



Ministry of Transport



Vietnam Expressway Corporation



Project Management Unit No. 85



THE WORLD BANK

IDA Credit No. / IDA tín dụng số : 4779-VN

Project ID No. / Mã dự án : P106235

Consulting Services for / Dịch vụ tư vấn
Detailed Design for Da nang – Quang Ngai Expressway Development Project /
Thiết kế kỹ thuật dự án Đường cao tốc Đà Nẵng-Quảng Ngãi

Detailed Engineering Design Report

Hồ sơ thiết kế kỹ thuật

Volume 4: Structural Calculation Report (PKG5: Km32+600 - Km42+000)

Tập 4: Hồ sơ tính toán kết cấu (Gói thầu 05: Km32+600 - Km42+000)

Volume 4.1.2: MSE Wall, Geotechnical Analysis

Tập 4.1.2: Tường chắn có cốt, phân tích địa kỹ thuật
(Final)

July 5, 2013

The Joint Venture of



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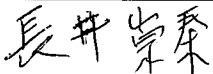

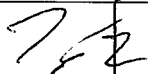
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Consulting Services
for
Detailed Design for Danang - QuangNgai Expressway Development Project
(Dịch vụ tư vấn Thiết kế kỹ thuật dự án Đường cao tốc Đà Nẵng – Quảng Ngãi)

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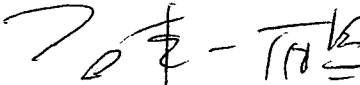
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(Final)

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THE JOINT VENTURE OF NK-NE-CHODAI-TEC/LIÊN DANH TƯ VẤN

Project Manager/Giám đốc Dự án


Ichizuru Ishimoto

Da Nang, July 5 2013 / Đà Nẵng ngày 5 tháng 07 năm 2013

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A. MSE WALL

1 BASIS OF THE DESIGN

1.1 Introduction

Mechanically Stabilized Earth (MSE) Wall, also referred to as Reinforced Earth (RE) Wall, is proposed to form as retaining wall to retain in Package 5. The general configuration of this Reinforced Earth Wall is presented as below:

	Type of Block	Max. Wall Height	Strip Length	Min. Embedment	Total Wall Length
		(m)	(m)	(m)	(m)
Package A5	A	6	4.5	1.0	760
	B	8	5.8	1.0	
	C	10	7	1.0	
	D	12	8.5	1.0	
	E	15	13	1.0	

The design is based upon the principles published by the American Association of State Highway and Transportation Officials (AASHTO LRFD Bridge Design Specifications 2007 & 2010). In common with other codes for the design of civil engineering structures, this code of practice adopts *limit state* principles. These principles involve the application of resistance factors and load factors for various structure types; design lives and load combinations to ensure sufficient safety margins.

The design of reinforced soil structures is considered in two parts. The first part is the *external stability*. First, the lateral earth pressure acting on the back of the reinforced soil structure is derived using the *active earth pressure coefficient*, k_a . Passive earth pressures on the foot of the wall are always ignored when considering any stabilizing forces. The reinforced soil structure is considered to behave as a mass gravity structure and is designed to prevent the following external failure modes from occurring:

- Overturning of the reinforced soil block
- Forward sliding of the structure on the foundation soil
- Bearing Failure
- Loss of overall stability

The external stability of the Reinforced Earth Walls is governed by the size of the Reinforced Earths Block. For the designed wall width, both overturning and sliding stabilities are satisfied as well as determining the number of reinforcing strips to satisfy the internal stability. Although the Bearing Capacity of the existing ground underneath the walls is provided for the calculation purposes, based on the results of geotechnical investigations, an assessment of the bearing capacity of the founding material should be undertaken during construction for confirmation.

The second part of the design is the *internal stability*. This aspect of the design is used to determine the amount of soil reinforcement required to maintain the structural integrity of the reinforced soil mass. Sufficient reinforcement is provided to ensure the following internal failure modes do not occur:

- Tensile rupture at any point along the length of the reinforcement
- Loss of frictional bond (adherence) between the reinforcement and the soil fill.

First, the tensile forces to be resisted at each layer of reinforcement in the structure are calculated. In the coherent gravity method, these tensile forces are derived from a lateral earth pressure coefficient, k_r . This value of k_r varies from the $1.7k_a$, at a depth of 0.0m, down to the $1.2k_a$ at 6m depth

and greater. Having determined the tensile forces at each layer of reinforcement, the number of strips required to resist these forces is calculated. This is based on the long term design strength of the strips/connections and the frictional force (adherence) that can be generated between the strip and the fill. The design life of the structure is used to determine the thickness of reinforcement steel which will be lost due to corrosion. This is referred to as the *sacrificial thickness* and is used to calculate the strength of the reinforcing elements at the end of the design life.

For steel strips galvanized with 610g/m² of zinc (equivalent thickness of 86 microns), the sacrificial thickness after 120 years will be 1.25 mm on each exposed face. This value has been derived from AASHTO LRFD - Article 11.10.6.4.2a

1.2 Materials Used in Reinforced Earth Walls for Analysis

1.2.1 Reinforcing Strips

Reinforcement system:	Galvanised Strips
Size:	45mm x 5mm – (HAR) section 50mm x 4mm – (HA) Section
Steel Specification and Grade:	Grade 65 complying with ASTM A572
Strength parameters:	Minimum Tensile Strength 550 MPa Minimum Yield Strength 450MPa
Galvanised Coating Mass:	610g/m ² (86µm equivalent thickness)
Sacrificial Corrosion Allowance:	1.25mm per exposed face (For 120-year service life)

1.2.2 Selected Fill within the Reinforced Earth Wall

The selected fill material within the RE wall shall comply with the following requirement.

Properties of Selected Fill

REQUIREMENT	
MAXIMUM SIZE (mm)	102
% Passing 102mm (4 in) U.S. Sieve Size	100
% Passing 0.425mm (NO.40) U.S. Sieve Size	0 - 60
% Passing 0.075mm (NO.200) U.S. Sieve Size	0 - 15
The Uniformity Coefficient (Cu)	>=2
Plasticity Index (PI)	<= 6

Electrochemical Index Properties of Selected Fill

PROPERTY	CRITERIA
RESISTIVITY	
Resistivity	>3000 ohm-cm
pH	>5 <10
Chlorides	<=100ppm
Sulphates	<=200ppm
Organic Content	<=1 %

1.3 Nominal Tensile Resistance of Reinforcing Strips

The 50x4 HA and 45x5 HAR (50mm wide by 4mm thick and 45mm wide by 5mm thick respectively) and reinforced at the hole connection, with the reduction of the effective cross section taking the total sacrificial thickness of 2.5mm, the nominal tensile resistance of the 50 x 4 HA and the 45 x

5 HAR at the main body and at the connection is presented as below:

TYPE	Tensile Resistance per one reinforcing strip
Reinforcing Strip (HA 50 x 4) – Main Body	25.27 KN
Reinforcing Strip (HA 50 x 4) – At Connection	25.27 KN
Reinforcing Strip (HAR 45 x 5) – Main Body	37.86 KN
Reinforcing Strip (HAR 45 x 5) – At Connection	37.86 KN

Remarks:

- The nominal tensile resistance per one reinforcing strip is determined in accordance with AASHTO LRFD Article 11.10.6.4.3.
- The sacrificial thickness of the reinforcing strips is determined in accordance with AASHTO LRFD Article 11.10.6.4.2.
- The Resistance Factor of 0.75 is determined in accordance with AASHTO LRFD – Table 11.5.6-1.
- Therefore, the tensile resistance for HA 50 x 4 and HAR 45 x 5 is controlled by the tensile resistance at the main body.

1.4 Soil Properties

The soil material properties after partial material factors have been applied are as follows:

Properties	Selected Fill within the Reinforced Earth Wall	Compacted Backfill behind the Reinforced Earth Wall	Foundation Ground (*)
Friction angle (deg)	36	35	17
Cohesion (kPa)	0	0	17
Density (kN/m ³)	19	19	18

Remark:

(*) The soil properties for the foundation ground shall be verified and confirmed during construction.

1.5 Topography & Site Geology

The above soil information for the foundation ground was obtained from the results of geotechnical investigation. These values shall be confirmed during construction. In particular, the angle of internal friction, cohesion, and bearing capacity of the existing ground (with the appropriate resistance factor of 0.45 or 0.5 specified in AASHTO LRFD – Table 10.5.5.2.2-1) shall be verified during construction. The design shall be revised/adjusted if any change in bearing capacity is observed during construction.

The Reinforced Earth Walls will retain a fill embankment, created to support the proposed new highway and are located at the toe of a hill. Generally the wall is located such that there will be no sloping ground at its toe. However in the few areas where there appears to be a slight toe-slope, it has been assumed that the walls will be excavated down to a depth which will ensure that the ground at the toe of the wall is flat during and after construction. No groundwater was available at the time of boring investigation.

Due to the location of the wall in relation to the proposed highway, the fact that the wall is generally retaining the fill embankment, and coupled with an appropriate drainage filter around the RE (Reinforced Earth) Block. It is not anticipated for water to build up within or behind the RE Block. Therefore, no water pressure is assumed to be within and behind the RE Block in the design.

The Reinforced Earth Walls are founded on flat ground, near slope or on slope. The topography near the Reinforced Earth Walls are summarized as below;

Wall	Foundation Configuration
REW1	Founded on Flat Ground

Remark

(*) The original proposed topography is 4m from slope crest and the slope angle = 40 degs. After the assessment on the overall slope stability, the front slope is recommended to be max. 20 degs.

Lack of information for the ground water table at the moment of boring, therefore the following assumption is made;

For Overall slope stability Assessment : The ground water table is assumed to be 0m or 3 below the formation level of the walls.

For Bearing Stability Assessment : The ground water table is assumed to be 0m or to be the embedment depth below the ground surface or well below the walls respectively.

The founding soil conditions and in particular the bearing capacity of the ground shall be verified during construction. The bearing capacity with the appropriate resistance factor of 0.65 is specified in AASHTO 2010. If the required bearing capacity is not met during construction, the design shall be revised/adjusted.

1.6 Design Loading

The live load surcharge for the design of reinforced earth wall is summarized as below:

Live Load Surcharge on top of the Reinforced Earth Wall	15.7kPa (*)
Live Load Surcharge behind of the Reinforced Earth Wall	15.7kPa (*)

Remark:

(*) Traffic load is evaluated in accordance with 22TCN-2000

Earthquake Load	
Maximum Earthquake Acceleration Coefficient, A	0.12
Reduction Factor for Live Load	0.5 (*)

(*) From AASHTO LRFD – Article 3.4.1

1.7 Load Factors and Load Combination

The load factors used in the design for Reinforced Earth Block stability are as follows:

Loading	1	2	3	1s	2s
Dead Load of the RE Structure (LFw)	1.35 (*)	1.00 (*)	1.00	1.00	1.35
Earth Pressure from Backfill (LFp)	1.5 (**)	1.5 (**)	1.00	1.50	1.50
Live Load on RE Structure (LFq1)	1.75 (#)	0.00 (#)	1.00	1.00	1.00
Live Load behind RE Structure (LFq2)	1.75 (#)	1.75 (#)	1.00	1.00	1.00
Earthquake Load	0	0	0	1.00	1.00

Remark:

Load Combination 1 : Typical Application of Load Factors for Bearing Resistance.

Load Combination 2 : Typical Application of Load Factors for Sliding and Overturning.

Load Combination 3 : Typical Application of Unit Load Factors for SLS (Settlement).

Load Combination 1s : Typical Application of Load Factors for Earthquake Load, the worst situation for Strip Adherence

Load Combination 2s : Typical Application of Load Factors for Earthquake Load, the worst situation for Strip Tension

(*) From AASHTO LRFD – Table 3.4.1-1 & 2 & Article C 11.5.5

(**) From AASHTO LRFD – Table 3.4.1-1 & 2 & Article C 11.5.5

(Active Horizontal Earth Pressure:1.5 & At-Rest Horizontal Earth Pressure: 1.35)

(#) From AASHTO LRFD – Table 3.4.1 -1

1.8 Resistance Factor and Equivalent Factor of Safety

The Resistance Factor used in the design for Load Combination 1 to 3 (without Earthquake Load) are as follows. They are derived from AASHTO LRFD for input into the calculation program:

Ultimate Limit State	
External Stability	Resistance Factor
Sliding Friction (RFg)	1.0 (*)
Sliding Cohesion (RFgc)	1.0 (*)
Overturning (RFr)	1.0
Bearing (RFc)	0.65 (**)
Overall Slope Stability	0.75 (FOS=1.3) (***)
Internal Stability	Resistance Factor
Rupture of Reinforcing Strips (RFt)	0.75 (#)
Pull out of Reinforcing Strips (RFf)	0.9 (##)

Remark:

(*) From AASHTO LRFD 2010

(**) From AASHTO LRFD 2010

(***) From AASHTO LRFD – Article 11.6.2.3, equivalent FOS in TALREN = 1.40

(#) From AASHTO LRFD – Table 11.5.6-1

(##) From AASHTO LRFD – Table 11.5.6-1

The Resistance Factor used in the design for Load Combination 1S to 2S (with Earthquake Load) are as follows. They are derived from AASHTO LRFD for input into the calculation program:

Ultimate Limit State	
External Stability	Resistance Factor
Sliding Friction (RFgs)	1.0 (*)
Sliding Cohesion (RFgcs)	1.0 (*)
Overturning (RFrs)	1.0
Bearing (RFcs)	0.65 (**)
Internal Stability	Resistance Factor
Rupture of Reinforcing Strips (RFt)	1.00 (#)
Pull out of Reinforcing Strips (RFf)	1.20 (##)

Remark:

(*) From AASHTO LRFD 2010

(**) From AASHTO LRFD 2010

(#) From AASHTO LRFD – Table 11.5.6-1

(##) From AASHTO LRFD – Table 11.5.6-1

1.9 Determination of Friction Factor, F^* , between the Fill and the Reinforcing Strips

The reinforcing strips have a ribbed profile which enhances the adherence of the strip when placed within a compacted granular fill. The apparent coefficient of friction α_p between the fill and the reinforcing strip are conservatively determined from the standard complying with AASHTO LRFD C11.10.6.3.2.

Coefficient of friction at depth = 0m: 1.5

Coefficient of friction at depth = 6m: $1.0 \tan \phi'$

Coefficient of friction at depth $0\text{m} < Z < 6\text{m}$: Varying from $1.5 \tan \phi'$ to $1.0 \tan \phi'$ proportionally.

Coefficient of friction of friction at depth = 6m: $1.0 \tan \phi'$

Coefficient of friction of friction at depth $h > 6\text{m}$: $1.0 \tan \phi'$

1.10 Reinforced Earth Wall to Resist the Traffic Barriers on Top

In refer to the Publication FHWA-NHI-10-024 by U.S. Department of Transportation Federal Highway Administration, the following specification are made in the design:

Reinforcement Rupture

The static impact force, adds an additional horizontal force to the upper 2 layers of soil reinforcement, It is recommended that the upper layer of soil reinforcement be designed for a rupture impact load equivalent to a static load of 33.5 kN/m of wall; and the second layer be designed with a rupture impact load equivalent to a static load of 8.8 kN/m. The load factor for impact is equal to 1.0.

Reinforcement Pullout

The pullout resistance of the soil reinforcement to the impact load is resisted over the full-length of the reinforcements (i.e. L). It is recommended that the upper layer of soil reinforcement be designed for a pullout impact load equivalent to a static load of 19.0 kN/m of wall; and the second layer be designed with a pullout impact load equivalent to a static load of 8.8 kN/m.

Resistance Factors for Tensile and Pullout Resistance

The resistance factors presented in Table 4-7 for "Combined static/traffic barrier impact" are recommended for Extreme Event II impact loading specified in FHWA-NHI-10-024. The tensile and connection rupture resistance factors are a function of the type of reinforcement. A tensile and pullout resistance factor of 1.00 is recommended for metallic reinforcements.

1.11 Design Analysis

The internal stability (Rupture and Adherence) and external design (Overturning and Sliding) is carried out by computer software VALDEZ. The general arrangement of Walls for VALDEZ analysis is summarized as below table. The detailed analysis results are covered at the end of this report.

Wall	Type	Max. Wall Height	MODEL RUN Number in Valdez
		(m)	
REW1	A	6	3
	B	8	2
	C	10	5
	D	12	1
	E	15	4

The overall stability analysis is carried out by the Limit Equilibrium Stability Analysis Program TALREN. The following critical sections are selected for the assessment on the overall stability.

Wall	Type	Max. Wall Height	Min. Embedment	Foundation Configuration
		(m)	(m)	
REW1	A	6	1.0	Founded on Flat Ground
	B	8	1.0	Founded on Flat Ground
	C	10	1.0	Founded on Flat Ground
	D	12	1.0	Founded on Flat Ground
	E	15	1.0	Founded on Flat Ground

Referring to the AASHTO, 11.6.2.3, the overall stability shall be assessed at the Service 1 Load Combination and an appropriate resistance of 0.75. The result of the analysis are expressed in terms of a factor of safety FOS, which is a measure of how stronger the structure is compared to how strong it needs to be at the point of failure. If a minimum overall factor of safety of 1.30 (1/0.75) is achieved, it indicates that the slope is stable.

1.12 Explanation of VALDEZ Program Outputs

General Data

This page shows the design life and reinforcing strip details. The strip strengths referred to on this page.

Section Data

This page defines the geometry of the RE structure and is self-explanatory. The surcharge on the RE mass is also defined on this page.

Soil Properties

The soil properties of the RE backfill, general retained backfill and foundation soils are defined. Where the foundation soil values are defined as zero, the program calculates the values needed to resist forward sliding.

Earth Pressure

The coefficient of lateral earth pressure acting on the back of the RE structure is calculated.

External Stability

This section calculates the imposed bearing pressures on the foundation soil beneath the RE structure. The program calculates the factored imposed bearing pressure, q_{ref} , for the permanent load conditions.

Internal Stability – Strip Rupture

The program calculates the tensile force per strip, at each layer of strips within the RE structure. The calculation is based on a 3m width of wall, which is equivalent to two stacks of panels. The overdiseign factors refer to how much margin of safety there is against strip rupture once all the partial load and safety factors have been applied. Provided the overdiseign factors exceed 1.0, the strips are adequately designed to resist tensile rupture. T_r/T_m refers to the overdiseign factor at the line of maximum tension. T_o/T_o is concerned with the tension at the connection.

Internal Stability – Adherence

The final section of the program checks that there is sufficient friction at each layer of strips to resist the maximum tensile force. Again, an overdiseign factor is quoted which indicates how much margin of safety there is against the strips pulling-out. For this check, the overdiseign factor is defined as T_f/T_m . T_f is defined as the frictional force which can be mobilised by the strips at each layer.

Reinforced Earth Wall to Resist the Traffic Barriers on Top

The VALDEZ does not take the impact load due to the traffic barriers into account during the assessment. The number of reinforcing strip for the first row and second row will be calculated separately and then added to the number of reinforcing strip calculated by VALDEZ.

2 Results of Analysis

The results of analysis are given from next page.


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* Reinforced Earth : Program Valdez AASHTO LRFD *
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*
*
*
*****
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Job number : danang
=====

Run number : 03
=====

Structure : Danang - Quang Ngai
=====

H=6

Designed by : nl
=====

* 1 . GENERAL DATA *

1 . 1 STRUCTURE CLASS :

Service life : 120 years

Site : No water

1 . 2 R.E. STRIPS :

protection : Galvanized

Type 1: HA 50X4

yield strength : 448.0 MPa
width b : 50.0 mm
thickness eo : 4.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 25.27 kN
connection Tro : 25.27 kN

Type 2: HAR 45X5

yield strength : 448.0 MPa
width b : 45.0 mm
thickness eo : 5.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 37.86 kN
connection Tro : 37.86 kN

1 . 3 FACING: TERRACCLASS

1 . 4 SEISMIC DATA :

Maximal horizontal acceleration a_0/g : 0.12
Reduction factor of live loads : 0.50
Reduction of active zone : 1.00
Earthquake load factor g_{EQ} : 1.00

 * 2 . SECTION 03 *

2 . 1 SECTION DATA :

2 . 1 . 1 GEOMETRY :

R.E MASS

Facing height	Hf : 5.230 m	R.E.backfill height	H1 : 6.000 m
Coping height	Hc : 0.770 m	Free board	Ht : 0.000 m
Slope height	H2 : 0.00 m	Mechanical height	Hm : 6.000 m
Slope angle	Beta : 0.00 deg.	Terrace angle	Omega : 0.00 deg.
Setback	F : 0.00 m	Angle at toe	Beta_s : 0.000

Strip Length : 4.50 m

SURCHARGES

Load	q : 15.70 kPa	Position Lq :	0.00 m
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2 . 1 . 2 SOIL PROPERTIES :

R.E. BACKFILL

Density	gamma1 maxi : 20.00 kN/m3	Friction	phi1 : 36.00 deg.
	gamma1 mini : 18.00 kN/m3		

GENERAL BACKFILL

Density	gamma2 : 18.00 kN/m3	Friction	phi2 : 35.00 deg.
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FOUNDATION

Cohesion	C3 : 17.00 kPa	Friction	phi3 : 17.00 deg.
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2 . 1 . 3 EARTH PRESSURE :

Inclination of earth pressure at back of R.E. mass delta = 0.00 deg.

Earth pressure coefficients:

k2x	= 0.271	k2y	= 0.271	(Static)
x	= 0.000 m	y	= 6.000 m	
kaex	= 0.367	kaey	= 0.271	(Dynamic)
x	= 0.000 m	y	= 6.000 m	

2 . 2 EXTERNAL STABILITY

2 . 2 . 1 EXTERNAL STABILITY :

case	Rv kN/m	Rh kN/m	M kNm/m	qref kPa	2.x m
1	501.12	176.37	765.18	164.09	3.05
2	875.32	176.37	1641.97	233.31	3.75
3	627.45	113.33	1208.45	162.89	3.85
1s	501.12	215.59	637.34	197.01	2.54
2s	751.68	242.65	1137.45	248.37	3.03

Minimum embedment depth = 0.47 m

2 . 2 . 2 SLIDING ON THE BASE - OVERTURNING :

case	SLIDING ON THE BASE				OVERTURNING
	Overdesign factor slip in R.E.	Overdesign factor slip in found.	minimal value phi(?)	minimal value Cohesion(kPa)	Overdesign factor
1	2.06	1.32	19.39	-	2.93
			-	38.01	
2	3.61	1.96	11.39	-	5.13
			-	38.01	
1s	1.69	1.08	23.28	-	2.21
			-	46.46	

2 . 3 INTERNAL STABILITY

Calculation width : 3.00 m

2 . 3 . 1 STRIP RUPTURE - TENSILE LOAD AT FACING : Overdesign factors

layer	z m	deltah m	Strip type	Num.	Ties Num.	case	k	sigmah kPa	Tmax kN	To kN	Tr/Tm	Tro/To	
1	1.135	1.510	1	8	8	1	.383	8.09	4.58	4.58	5.52	5.52	R8
						2	.383	22.53	12.76	12.76	1.98	1.98	
						1s	.383	7.95	6.26	6.26	5.38	5.38	
						2s	.383	11.87	8.68	8.68	3.88	3.88	
2	1.885	0.750	1	8	8	1	.364	13.18	3.71	3.71	6.82	6.82	R8
						2	.364	29.34	8.25	8.25	3.06	3.06	
						1s	.364	12.81	5.36	5.36	6.28	6.28	
						2s	.364	18.98	7.29	7.29	4.62	4.62	
3	2.635	0.750	1	4	4	1	.345	18.20	10.24	10.24	2.47	2.47	UR4
						2	.345	35.77	20.12	20.12	1.26	1.26	
						1s	.345	17.45	11.58	11.58	2.91	2.91	
						2s	.345	25.62	16.36	16.36	2.06	2.06	
4	3.385	0.750	1	4	4	1	.326	23.26	13.09	13.09	1.93	1.93	UR4
						2	.326	41.90	23.57	23.57	1.07	1.07	
						1s	.326	21.99	14.28	14.28	2.36	2.36	
						2s	.326	31.85	20.04	20.04	1.68	1.68	
5	4.135	0.750	2	4	4	1	.307	28.53	16.05	16.05	2.36	2.36	UR4
						2	.307	47.80	26.89	26.89	1.41	1.41	
						1s	.307	26.53	16.91	16.91	2.99	2.99	
						2s	.307	37.77	23.45	23.45	2.15	2.15	
6	4.885	0.750	2	4	4	1	.288	34.19	19.23	19.23	1.97	1.97	UR4
						2	.288	53.56	30.13	30.13	1.26	1.26	
						1s	.288	31.19	19.79	19.79	2.55	2.55	
						2s	.288	43.43	26.93	26.93	1.87	1.87	
7	5.635	0.740	2	4	4	1	.269	40.56	22.51	22.51	1.68	1.68	R4
						2	.269	59.26	32.89	32.89	1.15	1.15	
						1s	.269	36.14	22.57	22.57	2.24	2.24	
						2s	.269	48.91	29.94	29.94	1.69	1.69	

2 . 3 . 2 ADHERENCE : Overdesign factor

layer	z m	L m	La m	type	Num.	Ties	case	f*	Za m	Tmax kN	Tf kN	Tf/Tm	Eccen
1	1.135	4.50	2.70	1	8	8	1	1.354	1.135	4.58	6.72	1.47	0.07
							2	1.354	1.135	12.76	19.12	1.50	0.03
							1s	1.354	1.135	6.26	7.17	1.14	0.03
							2s	1.354	1.135	8.68	10.75	1.24	0.02
2	1.885	4.50	2.70	1	8	8	1	1.257	1.885	3.71	10.36	2.80	0.14
							2	1.257	1.885	8.25	23.94	2.90	0.06
							1s	1.257	1.885	5.36	11.05	2.06	0.08
							2s	1.257	1.885	7.29	16.58	2.27	0.05
3	2.635	4.50	2.70	1	4	4	1	1.160	2.635	10.24	13.37	1.31	0.23
							2	1.160	2.635	20.12	27.81	1.38	0.11
							1s	1.160	2.635	11.58	14.26	1.23	0.14
							2s	1.160	2.635	16.36	21.40	1.31	0.09
4	3.385	4.50	2.93	1	4	4	1	1.064	3.385	13.09	17.10	1.31	0.33
							2	1.064	3.385	23.57	33.35	1.42	0.17
							1s	1.064	3.385	14.28	18.24	1.28	0.22
							2s	1.064	3.385	20.04	27.35	1.36	0.14
5	4.135	4.50	3.38	2	4	4	1	0.967	4.135	16.05	19.71	1.23	0.45
							2	0.967	4.135	26.89	36.84	1.37	0.24
							1s	0.967	4.135	16.91	21.02	1.24	0.31
							2s	0.967	4.135	23.45	31.54	1.34	0.21
6	4.885	4.50	3.83	2	4	4	1	0.870	4.885	19.23	23.75	1.23	0.58
							2	0.870	4.885	30.13	43.04	1.43	0.32
							1s	0.870	4.885	19.79	25.33	1.28	0.42
							2s	0.870	4.885	26.93	37.99	1.41	0.28
7	5.635	4.50	4.28	2	4	4	1	0.774	5.635	22.51	27.21	1.21	0.74
							2	0.774	5.635	32.89	48.18	1.46	0.42
							1s	0.774	5.635	22.57	29.02	1.29	0.55
							2s	0.774	5.635	29.94	43.53	1.45	0.37

Strips type 1 : HA 50X4

Strips type 2 : HAR 45X5

Strips type 1 : 108.0 meters for 3.0 m width of wall

Strips type 2 : 54.0 m

 * COMPLEMENTARY DATA *

1 STANDARDISATION FILE : AASHTO_LRFD

2 CALCULATION METHOD : Limit state

3 FACTORS :

load cases	LFW	Load factors			R.E density
		LFp	LFq1	LFq2	
1	1.00	1.50	0.00	1.75	1
2	1.35	1.50	1.75	1.75	2
3	1.00	1.00	1.00	1.00	2
1s	1.00	1.50	0.00	1.00	1
2s	1.35	1.50	0.00	1.00	2

R.E density : 1 = min - 2 = max

Resistance factors	RFg	RFgc	RFr	RFc	RFt	RFf
Static	1.00	1.00	1.00	0.65	0.75	0.90
Seismic	1.00	1.00	1.00	0.65	1.00	1.20

4 STRIPS :

Strip type 1

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

Strip type 2

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

5 FACING :

Vertical strip spacing : 0.750 mm
 bottom height : 0.365 mm
 Facing flexibility : To=Tmax

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*****
*
* Reinforced Earth : Program Valdez AASHTO LRFD *
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Job number : danang
=====

Run number : 02
=====

Structure : Danang - Quang Ngai
=====

H=8

Designed by : nl
=====

* 1 . GENERAL DATA *

1 . 1 STRUCTURE CLASS :

Service life : 120 years

Site : No water

1 . 2 R.E. STRIPS :

protection : Galvanized

Type 1: HA 50X4

yield strength : 448.0 MPa
width b : 50.0 mm
thickness eo : 4.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 25.27 kN
connection Tro : 25.27 kN

Type 2: HAR 45X5

yield strength : 448.0 MPa
width b : 45.0 mm
thickness eo : 5.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 37.86 kN
connection Tro : 37.86 kN

1 . 3 FACING: TERRACCLASS

1 . 4 SEISMIC DATA :

Maximal horizontal acceleration a_0/g : 0.12
Reduction factor of live loads : 0.50
Reduction of active zone : 1.00
Earthquake load factor g_{EQ} : 1.00
Maximum lateral wall displacement (Newmark approximation) : 38 mm

 * 2 . SECTION 02 *

2 . 1 SECTION DATA :

2 . 1 . 1 GEOMETRY :

R.E MASS

Facing height	Hf : 7.295 m	R.E.backfill height	H1 : 8.000 m
Coping height	Hc : 0.705 m	Free board	Ht : 0.000 m
Slope height	H2 : 0.00 m	Mechanical height	Hm : 8.000 m
Slope angle	Beta : 0.00 deg.	Terrace angle	Omega : 0.00 deg.
Setback	F : 0.00 m	Angle at toe	Beta_s : 0.000

Strip Length : 5.80 m

SURCHARGES

Load	q : 15.70 kPa	Position Lq	: 0.00 m
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2 . 1 . 2 SOIL PROPERTIES :

R.E. BACKFILL

Density	gamma1 maxi : 20.00 kN/m3	Friction	phi1 : 36.00 deg.
	gamma1 mini : 18.00 kN/m3		

GENERAL BACKFILL

Density	gamma2 : 18.00 kN/m3	Friction	phi2 : 35.00 deg.
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FOUNDATION

Cohesion	C3 : 17.00 kPa	Friction	phi3 : 17.00 deg.
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2 . 1 . 3 EARTH PRESSURE :

Inclination of earth pressure at back of R.E. mass delta = 0.00 deg.

Earth pressure coefficients:

k2x	= 0.271	k2y	= 0.271	(Static)
x	= 0.000 m	y	= 8.000 m	
kaex	= 0.307	kaey	= 0.271	(Dynamic)
x	= 0.000 m	y	= 8.000 m	

2 . 2 EXTERNAL STABILITY

2 . 2 . 1 EXTERNAL STABILITY :

case	Rv kN/m	Rh kN/m	M kNm/m	qref kPa	2.x m
1	855.36	293.70	1677.80	218.04	3.92
2	1442.40	293.70	3432.45	303.06	4.76
3	1041.46	190.13	2547.12	212.91	4.89
1s	855.36	301.92	1635.91	223.62	3.83
2s	1283.04	321.66	2827.14	291.14	4.41

Minimum embedment depth = 0.61 m

2 . 2 . 2 SLIDING ON THE BASE - OVERTURNING :

case	SLIDING ON THE BASE			OVERTURNING	
	Overdesign factor slip in R.E.	minimal value slip in found.	phi(? Cohesion(kPa)	Overdesign factor	
1	2.12	1.23	18.95	-	2.95
			-	49.44	
2	3.57	1.85	11.51	-	4.98
			-	49.44	
1s	2.06	1.20	19.44	-	2.81
			-	50.83	

2 . 3 INTERNAL STABILITY

Calculation width : 3.00 m

2 . 3 . 1 STRIP RUPTURE - TENSILE LOAD AT FACING : Overdesign factors

layer	z m	deltah m	Strip type	Num.	Ties Num.	case	k	sigmah kPa	Tmax kN	To kN	Tr/Tm	Tro/To
1	1.070	1.352	1	8	8	1	.385	7.55	3.83	3.83	6.60	6.60 R8
						2	.385	21.83	11.07	11.07	2.28	2.28
						1s	.385	7.48	6.08	6.08	5.54	5.54
						2s	.385	11.19	8.21	8.21	4.10	4.10
2	1.635	0.658	1	8	8	1	.371	11.26	2.78	2.78	9.10	9.10 R8
						2	.371	26.89	6.63	6.63	3.81	3.81
						1s	.371	11.09	5.02	5.02	6.71	6.71
						2s	.371	16.54	6.62	6.62	5.09	5.09
3	2.385	0.750	1	4	4	1	.352	15.92	8.96	8.96	2.82	2.82 UR4
						2	.352	33.11	18.62	18.62	1.36	1.36
						1s	.352	15.58	11.05	11.05	3.05	3.05
						2s	.352	23.12	15.55	15.55	2.17	2.17
4	3.135	0.750	1	4	4	1	.332	20.35	11.45	11.45	2.21	2.21 UR4
						2	.332	38.80	21.83	21.83	1.16	1.16
						1s	.332	19.76	13.40	13.40	2.51	2.51
						2s	.332	29.13	18.92	18.92	1.78	1.78
5	3.885	0.750	1	4	4	1	.313	24.59	13.83	13.83	1.83	1.83 UR4
						2	.313	44.01	24.76	24.76	1.02	1.02
						1s	.313	23.68	15.61	15.61	2.16	2.16
						2s	.313	34.59	22.00	22.00	1.53	1.53
6	4.635	0.750	2	4	4	1	.294	28.67	16.13	16.13	2.35	2.35 UR4
						2	.294	48.75	27.42	27.42	1.38	1.38
						1s	.294	27.37	17.68	17.68	2.85	2.85
						2s	.294	39.54	24.79	24.79	2.04	2.04
7	5.385	0.750	2	4	4	1	.275	32.66	18.37	18.37	2.06	2.06 UR4
						2	.275	53.03	29.83	29.83	1.27	1.27
						1s	.275	30.87	19.93	19.93	2.53	2.53
						2s	.275	44.00	27.60	27.60	1.83	1.83
8	6.135	0.750	2	4	4	1	.260	37.09	20.86	20.86	1.81	1.81 R4
						2	.260	57.62	32.41	32.41	1.17	1.17
						1s	.260	34.67	22.34	22.34	2.26	2.26
						2s	.260	48.62	30.50	30.50	1.66	1.66
9	6.885	0.750	2	4	4	1	.260	44.41	24.98	24.98	1.52	1.52 R4
						2	.260	65.95	37.10	37.10	1.02	1.02
						1s	.260	40.99	26.16	26.16	1.93	1.93
						2s	.260	56.34	35.14	35.14	1.44	1.44
10	7.635	0.740	2	5	5	1	.260	53.15	23.60	23.60	1.60	1.60 R(4+6)
						2	.260	75.19	33.38	33.38	1.13	1.13
						1s	.260	48.32	24.83	24.83	2.03	2.03
						2s	.260	64.82	32.54	32.54	1.55	1.55

2 . 3 . 2 ADHERENCE : Overdesign factor

layer	z m	L m	La m	type	Num.	Ties	case	f*	Za m	Tmax kN	Tf kN	Tf/Tm	Eccen
1	1.070	5.80	3.40	1	8	8	1	1.362	1.070	3.83	8.03	2.10	0.05
							2	1.362	1.070	11.07	23.49	2.12	0.02
							1s	1.362	1.070	6.08	8.56	1.41	0.02
							2s	1.362	1.070	8.21	12.84	1.56	0.02
2	1.635	5.80	3.40	1	8	8	1	1.289	1.635	2.78	11.61	4.18	0.09
							2	1.289	1.635	6.63	28.25	4.26	0.04
							1s	1.289	1.635	5.02	12.38	2.47	0.05
							2s	1.289	1.635	6.62	18.58	2.81	0.03
3	2.385	5.80	3.40	1	4	4	1	1.193	2.385	8.96	15.67	1.75	0.15
							2	1.193	2.385	18.62	33.53	1.80	0.07
							1s	1.193	2.385	11.05	16.71	1.51	0.09
							2s	1.193	2.385	15.55	25.07	1.61	0.06
4	3.135	5.80	3.40	1	4	4	1	1.096	3.135	11.45	18.92	1.65	0.23
							2	1.096	3.135	21.83	37.60	1.72	0.11
							1s	1.096	3.135	13.40	20.18	1.51	0.15
							2s	1.096	3.135	18.92	30.28	1.60	0.10
5	3.885	5.80	3.40	1	4	4	1	0.999	3.885	13.83	21.38	1.55	0.31
							2	0.999	3.885	24.76	40.47	1.63	0.17
							1s	0.999	3.885	15.61	22.81	1.46	0.22
							2s	0.999	3.885	22.00	34.21	1.56	0.14
6	4.635	5.80	3.78	2	4	4	1	0.903	4.635	16.13	23.06	1.43	0.42
							2	0.903	4.635	27.42	42.18	1.54	0.23
							1s	0.903	4.635	17.68	24.60	1.39	0.30
							2s	0.903	4.635	24.79	36.90	1.49	0.20
7	5.385	5.80	4.23	2	4	4	1	0.806	5.385	18.37	26.77	1.46	0.53
							2	0.806	5.385	29.83	47.74	1.60	0.30
							1s	0.806	5.385	19.93	28.55	1.43	0.39
							2s	0.806	5.385	27.60	42.83	1.55	0.26
8	6.135	5.80	4.68	2	4	4	1	0.727	6.135	20.86	30.42	1.46	0.66
							2	0.727	6.135	32.41	53.20	1.64	0.38
							1s	0.727	6.135	22.34	32.45	1.45	0.50
							2s	0.727	6.135	30.50	48.67	1.60	0.33
9	6.885	5.80	5.13	2	4	4	1	0.727	6.885	24.98	37.42	1.50	0.80
							2	0.727	6.885	37.10	64.43	1.74	0.46
							1s	0.727	6.885	26.16	39.92	1.53	0.62
							2s	0.727	6.885	35.14	59.87	1.70	0.42
10	7.635	5.80	5.58	2	5	5	1	0.727	7.635	23.60	45.14	1.91	0.95
							2	0.727	7.635	33.38	76.73	2.30	0.56
							1s	0.727	7.635	24.83	48.15	1.94	0.76
							2s	0.727	7.635	32.54	72.22	2.22	0.51

Strips type 1 : HA 50X4
 Strips type 2 : HAR 45X5

Strips type 1 : 162.4 meters for 3.0 m width of wall
 Strips type 2 : 121.8 m

 * COMPLEMENTARY DATA *

1 STANDARDISATION FILE : AASHTO_LRFD

2 CALCULATION METHOD : Limit state

3 FACTORS :

load cases	LFW	Load factors			R.E density
		LFp	LFq1	LFq2	
1	1.00	1.50	0.00	1.75	1
2	1.35	1.50	1.75	1.75	2
3	1.00	1.00	1.00	1.00	2
1s	1.00	1.50	0.00	1.00	1
2s	1.35	1.50	0.00	1.00	2

R.E density : 1 = min - 2 = max

Resistance factors	RFg	RFgc	RFr	RFc	RFt	RFf
Static	1.00	1.00	1.00	0.65	0.75	0.90
Seismic	1.00	1.00	1.00	0.65	1.00	1.20

4 STRIPS :

Strip type 1

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

Strip type 2

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

5 FACING :

Vertical strip spacing : 0.750 mm

bottom height : 0.365 mm

Facing flexibility : To=Tmax

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*****  
* Reinforced Earth : Program Valdez AASHTO LRFD *  
* * * * *  
* * * * * 5.1 *  
*****
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Job number : danang
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Run number : 05
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Structure   : Danang - Quang Ngai
=====
                H=10m

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Designed by : nl
=====

* 1 . GENERAL DATA *

1 . 1 STRUCTURE CLASS :

Service life : 120 years

Site : No water

1 . 2 R.E. STRIPS :

protection : Galvanized

Type 1: HA 50X4

yield strength : 448.0 MPa
width b : 50.0 mm
thickness eo : 4.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 25.27 kN
connection Tro : 25.27 kN

Type 2: HAR 45X5

yield strength : 448.0 MPa
width b : 45.0 mm
thickness eo : 5.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 37.86 kN
connection Tro : 37.86 kN

1 . 3 FACING: TERRACCLASS

1 . 4 SEISMIC DATA :

Maximal horizontal acceleration a_0/g : 0.12
Reduction factor of live loads : 0.50
Reduction of active zone : 1.00
Earthquake load factor g_{EQ} : 1.00
Maximum lateral wall displacement (Newmark approximation) : 38 mm


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*****
*                2 . SECTION 05                *
*****
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2 . 1 SECTION DATA :

2 . 1 . 1 GEOMETRY :

R.E MASS

Facing height	Hf : 9.170 m	R.E.backfill height	H1 : 10.000 m
Coping height	Hc : 0.830 m	Free board	Ht : 0.000 m
Slope height	H2 : 0.00 m	Mechanical height	Hm : 10.000 m
Slope angle	Beta : 0.00 deg.	Terrace angle	Omega : 0.00 deg.
Setback	F : 0.00 m	Angle at toe	Beta_s : 0.000

Strip Length : 7.00 m

SURCHARGES

Load q : 15.70 kPa Position Lq : 0.00 m

2 . 1 . 2 SOIL PROPERTIES :

R.E. BACKFILL

Density gammal maxi : 20.00 kN/m3 Friction phi1 : 36.00 deg.
 gammal mini : 18.00 kN/m3

GENERAL BACKFILL

Density gamma2 : 18.00 kN/m3 Friction phi2 : 35.00 deg.

FOUNDATION

Cohesion C3 : 17.00 kPa Friction phi3 : 17.00 deg.

2 . 1 . 3 EARTH PRESSURE :

Inclination of earth pressure at back of R.E. mass delta = 0.00 deg.

Earth pressure coefficients:

k2x = 0.271 k2y = 0.271 (Static)
 x = 0.000 m y = 10.000 m
 kaex = 0.307 kaey = 0.271 (Dynamic)
 x = 0.000 m y = 10.000 m

2 . 2 EXTERNAL STABILITY

2 . 2 . 1 EXTERNAL STABILITY :

case	Rv kN/m	Rh kN/m	M kNm/m	qref kPa	2.x m
1	1285.20	440.29	2996.44	275.62	4.66
2	2120.12	440.29	5990.58	375.17	5.65
3	1537.90	286.44	4472.30	264.42	5.82
1s	1285.20	465.77	2851.66	289.61	4.44
2s	1927.80	496.41	4992.52	372.20	5.18

Minimum embedment depth = 0.75 m

2 . 2 . 2 SLIDING ON THE BASE - OVERTURNING :

case	SLIDING ON THE BASE				OVERTURNING
	Overdesign factor slip in R.E.	slip in found.	minimal value phi(?) Cohesion(kPa)		Overdesign factor
1	2.12	1.17	18.91	-	2.88
			-	61.67	
2	3.50	1.75	11.73	-	4.76
			-	61.67	
1s	2.00	1.10	19.92	-	2.64
			-	65.23	

2 . 3 INTERNAL STABILITY

Calculation width : 3.00 m

2 . 3 . 1 STRIP RUPTURE - TENSILE LOAD AT FACING : Overdesign factors

layer	z m	deltah m	Strip type	Num.	Ties Num.	case	k	sigmah kPa	Tmax kN	To kN	Tr/Tm	Tro/To	
1	1.195	1.290	1	8	8	1	.382	8.33	4.03	4.03	6.27	6.27	R8
						2	.382	22.93	11.09	11.09	2.28	2.28	
						1s	.382	8.27	6.66	6.66	5.06	5.06	
						2s	.382	12.38	8.94	8.94	3.77	3.77	
2	1.385	0.470	1	8	8	1	.377	9.56	1.69	1.69	14.99	14.99	R8
						2	.377	24.62	4.34	4.34	5.82	5.82	
						1s	.377	9.48	4.33	4.33	7.79	7.79	
						2s	.377	14.18	5.45	5.45	6.18	6.18	
3	2.135	0.750	1	4	4	1	.358	14.19	7.98	7.98	3.17	3.17	UR4
						2	.358	30.89	17.38	17.38	1.45	1.45	
						1s	.358	14.00	10.53	10.53	3.20	3.20	
						2s	.358	20.88	14.69	14.69	2.29	2.29	
4	2.885	0.750	1	4	4	1	.339	18.47	10.39	10.39	2.43	2.43	UR4
						2	.339	36.56	20.56	20.56	1.23	1.23	
						1s	.339	18.14	12.86	12.86	2.62	2.62	
						2s	.339	26.93	18.10	18.10	1.86	1.86	
5	3.635	0.750	1	4	4	1	.320	22.43	12.62	12.62	2.00	2.00	UR4
						2	.320	41.63	23.41	23.41	1.08	1.08	
						1s	.320	21.92	14.98	14.98	2.25	2.25	
						2s	.320	32.36	21.15	21.15	1.59	1.59	
6	4.385	0.750	2	4	4	1	.301	26.09	14.67	14.67	2.58	2.58	UR4
						2	.301	46.11	25.94	25.94	1.46	1.46	
						1s	.301	25.35	16.65	16.65	3.03	3.03	
						2s	.301	37.18	23.57	23.57	2.14	2.14	
7	5.135	0.750	2	4	4	1	.282	29.45	16.57	16.57	2.29	2.29	UR4
						2	.282	50.02	28.13	28.13	1.35	1.35	
						1s	.282	28.46	18.44	18.44	2.74	2.74	
						2s	.282	41.40	26.00	26.00	1.94	1.94	
8	5.885	0.750	2	4	4	1	.263	32.54	18.31	18.31	2.07	2.07	UR4
						2	.263	53.34	30.00	30.00	1.26	1.26	
						1s	.263	31.25	20.28	20.28	2.49	2.49	
						2s	.263	45.02	28.33	28.33	1.78	1.78	
9	6.635	0.750	2	4	4	1	.260	37.71	21.21	21.21	1.78	1.78	R4
						2	.260	59.78	33.63	33.63	1.13	1.13	
						1s	.260	35.96	23.20	23.20	2.18	2.18	
						2s	.260	51.21	32.11	32.11	1.57	1.57	
10	7.385	0.750	2	4	4	1	.260	43.86	24.67	24.67	1.53	1.53	R4
						2	.260	67.30	37.86	37.86	1.00	1.00	
						1s	.260	41.51	26.59	26.59	1.90	1.90	
						2s	.260	58.32	36.41	36.41	1.39	1.39	
11	8.135	0.750	2	5	5	1	.260	50.80	22.86	22.86	1.66	1.66	R(4+6)
						2	.260	75.40	33.93	33.93	1.12	1.12	
						1s	.260	47.68	24.97	24.97	2.02	2.02	
						2s	.260	65.93	33.57	33.57	1.50	1.50	
12	8.885	0.750	2	6	6	1	.260	58.75	22.03	22.03	1.72	1.72	R6
						2	.260	84.18	31.57	31.57	1.20	1.20	

layer	z m	deltah m	Strip		Ties		case	k	sigmah kPa	Tmax kN	To kN	Tr/Tm	Tro/To	
			type	Num.	Num.									
						2s	.260	74.13	32.00	32.00		1.58	1.58	
13	9.635	0.740	2	6	6	1	.260	68.02	25.17	25.17		1.50	1.50	R6
						2	.260	93.79	34.70	34.70		1.09	1.09	
						1s	.260	62.53	27.19	27.19		1.86	1.86	
						2s	.260	83.03	35.22	35.22		1.43	1.43	

2 . 3 . 2 ADHERENCE : Overdesign factor

layer	z m	L m	La m	type	Num.	Ties	case	f*	Za m	Tmax kN	Tf kN	Tf/Tm	Eccen
1	1.195	7.00	4.00	1	8	8	1	1.346	1.195	4.03	10.42	2.59	0.05
							2	1.346	1.195	11.09	28.95	2.61	0.02
							1s	1.346	1.195	6.66	11.12	1.67	0.02
							2s	1.346	1.195	8.94	16.68	1.87	0.02
2	1.385	7.00	4.00	1	8	8	1	1.321	1.385	1.69	11.86	7.04	0.06
							2	1.321	1.385	4.34	30.86	7.11	0.02
							1s	1.321	1.385	4.33	12.65	2.92	0.03
							2s	1.321	1.385	5.45	18.98	3.48	0.02
3	2.135	7.00	4.00	1	4	4	1	1.225	2.135	7.98	16.94	2.12	0.11
							2	1.225	2.135	17.38	37.53	2.16	0.05
							1s	1.225	2.135	10.53	18.07	1.72	0.06
							2s	1.225	2.135	14.69	27.11	1.85	0.04
4	2.885	7.00	4.00	1	4	4	1	1.128	2.885	10.39	21.09	2.03	0.17
							2	1.128	2.885	20.56	42.79	2.08	0.08
							1s	1.128	2.885	12.86	22.50	1.75	0.10
							2s	1.128	2.885	18.10	33.74	1.86	0.07
5	3.635	7.00	4.00	1	4	4	1	1.031	3.635	12.62	24.29	1.93	0.24
							2	1.031	3.635	23.41	46.64	1.99	0.12
							1s	1.031	3.635	14.98	25.91	1.73	0.16
							2s	1.031	3.635	21.15	38.87	1.84	0.11
6	4.385	7.00	4.00	2	4	4	1	0.935	4.385	14.67	23.90	1.63	0.32
							2	0.935	4.385	25.94	44.18	1.70	0.17
							1s	0.935	4.385	16.65	25.50	1.53	0.22
							2s	0.935	4.385	23.57	38.25	1.62	0.15
7	5.135	7.00	4.08	2	4	4	1	0.838	5.135	16.57	25.61	1.55	0.41
							2	0.838	5.135	28.13	46.02	1.64	0.23
							1s	0.838	5.135	18.44	27.31	1.48	0.30
							2s	0.838	5.135	26.00	40.97	1.58	0.20
8	5.885	7.00	4.53	2	4	4	1	0.741	5.885	18.31	28.82	1.57	0.51
							2	0.741	5.885	30.00	50.71	1.69	0.29
							1s	0.741	5.885	20.28	30.74	1.52	0.38
							2s	0.741	5.885	28.33	46.12	1.63	0.26
9	6.635	7.00	4.98	2	4	4	1	0.727	6.635	21.21	35.01	1.65	0.62
							2	0.727	6.635	33.63	60.57	1.80	0.36
							1s	0.727	6.635	23.20	37.34	1.61	0.48
							2s	0.727	6.635	32.11	56.01	1.74	0.32
10	7.385	7.00	5.43	2	4	4	1	0.727	7.385	24.67	42.49	1.72	0.75
							2	0.727	7.385	37.86	72.51	1.92	0.44
							1s	0.727	7.385	26.59	45.32	1.70	0.59
							2s	0.727	7.385	36.41	67.98	1.87	0.39
11	8.135	7.00	5.88	2	5	5	1	0.727	8.135	22.86	50.68	2.22	0.88
							2	0.727	8.135	33.93	85.53	2.52	0.52
							1s	0.727	8.135	24.97	54.06	2.17	0.71
							2s	0.727	8.135	33.57	81.09	2.42	0.47
12	8.885	7.00	6.33	2	6	6	1	0.727	8.885	22.03	59.59	2.70	1.03
							2	0.727	8.885	31.57	99.62	3.16	0.61
							1s	0.727	8.885	24.26	63.56	2.62	0.84
							2s	0.727	8.885	32.00	95.34	2.98	0.56
13	9.635	7.00	6.78	2	6	6	1	0.727	9.635	25.17	69.21	2.75	1.18
							2	0.727	9.635	34.70	114.78	3.31	0.71
							1s	0.727	9.635	27.19	73.82	2.72	0.98
							2s	0.727	9.635	35.22	110.73	3.14	0.65

Strips type 1 : HA 50X4
Strips type 2 : HAR 45X5

Strips type 1 : 196.0 meters for 3.0 m width of wall
Strips type 2 : 259.0 m

 * COMPLEMENTARY DATA *

1 STANDARDISATION FILE : AASHTO_LRFD

2 CALCULATION METHOD : Limit state

3 FACTORS :

load cases	LFw	Load factors		LFq2	R.E density
		LFp	LFq1		
1	1.00	1.50	0.00	1.75	1
2	1.35	1.50	1.75	1.75	2
3	1.00	1.00	1.00	1.00	2
1s	1.00	1.50	0.00	1.00	1
2s	1.35	1.50	0.00	1.00	2

R.E density : 1 = min - 2 = max

Resistance factors	RFg	RFgc	RFR	RFc	RFt	RFf
Static	1.00	1.00	1.00	0.65	0.75	0.90
Seismic	1.00	1.00	1.00	0.65	1.00	1.20

4 STRIPS :

Strip type 1

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

Strip type 2

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

5 FACING :

Vertical strip spacing : 0.750 mm
 bottom height : 0.365 mm
 Facing flexibility : To=Tmax

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*****
*
* Reinforced Earth : Program Valdez AASHTO LRFD *
*
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*****
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Job number : danang
=====

Run number : 01
=====

Structure : Danang - Quang Ngai
=====

H=12

Designed by : nl
=====

* 1 . GENERAL DATA *

1 . 1 STRUCTURE CLASS :

Service life : 120 years

Site : No water

1 . 2 R.E. STRIPS :

protection : Galvanized

Type 1: HA 50X4

yield strength : 448.0 MPa
width b : 50.0 mm
thickness eo : 4.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 25.27 kN
connection Tro : 25.27 kN

Type 2: HAR 45X5

yield strength : 448.0 MPa
width b : 45.0 mm
thickness eo : 5.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 37.86 kN
connection Tro : 37.86 kN

1 . 3 FACING: TERRACCLASS

1 . 4 SEISMIC DATA :

Maximal horizontal acceleration a_0/g : 0.12
Reduction factor of live loads : 0.50
Reduction of active zone : 1.00
Earthquake load factor g_{EQ} : 1.00
Maximum lateral wall displacement (Newmark approximation) : 38 mm

 * 2 . SECTION 01 *

2 . 1 SECTION DATA :

2 . 1 . 1 GEOMETRY :

R.E MASS

Facing height	Hf : 11.230 m	R.E.backfill height	H1 : 12.000 m
Coping height	Hc : 0.770 m	Free board	Ht : 0.000 m
Slope height	H2 : 0.00 m	Mechanical height	Hm : 12.000 m
Slope angle	Beta : 0.00 deg.	Terrace angle	Omega : 0.00 deg.
Setback	F : 0.00 m	Angle at toe	Beta_s : 0.000

Strip Length : 8.50 m

SURCHARGES

Load	q : 15.70 kPa	Position Lq :	0.00 m
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2 . 1 . 2 SOIL PROPERTIES :

R.E. BACKFILL

Density	gamma1 maxi : 20.00 kN/m3	Friction	phi1 : 36.00 deg.
	gamma1 mini : 18.00 kN/m3		

GENERAL BACKFILL

Density	gamma2 : 18.00 kN/m3	Friction	phi2 : 35.00 deg.
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FOUNDATION

Cohesion	C3 : 17.00 kPa	Friction	phi3 : 17.00 deg.
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2 . 1 . 3 EARTH PRESSURE :

Inclination of earth pressure at back of R.E. mass delta = 0.00 deg.

Earth pressure coefficients:

k2x	= 0.271	k2y	= 0.271	(Static)
x	= 0.000 m	y	= 12.000 m	
kaex	= 0.307	kaey	= 0.271	(Dynamic)
x	= 0.000 m	y	= 12.000 m	

2 . 2 EXTERNAL STABILITY

2 . 2 . 1 EXTERNAL STABILITY :

case	Rv kN/m	Rh kN/m	M kNm/m	qref kPa	2.x m
1	1866.24	616.15	5418.87	321.36	5.81
2	3032.90	616.15	10475.17	439.06	6.91
3	2207.05	402.26	7832.66	310.95	7.10
1s	1866.24	664.98	5096.16	341.71	5.46
2s	2799.36	708.90	8863.68	442.05	6.33

Minimum embedment depth = 0.88 m

2 . 2 . 2 SLIDING ON THE BASE - OVERTURNING :

case	SLIDING ON THE BASE			OVERTURNING	
	Overdesign factor	minimal value		Overdesign factor	
	slip in R.E.	slip in found.	phi(?) Cohesion(kPa)		
1	2.20	1.16	18.27	-	3.05
			-	71.31	
2	3.58	1.74	11.48	-	4.96
			-	71.31	
1s	2.04	1.08	19.61	-	2.72
			-	76.96	

2 . 3 INTERNAL STABILITY

Calculation width : 3.00 m

2 . 3 . 1 STRIP RUPTURE - TENSILE LOAD AT FACING : Overdesign factors

layer	z m	deltah m	Strip type	Ties Num.	case	k	sigmah kPa	Tmax kN	To kN	Tr/Tm	Tro/To	
1	1.135	1.510	1	8	8	1	.383	7.90	4.47	4.47	5.65	5.65 R8
						2	.383	22.35	12.66	12.66	2.00	2.00
						1s	.383	7.87	7.66	7.66	4.40	4.40
						2s	.383	11.78	10.23	10.23	3.29	3.29
2	1.885	0.750	1	8	8	1	.364	12.58	3.54	3.54	7.14	7.14 R8
						2	.364	28.77	8.09	8.09	3.12	3.12
						1s	.364	12.48	6.71	6.71	5.02	5.02
						2s	.364	18.66	8.81	8.81	3.82	3.82
3	2.635	0.750	2	4	4	1	.345	16.85	9.48	9.48	4.00	4.00 UR4
						2	.345	34.51	19.41	19.41	1.95	1.95
						1s	.345	16.66	12.26	12.26	4.12	4.12
						2s	.345	24.85	17.18	17.18	2.94	2.94
4	3.385	0.750	2	4	4	1	.326	20.72	11.65	11.65	3.25	3.25 UR4
						2	.326	39.60	22.27	22.27	1.70	1.70
						1s	.326	20.42	14.37	14.37	3.51	3.51
						2s	.326	30.35	20.28	20.28	2.49	2.49
5	4.135	0.750	2	4	4	1	.307	24.20	13.61	13.61	2.78	2.78 UR4
						2	.307	44.03	24.77	24.77	1.53	1.53
						1s	.307	23.78	16.26	16.26	3.10	3.10
						2s	.307	35.19	23.00	23.00	2.19	2.19
6	4.885	0.750	2	4	4	1	.288	27.31	15.36	15.36	2.46	2.46 UR4
						2	.288	47.81	26.89	26.89	1.41	1.41
						1s	.288	26.73	17.92	17.92	2.82	2.82
						2s	.288	39.37	25.35	25.35	1.99	1.99
7	5.635	0.750	2	4	4	1	.269	30.03	16.89	16.89	2.24	2.24 UR4
						2	.269	50.94	28.65	28.65	1.32	1.32
						1s	.269	29.29	19.36	19.36	2.61	2.61
						2s	.269	42.88	27.32	27.32	1.85	1.85
8	6.385	0.750	2	4	4	1	.260	33.64	18.92	18.92	2.00	2.00 UR4
						2	.260	55.50	31.22	31.22	1.21	1.21
						1s	.260	32.68	21.40	21.40	2.36	2.36
						2s	.260	47.51	30.08	30.08	1.68	1.68
9	7.135	0.750	2	4	4	1	.260	38.61	21.72	21.72	1.74	1.74 R4
						2	.260	62.08	34.92	34.92	1.08	1.08
						1s	.260	37.34	24.29	24.29	2.08	2.08
						2s	.260	53.86	33.95	33.95	1.49	1.49
10	7.885	0.750	2	5	5	1	.260	43.96	19.78	19.78	1.91	1.91 R(4+6)
						2	.260	68.99	31.05	31.05	1.22	1.22
						1s	.260	42.33	22.60	22.60	2.23	2.23
						2s	.260	60.49	31.17	31.17	1.62	1.62
11	8.635	0.750	2	5	5	1	.260	49.77	22.40	22.40	1.69	1.69 R(4+6)
						2	.260	76.27	34.32	34.32	1.10	1.10
						1s	.260	47.70	25.28	25.28	2.00	2.00
						2s	.260	67.45	34.59	34.59	1.46	1.46
12	9.385	0.750	2	5	5	1	.260	56.15	25.27	25.27	1.50	1.50 R(4+6)
						2	.260	83.97	37.79	37.79	1.00	1.00
						1s	.260	53.52	28.16	28.16	1.79	1.79

layer	z m	delta m	Strip		Ties		case	k	sigmah kPa	Tmax kN	To kN	Tr/Tm	Tro/To
			type	Num.	Num.								
						2s	.260	74.79	38.19	38.19	1.32	1.32	
13	10.135	0.750	2	6	6	1	.260	63.20	23.70	23.70	1.60	1.60	R6
						2	.260	92.17	34.56	34.56	1.10	1.10	
						1s	.260	59.89	26.80	26.80	1.88	1.88	
						2s	.260	82.56	35.79	35.79	1.41	1.41	
14	10.885	0.750	2	6	6	1	.260	71.09	26.66	26.66	1.42	1.42	R6
						2	.260	100.94	37.85	37.85	1.00	1.00	
						1s	.260	66.93	29.71	29.71	1.70	1.70	
						2s	.260	90.83	39.18	39.18	1.29	1.29	
15	11.635	0.740	2	7	7	1	.260	80.02	25.38	25.38	1.49	1.49	R(6+8)
						2	.260	110.38	35.00	35.00	1.08	1.08	
						1s	.260	74.78	28.59	28.59	1.77	1.77	
						2s	.260	99.70	37.03	37.03	1.36	1.36	

2 . 3 . 2 ADHERENCE : Overdesign factor

layer	z m	L m	La m	type	Num.	Ties	case	f*	Za m	Tmax kN	Tf kN	Tf/Tm	Eccen
1	1.135	8.50	4.90	1	8	8	1	1.354	1.135	4.47	12.20	2.73	0.04
							2	1.354	1.135	12.66	34.70	2.74	0.01
							1s	1.354	1.135	7.66	13.01	1.70	0.02
							2s	1.354	1.135	10.23	19.51	1.91	0.01
2	1.885	8.50	4.90	1	8	8	1	1.257	1.885	3.54	18.81	5.32	0.07
							2	1.257	1.885	8.09	43.44	5.37	0.03
							1s	1.257	1.885	6.71	20.06	2.99	0.04
							2s	1.257	1.885	8.81	30.09	3.42	0.03
3	2.635	8.50	4.90	2	4	4	1	1.160	2.635	9.48	21.84	2.31	0.12
							2	1.160	2.635	19.41	45.42	2.34	0.06
							1s	1.160	2.635	12.26	23.30	1.90	0.07
							2s	1.160	2.635	17.18	34.95	2.03	0.05
4	3.385	8.50	4.90	2	4	4	1	1.064	3.385	11.65	25.72	2.21	0.17
							2	1.064	3.385	22.27	50.18	2.25	0.09
							1s	1.064	3.385	14.37	27.44	1.91	0.11
							2s	1.064	3.385	20.28	41.16	2.03	0.08
5	4.135	8.50	4.90	2	4	4	1	0.967	4.135	13.61	28.57	2.10	0.24
							2	0.967	4.135	24.77	53.39	2.16	0.13
							1s	0.967	4.135	16.26	30.47	1.87	0.17
							2s	0.967	4.135	23.00	45.70	1.99	0.11
6	4.885	8.50	4.90	2	4	4	1	0.870	4.885	15.36	30.37	1.98	0.31
							2	0.870	4.885	26.89	55.05	2.05	0.17
							1s	0.870	4.885	17.92	32.40	1.81	0.22
							2s	0.870	4.885	25.35	48.60	1.92	0.15
7	5.635	8.50	4.90	2	4	4	1	0.774	5.635	16.89	31.14	1.84	0.39
							2	0.774	5.635	28.65	55.15	1.92	0.22
							1s	0.774	5.635	19.36	33.22	1.72	0.29
							2s	0.774	5.635	27.32	49.83	1.82	0.19
8	6.385	8.50	5.13	2	4	4	1	0.727	6.385	18.92	34.70	1.83	0.48
							2	0.727	6.385	31.22	60.35	1.93	0.28
							1s	0.727	6.385	21.40	37.02	1.73	0.37
							2s	0.727	6.385	30.08	55.53	1.85	0.25
9	7.135	8.50	5.58	2	4	4	1	0.727	7.135	21.72	42.18	1.94	0.58
							2	0.727	7.135	34.92	72.30	2.07	0.34
							1s	0.727	7.135	24.29	44.99	1.85	0.46
							2s	0.727	7.135	33.95	67.49	1.99	0.30
10	7.885	8.50	6.03	2	5	5	1	0.727	7.885	19.78	50.37	2.55	0.69
							2	0.727	7.885	31.05	85.31	2.75	0.41
							1s	0.727	7.885	22.60	53.73	2.38	0.55
							2s	0.727	7.885	31.17	80.60	2.59	0.37
11	8.635	8.50	6.48	2	5	5	1	0.727	8.635	22.40	59.28	2.65	0.80
							2	0.727	8.635	34.32	99.40	2.90	0.48
							1s	0.727	8.635	25.28	63.23	2.50	0.65
							2s	0.727	8.635	34.59	94.85	2.74	0.44
12	9.385	8.50	6.93	2	5	5	1	0.727	9.385	25.27	68.90	2.73	0.93
							2	0.727	9.385	37.79	114.56	3.03	0.56
							1s	0.727	9.385	28.16	73.50	2.61	0.77
							2s	0.727	9.385	38.19	110.25	2.89	0.51
13	10.135	8.50	7.38	2	6	6	1	0.727	10.135	23.70	79.24	3.34	1.07
							2	0.727	10.135	34.56	130.80	3.78	0.65
							1s	0.727	10.135	26.80	84.53	3.15	0.89
							2s	0.727	10.135	35.79	126.79	3.54	0.59

layer	z m	L m	La m	type	Num.	Ties	case	f*	Za m	Tmax kN	Tf kN	Tf/Tm	Eccen
14	10.885	8.50	7.83	2	6	6	1	0.727	10.885	26.66	90.30	3.39	1.21
							2	0.727	10.885	37.85	148.10	3.91	0.74
							1s	0.727	10.885	29.71	96.31	3.24	1.02
							2s	0.727	10.885	39.18	144.47	3.69	0.68
15	11.635	8.50	8.28	2	7	7	1	0.727	11.635	25.38	102.06	4.02	1.36
							2	0.727	11.635	35.00	166.48	4.76	0.84
							1s	0.727	11.635	28.59	108.87	3.81	1.16
							2s	0.727	11.635	37.03	163.30	4.41	0.77

Strips type 1 : HA 50X4

Strips type 2 : HAR 45X5

Strips type 1 : 136.0 meters for 3.0 m width of wall

Strips type 2 : 527.0 m

 * COMPLEMENTARY DATA *

1 STANDARDISATION FILE : AASHTO_LRFD

2 CALCULATION METHOD : Limit state

3 FACTORS :

load cases	LFW	Load factors			R.E density
		LFp	LFq1	LFq2	
1	1.00	1.50	0.00	1.75	1
2	1.35	1.50	1.75	1.75	2
3	1.00	1.00	1.00	1.00	2
1s	1.00	1.50	0.00	1.00	1
2s	1.35	1.50	0.00	1.00	2

R.E density : 1 = min - 2 = max

Resistance factors	RFg	RFgc	RFr	RFc	RFt	RFf
Static	1.00	1.00	1.00	0.65	0.75	0.90
Seismic	1.00	1.00	1.00	0.65	1.00	1.20

4 STRIPS :

Strip type 1

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

Strip type 2

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

5 FACING :

Vertical strip spacing : 0.750 mm
 bottom height : 0.365 mm
 Facing flexibility : To=Tmax


```
*****
*
* Reinforced Earth : Program Valdez AASHTO LRFD *
*
*                                     5.1 *
*****
```

Job number : danang
=====

Run number : 04
=====

Structure : Danang - Quang Ngai
=====

H=15

Designed by : nl
=====

* 1 . GENERAL DATA *

1 . 1 STRUCTURE CLASS :

Service life : 120 years

Site : No water

1 . 2 R.E. STRIPS :

protection : Galvanized

Type 1: HA 50X4

yield strength : 448.0 MPa
width b : 50.0 mm
thickness eo : 4.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 25.27 kN
connection Tro : 25.27 kN

Type 2: HAR 45X5

yield strength : 448.0 MPa
width b : 45.0 mm
thickness eo : 5.0 mm
sacrif. thick. es : 2.496 mm
Allowable tensile strength :
full section Tr : 37.86 kN
connection Tro : 37.86 kN

1 . 3 FACING: TERRACCLASS

1 . 4 SEISMIC DATA :

Maximal horizontal acceleration a_0/g : 0.12
Reduction factor of live loads : 0.50
Reduction of active zone : 1.00
Earthquake load factor g_{EQ} : 1.00

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*****
*           2 . SECTION 04           *
*****
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2 . 1 SECTION DATA :

2 . 1 . 1 GEOMETRY :

R.E MASS

Facing height	Hf : 14.230 m	R.E.backfill height	H1 : 15.000 m
Coping height	Hc : 0.770 m	Free board	Ht : 0.000 m
Slope height	H2 : 0.00 m	Mechanical height	Hm : 15.000 m
Slope angle	Beta : 0.00 deg.	Terrace angle	Omega : 0.00 deg.
Setback	F : 0.00 m	Angle at toe	Beta_s : 0.000

Strip Length : 13.00 m

SURCHARGES

Load	q : 15.70 kPa	Position Lq :	0.00 m
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2 . 1 . 2 SOIL PROPERTIES :

R.E. BACKFILL

Density	gamma1 maxi : 20.00 kN/m3	Friction	phi1 : 36.00 deg.
	gamma1 mini : 18.00 kN/m3		

GENERAL BACKFILL

Density	gamma2 : 18.00 kN/m3	Friction	phi2 : 35.00 deg.
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FOUNDATION

Cohesion	C3 : 17.00 kPa	Friction	phi3 : 17.00 deg.
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2 . 1 . 3 EARTH PRESSURE :

Inclination of earth pressure at back of R.E. mass delta = 0.00 deg.

Earth pressure coefficients:

k2x	= 0.271	k2y	= 0.271	(Static)
x	= 0.000 m	y	= 15.000 m	
kaex	= 0.367	kaey	= 0.271	(Dynamic)
x	= 0.000 m	y	= 15.000 m	

2 . 2 EXTERNAL STABILITY

2 . 2 . 1 EXTERNAL STABILITY :

case	Rv kN/m	Rh kN/m	M kNm/m	qref kPa	2.x m
1	3547.80	934.81	18355.77	342.86	10.35
2	5678.87	934.81	32381.94	497.96	11.40
3	4146.10	612.57	24031.75	357.65	11.59
1s	3547.80	1284.88	15579.35	403.96	8.78
2s	5321.70	1449.49	25999.29	544.64	9.77

Minimum embedment depth = 1.00 m

2 . 2 . 2 SLIDING ON THE BASE - OVERTURNING :

case	SLIDING ON THE BASE			OVERTURNING	
	Overdesign factor slip in R.E.	minimal value slip in found.	phi(? Cohesion(kPa)	Overdesign factor	
1	2.76	1.40	14.76	-	4.71
			-	71.14	
2	4.41	2.10	9.35	-	7.54
			-	71.14	
1s	2.01	1.02	19.91	-	3.02
			-	97.78	

2 . 3 INTERNAL STABILITY

Calculation width : 3.00 m

2 . 3 . 1 STRIP RUPTURE - TENSILE LOAD AT FACING : Overdesign factors

layer	z m	deltah m	Strip type	Ties Num.	case	k	sigmah kPa	Tmax kN	To kN	Tr/Tm	Tro/To	
1	1.135	1.510	1	8	8	1 .383	7.86	4.45	4.45	5.68	5.68	R8
						2 .383	22.31	12.63	12.63	2.00	2.00	
						1s .383	7.85	8.28	8.28	4.07	4.07	
						2s .383	11.76	10.93	10.93	3.08	3.08	
2	1.885	0.750	1	8	8	1 .364	12.45	3.50	3.50	7.21	7.21	R8
						2 .364	28.64	8.06	8.06	3.14	3.14	
						1s .364	12.41	7.33	7.33	4.60	4.60	
						2s .364	18.59	9.50	9.50	3.55	3.55	
3	2.635	0.750	1	4	4	1 .345	16.57	9.32	9.32	2.71	2.71	UR4
						2 .345	34.24	19.26	19.26	1.31	1.31	
						1s .345	16.49	13.12	13.12	2.57	2.57	
						2s .345	24.68	18.15	18.15	1.86	1.86	
4	3.385	0.750	1	4	4	1 .326	20.22	11.38	11.38	2.22	2.22	UR4
						2 .326	39.12	22.00	22.00	1.15	1.15	
						1s .326	20.10	15.15	15.15	2.22	2.22	
						2s .326	30.04	21.16	21.16	1.59	1.59	
5	4.135	0.750	1	4	4	1 .307	23.41	13.17	13.17	1.92	1.92	UR4
						2 .307	43.27	24.34	24.34	1.04	1.04	
						1s .307	23.24	16.91	16.91	1.99	1.99	
						2s .307	34.66	23.77	23.77	1.42	1.42	
6	4.885	0.750	2	4	4	1 .288	26.13	14.70	14.70	2.58	2.58	UR4
						2 .288	46.70	26.27	26.27	1.44	1.44	
						1s .288	25.91	18.03	18.03	2.80	2.80	
						2s .288	38.56	25.53	25.53	1.98	1.98	
7	5.635	0.750	2	4	4	1 .269	28.39	15.97	15.97	2.37	2.37	UR4
						2 .269	49.39	27.78	27.78	1.36	1.36	
						1s .269	28.10	19.26	19.26	2.62	2.62	
						2s .269	41.73	27.31	27.31	1.85	1.85	
8	6.385	0.750	2	4	4	1 .260	31.35	17.64	17.64	2.15	2.15	UR4
						2 .260	53.37	30.02	30.02	1.26	1.26	
						1s .260	30.99	20.89	20.89	2.42	2.42	
						2s .260	45.89	29.66	29.66	1.70	1.70	
9	7.135	0.750	2	4	4	1 .260	35.41	19.92	19.92	1.90	1.90	R4
						2 .260	59.16	33.28	33.28	1.14	1.14	
						1s .260	34.94	23.11	23.11	2.18	2.18	
						2s .260	51.59	32.86	32.86	1.54	1.54	
10	7.885	0.750	2	4	4	1 .260	39.58	22.27	22.27	1.70	1.70	R4
						2 .260	65.06	36.60	36.60	1.03	1.03	
						1s .260	39.01	25.49	25.49	1.98	1.98	
						2s .260	57.39	36.23	36.23	1.39	1.39	
11	8.635	0.750	2	5	5	1 .260	43.90	19.76	19.76	1.92	1.92	R(4+6)
						2 .260	71.09	31.99	31.99	1.18	1.18	
						1s .260	43.20	23.17	23.17	2.18	2.18	
						2s .260	63.31	32.64	32.64	1.55	1.55	
12	9.385	0.750	2	5	5	1 .260	48.39	21.77	21.77	1.74	1.74	R(4+6)
						2 .260	77.27	34.77	34.77	1.09	1.09	

layer	z m	deltah m	type	Strip Num.	Ties Num.	case	k	sigmah kPa	Tmax kN	To kN	Tr/Tm	Tro/To
						2s	.260	69.35	35.56	35.56	1.42	1.42
13	10.135	0.750	2	5	5	1	.260	53.05	23.87	23.87	1.59	1.59 R(4+6)
						2	.260	83.60	37.62	37.62	1.01	1.01
						1s	.260	52.01	27.51	27.51	1.84	1.84
						2s	.260	75.55	38.55	38.55	1.31	1.31
14	10.885	0.750	2	6	6	1	.260	57.91	21.72	21.72	1.74	1.74 R6
						2	.260	90.12	33.79	33.79	1.12	1.12
						1s	.260	56.68	25.54	25.54	1.98	1.98
						2s	.260	81.90	35.47	35.47	1.42	1.42
15	11.635	0.750	2	6	6	1	.260	63.00	23.63	23.63	1.60	1.60 R6
						2	.260	96.82	36.31	36.31	1.04	1.04
						1s	.260	61.55	27.55	27.55	1.83	1.83
						2s	.260	88.44	38.12	38.12	1.32	1.32
16	12.385	0.750	2	7	7	1	.260	68.35	21.97	21.97	1.72	1.72 R(6+8)
						2	.260	103.74	33.35	33.35	1.14	1.14
						1s	.260	66.65	26.07	26.07	1.94	1.94
						2s	.260	95.17	35.75	35.75	1.41	1.41
17	13.135	0.750	2	7	7	1	.260	74.00	23.78	23.78	1.59	1.59 R(6+8)
						2	.260	110.90	35.65	35.65	1.06	1.06
						1s	.260	72.00	27.97	27.97	1.80	1.80
						2s	.260	102.11	38.19	38.19	1.32	1.32
18	13.885	0.750	2	8	8	1	.260	79.96	22.49	22.49	1.68	1.68 R8
						2	.260	118.32	33.28	33.28	1.14	1.14
						1s	.260	77.64	26.85	26.85	1.88	1.88
						2s	.260	109.30	36.31	36.31	1.39	1.39
19	14.635	0.740	2	8	8	1	.260	86.30	23.95	23.95	1.58	1.58 R8
						2	.260	126.02	34.97	34.97	1.08	1.08
						1s	.260	83.60	28.40	28.40	1.78	1.78
						2s	.260	116.75	38.17	38.17	1.32	1.32

2 . 3 . 2 ADHERENCE : Overdesign factor

layer	z m	L m	La m	type	Num.	Ties	case	f*	Za m	Tmax kN	Tf kN	Tf/Tm	Eccen
1	1.135	13.00	8.50	1	8	8	1	1.354	1.135	4.45	21.16	4.75	0.02
							2	1.354	1.135	12.63	60.19	4.76	0.01
							1s	1.354	1.135	8.28	22.57	2.72	0.01
							2s	1.354	1.135	10.93	33.85	3.10	0.01
2	1.885	13.00	8.50	1	8	8	1	1.257	1.885	3.50	32.63	9.32	0.05
							2	1.257	1.885	8.06	75.36	9.36	0.02
							1s	1.257	1.885	7.33	34.80	4.75	0.03
							2s	1.257	1.885	9.50	52.20	5.50	0.02
3	2.635	13.00	8.50	1	4	4	1	1.160	2.635	9.32	42.10	4.52	0.08
							2	1.160	2.635	19.26	87.54	4.54	0.04
							1s	1.160	2.635	13.12	44.91	3.42	0.05
							2s	1.160	2.635	18.15	67.36	3.71	0.03
4	3.385	13.00	8.50	1	4	4	1	1.064	3.385	11.38	49.58	4.36	0.11
							2	1.064	3.385	22.00	96.72	4.40	0.06
							1s	1.064	3.385	15.15	52.88	3.49	0.08
							2s	1.064	3.385	21.16	79.32	3.75	0.05
5	4.135	13.00	8.50	1	4	4	1	0.967	4.135	13.17	55.06	4.18	0.15
							2	0.967	4.135	24.34	102.91	4.23	0.08
							1s	0.967	4.135	16.91	58.73	3.47	0.11
							2s	0.967	4.135	23.77	88.09	3.71	0.07
6	4.885	13.00	8.50	2	4	4	1	0.870	4.885	14.70	52.69	3.58	0.20
							2	0.870	4.885	26.27	95.49	3.64	0.11
							1s	0.870	4.885	18.03	56.20	3.12	0.15
							2s	0.870	4.885	25.53	84.30	3.30	0.10
7	5.635	13.00	8.50	2	4	4	1	0.774	5.635	15.97	54.02	3.38	0.26
							2	0.774	5.635	27.78	95.67	3.44	0.14
							1s	0.774	5.635	19.26	57.63	2.99	0.19
							2s	0.774	5.635	27.31	86.44	3.16	0.13
8	6.385	13.00	8.50	2	4	4	1	0.727	6.385	17.64	57.49	3.26	0.31
							2	0.727	6.385	30.02	99.98	3.33	0.18
							1s	0.727	6.385	20.89	61.32	2.94	0.24
							2s	0.727	6.385	29.66	91.99	3.10	0.16
9	7.135	13.00	8.50	2	4	4	1	0.727	7.135	19.92	64.24	3.23	0.38
							2	0.727	7.135	33.28	110.11	3.31	0.22
							1s	0.727	7.135	23.11	68.53	2.97	0.30
							2s	0.727	7.135	32.86	102.79	3.13	0.20
10	7.885	13.00	8.73	2	4	4	1	0.727	7.885	22.27	72.93	3.28	0.45
							2	0.727	7.885	36.60	123.51	3.37	0.27
							1s	0.727	7.885	25.49	77.79	3.05	0.36
							2s	0.727	7.885	36.23	116.68	3.22	0.24
11	8.635	13.00	9.18	2	5	5	1	0.727	8.635	19.76	83.98	4.25	0.53
							2	0.727	8.635	31.99	140.81	4.40	0.31
							1s	0.727	8.635	23.17	89.58	3.87	0.43
							2s	0.727	8.635	32.64	134.37	4.12	0.29
12	9.385	13.00	9.63	2	5	5	1	0.727	9.385	21.77	95.75	4.40	0.61
							2	0.727	9.385	34.77	159.19	4.58	0.37
							1s	0.727	9.385	25.30	102.13	4.04	0.50
							2s	0.727	9.385	35.56	153.19	4.31	0.33
13	10.135	13.00	10.08	2	5	5	1	0.727	10.135	23.87	108.23	4.53	0.70
							2	0.727	10.135	37.62	178.64	4.75	0.42
							1s	0.727	10.135	27.51	115.44	4.20	0.58
							2s	0.727	10.135	38.55	173.17	4.49	0.39

layer	z m	L m	La m	type	Num.	Ties	case	f*	Za m	Tmax kN	Tf kN	Tf/Tm	Eccen
14	10.885	13.00	10.53	2	6	6	1	0.727	10.885	21.72	121.43	5.59	0.79
							2	0.727	10.885	33.79	199.17	5.89	0.48
							1s	0.727	10.885	25.54	129.52	5.07	0.67
							2s	0.727	10.885	35.47	194.28	5.48	0.44
15	11.635	13.00	10.98	2	6	6	1	0.727	11.635	23.63	135.34	5.73	0.89
							2	0.727	11.635	36.31	220.77	6.08	0.55
							1s	0.727	11.635	27.55	144.36	5.24	0.76
							2s	0.727	11.635	38.12	216.54	5.68	0.51
16	12.385	13.00	11.43	2	7	7	1	0.727	12.385	21.97	149.97	6.83	1.00
							2	0.727	12.385	33.35	243.43	7.30	0.61
							1s	0.727	12.385	26.07	159.97	6.14	0.86
							2s	0.727	12.385	35.75	239.95	6.71	0.57
17	13.135	13.00	11.88	2	7	7	1	0.727	13.135	23.78	165.31	6.95	1.11
							2	0.727	13.135	35.65	267.18	7.50	0.69
							1s	0.727	13.135	27.97	176.33	6.30	0.96
							2s	0.727	13.135	38.19	264.50	6.93	0.64
18	13.885	13.00	12.33	2	8	8	1	0.727	13.885	22.49	181.37	8.06	1.23
							2	0.727	13.885	33.28	291.99	8.77	0.76
							1s	0.727	13.885	26.85	193.46	7.21	1.07
							2s	0.727	13.885	36.31	290.19	7.99	0.71
19	14.635	13.00	12.78	2	8	8	1	0.727	14.635	23.95	198.14	8.27	1.35
							2	0.727	14.635	34.97	317.88	9.09	0.84
							1s	0.727	14.635	28.40	211.35	7.44	1.18
							2s	0.727	14.635	38.17	317.03	8.31	0.79

Strips type 1 : HA 50X4
Strips type 2 : HAR 45X5

Strips type 1 : 364.0 meters for 3.0 m width of wall
Strips type 2 : 1001.0 m

 * COMPLEMENTARY DATA *

1 STANDARDISATION FILE : AASHTO_LRFD

2 CALCULATION METHOD : Limit state

3 FACTORS :

load cases	LFw	Load factors LFp	LFq1	LFq2	R.E density
1	1.00	1.50	0.00	1.75	1
2	1.35	1.50	1.75	1.75	2
3	1.00	1.00	1.00	1.00	2
1s	1.00	1.50	0.00	1.00	1
2s	1.35	1.50	0.00	1.00	2

R.E density : 1 = min - 2 = max

Resistance factors	RFg	RFgc	RFr	RFc	RFt	RFf
Static	1.00	1.00	1.00	0.65	0.75	0.90
Seismic	1.00	1.00	1.00	0.65	1.00	1.20

4 STRIPS :

Strip type 1

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

Strip type 2

Width tolerance : 0.00 mm Thickness tolerance : 0.00 mm

5 FACING :

Vertical strip spacing : 0.750 mm
 bottom height : 0.365 mm
 Facing flexibility : To=Tmax

Calculations

PROJECT: - Danang - Quang Ngai
REFERENCE: - 8m Max Height

SUBJECT: - Design of Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

Design of 1st Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

In refer to the Publication FHWA-NHI-10-024 by U.S. Department of Transportation Federal Highway Administration, the following specification are made in the design:

Reinforcement Rupture

The static impact force, adds an additional horizontal force to the upper 2 layers of soil reinforcement, It is recommended that the upper layer of soil reinforcement be designed for a rupture impact load equivalent to a static load of **33.5 kN/m** of wall; and the second layer be designed with a rupture impact load equivalent to a static load of **8.8 kN/m**. The load factor for impact is equal to **1.0**.

Reinforcement Pullout

The pullout resistance of the soil reinforcement to the impact load is resisted over the full-length of the reinforcements (i.e., L). It is recommended that the upper layer of soil reinforcement be designed for a pullout impact load equivalent to a static load of **19.0 kN/m** of wall; and the second layer be designed with a pullout impact load equivalent to a static load of **8.8 kN/m**.

Resistance Factors for Tensile and Pullout Resistance

The resistance factors presented in Table 4-7 for "Combined static/traffic barrier impact" are recommended for Extreme Event II impact loading specified in FHWA-NHI-10-024. The tensile and connection rupture resistance factors are a function of the type of reinforcement. For strip strips, **Tensile resistance factor of 1 is recommended**. A **pullout resistance factor of 1.00** is recommended for metallic reinforcements.

Reinforcement Rupture Assessment for 1st Uppermost Layer of Strip

Calculation Width	=	3	m
Additional External Static Load due to Impact Load from Barrier	=	33.5	kN/m
Total Additional External Static Load due to Impact Load from Barrier	=	100.5	kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez)	=	25.27	kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez)	=	37.86	kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	7	5.23	36.61	137.11	25.27	6.00	1.11	OK
2	1	7	14.58	102.06	202.58	25.27	8.00	1.00	OK

Min Reinforcing Strip shall be Provided = 8

Reinforcement Rupture Assessment for 2nd Uppermost Layer of Strip

Calculation Width	=	3	m
Additional External Static Load due to Impact Load from Barrier	=	8.8	kN/m
Total Additional External Static Load due to Impact Load from Barrier	=	26.4	kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez)	=	25.27	kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez)	=	37.86	kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	7.41	29.64	56.04	25.27	3.00	1.35	OK
2	1	4	16.50	66	92.4	25.27	4.00	1.09	OK

Min Reinforcing Strip shall be Provided = 4

Reinforcement Pullout Assessment for 1st Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 19 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 57 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip	Length of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(m)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	7	4.5	5.23	36.61	93.61	12.44	8.00	1.06	OK
2	1	7	4.5	14.58	102.06	159.06	35.41	5.00	1.11	OK

Min Reinforcing Strip shall be Provided = 8

Reinforcement Pullout Assessment for 2nd Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 8.8 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 26.4 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip	Length of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(m)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	4.5	7.41	29.64	56.04	19.19	3.00	1.03	OK
2	1	4	4.5	16.50	66	92.4	44.33	3.00	1.44	OK

Min Reinforcing Strip shall be Provided = 3

Conclusion

Min Reinforcing Strip Provided for 1st Uppermost Row	8	Nos
Min Reinforcing Strip Provided for 2nd Uppermost Row	4	Nos

Calculations

PROJECT: - Danang - Quang Ngai
REFERENCE: - 8m Max Height

SUBJECT: - Design of Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

Design of 1st Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

In refer to the Publication FHWA-NHI-10-024 by U.S. Department of Transportation Federal Highway Administration, the following specification are made in the design:

Reinforcement Rupture

The static impact force, adds an additional horizontal force to the upper 2 layers of soil reinforcement, It is recommended that the upper layer of soil reinforcement be designed for a rupture impact load equivalent to a static load of **33.5 kN/m** of wall; and the second layer be designed with a rupture impact load equivalent to a static load of **8.8 kN/m**. The load factor for impact is equal to **1.0**.

Reinforcement Pullout

The pullout resistance of the soil reinforcement to the impact load is resisted over the full-length of the reinforcements (i.e., L). It is recommended that the upper layer of soil reinforcement be designed for a pullout impact load equivalent to a static load of **9.0 kN/m** of wall; and the second layer be designed with a pullout impact load equivalent to a static load of **8.8 kN/m**.

Resistance Factors for Tensile and Pullout Resistance

The resistance factors presented in Table 4-7 for "Combined static/traffic barrier impact" are recommended for Extreme Event II impact loading specified in FHWA-NHI-10-024. The tensile and connection rupture resistance factors are a function of the type of reinforcement. For strip strips, **Tensile resistance factor of 1 is recommended**. A **pullout resistance factor of 1.00** is recommended for metallic reinforcements.

Reinforcement Rupture Assessment for 1st Uppermost Layer of Strip

Calculation Width	=	3	m
Additional External Static Load due to Impact Load from Barrier	=	33.5	kN/m
Total Additional External Static Load due to Impact Load from Barrier	=	100.5	kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez)	=	25.27	kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez)	=	37.86	kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip (kN)	Total Max Tensile Load (kN)	Total Max Tensile Load including Impact Load (kN)	Capacity per Strip (kN)	Min No. of Strip Required (Nos)	Capacity/Demand Ratio	Status
1	1	6	5.11	30.66	131.16	25.27	6.00	1.18	OK
2	1	6	14.76	88.56	189.06	25.27	8.00	1.07	OK

Min Reinforcing Strip shall be Provided = 8

Reinforcement Rupture Assessment for 2nd Uppermost Layer of Strip

Calculation Width	=	3	m
Additional External Static Load due to Impact Load from Barrier	=	8.8	kN/m
Total Additional External Static Load due to Impact Load from Barrier	=	26.4	kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez)	=	25.27	kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez)	=	37.86	kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip (kN)	Total Max Tensile Load (kN)	Total Max Tensile Load including Impact Load (kN)	Capacity per Strip (kN)	Min No. of Strip Required (Nos)	Capacity/Demand Ratio	Status
1	1	4	5.55	22.2	48.6	25.27	2.00	1.04	OK
2	1	4	13.26	53.04	79.44	25.27	4.00	1.27	OK

Min Reinforcing Strip shall be Provided = 4

Reinforcement Pullout Assessment for 1st Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 19 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 57 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip	Length of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(m)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	6	5.8	5.11	30.66	87.66	15.22	6.00	1.04	OK
2	1	6	5.8	14.76	88.56	145.56	44.52	4.00	1.22	OK

Min Reinforcing Strip shall be Provided = 6

Reinforcement Pullout Assessment for 2nd Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 8.8 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 26.4 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip	Length of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(m)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	5.8	5.55	22.2	48.6	22.01	3.00	1.36	OK
2	1	4	5.8	13.26	53.04	79.44	53.55	2.00	1.35	OK

Min Reinforcing Strip shall be Provided = 3

Conclusion

Min Reinforcing Strip Provided for 1st Uppermost Row	8	Nos
Min Reinforcing Strip Provided for 2nd Uppermost Row	4	Nos

Calculations

PROJECT: - Danang - Quang Ngai
REFERENCE: - 10m Max Height

SUBJECT: - Design of Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

Design of 1st Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

In refer to the Publication FHWA-NHI-10-024 by U.S. Department of Transportation Federal Highway Administration, the following specification are made in the design:

Reinforcement Rupture

The static impact force, adds an additional horizontal force to the upper 2 layers of soil reinforcement, It is recommended that the upper layer of soil reinforcement be designed for a rupture impact load equivalent to a static load of **33.5 kN/m** of wall; and the second layer be designed with a rupture impact load equivalent to a static load of **8.8 kN/m**. The load factor for impact is equal to **1.0**.

Reinforcement Pullout

The pullout resistance of the soil reinforcement to the impact load is resisted over the full-length of the reinforcements (i.e., L). It is recommended that the upper layer of soil reinforcement be designed for a pullout impact load equivalent to a static load of **19.0 kN/m** of wall; and the second layer be designed with a pullout impact load equivalent to a static load of **8.8 kN/m**.

Resistance Factors for Tensile and Pullout Resistance

The resistance factors presented in Table 4-7 for "Combined static/traffic barrier impact" are recommended for Extreme Event II impact loading specified in FHWA-NHI-10-024. The tensile and connection rupture resistance factors are a function of the type of reinforcement. For strip strips, **Tensile resistance factor of 1 is recommended**. A **pullout resistance factor of 1.00** is recommended for metallic reinforcements.

Reinforcement Rupture Assessment for 1st Uppermost Layer of Strip

Calculation Width	=	3	m
Additional External Static Load due to Impact Load from Barrier	=	33.5	kN/m
Total Additional External Static Load due to Impact Load from Barrier	=	100.5	kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez)	=	25.27	kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez)	=	37.86	kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	8.06	32.24	132.74	25.27	6.00	1.14	OK
2	1	4	22.18	88.72	189.22	25.27	8.00	1.07	OK

Min Reinforcing Strip shall be Provided = 8

Reinforcement Rupture Assessment for 2nd Uppermost Layer of Strip

Calculation Width	=	3	m
Additional External Static Load due to Impact Load from Barrier	=	8.8	kN/m
Total Additional External Static Load due to Impact Load from Barrier	=	26.4	kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez)	=	25.27	kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez)	=	37.86	kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	3.37	13.48	39.88	25.27	2.00	1.27	OK
2	1	4	8.68	34.72	61.12	25.27	3.00	1.24	OK

Min Reinforcing Strip shall be Provided = 3

Reinforcement Pullout Assessment for 1st Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 19 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 57 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip	Length of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(m)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	7	8.06	32.24	89.24	20.26	5.00	1.14	OK
2	1	4	7	22.18	88.72	145.72	56.29	3.00	1.16	OK

Min Reinforcing Strip shall be Provided = 5

Reinforcement Pullout Assessment for 2nd Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 8.8 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 26.4 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip	Length of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(m)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	7	3.37	13.48	39.88	23.06	2.00	1.16	OK
2	1	4	7	8.68	34.72	61.12	60.01	2.00	1.96	OK

Min Reinforcing Strip shall be Provided = 2

Conclusion

Min Reinforcing Strip Provided for 1st Uppermost Row	8	Nos
Min Reinforcing Strip Provided for 2nd Uppermost Row	3	Nos

Calculations

PROJECT: - Danang - Quang Ngai
REFERENCE: - 12m Max Height

SUBJECT: - Design of Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

Design of 1st Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

In refer to the Publication FHWA-NHI-10-024 by U.S. Department of Transportation Federal Highway Administration, the following specification are made in the design:

Reinforcement Rupture

The static impact force, adds an additional horizontal force to the upper 2 layers of soil reinforcement, It is recommended that the upper layer of soil reinforcement be designed for a rupture impact load equivalent to a static load of **33.5 kN/m** of wall; and the second layer be designed with a rupture impact load equivalent to a static load of **8.8 kN/m**. The load factor for impact is equal to **1.0**.

Reinforcement Pullout

The pullout resistance of the soil reinforcement to the impact load is resisted over the full-length of the reinforcements (i.e., L). It is recommended that the upper layer of soil reinforcement be designed for a pullout impact load equivalent to a static load of **9.0 kN/m** of wall; and the second layer be designed with a pullout impact load equivalent to a static load of **8.8 kN/m**.

Resistance Factors for Tensile and Pullout Resistance

The resistance factors presented in Table 4-7 for "Combined static/traffic barrier impact" are recommended for Extreme Event II impact loading specified in FHWA-NHI-10-024. The tensile and connection rupture resistance factors are a function of the type of reinforcement. For strip strips, **Tensile resistance factor of 1 is recommended**. A **pullout resistance factor of 1.00** is recommended for metallic reinforcements.

Reinforcement Rupture Assessment for 1st Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 33.5 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 100.5 kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez) = 25.27 kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez) = 37.86 kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	5	7.16	35.8	136.3	25.27	6.00	1.11	OK
2	1	5	20.25	101.25	201.75	25.27	8.00	1.00	OK

Min Reinforcing Strip shall be Provided = 8

Reinforcement Rupture Assessment for 2nd Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 8.8 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 26.4 kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez) = 25.27 kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez) = 37.86 kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	7.08	28.32	54.72	25.27	3.00	1.39	OK
2	1	4	16.18	64.72	91.12	25.27	4.00	1.11	OK

Min Reinforcing Strip shall be Provided = 4

Reinforcement Pullout Assessment for 1st Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 19 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 57 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip	Length of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(m)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	5	8.5	7.16	35.8	92.8	23.51	4.00	1.01	OK
2	1	5	8.5	20.25	101.25	158.25	66.88	3.00	1.27	OK

Min Reinforcing Strip shall be Provided = 4

Reinforcement Pullout Assessment for 2nd Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 8.8 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 26.4 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip	Length of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(m)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	8.5	7.08	28.32	54.72	32.63	2.00	1.19	OK
2	1	4	8.5	16.18	64.72	91.12	75.36	2.00	1.65	OK

Min Reinforcing Strip shall be Provided = 2

Conclusion

Min Reinforcing Strip Provided for 1st Uppermost Row	8	Nos
Min Reinforcing Strip Provided for 2nd Uppermost Row	4	Nos

Calculations

PROJECT : - Danang - Quang Ngai
REFERENCE : - 15m Max Height

SUBJECT: - Design of Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

Design of 1st Uppermost Row and 2nd Uppermost Row Strip to resist Impact Load from Barrier

In refer to the Publication FHWA-NHI-10-024 by U.S. Department of Transportation Federal Highway Administration, the following specification are made in the design:

Reinforcement Rupture

The static impact force, adds an additional horizontal force to the upper 2 layers of soil reinforcement, It is recommended that the upper layer of soil reinforcement be designed for a rupture impact load equivalent to a static load of **33.5 kN/m** of wall; and the second layer be designed with a rupture impact load equivalent to a static load of **8.8 kN/m**. The load factor for impact is equal to **1.0**.

Reinforcement Pullout

The pullout resistance of the soil reinforcement to the impact load is resisted over the full-length of the reinforcements (i.e., L). It is recommended that the upper layer of soil reinforcement be designed for a pullout impact load equivalent to a static load of **19.0 kN/m** of wall; and the second layer be designed with a pullout impact load equivalent to a static load of **8.8 kN/m**.

Resistance Factors for Tensile and Pullout Resistance

The resistance factors presented in Table 4-7 for "Combined static/traffic barrier impact" are recommended for Extreme Event II impact loading specified in FHWA-NHI-10-024. The tensile and connection rupture resistance factors are a function of the type of reinforcement. For strip strips, **Tensile resistance factor of 1 is recommended**. A **pullout resistance factor of 1.00** is recommended for metallic reinforcements.

Reinforcement Rupture Assessment for 1st Uppermost Layer of Strip

Calculation Width	=	3	m
Additional External Static Load due to Impact Load from Barrier	=	33.5	kN/m
Total Additional External Static Load due to Impact Load from Barrier	=	100.5	kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez)	=	25.27	kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez)	=	37.86	kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	8.90	35.6	136.1	25.27	6.00	1.11	OK
2	1	4	25.27	101.08	201.58	25.27	8.00	1.00	OK

Min Reinforcing Strip shall be Provided = 8

Reinforcement Rupture Assessment for 2nd Uppermost Layer of Strip

Calculation Width	=	3	m
Additional External Static Load due to Impact Load from Barrier	=	8.8	kN/m
Total Additional External Static Load due to Impact Load from Barrier	=	26.4	kN (Per Calculation Width)
Tensile Capacity for HA 50 x 4 Strip (Denote Type 1 Strip in Valdez)	=	25.27	kN (With Resistance Factor of 1)
Tensile Capacity for HAR 45 x 5 Strip (Denote Type 2 Strip in Valdez)	=	37.86	kN (With Resistance Factor of 1)

Result Extracted from Valdez (Force without Impact Load)					Reinforcement Rupture Assessment				
Load Case	Strip Type	Nos. of Strip	Max Tensile Load per Strip	Total Max Tensile Load	Total Max Tensile Load including Impact Load	Capacity per Strip	Min No. of Strip Required	Capacity/Demand Ratio	Status
		(Nos)	(kN)	(kN)	(kN)	(kN)	(Nos)		
1	1	4	7.00	28	54.4	25.27	3.00	1.39	OK
2	1	4	16.11	64.44	90.84	25.27	4.00	1.11	OK

Min Reinforcing Strip shall be Provided = 4

Reinforcement Pullout Assessment for 1st Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 19 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 57 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip (Nos)	Length of Strip (m)	Max Tensile Load per Strip (kN)	Total Max Tensile Load (kN)	Total Max Tensile Load including Impact Load (kN)	Capacity per Strip (kN)	Min No. of Strip Required (Nos)	Capacity/Demand Ratio	Status
1	1	4	13	8.90	35.6	92.6	35.96	3.00	1.16	OK
2	1	4	13	25.27	101.08	158.08	102.28	2.00	1.29	OK

Min Reinforcing Strip shall be Provided

= 3

Reinforcement Pullout Assessment for 2nd Uppermost Layer of Strip

Calculation Width = 3 m
Additional External Static Load due to Impact Load from Barrier = 8.8 kN/m
Total Additional External Static Load due to Impact Load from Barrier = 26.4 kN (Per Calculation Width)

Result Extracted from Valdez (Force without Impact Load)						Reinforcement Pullout Assessment				
Load Case	Strip Type	Nos. of Strip (Nos)	Length of Strip (m)	Max Tensile Load per Strip (kN)	Total Max Tensile Load (kN)	Total Max Tensile Load including Impact Load (kN)	Capacity per Strip (kN)	Min No. of Strip Required (Nos)	Capacity/Demand Ratio	Status
1	1	4	13	7.00	28	54.4	55.45	1.00	1.02	OK
2	1	4	13	16.11	64.44	90.84	128.06	1.00	1.41	OK

Min Reinforcing Strip shall be Provided

= 1

Conclusion

Min Reinforcing Strip Provided for 1st Uppermost Row	8	Nos
Min Reinforcing Strip Provided for 2nd Uppermost Row	4	Nos

B. MSE WALL (Barrier)

BARRIER ON MSE WALL CALCULATION SHEET

1. General

- Live load : HL93
- Test level : 44.5 KN
- Design standard: 22TCN-272-05 Viet Nam bridge design specification
AASHTO LRFD 2007 - bridge design specification
- Unit : KN and m, N and mm

2. Material property

2.1. Concrete

- Compressive strength of cylindrical at 28 days: $f_c = 25$ MPa
- Concrete density $\gamma_c = 24.5$ KN/m³
- Elastic modulus $E_c = 0.043 \cdot \gamma_c^{1.5} \cdot \sqrt{f_c} = 26875$ N/mm²
- Tensile strength of concrete: $f_r = 0.63 \cdot \sqrt{f_c} = 3.15$ N/mm²

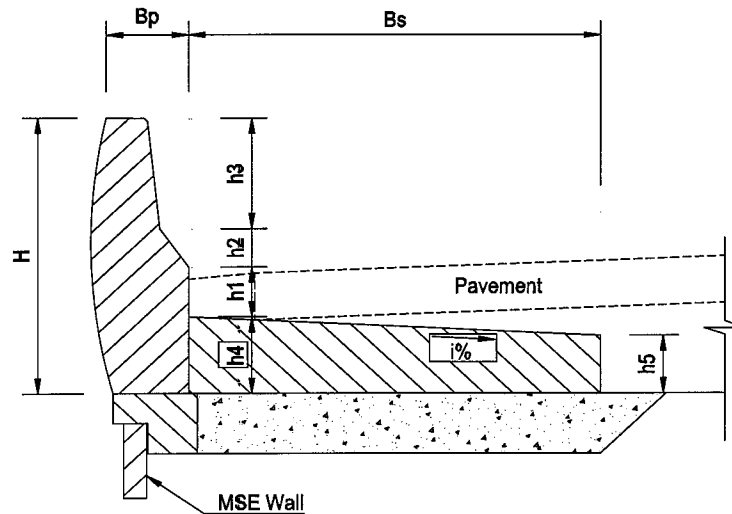
2.2. Steel

- Elastic module of steel : $E_s = 200000$ N/mm²
- Liquid limit: $f_y = 400$ N/mm²

2.2. Pavement and soil

- Thickness of Asphal pavement $t = 0.31$ m
- Unit weight of soil $\gamma_s = 17.66$ KN/m³
- Seftweight of Pavement $\gamma_{as} = 22.5$ KN/m³
- Internal friction angle of soil $\phi'_f = 30$ deg

3. Dimention of Barrier on MSE Wall



Barrier dimension			
Item	Unit	Symbol	Value
Thickness of barrier wall	m	B_p	0.500
Width of Moment slab	m	B_s	1.000
Height of Barrier wall	m	h_1	0.270
Height of Barrier wall	m	h_2	0.255
Height of Barrier wall	m	h_3	0.815
Height of pavement structure	m	h_p	0.160
Height of Moment slab	m	h_4	0.300
Height of Moment slab	m	h_5	0.250
Longitudinal length of Precast wall	m	L_p	6.000
Longitudinal length of moment slab	m	L_s	6.000

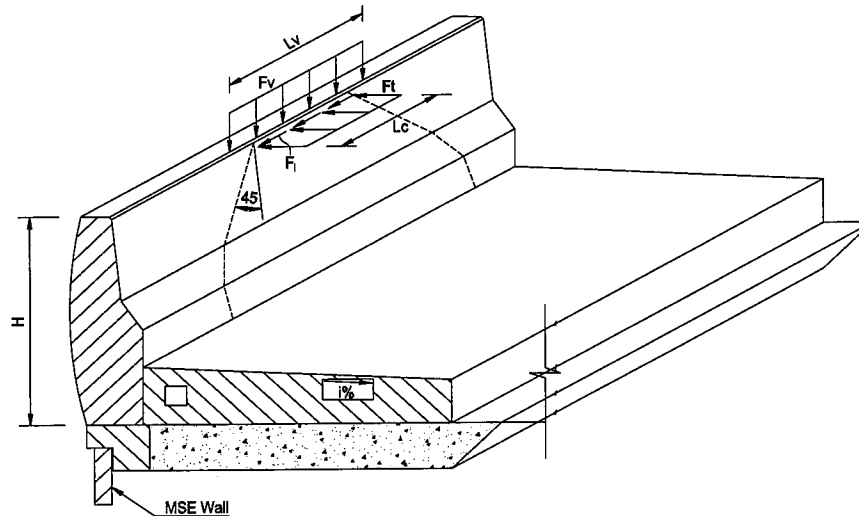
4. Loading

4.1. Deadload

Item	Unit	Value	Transverse eccentricity (m)
Precast parapet	Kn/m	20.58	0.22
Moment slab	Kn/m	6.74	0.50
Overburden material	Kn/m	6.86	0.50

4.2. Impact load

- Impact load in accordance to Table A13.2.-1 AASHTO LRFD 2007



- Impact force equivalent with Test level TL4

Design forces and designations	Unit	Symbol	Value
Transverse force	Kn	F_t	44.50
Longitudinal force	Kn	F_L	0.00
Vertical force	Kn	F_v	0.00
Effective Length of Longitudinal force	m	$L_L = L_t$	1.07
Effective Length of Vertical force	m	L_v	0.00
Effective Height	m	H_e	1.07

4.3. Horizontal earth pressure: (EH)

- Basic earth pressure shall be assumed to be linearly proportional to the depth of earth and taken as.

$$P_h = K_a \cdot \gamma_s \cdot g \cdot h_4 \cdot 10^{-9} \quad (3.11.5.1-1)$$

- Active earth pressure coefficient $K_a = 0.33$

Covering (h_4)	K_a	γ_s (Kg/m ³)	g (m/s ²)	P_h (Kn/m ²)
0.30 m	0.33	1800.	9.81	1.75

4.4. Horizontal earthquake force: (Pe)

- Calculate the equivalent static earthquake loading P_e

$$P_e = C_{sm} \cdot W / L$$

In which:

- P_e : Equivalent uniform static seismic loading per unit length (N/mm)

- C_{sm} : The dimensionless elastic seismic response coefficient

In here C_{sm} applied with maximum value $C_{sm} = 2.5A$ with A is ground acceleration

P_e (N/mm)	A	C_{sm}	W (N/mm)	L (mm)
6.23	0.091	0.23	163905.00	6000.00

4.5. Live load (LL)

- Live load will be considered as equivalent uniform load of 13.0 KN/m² and applied to service state and bearing reaction of soil

5. Load combination and Summarize design force

- Load combination and load combination factor shall be taken as Table 3.4.1-1

Loading	Mark	Service I	Ex IA (CT)	Ex IB (CT)	Ex IIA (EQ)	Ex IIB (EQ)
Dead load of structural	DC	1.00	1.25	0.90	1.25	0.90
Dead load of wearing	DW	1.00	1.50	0.65	1.50	0.65
Live load	LL	1.00	0.50	0.50	0.00	0.00
Horizontal earth pressure	EH	1.00	1.50	0.90	1.50	0.90
Collision load	CT	1.00	1.00	1.00	0.00	0.00
Earthquake load	EQ	1.00	0.00	0.00	1.00	1.00

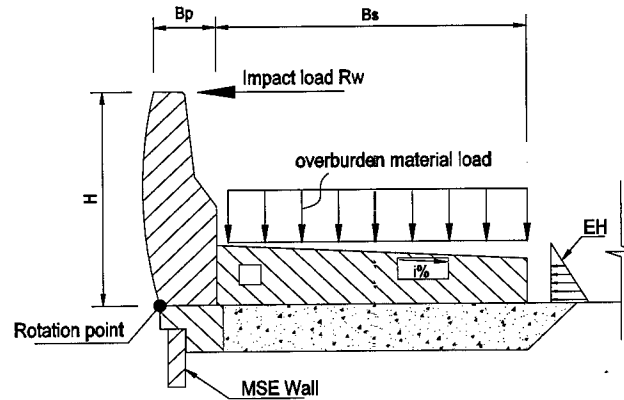
- Member force applied to Parapet (no factor) with length of 6 (m)

Loading	Vertical N (Kn)	Lateral H (Kn)	Arm length		Moment	
			X (m)	Y (m)	Mx (Kn.m)	My (Kn.m)
Dead load of parapet wall	123.48	-	0.22	-	27.17	-
Dead load of moment slab	40.43	-	1.00	-	40.43	-
Dead load of wearing	41.18	-	1.00	-	41.18	-
Horizontal earth pressure	-	10.49	-	0.10	-	1.05
Live load	78.00	-	1.00	-	78.00	-
Collision load	-	44.50	0.22	1.64	-	72.98
Earthquake load	-	37.37	-	0.48	-	17.90

Combination Loading	Mark	Vertical	Lateral	Moment	
		N (Kn)	H (Kn)	Mx (Kn.m)	My (Kn.m)
Service I A (without Live load)	Ser IA	205.08	10.49	108.77	1.05
Service I B (with Live load)	Ser IB	283.08	10.49	186.77	1.05
Extreme event IA (CT)	Ex IA	305.64	60.23	146.25	74.55
Extreme event IB (CT)	Ex IB	213.28	53.94	126.60	73.92
Extreme event IIA (EQ)	Ex IIA	266.64	53.10	146.25	19.47
Extreme event IIB (EQ)	Ex IIB	174.28	46.81	87.60	18.84

6. Stability checking

6.1. Overturning of the barrier



- Overturning of the barrier may be taken by below fomular:

$$\phi.M_g \geq \gamma.M_L$$

In which:

- Resistance factor: ϕ 0.9

- Load factor: γ 1.0 for extreme state

- The factored static moment resistance (due to seft weight of Parapet wall, slab, and overburden material)

$$M_g = M_{xDC} + M_{xDW}$$

- The factored static moment (due to Collision load or Earthquake, and horizontal earth pressure)

$$M_L = M_{yCT} + M_{yEH} \quad \text{or} \quad M_L = M_{yEQ} + M_{yEH}$$

Combination Loading	Mark	Moment		Check
		$\phi.M_g$ (Kn.m)	$\gamma.M_L$ (Kn.m)	$\phi.M_g \geq \gamma.M_L$
Service I A (without Live load)	Ser IA	97.89	1.05	OK
Service I B (with Live load)	Ser IB	168.09	1.05	OK
Extreme event IA (CT)	Ex IA	131.63	74.55	OK
Extreme event IB (CT)	Ex IB	113.94	73.92	OK
Extreme event IIA (EQ)	Ex IIA	131.63	19.47	OK
Extreme event IIB (EQ)	Ex IIB	78.84	18.84	OK

6.2. Sliding

- Sliding of the barrier may be taken by below fomular:

$$\phi.P \geq \gamma.H$$

In which:

- Resistance factor: ϕ 0.8

- Load factor: γ 1.0 for extreme state

- P is sliding resistance force due to friction force between moment slab and soil

$$P = \tan(\phi).N$$

- ϕ is friction angle soil under moment slab

$$\phi = 30 \quad (\text{deg})$$

- N is nominal force of all member effect to moment slab

- H is factored lateral force

Combination Loading	Mark	N	$\phi.P$	H	Check
		(Kn)	(Kn)	(Kn)	$\phi.P \geq H$
Service I A (without Live load)	Ser IA	81.60	37.69	10.49	OK
Service I B (with Live load)	Ser IB	159.60	130.75	10.49	OK
Extreme event IA (CT)	Ex IA	151.29	141.17	60.23	OK
Extreme event IB (CT)	Ex IB	102.15	98.51	53.94	OK
Extreme event IIA (EQ)	Ex IIA	112.29	123.16	53.10	OK
Extreme event IIB (EQ)	Ex IIB	63.15	80.50	46.81	OK

C. GEOTECHNICAL ANALYSIS

A. SOIL CONDITION AND SECTION SEGMENTATION

Combining the geological condition with embankment height, and structures – abutment, culverts as well as length of the section after being divided for sectioning. Following are only principles in general for sectioning according to the soil condition, design level and recommendation for selection of soft soil treatment method and summarized in the tables below:

Table 1: Soil condition and section segmentation for main line

No	SECTION	Locaton(STA.)	Extention (m)	Standard section	Height of embankment (m)	Layer thickness (m)				
						1a	1b	1c	2a	2b
1	P5-S1	Km32+000 – Km37+400	5400	None						
2	P5-S2	Km37+400 – Km37+760	360	Km37+580	6.6				3.5	
3	P5-S3	Km37+760 – Km38+800	1040	None						
4	P5-S4	Km38+800 – Km39+120	320	Km38+960	7.0				4.5	
5	P5-S5	Km39+120 – Km39+748	628	None						
6	IB LRB08-A2	Km39+748 – Km39+772	24	Km39+751	7.1				4.1	
7	OB LRB08-A2	Km39+761 – Km39+785	24	Km39+764	6.4				4.1	
8	P5-S6	Km39+785 – Km40+620	835	None						
9	P5-S7	Km40+620 – Km40+820	200	Km40+800	8.7				4.1	
10	P5-S8	Km40+620 – Km42+000	1380	None						

B. SOIL PROPERTIES

According to Soil Investigation Report, soil properties for soft soil treatment design as well as filling material are summarized in the tables below:

1. Soil properties for filling material

According to material investigation test result, the quantity of each quarry, filling material properties for calculating is selected as in the table 2.

Table2: Filling material properties using for design

Properties	Unit	Calculating value (Ho Dinh pits)
γ	t/m ³	2.07
C	t/m ²	2.10
ϕ	degree	21.5

2. Soil properties for soft soil treatment design

According to the soil investigation data, the subsoil is relatively uniform comprising of soft to medium clay, distributes from the ground surface to the depth of 4.5m approximately. Sandy soil was some time detected but only as seams. The soft soil, which will mostly affect to the stability of the embankment, was stratified into soil 2a and 2b in the Soil Investigation Report. The following content will be the evaluation of soil values of these soils for soft soil treatment design.

(Pls. refer to Soil Investigation Report for PKG5 made by Thanh Cong Construction Consultant Joint Stock Company for more detailed)

Table 3 Summary of Soil Parameters Recommended for Soft Soil Treatment Design

Layer No.	Soil	SPT Value	γ_t (ton/m3)	γ_{sat} (ton/m3)	C (ton/m2)	ϕ (deg.)	m	Cc	Cs	OCR	Cvx10-3 (cm2/s)	Cv/Ch
1a	GRAVEL	50				47.4						
1b	SAND	11	2.03	2.07		32.8						
2a-1	CLAY (CL)	6.0	1.84	1.86	3.68	0.0	0.13	0.231	0.027	6.3	0.458	1
2a-2	CLAY (CL)	5.0	1.84	1.86	3.1	0.0	0.13	0.231	0.027	6.3	0.458	1
2b	CLAY (CL)	9.8	1.88	1.91	6.01	0.0						

2a-1: Layer 2a for LRB08-A2 (Km39+748-Km39+785)

2a-2: Layer 2a for other sections

1. Treatment method

SECTION	Extention (m)	Height of embankment (m)	Soft soil thickness (m)	Height of embankment (m)	Treatment method				Remark
					Treatment method Spacing(m)	Treatment depth (m)	Geotextile layer		
							(200KN /m)	(400KN /m)	
Km32+000 - Km37+400	5400				NT				
Km37+400 - Km37+760	360	6.6	3.5	6.6	NT		1		
Km37+760 - Km38+800	1040				NT				
Km38+800 - Km39+120	320	7	4.5	7	NT			1	
Km39+120 - Km39+748	628				NT				
Km39+748 - Km39+772	24	7.1	4.1	7.1	SR	2.5			IB LRB08 A2
Km39+748 - Km39+772	24	7.1		7.1	SR				Longitude
Km39+761 - Km39+785	24	6.4	4.1	6.4	SR	2.5			OB LRB08 A2
Km39+761 - Km39+785	24	6.4		6.4	SR				Longitude
Km39+785 - Km40+620	835				NT				
Km40+620 - Km40+820	200	8.7	4.1	8.7	NT		1		
Km40+620 - Km42+000	1380				NT				

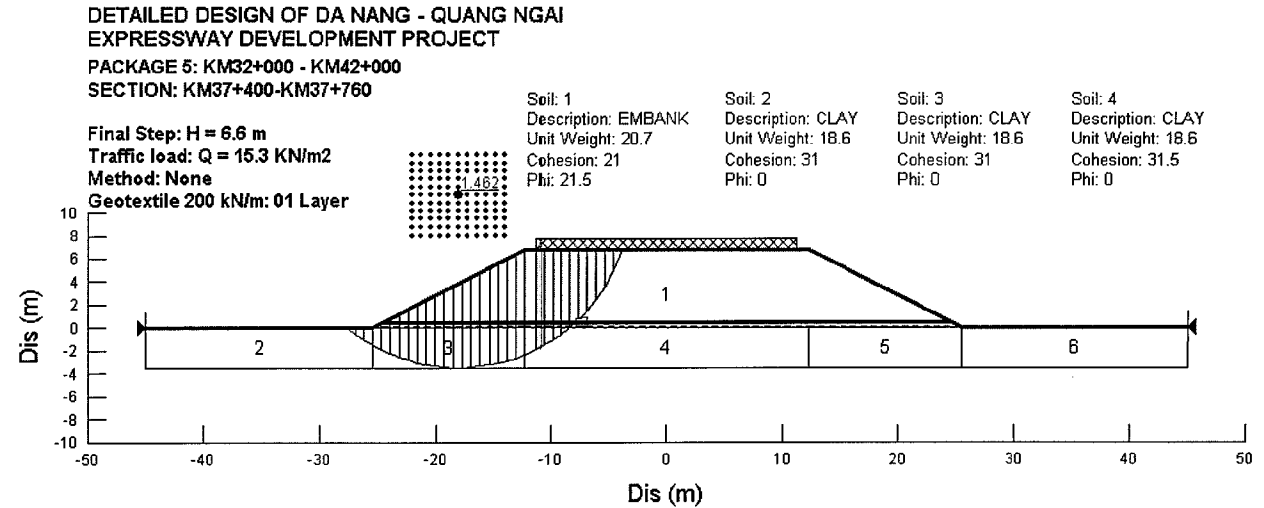
SECTION	Filling process						Total time (month)	Remark
	First stage		Second stage		Thirst stage			
	Filling height (m)	Waiting time (month)	Filling height (m)	Waiting time (month)	Filling height (m)	Waiting time (month)		
Km32+000 - Km37+400								
Km37+400 - Km37+760								
Km37+760 - Km38+800								
Km38+800 - Km39+120								
Km39+120 - Km39+748								
Km39+748 - Km39+772								IB LRB08 A2
Km39+748 - Km39+772								Longitude
Km39+761 - Km39+785								OB LRB08 A2
Km39+761 - Km39+785								Longitude
Km39+785 - Km40+620								
Km40+620 - Km40+820								
Km40+620 - Km42+000								

[illegible]

2) Slope Stability Analysis

Content	Analysis Step				Remark
	Step 1	Step 2	Step 3	Final	
H(m)	-	-	-	6.6	
FS	-	-	-	1.462	

1. Final Step



3) Settlement analysis calculate output data

1. Input Data For Calculation Settlement

Analysis Control

- Total Load Stage : 2
- Calculation Method : Total Load Method
- Calculation Max. Time : 12 day

Node Coordinate Data

- Total Node No. : 15

Node No.	X (m)	Y (m)
1	-12.25	6.70
2	0.00	6.70
3	12.25	6.70
4	-50.00	0.00
5	-25.45	0.00
6	-12.25	0.00
7	12.25	0.00
8	25.45	0.00
9	50.00	0.00
10	-50.00	-3.50
11	-25.45	-3.50
12	-12.25	-3.50
13	12.25	-3.50
14	25.45	-3.50
15	50.00	-3.50

Line Information

- Total Line No. : 7

Line No.	Layer No.	Nodes On Line	rt (tf/m ²)	rsat (tf/m ²)	c (tf/m ²)	Friction Angle(deg)	Soil Type	Soil Mat.No
1		4 5 1 2 3 8 9	2.070	2.070	2.10	21.5	EMBANK	0
2	1	4 5 6 7 8 9	1.840	1.860	3.10	0.0	CLAY	1
3	2	10 11 5-9	1.840	1.860	3.10	0.0	CLAY	2

4	3	10-12 6-9	1.840	1.860	3.10	0.0	CLAY	3
5	4	10-13 7-9	1.840	1.860	3.10	0.0	CLAY	4
6	5	10-14 8 9	1.840	1.860	3.10	0.0	CLAY	5
7	6	10 11 12 13 14 15	0.000	0.000	0.00	0.0	BEDROCK	6

Embankment Step Information

- Total Step No. : 1

Step No.	Line No.	Type
1	1	EMBANK

Soil Properties

- Total Soil No. : 6

Soil No.	Soil Type	Cal.Method	Drainage Condition	Rebound Coefficient	Cu'/P	Ca	(ts/tp)
1	CLAY	Cc	Single	0.000	0.130	0.000	0.00
2	CLAY	Cc	Single	0.000	0.130	0.000	0.00
3	CLAY	Cc	Single	0.000	0.130	0.000	0.00
4	CLAY	Cc	Single	0.000	0.130	0.000	0.00
5	CLAY	Cc	Single	0.000	0.130	0.000	0.00
6	BEDROCK	NONE		0.000	0.000	0.000	0.00

Soil No.	Soil Type	N-Value	Cc	Cs	Pc (tf/m ²)	OCR	e-logP No.	logMv -logP	logCv -logP
1	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
2	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
3	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
4	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
5	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
6	BEDROCK	0.0	0.000	0.000	0.00	0.00	0	0	0

Water Table Information

- Consideration Of Buoyancy : No
- Unit Weight Of Water :1.000 (tf/m³)
- Nodes On Water Surface :4 5 6 7 8 9

Node No.	X (m)	Y (m)
4	-50.00	0.00
5	-25.45	0.00
6	-12.25	0.00
7	12.25	0.00
8	25.45	0.00
9	50.00	0.00

External Load

► Strip Load
- Total Strip Load No. : 1

Load No.	Left			Right			Used State
	X (m)	Y (m)	Load (tf/m ²)	X (m)	Y (m)	Load (tf/m ²)	
1	-11.25	6.70	1.53	11.25	6.70	1.53	Used

Loading Stage Information

- Total Loading Stage No. : 2

Stage No.	Load			Construction Time	
	Loading Type	Load Type	Embankment Step No. or External Load No.	Start (day)	End (day)
1	Load	EMBANK	1	0	10
2	재하	STRIP	1	11	12

Information Of Vertical Drain

- Calculation Method Of the Consolidation :
⇒ Only the degree U_h Of Horizontal Consolidation

Soil Mat. No.	Drain Type	Cal. Method	Well /Smear	Drain			Well Resistance		Soil		Smear Zone	
				Patt-ern	Dis. (m)	Dia. (cm)	Vertical Drainage	Kw (cm/sec)	α (Cv/Ch)	Kh (cm/sec)	Dia. (cm)	Ks (cm/sec)
1	NONE											
2	NONE											
3	NONE											
4	NONE											
5	NONE											

Drain Type → SD:SAND DRAIN, PD:PAPER BOARD DRAIN, SCP:SAND COMPACTION PILE, PACK:PACK DRAIN
GCP:GRAVEL COMPACTION PILE, CD:CYLINDRICAL DRAIN,FIBER:FIBER DRAIN,NONE:None Drain

Well/Smear → NONE:None Consideration both Smear and Well Resistance.

W/S:Both Consideration Well Resistance and Smear Effect

SMEAR:Only Consideration Smear Effect. WELL:Only Consideration Well Resistance

Testing Result Curve

► e-logP Curve

- Curve No. : 1 ⇒ 2a

- Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.130	0.250	0.500	1.000	2.000	4.000	8.000		
e	1.043	1.019	0.992	0.954	0.905	0.840	0.770		

► logCv-logP Curve

- Curve No. : 1 ⇒ 2a

- Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.060	0.180	0.360	0.720	1.440	2.880	5.770		
Cv(cm ² /day)	61.260	54.860	50.110	45.270	39.570	35.080	30.410		

2. Settlement Result

► Settlement each Calculation Point

◎ Calculation Point 1 : x = 0 m

- Total Layer No. : 1

Layer No.	Soil Mat.No	Soil Type	Cal.Method	Height (m)	r_t (tf/m ²)	r_{sat} (tf/m ²)	P_o (tf/m ²)	ΔP (tf/m ²)	Settlement (Sf,cm)
3	3	CLAY	Cc	3.50	1.840	1.860	1.51	15.23	13.36

$\Sigma = 13.36$ cm

Layer No.	Soil Mat.No	eo	e1	Mv (cm ³ /kgf)	Cc	Cs	Drain Type	Drainage Condition	Cv (cm ² /day)
3	3	1.038	0.000	0.000	0.231	0.027	NONE	Single	43.240

- Settlement and Ratio of Consolidation at Calculation Time : 12 day

Layer No.	Soil Mat.No	Soil Type	Cal. Time(day)	U (%)	Settlement (St,cm)	Residual Settlement (Sr,cm)
3	3	CLAY	12	4.94	0.66	12.70

$$[U = 4.94 \% \quad \sum St = 0.66 \text{ cm} \quad \sum Sr = 12.70 \text{ cm}]$$

3. Time and Settlement for Ratio Of Consolidation at each calculation Point

⊙ Calculation Point 1 : x = 0 m

► Degree Of Consolidation and Settlement with time at converted 1 layer
[Calculation Method]

*** Terzaghi's Solution ***

$$\therefore Cv \times t = Tv \times H^2$$

$$- Tv \leq 0.224$$

$$\therefore Ur = 100 * \sqrt{(4 * Tv / \pi)}$$

$$- Tv > 0.224$$

$$\therefore Ur = 100 - 10 * ((1.781 - Tv) / 0.933)$$

- Drain Type : None

- Vertical drainage condition of clay : Single

- Conversion Coefficient Of Consolidation of clay(Cv') : 43.24 cm²/day

- Converted Length Of Clay(H') : 3.5 m

- Vertical drainage path length of clay(H=H') : 3.5 m

☐ Summation of the time and settlement at each layer

☞ at 3 Layer : CLAY(Soil Material No. → 3)

U(%)	5	10	15	20	25	30	35	40	45	50
Time Sett.	--	--	--	--	--	--	--	--	--	--

U(%)	55	60	65	70	75	80	85	90	95	100
Time Sett.	--	--	--	--	--	--	--	--	--	13.36

☐ U & Time & Settlement Of Conversion 1 layer at each Calculation Point

U(%)	5	10	15	20	25	30	35	40	45	50
Time Sett.	0.67	1.34	2.00	2.67	3.34	4.01	4.68	5.34	6.01	6.68

U(%)	55	60	65	70	75	80	85	90	95	100
Time Sett.	7.35	8.02	8.68	9.35	10.02	10.69	11.36	12.02	12.69	13.36

◆ Total time & settlement & U at each Calculation Points ◆

☞ Total degree of consolidation at each calculation points(ratio of settlement) :

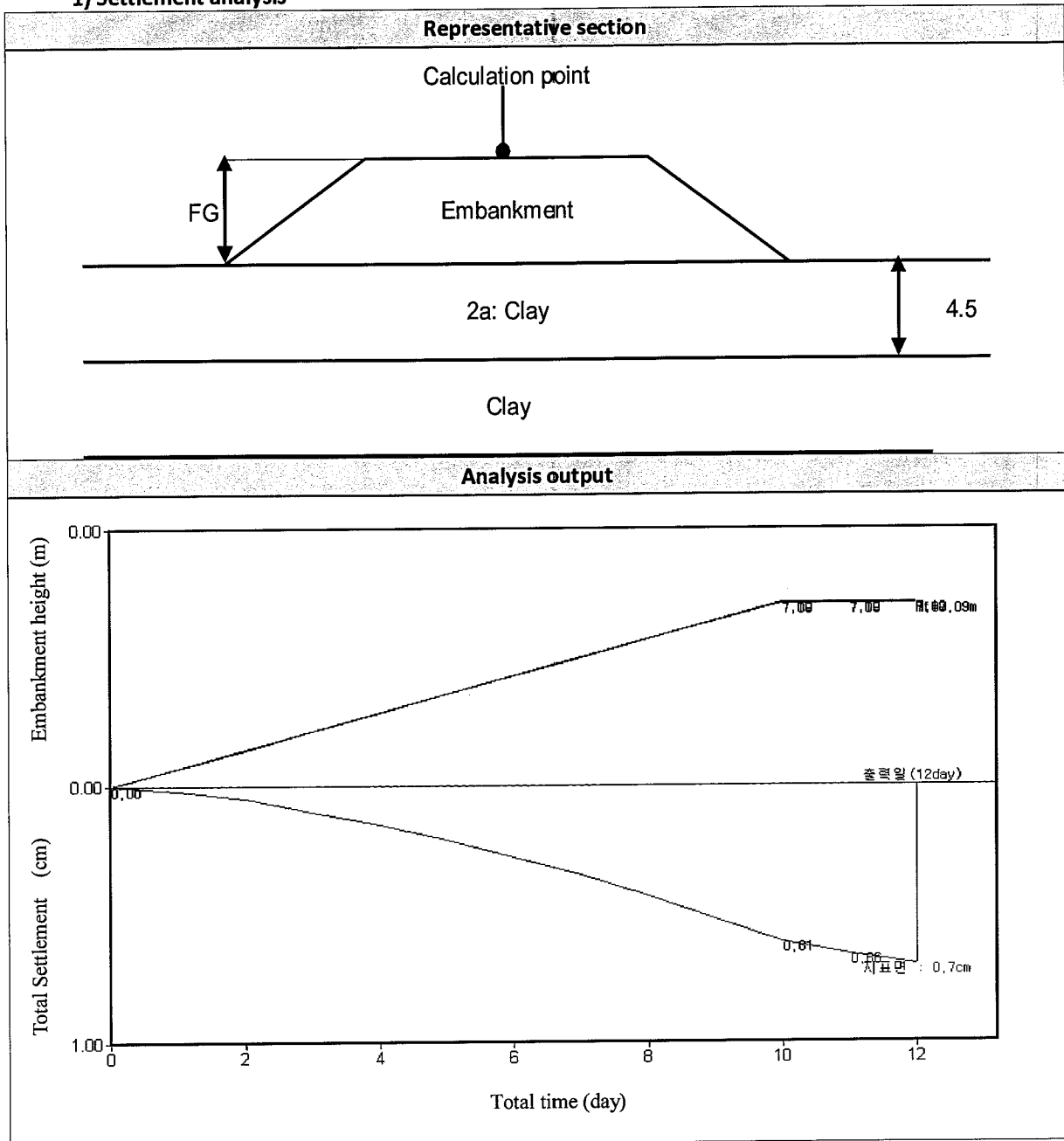
==>[consideration both consolidation settlement and immediately settlement of sandy soil]

U(%)	5	10	15	20	25	30	35	40	45	50
Time Sett.	0.67	1.34	2.00	2.67	3.34	4.01	4.68	5.34	6.01	6.68

U(%)	55	60	65	70	75	80	85	90	95	100
Time Sett.	7.35	8.02	8.68	9.35	10.02	10.69	11.36	12.02	12.69	13.36

2. ANALYSIS OUTPUT (Sta. 38+800 - 39+120) – NO TREATMENT

1) Settlement analysis



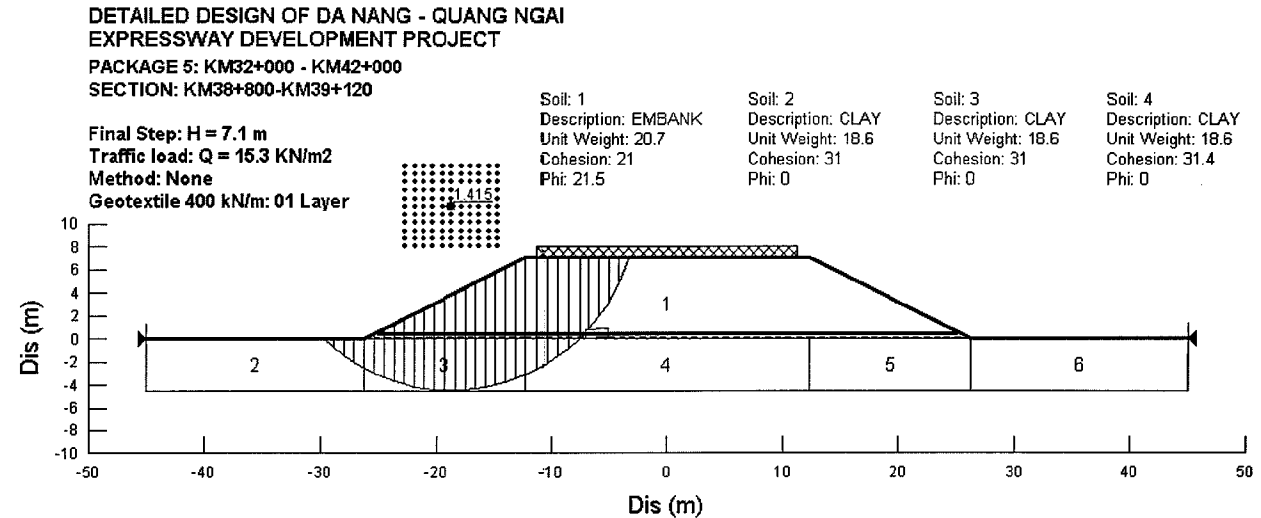
	Section (STA.)	Extention (m)	Standard section	Height of embankment F.G(m)	Allowable residual settlement (cm)	Total Soft soil thickness (m)
1.	38+800 - 39+120	320	38+800	7.1	20	4.5

Treatment method	Spacing (m)	Height of surcharge (m)	Geotextile layer (400KN/m)	Embank step	Treatment Depth(m)	Degree of consolidation (%)	Total settlement (cm)		Residual settlement (cm3)
							Without traffic load	Include traffic load	
NONE	-	-	1	1	-	-	-	18.16	-

2) Slope Stability Analysis

Content	Analysis Step				Remark
	Step 1	Step 2	Step 3	Final	
H(m)	-	-	-	7.1	
FS	-	-	-	1.415	

1. Final Step



3) Settlement analysis calculate output data

1. Input Data For Calculation Settlement

Analysis Control

- Total Load Stage : 2
- Calculation Method :Total Load Method
- Calculation Max. Time : 12 day

Node Coordinate Data

- Total Node No. : 15

Node No.	X (m)	Y (m)
1	-12.25	7.10
2	0.00	7.10
3	12.25	7.10
4	-50.00	0.00
5	-26.25	0.00
6	-12.25	0.00
7	12.25	0.00
8	26.25	0.00
9	50.00	0.00
10	-50.00	-4.50
11	-26.25	-4.50
12	-12.25	-4.50
13	12.25	-4.50
14	26.25	-4.50
15	50.00	-4.50

Line Information

- Total Line No. : 7

Line No.	Layer No.	Nodes On Line	rt (tf/m ²)	rsat (tf/m ²)	c (tf/m ²)	Friction Angle(deg)	Soil Type	Soil Mat.No
1		4 5 1 2 3 8 9	2.070	2.070	2.10	21.5	EMBANK	0
2	1	4 5 6 7 8 9	1.840	1.860	3.10	0.0	CLAY	1

3	2	10 11 5-9	1.840	1.860	3.10	0.0	CLAY	2
4	3	10-12 6-9	1.840	1.860	3.10	0.0	CLAY	3
5	4	10-13 7-9	1.840	1.860	3.10	0.0	CLAY	4
6	5	10-14 8 9	1.840	1.860	3.10	0.0	CLAY	5
7	6	10 11 12 13 14 15	0.000	0.000	0.00	0.0	BEDROCK	6

Embankment Step Information

- Total Step No. : 1

Step No.	Line No.	Type
1	1	EMBANK

Soil Properties

- Total Soil No. : 6

Soil No.	Soil Type	Cal.Method	Drainage Condition	Rebound Coefficient	Cu'/P	Ca	(ts/tp)
1	CLAY	Cc	Single	0.000	0.130	0.000	0.00
2	CLAY	Cc	Single	0.000	0.130	0.000	0.00
3	CLAY	Cc	Single	0.000	0.130	0.000	0.00
4	CLAY	Cc	Single	0.000	0.130	0.000	0.00
5	CLAY	Cc	Single	0.000	0.130	0.000	0.00
6	BEDROCK	NONE		0.000	0.000	0.000	0.00

Soil No.	Soil Type	N-Value	Cc	Cs	Pc (tf/m ²)	OCR	e-logP No.	logMv -logP	logCv -logP
1	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
2	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
3	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
4	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
5	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
6	BEDROCK	0.0	0.000	0.000	0.00	0.00	0	0	0

Water Table Information

- Consideration Of Buoyancy : No
- Unit Weight Of Water :1.000 (tf/m³)
- Nodes On Water Surface :4 5 6 7 8 9

Node No.	X (m)	Y (m)
4	-50.00	0.00
5	-26.25	0.00
6	-12.25	0.00
7	12.25	0.00
8	26.25	0.00
9	50.00	0.00

External Load

► Strip Load
- Total Strip Load No. : 1

Load No.	Left			Right			Used State
	X (m)	Y (m)	Load (tf/m ²)	X (m)	Y (m)	Load (tf/m ²)	
1	-11.25	7.10	1.53	11.25	7.10	1.53	Used

▣ Loading Stage Information

- Total Loading Stage No. : 2

Stage No.	Load			Construction Time	
	Loading Type	Load Type	Embankment Step No. or External Load No.	Start (day)	End (day)
1	Load	EMBANK	1	0	10
2	Load	STRIP	1	11	12

▣ Information Of Vertical Drain

- Calculation Method Of the Consolidation :

⇒ Only the degree U_h Of Horizontal Consolidation

Soil Mat. No.	Drain Type	Cal. Method	Well /Smear	Drain			Well Resistance		Soil		Smear Zone	
				Patt-ern	Dis. (m)	Dia. (cm)	Vertical Drainage	Kw (cm/sec)	α (Cv/Ch)	Kh (cm/sec)	Dia. (cm)	Ks (cm/sec)
1	NONE											
2	NONE											
3	NONE											
4	NONE											
5	NONE											

Drain Type → SD:SAND DRAIN, PD:PAPER BOARD DRAIN, SCP:SAND COMPACTION PILE, PACK:PACK DRAIN
GCP:GRAVEL COMPACTION PILE, CD:CYLINDRICAL DRAIN,FIBER:FIBER DRAIN,NONE:None Drain

Well/Smear → NONE:None Consideration both Smear and Well Resistance.

W/S:Both Consideration Well Resistance and Smear Effect

SMEAR:Only Consideration Smear Effect. WELL:Only Consideration Well Resistance

▣ Testing Result Curve

► e-logP Curve

- Curve No. : 1 ⇒ 2a

- Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.130	0.250	0.500	1.000	2.000	4.000	8.000		
e	1.043	1.019	0.992	0.954	0.905	0.840	0.770		

► logCv-logP Curve

- Curve No. : 1 ⇒ 2a

- Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.060	0.180	0.360	0.720	1.440	2.880	5.770		
Cv(cm ² /day)	61.260	54.860	50.110	45.270	39.570	35.080	30.410		

2. Settlement Result

► Settlement each Calculation Point

⊙ Calculation Point 1 : x = 0 m

- Total Layer No. : 1

Layer No.	Soil Mat.No	Soil Type	Cal.Method	Height (m)	r_t (tf/m ²)	r_{sat} (tf/m ²)	Po (tf/m ²)	ΔP (tf/m ²)	Settlement (Sf,cm)
3	3	CLAY	Cc	4.50	1.840	1.860	1.94	16.02	18.16

$$\Sigma = 18.16 \text{ cm}$$

Layer No.	Soil Mat.No	eo	e1	Mv (cm ³ /kgf)	Cc	Cs	Drain Type	Drainage Condition	Cv (cm ² /day)
3	3	1.028	0.000	0.000	0.231	0.027	NONE	Single	42.520

- Settlement and Ratio of Consolidation at Calculation Time : 12 day

Layer No.	Soil Mat.No	Soil Type	Cal. Time(day)	U (%)	Settlement (St,cm)	Residual Settlement (Sr,cm)
3	3	CLAY	12	3.85	0.70	17.46

$$[U = 3.85 \% \quad \Sigma St = 0.70 \text{ cm} \quad \Sigma Sr = 17.46 \text{ cm}]$$

3. Time and Settlement for Ratio Of Consolidation at each calculation Point

⊙ Calculation Point 1 : x = 0 m

► Degree Of Consolidation and Settlement with time at converted 1 layer
[Calculation Method]

*** Terzaghi's Solution ***

$$\therefore Cv \times t = Tv \times H^2$$

$$- Tv \leq 0.224$$

$$\therefore Ur = 100 * \sqrt{4 * Tv / \pi}$$

$$- Tv > 0.224$$

$$\therefore Ur = 100 - 10^{((1.781 - Tv) / 0.933)}$$

- Drain Type : None

- Vertical drainage condition of clay : Single

- Conversion Coefficient Of Consolidation of clay(Cv'') : 42.52 cm²/day

- Converted Length Of Clay(H') : 4.5 m

- Vertical drainage path length of clay(H=H') : 4.5 m

▢ Summation of the time and settlement at each layer

☞ at 3 Layer : CLAY(Soil Material No. --> 3)

U(%)	5	10	15	20	25	30	35	40	45	50
Time Sett.	--	--	--	--	--	--	--	--	--	--

U(%)	55	60	65	70	75	80	85	90	95	100
Time Sett.	--	--	--	--	--	--	--	--	--	18.16

▢ U & Time & Settlement Of Conversion 1 layer at each Calculation Point

U(%)	5	10	15	20	25	30	35	40	45	50
Time Sett.	0.91	1.82	2.72	3.63	4.54	5.45	6.36	7.26	8.17	9.08

U(%)	55	60	65	70	75	80	85	90	95	100
Time Sett.	9.99	10.90	11.80	12.71	13.62	14.53	15.44	16.34	17.25	18.16

◆ Total time & settlement & U at each Calculation Points ◆

☞ Total degree of consolidation at each calculation points(ratio of settlement) :

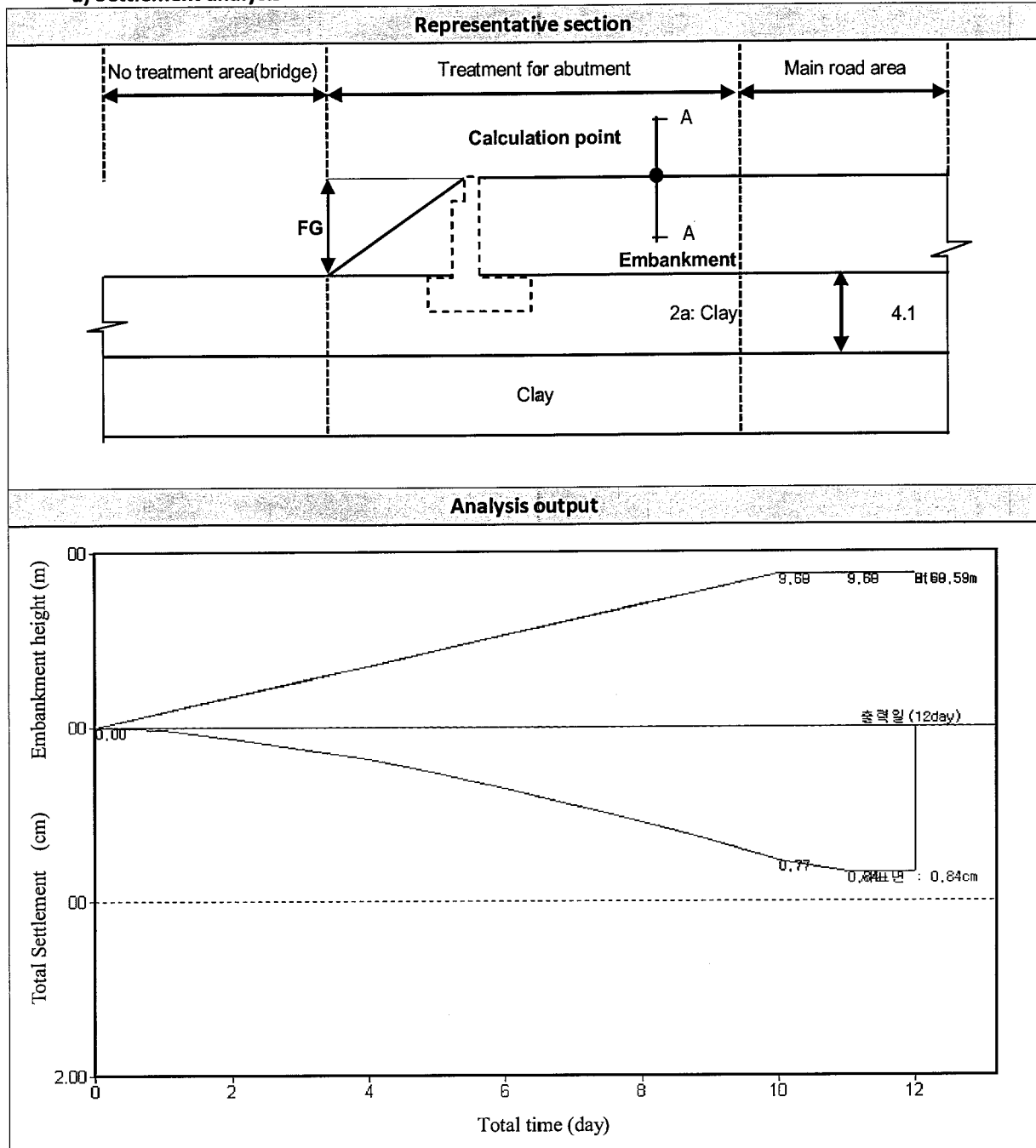
==>[consideration both consolidation settlement and immediately settlement of sandy soil]

U(%)	5	10	15	20	25	30	35	40	45	50
Time Sett.	0.91	1.82	2.72	3.63	4.54	5.45	6.36	7.26	8.17	9.08

U(%)	55	60	65	70	75	80	85	90	95	100
Time Sett.	9.99	10.90	11.80	12.71	13.62	14.53	15.44	16.34	17.25	18.16

3. ANALYSIS OUTPUT (STA. Bridge IB-LRB08-A2: 39+748 – 39+772) – SOIL REPLACEMENT

1) Settlement analysis



Section (STA.)	Extention (m)	Standard section	Height of embankment F.G(m)	Allowable residual settlement (cm)	Total Soft soil thickness (m)
1. IB-LRB08-A2	24	39+750	7.1	10	4.1

Treatment method	Spacing (m)	Height of surcharge (m)	Geotextile layer (200KN/m)	Embank step	Treatment Depth(m)	Degree of consolidation (%)	Total settlement (cm)		Residual settlement (cm3)
							Without traffic load	Include traffic load	
SR	-	-	-	1	2.5	-	-	7.82	-

2) Longitude Slope Stability Analysis

Content	Analysis Step				Remark
	Step 1	Step 2	Step 3	Final	
H(m)	-	-	-	7.1	
FS	-	-	-	1.501	

1. Final Step

DETAILED DESIGN OF DA NANG - QUANG NGAI EXPRESSWAY DEVELOPMENT PROJECT
PACKAGE 5: KM52+000 - KM65+000
TREATMENT FOR ABUTMENT A2 - BRIDGE (IB) LRB08
SECTION: KM39+748 - KM39+722

Final Step: H = 7.1 m
Traffic load: Q = 15.3 kN/m²
Method: Soil Replacement
Geotextile 200 kN/m: 0 Layer

Soil: 1
Description: EMBANK
Unit Weight: 20.307
Cohesion: 20.601
Phi: 21.5

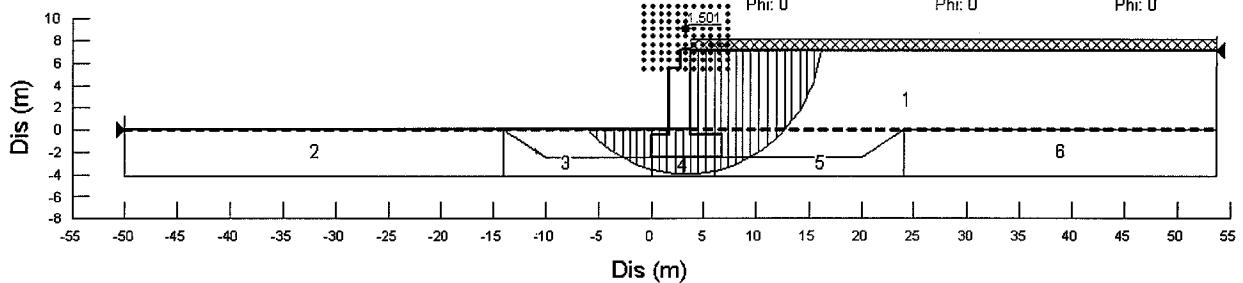
Soil: 3
Description: CLAY
Unit Weight: 18.247
Cohesion: 37
Phi: 0

Soil: 5
Description: CLAY
Unit Weight: 18.247
Cohesion: 38.2
Phi: 0

Soil: 2
Description: CLAY
Unit Weight: 18.247
Cohesion: 36.8
Phi: 0

Soil: 4
Description: CLAY
Unit Weight: 18.247
Cohesion: 38.1
Phi: 0

Soil: 6
Description: CLAY
Unit Weight: 18.247
Cohesion: 37.3
Phi: 0



3) Cross section Slope Stability Analysis

Content	Analysis Step				Remark
	Step 1	Step 2	Step 3	Final	
H(m)	-	-	-	7.1	
FS	-	-	-	1.614	

1. Final Step

DETAILED DESIGN OF DA NANG - QUANG NGAI EXPRESSWAY DEVELOPMENT PROJECT
PACKAGE 5: KM52+000 - KM65+000
TREATMENT FOR ABUTMENT A2 - BRIDGE (IB) LRB08
SECTION: KM39+748 - KM39+722

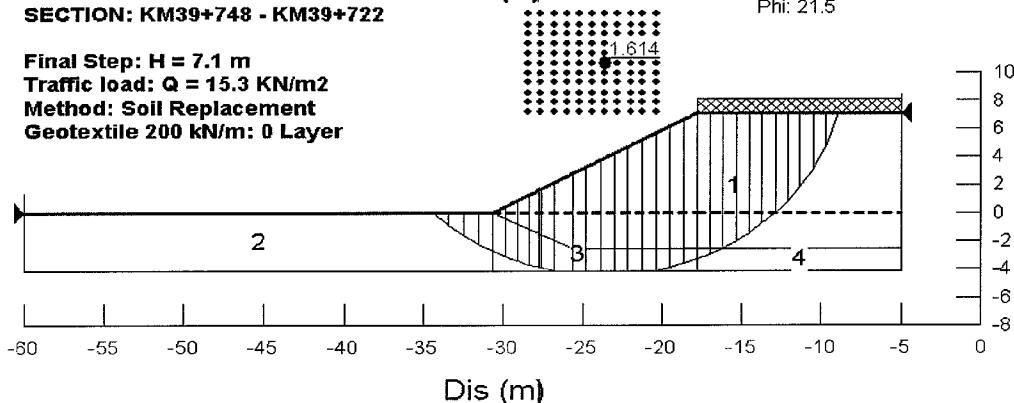
Final Step: H = 7.1 m
Traffic load: Q = 15.3 kN/m²
Method: Soil Replacement
Geotextile 200 kN/m: 0 Layer

Soil: 1
Description: EMBANK
Unit Weight: 20.7
Cohesion: 21
Phi: 21.5

Soil: 2
Description: CLAY
Unit Weight: 18.6
Cohesion: 36.8
Phi: 0

Soil: 3
Description: CLAY
Unit Weight: 18.6
Cohesion: 37
Phi: 0

Soil: 4
Description: CLAY
Unit Weight: 18.6
Cohesion: 38.1
Phi: 0



4) Settlement analysis calculate output data

1. Input Data For Calculation Settlement

Analysis Control

- Total Load Stage : 2
- Calculation Method : Total Load Method
- Calculation Max. Time : 12 day

Node Coordinate Data

- Total Node No. : 19

Node No.	X (m)	Y (m)	Node No.	X (m)	Y (m)
1	-6.38	7.10	16	-14.24	-2.50
2	0.00	7.10	17	-6.38	-2.50
3	6.38	7.10	18	6.38	-2.50
4	-50.00	0.00	19	20.61	-2.50
5	-19.24	0.00			
6	-6.38	0.00			
7	6.38	0.00			
8	25.61	0.00			
9	50.00	0.00			
10	-50.00	-4.10			
11	-19.24	-4.10			
12	-6.38	-4.10			
13	6.38	-4.10			
14	25.61	-4.10			
15	50.00	-4.10			

Line Information

- Total Line No. : 6

Line No.	Layer No.	Nodes On Line	rt (tf/m ²)	rsat (tf/m ²)	c (tf/m ²)	Friction Angle(deg)	Soil Type	Soil Mat.No
1		4 5 1 2 3 7 8 9	2.070	2.070	2.10	21.5	EMBANK	0
2	1	4 5 16 17 18 7 8 9	1.840	1.860	3.68	0.0	CLAY	1
3	2	10 11 5 16 17 18 7 8 9	1.840	1.860	3.68	0.0	CLAY	2
4	3	10 11 12 17 18 7 8 9	1.840	1.860	3.68	0.0	CLAY	3
5	4	10 11 12 13 18 7 8 9	1.840	1.860	3.68	0.0	CLAY	4
6	5	10 11 12 13 14 15	0.000	0.000	0.00	0.0	BEDROCK	6

Embankment Step Information

- Total Step No. : 1

Step No.	Line No.	Type
1	1	EMBANK

Soil Properties

- Total Soil No. : 6

Soil No.	Soil Type	Cal.Method	Drainage Condition	Rebound Coefficient	Cu'/P	Ca	(ts/tp)
1	CLAY	Cc	Single	0.000	0.130	0.000	0.00
2	CLAY	Cc	Single	0.000	0.130	0.000	0.00
3	CLAY	Cc	Single	0.000	0.130	0.000	0.00
4	CLAY	Cc	Single	0.000	0.130	0.000	0.00
5	CLAY	Cc	Single	0.000	0.130	0.000	0.00
6	BEDROCK	NONE		0.000	0.000	0.000	0.00

Soil No.	Soil Type	N-Value	Cc	Cs	Pc (tf/m ²)	OCR	e-logP No.	logMv -logP	logCv -logP
1	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
2	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
3	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
4	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
5	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
6	BEDROCK	0.0	0.000	0.000	0.00	0.00	0	0	0

Water Table Information

- Consideration Of Buoyancy : No
- Unit Weight Of Water : 1.000 (tf/m³)
- Nodes On Water Surface : 4 5 6 7 8 9

Node No.	X (m)	Y (m)
4	-50.00	0.00
5	-19.24	0.00
6	-6.38	0.00
7	6.38	0.00
8	25.61	0.00
9	50.00	0.00

External Load

► Strip Load

- Total Strip Load No. : 1

Load No.	Left			Right			Used State
	X (m)	Y (m)	Load (tf/m ²)	X (m)	Y (m)	Load (tf/m ²)	
1	-6.38	7.10	1.53	6.38	7.10	1.53	Used

Loading Stage Information

- Total Loading Stage No. : 2

Stage No.	Load			Construction Time	
	Loading Type	Load Type	Embankment Step No. or External Load No.	Start (day)	End (day)
1	재하	EMBANK	1	0	10
2	재하	STRIP	1	11	12

Information Of Vertical Drain

- Calculation Method Of the Consolidation :

⇒ Only the degree U_h Of Horizontal Consolidation

Soil Mat. No.	Drain Type	Cal. Method	Well /Smear	Drain			Well Resistance		Soil		Smear Zone	
				Patt-ern	Dis. (m)	Dia. (cm)	Vertical Drainage	Kw (cm/sec)	α (Cv/Ch)	Kh (cm/sec)	Dia. (cm)	Ks (cm/sec)
1	NONE											
2	NONE											
3	NONE											
4	NONE											
5	NONE											

Drain Type → SD:SAND DRAIN, PD:PAPER BOARD DRAIN, SCP:SAND COMPACTION PILE, PACK:PACK DRAIN

GCP:GRAVEL COMPACTION PILE, CD:CYLINDRICAL DRAIN,FIBER:FIBER DRAIN,NONE:None Drain

Well/Smear → NONE:None Consideration both Smear and Well Resistance.

W/S:Both Consideration Well Resistance and Smear Effect

SMEAR:Only Consideration Smear Effect. WELL:Only Consideration Well Resistance

Testing Result Curve

► e-logP Curve

- Curve No. : 1 ⇒ 2a

- Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.130	0.250	0.500	1.000	2.000	4.000	8.000		
e	1.043	1.019	0.992	0.954	0.905	0.840	0.770		

► logCv-logP Curve

- Curve No. : 1 => 2a
 - Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.060	0.180	0.360	0.720	1.440	2.880	5.770		
Cv(cm ² /day)	61.260	54.860	50.110	45.270	39.570	35.080	30.410		

2. Settlement Result

► Settlement each Calculation Point

⊙ Calculation Point 1 : x = 0 m

- Total Layer No. : 1

Layer No.	Soil Mat.No	Soil Type	Cal.Method	Height (m)	rt (tf/m ²)	rsat (tf/m ²)	Po (tf/m ²)	ΔP (tf/m ²)	Settlement (Sf,cm)
3	3	CLAY	Gc	1.60	1.840	1.860	0.69	18.34	7.82

Σ = 7.82 cm

Layer No.	Soil Mat.No	eo	e1	Mv (cm ² /kgf)	Cc	Cs	Drain Type	Drainage Condition	Cv (cm ² /day)
3	3	1.043	0.000	0.000	0.231	0.027	NONE	Single	42.590

- Settlement and Ratio of Consolidation at Calculation Time : 12 day

Layer No.	Soil Mat.No	Soil Type	Cal. Time(day)	U (%)	Settlement (St,cm)	Residual Settlement (Sr,cm)
3	3	CLAY	12	10.74	0.84	6.98

[U = 10.74 % ΣSt = 0.84 cm ΣSr = 6.98 cm]

3. Time and Settlement for Ratio Of Consolidation at each calculation Point

⊙ Calculation Point 1 : x = 0 m

► Degree Of Consolidation and Settlement with time at converted 1 layer [Calculation Method]

*** Terzaghi's Solution ***

$$\therefore Cv \times t = Tv \times H^2$$

$$- Tv \leq 0.224$$

$$\therefore Ur = 100 * \sqrt{(4 * Tv / \pi)}$$

$$- Tv > 0.224$$

$$\therefore Ur = 100 - 10 * ((1.781 - Tv) / 0.933)$$

- Drain Type : None

- Vertical drainage condition of clay : Single

- Conversion Coefficient Of Consolidation of clay(Cv') : 42.59 cm²/day

- Converted Length Of Clay(H') : 1.6 m

- Vertical drainage path length of clay(H=H') : 1.6 m

■ Summation of the time and settlement at each layer

⊞ at 3 Layer : CLAY(Soil Material No. --> 3)

U(%)	5	10	15	20	25	30	35	40	45	50
Time	6.33	10.14	--	--	--	--	--	--	--	--
Sett.	0.39	0.78	--	--	--	--	--	--	--	--

U(%)	55	60	65	70	75	80	85	90	95	100
Time	--	--	--	--	--	--	--	--	--	--
Sett.	--	--	--	--	--	--	--	--	--	7.82

U & Time & Settlement Of Conversion 1 layer at each Calculation Point

U(%)	5	10	15	20	25	30	35	40	45	50
Time	6.33	10.14	—	—	—	—	—	—	—	—
Sett.	0.39	0.78	1.17	1.56	1.96	2.35	2.74	3.13	3.52	3.91

U(%)	55	60	65	70	75	80	85	90	95	100
Time	—	—	—	—	—	—	—	—	—	—
Sett.	4.30	4.69	5.08	5.47	5.87	6.26	6.65	7.04	7.43	7.82

◆ Total time & settlement & U at each Calculation Points ◆

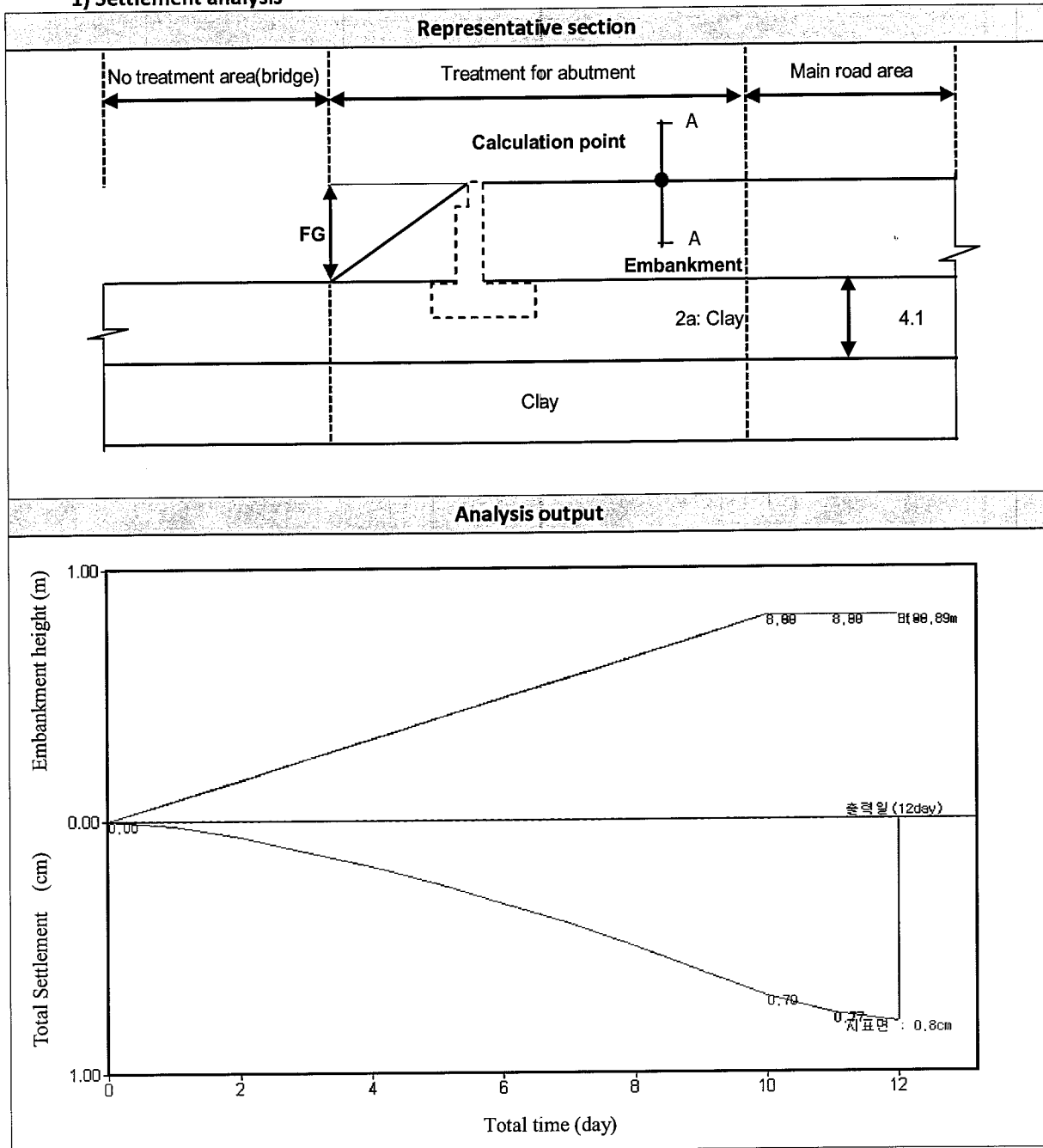
☞ Total degree of consolidation at each calculation points(ratio of settlement) :
==>[consideration both consolidation settlement and immediately settlement of sandy soil]

U(%)	5	10	15	20	25	30	35	40	45	50
Time	6.33	10.14	—	—	—	—	—	—	—	—
Sett.	0.39	0.78	1.17	1.56	1.96	2.35	2.74	3.13	3.52	3.91

U(%)	55	60	65	70	75	80	85	90	95	100
Time	—	—	—	—	—	—	—	—	—	—
Sett.	4.30	4.69	5.08	5.47	5.87	6.26	6.65	7.04	7.43	7.82

4. ANALYSIS OUTPUT (STA. Bridge OB-LRB08 - A2: 39+761 – 39+785) – SOIL REPLACEMENT

1) Settlement analysis



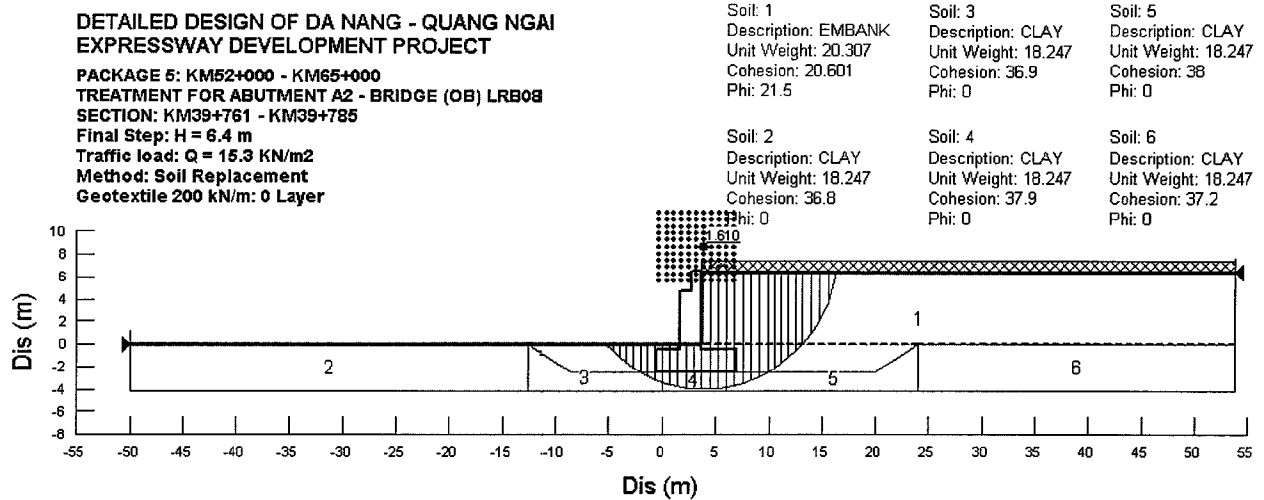
	Section (STA.)	Extention (m)	Standard section	Height of embankment F.G (m)	Allowable residual settlement (cm)	Total Soft soil thickness (m)
1.	LRB08A2	24	39+746	6.4	10	4.1

Treatment method	Spacing (m)	Height of surcharge (m)	Geotextile layer (200KN/m)	Embank step	Treatment Depth(m)	Degree of consolidation (%)	Total settlement (cm)		Residual settlement (cm3)
							Without traffic load	Include traffic load	
SR	-	-	-	1	2.5	-	-	7.35	-

2) Longitude Slope Stability Analysis

Content	Analysis Step				Remark
	Step 1	Step 2	Step 3	Final	
H(m)	-	-	-	6.4	
FS	-	-	-	1.610	

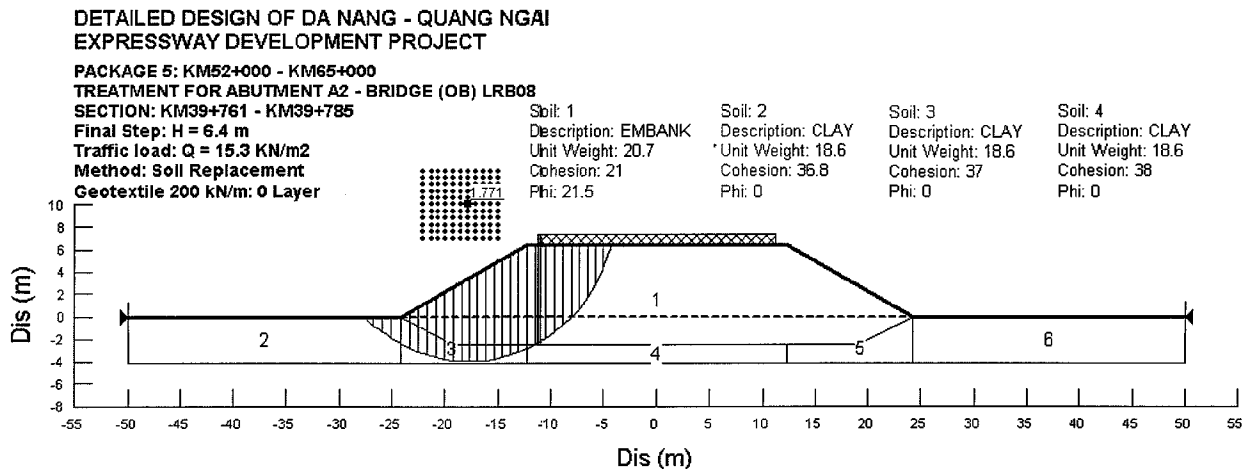
1. Final Step



3) Cross section Slope Stability Analysis

Content	Analysis Step				Remark
	Step 1	Step 2	Step 3	Final	
H(m)	-	-	-	6.4	
FS	-	-	-	1.771	

1. Final Step



4) Settlement analysis calculate output data

1. Input Data For Calculation Settlement

Analysis Control

- Total Load Stage : 2
- Calculation Method :Total Load Method
- Calculation Max. Time : 12 day

Node Coordinate Data

- Total Node No. : 19

Node No.	X (m)	Y (m)	Node No.	X (m)	Y (m)
1	-12.25	6.40	16	-19.25	-2.50
2	0.00	6.40	17	-12.25	-2.50
3	12.25	6.40	18	12.25	-2.50
4	-50.00	0.00	19	19.25	-2.50
5	-24.25	0.00			
6	-12.25	0.00			
7	12.25	0.00			
8	24.25	0.00			
9	50.00	0.00			
10	-50.00	-4.10			
11	-24.25	-4.10			
12	-12.25	-4.10			
13	12.25	-4.10			
14	24.25	-4.10			
15	50.00	-4.10			

Line Information

- Total Line No. : 7

Line No.	Layer No.	Nodes On Line	rt (tf/m ²)	rsat (tf/m ²)	c (tf/m ²)	Friction Angle(deg)	Soil Type	Soil Mat.No
1		4 5 1 2 3 8 9	2.070	2.070	2.10	21.5	EMBANK	0
2	1	4 5 16 17 18 19 8 9	1.840	1.860	3.68	0.0	CLAY	1
3	2	10 11 5 16 17 18 19 8 9	1.840	1.860	3.68	0.0	CLAY	2
4	3	10 11 12 17 18 19 8 9	1.840	1.860	3.68	0.0	CLAY	3
5	4	10 11 12 13 18 19 8 9	1.840	1.860	3.68	0.0	CLAY	4
6	5	10 11 12 13 14 8 9	1.840	1.860	3.68	0.0	CLAY	5
7	6	10 11 12 13 14 15	0.000	0.000	0.00	0.0	BEDROCK	6

Embankment Step Information

- Total Step No. : 1

Step No.	Line No.	Type
1	1	EMBANK

Soil Properties

- Total Soil No. : 6

Soil No.	Soil Type	Cal.Method	Drainage Condition	Rebound Coefficient	Cu'/P	Ca	(ts/tp)
1	CLAY	Cc	Single	0.000	0.130	0.000	0.00
2	CLAY	Cc	Single	0.000	0.130	0.000	0.00
3	CLAY	Cc	Single	0.000	0.130	0.000	0.00
4	CLAY	Cc	Single	0.000	0.130	0.000	0.00
5	CLAY	Cc	Single	0.000	0.130	0.000	0.00
6	BEDROCK	NONE		0.000	0.000	0.000	0.00

Soil No.	Soil Type	N-Value	Cc	Cs	Pc (tf/m ²)	OCR	e-logP No.	logMv -logP	logCv -logP
1	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
2	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
3	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
4	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
5	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
6	BEDROCK	0.0	0.000	0.000	0.00	0.00	0	0	0

Water Table Information

- Consideration Of Buoyancy : No
- Unit Weight Of Water : 1.000 (tf/m³)
- Nodes On Water Surface : 4 5 6 7 8 9

Node No.	X (m)	Y (m)
4	-50.00	0.00
5	-24.25	0.00
6	-12.25	0.00
7	12.25	0.00
8	24.25	0.00
9	50.00	0.00

External Load

- Strip Load
- Total Strip Load No. : 1

Load No.	Left			Right			Used State
	X (m)	Y (m)	Load (tf/m ²)	X (m)	Y (m)	Load (tf/m ²)	
1	-11.25	6.40	1.53	11.25	6.40	1.53	Used

Loading Stage Information

- Total Loading Stage No. : 2

Stage No.	Load			Construction Time	
	Loading Type	Load Type	Embankment Step No. or External Load No.	Start (day)	End (day)
1	Load	EMBANK	1	0	10
2	Load	STRIP	1	11	12

Information Of Vertical Drain

- Calculation Method Of the Consolidation :
- ⇒ Only the degree U_h Of Horizontal Consolidation

Soil Mat. No.	Drain Type	Cal. Method	Well /Smear	Drain			Well Resistance		Soil		Smear Zone	
				Patt-ern	Dis. (m)	Dia. (cm)	Vertical Drainage	Kw (cm/sec)	α (Cv/Ch)	Kh (cm/sec)	Dia. (cm)	Ks (cm/sec)
1	NONE											
2	NONE											
3	NONE											
4	NONE											
5	NONE											

Drain Type → SD:SAND DRAIN, PD:PAPER BOARD DRAIN, SCP:SAND COMPACTION PILE, PACK:PACK DRAIN
GCP:GRAVEL COMPACTION PILE, OD:CYLINDRICAL DRAIN,FIBER:FIBER DRAIN,NONE:None Drain

Well/Smear → NONE:None Consideration both Smear and Well Resistance.
W/S:Both Consideration Well Resistance and Smear Effect
SMEAR:Only Consideration Smear Effect. WELL:Only Consideration Well Resistance

Testing Result Curve

- e-logP Curve
- Curve No. : 1 ⇒ 2a
- Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.130	0.250	0.500	1.000	2.000	4.000	8.000		
e	1.043	1.019	0.992	0.954	0.905	0.840	0.770		

- logCv-logP Curve
 - Curve No. : 1 ⇒ 2a
 - Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.060	0.180	0.360	0.720	1.440	2.880	5.770		
Cv(cm ² /day)	61.260	54.860	50.110	45.270	39.570	35.080	30.410		

2. Settlement Result

- Settlement each Calculation Point
 ◎ Calculation Point 1 : x = 0 m
 - Total Layer No. : 1

Layer No.	Soil Mat.No	Soil Type	Cal.Method	Height (m)	rt (tf/m ²)	rsat (tf/m ²)	Po (tf/m ²)	ΔP (tf/m ²)	Settlement (Sf,cm)
3	3	CLAY	Cc	1.60	1.840	1.860	0.69	17.24	7.35

Σ = 7.35 cm

Layer No.	Soil Mat.No	eo	e1	Mv (cm ² /kgf)	Cc	Cs	Drain Type	Drainage Condition	Cv (cm ² /day)
3	3	1.043	0.000	0.000	0.231	0.027	NONE	Single	43.070

- Settlement and Ratio of Consolidation at Calculation Time : 12 day

Layer No.	Soil Mat.No	Soil Type	Cal. Time(day)	U (%)	Settlement (St,cm)	Residual Settlement (Sr,cm)
3	3	CLAY	12	10.88	0.80	6.55

[U = 10.88 % ΣSt = 0.80 cm ΣSr = 6.55 cm]

3. Time and Settlement for Ratio Of Consolidation at each calculation Point

- ◎ Calculation Point 1 : x = 0 m

- Degree Of Consolidation and Settlement with time at converted 1 layer
 [Calculation Method]

*** Terzaghi's Solution ***

$$\therefore C_v \times t = T_v \times H^2$$

$$- T_v \leq 0.224$$

$$\therefore U_r = 100 * \sqrt{(4 * T_v / \pi)}$$

$$- T_v > 0.224$$

$$\therefore U_r = 100 - 10^{((1.781 - T_v) / 0.933)}$$

- Drain Type : None

- Vertical drainage condition of clay : Single

- Conversion Coefficient Of Consolidation of clay(Cv') : 43.07 cm²/day

- Converted Length Of Clay(H') : 1.6 m

- Vertical drainage path length of clay(H=H') : 1.6 m

☐ Summation of the time and settlement at each layer

☞ at 3 Layer : CLAY(Soil Material No. → 3)

U(%)	5	10	15	20	25	30	35	40	45	50
Time	6.50	10.57	—	—	—	—	—	—	—	—
Sett.	0.37	0.74	—	—	—	—	—	—	—	—

U(%)	55	60	65	70	75	80	85	90	95	100
Time	—	—	—	—	—	—	—	—	—	—
Sett.	—	—	—	—	—	—	—	—	—	7.35

U & Time & Settlement Of Conversion 1 layer at each Calculation Point

U(%)	5	10	15	20	25	30	35	40	45	50
Time	6.50	10.57	—	—	—	—	—	—	—	—
Sett.	0.37	0.74	1.10	1.47	1.84	2.21	2.57	2.94	3.31	3.68

U(%)	55	60	65	70	75	80	85	90	95	100
Time	—	—	—	—	—	—	—	—	—	—
Sett.	4.04	4.41	4.78	5.15	5.51	5.88	6.25	6.62	6.98	7.35

◆ Total time & settlement & U at each Calculation Points ◆

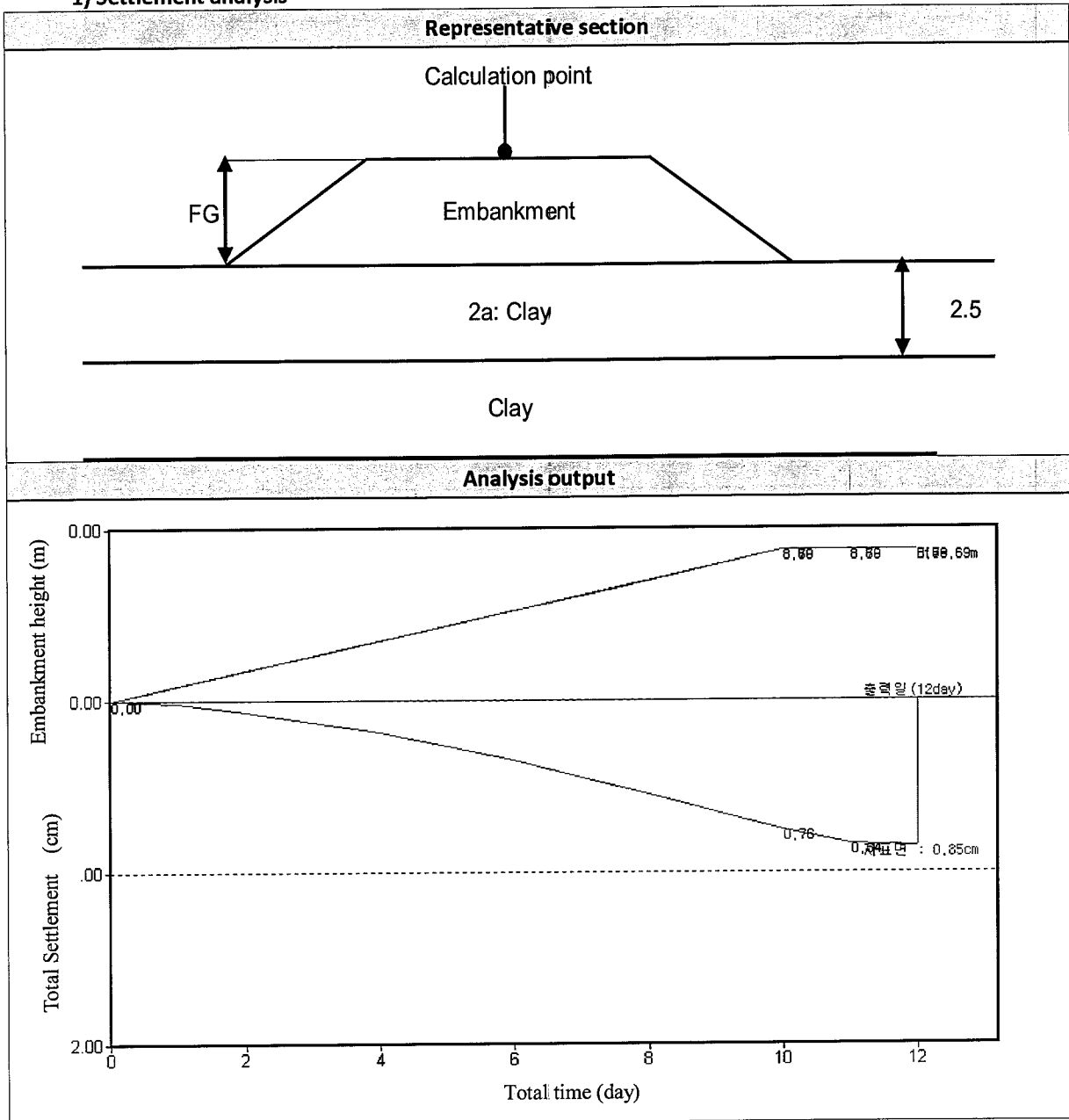
☞ Total degree of consolidation at each calculation points (ratio of settlement) :
==> [consideration both consolidation settlement and immediately settlement of sandy soil]

U(%)	5	10	15	20	25	30	35	40	45	50
Time	6.50	10.57	—	—	—	—	—	—	—	—
Sett.	0.37	0.74	1.10	1.47	1.84	2.21	2.57	2.94	3.31	3.68

U(%)	55	60	65	70	75	80	85	90	95	100
Time	—	—	—	—	—	—	—	—	—	—
Sett.	4.04	4.41	4.78	5.15	5.51	5.88	6.25	6.62	6.98	7.35

5. ANALYSIS OUTPUT (Sta. 40+620 - 40+820) – NO TREATMENT

1) Settlement analysis



	Section (STA.)	Extention (m)	Standard section	Height of embankment F.G(m)	Allowable residual settlement (cm)	Total Soft soil thickness (m)
1.	40+620 - 40+820	200	40+620	8.7	20	2.5

Treatment method	Spacing (m)	Height of surcharge (m)	Geotextile layer (400KN/m)	Embank step	Treatment Depth(m)	Degree of consolidation (%)	Total settlement (cm)		Residual settlement (cm3)
							Without traffic load	Include traffic load	
NONE	-	-	1	1	-	-	-	12.42	-

2) Slope Stability Analysis

Content	Analysis Step				Remark
	Step 1	Step 2	Step 3	Final	
H(m)	-	-	-	8.7	
FS	-	-	-	1.479	

1. Final Step

DETAILED DESIGN OF DA NANG - QUANG NGAI EXPRESSWAY DEVELOPMENT PROJECT

PACKAGE 5: KM32+000 - KM42+000
SECTION: KM40+620-KM40+820

Final Step: H = 8.7 m
Traffic load: Q = 15.3 kN/m²
Method: None
Geotextile 400 kN/m: 01 Layer

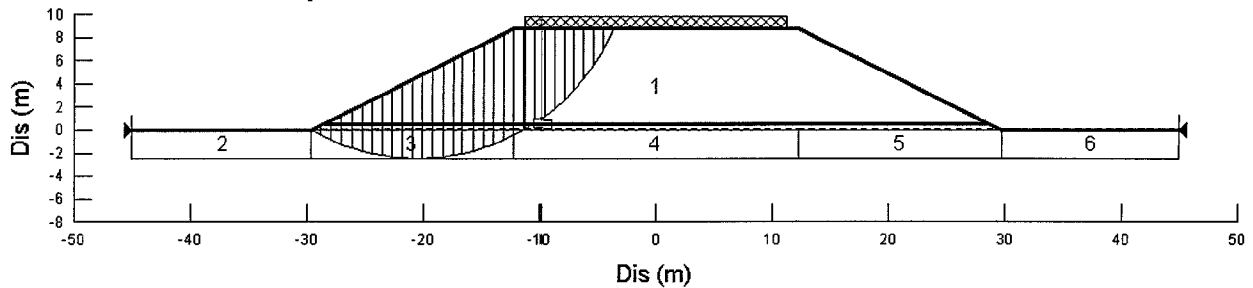


Soil: 1
Description: EMBANK
Unit Weight: 20.7
Cohesion: 21
Phi: 21.5

Soil: 2
Description: CLAY
Unit Weight: 18.6
Cohesion: 31
Phi: 0

Soil: 3
Description: CLAY
Unit Weight: 18.6
Cohesion: 31.1
Phi: 0

Soil: 4
Description: CLAY
Unit Weight: 18.6
Cohesion: 32
Phi: 0



3) Settlement analysis calculate output data

1. Input Data For Calculation Settlement

Analysis Control

- Total Load Stage : 2
- Calculation Method : Total Load Method
- Calculation Max. Time : 12 day

Node Coordinate Data

- Total Node No. : 15

Node No.	X (m)	Y (m)
1	-12.25	8.70
2	0.00	8.70
3	12.25	8.70
4	-50.00	0.00
5	-29.65	0.00
6	-12.25	0.00
7	12.25	0.00
8	29.65	0.00
9	50.00	0.00
10	-50.00	-2.50
11	-29.65	-2.50
12	-12.25	-2.50
13	12.25	-2.50
14	29.65	-2.50
15	50.00	-2.50

Line Information

- Total Line No. : 7

Line No.	Layer No.	Nodes On Line	rt (tf/m ²)	rsat (tf/m ²)	c (tf/m ²)	Friction Angle(deg)	Soil Type	Soil Mat.No
1		4 5 1 2 3 8 9	2.070	2.070	2.10	21.5	EMBANK	0
2	1	4 5 6 7 8 9	1.840	1.860	3.10	0.0	CLAY	1

3	2	10 11 5-9	1.840	1.860	3.10	0.0	CLAY	2
4	3	10-12 6-9	1.840	1.860	3.10	0.0	CLAY	3
5	4	10-13 7-9	1.840	1.860	3.10	0.0	CLAY	4
6	5	10-14 8 9	1.840	1.860	3.10	0.0	CLAY	5
7	6	10 11 12 13 14 15	0.000	0.000	0.00	0.0	BEDROCK	6

Embankment Step Information

- Total Step No. : 1

Step No.	Line No.	Type
1	1	EMBANK

Soil Properties

- Total Soil No. : 6

Soil No.	Soil Type	Cal.Method	Drainage Condition	Rebound Coefficient	Cu'/P	Ca	(ts/tp)
1	CLAY	Cc	Single	0.000	0.130	0.000	0.00
2	CLAY	Cc	Single	0.000	0.130	0.000	0.00
3	CLAY	Cc	Single	0.000	0.130	0.000	0.00
4	CLAY	Cc	Single	0.000	0.130	0.000	0.00
5	CLAY	Cc	Single	0.000	0.130	0.000	0.00
6	BEDROCK	NONE		0.000	0.000	0.000	0.00

Soil No.	Soil Type	N-Value	Cc	Cs	Pc (tf/m ²)	OCR	e-logP No.	logMv -logP	logCv -logP
1	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
2	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
3	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
4	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
5	CLAY	0.0	0.231	0.027	9.57	0.00	1	0	1
6	BEDROCK	0.0	0.000	0.000	0.00	0.00	0	0	0

Water Table Information

- Consideration Of Buoyancy : No
- Unit Weight Of Water :1.000 (tf/m³)
- Nodes On Water Surface :4 5 6 7 8 9

Node No.	X (m)	Y (m)
4	-50.00	0.00
5	-29.65	0.00
6	-12.25	0.00
7	12.25	0.00
8	29.65	0.00
9	50.00	0.00

External Load

► Strip Load

- Total Strip Load No. : 1

Load No.	Left			Right			Used State
	X (m)	Y (m)	Load (tf/m ²)	X (m)	Y (m)	Load (tf/m ²)	
1	-11.25	8.70	1.53	11.25	8.70	1.53	Used

▣ Loading Stage Information

- Total Loading Stage No. : 2

Stage No.	Load			Construction Time	
	Loading Type	Load Type	Embankment Step No. or External Load No.	Start (day)	End (day)
1	Load	EMBANK	1	0	10
2	Load	STRIP	1	11	12

▣ Information Of Vertical Drain

- Calculation Method Of the Consolidation :

⇒ Only the degree U_h Of Horizontal Consolidation

Soil Mat. No.	Drain Type	Cal. Method	Well /Smear	Drain			Well Resistance		Soil		Smear Zone	
				Pattern	Dis. (m)	Dia. (cm)	Vertical Drainage	Kw (cm/sec)	α (Cv/Ch)	Kh (cm/sec)	Dia. (cm)	Ks (cm/sec)
1	NONE											
2	NONE											
3	NONE											
4	NONE											
5	NONE											

Drain Type → SD:SAND DRAIN, PD:PAPER BOARD DRAIN, SCP:SAND COMPACTION PILE, PACK:PACK DRAIN
GCP:GRAVEL COMPACTION PILE, CD:CYLINDRICAL DRAIN,FIBER:FIBER DRAIN,NONE:None Drain

Well/Smear → NONE:None Consideration both Smear and Well Resistance.

W/S:Both Consideration Well Resistance and Smear Effect

SMEAR:Only Consideration Smear Effect. WELL:Only Consideration Well Resistance

▣ Testing Result Curve

► e-logP Curve

- Curve No. : 1 ⇒ 2a

- Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.130	0.250	0.500	1.000	2.000	4.000	8.000		
e	1.043	1.019	0.992	0.954	0.905	0.840	0.770		

► logCv-logP Curve

- Curve No. : 1 ⇒ 2a

- Data No. : 7

No.	1	2	3	4	5	6	7	8	9
P (kgf/cm ²)	0.060	0.180	0.360	0.720	1.440	2.880	5.770		
Cv(cm ² /day)	61.260	54.860	50.110	45.270	39.570	35.080	30.410		

2. Settlement Result

► Settlement each Calculation Point

⊙ Calculation Point 1 : x = 0 m

- Total Layer No. : 1

Layer No.	Soil Mat.No	Soil Type	Cal.Method	Height (m)	rt (tf/m ²)	rsat (tf/m ²)	Po (tf/m ²)	ΔP (tf/m ²)	Settlement (Sf,cm)
3	3	CLAY	Cc	2.50	1.840	1.860	1.08	19.31	12.42

$\Sigma = 12.42$ cm

Layer No.	Soil Mat.No	eo	e1	Mv (cm ³ /kgf)	Cc	Cs	Drain Type	Drainage Condition	Cv (cm ² /day)
3	3	1.043	0.000	0.000	0.231	0.027	NONE	Single	41.890

- Settlement and Ratio of Consolidation at Calculation Time : 12 day

Layer No.	Soil Mat.No	Soil Type	Cal. Time(day)	U (%)	Settlement (St,cm)	Residual Settlement (Sr,cm)
3	3	CLAY	12	6.84	0.85	11.57

$$[U = 6.84 \% \quad \sum St = 0.85 \text{ cm} \quad \sum Sr = 11.57 \text{ cm}]$$

3. Time and Settlement for Ratio Of Consolidation at each calculation Point

① Calculation Point 1 : x = 0 m

► Degree Of Consolidation and Settlement with time at converted 1 layer
[Calculation Method]

*** Terzaghi's Solution ***

$$\therefore Cv \times t = Tv \times H^2$$

$$- Tv \leq 0.224$$

$$\therefore Ur = 100 * \sqrt{4 * Tv / \pi}$$

$$- Tv > 0.224$$

$$\therefore Ur = 100 - 10^{((1.781 - Tv) / 0.933)}$$

- Drain Type : None

- Vertical drainage condition of clay : Single

- Conversion Coefficient Of Consolidation of clay(Cv') : 41.89 cm²/day

- Converted Lengh Of Clay(H') : 2.5 m

- Vertical drainage path length of clay(H=H') : 2.5 m

■ Summation of the time and settlement at each layer

☞ at 3 Layer : CLAY(Soil Material No. --> 3)

U(%)	5	10	15	20	25	30	35	40	45	50
Time	8.70	--	--	--	--	--	--	--	--	--
Sett.	0.62	--	--	--	--	--	--	--	--	--

U(%)	55	60	65	70	75	80	85	90	95	100
Time	--	--	--	--	--	--	--	--	--	--
Sett.	--	--	--	--	--	--	--	--	--	12.42

■ U & Time & Settlement Of Conversion 1 layer at each Calculation Point

U(%)	5	10	15	20	25	30	35	40	45	50
Time	8.70	--	--	--	--	--	--	--	--	--
Sett.	0.62	1.24	1.86	2.48	3.11	3.73	4.35	4.97	5.59	6.21

U(%)	55	60	65	70	75	80	85	90	95	100
Time	--	--	--	--	--	--	--	--	--	--
Sett.	6.83	7.45	8.07	8.69	9.32	9.94	10.56	11.18	11.80	12.42

◆ Total time & settlement & U at each Calculation Points ◆

☞ Total degree of consolidation at each calculation points(ratio of settlement) :

=>[consideration both consolidation settlement and immediately settlement of sandy soil]

U(%)	5	10	15	20	25	30	35	40	45	50
Time	8.70	--	--	--	--	--	--	--	--	--
Sett.	0.62	1.24	1.86	2.48	3.11	3.73	4.35	4.97	5.59	6.21

U(%)	55	60	65	70	75	80	85	90	95	100
Time Sett.	-- 6.83	-- 7.45	-- 8.07	-- 8.69	-- 9.32	-- 9.94	-- 10.56	-- 11.18	-- 11.80	-- 12.42

