	>	1.5	79.52035	44.063732	0.5809169	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	9.5390244	>	1.5	ok	16.566343	0	0.2869746	38.4051	23.333333	1.9403076	>	1.5	91.228381	50.306591	0.576445	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	9.2122718	>	1.5	ok	20.838398	0	0.294858	48.308837	23.333333	1.9220241	>	1.5	102.34733	56.074495	0.5706078	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.9410043	>	1.5	ok	25.556478	0	0.2974093	59.246575	23.333333	1.904804	>	1.5	113.08375	61.542578	0.5646823	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.7141539	>	1.5	ok	30.720582	0	0.2968117	71.218314	23.333333	1.8890031	>	1.5	123.56108	66.81342	0.5591258	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
<	0.25	ok	3.8859529	>	1.5	ok	1.8094727	0	0.8938775	4.1948292	23.333333	1.1739956	>	1.5	5.7015334	2.4201107	0.067339	<	0.167	<	10	ok	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
<	0.25	ok	3.4770371	>	1.5	ok	2.8410252	0	1.014629	6.5862367	23.333333	1.1520453	>	1.5	8.222977	2.365828	0.0921909	<	0.167	<	10	ok	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
<	0.25	ok	3.2314934	>	1.5	ok	4.0867752	0	1.1342692	9.4742098	23.333333	1.1363665	>	1.5	10.817533	2.2054357	0.1102168	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
<	0.25	ok	3.0676966	>	1.5	ok	5.5467227	0	1.2531843	12.858748	23.333333	1.1246074	>	1.5	13.455883	1.9807901	0.1238943	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
<	0.25	ok	2.9506411	>	1.5	ok	7.2208676	0	1.3716001	16.739853	23.333333	1.1154614	>	1.5	16.122505	1.7143122	0.1346297	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
<	0.25	ok	2.8628141	>	1.5	ok	9.10921	0	1.4896575	21.117522	23.333333	1.1081446	>	1.5	18.808425	1.4190867	0.1432812	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
<	0.25	ok	2.7944813	>	1.5	ok	11.21175	0	1.607449	25.991758	23.333333	1.1021581	>	1.5	21.508099	1.1032606	0.1504026	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
<	0.25	ok	2.7397996	>	1.5	ok	13.528487	0	1.7250377	31.362559	23.333333	1.0971694	>	1.5	24.217917	0.7721698	0.156367	<	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.5223812	>	1.5	ok	2.7391378	0	0.4066514	6.3500353	23.333333	1.7771674	>	1.5	17.329007	5.0346502	0.3031697	>	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.3178886	>	1.5	ok	4.4937632	0	0.4002891	10.417714	23.333333	1.8222361	>	1.5	25.413466	8.6647298	0.3391121	>	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.2183616	>	1.5	ok	6.6691784	0	0.3890655	15.460893	23.333333	1.8544281	>	1.5	33.979994	12.727907	0.3663005	>	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.1640772	>	1.5	ok	9.2653832	0	0.3749678	21.479573	23.333333	1.878572	>	1.5	42.86616	17.080359	0.3874646	>	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.1321981	>	1.5	ok	12.282378	0	0.3590297	28.473752	23.333333	1.8973507	>	1.5	51.974299	21.634659	0.4043608	>	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.1125122	>	1.5	ok	15.720162	0	0.3418425	36.443432	23.333333	1.9123736	>	1.5	61.242541	26.335039	0.4181412	>	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.0999312	>	1.5	ok	19.578736	0	0.3237686	45.388612	23.333333	1.9246651	>	1.5	70.629922	31.144395	0.4295849	>	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111
>	0.25	no	8.0917094	>	1.5	ok	23.8581	0	0.3050425	55.309292	23.333333	1.934908	>	1.5	80.108291	36.037141	0.4392346	>	0.167	>	10	no	35	0	17.5	0.1488899	18.417758	0.4040833	16.433352	0.1488899	18.417758	36.066648	52.5	34.85111

C-5
confirmation to sliding
RH
sliding resist
RH=c*A'+V*tan(φB)
c
adhesion between bearing ground and foundation bottom surface
A'
effective loading area
v
total vertical load
(φB)
=(2/3)*(φ)
friction angle between bearing ground and foundation bottom surface
f
safety ratio
f=RH/PH

C-6
confirmation to ground reaction
p1=(@sum(N)/B)*(1+6*e/B)
p2=(@sum(N)/B)*(1 -6*e/B)

compare to (p1,p2)

D-1
earth pressure calculation(earthquake time)
φ
Internal friction angle of soil
χ
internal angle betwenn ground surface and horizontal line
δ φ/2
behind soil internal friction angle
θ
internal angle between estimated behind surface and vertical line
θo =ATAN(Kh)

kEA
kEA=(cos^2(φ-θo−θ))/(((cosθocos^2*θ*cos(θo+φ+θ)*(1+(sin(φ+δ)*sin(φ-χ−θo)/(cos(θ+φ+θ)*cos(θ-χ))^0.5)^2

(6-4-2)

(6-5-1)

											table-2	table-5	table-1				
=(δ+θo+θ)	=(θ-γ)	cos^2(φ-θo-θ)	cos(θo)	cos^2(θ)	cos(δ+θo+θ)	sin(δ+φ)	sin(φ-γ-θo)	cos(δ+θo+θ)	cos(θ-γ)	P	q	c	r	H2	Ph	Pv	y
										t	t/m2		t/m3	m	t	t	m
EL	EM	EN	EO	EP	EQ	ER	ES	ET	EU	EV	EW	EX	EY	EZ	FA	FB	FC
=(EB37+EC37+ED37)	=ABS(ED37-EA37)	=(COS(EF37*PI()/180))^2	=COS(EG37*PI()/180)	=(COS(EH37*PI()/180))^2	=COS(EI37*PI()/180)	=SIN(EJ37*PI()/180)	=SIN(EK37*PI()/180)	=COS(EL37*PI()/180)	=COS(EM37*PI()/180)	=(1/2)*EY37*EE37*EZ37^2	=AE37	=AF37	=AG37	=AM37	=EV37*COS(M37*PI()/180)	=EV37*SIN(M37*PI()/180)	=EZ37/3
142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	3.6367501	1	0	2	3.000	3.3393225	1.4404431	1
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	4.9500209	1	0	2	3.500	4.5451889	1.9606031	1.1666667
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	6.4653334	1	0	2	4.000	5.9365733	2.5607878	1.3333333
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	8.1826876	1	0	2	4.500	7.5134756	3.240997	1.5
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	10.102084	1	0	2	5.000	9.2758958	4.0012309	1.6666667
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	12.223521	1	0	2	5.500	11.223834	4.8414894	1.8333333
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	14.547	1	0	2	6.000	13.35729	5.7617725	2
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	17.072521	1	0	2	6.500	15.676264	6.7620802	2.1666667
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	0.9091875	1	0	2	1.500	0.8348306	0.3601108	0.5
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	1.6163334	1	0	2	2.000	1.4841433	0.6401969	0.6666667
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	2.5255209	1	0	2	2.500	2.3189739	1.0003077	0.8333333
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	3.6367501	1	0	2	3.000	3.3393225	1.4404431	1
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	4.9500209	1	0	2	3.500	4.5451889	1.9606031	1.1666667
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	6.4653334	1	0	2	4.000	5.9365733	2.5607878	1.3333333
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	8.1826876	1	0	2	4.500	7.5134756	3.240997	1.5
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	10.102084	1	0	2	5.000	9.2758958	4.0012309	1.6666667
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	0.9091875	1	0	2	1.500	0.8348306	0.3601108	0.5
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	1.6163334	1	0	2	2.000	1.4841433	0.6401969	0.6666667
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	2.5255209	1	0	2	2.500	2.3189739	1.0003077	0.8333333
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	3.6367501	1	0	2	3.000	3.3393225	1.4404431	1
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	4.9500209	1	0	2	3.500	4.5451889	1.9606031	1.1666667
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	6.4653334	1	0	2	4.000	5.9365733	2.5607878	1.3333333
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	8.1826876	1	0	2	4.500	7.5134756	3.240997	1.5
36.066648	18.417758	0.9199677	0.9999966	0.9001799	0.8083327	0.7933533	0.5714458	0.8083327	0.9487781	10.102084	1	0	2	5.000	9.2758958	4.0012309	1.6666667

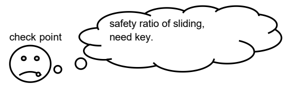
D-2 weight and gravity center figure5-7 horizontal force							horizontal force									
H1=w1*kh	H2=w2*kh	H3=w3*kh	H4=w4*kh	H5=w5*kh	Σ(H)	Σ(pH)	MH	y1	y2	y3	y4	y5	mo-1	mo-2	mo-3	mo-4
t	t	t	t	t	t	t	t	m	m	m	m	m	t.m	t.m	t.m	t.m
FD	FE	FF	FG	FH	FI	FJ	FK	FL	FM	FN	FO	FP	FQ	FR	FS	FT
=BO37*F37	=BP37*F37	=BQ37*F37	=BR37*F37	=BS37*F37	=SUM(FD37:FH37)	=FA37	=FI37+FJ37	=EP37+(1/3)*EQ37	=EQ37+(1/3)*ER37	=ER37+(1/3)*ES37	=ES37+(1/3)*ET37	=ET37+(1/3)*EU37	=FD37*FL37	=FE37*FM37	=FF37*FN37	=FG37*FO37
160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
0.0793125	0.2115	0.1320553	0.3232809	0.3232809	1.0694296	3.3393225	4.4087521	1.170	1.073	0.984	0.841	1.125	0.0927658	0.2268938	0.1299207	0.2718437
0.141	0.282	0.234765	0.5747216	0.4310412	1.6635278	4.5451889	6.2087168	1.170	1.073	0.984	0.841	1.125	0.164917	0.302525	0.2309701	0.4832777
0.2203125	0.3525	0.3668203	0.8980025	0.5388015	2.3764368	5.9365733	8.3130101	1.170	1.073	0.984	0.841	1.125	0.2576828	0.3781563	0.3608908	0.7551214
0.31725	0.423	0.5282213	1.2931236	0.6465618	3.2081567	7.5134756	10.721632	1.170	1.073	0.984	0.841	1.125	0.3710633	0.4537876	0.5196827	1.0873748
0.4318125	0.4935	0.7189678	1.7600849	0.7543221	4.1586874	9.2758958	13.434583	1.170	1.073	0.984	0.841	1.125	0.5050583	0.5294188	0.7073459	1.480038
0.564	0.564	0.93906	2.2988864	0.8620824	5.2280289	11.223834	16.451863	1.170	1.073	0.984	0.841	1.125	0.659668	0.6050501	0.9238804	1.9331108
0.7138125	0.6345	1.1884978	2.9095282	0.9698427	6.4161812	13.35729	19.773471	1.170	1.073	0.984	0.841	1.125	0.8348924	0.6806813	1.1692861	2.4465934
0.88125	0.705	1.4672813	3.5920101	1.077603	7.7231443	15.676264	23.399408	1.170	1.073	0.984	0.841	1.125	1.0307313	0.7563126	1.4435631	3.0204856
0.0793125	0.2115	0.1320553	0	0	0.4228678	0.8348306	1.2576984	1.170	1.073	0.984	0.841	1.125	0.0927658	0.2268938	0.1299207	0
0.141	0.282	0.234765	0	0	0.657765	1.4841433	2.1419083	1.170	1.073	0.984	0.841	1.125	0.164917	0.302525	0.2309701	0
0.2203125	0.3525	0.3668203	0	0	0.9396328	2.3189739	3.2586068	1.170	1.073	0.984	0.841	1.125	0.2576828	0.3781563	0.3608908	0
0.31725	0.423	0.5282213	0	0	1.2684713	3.3393225	4.6077937	1.170	1.073	0.984	0.841	1.125	0.3710633	0.4537876	0.5196827	0
0.4318125	0.4935	0.7189678	0	0	1.6442803	4.5451889	6.1894692	1.170	1.073	0.984	0.841	1.125	0.5050583	0.5294188	0.7073459	0
0.564	0.564	0.93906	0	0	2.06706	5.9365733	8.0036333	1.170	1.073	0.984	0.841	1.125	0.659668	0.6050501	0.9238804	0
0.7138125	0.6345	1.1884978	0	0	2.5368103	7.5134756	10.050286	1.170	1.073	0.984	0.841	1.125	0.8348924	0.6806813	1.1692861	0
0.88125	0.705	1.4672813	0	0	3.0535313	9.2758958	12.329427	1.170	1.073	0.984	0.841	1.125	1.0307313	0.7563126	1.4435631	0
0.0793125	0.2115	0.1320553	0.3232809	0	0.7461487	0.8348306	1.5809793	1.170	1.073	0.984	0.841	1.125	0.0927658	0.2268938	0.1299207	0.2718437
0.141	0.282	0.234765	0.5747216	0	1.2324866	1.4841433	2.7166299	1.170	1.073	0.984	0.841	1.125	0.164917	0.302525	0.2309701	0.4832777
0.2203125	0.3525	0.3668203	0.8980025	0	1.8376353	2.3189739	4.1566093	1.170	1.073	0.984	0.841	1.125	0.2576828	0.3781563	0.3608908	0.7551214
0.31725	0.423	0.5282213	1.2931236	0	2.5615949	3.3393225	5.9009174	1.170	1.073	0.984	0.841	1.125	0.3710633	0.4537876	0.5196827	1.0873748
0.4318125	0.4935	0.7189678	1.7600849	0	3.4043652	4.5451889	7.9495542	1.170	1.073	0.984	0.841	1.125	0.5050583	0.5294188	0.7073459	1.480038
0.564	0.564	0.93906	2.2988864	0	4.3659464	5.9365733	10.30252	1.170	1.073	0.984	0.841	1.125	0.659668	0.6050501	0.9238804	1.9331108
0.7138125	0.6345	1.1884978	2.9095282	0	5.4463385	7.5134756	12.959814	1.170	1.073	0.984	0.841	1.125	0.8348924	0.6806813	1.1692861	2.4465934
0.88125	0.705	1.4672813	3.5920101	0	6.6455413	9.2758958	15.921437	1.170	1.073	0.984	0.841	1.125	1.0307313	0.7563126	1.4435631	3.0204856

Pa
total earth pressure to estimated behind surface
P=(1/2)*eb117*KEA*ec117^2
q
loading on ground surface in normal time
c
soil adhesion(sand)
r
soil unit weight
H2
wall height or estimated behind surface
PH
horizontal earthpressure(PH)=P*cos(δ)
PV
vertical earthpressure(PV)=P*sin(δ)
y

D-2
horizontal prssure and working height
H1-H6
H=w*Kh

(6-5-2)

(6-6-1)



				D-3 resultant force working point										D-4 confirmation to falling	table-3		
				vertical force		moment			arm								
mo-5	Σ(mo)	=PH*y	Σ(mo)+PH*y	Σ(W)	arm	Mr-1	PV	Σ(N)	B	Mr-2	Σ(Mr)	ΣM=Mr-Mo	e'=ΣM/ΣN	e	e/B		1/4=0.25
t.m	t.m	t.m	t.m	t		t.m	t	t	m				m				
FU	FV	FW	FX	FY	FZ	GA	GB	GC	GD	GE	GF	GG	GH	GI	GJ	GK	GL
=FH37*FP37	=SUM(FQ37:FU37)	=FA37*FC37	=FV37+FW37	=BU37		=CN37	=EV37*SIN(M37*PI()/180)	=FY37+GB37	=BA37	=GB37*GD37	=GA37+GE37	=GF37-FX37	=GG37/GC37	=ABS(GD37/2-GH37)	=ABS(GI37/GD37)	<	1/4=0.25
177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194
0.3635592	1.0849831	3.3393225	4.4243056	7.3156929		9.2804199	1.4404431	8.756136	1.1995	1.7278115	11.008231	6.5839258	0.7519214	0.1521714	0.1268623	<	1/4=0.25
0.4847455	1.6664354	5.3027204	6.9691558	11.99475		19.937394	1.9606031	13.955353	1.466	2.8742442	22.811638	15.842483	1.1352262	0.4022262	0.2743699	>	1/4=0.25
0.6059319	2.3577832	7.9154311	10.273214	17.465878		34.917191	2.5607878	20.026666	1.7325	4.4365648	39.353756	29.080542	1.452091	0.585841	0.3381478	>	1/4=0.25
0.7271183	3.1590267	11.270213	14.42924	23.729079		54.937014	3.240997	26.970076	1.999	6.478753	61.415767	46.986526	1.7421725	0.7426725	0.371522	>	1/4=0.25
0.8483047	4.0701657	15.459826	19.529992	30.784353		80.714063	4.0012309	34.785583	2.2655	9.0647885	89.778851	70.248859	2.019482	0.886732	0.3914067	>	1/4=0.25
0.9694911	5.0912004	20.577029	25.668229	38.631698		112.96554	4.8414894	43.473187	2.532	12.258651	125.22419	99.555963	2.2900544	1.0240544	0.4044449	>	1/4=0.25
1.0906775	6.2221306	26.71458	32.93671	47.271115		152.40865	5.7617725	53.032888	2.7985	16.12432	168.53297	135.59626	2.5568334	1.1575834	0.4136442	>	1/4=0.25
1.2118638	7.4629564	33.965238	41.428195	56.702605		199.76059	6.7620802	63.464685	3.065	20.725776	220.48637	179.05817	2.8213828	1.2888828	0.4205164	>	1/4=0.25
0	0.4495803	0.4174153	0.8669956	2.8191188		1.5735895	0.3601108	3.1792295	1.1995	0.4319529	2.0055424	1.1385468	0.3581204	0.2416296	0.201442	<	1/4=0.25
0	0.6984121	0.9894289	1.687841	4.3851		2.9781989	0.6401969	5.0252969	1.466	0.9385287	3.9167276	2.2288866	0.4435333	0.2894667	0.1974534	<	1/4=0.25
0	0.9967299	1.9324783	2.9292082	6.2642188		5.0141228	1.0003077	7.2645265	1.7325	1.7330331	6.7471559	3.8179477	0.5255604	0.3406896	0.1966462	<	1/4=0.25
0	1.3445335	3.3393225	4.683856	8.456475		7.7961262	1.4404431	9.8969181	1.999	2.8794458	10.675572	5.9917159	0.6054123	0.3940877	0.1971424	<	1/4=0.25
0	1.7418231	5.3027204	7.0445435	10.961869		11.438974	1.9606031	12.922472	2.2655	4.4417464	15.88072	8.8361768	0.6837838	0.4489662	0.1981753	<	1/4=0.25
0	2.1885985	7.9154311	10.10403	13.7804		16.057431	2.5607878	16.341188	2.532	6.4839146	22.541346	12.437316	0.7611023	0.5048977	0.1994067	<	1/4=0.25
0	2.6848598	11.270213	13.955073	16.912069		21.766262	3.240997	20.153066	2.7985	9.0699301	30.836192	16.881119	0.8376452	0.5616048	0.2006806	<	1/4=0.25
0	3.230607	15.459826	18.690433	20.356875		28.680232	4.0012309	24.358106	3.065	12.263773	40.944005	22.253572	0.9136003	0.6188997	0.2019249	<	1/4=0.25
0	0.721424	0.4174153	1.1388393	4.9743248		5.1466396	0.3601108	5.3344356	1.1995	0.4319529	5.5785924	4.4397532	0.8322817	0.2325317	0.1938572	<	1/4=0.25
0	1.1816898	0.9894289	2.1711187	8.2165774		10.936787	0.6401969	8.8567743	1.466	0.9385287	11.875316	9.7041972	1.0956807	0.3626807	0.2473948	<	1/4=0.25
0	1.7518513	1.9324783	3.6843296	12.250902		19.959572	1.0003077	13.25121	1.7325	1.7330331	21.692605	18.008276	1.3589911	0.4927411	0.2844104	>	1/4=0.25
0	2.4319084	3.3393225	5.7712308	17.077299		32.932197	1.4404431	18.517742	1.999	2.8794458	35.811643	30.040412	1.6222502	0.6227502	0.3115309	>	1/4=0.25
0	3.221861	5.3027204	8.5245814	22.695768		50.571863	1.9606031	24.656371	2.2655	4.4417464	55.01361	46.489028	1.8854773	0.7527273	0.3322566	>	1/4=0.25
0	4.1217093	7.9154311	12.03714	29.10631		73.595773	2.5607878	31.667097	2.532	6.4839146	80.079688	68.042548	2.1486828	0.8826828	0.3486109	>	1/4=0.25
0	5.1314531	11.270213	16.401667	36.308923		102.72113	3.240997	39.54992	2.7985	9.0699301	111.79106	95.389393	2.4118732	1.0126232	0.361845	>	1/4=0.25
0	6.2510926	15.459826	21.710919	44.303609		138.66513	4.0012309	48.30484	3.065	12.263773	150.92891	129.21799	2.6750526	1.1425526	0.3727741	>	1/4=0.25

check point			table-4	check point	D-5 confirmation to sliding figure5-8		table-5				table-4	check point				
judgement	f				RH	V=ΣN	(φB)=(2/3)*Φ	c	f			judgement	B	b=0.15*B	A'	Hu
					t	t	degree						m	m	m	t
GM	GN	GO	GP	GQ	GR	GS	GT	GU	GV	GW	GX	GY	GZ	HA	HB	HC
ok	=GF37/FX37	>	1.2	ok	=GC37*TAN(GT37*PI()/180)	=GC37	=(2/3)*DZ37	=EX37	=GR37/FK37	<	1.2	no	=GD37	=0.15*GD37	=GZ37-2*GI37	=GS37*TAN(DZ37*PI()/180)
195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211
ok	2.4881263	>	1.2	ok	3.7770284	8.756136	23.333333	0	0.8567114	<	1.2	no	1.1995	0.2	0.8951573	6.1311125
no	3.2732284	>	1.2	ok	6.0197515	13.955353	23.333333	0	0.9695645	<	1.2	no	1.466	0.2	0.6615475	9.7716431
no	3.830715	>	1.2	ok	8.6386605	20.026666	23.333333	0	1.0391736	<	1.2	no	1.7325	0.3	0.560818	14.022823
no	4.256341	>	1.2	ok	11.633755	26.970076	23.333333	0	1.0850732	<	1.2	no	1.999	0.3	0.5136549	18.884651
no	4.5969733	>	1.2	ok	15.005036	34.785583	23.333333	0	1.1168963	<	1.2	no	2.2655	0.3	0.492036	24.357128
no	4.8785676	>	1.2	ok	18.752502	43.473187	23.333333	0	1.1398407	<	1.2	no	2.532	0.4	0.4838912	30.440253
no	5.1168732	>	1.2	ok	22.876155	53.032888	23.333333	0	1.1569114	<	1.2	no	2.7985	0.4	0.4833332	37.134028
no	5.3221332	>	1.2	ok	27.375993	63.464685	23.333333	0	1.1699438	<	1.2	no	3.065	0.5	0.4872343	44.438451
ok	2.3132095	>	1.2	ok	1.3713858	3.1792295	23.333333	0	1.0903931	<	1.2	no	1.1995	0.2	0.7162407	2.2261205
ok	2.3205548	>	1.2	ok	2.1677015	5.0252969	23.333333	0	1.0120421	<	1.2	no	1.466	0.2	0.8870666	3.5187508
ok	2.3034061	>	1.2	ok	3.1336108	7.2645265	23.333333	0	0.9616413	<	1.2	no	1.7325	0.3	1.0511209	5.0866762
ok	2.2792272	>	1.2	ok	4.2691138	9.8969181	23.333333	0	0.9264985	<	1.2	no	1.999	0.3	1.2108246	6.9298967
ok	2.2543292	>	1.2	ok	5.5742103	12.922472	23.333333	0	0.9005958	<	1.2	no	2.2655	0.3	1.3675676	9.0484122
ok	2.2309263	>	1.2	ok	7.0489003	16.341188	23.333333	0	0.8807126	<	1.2	no	2.532	0.4	1.5222046	11.442223
ok	2.2096761	>	1.2	ok	8.693184	20.153066	23.333333	0	0.8649688	<	1.2	no	2.7985	0.4	1.6752904	14.111329
ok	2.1906397	>	1.2	ok	10.507061	24.358106	23.333333	0	0.8521938	<	1.2	no	3.065	0.5	1.8272005	17.055729
ok	4.8984896	>	1.2	ok	2.3010509	5.3344356	23.333333	0	1.4554592	>	1.2	ok	1.1995	0.2	0.7344366	3.735212
ok	5.469676	>	1.2	ok	3.8204395	8.8567743	23.333333	0	1.4063158	>	1.2	ok	1.466	0.2	0.7406385	6.2015802
no	5.8878026	>	1.2	ok	5.716014	13.25121	23.333333	0	1.3751627	>	1.2	ok	1.7325	0.3	0.7470179	9.2785971
no	6.2052002	>	1.2	ok	7.9877743	18.517742	23.333333	0	1.3536496	>	1.2	ok	1.999	0.3	0.7534995	12.966263
no	6.4535262	>	1.2	ok	10.63572	24.656371	23.333333	0	1.3379015	>	1.2	ok	2.2655	0.3	0.7600454	17.264577
no	6.652717	>	1.2	ok	13.659852	31.667097	23.333333	0	1.3258749	>	1.2	ok	2.532	0.4	0.7666344	22.17354
no	6.8158354	>	1.2	ok	17.06017	39.54992	23.333333	0	1.31639	>	1.2	ok	2.7985	0.4	0.7732536	27.693152
no	6.9517512	>	1.2	ok	20.836674	48.30484	23.333333	0	1.3087182	>	1.2	ok	3.065	0.5	0.7798948	33.823413

D-3
resultant force working point

D-4
confirmation to falling
e:eccentric length
e=B/2-e'
e'=ΣM/ΣN
e'
f:safety ratio
f=Mr/Mo

D-5
confirmation to sliding
sliding resist
c=0
(φB)=(2/3)*Φ
RH=c*A'+V*tan(φB)=tanΣN*tan27=18.056*0.510=9.2t
safety ratio
f=RH/ΣH=9.2/11.767=0.78<1.2
to set key, due to shortage of sliding resist
key height=b
0.1<b/B<0.15
effective loading area
A'=B-2e=2.6-2*0.512=1.576
sliding resist by key
Hu=V*tanφ
Hu=ΣN*tanφ
safety ratio
f=Hu/ΣH
(φB)=(2/3)*Φ

0.1<b/B<0.15

to set key, due to shortage of sliding resist
key height=b
0.1<b/B<0.15
A'=B-2e
effective loading area

Hu=V*tanφ
sliding resist by key

(6-6-2)

(6-7-1)

according to
(japan road cooperation)
(road eartworks)
(retainging wall)

D-6

confirmation to ground reaction force

φ	f=Hu/ΣH		f	judgement	e/B		1	P1	P2		qa2	judgement
			table-4	check point	table-3							check point
degree								t/m2	t/m2		t/m2	
HD	HE	HF	HG	HH	HI	HJ	HK	HL	HM	HN	HO	HP
=DZ37	=HC37/FK37	>	1.2	ok	=ABS(GI38/GD38)	<	1	=ABS((GS37/GD37)*(1+6*GI37/GD37))	=ABS(GS37/GD37)*(1-6*GI37/GD37)	<	=P37	ok
212	213	214	215	216	217	218	219	220	221	222	223	224
35	1.3906684	>	1.2	ok	0.1268623	<	1	12.856256	1.7433873	<	15	ok
35	1.5738587	>	1.2	ok	0.2743699	<	1	25.190262	6.1515813	>	15	no
35	1.6868526	>	1.2	ok	0.3381478	<	1	35.012122	11.893315	>	15	no
35	1.7613597	>	1.2	ok	0.371522	<	1	43.566754	16.583186	>	15	no
35	1.813017	>	1.2	ok	0.3914067	<	1	51.413576	20.704608	>	15	no
35	1.8502618	>	1.2	ok	0.4044449	<	1	58.834214	24.495203	>	15	no
35	1.8779721	>	1.2	ok	0.4136442	<	1	65.982984	28.082046	>	15	no
35	1.8991271	>	1.2	ok	0.4205164	<	1	72.950193	31.537674	>	15	no
35	1.7699954	>	1.2	ok	0.201442	<	1	5.8539484	0.5530238	<	15	ok
35	1.6428111	>	1.2	ok	0.1974534	<	1	7.4889966	0.6332027	<	15	ok
35	1.5609973	>	1.2	ok	0.1966462	<	1	9.1404191	0.7542414	<	15	ok
35	1.5039511	>	1.2	ok	0.1971424	<	1	10.80717	0.9053008	>	15	no
35	1.4619044	>	1.2	ok	0.1981753	<	1	12.48641	1.0783575	>	15	no
35	1.4296286	>	1.2	ok	0.1994067	<	1	14.175529	1.2677973	>	15	no
35	1.4040724	>	1.2	ok	0.2006806	<	1	15.872449	1.4696858	>	15	no
35	1.3833351	>	1.2	ok	0.2019249	<	1	17.575579	1.68122	>	15	no
35	2.3625938	>	1.2	ok	0.1938572	<	1	9.619965	0.725533	<	15	ok
35	2.2828211	>	1.2	ok	0.2473948	<	1	15.009204	2.9262921	>	15	no
35	2.2322514	>	1.2	ok	0.2844104	<	1	20.700666	5.4034535	>	15	no
35	2.19733	>	1.2	ok	0.3115309	<	1	26.578706	8.0517006	>	15	no
35	2.1717667	>	1.2	ok	0.3322566	<	1	32.579926	10.8131	>	15	no
35	2.1522444	>	1.2	ok	0.3486109	<	1	38.666694	13.653189	>	15	no
35	2.136848	>	1.2	ok	0.361845	<	1	44.815281	16.550196	>	15	no
35	2.1243945	>	1.2	ok	0.3727741	<	1	51.009983	19.489696	>	15	no

D-6

confirmation to ground reaction

ground reaction

$e/B>1/6$

$q=2*\Sigma*N/3*e'$

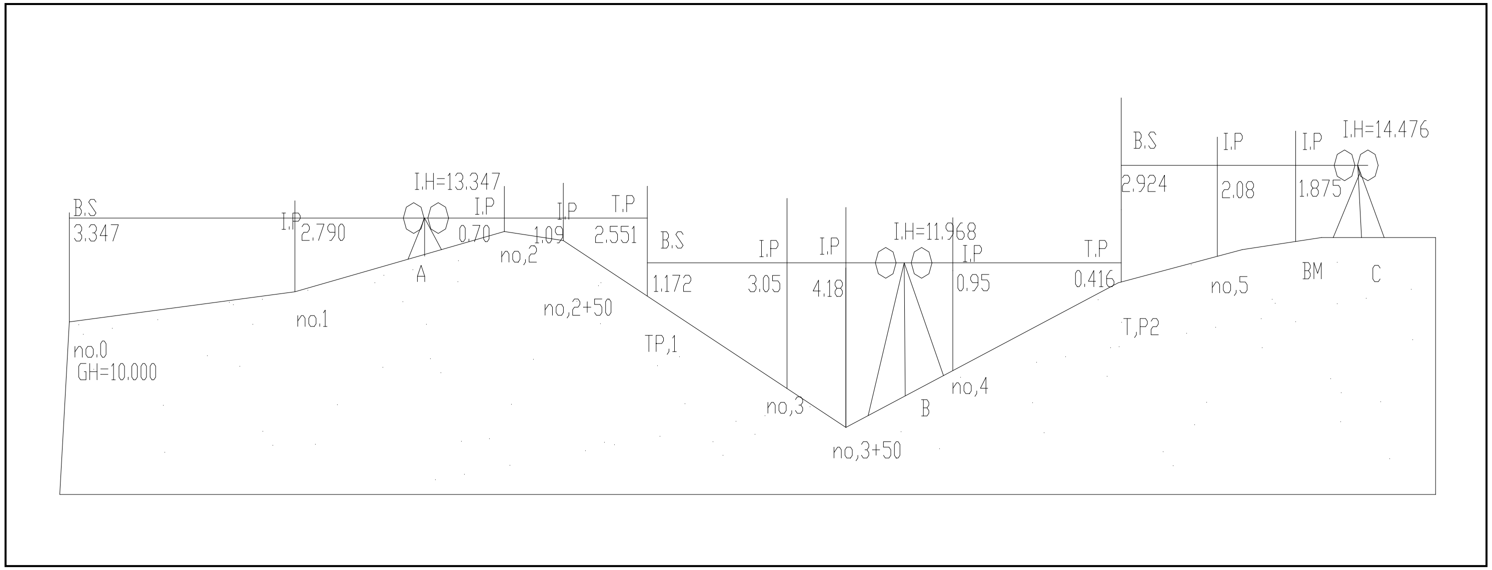
ground reaction is triangle destibution

$e/B<1/6$

$p1=(N/B)(1+6e/B)$

$p2=(N/B)(1-6e/B)$

(7)leveling



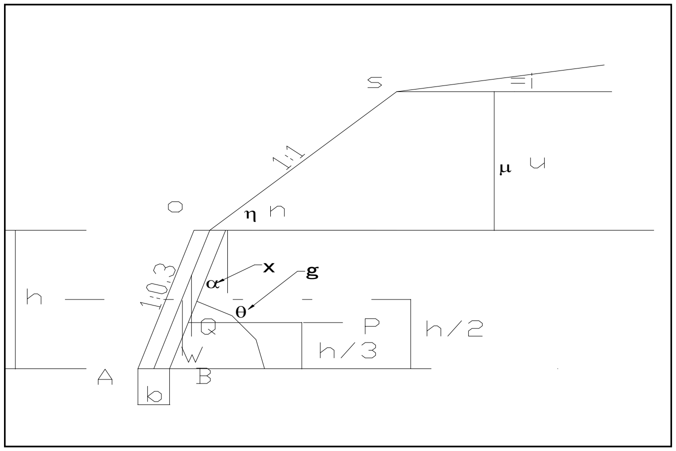
ST	DT	B.S	I.H(1)	I.H(2)	I.H(3)	T.P	I.P	G.H	remarks
	(1)	(2)	(3)=(2)+(8)	(4)=(2)+(8)	(5)=(2)+(8)	(6)	(7)	(8)=(3,4,5)−(6,7)	
no.0		3.347	13.347					10.000	no.0
no.1			13.347				2.79	10.557	no.1
no.2			13.347				0.7	12.647	no.2
no.2+50			13.347				1.09	12.257	no.2+50
T.P.1		1.172	13.347	11.968		2.551		10.796	T.P.1
no.3				11.968			3.05	8.918	no.3
no.3+50				11.968			4.18	7.788	no.3+50
no.4				11.968			0.95	11.018	no.4
T.P.2		2.924		11.968	14.476	0.416		11.552	T.P.2
no.5					14.476		2.08	12.396	no.5
B.M					14.476	1.875		12.601	B.M
total		7.443				4.842			total
confirmation		=7.443−4.842=2.601						12.601−10.000=2.601	

DT:distance
B.S:back sight
I.H:instrument height
F.S:fore sight
T.P:transeformation point
I.P:internal ponit
G.H:ground height
B.M:bench mark

(8)retaing wall stability calculation

gravity wall retaingwall design

No	symbol	Unit	Description	actual quantity	Remarks
1	unit weight				
1	u	t/m3	concrete unit weight	2.35	
2	w	t/m3	Unit weight of soil	1.8	
2	allowable stress				
1	σ28	kg/cm2	concrete design standard strength	180	
2	σca	kg/cm2	concrete allowable bending copressive stre	60	
3	τa	kg/cm2	concrete allowable shearing stress	8	
4	σta	kg/cm2	concrete allowable bending tensile strength	3	
5	σ				
6	Kh		horizontal seismic coefficient	0.15	
7	Kv		horizontal seismic coefficient	0	
8	safety ratio				
			resultant working position is (following length from center)		
	w	m	Foundation bottom width		
			normal time within 1/6 of w		
			earthquake time within 1/4 of w		
	sr		safety ratio to falling		
			normal time 1.5		
			earthquake time 1.2		
	allowable ground bearing force				
	qa	t	ultimate bearing capacity	24	
	q'a	t	ultimate bearing capacity(normal)	8	
	q''a	t	ultimate bearing capacity(eartquake)	12	
	earth pressure				
	if	degree	Internal friction angle of soil	30	
	H	m	wall height	2.3	
	H1	m	soil height	0.46	
	H1/H			0.2	
	Kh			0.66	according to gigure2-14
	Kv			0.12	according to gigure2-14
	loading				
	q	t/m2	loading	1	
	pq	t/m2	earth pressure of loading	0.3	
	pq-h	h	working height position	2.05	
	stability calculation to falling				
	Ph=(1/2)Kh*H^		earth pressure horizontal load	1.7457	
	Pv=(1/2)Kv*H^		earth pressure bertical load	0.3174	
	earth pressure by loading				
	Eq	t	Eq=Pq*H	0.69	

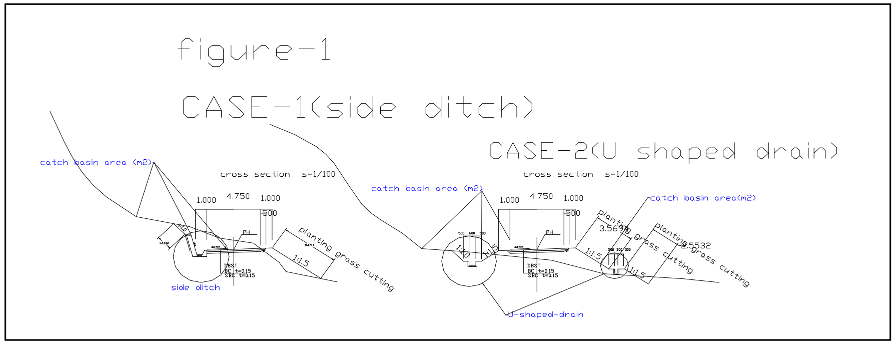


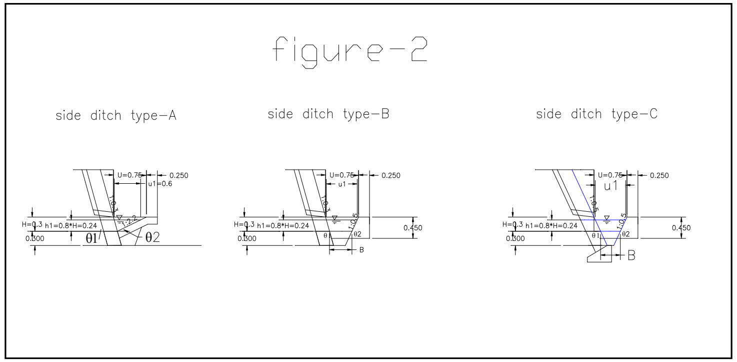
No	symbol	Unit	Description	actual	Remarks
				quantity	
	unit weight				
1	H1		banking height	2	
2	H2		wall height	3	
3	gr		slope gradient	1:1.5	
4	w	Kg/m3	Unit weight of soil	1800	
5	if	degree	Internal friction angle of soil	30	
6	fws	degree	Friction angle between wall and soil	20	?
7	wc	Kg/m3	Unit weight of wall	2400	
8	wsa	Kg/m3	Wall behind slope angle	70.708	slope gradient1:0.35
9	lo		loading	20	T-20
10	f		Foundation bottom friction co-efficient	0.6	
11	bca	T/m3	Allowable bearing force of foundation groun	20	

stability calculation to falling

Ph=(1/2)Kh*H^2	earth pressure horizontal load	0.98	soil(b),gradient 1:1.5
Pv=(1/2)Kv*H^2	earth pressure bertical load	0.5	H1/H=0.67
Kh			
Kv			

(9)side ditch (9-1)





(Pipe and Box Culvert)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
No.	**Station**	**Catchment area**	**Runoff coefficient**	**Runoff coefficient**	**Catchment area**	**Runoff coefficient**	**Catchment area**	**Runoff coefficient**	**Catchment area**	**Rainfall Intensity**	**rainning time**	**safety ratio**	**Discharge**	**Structure type**	**height**	**base width**	**upper width**	**upper width**	**height(80%)**	**left slope gradient**
		Ac	**C**	**C1**	**Ac1**	**C2**	**Ac2**	**C3**	**Ac3**	**I**	**t**	**f**	**Q**		**H**	**B**	**U**	**U1**	**h1**	
		(m^2)		**road surface**	**(m^2)**	**bank slope**	**(m^2)**	**cut slope**	**(m^2)**	**(mm/hr)**	**(min)**		**(m^3/s)**		**m**	**m**	**m**	**m**		
		(1)	=((3)*(4)+(5)*(6)+(7)*(8))/((4)+(6)+(8))	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	(9)=5775/((10)+45)*(11)	**(10)**	**(11)**	(12)=(1)*(2)*(9)/(1000*60*60)	**(13)**	**(14)**	(15)=(16)-((14)/(TAN((20)*PI()/180))+(14)/(TAN((22)*PI()/180)))	**(16)**	(17)=(18)/TAN((20)*PI()/180)+(18)/TAN((22)*PI()/180)+(15)	(18)=(14)*0.8	**(19)**
		1500	0.800	0.8	500			0.8	1000	147	10	1.4	0.049	side-ditch-A	0.3	0	0.75	0.600	0.24	0.3
		1500	0.800	0.8	500			0.8	1000	147	10	1.4	0.049	side-ditch-B	0.3	0.51	0.75	0.702	0.24	0.3
		1500	0.800	0.8	500			0.8	1000	147	10	1.4	0.049	side-ditch-C	0.3	0.45	0.75	0.690	0.24	0.5
		1500	0.800	0.8	500			0.8	1000	147	10	1.4	0.049	side-ditch-D	0.3	0.45	0.75	0.690	0.24	0.5
		72000	0.765	0.8	2000	0.7	25000	0.8	45000	147	10	1.4	2.250	U-shaped -H	1	1	1.6	1.480	0.8	0.3
			table-1							table-2		table-3								
		figure-1												figure-2						
													formula-1							

table-1 **Runoff coefficient**

area	C
road surface	0.7~1.0
steep hill	0.75~0.9
smooth hill	0.7~0.8
steep area	0.5~0.75
plain	0.45~0.6
rice field	0.7~0.8
city	0.6~0.9
forest	0.2~0.4
river area in hil	0.75~0.85
small river in plai	0.45~0.75
big river area	0.5~0.75

table-2 I = Average Runoff Intensity:(mm/h)

year n	In
2	4725/(t+45)
3	5775/(t+45)
5	7150/(t+50)
7	7700/(t+50)
10	8625/(t+55)
20	I0625/(t+65)

t=t1+t2

rainning time(min)

table-3 **safety ratio**

safety ratio

steep hill(nepal)

(1.2~1.4)

order

purpose: to decide dimension of side ditch?

1 **calculate discharge(Q) of catchment area, (12)**

2 **propse structure type,(13)**

3 **calculate capacity(Q) of sideditch,(29)**

4 **compare (12),(29)**

5 (29) >(12) ok

6 (29) <(12) ,to change structure type

formula-1

Q = C*I*A

Q = Discharge

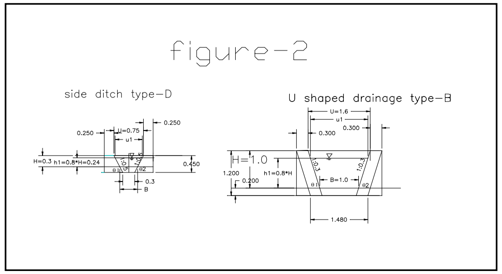
C = runoff Coefficeint

I = Average Runoff Intensity(mm/h)

Q=(1/3600000)*C*I*a(m3/sec)

Q=(1/3.6)*C*I*A(m3/sec)

(9-2)



according to
(Road eartwork drainage)
Japan Road Cooperation

V

left slope angle	right slope gradient	right slope angle	Area	Wetted perimeter	Hydraulic Mean Depth	Manning's coefficient	Gradient	Flow Velocity	Capacity	Judgement
θ1		θ2	80%A	P	R	n	i	V	80%Q	
degree		degree	m2	(m)	(m)		(%)	(m/s)	(m^3/s)	
(20)=ABS(ATAN((1)/(19))/PI()*180)	**(21)**	**(22)=ABS(ATAN((1)/(21))/PI()*180)**	(23)=((15)+(17))*0.5*(18)	(24)=(18)/SIN((20)*PI()/180)+(18)/(SIN((22)*PI()/180))+(15)	**(25)=(22)/(24)**	**(26)**	**(27)**	(28)=(1/(26))*((25)^0.667)*((27)/100)^0.5	(29)=(23)*(28)*(18)	**(30)**
73.3008	**2.2000**	**24.4440**	0.072	0.831	**0.087**	0.015	3	2.260	0.039	
73.3008	**0.5000**	**63.4349**	0.145	1.029	**0.141**	0.015	2.5	2.858	0.100	
63.4349	**0.5000**	**63.4349**	0.137	0.987	**0.139**	0.015	2.5	2.822	0.093	
63.4349	**0.5000**	**63.4349**	0.137	0.987	**0.139**	0.015	2.5	2.822	0.093	
73.3008	**0.3000**	**73.3008**	0.992	2.670	**0.371**	0.015	0.7	2.881	2.287	

table-4 table-5

formula-2

table-4 **Manning's coefficient(n)**

		n
culvert	cast in concrete	0.015
	concrete pipe	0.013
channel	mortar	0.013
	cocrete	0.015
	stone masonry	0.025
	asphalt	0.013
	soil	0.027
	gravel	0.025
	rock	0.035

table-5

limit of allowable mean velocity (m3/s)

material of drain	allowable mean velocity
concrete	0.6~3.0
aspahlat	0.6~1.5
stone masonry,block	0.6~1.8
gravelclay	0.6~1.0
sandy soil	0.3~0.6
clay mixed sandy soil	0.2~0.3
silt	0.1~0.2

formula-2

$V = 1/n X R^{2/3} X i^{1/2}$

= Flow Velocity (m/s)

n = Manning's Coefficient of roughness

R = HydraulicMean Depth (m)

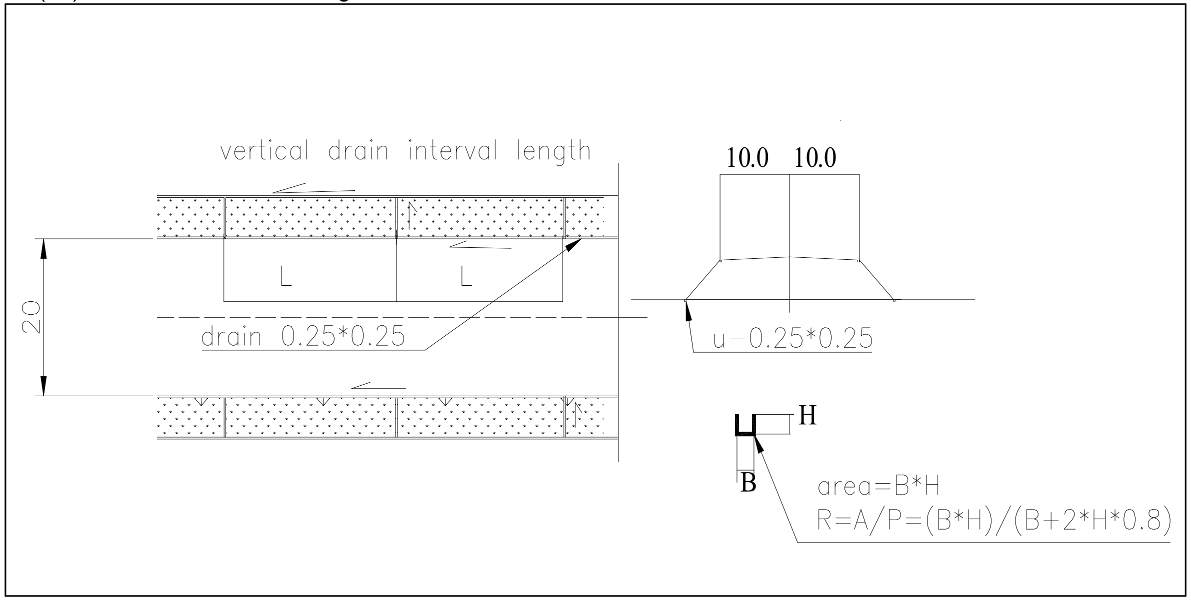
R = A/P

i = Gradient (%)

Q = Capacity (m^3/s)

Q = AV

(10)vertical drain interval length



vertical drain interval length

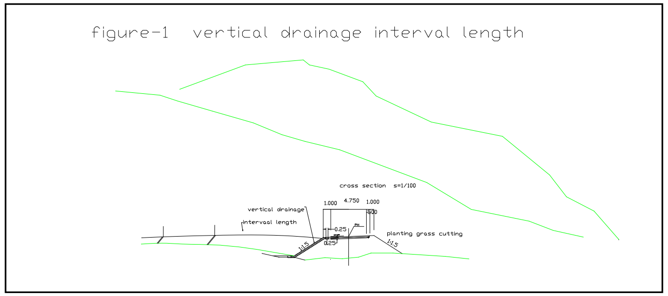
no		item	unit	quantity	remarks
1		drain section	mm		250*250
2	I	vertical gradient	%	0.0033	1/300
3	I3	intensity of rainfall	mm/h	85.9091	I3=4725/(t+45)
4	t	time of concentration	min	10.0000	
5	C	coefficient of discharge		0.9500	
6	L	vertical drain interval length	m	?	
7	Q	discharge of storm sewage	m3/sec		Q=C*I*A/(3.6*1000000)
8	a	catchment area	m2		Q=C*I*a/(3.6*1000000(a=10*L
9	A	catchment area	km2		Q=C*I*A/(3.6)
10	n	coefficient of roughness		0.0160	
11	R	hydraulic mean depth		0.0769	R=A/P
12	P	Wetted perimeter of the channel		0.6500	P=B+2*H*0.8
13	A	drain section area	m2	0.0500	A=B*H*0.8
14	B	drain width	m	0.2500	
15	H	drain height	m	0.2500	80%height
16	w	road width(half)	m	15	

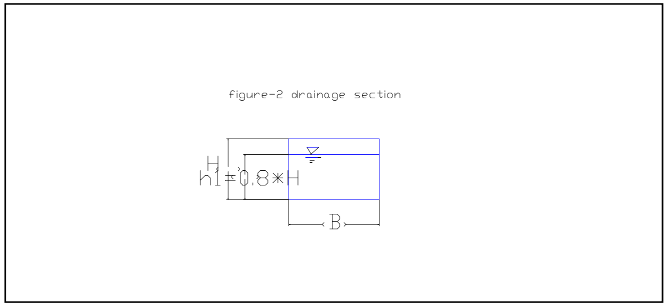
road surface

discharge of storm sewage	discharge drain capacity	vertical drain interval length
m3/sec	m3/sec	m
Q=C*I*a/(3.6*1000000)	Qc=A*(1/n)*(R^0.67)*(I)^0.5	L=(Qc/(C*I*w))(3.6*1000000))
Q=C*I*10L/(3.6*1000000)	0.032355443	95.14716692
Q<Qc(drain flowing capacity)		
Length shoud be below 142m		

(11)vertical drainage

vertival drainage interval length





according to
(Road eartwork drainage)
Japan Road Cooperation

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
No.	Station	Catchment area	Road width	drainnage interval length	Runoff coefficient	Rainfall Intensity	rainning time	safety ratio	Discharge	Structure type	height	base width	height(80%)	Area	Wetted perimeter	Hydraulic Mean Depth	Manning's coefficient	Gradient	Flow Velocity	Capacity	Judgement
		Ac	W	L	C	I	t	f	Q		H	B	h1	80%A	P	R	n	i	V	80%Q	
		(m^2)	(m)	(m)		(mm/hr)	(min)		(m^3/s)		m	m		m2	(m)	(m)		(%)	(m/s)	(m^3/s)	
		=(E)*(D)	5.5	=(U)/((D)*(F)*(G)/(1000*60*60))	0.800	=5775/((H)+45)*(I)	10	1.4	=(D)*(E)*(F)*(G)/(1000*60*60)	u-250*250			=(L)*0.8	=((M)*(N))	=(N)*2+(M)	**=((O))/((P))**	0.015	0.05	=(1/(R))*(((Q))^0.667)*((S)/100)^0.5	=(O)*(T)	
		412.34308	6.75	61.088	0.800	147	10	1.4	0.013	u-250*250	0.25	0.25	0.2	0.050	0.650	**0.077**	0.015	0.05	0.269	0.013	
		670.55606	6.75	99.342	0.800	147	10	1.4	0.022	u-300*300	0.3	0.3	0.24	0.072	0.780	**0.092**	0.015	0.05	0.304	0.022	

figure-1 | table-1 | table-2 | table-3 | figure-2 | formula-1 | table-4 | table-5 | formula-2

table-1 **Runoff coefficient**

area	C
road surface	0.7~1.0
steep hill	0.75~0.9
smooth hill	0.7~0.8
steep area	0.5~0.75
plain	0.45~0.6
rice field	0.7~0.8
city	0.6~0.9
forest	0.2~0.4
river area in hi	0.75~0.85
small river in pla	0.45~0.75
big river area	0.5~0.75

table-2 I = Average Runoff Intensity:(mm/h)

year n	In
2	4725/(t+45)
3	5775/(t+45)
5	7150/(t+50)
7	7700/(t+50)
10	8625/(t+55)
20	10625/(t+65)

t=t1+t2

rainning time(min)

table-3 **safety ratio**

safety ratio

steep hill(nepal)

(1.2~1.4)

table-4 **Manning's coefficient(n)**

		n
culvert	cast in concre	0.015
	concrete pipe	0.013
channel	mortar	0.013
	cocrete	0.015
	stone masonry	0.025
	asphalt	0.013
	soil	0.027
	gravel	0.025
	rock	0.035

table-5

limit of allowable mean velocity (m3/s)

material of drain	allowable mean velocity
concrete	0.6~3.0
asphalat	0.6~1.5
stone masonry,block	0.6~1.8
gravelclay	0.6~1.0
sandy soil	0.3~0.6
clay mixed sandy soil	0.2~0.3
silt	0.1~0.2

order

purpose: to decide vertical drainage interval length(E)?

1 **calculate discharge(Q) of catchment area, (J)**

2 **propse structure type,(K)**

3 **calculate capacity(Q) of sideditch,(U)**

4 (J) <(U) ok

5 **calculate drainage interval length,(E)**

formula-1

Q = C*I*A

Q = Discharge

C = runoff Coefficeint

I = Average Runoff Intensity(mm/h)

Q=(1/3600000)*C*I*a(m3/sec)

Q=(1/3.6)*C*I*A(m3/sec)

formula-2

$V = 1/nXR^{2/3}Xi^{1/2}$

= Flow Velocity (m/s)

n = Manning's Coefficient of roughness

R = HydraulicMean Depth (m)

R = A/P

i = Gradient (%)

Q = Capacity (m^3/s)

Q = AV