資料編

資料-1

土質調査報告書

REPORT

ON

SOIL INVESTIGATION

FOR

EINME RAIL-WAY PROJECT

EINME TOWNSHIP, AYEYARWADDY REGION

THE REPUBLIC OF THE UNION OF MYANMAR

PACIFIC CONSULTANT CO., LTD.

FKYB- SI-212/2016-032

JANUARY, 2017

Submitted by;

FGEX FUKKEN

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1 INTRODUCTION

Geotechnical investigation is generally carried out to determine the substratum of ground (soil and rock) for small and large scale constructions, such as high-rise buildings, bridges, dams, factories, road, rail-way construction, ports & jetties to be constructed and needs proper design of required structures. *PACIFIC CONSULTANT CO., LTD.* is planning to improve near the Chaungphyar and Daunggyi Rail-way Stations on Pathein-Einme Rail-way, Einme Township, Ayeyarwaddy Region. Therefore, Fukken Co., Ltd. was assigned to conduct soil investigation works to obtain soil properties of selected locations in the project area.

1.1 Objective of Project

The soil investigation conducted during this project phase intends to define the subsurface conditions at project site as much as possible to evaluate the requirements of designing the structure. The specific objectives envisage to-

1. To understand the distribution condition of stratum in this project area
2. To recognize the physical and mechanical properties of soil
3. To evaluate the appropriate soil design parameter for construction design process
4. To point out the hazardous effects of ground respond during and after construction

1.2 Scope of Work

The scope of investigation works include three portions; field investigation work, laboratory testing and report preparation. The field investigation work includes soil boring, soil undisturbed sampling and Standard Penetration Test (SPT). There are two boring points and the total depth of investigation for two boreholes is 20.0 meter in this project area. The depth of boreholes is in accordance with soil condition of the points selected by expert's direction, according to the client requirements. Standard penetration tests were performed in two boreholes of designated locations in complies with ASTM (American Society for Testing and Materials). The collected disturbed samples and undisturbed samples from the boreholes were analyzed at Fukken's Yangon Branch Laboratory. Moreover, three number of Swedish Sounding Test were done in this project area.

(1) Field Works

Boring works by TOHO-D1drilling machine.

Standard Penetration Test

- Soil Disturbed Sampling
- Soil Undisturbed Sampling
- Water Level Measuring and Sampling

- Swedish Sounding Test

(2) Laboratory Test

- Physical properties test of soil
- Mechanical properties test of soil

(3) Reports

All the field investigation works and laboratory tests were carried out in accordance with ASTM, and the units are applied with SI.

1.3 Project Location

Project area is located near Chaungphyar and Daunggyi Rail-way Station on Pathein-Einme Rail-Way, Einme Township, Ayeyarwaddy Region. The detailed location of project area is indicated as a google map in Figure-1.1.

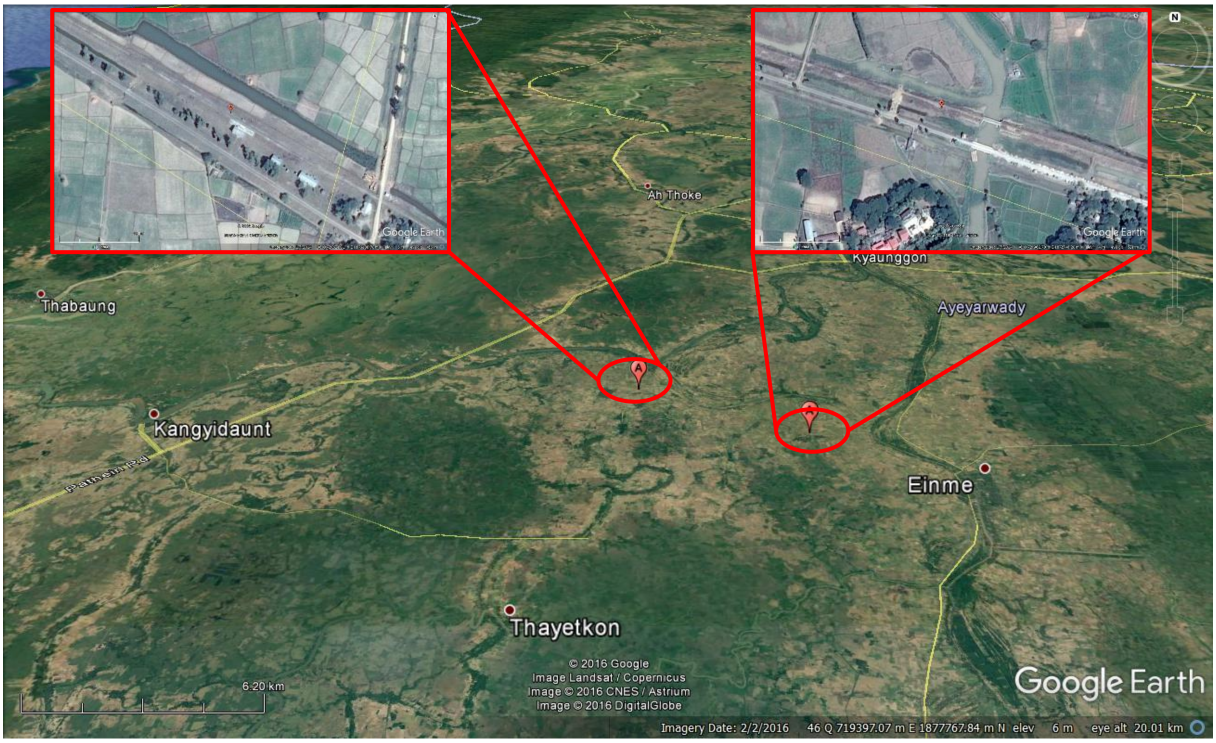


Figure - 1.1 Google map of project area

1.4 Project Duration and Personnel

Fukken Co., Ltd. conducted field investigation work at the designated area at Pathein-Einme Rail-way, Einme Township, Ayeyarwaddy Region. The field investigation works were started from 25th November, 2016 and completed two boreholes and three Swedish Sounding Test on 30th November, 2016. The laboratory tests were carried out after field work and completed on 5th January, 2017.

The executed detailed actual working schedule is illustrated in Table-1.1, indicating the organization chart of personnel of the operation, including list of geotechnical engineers, drilling crews for boring machines, technicians and the entire persons involved in this operation.

Photo - 1.1 Mobilization of Equipment

Photo - 1.2 Panoramic view of project area

Photo - 1.3 One of drilling condition

Photo - 1.4 One of drilling condition

Photo - 1.5 View of Swedish Sounding Test

Photo - 1.6 Demobilization of Equipment

Table - 1.1 Actual Working Schedule of Geotechnical Investigation Works

Description	November-2016							December-2016								January-2017												
	23	25	26	27	28	29	30	1	~	5	~	28	29	30	31	1	2	3	4	5	6	7	8	9	10	~	25	26
Preparation																												
Mobilization																												
Field Investigation Works			BH-02																									
			SW-02 & 03																									
						BH-01																						
						SW-1																						
De-mobilization																												
Laboratory Testing																												
Report Preparation																												
Final Report Submission																												

Mobilization the drilling machine
De-mobilization the drilling machine
Shifting the machine from BH to BH
Holiday

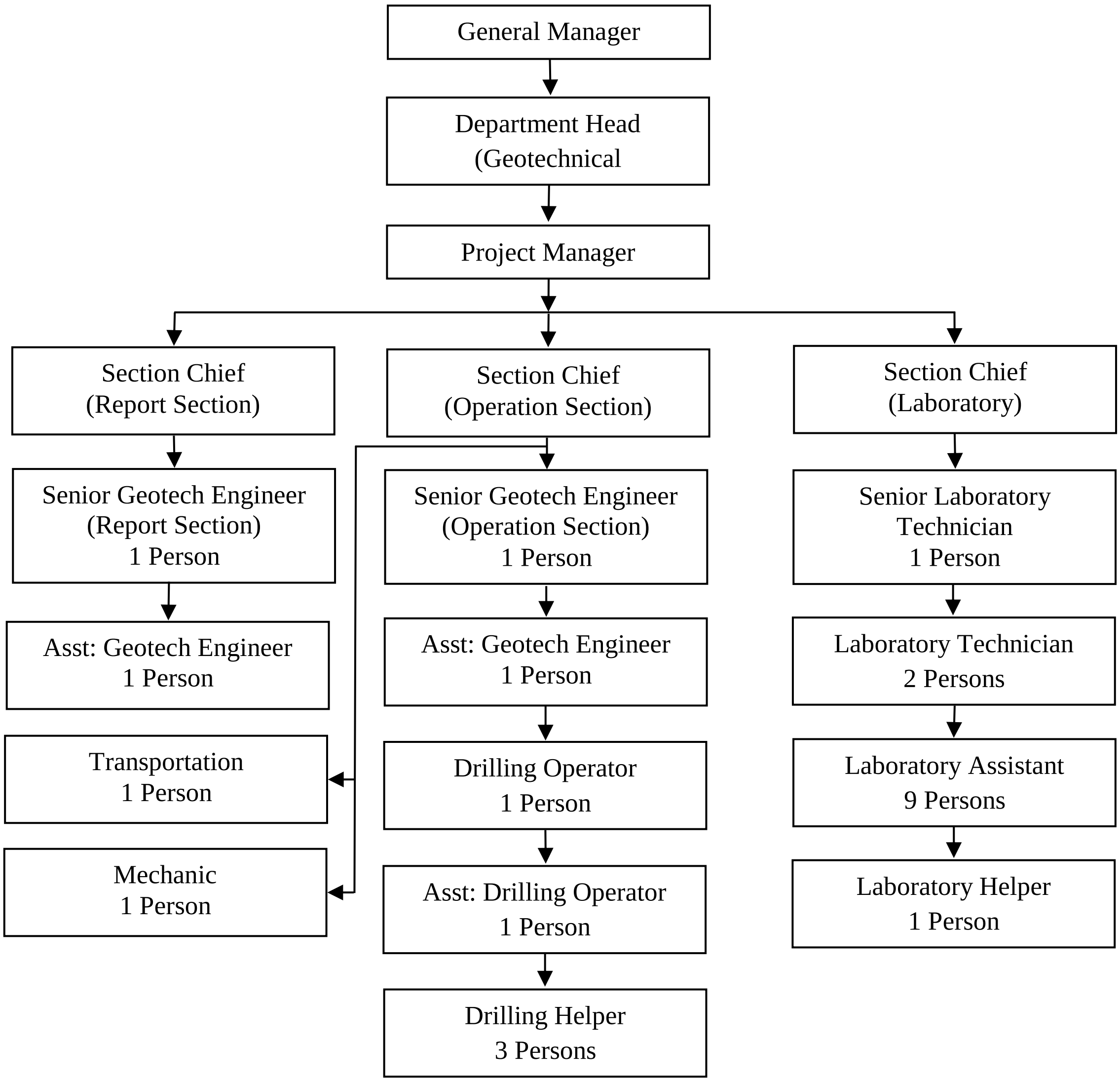


Figure - 1.2 Organization Chart of the works

1.5 Equipment Applied in the Project

1.5.1 Boring Equipment

The boring equipment, TOHO-D1 was applied in the soil investigation work of project area, to study general condition of soil layers under planned area for future construction. The specification and the types of boring equipment were presented in Table-1.2.

Photo - 1.7 TOHO-D1 Drilling Machine

Table - 1.2 Specification of Boring Equipment

Parts of Equipment	Particulars
Brand of Boring machine	TOHO-“D1”
Boring Type	Rotary
Feeding Type	Hydraulic Feed Type
Drilling Capacity	150m
Spindle Stroke	400mm
Spindle Inner Dia.	43mm
Hoisting Speed	10~59m/min
Weight	476kgf
Oil Pump Delivery Capacity	19 l/min
Oil Pump Working Pressure	45~70kgf/cm^2
Attached Water Pump Type	Toho “BG-3B”
Discharge Capacity	54 l/min
Working Pressure	15 kgf/cm^2
Engine	Yanmar Engine 110
Power	11.0 HP

1.5.2 Swedish Sounding Equipment

In this field investigation, SW was applied to estimate N value for calculation of a bearing capacity. The specifications of SW equipment are as follows;

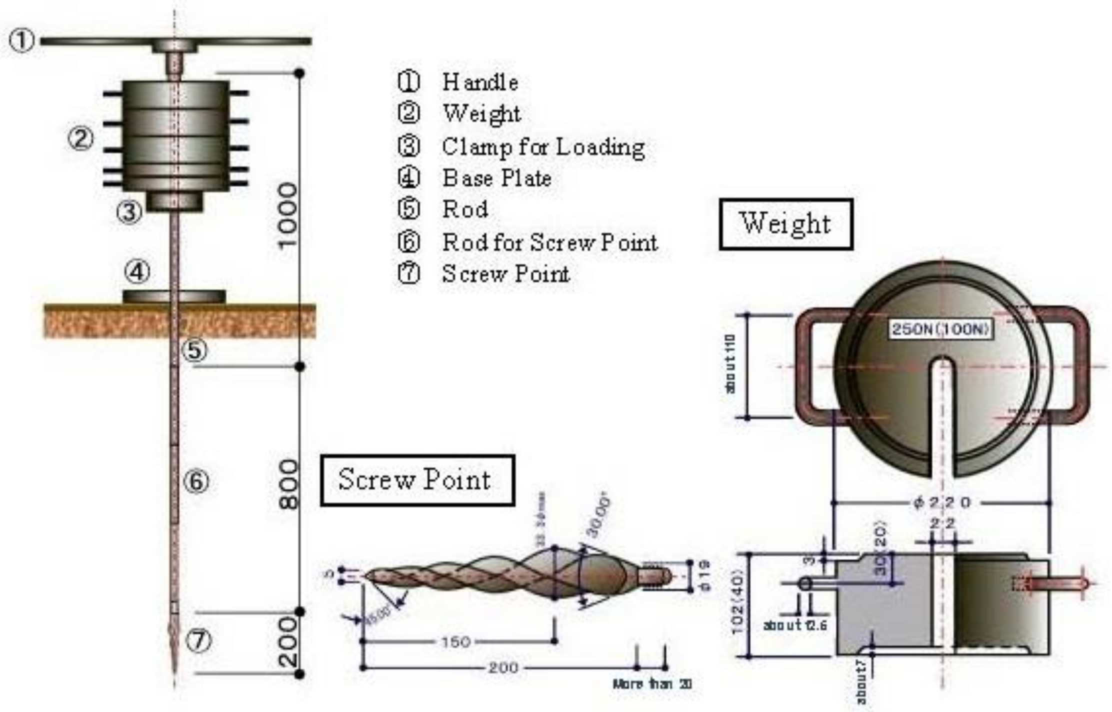


Photo - 1.8 View of Swedish Sounding Test Equipment

1.6 Laboratory Instruments

The principal instruments applied for soil laboratory tests are as shown in the following table.

Table - 1.3 Applied Laboratory Instruments

Instrument Name	Manufacturer and Type
Drying Oven	YF-STHX-3A
Electrical Balance	SARTORIUS 1404B (MP8-1)
Atterberg Limits Test Apparatus	MARUI 1115013
Sieve Test Equipment	TOKYO SAITAMA (JIS Z 8801)
Unconfined Compression Test Machine	MARUI 19047
Consolidation Test Apparatus	YF-WG-1B
Triaxial Compression Test Machine	HUMBOLDT-HM-4165

Photo - 1.9 Drying Oven

Photo - 1.10 Electrical Balance

Photo - 1.11 Atterberg Limits Apparatus

Photo - 1.12 Sieve Test Equipment

Photo - 1.13 Unconfined Compression Test Machine

Photo - 1.14 Pycnometer for Specific Gravity Test

Photo - 1.15 Consolidation Test Apparatus

Photo - 1.16 Triaxial Compression Test Machine

2 SITE CHARACTERIZATION

In this chapter, it would be included about the topography, regional geologic setting and geology of the project area, Pathein and Einme Township, Ayeyarwaddy Division.

2.1 Topography

Since the proposed project area is located in the Ayeyarwaddy Delta Region, the topographic feature of the region is regards as relatively flat lying area. The project area is mainly composed of flood plain deposit and marine sediments. As it is located at the delta region, the braided channels are very common. The river and its tributary are meandering, shows old age stage of Ayeyarwaddy River. Flat lying topography with abundant channel is typical features of project area.

2.2 Regional Geological Setting

Refer to the geological map Burma, published by Earth Science and Research Division in 1977, the project area is covered by Younger Alluvial Deposit of Holocene age. The boring results of recent soil investigation confirmed that the project area is covered with the clastic sediments of flood plain deposit of deltaic environment in upper portion and shallow marine deposit of lower portion. Clay and Silt are major unit of both flood plain and marine. According to the geological map, the regional geological setting of the area is described as follow.

Formation	**Age**	**Lithology**
Younger Alluvium	HOLOCENE	Clastic sediments of marine and flood plain deposits
---------------------	Unconformity	
Irrawaddy Formation	MIOCENE-PLIOCENE	Sand, sandstone, silt, subordinated clays and soil
---------------------	Unconformity	
Upper Pegu Group	MIOCEN	Tuffaceous shale, sandstone, limestone of shallow marine origin

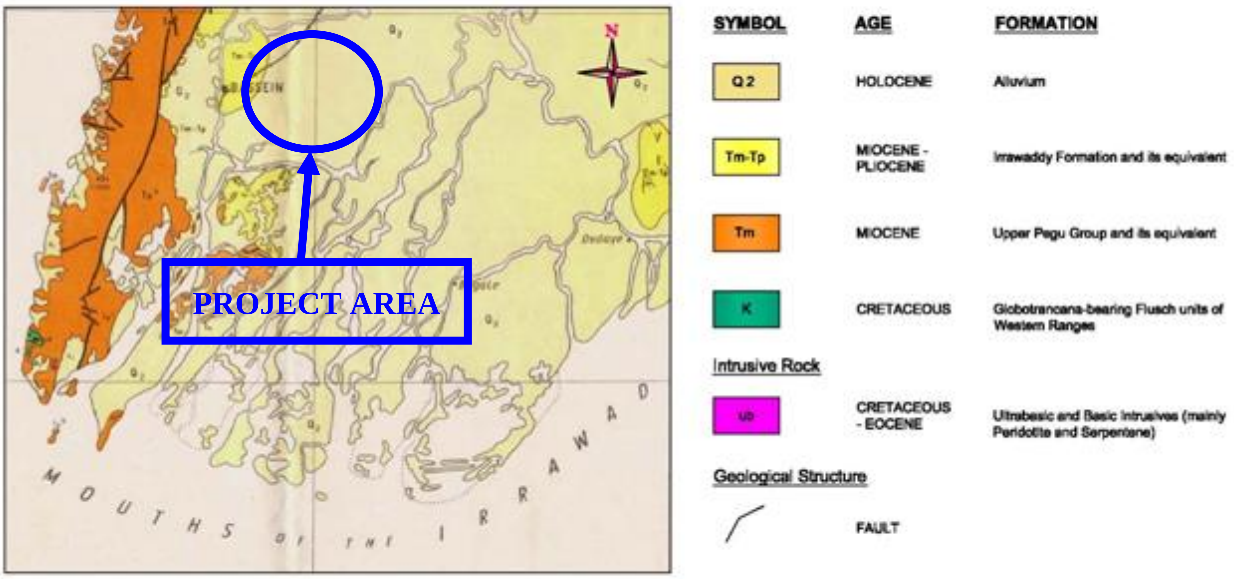


Figure - 2.1 Regional Geological Map of Project Area

2.3 Geological Observation from Boreholes

The boring site was geologically formed with younger alluvim (Quaternary to recent). According to the investigation results, the rock outcrop or any evidence of bed rock is not observed throughout the boreholes in project area. By the result of disturbed and undisturbed samples by drill holes, it is showing that it is reflecting the recent Alluvial deposit. Most of soil layers in the project area are mainly Clayey soil layers.

3 FIELD INVESTIGATION

3.1 Investigation works

The objective of the present investigation is to identify the general stratification of the ground and the nature of the soil. Total two boring points was planned to investigate by the client's requirements. The field investigation included soil boring with the performing of the test associated with Standard Penetration Test (SPT), Disturbed Soil Sampling, Undisturbed Soil Sampling, Water Level Measuring and Water Sampling. Total boring length is 20.0m and the total quantity of investigation work is listed in Table-3.1.

Table - 3.1 Total Quantity of Boring Works

No.	BH. No.	Soil Drilling (m)			Standard Penetration Test (Nos)	Undisturbed Sampling (Nos)	Water Sample (Nos)	Swedish Sounding Test (10.0m)
		Ø 112 mm	Ø 64 mm	Total				
1	BH-01	2.0	8.0	10.0	7	3	1	1
2	BH-02	2.0	8.0	10.0	7	3	1	2
Total		**4.0**	**16.0**	**20.0**	**14**	**6**	**2**	**3**

3.2 Location of Boring Points

The locations of investigated points were designated by client. The plan map showing geotechnical investigated points and Swedish sounding test points are indicated in Figure-3.1 and Figure-3.2. The coordinate of two borehole points and three Swedish Sounding Test Points are shown in Table-3.2. The coordinate of all investigated points were measured by Hand GPS.

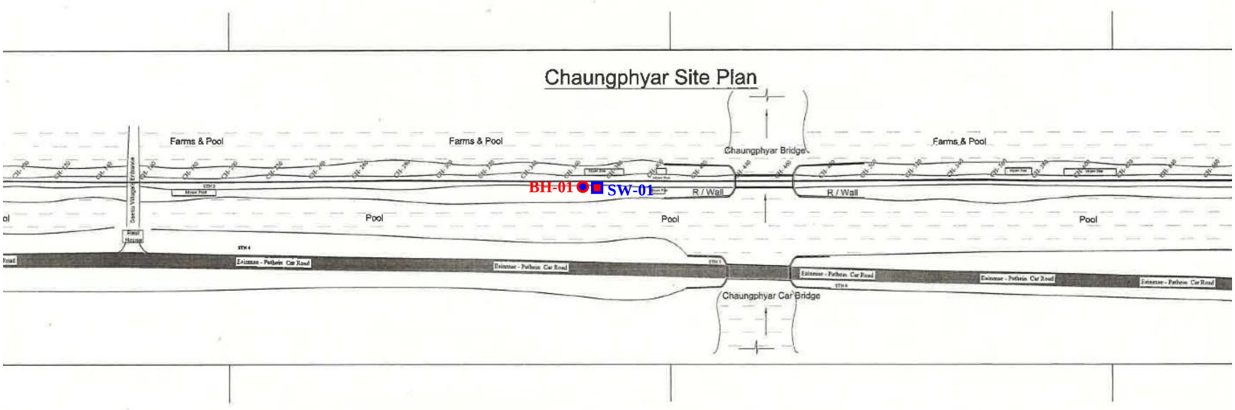


Figure - 3.1 Location Map of Investigated Points for Chaungphyar Station

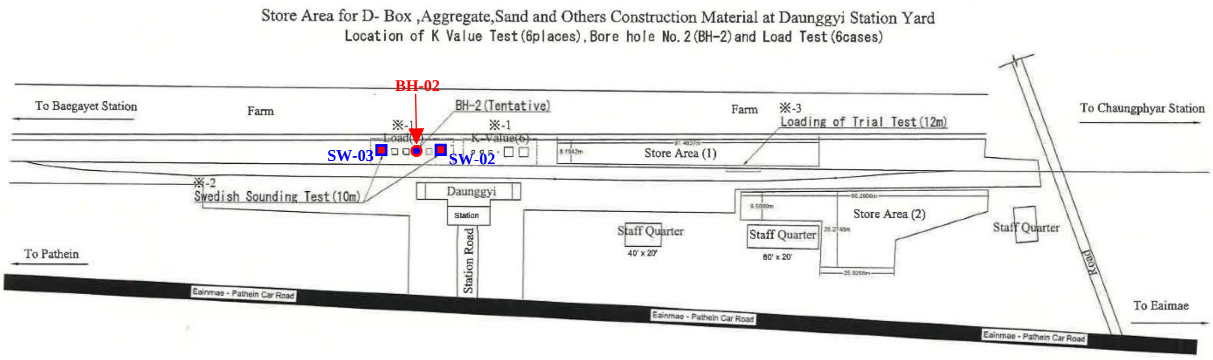


Figure - 3.2 Location Map of Investigated Points for Daunggyi Station

Table - 3.2 Coordinates and Boring Ponts

No.	BH No.	Easting (E)	Northing (N)
1	BH-01	726947.762	1872781.913
2	BH-02	720601.470	1876211.980
3	SW-01	726945.000	1872782.000
4	SW-02	720622.600	1876200.830
5	SW-03	720568.720	1876230.400

Photographs showing location of boring points

Photo - 3.1 View of BH-01

Photo - 3.2 View of BH-02

Photo - 3.3 View of SW-01

Photo - 3.4 View of SW-02

Photo - 3.5 View of SW-03

Photo - 3.6 View of Project Area

3.3 Boring Works

In boring, rotary direct circulation method is appropriately applied using metal crown bits attached to casings of Ø112mm and metal crown bits of Ø64mm in diameter setting with single core tube are properly applied depending on soil condition to drilling process. The drilling machines are operated by setting on the stage with maintaining horizontal level of drilling machine and vertical position of drilling direction while drilling on field investigation works. Boring and SPT testing in all the points are operated from drilling stage maintaining the stability of boring machine. In the way of direct circulation of drilling fluid, water and bentonite slurry was inevitably utilized to control the circulation of the sludge. The schematic diagram of boring equipment is shown in following Figure - 3.2.

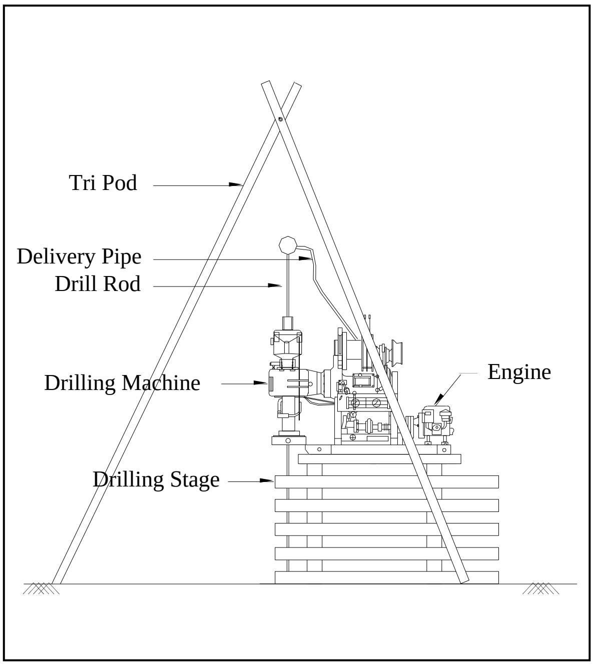


Figure - 3.3 Schematic View of Drilling Machine setting

3.4 Standard Penetration Test (SPT)

The standard penetration test was done in accordance with the ASTM Standard (American Society for Testing and Materials; D 1586-99). The test was performed using a spilt barrel sampler (50mm diameter) connected to the end of boring rods. The sampler was driven into the soil by means of a 63.5kg (140lb) hammer falling freely through the height of 76cm onto the anvil attached to the rod. The sampler is driven 450mm into the soil. SPT N-value is recorded for each 150mm penetration of the sampling tube. In this case, seating drive of 150mm is first reached and the blow count for the seating drive is not applied because the bottom of the hole may be apart from natural condition at a certain extent. The resistance, N-value, is taken as number of blow for the penetration of test drive of next 300mm. When 50 blows are reached before the full penetration 300mm, no other blows are applied but final penetration is recorded. At the conclusion of the test, the retained soil sample is extracted and stored in plastic bag for further analysis. In which, Figure-3.4 indicates the procedure and apparatus of standard penetration test. The distribution of N-value for each stratum is summarized in Figure-3.5 and Figure-3.6.

Photo - 3.7 View of Standard Penetration Test and SPT Sample

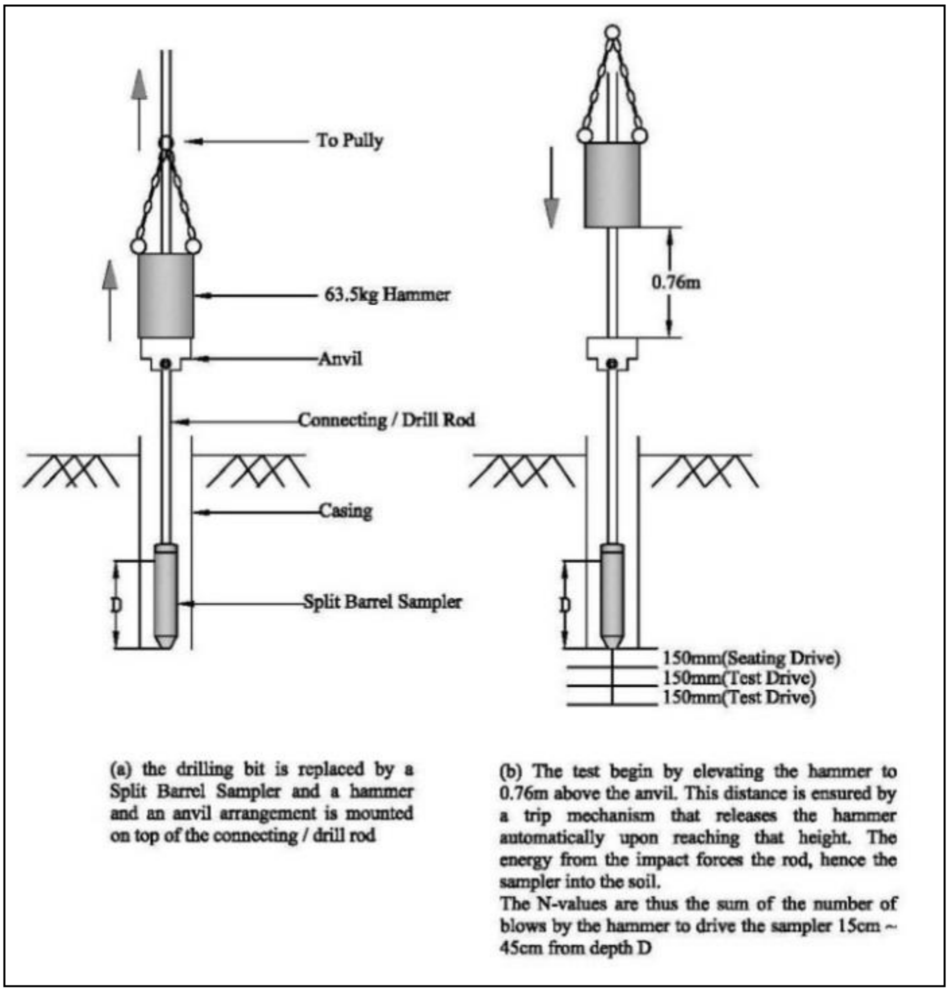


Figure - 3.4 Procedure and Apparatus of Standard Penetration Test

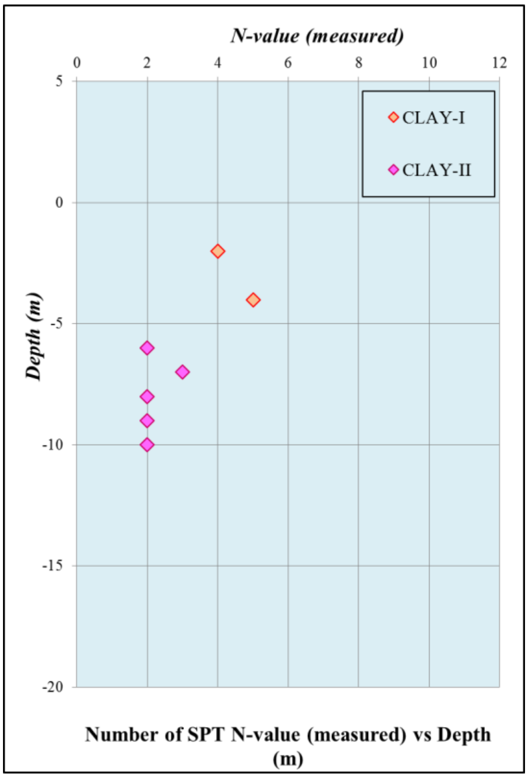


Figure - 3.5 Number of N-Value (measured) vs Depth (m) for Chaungphyar Station

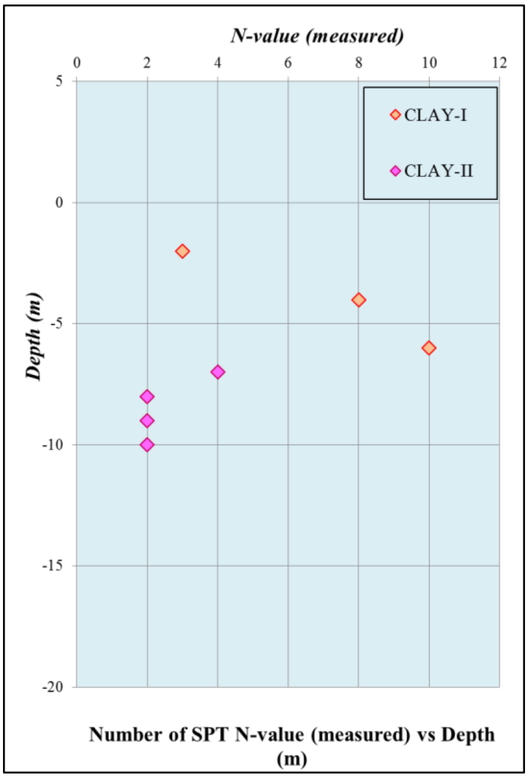


Figure - 3.6 Number of N-Value (measured) vs Depth (m) for Daunggyi Station

3.5 Undisturbed Sampling

Undisturbed soil samplers, which are required for physical and especially for mechanical properties tests such as unconfined compression test, and one dimensional consolidation test were obtained by techniques which aim at preserving in-situ structure and water content of soil without any disturbance.

During the course of SPT testing, when SPT value was as low as N-value of 1 to 4 due to existence of fine soil. Piston Thin Wall samplers (Figure-3.7) are used to take as undisturbed sample in the layer of N-value below 5 in accordance with ASTM Standard for site investigation; by applying piston samplers by water pressure type, properly designed not to disturb in-situ condition of soil.

In this project, total (6) numbers of undisturbed samples were carried out in clayey soil layers by using Piston undisturbed samplers. Detailed list of undisturbed samples are described in Table-3.3.

Table - 3.3 List of undisturbed samples

Sr. No	Borehole No.	Date	Sample No.	Depth (m)	Soil Type	Recovery	Type of Sampler
1	BH-01	26.11.16	T-1	0.50 ~ 1.15	CLAY	80%	Piston sampler
2			T-2	2.50 ~ 3.00	CLAY	60%	
3			T-3	5.00 ~ 5.80	CLAY	100%	
4	BH-02	28.11.16	T-1	0.50 ~ 1.05	CLAY	68%	
5			T-2	2.50 ~ 2.95	CLAY	55%	
6			T-3	5.00 ~ 5.45	CLAY	55%	

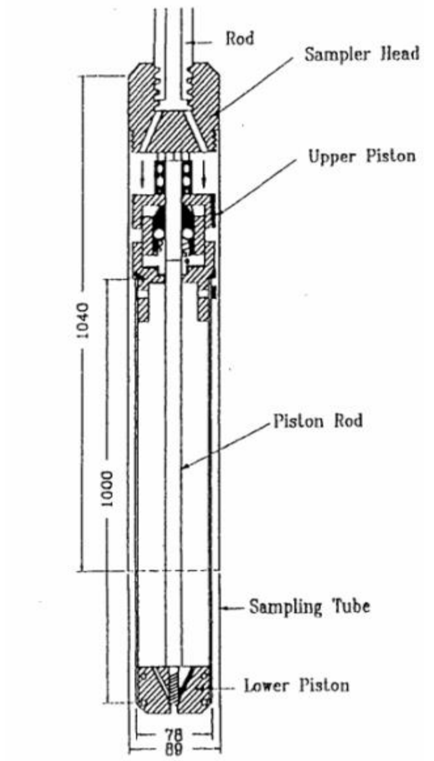


Figure - 3.7 Thin wall tube attached to Piston (undisturbed soil) sampler

Photo - 3.8 Taking Undisturbed Sampling

Photo - 3.9 After taking Undisturbed Sample

3.6 Swedish Sounding Test

The Swedish sounding was done in accordance with JIS *(Japan Industrial Standard)*. Weight is loaded in stages (W_{sw}: 50N, 150N, 250N, 500N, 750N and 1kN). Next, the number of times of the half-rotation in every 10 cm is counted. The number of the half-rotation per 1m (N_{sw}) is calculated by the following formula using this number.

$$N_{SW} = \frac{100}{L} N_a$$

N_{sw} : Number of half-rotation per 1m (time/m)

L : Penetration length (cm)

N_a : Number of half-rotation (time)

The result of SW is shown as follows.

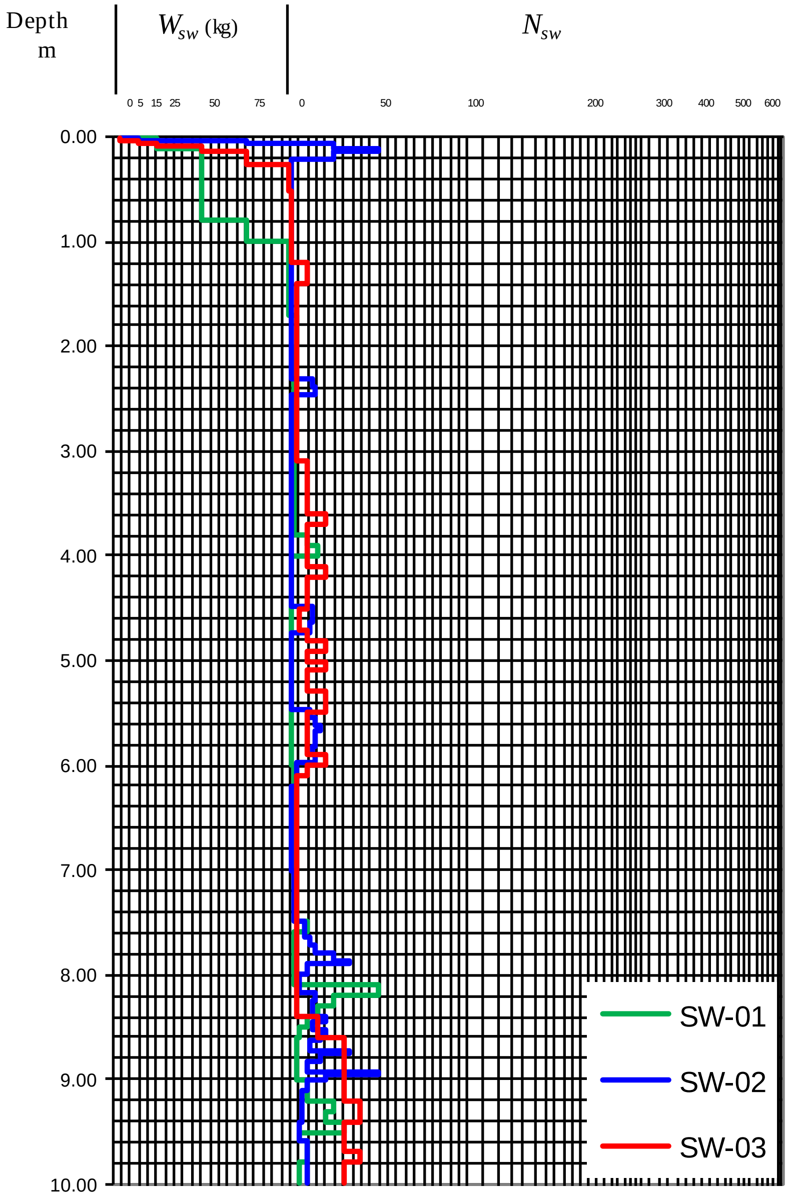


Figure - 3.8 Results of SW for each points

As for the relation between the result of SW and N value, the following formulas are proposed.

For gravel, sandy soil : $N=0.002W_{sw}+0.067N_{sw}$

For cohesive soil : $N=0.003W_{sw}+0.050N_{sw}$

N : N value

W_{sw} : Penetrating load at 1kN or less

N_{sw} : Number of half-rotation per 1m (time/m)

The results of calculated N value are shown as follows.

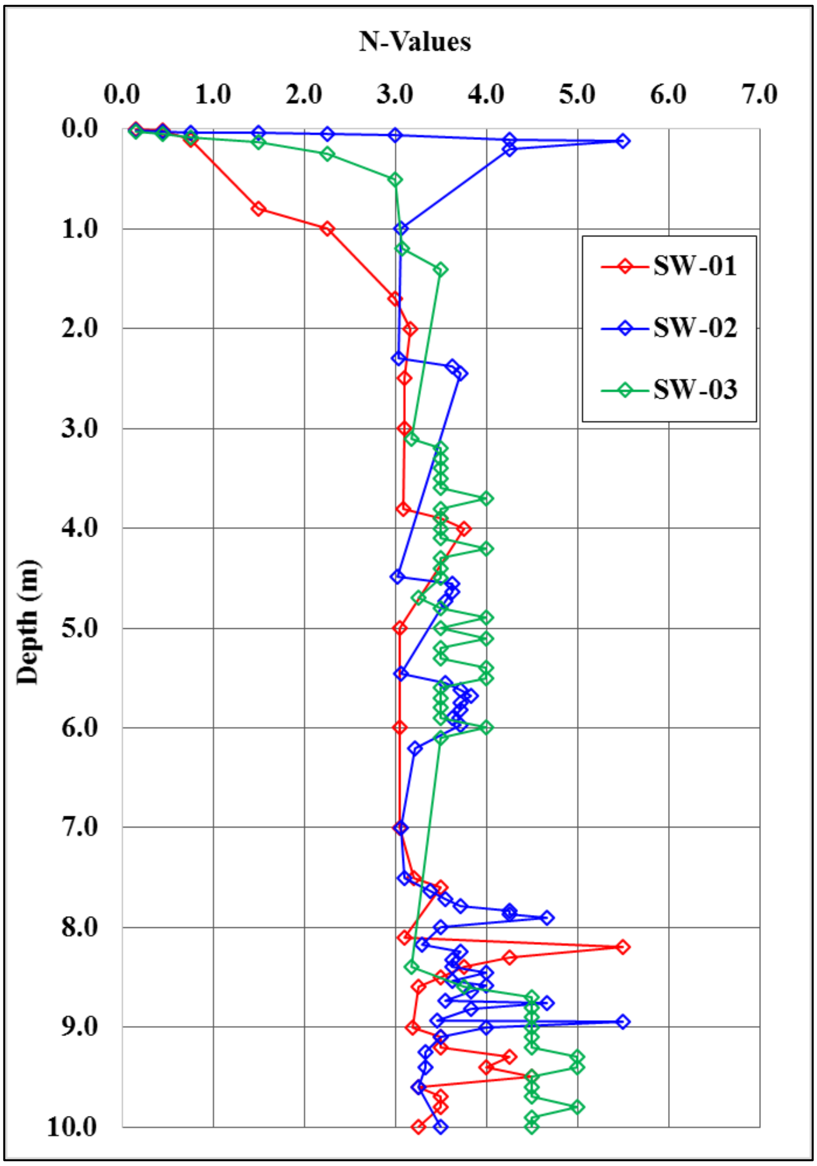


Figure - 3.9 Results of calculated N value by SW for each points

3.7 Observation of Groundwater Level

During the boring works, groundwater level recording was carefully carried out by using automatic alarm water level indicator twice a day in the borehole before and completion of drilling works. The groundwater table is recorded from ground elevation which is 1.55m in minimum to 2.35m in maximum (see Boring Logs in Appendix-A). Groundwater level that confirmed at the boring points through project area during 26th November, 2016 to 28th November, 2016 are shown in Table-3.4.

Table - 3.4 Groundwater level of investigation points through project area

No.	BH-No.	GL- (m)	Measured Date
1	BH-01	-2.35	28.11.2016
2	BH-02	-1.55	26.11.2016

3.8 Characteristics of Soil Strata Relying on Field Test

According to the investigation results, soil profiles were drawn based on not only visual check of soil samples at site and SPT results of the boreholes but also laboratory test results to determine the cross section throughout project area.

3.9 Chaungphyar Station (BH-01)

Figure-3.10 shows the soil profile for Chaungphyar Station (BH-01).

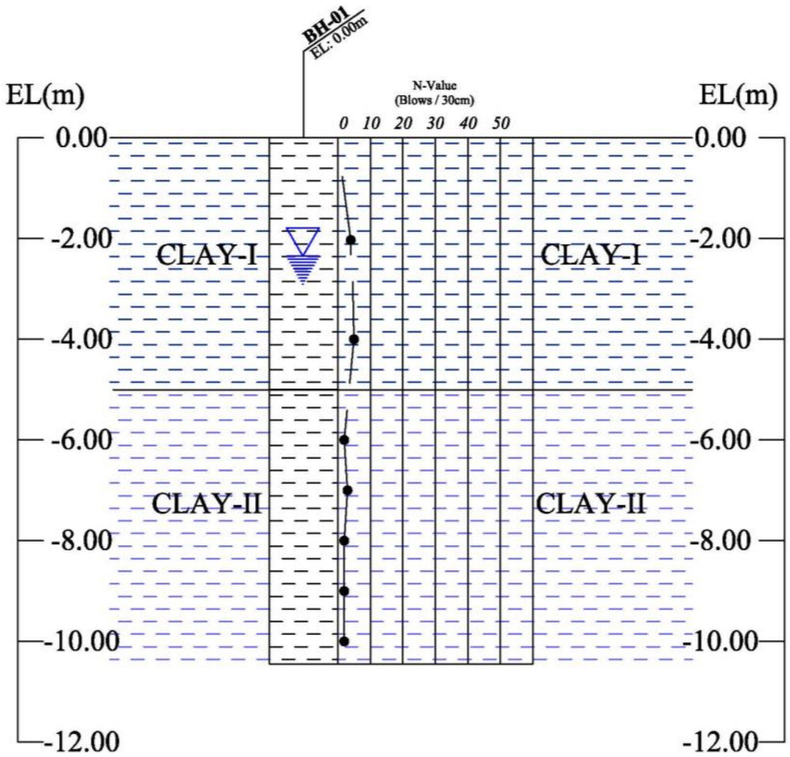


Figure - 3.10 Soil Profile for Chaungphyar Station (BH-01)

The depth of boreholes in this area is 10.0m from ground level with the performance of Standard Penetration Test. In this operation, total two numbers of different layers have been recognized. The soil layers are classified in accordance with their physical properties and/or their relative density. The two different layers observed in project area are described from top to bottom as follows.

1. CLAY-I
2. CLAY-II

3.9.1 CLAY-I

According to the investigation results, the uppermost layer is CLAY-I layer. The thickness of this layer is about 5m. The color of this layer is brownish gray. The plasticity of this layer is medium to high plasticity and the water content is moist. Moreover, trace of organic matter are observed in this layer. SPT N-value range of this layer is 4/30 to 5/30 blows, and it can be described as soft to firm in consistency.

3.9.2 CLAY-II

The second layer is CLAY-II layer in investigated holes. The thickness of this layer cannot be estimated due to terminate in this soil layer. But, the thickness of it is more than 5.0m. The color of it is gray, and the water content is moist to wet. The plasticity of clay is medium to high plasticity. Moreover, decayed wood fragments are also observed in this soil layer. SPT N-value range is varying from 2/30 to 3/30 blows, and it can be described as soft in consistency.

3.10 Daunggyi Station

Figure-3.11 shows the soil profile for Daunggyi Station (BH-02).

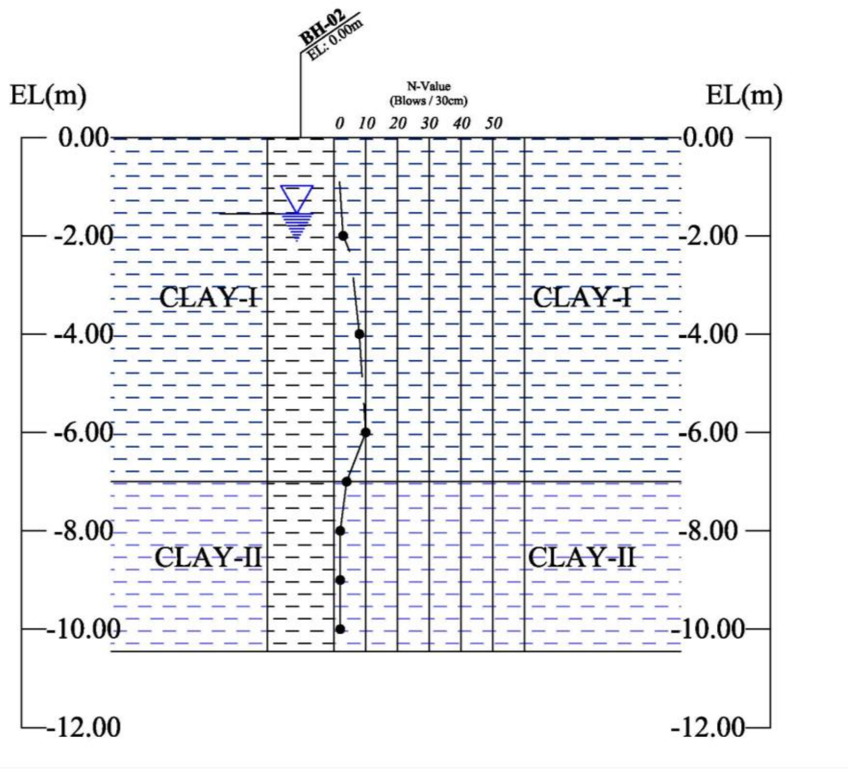


Figure - 3.11 Soil profile of Daunggyi Station (BH-02)

The depth of boreholes in this area is 10.0m from ground level with the performance of Standard Penetration Test. In this operation, total two numbers of different layers have been recognized. The soil layers are classified in accordance with their physical properties and/or their relative density. The two different layers observed in project area are described from top to bottom as follows.

1. CLAY-I
2. CLAY-II

3.10.1 CLAY-I

According to the investigation results, the uppermost layer is CLAY-I layer. The thickness of this layer is about 7m. The color of this layer is brownish gray. The plasticity of this layer is medium to high plasticity and the water content is moist. Moreover, trace of organic matter are observed in this layer. SPT N-value range of this layer is 3/30 to 10/30 blows, and it can be described as soft to stiff in consistency.

3.10.2 CLAY-II

The second layer is CLAY-II layer in investigated holes. The thickness of this layer cannot be estimated due to terminate in this soil layer. But, the thickness of it is more than 3.0m. The color of it is gray, and the water content is moist to wet. The plasticity of clay is medium to high plasticity. Moreover, decayed wood fragments are also observed in this soil layer. SPT N-value range is varying from 2/30 to 4/30 blows, and it can be described as soft in consistency.

4 LABORATORY TEST

There have been two numbers of investigation boreholes and total (14) numbers of disturbed samples and (6) numbers of undisturbed samples with Piston sampler was collected in project site. All disturbed and undisturbed samples were sent to office laboratory and purposed to test physical and mechanical properties of soil in consulting with expert's discretion. The entire tests were carried out in accordance with ASTM Standard.

The physical properties tests include the following items.

- Natural Moisture Content Test (ASTM D 2216-05)
- Specific Gravity Test (ASTM D 854-06)
- Particle Size Analysis Test (ASTM D 422-63)
  - Grain Size Distribution Test
  - Hydrometer Test
- Atterberg Limits Test (ASTM D 4318-05)
  - Liquid Limit Test
  - Plastic Limit Test

The mechanical properties tests include the following items.

- Unconsolidated Undrained Triaxial Compression Test (ASTM D 2850)
- Consolidated Undrained Triaxial Compression Test (ASTM D 4767)
- One Dimensional Consolidation Test (ASTM D 2435-04)

Total quantity of laboratory tests are described in Table-4.1 and summary of laboratory test results for each borehole are illustrated in Table-4.2.

Table - 4.1 Total Quantity of Laboratory Tests

BH-No.	Physical Properties Test							Engineering Properties Test		
	Natural Moisture Content Test	Specific Gravity Test	Particle Size Analysis Test		Atterberg Limits Test		Unit Weight	Unconsolidated Undrained Triaxial Compression Test	Consolidated Undrained Triaxial Compression Test	One Dimensional Consolidation Test
			Sieve Analysis Test	Hydrometer Analysis Test	Liquid Limit Test	Plastic Limit Test				
BH-01	16	10	10	10	7	7	3	2	1	3
BH-02	15	10	10	10	6	6	3	1	-	3
Total	**31**	**20**	**20**	**20**	**13**	**13**	**6**	**3**	**1**	**6**

Table - 4.2 Summary of Laboratory Test Results

BH No.	Sample No.	Depth		Soil Types	Water Content	Specific Gravity	Grain Size Distribution				Atterberg Limits			Bulk Density		One Dimensional Consolidation Test			Unconsolidated Undrained Triaxial Compression Test		Consolidated Undrained Triaxial Compression Test			
		GL - (m)	EL; (m)		W	Gs	Gravel	Sand	Silt	Clay	LL	PL	PI	ρ_t		e_o	Py	Cc	C_{UU}	φ_{UU}	C'	φ'	C	φ
					(%)		(%)	(%)	(%)	(%)	(%)	(%)	(%)	g/cm^3			kN/m^2		kN/m^2	Degree	kN/m^2	Degree	kN/m^2	Degree
BH-01	T-1	0.50	8.25	CH	39.34	2.715	-	0.83	52.08	47.10	83.18	30.80	52.38	1.818	-	1.080	251.4	0.308	16.10	9.95	-	-	-	-
	P-1	2.00	-2.00	MH	36.85	2.674	-	1.05	33.95	65.00	73.78	36.08	37.70	-	-				-	-	-	-	-	-
	T-2	2.50	-2.50	CH	39.71	2.682	-	1.00	44.20	54.80	81.45	35.30	46.15	1.798	-	1.080	228.9	0.335	-	-	0.00	18.00	3.50	14.50
	P-2	4.00	-4.00	CH	39.07	2.710	-	0.47	61.43	38.10	90.92	34.58	56.34	-	-	-	-	-	-	-	-	-	-	-
	T-3	5.00	-5.00	MH	108.53	2.517	-	5.80	57.00	37.20	86.37	43.56	42.81	1.386	-	2.730	78.5	1.388	17.80	0.00	-	-	-	-
	P-3	6.00	-6.00	MH	87.17	2.482	-	2.95	53.05	44.00	73.80	42.22	31.58	-	-	-	-	-	-	-	-	-	-	-
	P-4	7.00	-7.00	F	62.04	2.599	-	1.70	36.20	62.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-5	8.00	-8.00	MH	67.63	2.594	-	0.97	27.03	72.00	71.15	35.17	35.98	-	-	-	-	-	-	-	-	-	-	-
	P-6	9.00	-9.00	F	58.67	2.661	-	0.38	25.73	73.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-7	10.00	-10.00	F	67.22	2.612	-	0.83	21.28	77.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH-02	T-1	0.50	-0.50	CH	33.36	2.670	-	0.67	65.43	33.90	75.10	29.82	45.28	1.888	-	0.880	232.8	0.281	12.50	15.14	-	-	-	-
	P-1	2.00	-2.00	F	32.15	2.682	-	2.00	56.20	41.80	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	T-2	2.50	-2.50	CH	30.54	2.686	-	1.12	67.08	31.80	62.40	26.05	36.35	1.904	1.885	0.870	221.1	0.262	-	-	-	-	-	-
	P-2	4.00	-4.00	CH	28.57	2.659	-	1.36	72.74	25.90	64.37	26.36	38.01	-	-	-	-	-	-	-	-	-	-	-
	T-3	5.00	-5.00	CH	28.42	2.692	-	0.67	67.33	32.00	63.30	30.13	33.17	1.915	-	0.820	311.5	0.215	-	-	-	-	-	-
	P-3	6.00	-6.00	CH	31.41	2.582	-	0.20	52.80	47.00	72.45	27.34	45.11	-	-	-	-	-	-	-	-	-	-	-
	P-4	7.00	-7.00	CH	39.49	2.638	-	3.53	53.68	42.80	59.68	28.34	31.34	-	-	-	-	-	-	-	-	-	-	-
	P-5	8.00	-8.00	F	51.35	2.642	-	0.35	52.65	47.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-6	9.00	-9.00	F	51.45	2.641	-	5.72	47.08	47.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-7	10.00	-10.00	F	60.34	2.663	-	1.05	45.05	53.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-

4.1 Index Property of Soil

Physical and mechanical properties tests were done for investigation. The detailed laboratory test results are illustrated in Appendix-C in this report.

4.1.1 Natural Moisture Content Test

Natural moisture content tests of (20) numbers have been carried out on soil samples for required two different soil layers at office laboratory in accordance with ASTM Standard (ASTM D 2216-05). The photograph of testing natural moisture content is shown in Photo-4.1. The detailed laboratory test results are illustrated in Appendix-C.

Photo - 4.1 Natural Moisture Content Test

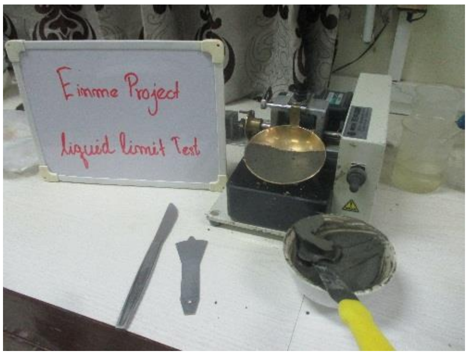
4.1.2 Specific Gravity Test

The specific gravity tests in this project were carried out in accordance with ASTM Standard (ASTM D 854-06) at office laboratory. There have been (20) numbers of specific gravity tests. The photograph of specific gravity testing is shown in Photo-4.2. The detailed test results were described in Appendix-C.

Photo - 4.2 Specific Gravity Test

4.1.3 Atterberg Limits Test

The Atterberg Limits tests were made on (13) numbers for liquid limit tests and same numbers for plastic limit tests of specimens from disturbed and undisturbed samples by ASTM Standard (ASTM D 4318-05) at office laboratory. The photograph of testing is shown in Photo-4.3. The detailed test results were shown in Appendix-C.



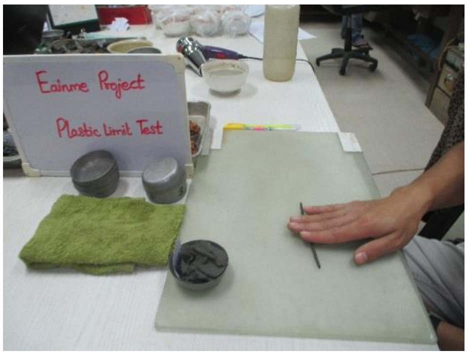


Photo - 4.3 Atterberg Limits Test (Liquid Limit & Plastic Limit)

4.1.4 Grain Size Analysis Test

Soil classifications or grain size distribution test were done by ASTM Standard (ASTM D 422-63). In this project, (20) numbers of sieve analysis tests including same numbers of hydrometer tests were carried out in laboratory of Fukken Co., Ltd. Grain size analysis testing and hydrometer testing are shown in Photo-4.4 and 4.5. The details of Grain Size Analysis Test results were shown in Appendix-C.

Photo - 4.4 Grain Size Distribution Test

Photo - 4.5 Hydrometer Test

4.2 Mechanical Properties of Soil

In order to obtain the mechanical properties of soils, (6) numbers of undisturbed soil samples from two boreholes was sent to laboratory for unconsolidated undrained triaxial compression test, consolidated undrained triaxial compression test and one dimensional consolidation test.

4.2.1 Unconsolidated Undrained Triaxial Compression Test (UU)

The unconsolidated undrained triaxial compression tests were be carried out in undisturbed samples taken from the project area. There are total (3) numbers of UU test were carried out in accordance with ASTM Standard (ASTM D 2850).

Photo - 4.6 Data reading for one dimensional Consolidation Test Results

4.2.2 Consolidated Undrained Triaxial Compression Test (CIU)

The consolidated undrained triaxial compression was be carried out in undisturbed samples taken from the project area. There are total (1) number of CIU test was be carried out in accordance with ASTM Standard (ASTM D 4767).

Photo - 4.7 Data reading for one dimensional Consolidation Test Results

4.2.3 One Dimensional Consolidation Test

The one dimensional consolidation tests were carried out in undisturbed samples taken from the project area. There are total (6) numbers of one dimensional consolidation test were carried out in accordance with ASTM Standard (ASTM D 2435-04).

Photo - 4.8 Data reading for one dimensional Consolidation Test Results

4.3 Laboratory Test Results

4.3.1 Natural Moisture Content Test

Table-4.3 illustrates the summary of natural moisture content in each soil layers. The variation of moisture content with depth in elevation can be seen in Figure-4.1 and Figure-4.2 for each location. The detailed laboratory test results are illustrated in Appendix-C.

Table - 4.3 Summary of Natural Moisture Content of Test Results

No.	Soil Types	Natural Moisture Content (%) (Chaungphyar Station)	Natural Moisture Content (%) (Daunggyi Station)
1	CLAY-I	36.85 ~ 39.71	28.42 ~ 33.36
2	CLAY-II	58.67 ~ 108.53	39.49 ~ 60.34

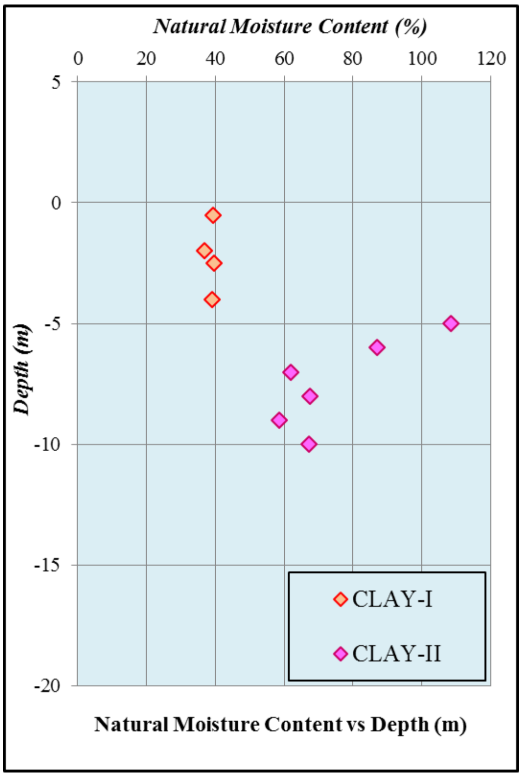


Figure - 4.1 Natural Moisture Content vs Depth (m) (Chaungphyar Station)

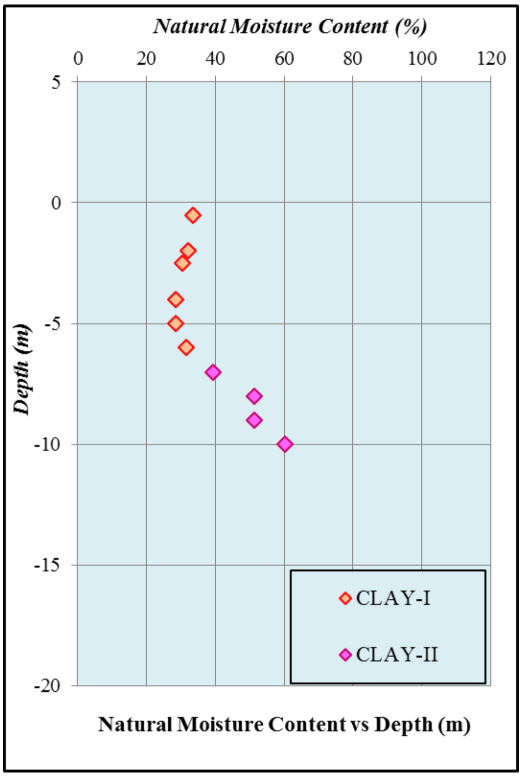


Figure - 4.2 Natural Moisture Content vs Depth (m) (Daungyi Station)

4.3.2 Specific Gravity Test

Table-4.4 illustrates the summary of specific gravity for each soil layer. The relationship between specific gravity and depth in elevation of each soil layer is shown in Figure-4.3 and Figure-4.4. The detailed test results were described in Appendix-C.

Table - 4.4 Summary of Specific Gravity Test Results

No.	Soil Types	Specific Gravity (Chaungphyar Station)	Specific Gravity (Daunggyi Station)
1	CLAY-I	2.674 ~ 2.715	2.582 ~ 2.692
2	CLAY-II	2.482 ~ 2.661	2.638 ~ 2.663

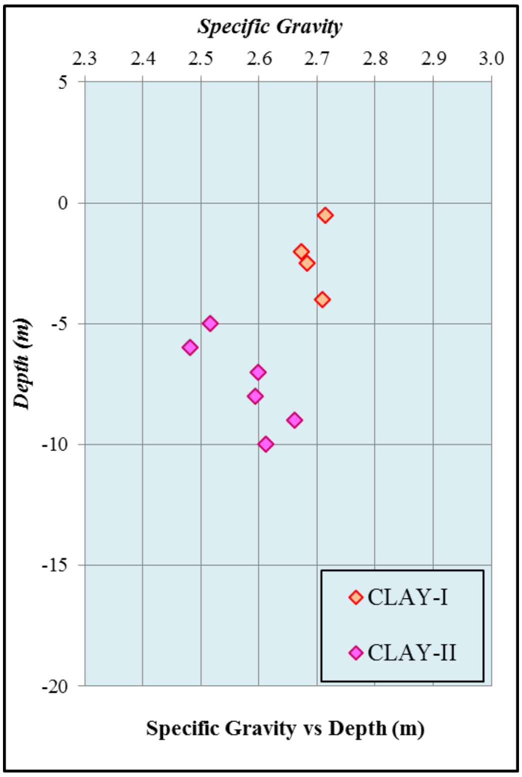


Figure - 4.3 Specific Gravity vs Depth (m) (Chaungphyar Station)

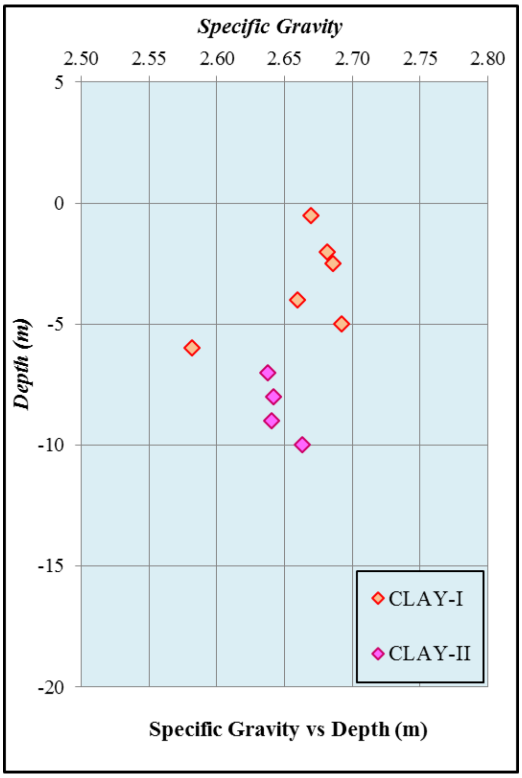


Figure - 4.4 Specific Gravity vs Depth (m) (Daunggyi Station)

4.3.3 Atterberg Limits Test

The summary of Atterberg Limits Test results are shown in Table-4.5. Figure-4.5 to 4.10 illustrate the Plastic Limit, Liquid Limit and Plasticity Index of each soil layer versus depth in elevation (m) for each station. Moreover, Figure-4.11 and Figure-4.12 show the condition of soil in project area by ranges in plasticity chart for each station. The detailed test results were shown in Appendix-C.

Table - 4.5 Summary of Atterberg Limits Test Results

No.	Soil Types	Liquid Limit (LL) (%)	Plastic Limit (PL) (%)	Plasticity Index (PI)	Remarks
1	CLAY-I	73.78 ~ 90.92	30.80 ~ 36.08	37.70 ~ 56.34	**Chaungphyar Station**
2	CLAY-II	71.15 ~ 86.37	35.17 ~ 43.56	31.58 ~ 42.81	
3	CLAY-I	62.40 ~ 75.10	26.05 ~ 30.13	33.17 ~ 45.28	**Daunggyi Station**
4	CLAY-II	59.68*	28.34*	31.34*	

*One sample testing results

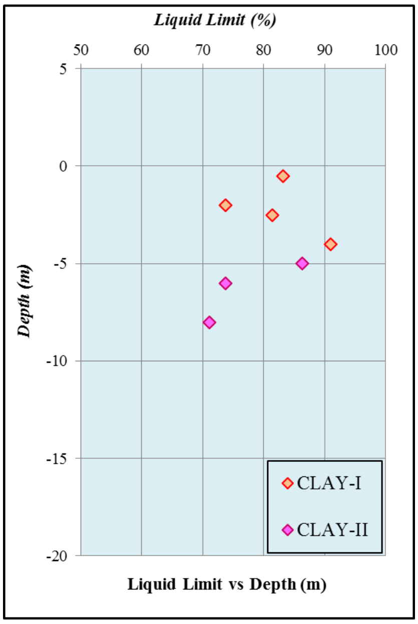


Figure - 4.5 Liquid Limit vs Depth (m) (Chaungphyar Station)

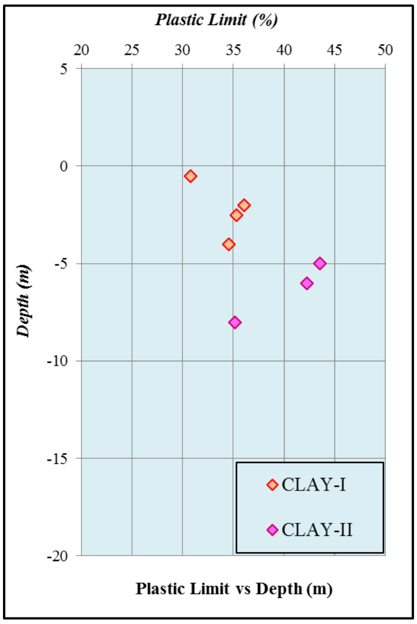


Figure - 4.6 Plastic Limit vs Depth (m) (Chaungphyar Station)

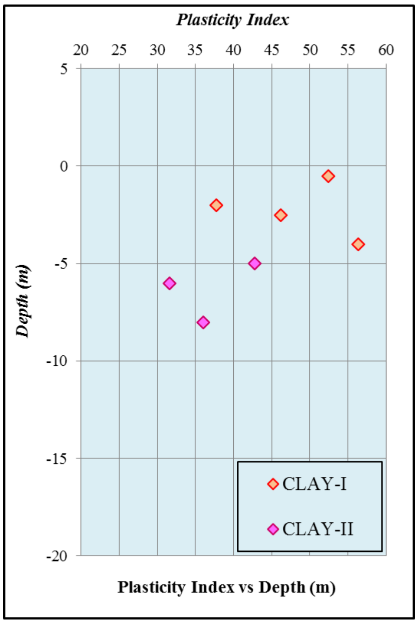


Figure - 4.7 Plasticity Index vs Depth (m) (Chaungphyar Station)

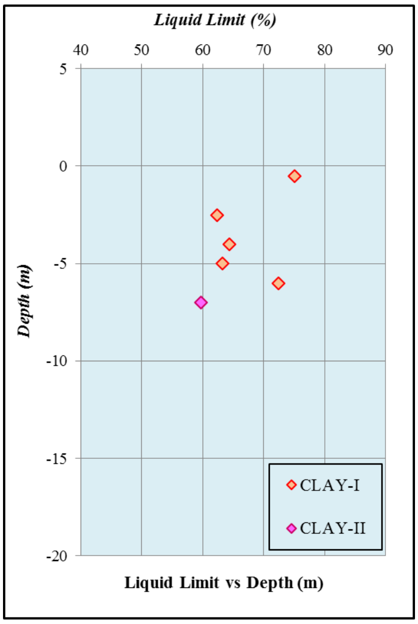


Figure - 4.8 Liquid Limit vs Depth (m) (Daunggyi Station)

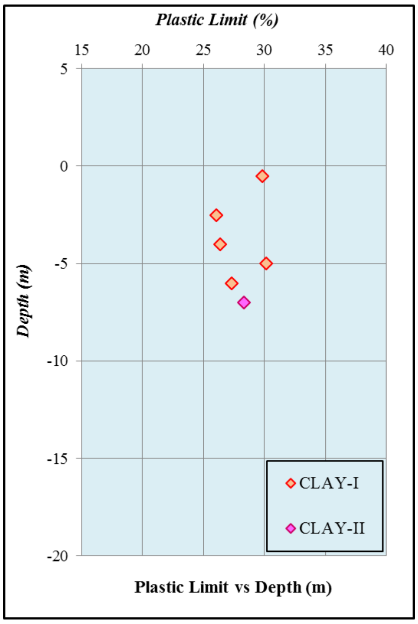


Figure - 4.9 Plastic Limit vs Depth (m) (Daungyi Station)

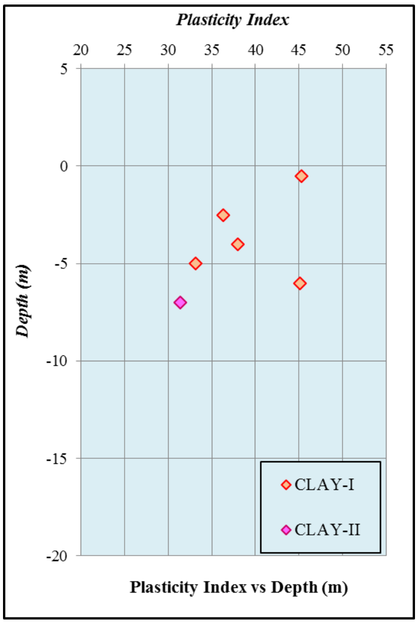


Figure - 4.10 Plasticity Index vs Depth (m) (Daungyi Station)

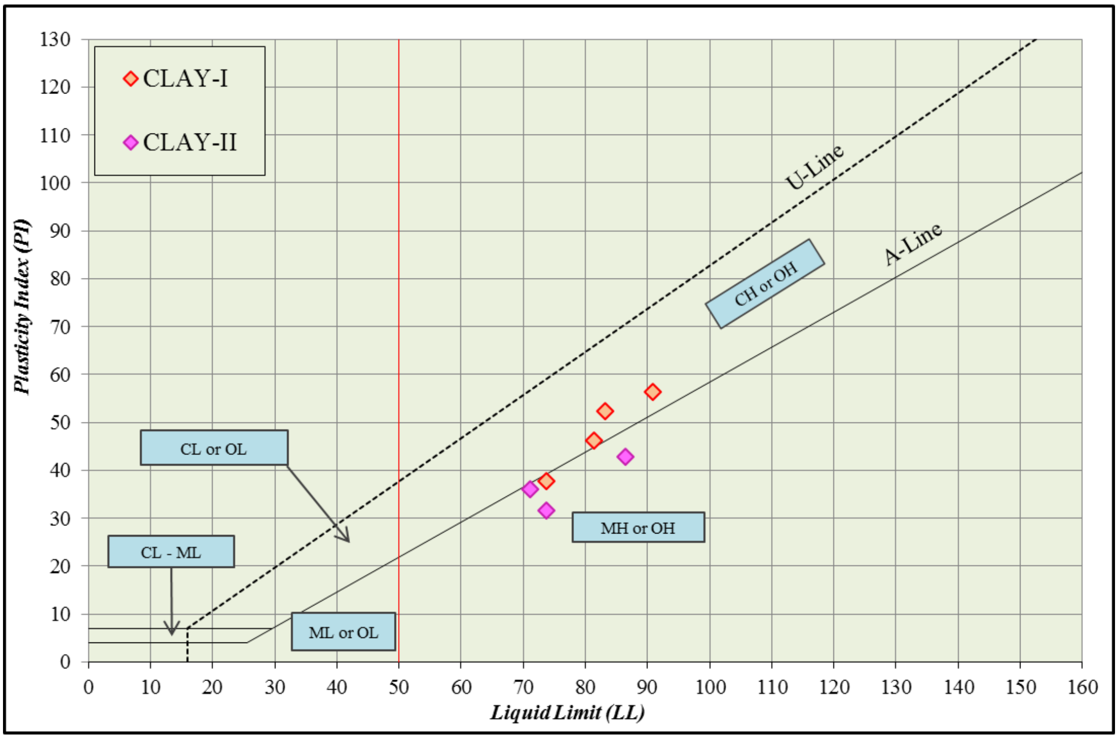


Figure - 4.11 Condition of Atterberg Limits Test Results (Chaungphyar Station)

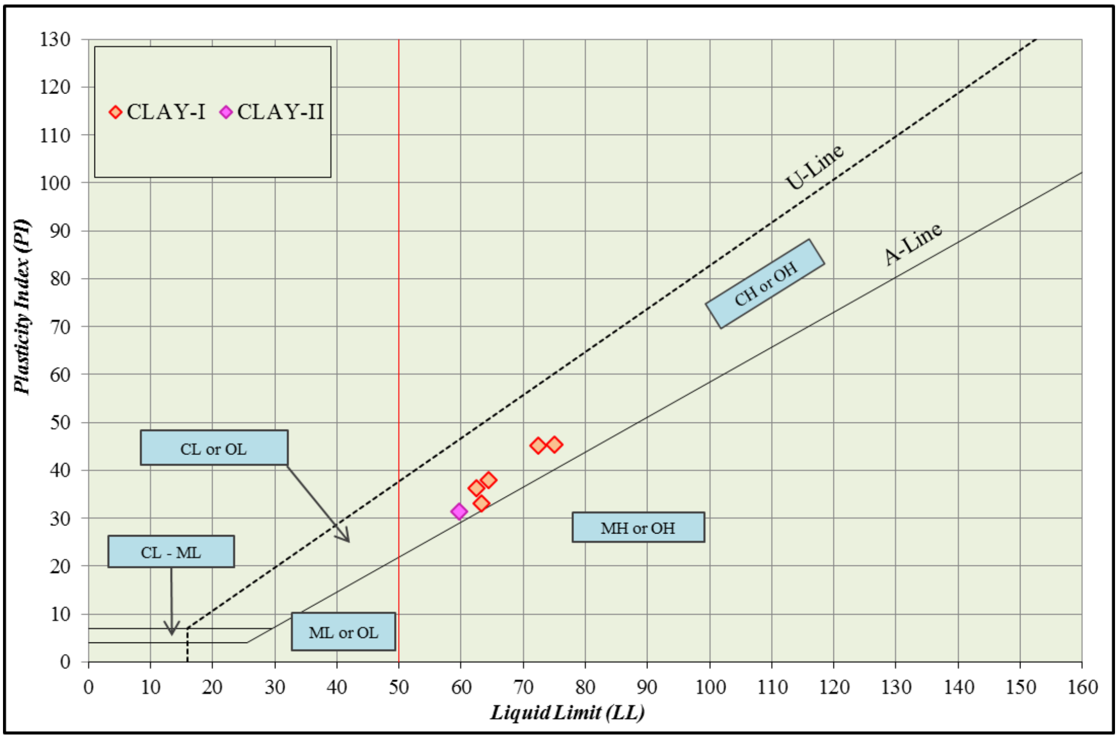


Figure - 4.12 Condition of Atterberg Limits Test Results (Daunggyi Station)

4.3.4 Grain Size Analysis Test

Figure-4.13 and Figure-4.14 are illustrated the grain size distribution of each soil layer versus depth. The details of Grain Size Analysis Test results were shown in Appendix-C.

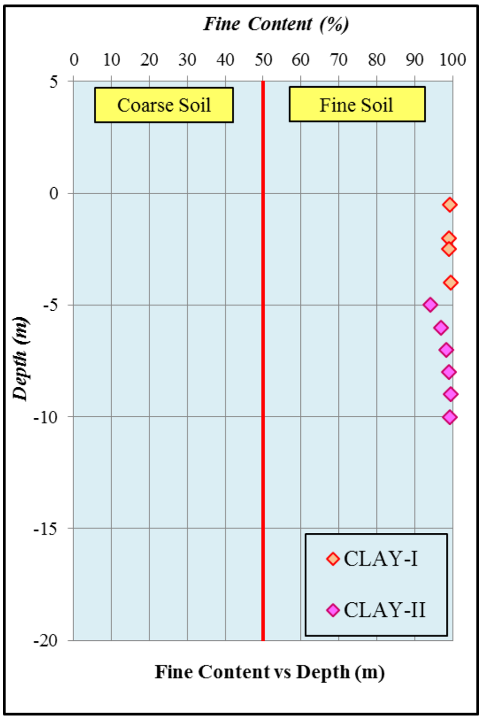


Figure - 4.13 Fine Content vs Depth (m)
(Chaungphyar Station)

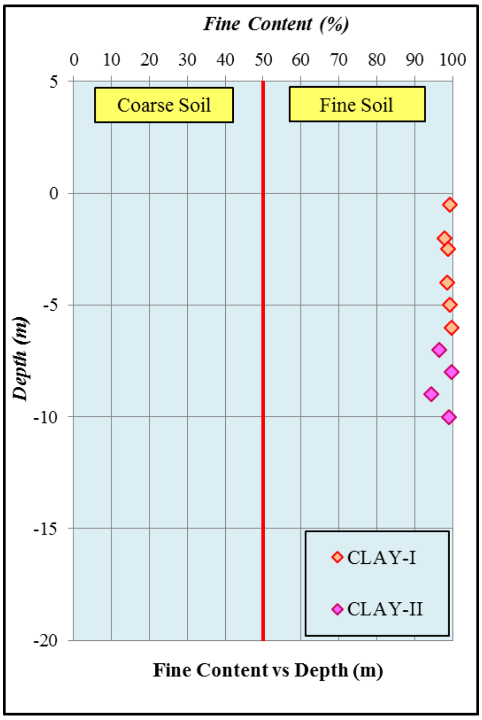


Figure - 4.14 Fine Content vs Depth (m)
(Daunggyi Station)

4.3.5 Unconsolidated Undrained Triaxial Compression Test (UU)

The summary of unconsolidated undrained triaxial comperssion test results are described in Table-4.6. Figure-4.15 to Figure-4.18 show the the cohesion and friction angle versus their depth of each location. Moreover, the detailed test results were shown in Appendix-C.

Table - 4.6 Summary of Unconsolidated Undrained Triaxial Compression Test Results

No.	Soil Types	Cohesion (C_{UU}) (kN/m^2)	Friction Angle (ϕ_{UU})°	Remarks
		Range	Range	
1	CLAY-I	16.10	9.95	Chaungphyar Station
2	CLAY-II	17.80	0.00	
3	CLYA-I	12.50	15.14	Daunggyi Station

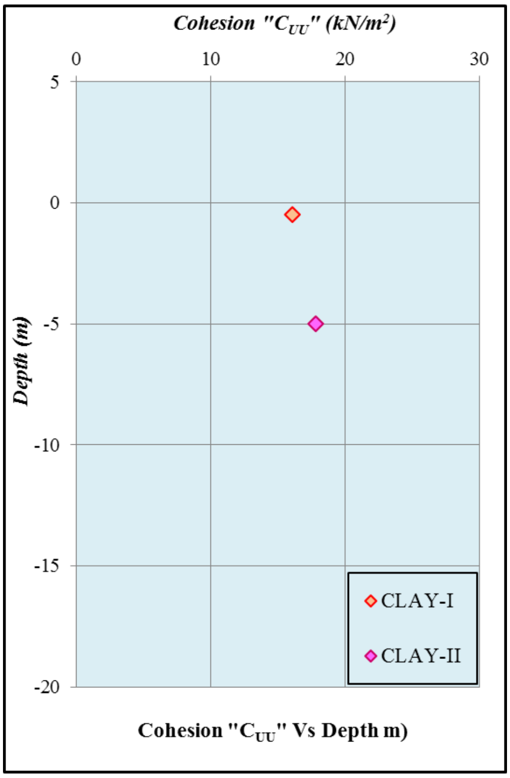


Figure - 4.15 Cohesion "C_{UU}" vs Depth (m) for Chaungphyar Station

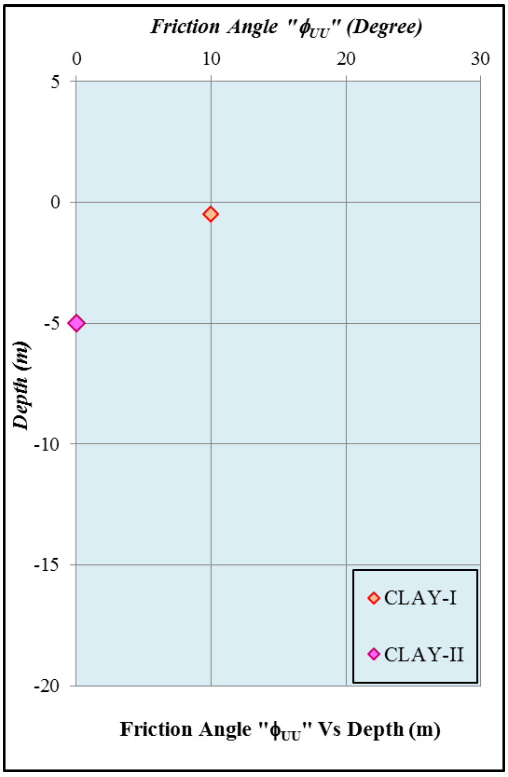


Figure - 4.16 Cohesion "ϕ_{UU}" vs Depth (m) for Chaungphyar Station

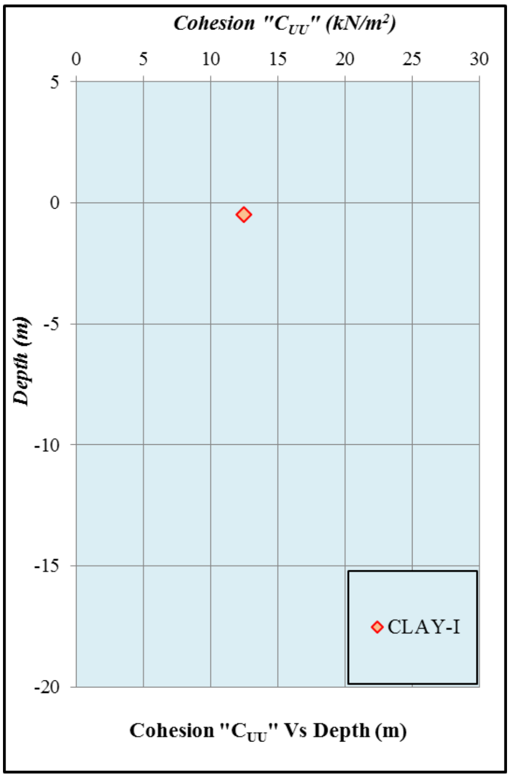


Figure - 4.17 Cohesion "C_{UU}" vs Depth (m) for Daunggyi Station

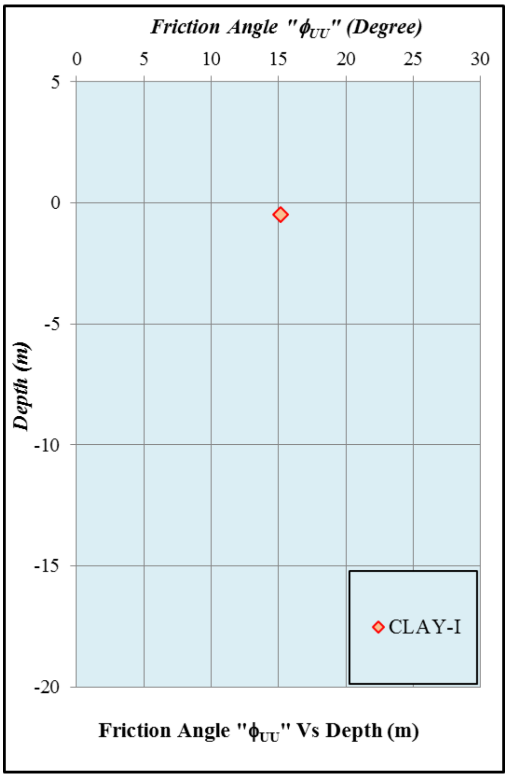


Figure - 4.18 Cohesion "ϕ_{UU}" vs Depth (m) for Daunggyi Station

4.3.6 Consolidated Undrained Triaxial Compression Test (CIU)

Summary of consolidated undrained triaxial compression test results are described in Table-4.7. Figure-4.19 and Figure-4.20 indicate the relationship between cohesion (C) and friction angle (ϕ) versus their depth in elevation (m) of investigation area. Moreover, Figure-4.21 and Figure-4.22 show the relationship between the effective cohesion (c') and effective friction angle (ϕ') versus their depth in elevation (m) at the investigation area. The detailed test results were shown in Appendix-C.

Table - 4.7 Summary of Consolidated Undrained Triaxial Compression Test Results for Chaungphyar Station

No.	Soil Type	**Cohesion (C) (kN/m²)**	**Friction Angle (ϕ) (Degree)**	**Effective Cohesion (c') (kN/m²)**	**Effective Friction Angle (ϕ') (Degree)**
		Range	Range	Range	Range
1	CLAY-I	3.5	14.5	0.0	18.0

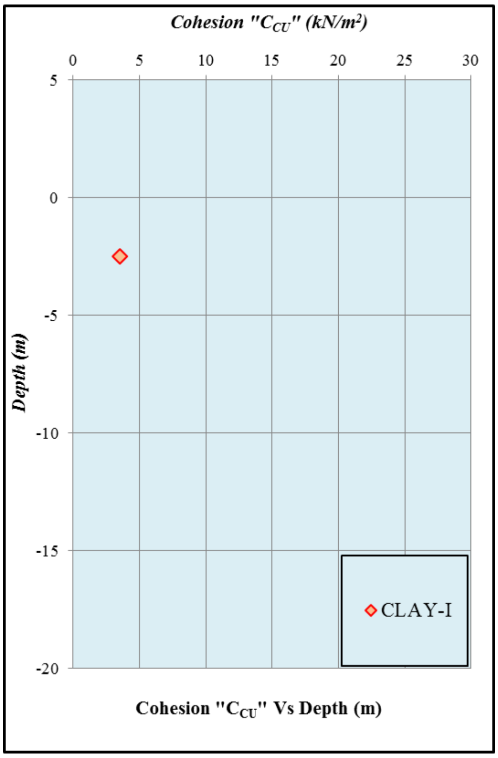


Figure - 4.19 Cohesion “ C_{CU} ” vs Depth (m)

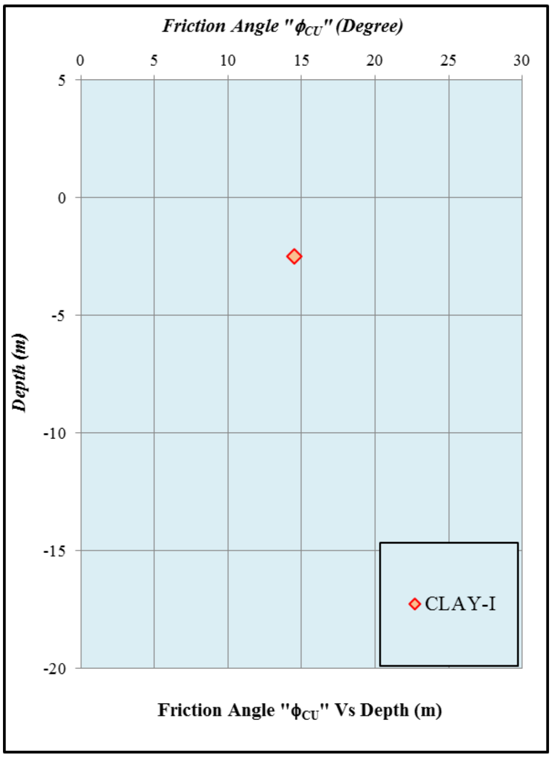


Figure - 4.20 Friction Angle “ ϕ_{CU} ” vs Depth (m)

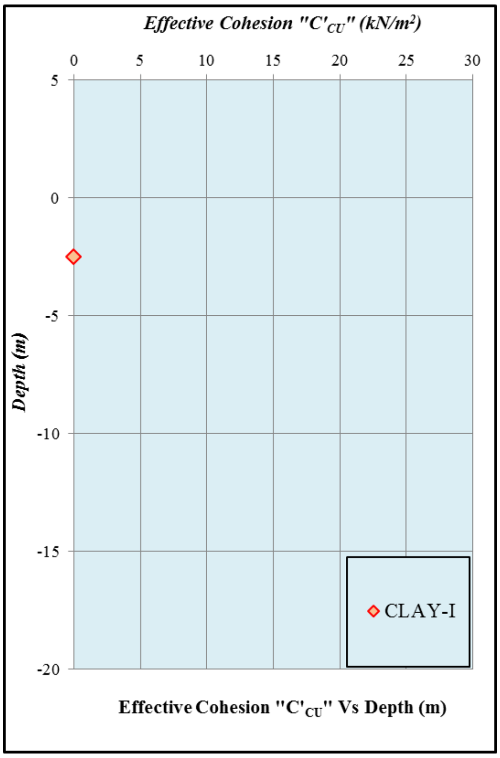


Figure - 4.21 Effective Cohesion “ c'_{CU} ” vs Depth (m)

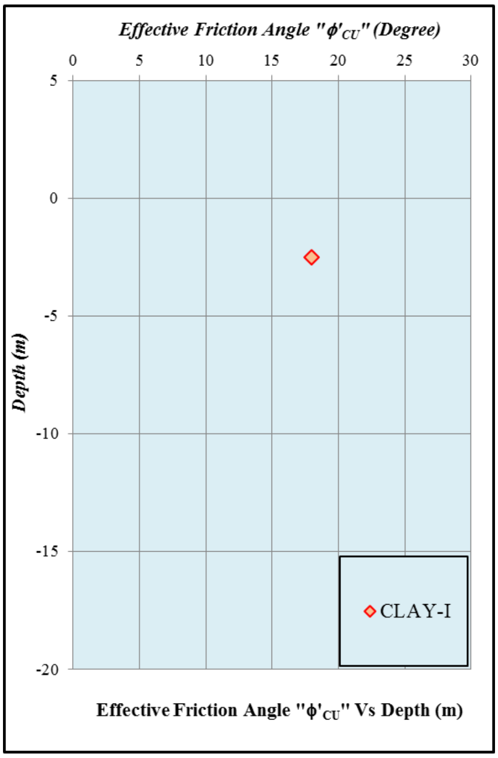


Figure - 4.22 Effective Friction Angle “ ϕ'_{CU}” vs Depth (m)

4.3.7 One Dimensional Consolidation Test

Table-4.8 summarized some results of one dimensional consolidation test such as initial void ratio (e_0), pre-consolidation pressure (Pc) and compression index (Cc). Figure-4.23 to Figure-4.28 indicate the relationship between (e_0), (Pc) and (Cc) versus depth in elevation for each station. Moreover, Figure-4.29, Figure-4.30 and Figure-4.33 show the e-log-P curve results from one dimensional consolidation tests of soil from each location. Moreover, Figure-4.31, Figure-4.32 and Figure-4.34 show the relationship between coefficient of consolidation (Cv) versus mean consolidation pressure of that soil.

Table - 4.8 Summary of One Dimensional Consolidation Test Results

No.	Soil Type	Initial Void Ratio (e_0)	Consolidation Yield Stress Pc (kN/m^2)	Compression Index (Cc)	Remarks
1	CLAY-I	1.080	228.9 ~ 251.4	0.308 ~ 0.335	Chaungphyar Station
2	CLAY-II	2.730*	78.5*	1.388*	
3	CLAY-I	0.820 ~ 0.880	221.1 ~ 311.5	0.215 ~ 0.281	Daunggyi Station

*One sample testing results

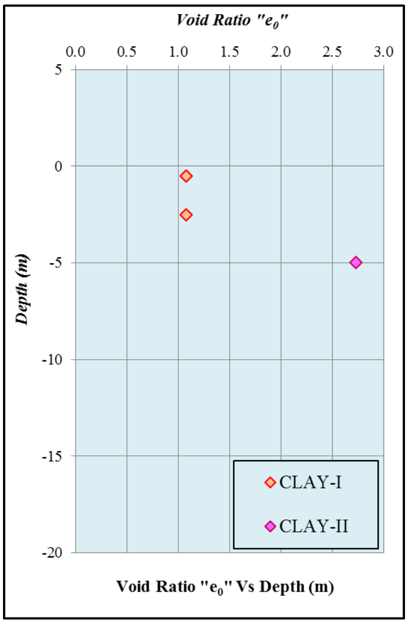


Figure - 4.23 Void Ratio vs Depth (m) (Chaungphyar Station)

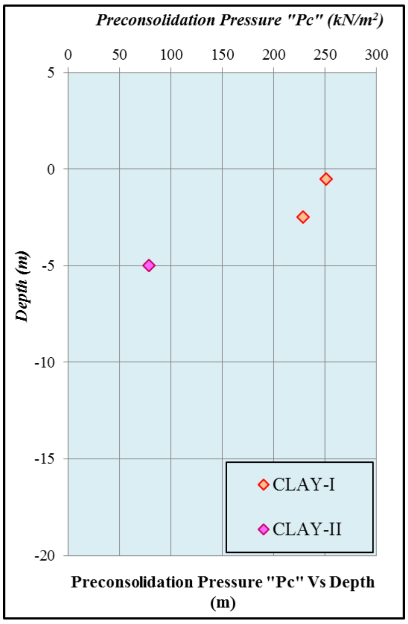


Figure - 4.24 Preconsolidation Pressure vs Depth (m) (Chaungphyar Station)

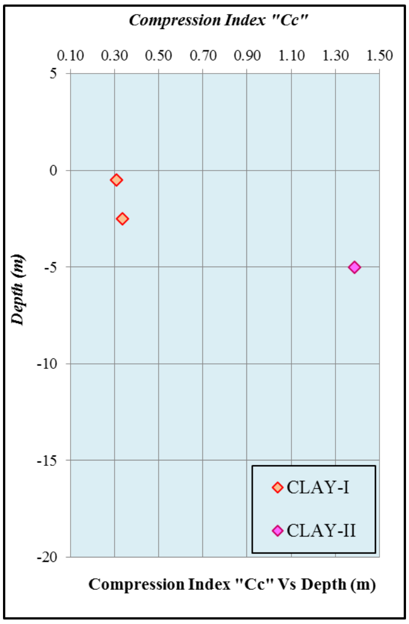


Figure - 4.25 Compression Index "Cc" vs Depth (m) (Chaungphyar Station)

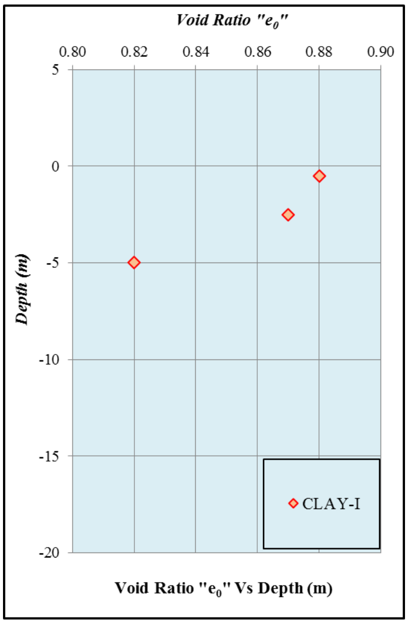


Figure - 4.26 Void Ratio vs Depth in elevation (m) (Daungyi Station)

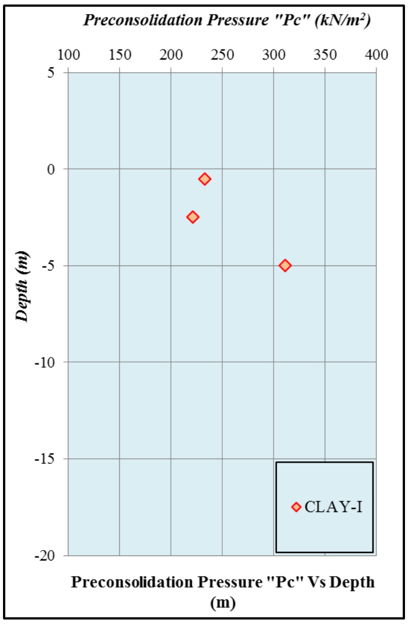


Figure - 4.27 Preconsolidation Pressure vs Depth in elevation (m) (Daungyi Station)

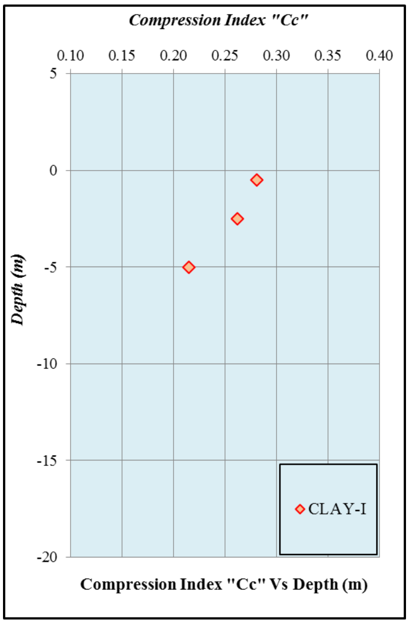


Figure - 4.28 Compression Index "Cc" vs Depth in elevation (m) (Daungyi Station)

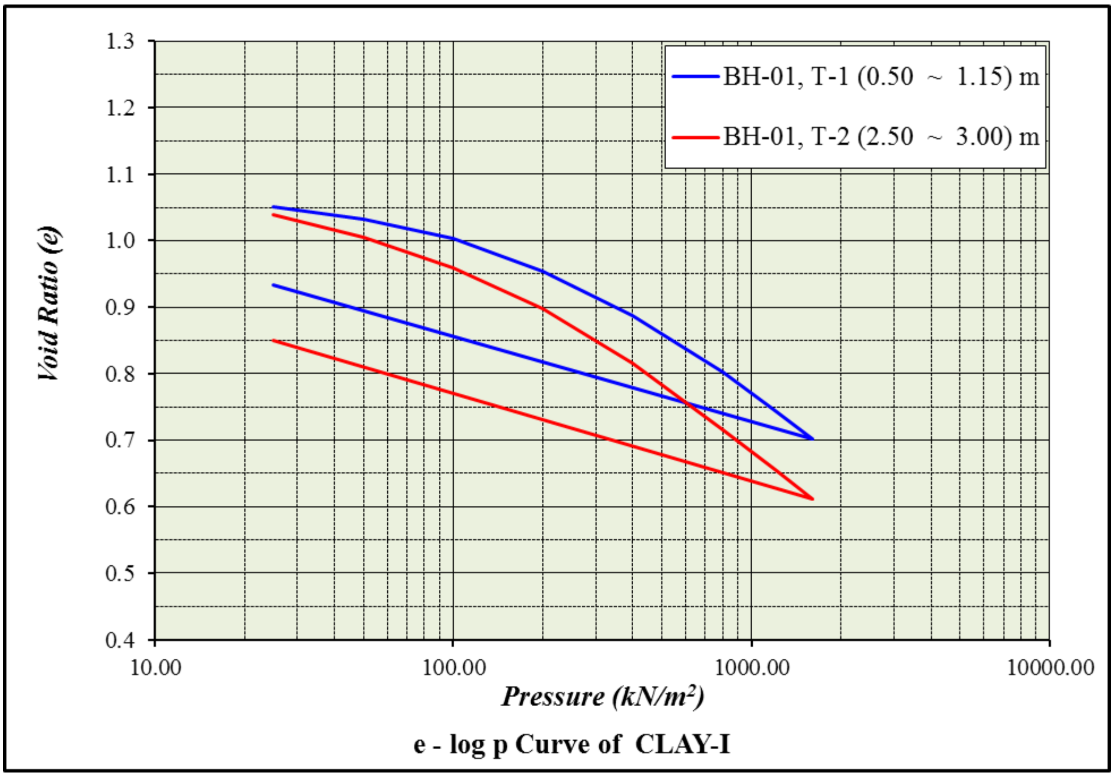


Figure - 4.29 e-log P Curve of CLAY-I for Chaungphyar Station

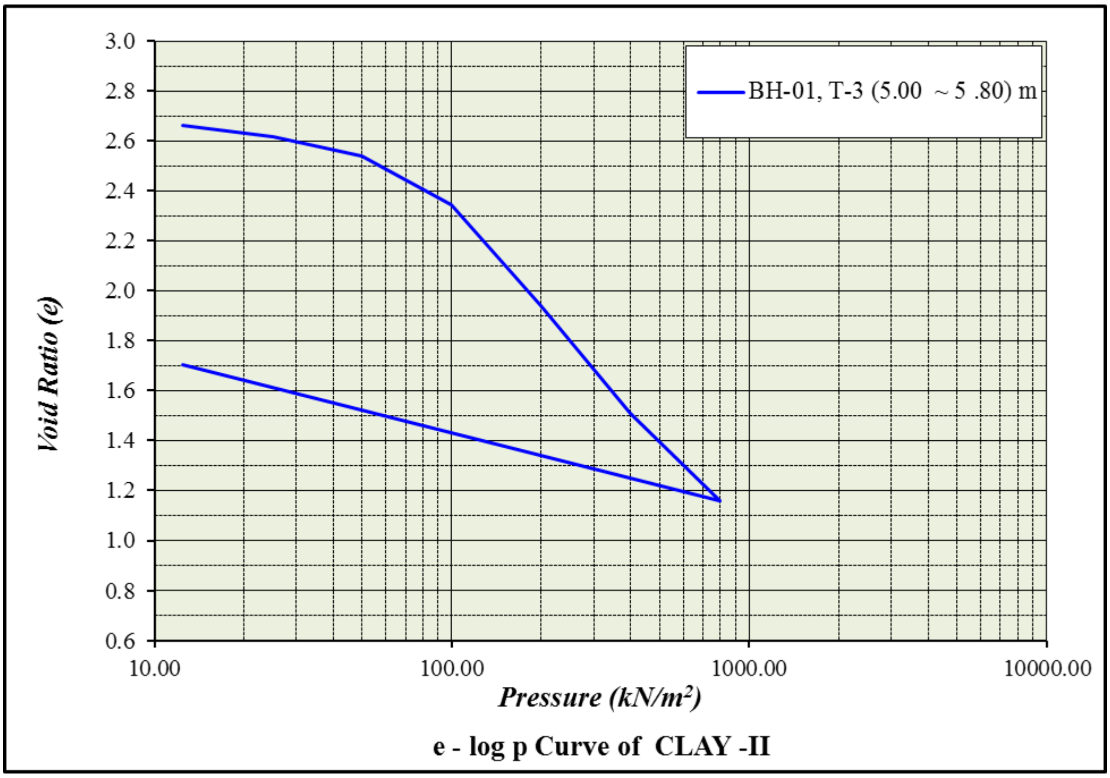


Figure - 4.30 e-log P Curve of CLAY-II for Chaungphyar Station

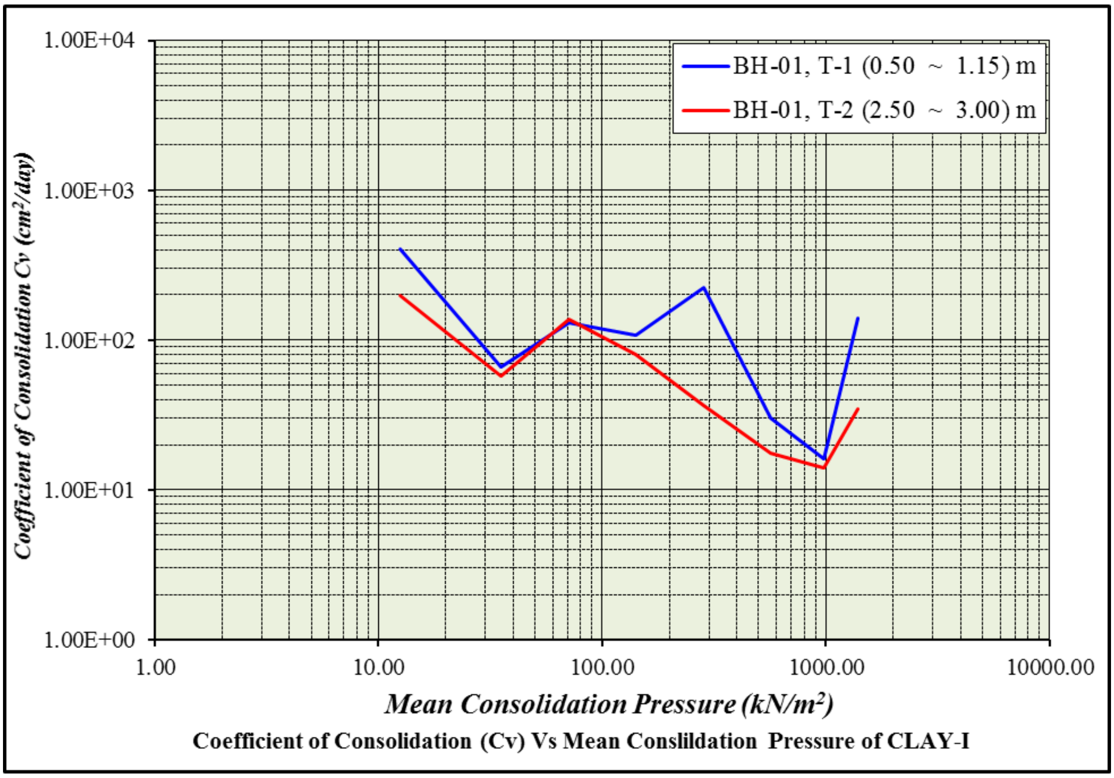


Figure - 4.31 Coefficient of consolidation (Cv) vs mean consolidation pressure of CLAY-I for Chaungphyar Station

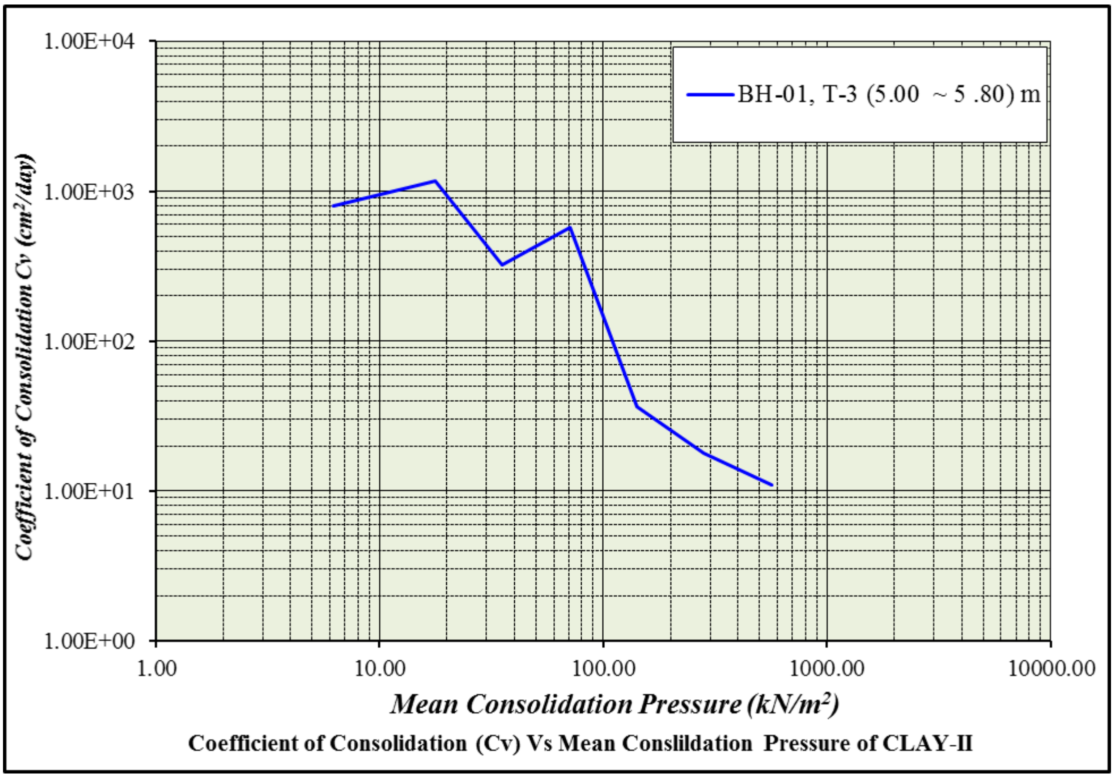


Figure - 4.32 Coefficient of consolidation (Cv) vs mean consolidation pressure of CLAY-II for Chaungphyar Station

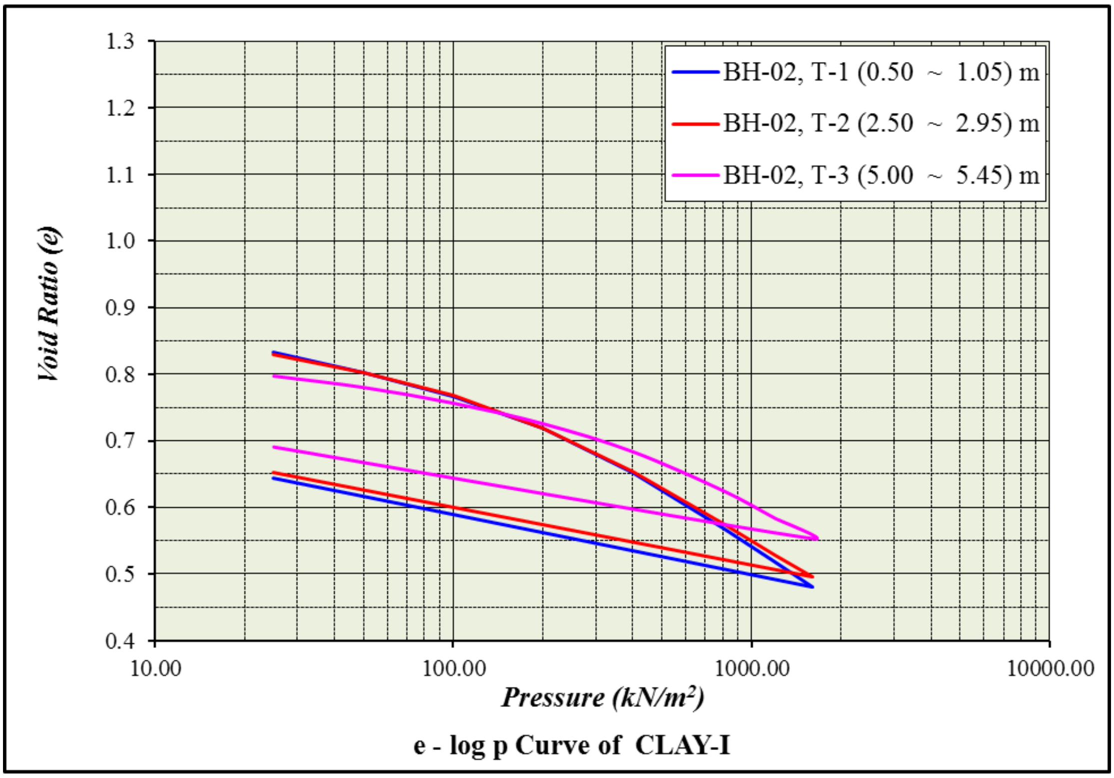


Figure - 4.33 e-log P Curve of CLAY-I for Daunggyi Station

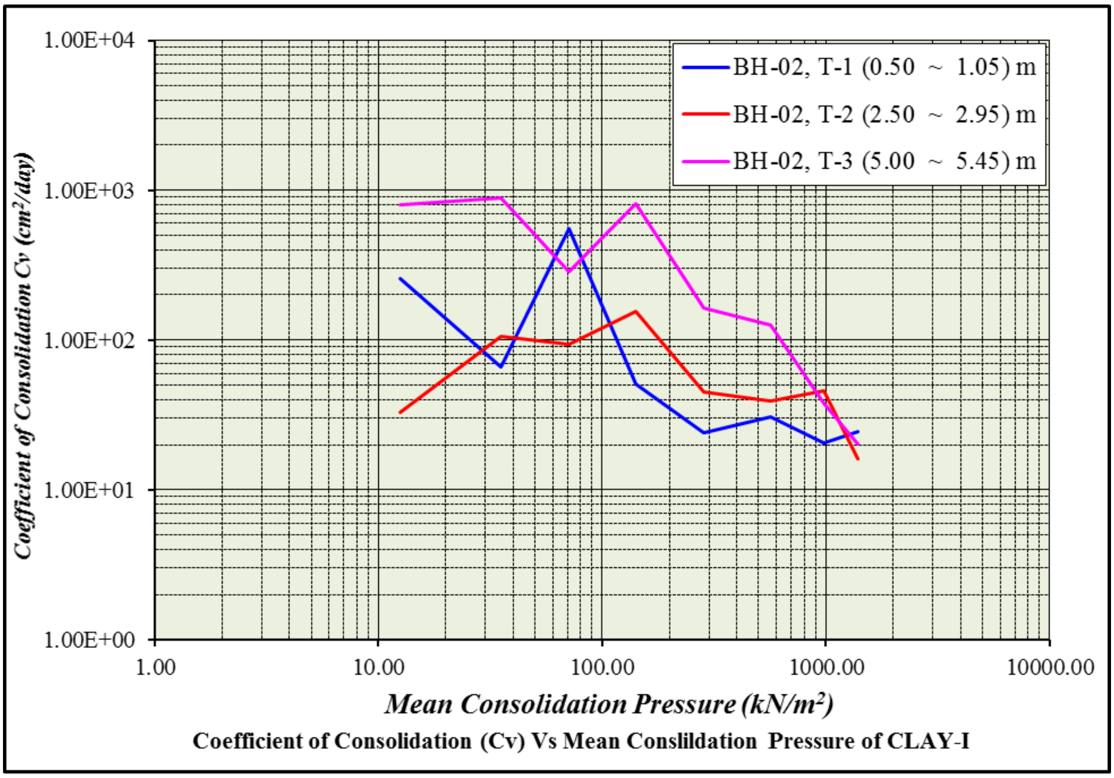


Figure - 4.34 Coefficient of consolidation (Cv) vs mean consolidation pressure of CLAY-I for Daunggyi Station

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資料-2

測量調査報告書

REPORT
ON
TOPOGRAPHIC SURVEY
AT
NEAR CHAUNG PHYAR STATION,
EINME TOWNSHIP, AYEYARWADDY REGION
UNION OF MYANMAR

METRY TECHNICAL INSTITUTE CO., LTD.

FKYB - 2016-032

NOVEMBER, 2016

FGEX
FUKKEN

Submitted by:
Fukken Co., Ltd. (Consulting Engineers)
www.myanmargeoconsultant.com

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REPORT
ON
TOPOGRAPHIC SURVEY AT NEAR CHAUNG PHYAR STATION EINME TOWNSHIP

1 INTRODUCTION

METRY TECHNICAL INSTITUTE CO., LTD. assigned Fukken Co., Ltd. to carry out Topographic Survey at near chaung phyar station, Einme Township, Ayeyarwaddy Region. One survey team has conduct topographic survey associate with Reflectorless Totalstation and level survey for topographic map of this project area.

1.1 Objective of Survey

The survey includes topographic survey to show ground feature of project area and related existing features such as existing rail-way line and bridge, existing retaining wall and other structures, drain line, water tank, tube well, electric post, tree, pavement, manhole and septic tank in the project area. The topographic survey conducted for planning, designing and construction for Patherin - Einme Rail-way upgrading project in the future.

1.2 Scope of Work

The scope of work is as follows;

- Topographic Survey: appropriately 8000.00 m^2
- Temporary Bench Mark: 3 points
- Rail-way Length : 400m
- Cross Section Survey: 83 Sections
- Drawing

1.3 Project Location

Project area is located near Chaungphyar Rail-way Station on Pathein-Einme Rail-Way, Einme Township, Ayeyarwaddy Region. The detailed location of project area is indicated as a google map in Figure-1.1.

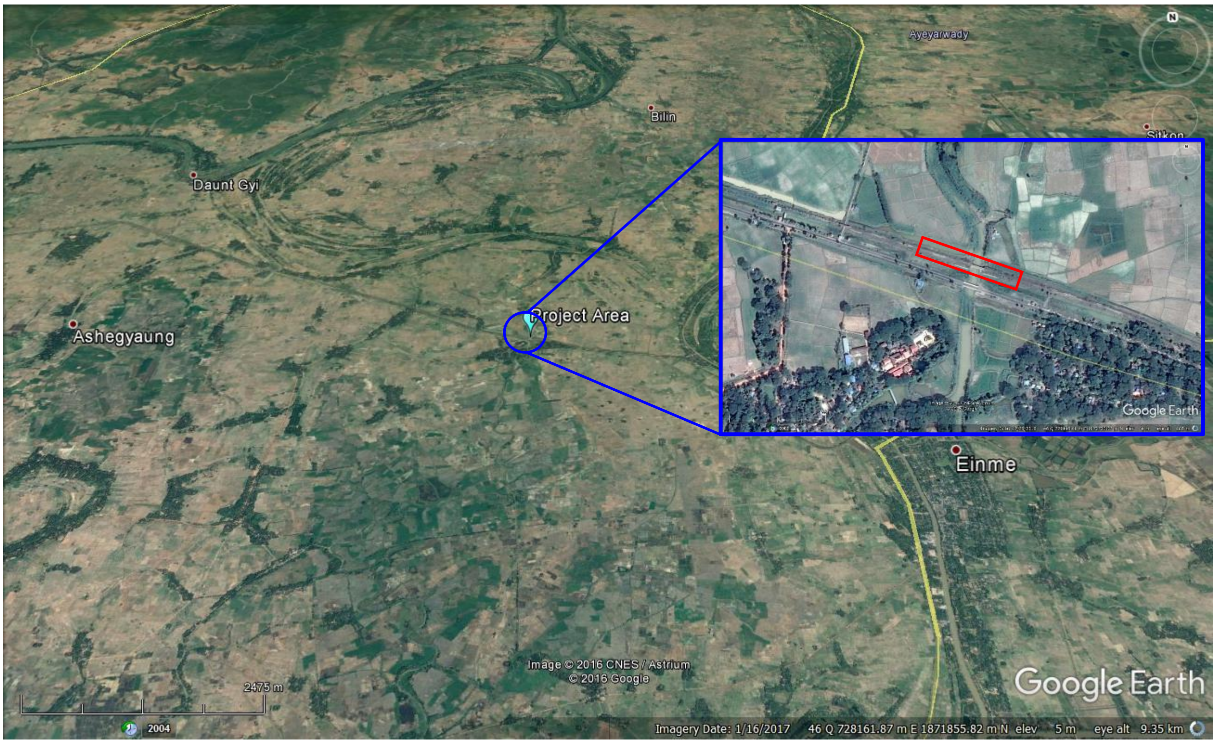


Figure - 1.1 Google Map of Project Area

1.4 Equipment Applied in the Project

The survey equipment is shown in Table-1.1.

Table - 1.1 Specification of Survey Equipment

Name	Type	Spec	Set
Total Station	Sokkia CX 103 (Reflectorless Totalstation)	±(2mm+2ppm×D)m.s.e	1 set
Auto Level	SOKKIA SDL30 (Digital Level)	Up to 0.6mm	1 set
Survey Software	Civil CAD 6.4		1 set
Drawing Software	AutoCAD 2010/2015		1 set

1.5 Survey Team

The following persons are participated in this project.

Table - 1.2 Member List of Survey Team

Sr.	Name	Position
1	U Si Thu Aung	Project Coordinator
2	U Soe Moe Kyaw	Site Engineer
3	U Soe Lwin	Chief Surveyor
4	U Kyaw Zin Htun	Senior Surveyor
5	U Myo Han Htun	Senior Surveyor
6	U Kyaw Thu	Surveyor
7	Survey Assistant	6 Persons

1.6 Project Duration

Actual project period is shown in the following table.

Table - 1.3 Actual Working Schedule of Survey Works

Date	Activities
09/November/2016	Moving survey equipment and Field surveying
11/November/2016 to 12/November/2016	Surveying, Level Survey and Cross Section Survey
13/November/2016 to 18/November/2016	Data processing
19/November/2016 to 30/November/2016	Preparation of report

2 SITE CONDITION

Since the proposed project area is located in the Ayeyarwaddy Delta Region, the topographic feature of the region is regards as relatively flat lying area. The project area is mainly composed of flood plain deposit and marine sediments. As it is located at the delta region, the braided channels are very common. The river and its tributary are meandering, shows old age stage of Ayeyarwaddy River. Flat lying topography with abundant channel is typical features of project area.

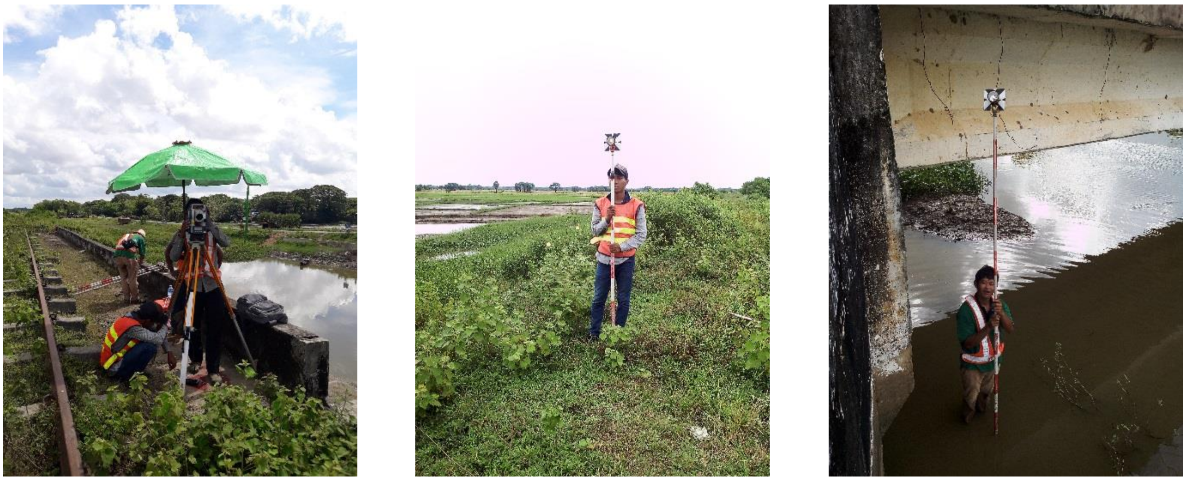


Photo - 2.1 View of Topographic Surveying

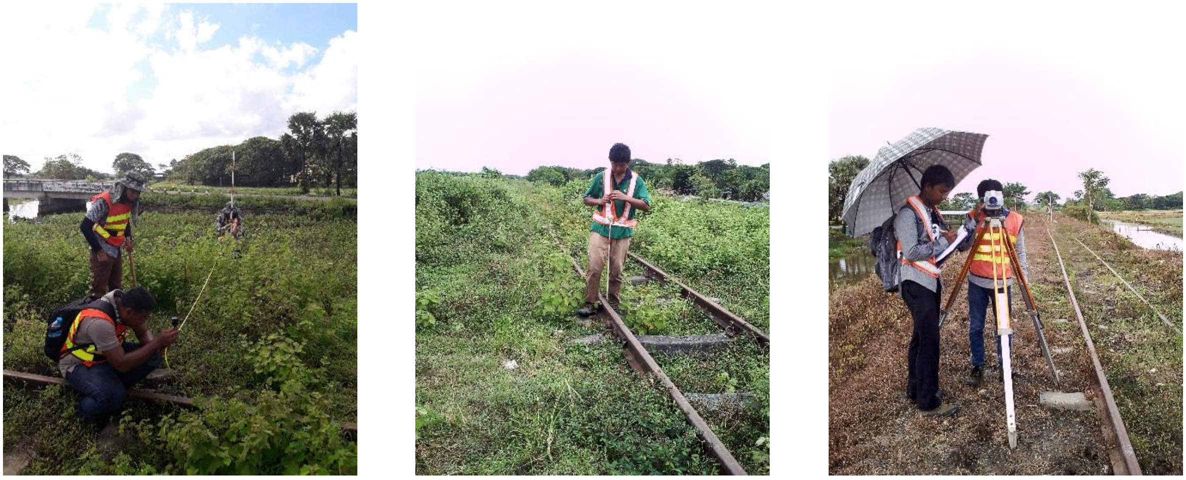


Photo - 2.2 View of Topographic Surveying

3 CONTROL POINTS

For this survey, three temporatry bench marks were set up in this project area. The coordinate system used WGS-84 (World Geodetic System 1984). Moreover, the elevation of one was surveyed by leveling survey referring to the bench mark shown by Client. This BM is located infront of Phayar Gyi Rail-way Station. Elevation of this BM is assumed 10.0m.

Table - 3.1 Coordinate and Elevation of Control Points

Control Point	Easting (m)	Northing (m)	Elevation (m)	Remarks
BM	726600.7900	1872893.7600	10.000	Iron Nail Points
TBM-1	726600.1400	1872890.4600	10.614	
TBM-2	727037.0761	1872759.4465	10.156	
TBM-3	727011.0000	1872764.0000	10.148	

TBM-01 is located on the bottom beam beside the Rail-way Station Staff Office. TBM-02 and TBM-03 are located on the Chaung Phyar Bridge. The detailed location are shown in following photos.

Photo - 3.1 BM (Close View)

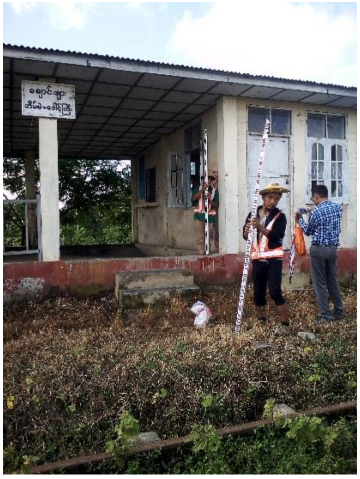


Photo - 3.2 BM (Panoramic View)

Photo - 3.3 TBM-1 (Close View)

Photo - 3.4 TBM-1 (Panoramic View)

Photo - 3.5 TBM-2 (Close View)

Photo - 3.6 TBM-2 (Panoramic View)

Photo - 3.7 TBM-3 (Panoramic View)

Photo - 3.8 TBM-3 (Panoramic View)

4 TOPOGRAPHIC SURVEY

Topographic survey was carried out by using Reflectorless Total Station and Auto Level based on Temporatory Bench Mark (TBM-1, TBM-2 and TBM-3). The changing point of topography was observed in this survey.

5 CROSS SECTION SURVEY

In this project, cross section survey was also carried out with 5.0m interval along rail-way. Total 83 numbers of corss section are measured by total station. The detailed measuring results are shown in Appendix-C.

6 DRAWING

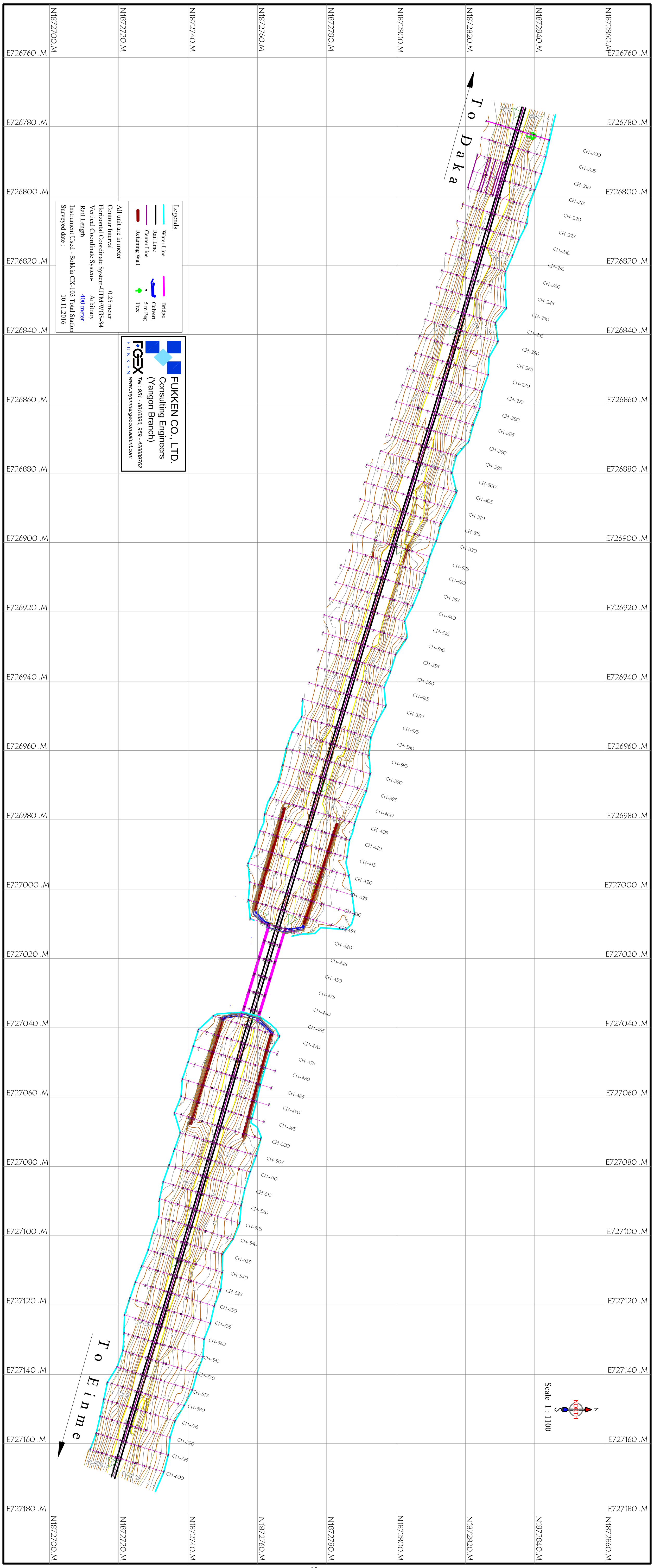
Drawing condition is shown as follows;

1) Topographic Map
   - Detail Topographic Map is shown in Appendix-A.
   - Control points, all spot level and existing facilities etc. are shown.
2) Contour Lines
   - Contour lines are drawn by 0.5meter major contour and 0.5 meter minor contour line.
3) Cross Section Survey
   - Cross Section Survey are drawn by 5.0m interval.
4) Mapping Symbols
   - All mapping symbols are in accordance with the standard of Myanmar.
5) Control Points
   - Location of Control Points with these coordinate and elevation are shown in Topographic Map.

6.1 Survey Area

The total area of project compound in measuring area as shown in map is 8934.7865 m^2 (2.207825 acre). The detail topographic map can be seen in Appendix-A.

---------- End of Document ----------


Legends
Water Line
Rail Line
Center Line
Retaining Wall
Bridge
Culvert
5 m Peg
Tree
All unit are in meter
Contour Interval 0.25 meter
Horizontal Coordinate System-UTM WGS-84
Vertical Coordinate System- Arbitrary
Rail Length 400 meter
Instrument Used - Sokkia CX-103 Total Station
Surveyed date : 10.11.2016
FUKKEN CO., LTD.
Consulting Engineers
(Yangon Branch)
To Daka
To Einme
Scale 1 : 1100

Project

Project name: Elevation Transfer.ttp
Created by: Soe Lwin
Comment:

Benchmarks

Name	Grid Northing (m)	Grid Easting (m)	Elevation (m)	Code
1			10.0000	BM
27			10.0000	BM

Point Summary

Name	Grid Northing (m)	Grid Easting (m)	Elevation (m)	Code	Photo Notes
1			**10.0000**	**BM**	
2			**10.6140**	**TBM-1**	
3			9.6233		
4			9.7144		
5			9.5425		
6			9.3075		
7			9.5094		
8			9.6796		
9			9.4711		

10			**10.1558**	**TBM-2**	
11			**10.1476**	**TBM-3**	
12			9.6359		
13			9.7889		
14			9.6955		
15			9.7659	STN-1	
16			9.8460	STN-2	
17			10.1477	TBM-3	
18			10.1555	TBM-2	
19			9.4317	STN-3	
20			9.6926	STN-4	
21			9.4847	STN-5	
22			9.3128	STN-6	
23			9.5500		
24			9.6541		
25			9.5946		
26			10.6134	TBM-1	
27			10.0000	BM	

DL Observations

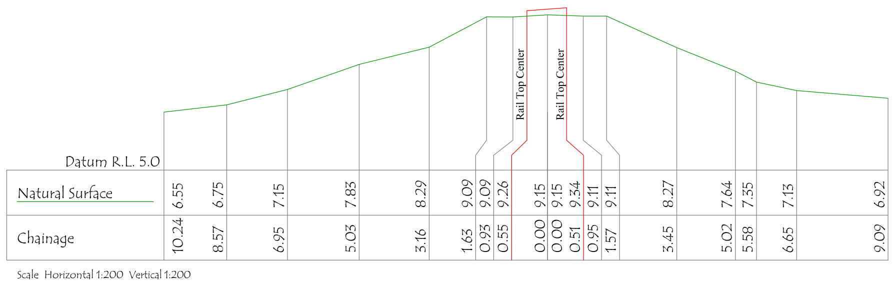
Point	BS (m)	SS (m)	FS (m)	Elevation (m)	Distance (m)	Ht Residual (m)
1	0.9676			10.0000	9.06	
2			0.3536	10.6140	10.42	0.0000
2	0.3536			10.6140	10.42	
3			1.3443	9.6233	10.75	0.0000
3	1.2898			9.6233	28.89	
4			1.1986	9.7144	29.66	0.0001
4	1.1360			9.7144	30.46	
5			1.3079	9.5425	29.99	0.0001
5	1.2252			9.5425	24.86	
6			1.4601	9.3075	25.54	0.0000
6	1.2778			9.3075	33.61	

7			1.0759	9.5094	32.59	0.0001
7	1.3902			9.5094	33.74	
8			1.2199	9.6796	33.12	0.0001
8	1.2606			9.6796	33.04	
9			1.4691	9.4711	33.75	0.0001
9	1.7000			9.4711	21.01	
10			1.0152	10.1558	22.54	0.0000
10	1.4668			10.1558	13.42	
11			1.4750	10.1476	13.21	0.0000
11	1.2743			10.1476	29.71	
12			1.7860	9.6359	30.34	0.0001
12	1.4360			9.6359	37.53	
13			1.2829	9.7889	37.44	0.0001
13	1.4034			9.7889	19.43	
14			1.4968	9.6955	19.94	0.0000
14	1.4968			9.6955	19.95	
15			1.4263	9.7659	19.74	0.0000
15	1.3202			9.7659	30.85	
16			1.2401	9.8460	29.68	0.0001
16	1.3144			9.8460	36.73	
17			1.0126	10.1477	37.46	0.0001
17	1.4730			10.1477	13.64	
18			1.4652	10.1555	12.98	0.0000
18	1.0342			10.1555	22.33	
19			1.7579	9.4317	21.23	0.0000
19	1.4438			9.4317	35.49	
20			1.1829	9.6926	36.26	0.0001
20	1.4205			9.6926	32.80	
21			1.6283	9.4847	32.19	0.0001
21	1.0986			9.4847	32.71	
22			1.2705	9.3128	32.53	0.0001
22	1.4551			9.3128	23.52	
23			1.2178	9.5500	23.95	0.0000
23	1.3346			9.5500	31.21	
24			1.2305	9.6541	30.42	0.0001
24	1.3432			9.6541	28.20	
25			1.4026	9.5946	29.67	0.0001
25	1.4417			9.5946	11.27	
26			0.4229	10.6134	10.40	0.0000
26	0.4227			10.6134	10.40	
27			1.0361	10.0000	8.90	0.0000
				Total Closing Error		**0.0014**

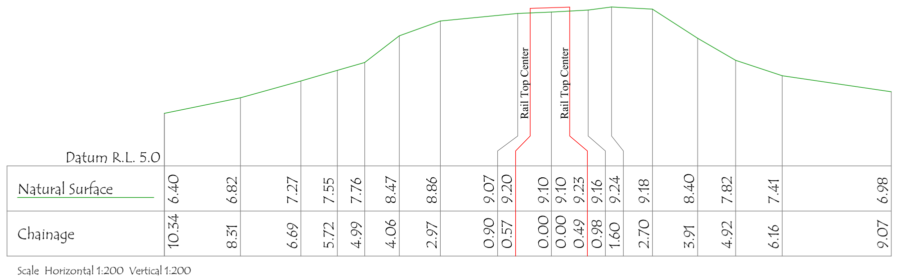
Adjustment

Adjustment type: Height, Constraint
Confidence level: 95 %
Number of adjusted points: 0
Number of height adjusted points: 27
Number of height control points: 2
Number of DL conditions: 26
A posteriori height UWE: 0.3013344 , Bounds: (3.130495E-02 , 2.240536)

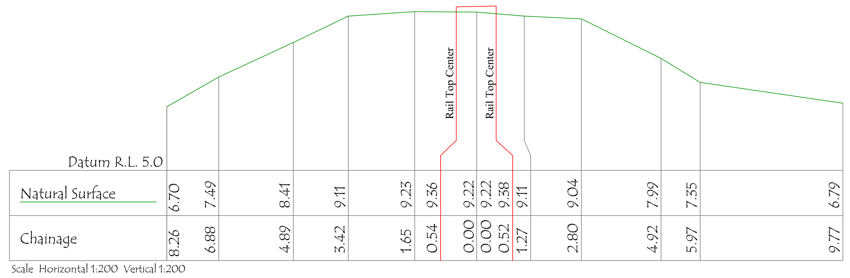
Cross Section of Railway from (CH 200 To 240)



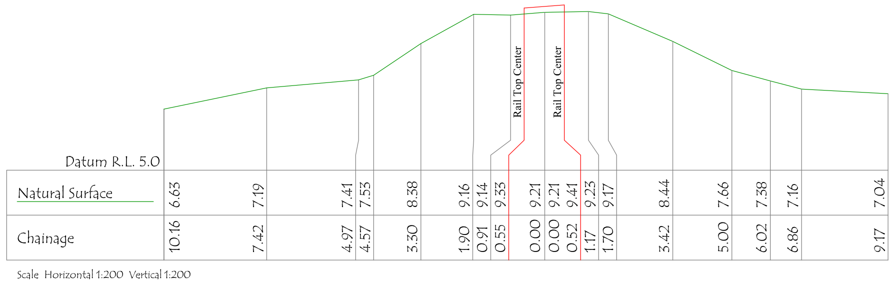
Chainage: 210 m



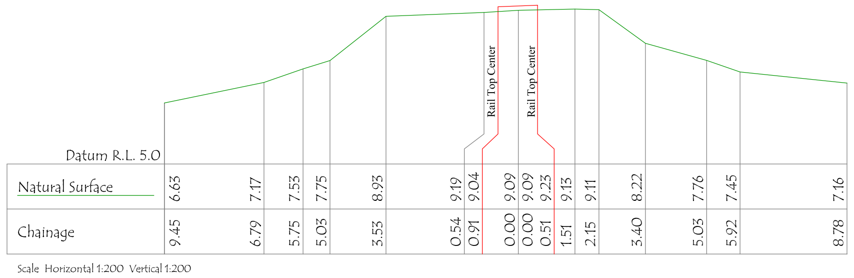
Chainage: 225 m



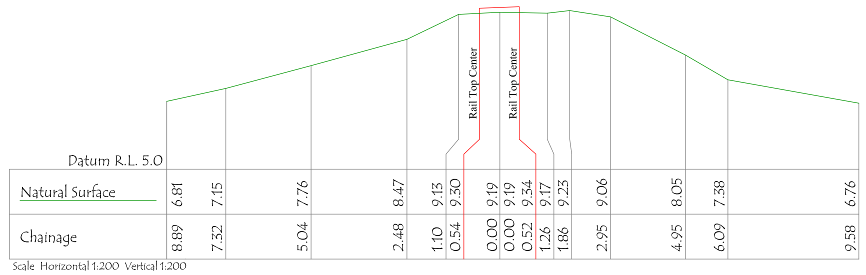
Chainage: 240 m



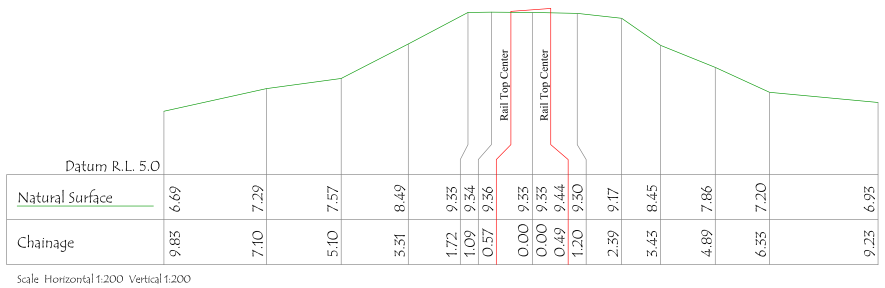
Chainage: 205 m



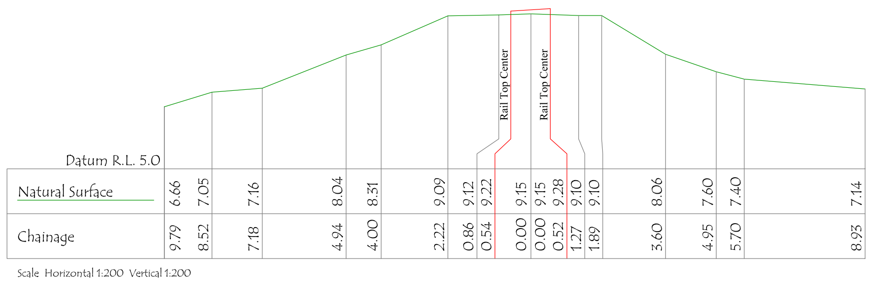
Chainage: 220 m



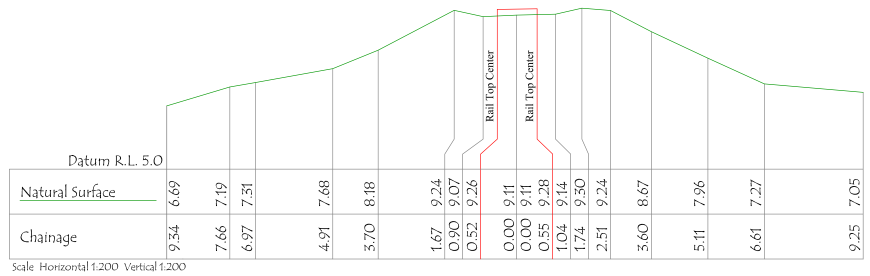
Chainage: 235 m



Chainage: 200 m

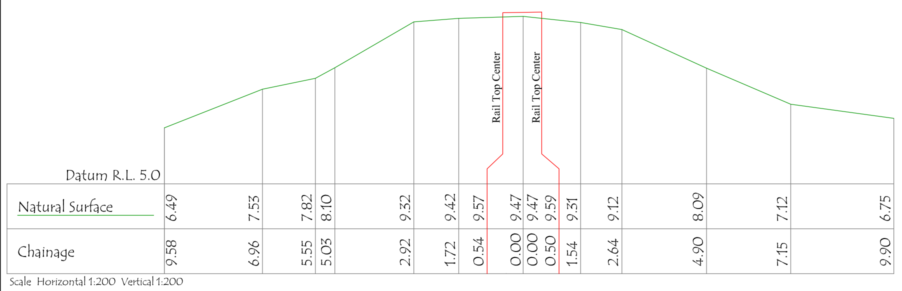


Chainage: 215 m

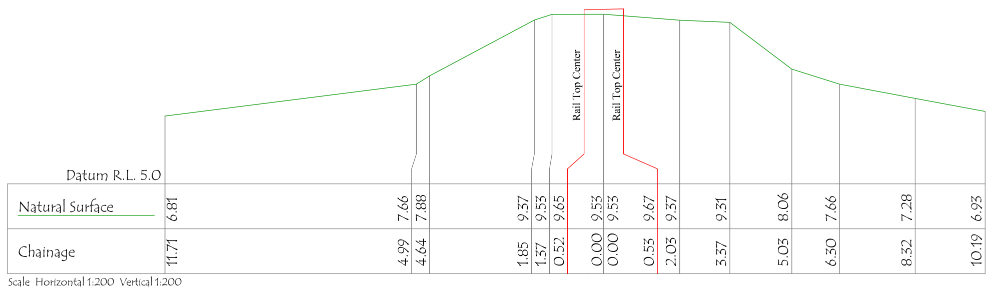


Chainage: 230 m

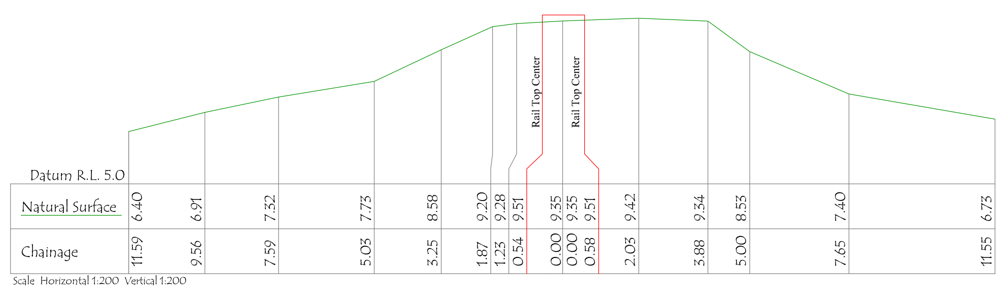
Cross Section of Railway from (CH 245 To 285)



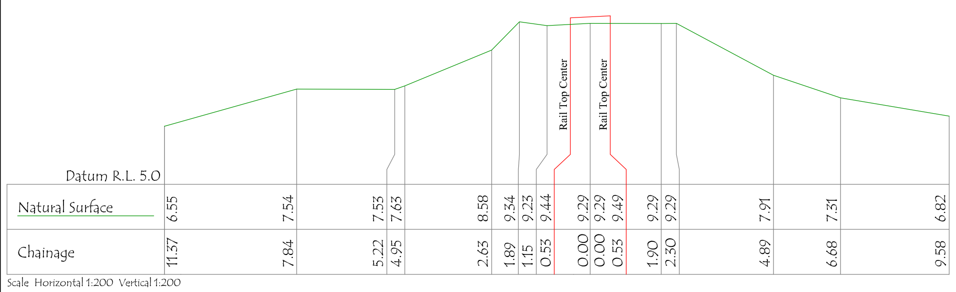
Chainage: 255 m



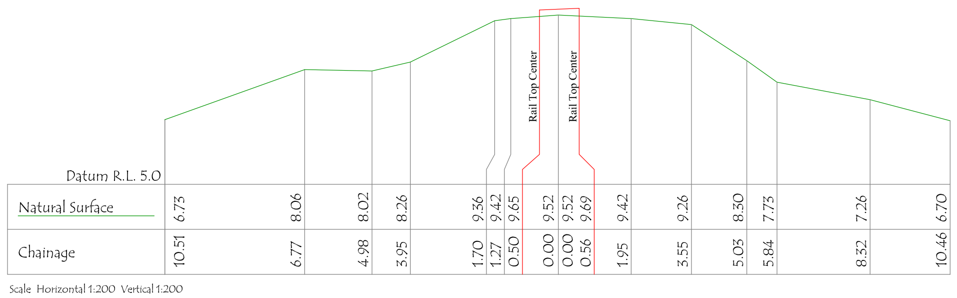
Chainage: 270 m



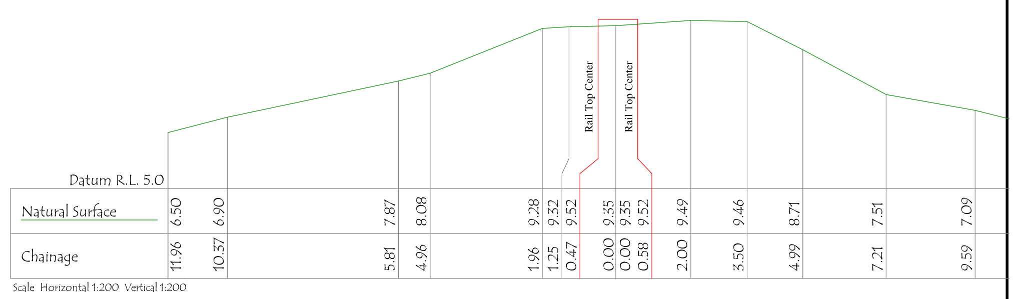
Chainage: 285 m



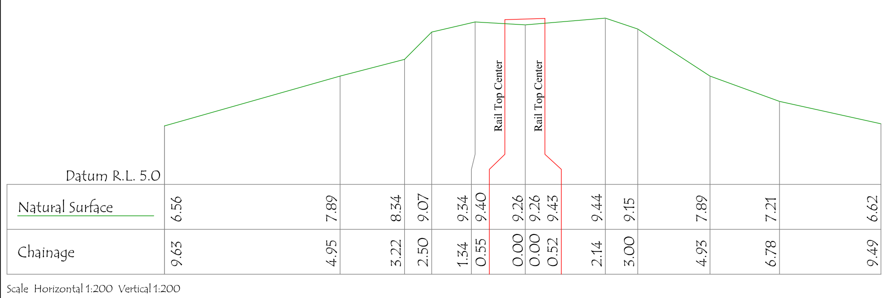
Chainage: 250 m



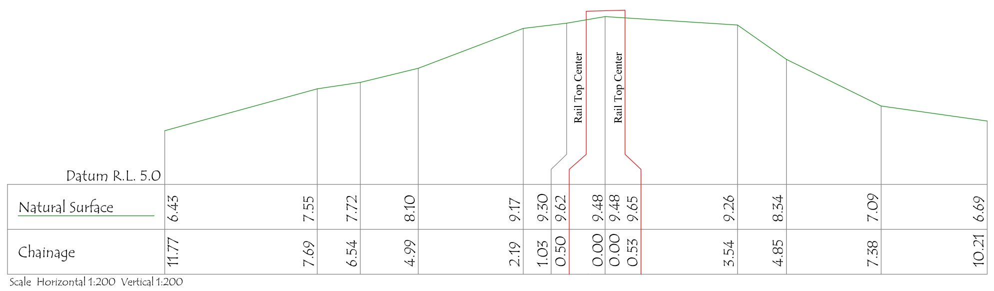
Chainage: 265 m



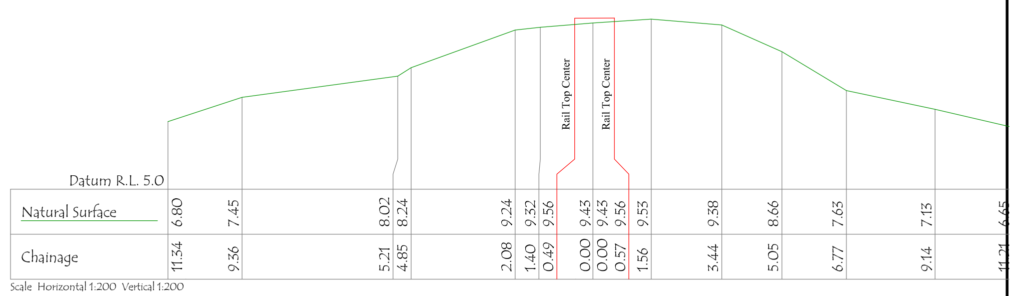
Chainage: 280 m



Chainage: 245 m

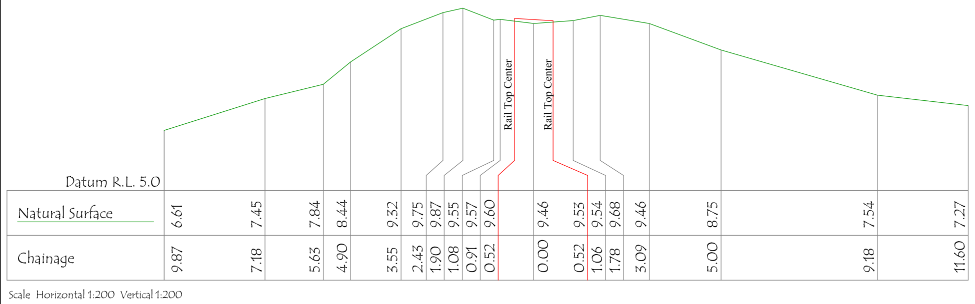


Chainage: 260 m

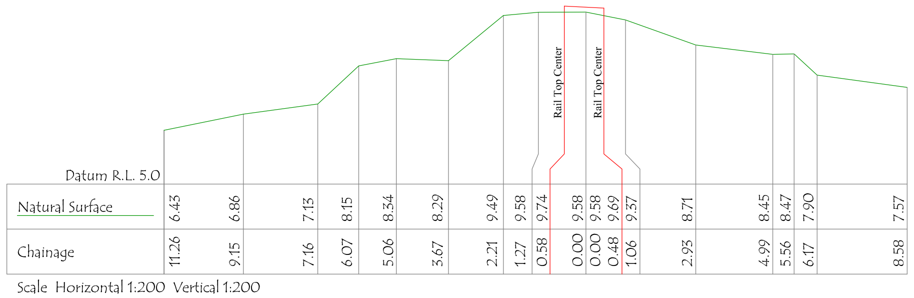


Chainage: 275 m

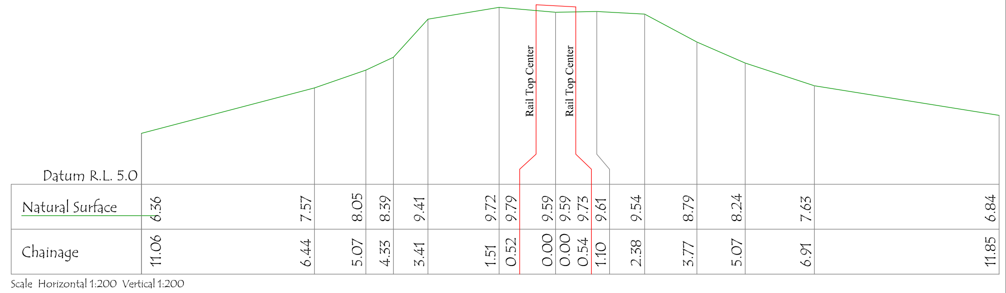
Cross Section of Railway from (CH 290 To 330)



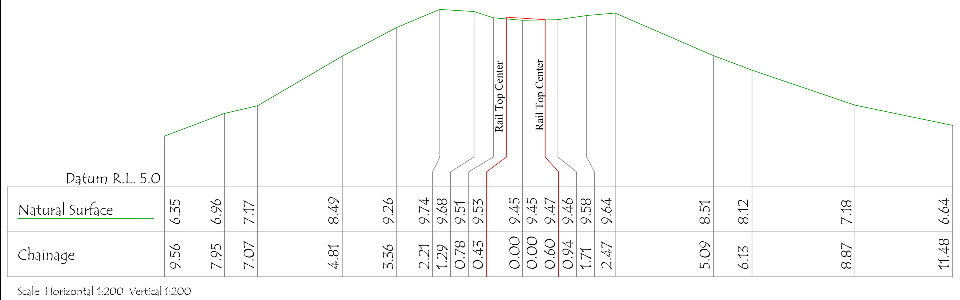
Chainage:300 m



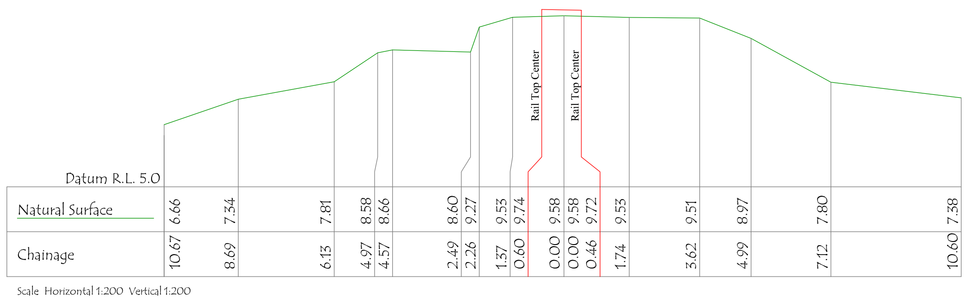
Chainage: 315 m



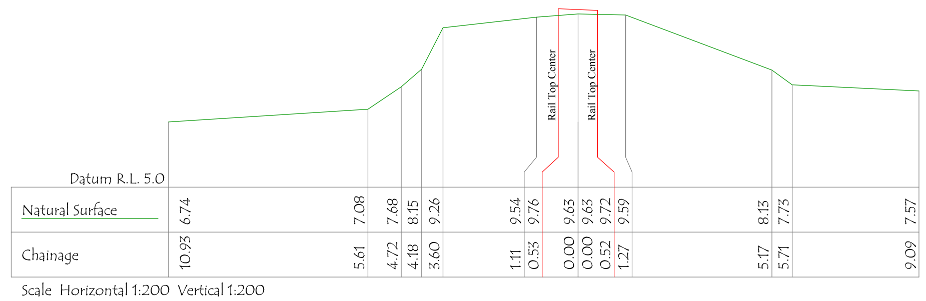
Chainage: 330 m



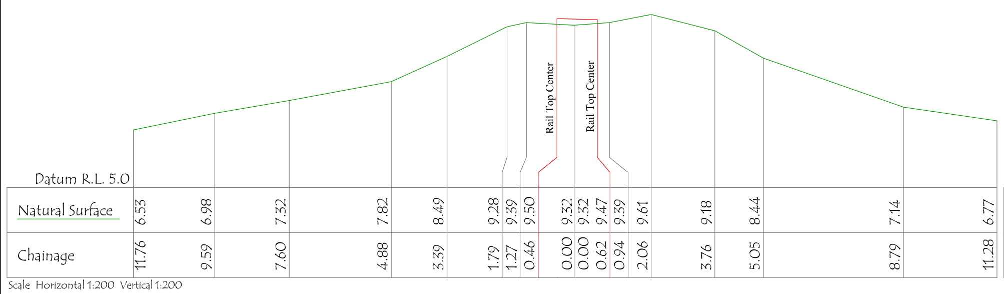
Chainage: 295 m



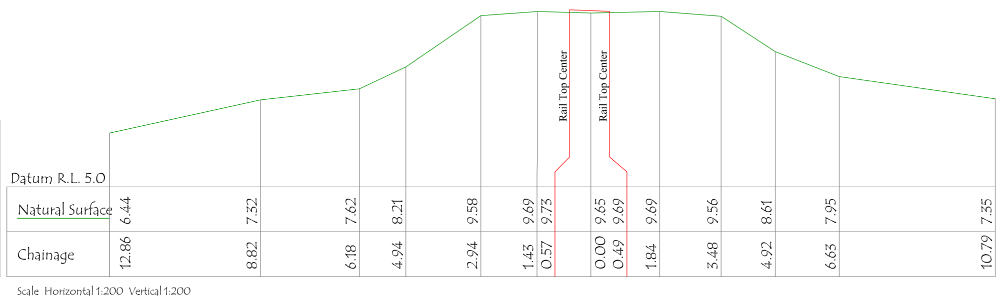
Chainage: 310 m



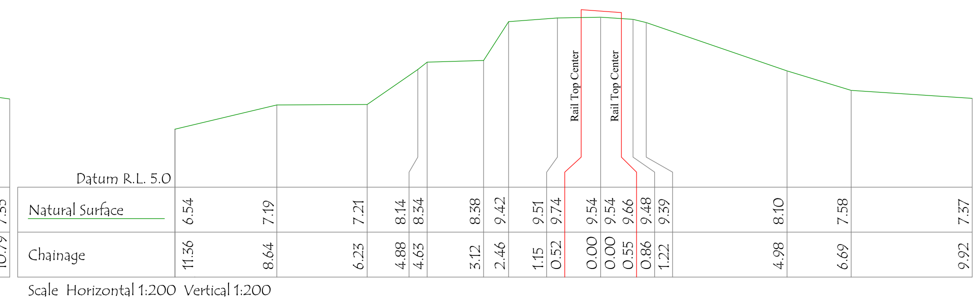
Chainage: 325m



Chainage: 290 m

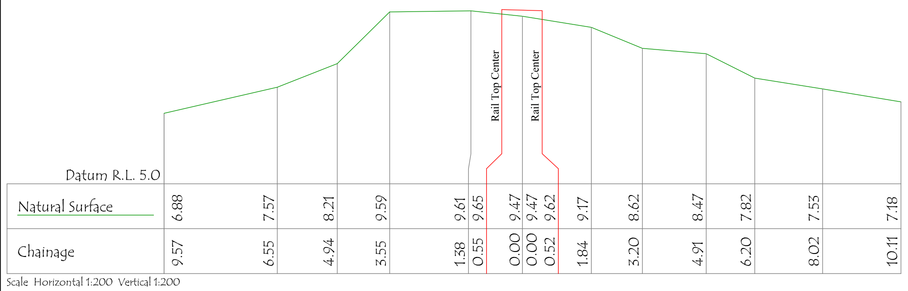


Chainage: 305 m

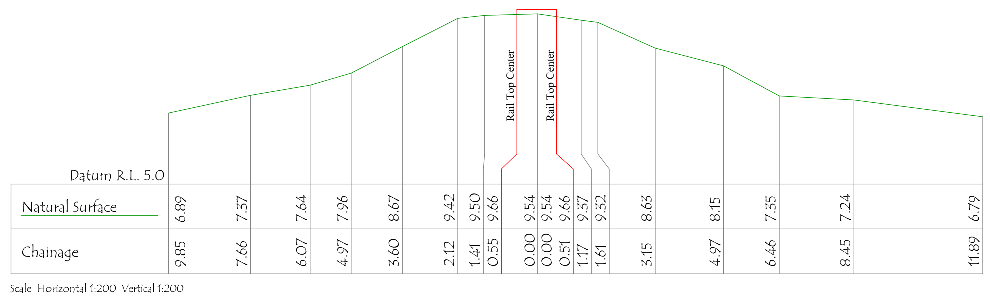


Chainage: 320 m

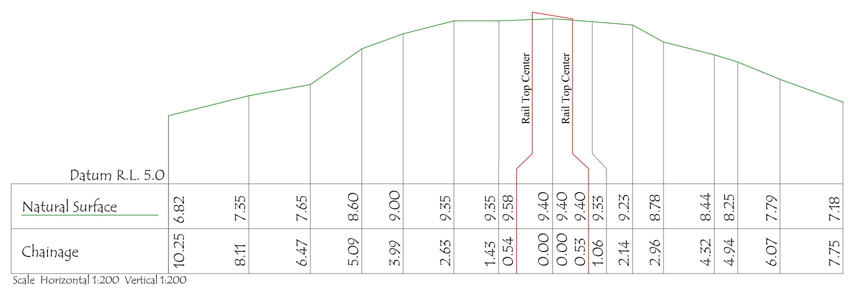
Cross Section of Railway from (CH 335 To 375)



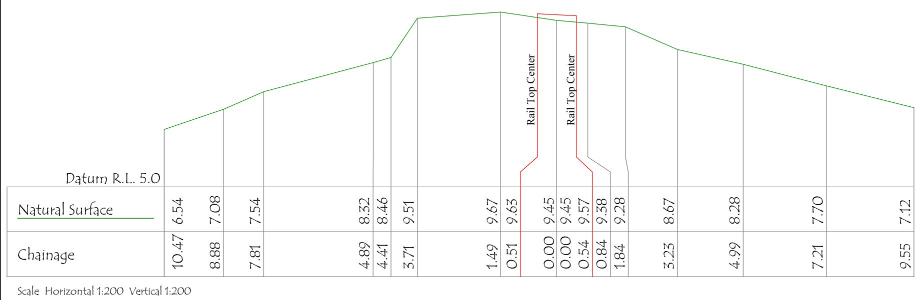
Chainage: 345 m



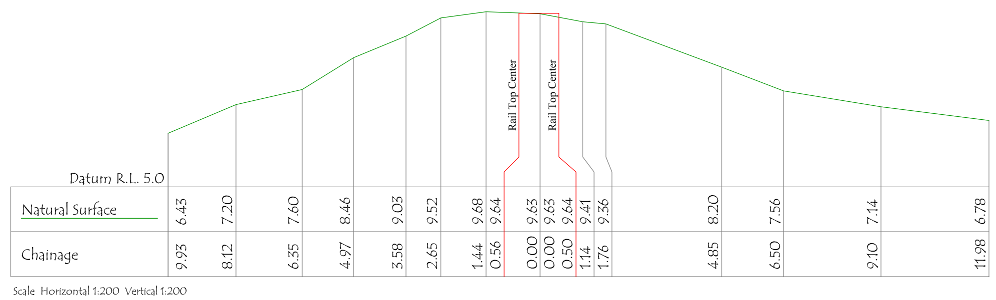
Chainage: 360 m



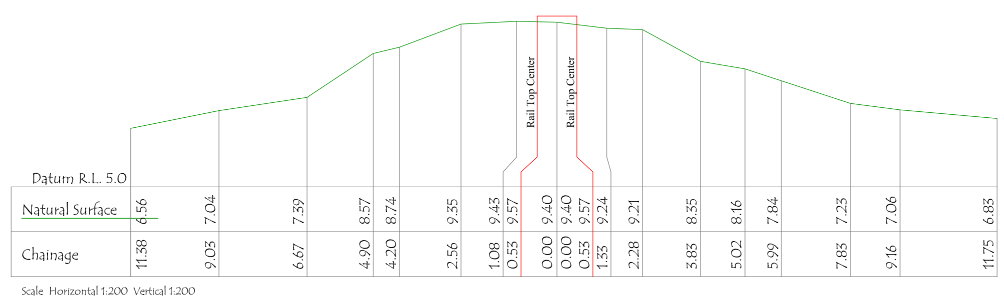
Chainage: 375 m



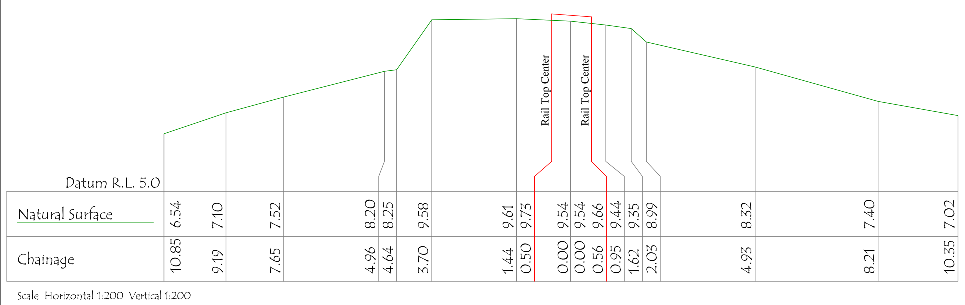
Chainage: 340 m



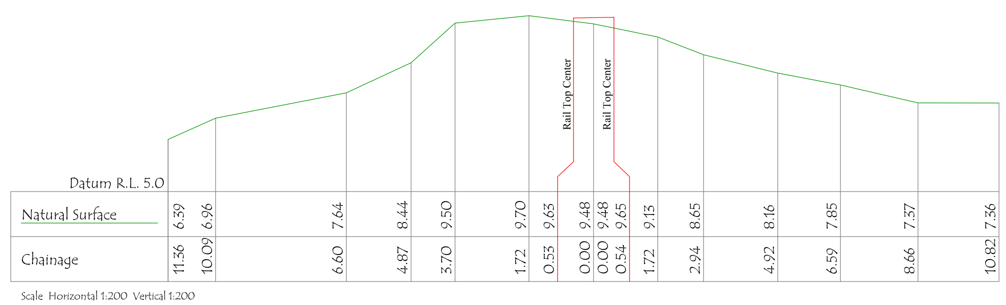
Chainage: 355 m



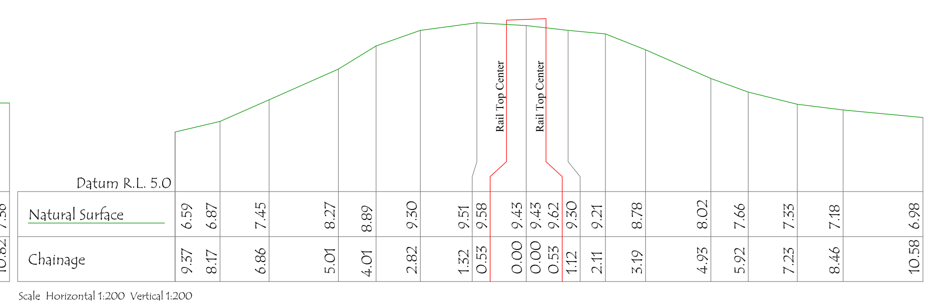
Chainage: 370 m



Chainage: 335 m

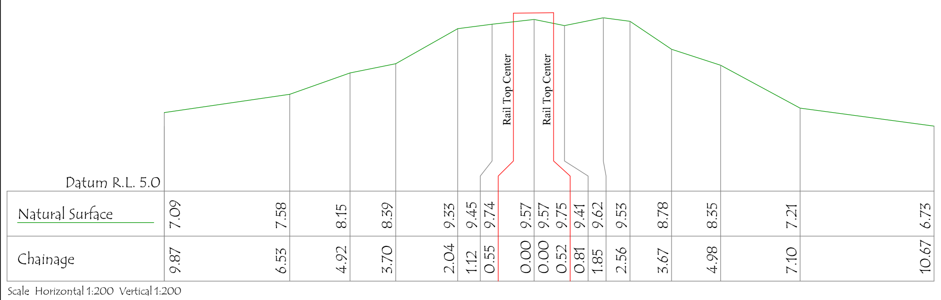


Chainage: 350 m

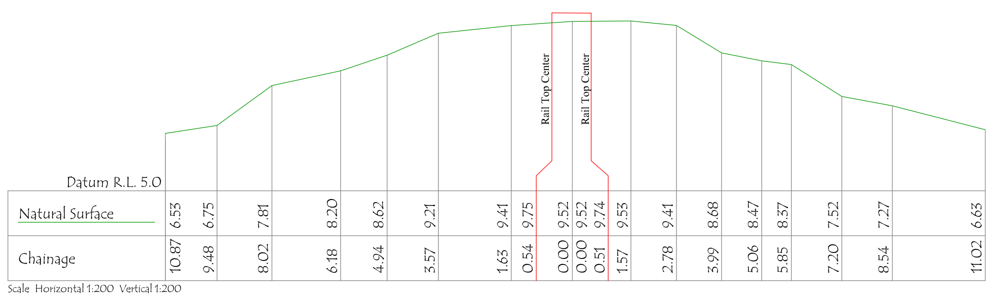


Chainage: 365 m

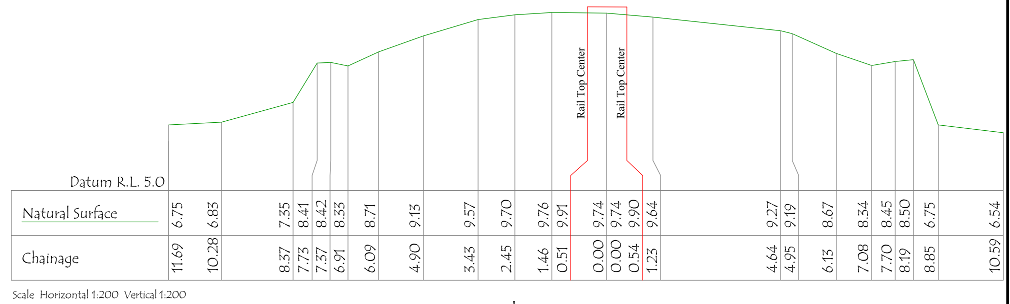
Cross Section of Railway from (CH 380 To 420)



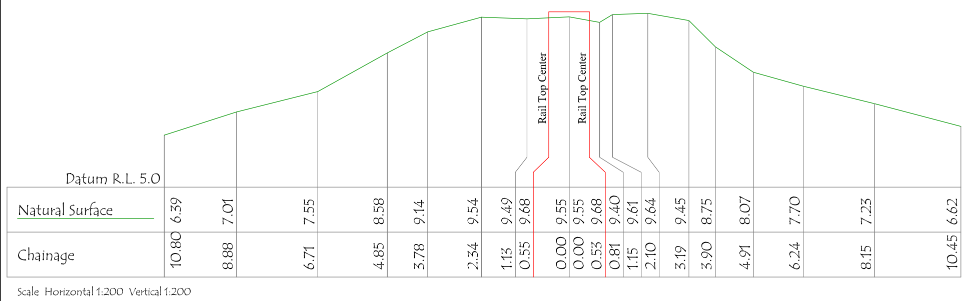
Chainage: 390 m



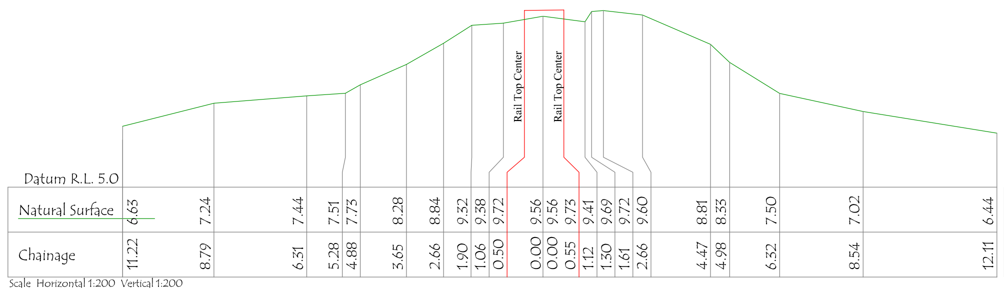
Chainage: 405 m



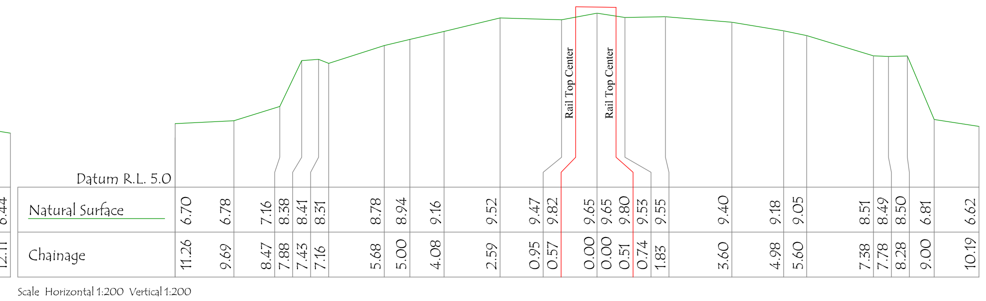
Chainage: 420 m



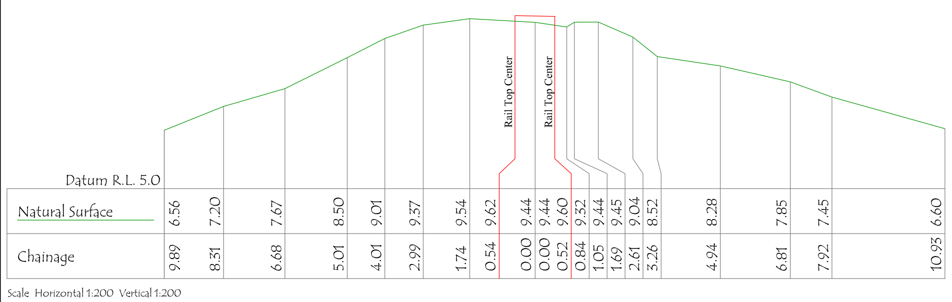
Chainage: 385 m



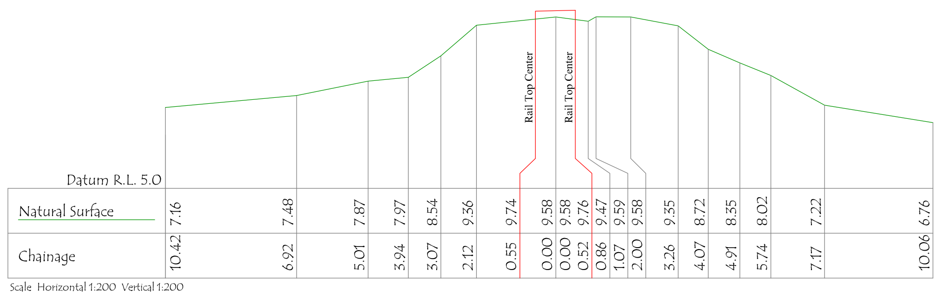
Chainage: 400 m



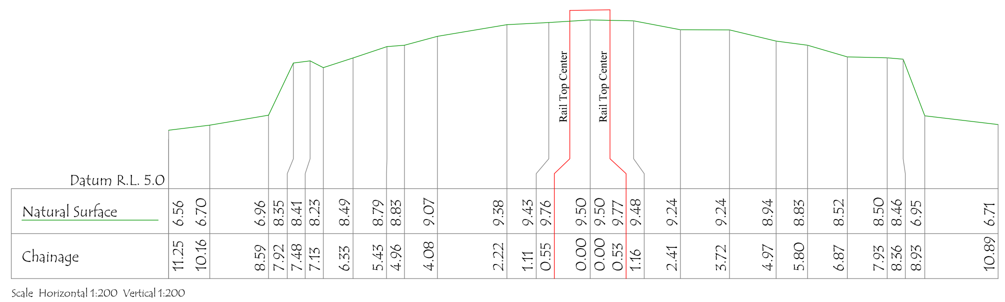
Chainage: 415 m



Chainage: 380 m

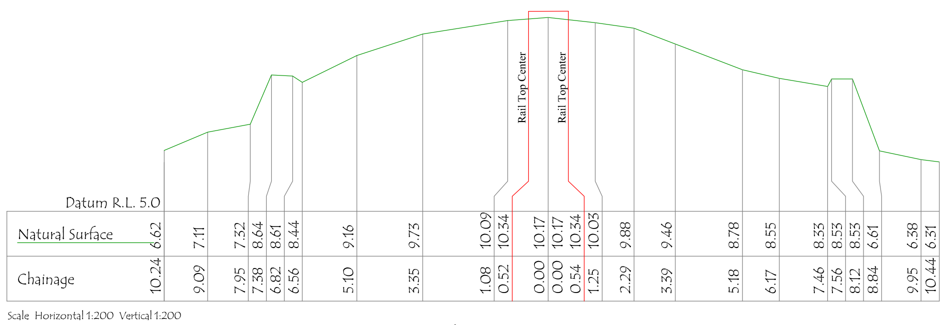


Chainage: 395 m

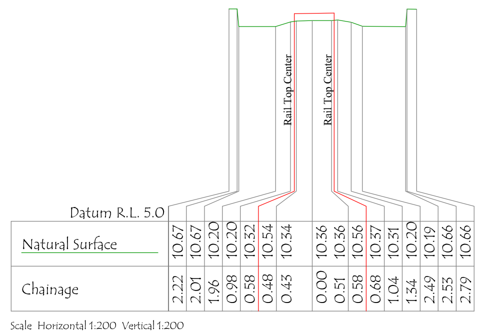


Chainage : 410 m

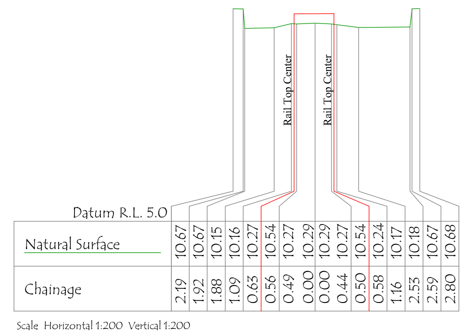
Cross Section of Railway from (CH 420 To 465)



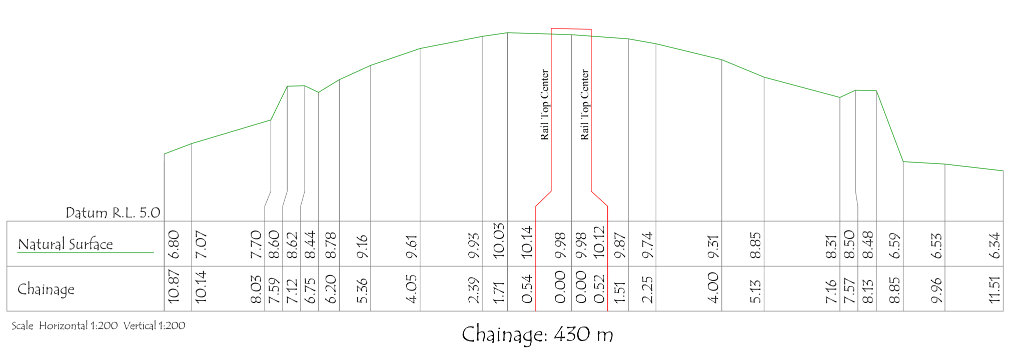
Chainage: 435 m



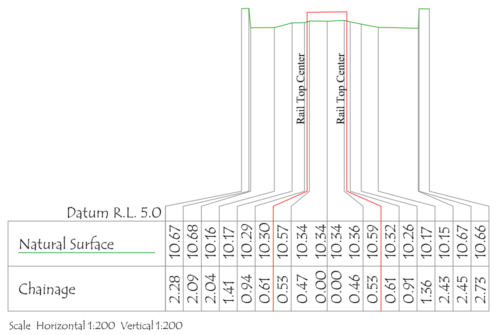
Chainage: 450 m



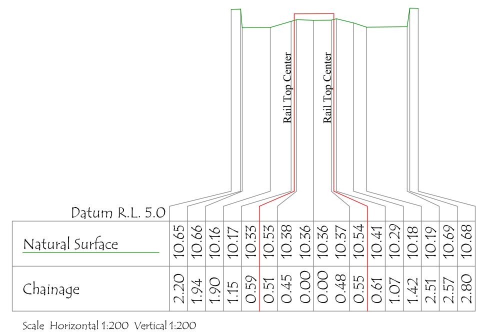
Chainage: 465 m



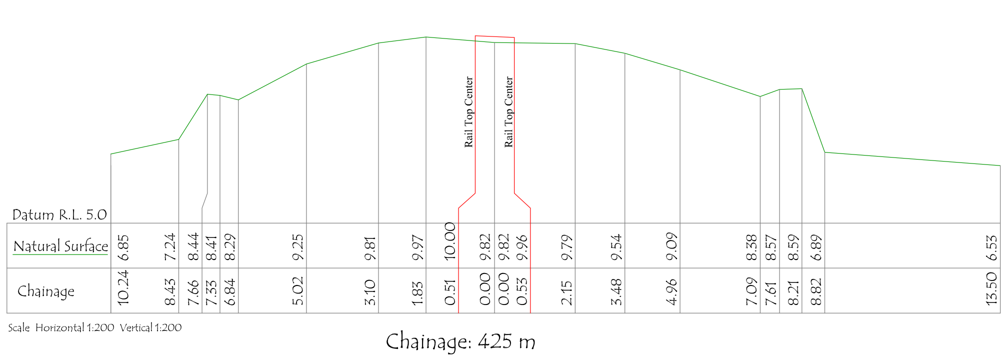
Chainage: 430 m



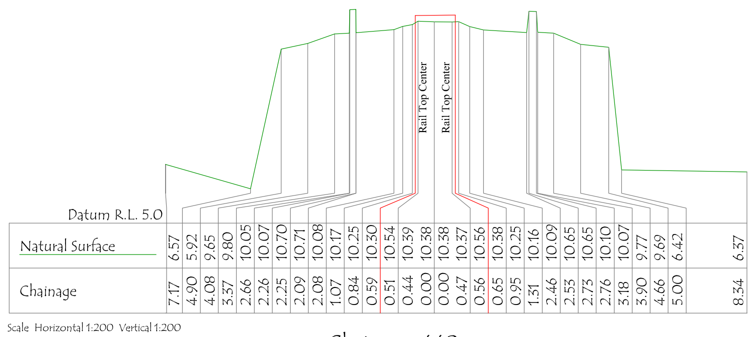
Chainage: 445 m



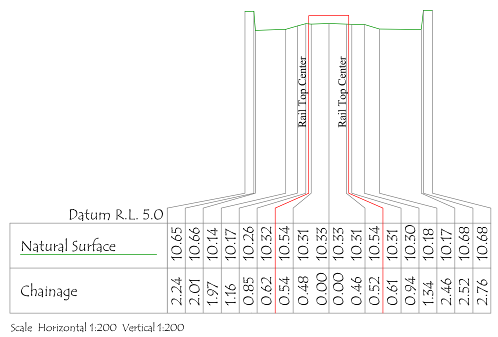
Chainage: 540 m



Chainage: 425 m

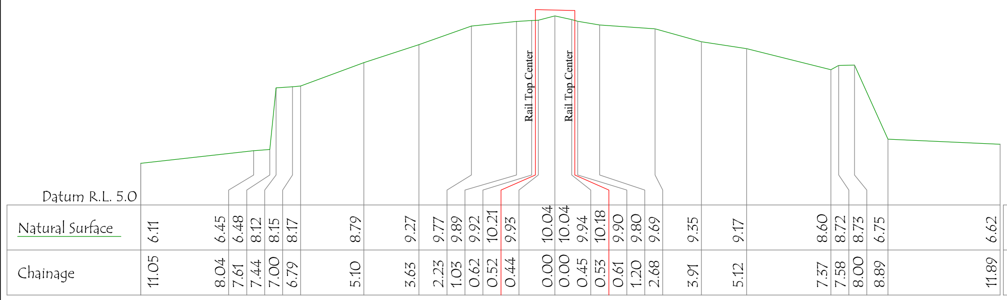


Chainage: 440m

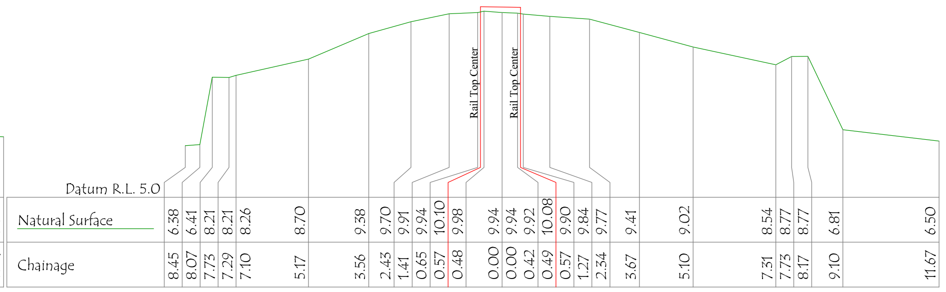


Chainage: 455 m

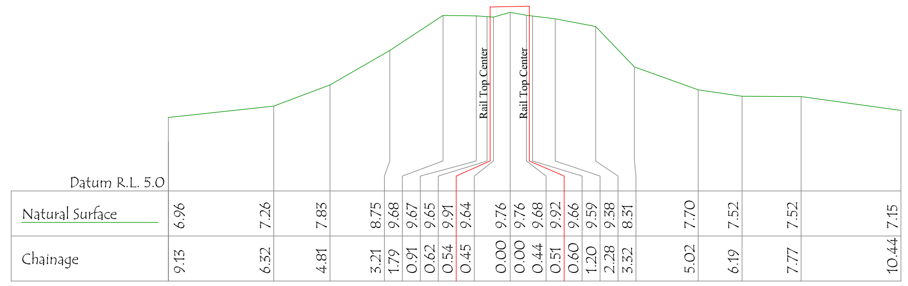
Cross Section of Railway from (CH 470 To 510)



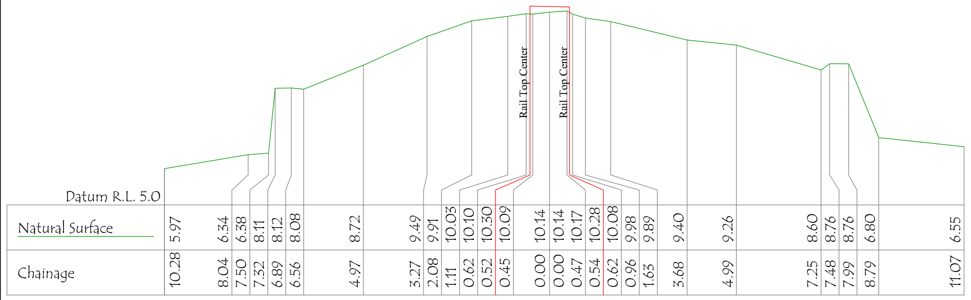
Chainage: 480 m



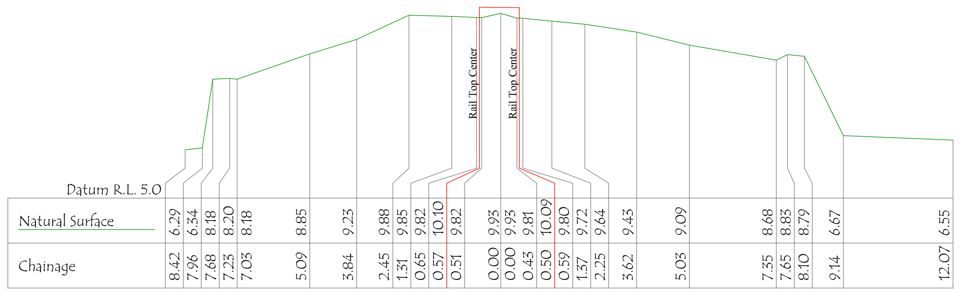
Chainage: 495 m



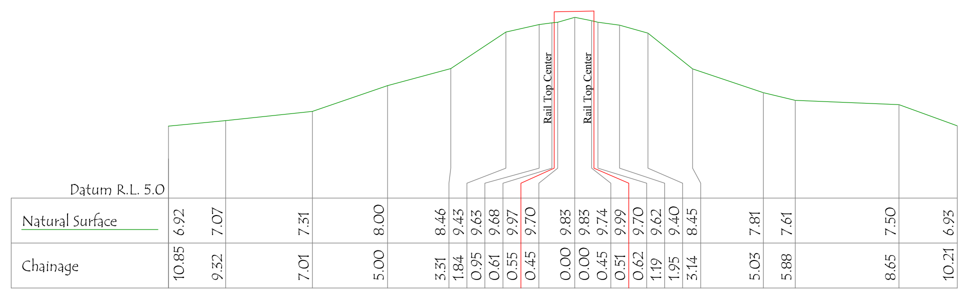
Chainage: 510 m



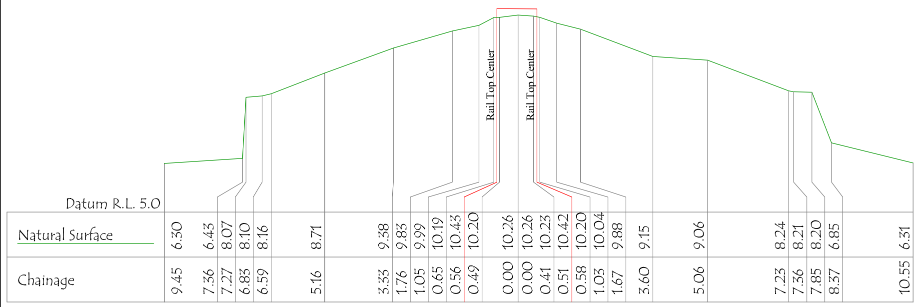
Chainage: 475 m



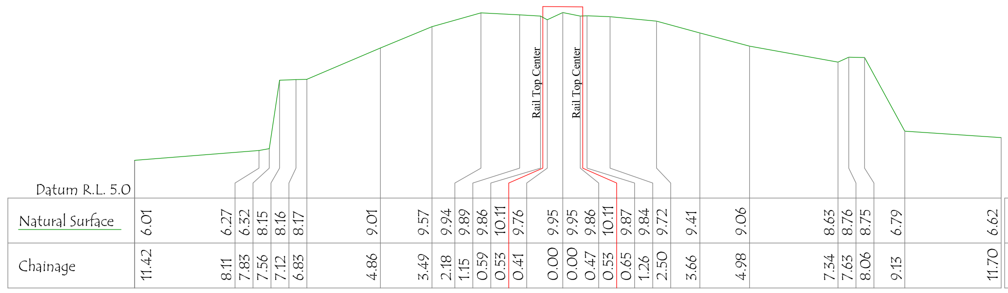
Chainage: 490 m



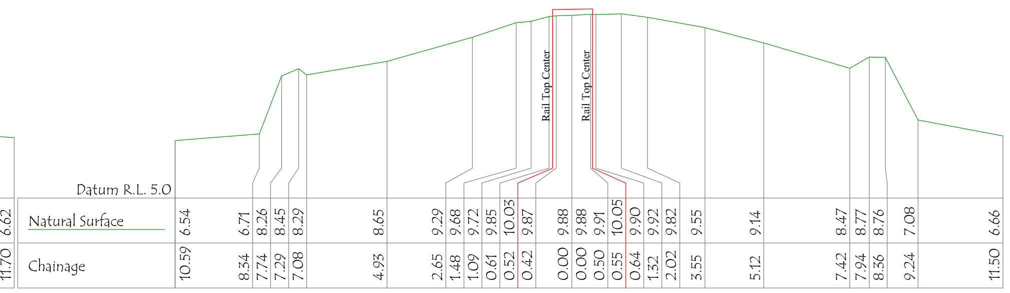
Chainage: 505 m



Chainage: 470 m

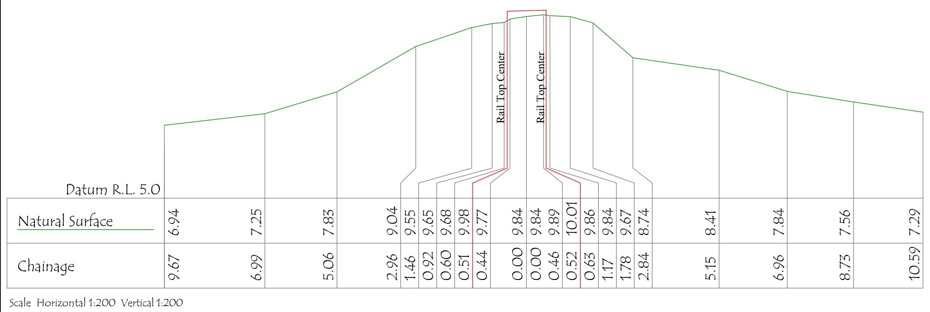


Chainage: 485 m

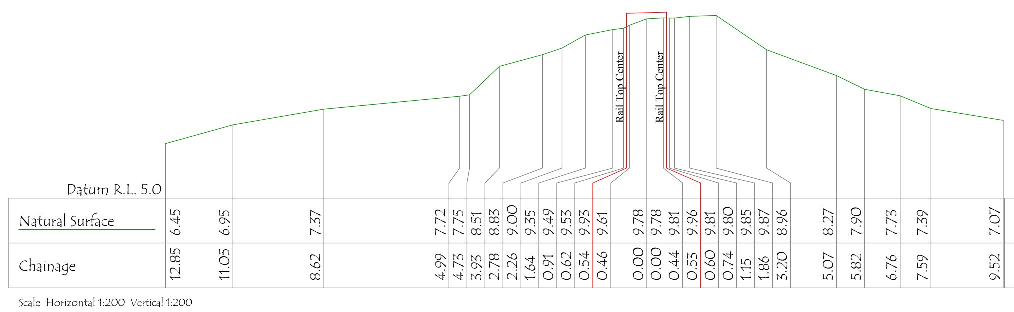


Chainage: 500 m

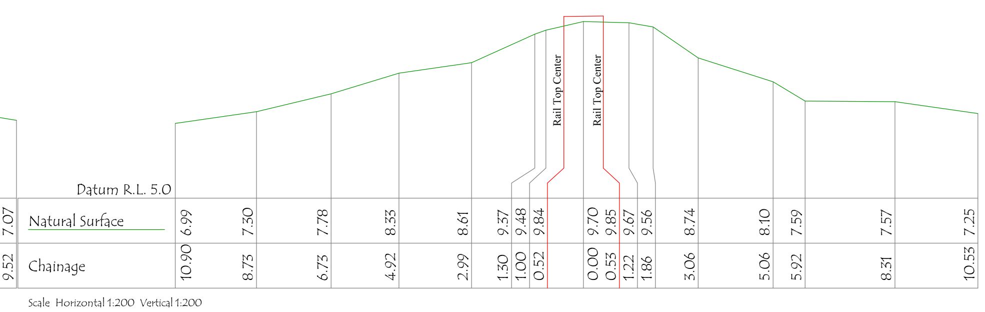
Cross Section of Railway from (CH 515 To 555)



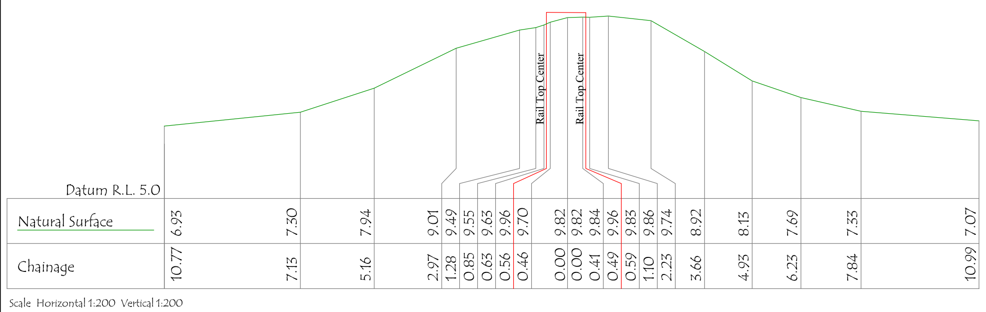
Chainage: 525 m



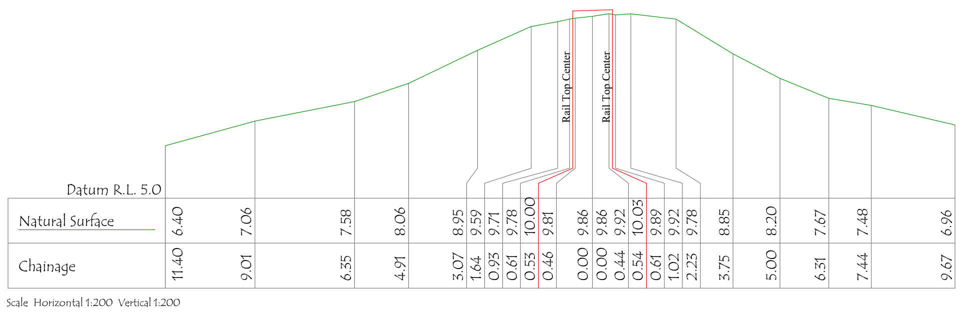
Chainage: 540 m



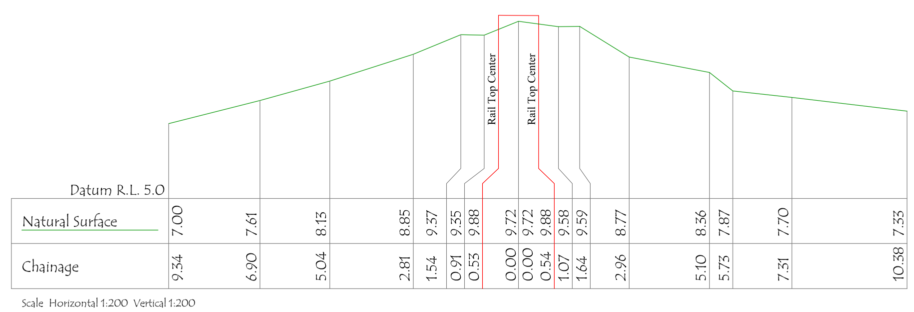
Chainage: 555 m



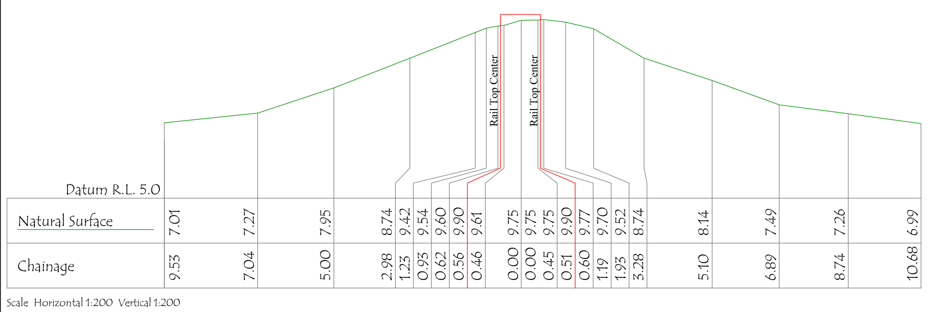
Chainage: 520 m



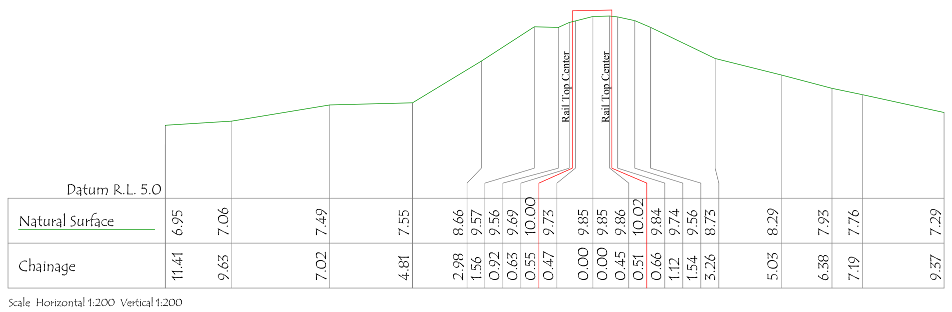
Chainage: 535 m



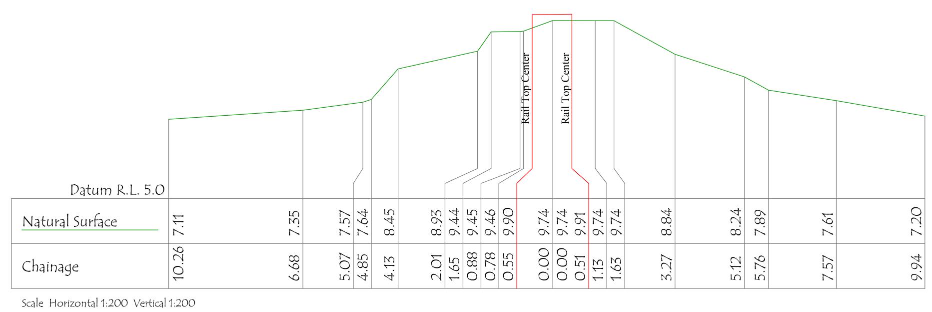
Chainage: 550 m



Chainage: 515 m

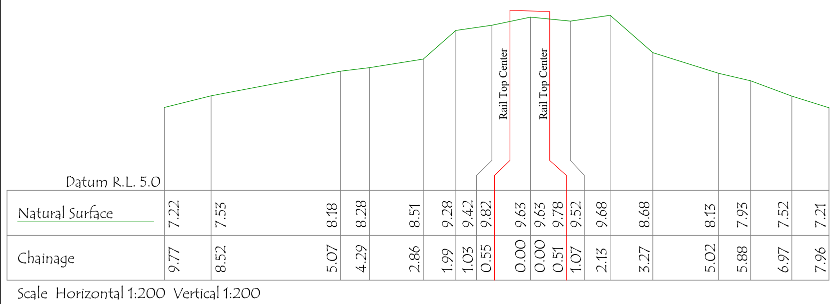


Chainage: 530 m

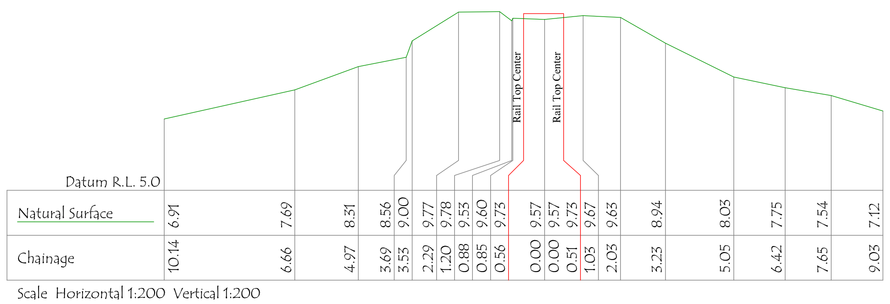


Chainage: 545 m

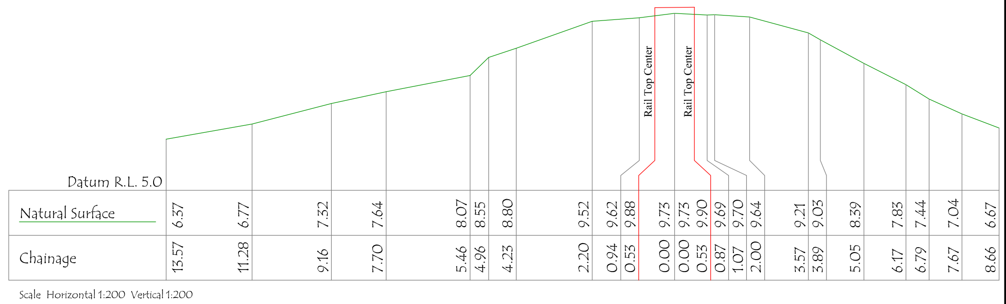
Cross Section of Railway from (CH 560 To 600)



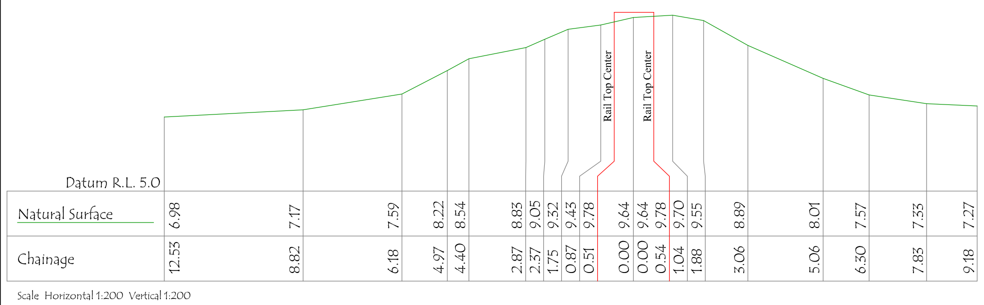
Chainage: 570 m



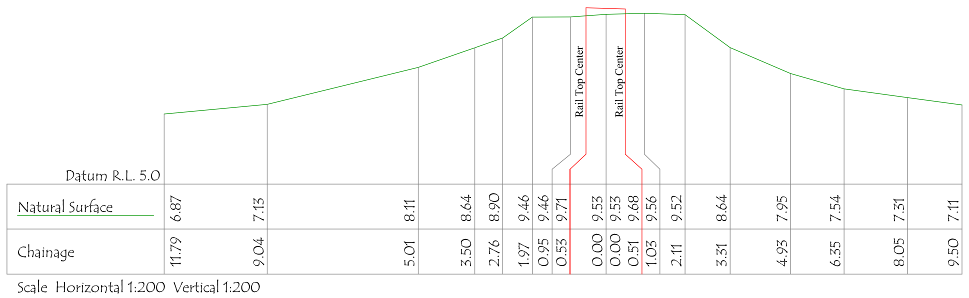
Chainage: 585 m



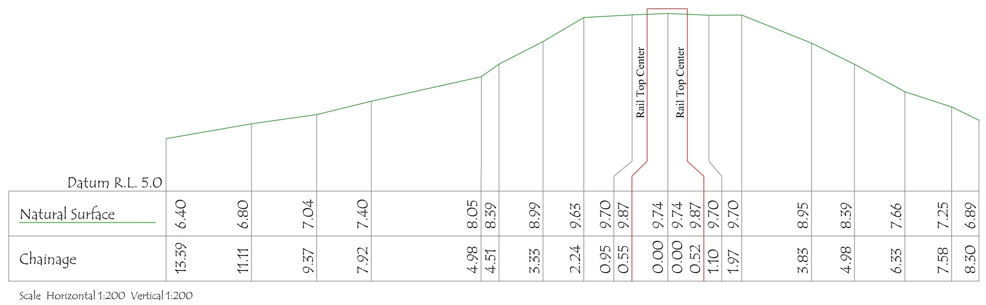
Chainage: 600 m



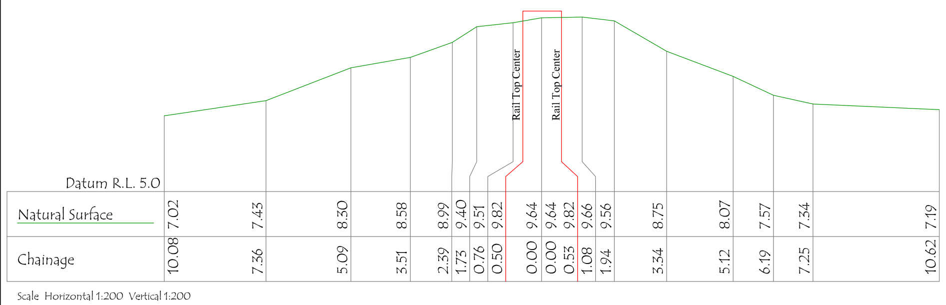
Chainage: 565 m



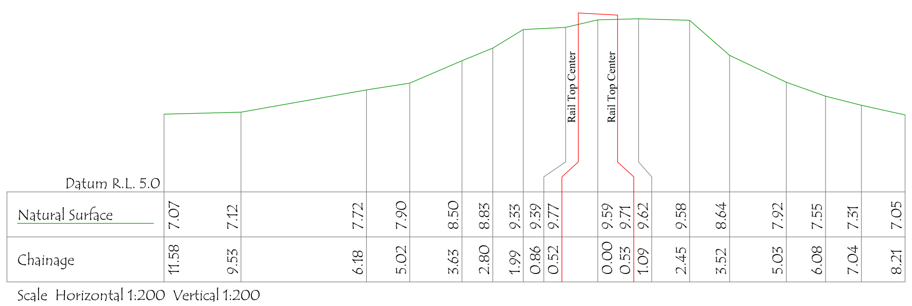
Chainage: 580 m



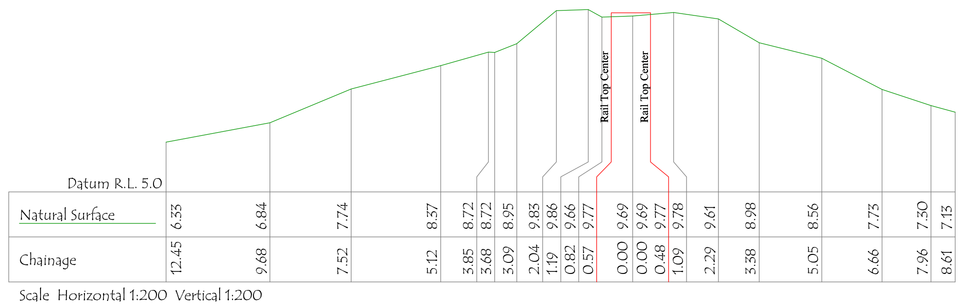
Chainage: 595 m



Chainage: 560 m



Chainage: 575 m



Chainage: 590 m

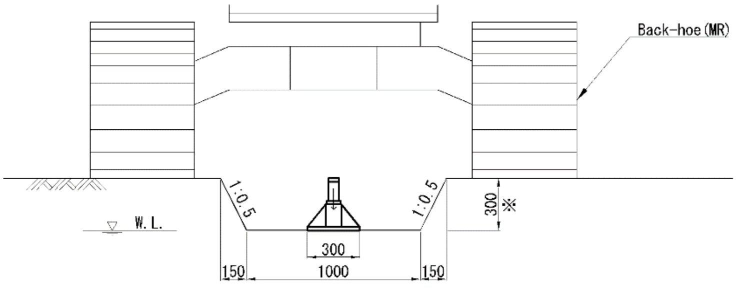
資料-3

平板載荷試験報告書

(1) 平板載荷試験の実施ケース

現状地盤，及び D-Box を用いた基礎の支持力の違いを把握するため，以下の①～⑥の計 6 ケースの異なる条件で平板載荷試験（PLT-K-1～6）を実施した。

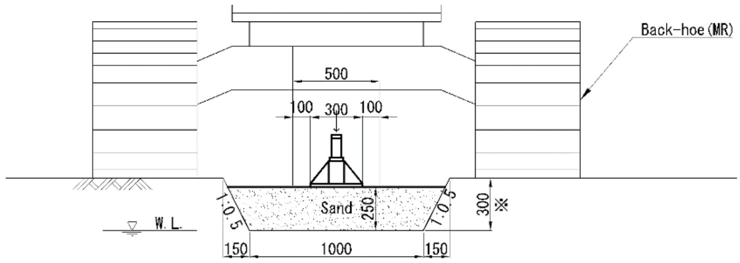
①　基礎地盤（粘性土）の上で直接平板載荷試験
⇒粘性土の極限支持力の測定（基礎地盤（粘性土）の正確な強度定数を算出する）



K-1 Existing Ground

図 1　平板載荷試験(1)　PLT-K-1

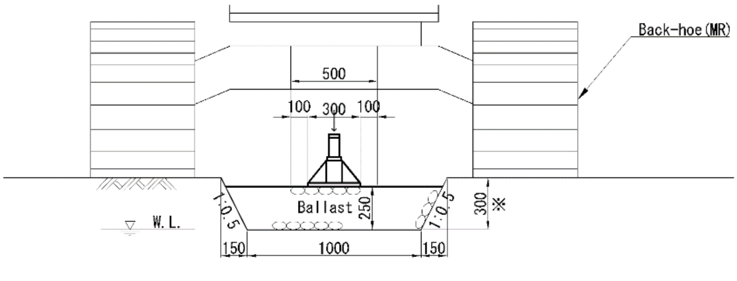
②　基礎地盤を厚さ 25cm の砂を敷き，その上で平板載荷試験
⇒砂を敷いた場合の極限支持力の測定（D-Box と等厚の砂との違いを比較する）



K-2 Sand t=250

図 2　平板載荷試験（2）　PLT-K-2

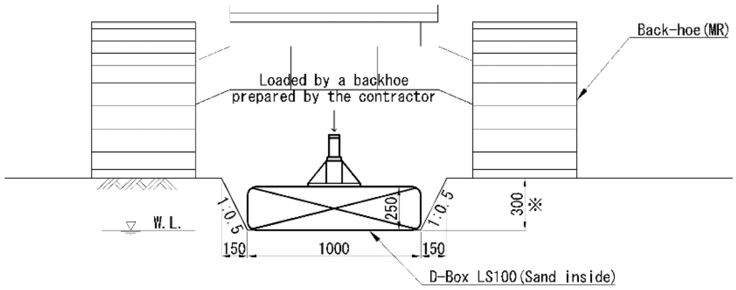
③　基礎地盤を厚さ 25cm のバラストで置換え，その上で平板載荷試験
⇒バラストの極限支持力の測定（バラストと D-Box との強度を比較する）



K-3 Ballast t=250

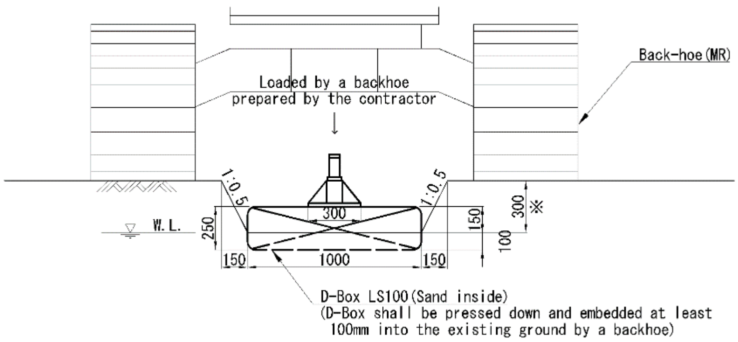
図 3　平板載荷試験（3）　PLT-K-3

④　基礎地盤上で D-Box（厚さ 25cm）を設置し，その上で平板載荷試験
⇒D-Box（中詰材＝砂）の極限支持力測定（D-Box による支持力増加を確認する）



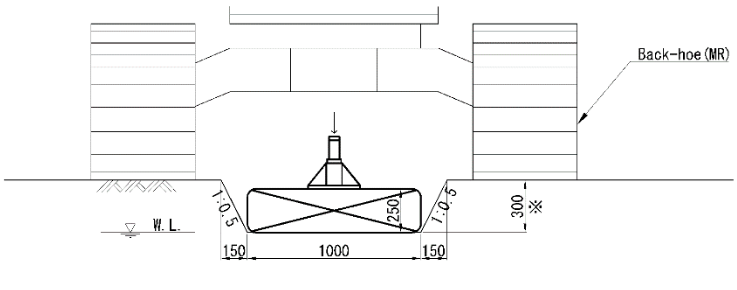
K-4 (Sand Inside)
図 4　平板載荷試験(4)　　　PLT-K-4

⑤　④の D-Box（中詰材＝砂）を地面に 10cm 押込み後、平板載荷試験
⇒押込んだ D-Box の極限支持力測定（D-Box の押込みによる支持力増加を確認する）



K-5 (Sand Inside Embedded 100mm)
図 5　平板載荷試験(5)　　　PLT-K-5

⑥　④の D-Box の中詰材を現地発生土に変えての平板載荷試験
⇒D-Box（中詰材＝現地発生土）の極限支持力測定（中詰材の違いによる支持力を確認）



K-6 (Soil come from Chaung phyar site Inside)
図 6　平板載荷試験(6)　　　PLT-K-6

⑵ 平板載荷試験の試験結果

平板載荷試験より得られた荷重と沈下量の関係（P-S 曲線）を図 7 に示す。

（「Report on the Works of Plate Loading Test for Soil Improvemwnt Work at Dauntgyi Station Railway Project, FKYB-SI-217/2016-032, March 2017」ｐ.7～9 より）

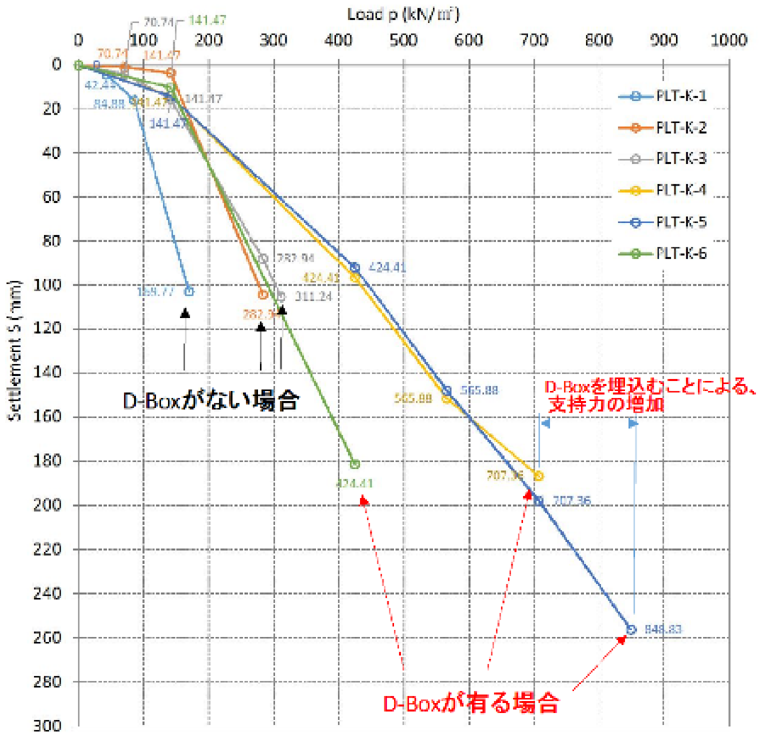


図 7　平板載荷試験結果（P-S 曲線の重ね合わせ図）

平板載荷試験の結果から求めた各ケースの極限支持力を表 1 に示す。

表 1　平板載荷試験結果（極限支持力）

Point No.	極限支持力 （ kN/m² ）
PLT-K-1	84.88
PLT-K-2	141.47
PLT-K-3	141.47
PLT-K-4	707.19
PLT-K-5	962.74
PLT-K-6	424.62

資料-4

振動試験結果

表4-1　振動試験実施日

No.	日付	CH340 (左側)	CH300 (右側)	CH240 (左側)
① D･Box 設置前	2017 年 2 月 15 日	30 km/ hr	30 km/ hr	30 km/ hr
②施工完了時	2017 年 4 月 4 日	31 km/ hr	29 km/ hr	31 km/ hr
③雨季経過後	2017 年 6 月 12 日	32 km/ hr	32 km/ hr	32 km/ hr
④雨季経過後	2017 年 9 月 20 日	31 km/ hr	31 km/ hr	30 km/ hr
⑤乾季経過後	2018 年 2 月 6 日	30 km/ hr	30 km/ hr	30 km/ hr
施工完了 1 年後	2018 年 5 月 2 日	中止 (RGC が搬入されなかったことによる中止)	中止	中止

出典：調査団作成

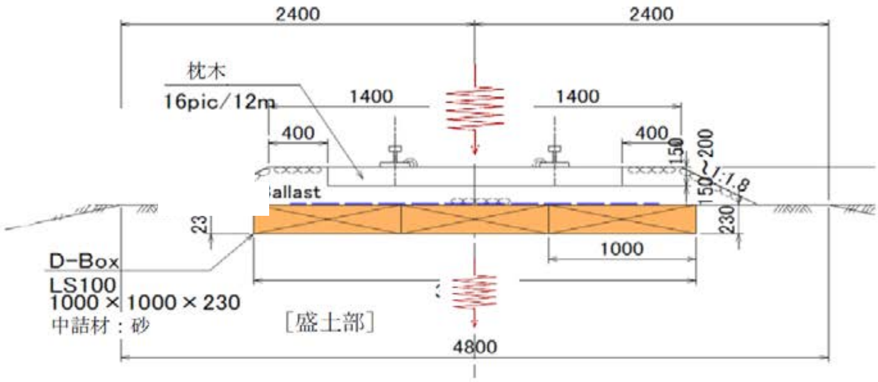


図 4.2-16 D-Box による振動低減のイメージ

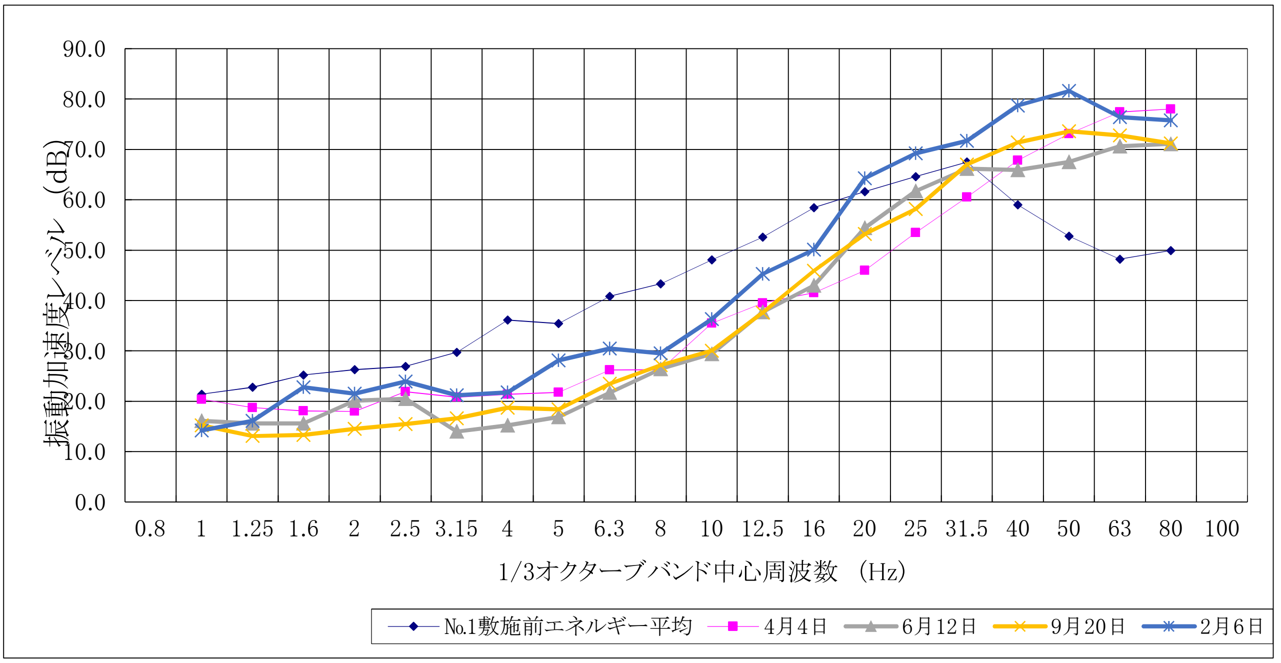
図 4.2-17 振動試験のイメージ（2017 年 2 月 15 日）

0 2017年4月4日計測

CH340

X方向

	№1敷施前エネルギー平均	4月4日	6月12日	9月20日	2月6日
0.8					
1	21.4	20.4	16.1	15.2	14.2
1.25	22.8	18.7	15.6	13.1	16.1
1.6	25.2	18.1	15.6	13.3	22.8
2	26.3	18.0	20.1	14.5	21.5
2.5	26.9	21.9	20.5	15.5	23.9
3.15	29.7	20.8	14.0	16.6	21.2
4	36.1	21.4	15.2	18.7	21.8
5	35.4	21.8	16.9	18.4	28.1
6.3	40.8	26.2	21.7	23.5	30.5
8	43.3	26.3	26.4	27.2	29.5
10	48.1	35.5	29.4	30.0	36.3
12.5	52.6	39.5	37.7	37.6	45.3
16	58.4	41.5	43.0	45.9	50.1
20	61.6	46.0	54.4	53.2	64.3
25	64.6	53.5	61.7	58.2	69.2
31.5	67.5	60.5	66.2	67.0	71.7
40	59	67.8	65.9	71.4	78.7
50	52.8	73.1	67.5	73.6	81.6
63	48.2	77.4	70.6	72.8	76.4
80	49.9	78.0	71.1	71.2	75.8
100					

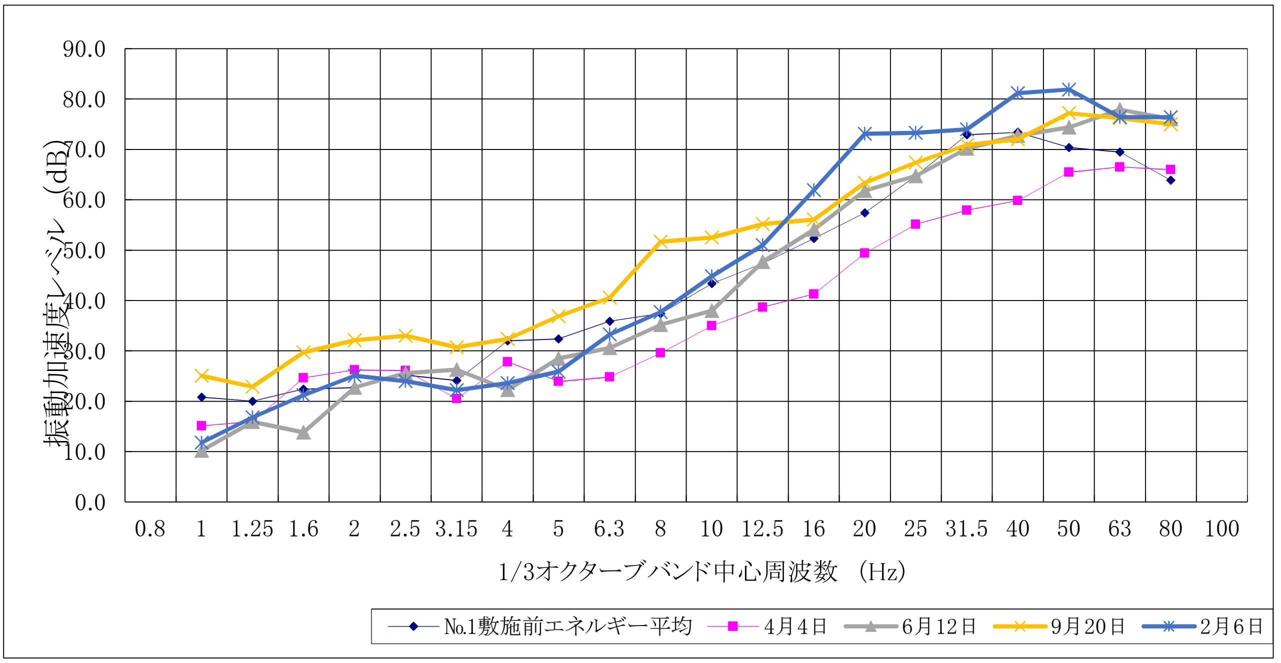


0 2017年4月4日計測

CH300

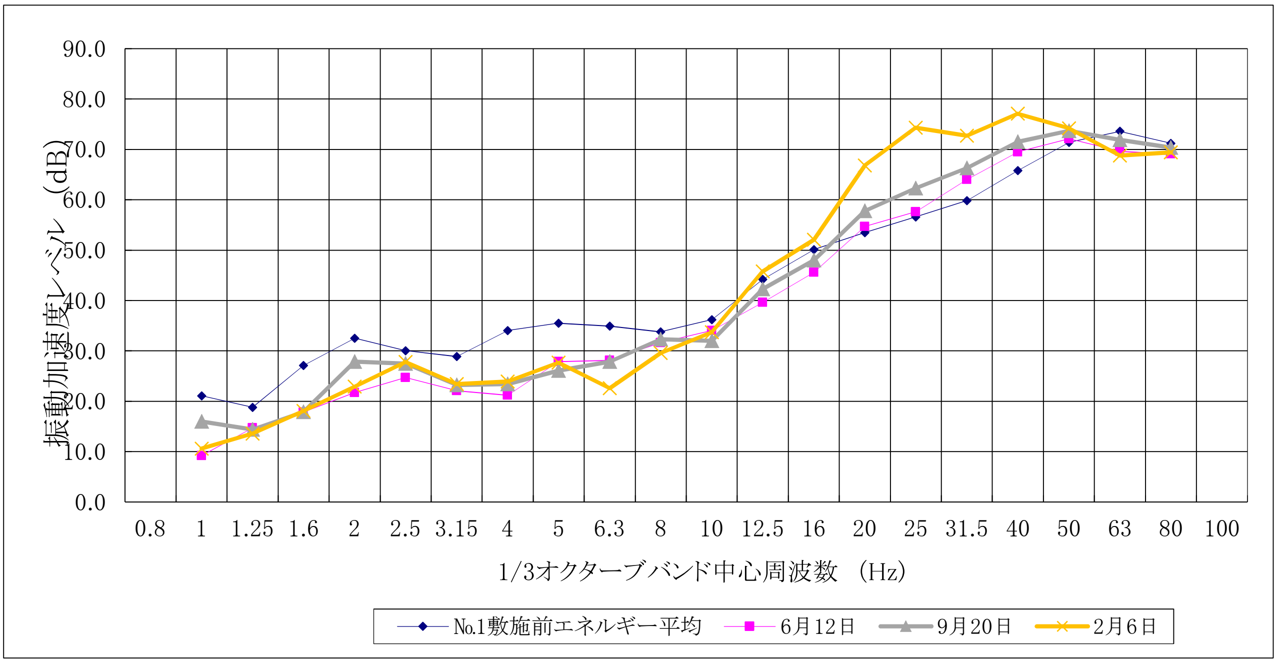
X方向

	No.1敷施前エネルギー平均	4月4日	6月12日	9月20日	2月6日
0.8					
1	20.8	15.1	10.2	25.1	11.8
1.25	20.0	16.0	15.9	22.9	16.8
1.6	22.4	24.6	13.8	29.7	21.2
2	22.7	26.2	22.7	32.1	25.1
2.5	25.2	26.1	25.6	33.0	24.0
3.15	24.1	20.5	26.3	30.7	22.2
4	32.0	27.8	22.3	32.4	23.6
5	32.4	23.9	28.5	36.9	25.9
6.3	35.9	24.8	30.6	40.6	33.3
8	37.4	29.6	35.2	51.7	37.7
10	43.4	35.0	38.0	52.5	44.8
12.5	47.4	38.7	47.7	55.2	51.0
16	52.3	41.3	54.1	56.1	61.9
20	57.4	49.4	61.8	63.4	73.1
25	64.7	55.1	64.7	67.4	73.3
31.5	72.9	57.9	70.2	70.9	74.0
40	73.4	59.8	72.7	72.0	81.2
50	70.4	65.5	74.4	77.2	81.9
63	69.5	66.5	77.9	76.2	76.4
80	63.9	66.0	76.0	75.0	76.4
100					



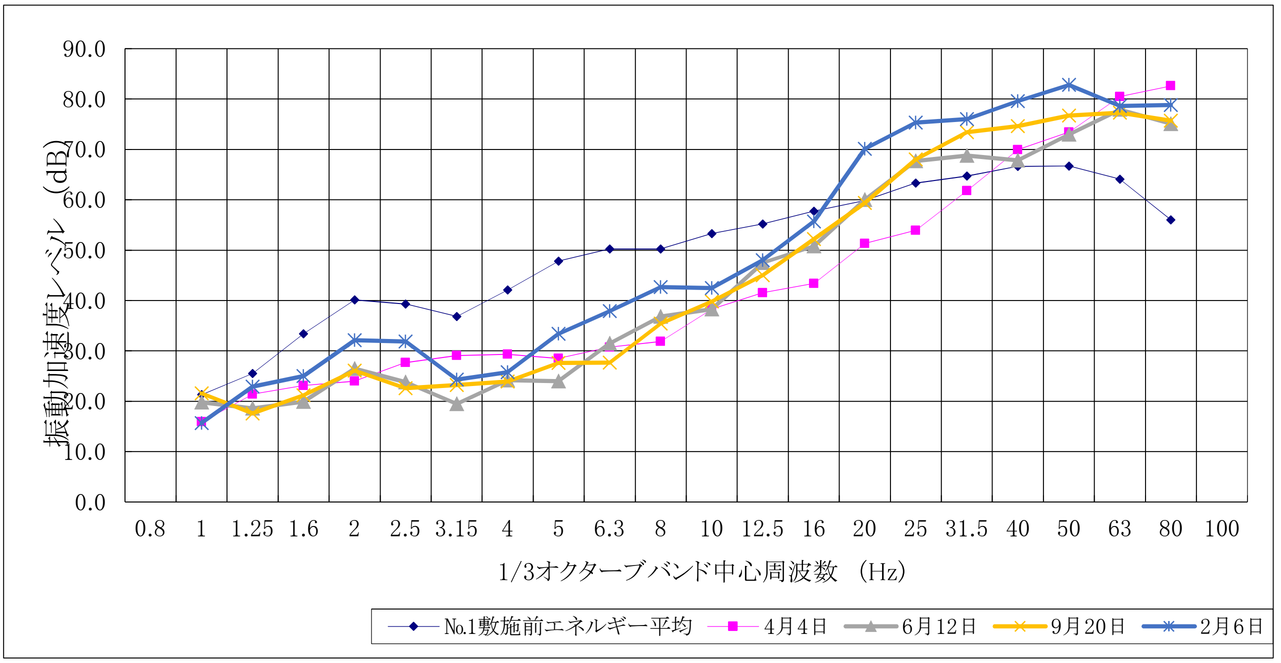
0 2017年4月4日計測
CH240
X方向

	No.1敷施前エネルギー平均	6月12日	9月20日	2月6日
0.8				
1	21.1	9.2	16.0	10.6
1.25	18.8	14.7	14.4	13.6
1.6	27.1	17.8	17.9	18.1
2	32.5	21.7	27.9	22.9
2.5	30.0	24.7	27.5	27.8
3.15	28.9	22.1	23.2	23.4
4	34.0	21.2	23.4	23.9
5	35.5	27.9	26.1	27.7
6.3	34.9	28.1	27.9	22.6
8	33.8	31.6	32.3	29.6
10	36.2	34.0	32.0	33.7
12.5	44.2	39.6	42.3	45.8
16	50.1	45.6	48.0	52.1
20	53.5	54.7	57.8	66.8
25	56.6	57.6	62.3	74.3
31.5	59.8	64.0	66.3	72.7
40	65.8	69.5	71.5	77.1
50	71.4	72.1	73.7	74.2
63	73.6	69.6	71.9	68.8
80	71.2	69.1	70.4	69.4
100				



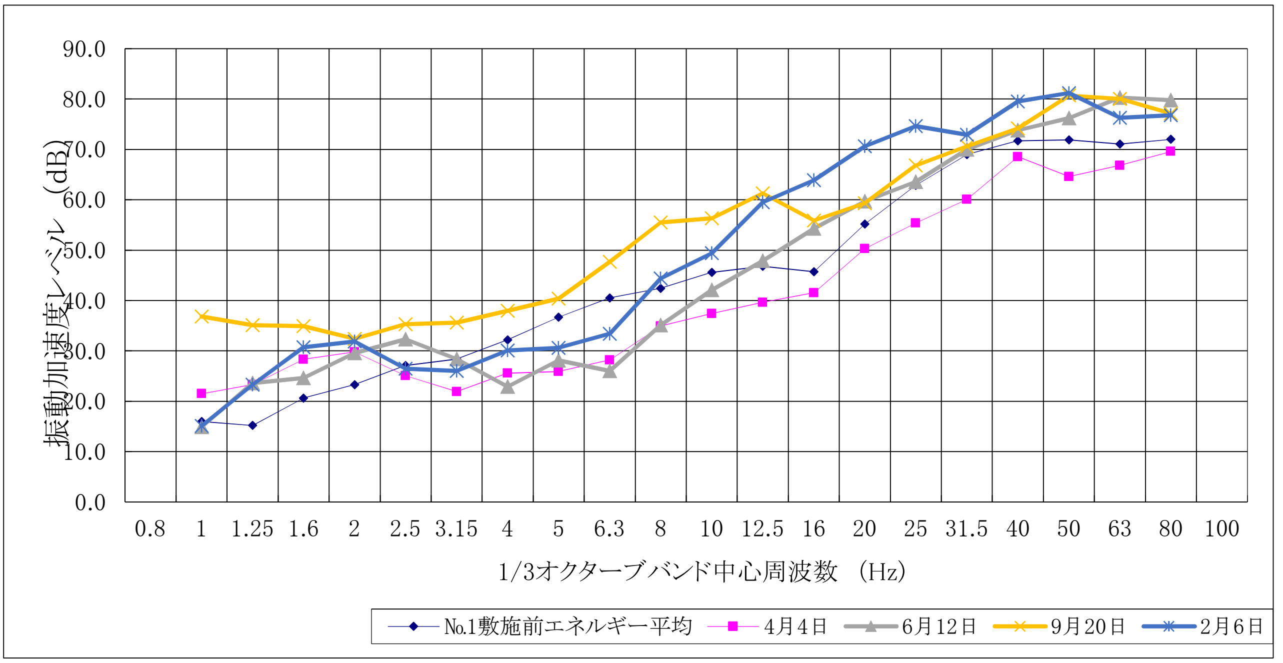
2017年4月4日計測
CH340
Y方向

	№1敷施前エネルギー平均	4月4日	6月12日	9月20日	2月6日
0.8					
1	21.3	15.9	19.8	21.6	15.7
1.25	25.5	21.4	18.6	17.6	22.9
1.6	33.4	23.1	19.9	21.2	25.0
2	40.1	24.0	26.5	26.1	32.1
2.5	39.3	27.7	23.8	22.6	31.9
3.15	36.8	29.1	19.5	23.2	24.3
4	42.1	29.3	24.2	23.9	25.8
5	47.8	28.5	24.0	27.6	33.4
6.3	50.2	30.7	31.5	27.7	37.9
8	50.2	31.9	36.8	35.4	42.7
10	53.3	38.3	38.3	39.8	42.5
12.5	55.2	41.5	47.5	45.0	48.0
16	57.7	43.4	50.8	52.2	55.7
20	59.8	51.3	60.0	59.4	70.1
25	63.3	53.9	67.7	68.0	75.3
31.5	64.7	61.8	68.8	73.4	76.0
40	66.6	69.9	67.8	74.6	79.6
50	66.7	73.4	73.0	76.7	82.8
63	64.1	80.5	77.9	77.3	78.6
80	56.0	82.6	75.1	75.7	78.8
100					



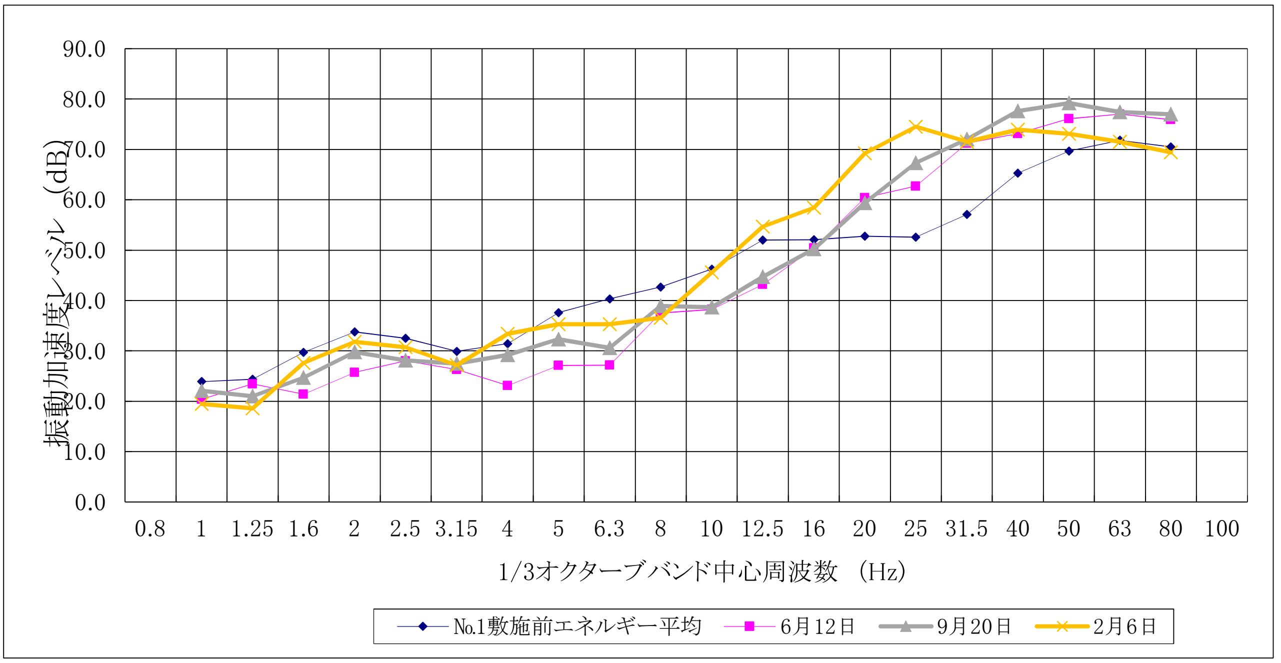
2017年4月4日計測
CH300
Y方向

	No.1敷施前エネルギー平均	4月4日	6月12日	9月20日	2月6日
0.8					
1	16.0	21.5	14.9	36.8	15.1
1.25	15.2	23.3	23.6	35.1	23.3
1.6	20.6	28.3	24.6	34.9	30.7
2	23.3	29.8	29.6	32.4	31.9
2.5	27.1	25.1	32.3	35.3	26.5
3.15	28.4	21.9	28.4	35.6	26.0
4	32.2	25.6	22.9	38.0	30.1
5	36.7	25.9	28.1	40.4	30.6
6.3	40.5	28.2	26.0	47.7	33.4
8	42.4	34.9	35.1	55.5	44.4
10	45.6	37.4	42.1	56.3	49.4
12.5	46.8	39.6	47.9	61.3	59.5
16	45.7	41.5	54.3	55.9	63.9
20	55.2	50.3	59.7	59.3	70.6
25	62.9	55.4	63.6	66.8	74.6
31.5	69.0	60.1	70.0	70.6	72.9
40	71.7	68.5	73.8	74.2	79.5
50	71.9	64.6	76.2	80.7	81.2
63	71.1	66.8	80.3	80.0	76.3
80	72.0	69.6	79.8	77.1	76.8
100					



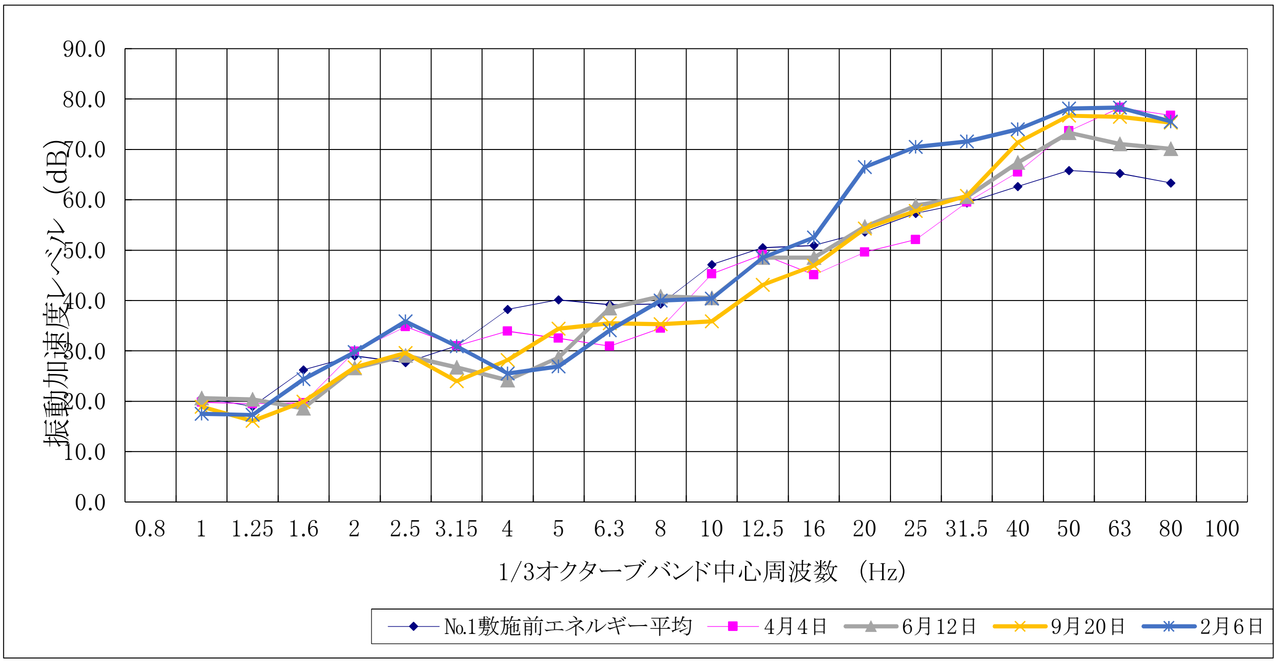
2017年4月4日計測
CH240
Y方向

	No.1敷施前エネルギー平均	6月12日	9月20日	2月6日
0.8				
1	23.9	20.4	22.1	19.5
1.25	24.4	23.4	21.0	18.6
1.6	29.7	21.4	24.7	27.6
2	33.8	25.7	29.8	31.8
2.5	32.5	28.0	28.1	30.7
3.15	29.9	26.3	27.5	27.2
4	31.4	23.1	29.2	33.4
5	37.6	27.1	32.3	35.3
6.3	40.3	27.2	30.6	35.3
8	42.7	37.5	38.9	36.6
10	46.2	38.2	38.7	45.6
12.5	52.0	43.2	44.7	54.7
16	52.1	50.4	50.2	58.4
20	52.8	60.4	59.4	69.2
25	52.6	62.7	67.3	74.5
31.5	57.1	71.2	72.0	71.5
40	65.3	73.1	77.6	73.9
50	69.7	76.1	79.2	73.1
63	71.8	77.0	77.4	71.5
80	70.5	75.9	77.0	69.4
100				



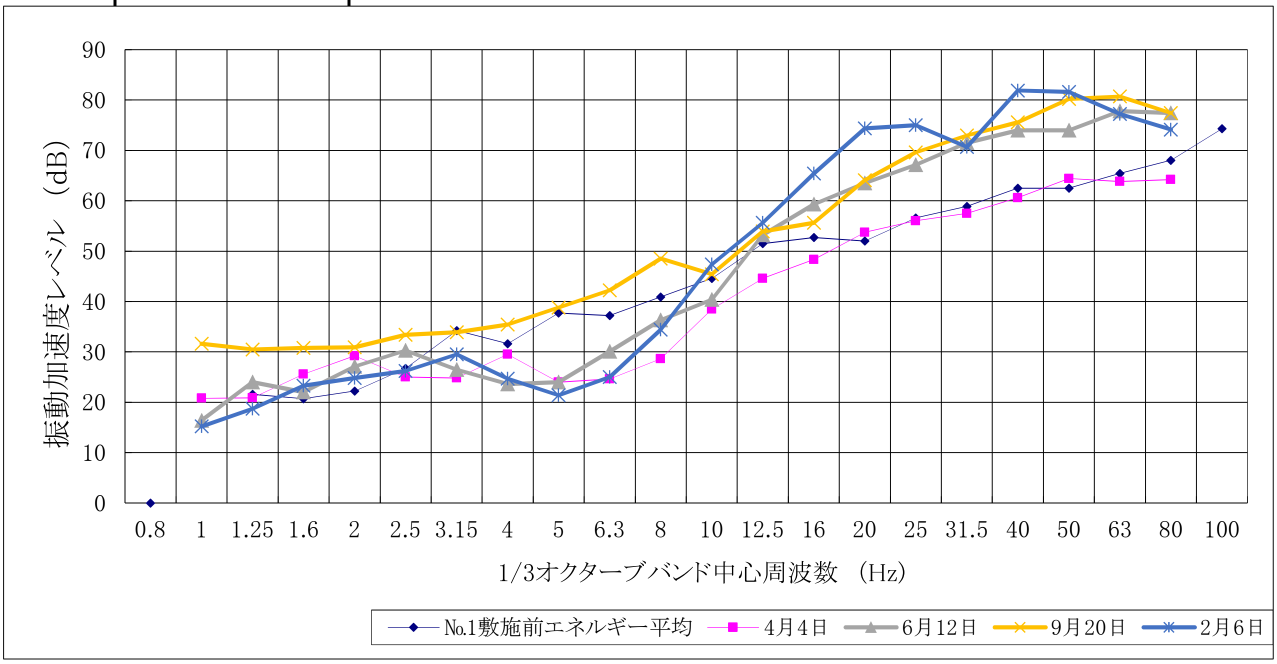
2017年4月4日計測
CH340
Z方向

	No.1敷施前エネルギー平均	4月4日	6月12日	9月20日	2月6日
0.8					
1	20.6	19.8	20.6	18.9	17.5
1.25	19.0	19.5	20.4	16.1	17.3
1.6	26.2	19.7	18.6	19.9	24.4
2	29.0	29.9	26.6	26.7	29.8
2.5	27.7	34.8	29.1	29.6	35.9
3.15	31.0	31.0	26.7	24.0	30.9
4	38.2	33.9	24.2	28.2	25.5
5	40.1	32.5	28.7	34.4	26.9
6.3	39.2	30.9	38.5	35.5	34.1
8	39.3	34.5	40.8	35.3	40.0
10	47.1	45.3	40.5	35.9	40.4
12.5	50.5	49.1	48.5	43.1	48.5
16	50.9	45.1	48.5	46.9	52.5
20	53.6	49.6	54.7	54.3	66.5
25	57.3	52.1	58.9	57.8	70.5
31.5	59.4	59.5	60.6	60.8	71.6
40	62.6	65.5	67.4	71.4	74.0
50	65.8	73.7	73.3	76.7	78.1
63	65.2	78.3	71.1	76.5	78.3
80	63.3	76.7	70.1	75.3	75.5
100					



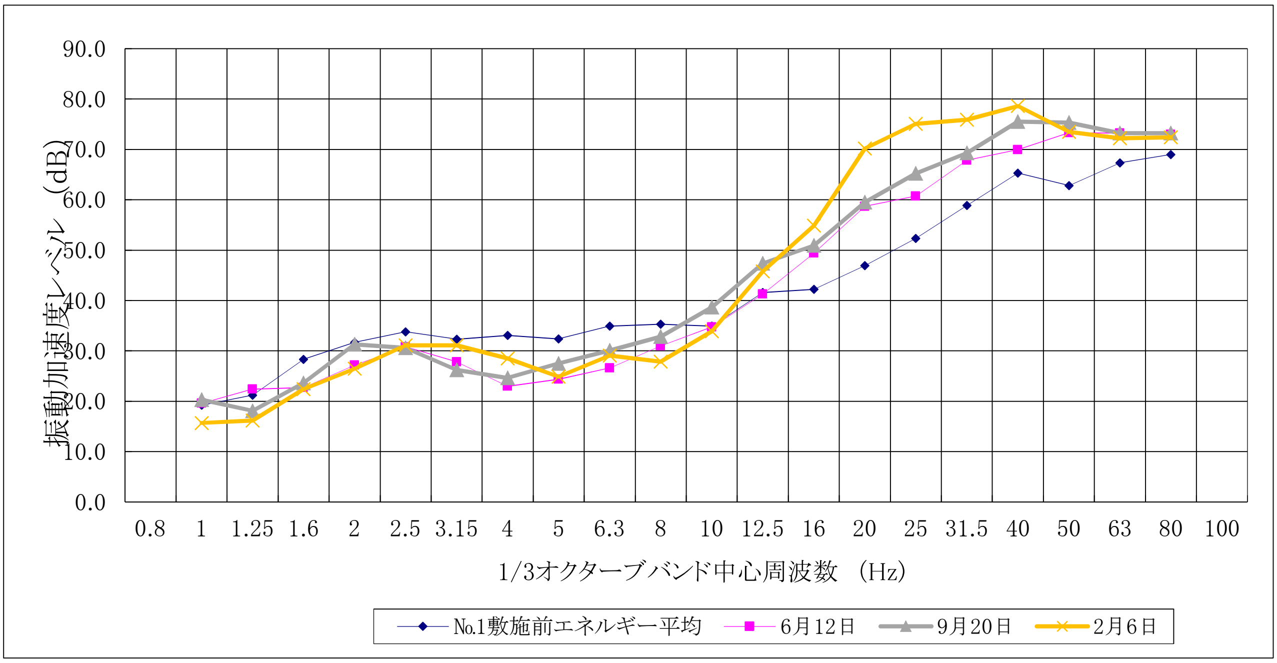
2017年4月4日計測
CH300
Z方向

	No.1敷施前エネルギー平均	4月4日	6月12日	9月20日	2月6日
0.8	No.1敷施前エネルギー平均				
1		20.8	16.4	31.6	15.2
1.25	21.6	20.9	24.0	30.5	18.7
1.6	20.7	25.6	22.0	30.8	23.3
2	22.2	29.2	27.1	30.9	24.8
2.5	26.7	25.0	30.3	33.4	26.2
3.15	34.2	24.8	26.5	33.9	29.5
4	31.6	29.5	23.6	35.4	24.7
5	37.7	24.0	24.0	38.8	21.4
6.3	37.2	24.6	30.1	42.2	25.0
8	40.9	28.6	36.3	48.5	34.4
10	44.6	38.5	40.4	45.4	47.4
12.5	51.5	44.6	53.2	53.9	55.6
16	52.7	48.3	59.3	55.6	65.4
20	52.0	53.7	63.5	64.1	74.4
25	56.6	56.0	67.1	69.6	75.0
31.5	58.9	57.5	71.5	73.0	70.7
40	62.5	60.6	74.0	75.6	81.9
50	62.5	64.4	74.0	80.2	81.6
63	65.4	63.8	77.8	80.7	77.2
80	68.0	64.2	77.4	77.4	74.1
100	74.3				



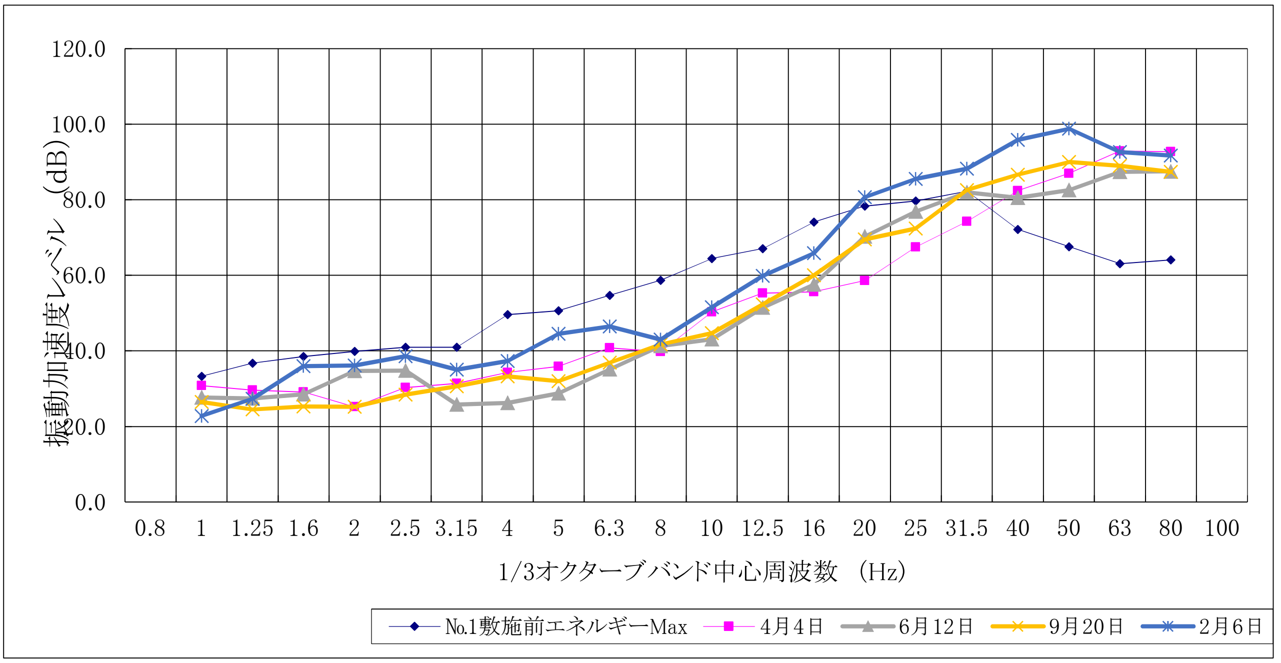
2017年4月4日計測
CH240
Z方向

	No.1敷施前エネルギー平均	6月12日	9月20日	2月6日
0.8				
1	19.2	19.6	20.3	15.7
1.25	21.2	22.4	18.1	16.2
1.6	28.3	22.7	23.6	22.4
2	31.7	27.2	31.3	26.5
2.5	33.8	30.8	30.6	31.1
3.15	32.3	27.8	26.2	31.1
4	33.1	23.0	24.6	28.5
5	32.4	24.4	27.5	24.9
6.3	34.9	26.6	30.1	29.1
8	35.3	31.0	32.8	27.9
10	34.9	34.7	38.7	33.9
12.5	41.6	41.3	47.4	45.8
16	42.2	49.4	50.9	54.9
20	46.9	58.7	59.5	70.2
25	52.3	60.7	65.2	75.1
31.5	58.9	67.8	69.3	75.9
40	65.3	69.9	75.5	78.6
50	62.8	73.3	75.3	73.5
63	67.3	73.2	73.2	72.2
80	69.0	73.0	73.2	72.4
100				



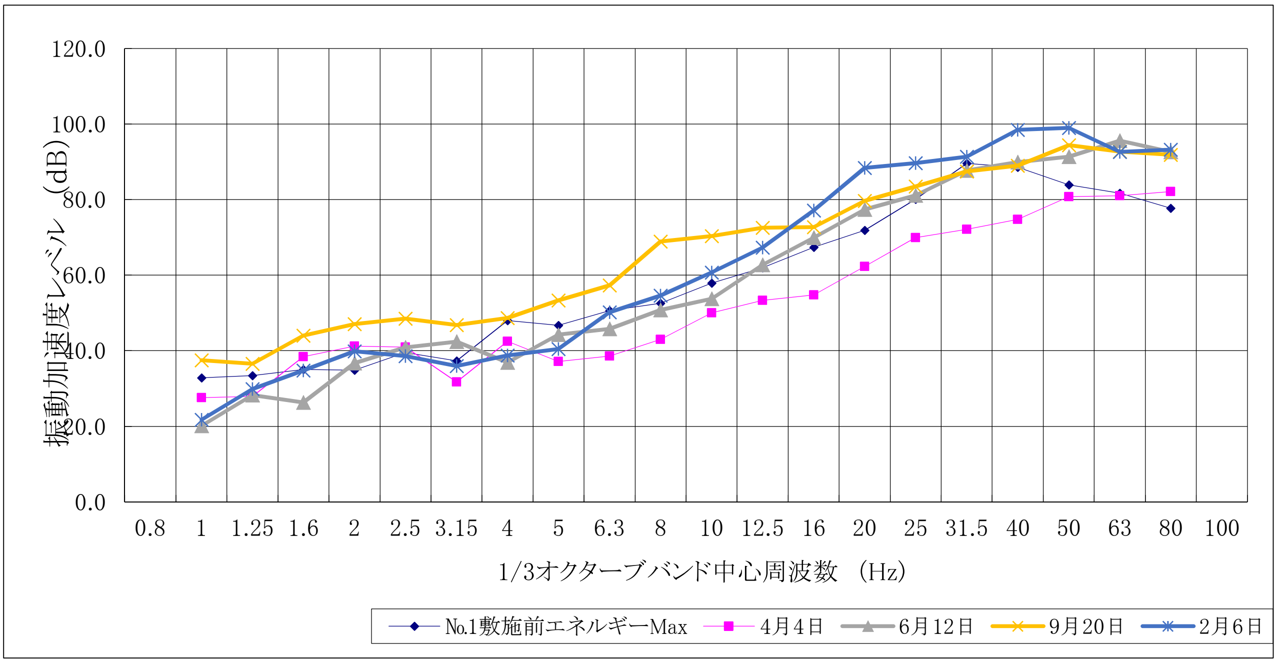
0 2017年4月4日計測
CH340
X方向

	№1敷施前エネルギーMax	4月4日	6月12日	9月20日	2月6日
0.8					
1	33.3	30.8	27.7	26.5	22.8
1.25	36.7	29.6	27.4	24.5	27.3
1.6	38.5	29.1	28.5	25.3	36.0
2	39.9	25.2	34.7	25.2	36.1
2.5	41.0	30.3	34.8	28.4	38.6
3.15	41.0	31.4	25.8	30.6	35.0
4	49.6	34.3	26.2	33.3	37.3
5	50.6	35.9	28.8	32.0	44.5
6.3	54.7	40.8	35.1	36.9	46.5
8	58.7	39.8	41.3	41.7	43.0
10	64.4	50.3	43.1	44.7	51.6
12.5	67.1	55.3	51.5	52.3	59.9
16	74.1	55.6	57.6	60.0	65.9
20	78.3	58.6	70.3	69.5	80.7
25	79.7	67.5	76.9	72.4	85.5
31.5	82.3	74.3	82.0	82.6	88.2
40	72.1	82.4	80.5	86.6	95.9
50	67.6	87.0	82.6	90.0	98.8
63	63.1	92.9	87.4	89.0	92.6
80	64.1	92.7	87.5	87.4	91.7
100					



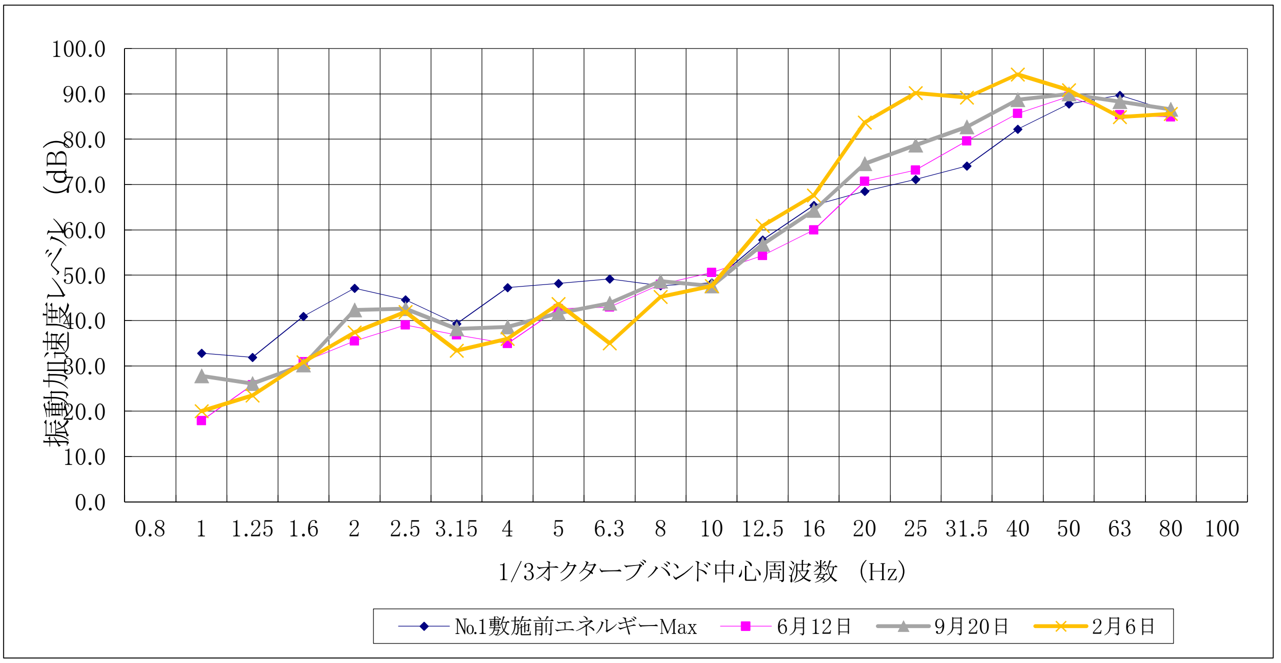
0 2017年4月4日計測
CH300
X方向

	No.1敷施前エネルギーMax	4月4日	6月12日	9月20日	2月6日
0.8					
1	32.8	27.6	20.1	37.5	21.7
1.25	33.4	27.9	28.3	36.6	29.9
1.6	35.0	38.4	26.3	44.0	34.8
2	34.9	41.2	36.7	47.1	39.9
2.5	39.5	41.0	40.9	48.5	38.6
3.15	37.3	31.7	42.4	46.8	36.0
4	48.0	42.5	36.9	48.7	38.8
5	46.7	37.2	44.3	53.3	40.5
6.3	50.6	38.6	45.8	57.3	50.2
8	52.6	43.0	50.8	68.9	54.6
10	57.9	50.0	53.8	70.4	60.7
12.5	62.0	53.3	62.7	72.6	67.3
16	67.4	54.8	69.9	72.7	77.1
20	71.9	62.3	77.4	79.7	88.4
25	80.1	69.9	81.1	83.5	89.7
31.5	89.6	72.1	87.7	87.5	91.4
40	88.6	74.8	89.9	89.0	98.5
50	83.9	80.8	91.4	94.4	99.0
63	81.7	81.0	95.6	92.7	92.6
80	77.7	82.1	92.6	91.9	93.2
100					



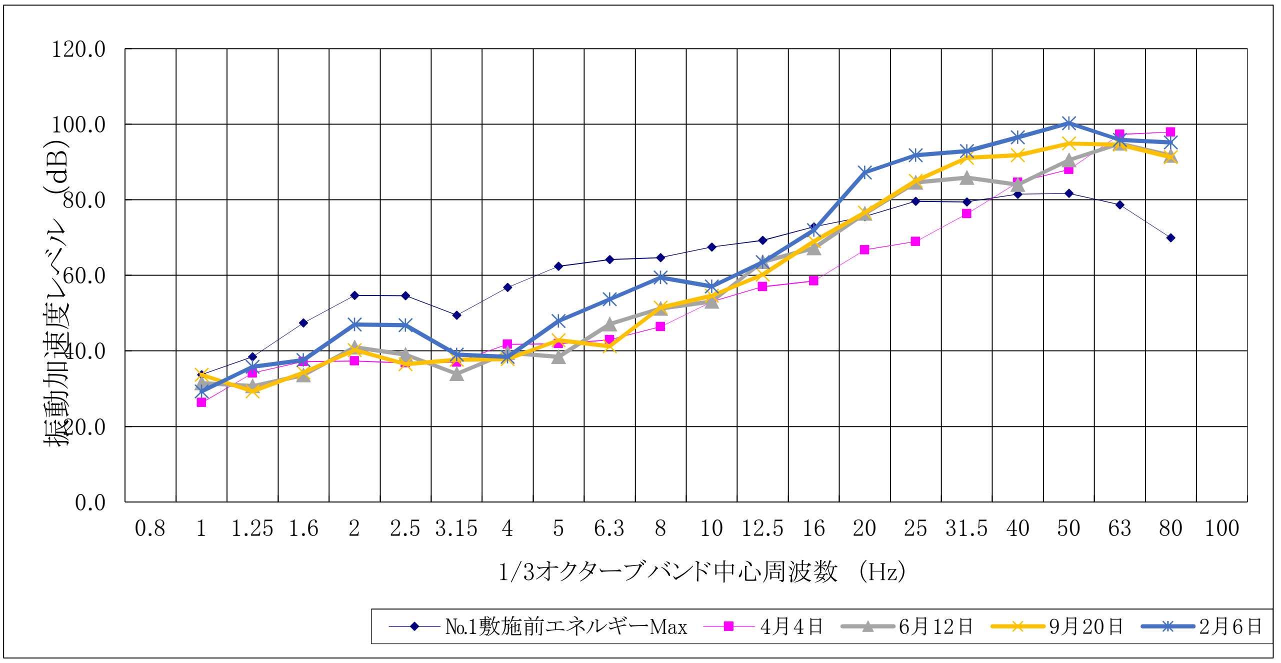
0 2017年4月4日計測
CH240
X方向

	№1敷施前エネルギーMax	6月12日	9月20日	2月6日
0.8				
1	32.8	17.9	27.8	20.0
1.25	31.9	25.8	26.1	23.5
1.6	40.9	30.9	30.2	30.8
2	47.1	35.5	42.3	37.4
2.5	44.6	39.0	42.6	41.9
3.15	39.3	36.8	38.2	33.4
4	47.3	34.9	38.6	36.0
5	48.2	42.6	41.6	43.7
6.3	49.2	43.0	43.8	35.0
8	47.7	48.0	48.7	45.2
10	48.3	50.6	47.6	47.6
12.5	57.8	54.3	56.8	60.9
16	65.4	60.0	64.3	67.6
20	68.5	70.7	74.6	83.7
25	71.1	73.2	78.7	90.2
31.5	74.1	79.6	82.7	89.2
40	82.2	85.7	88.7	94.3
50	87.8	89.4	90.0	90.8
63	89.7	85.4	88.3	84.9
80	86.2	84.9	86.6	85.6
100				



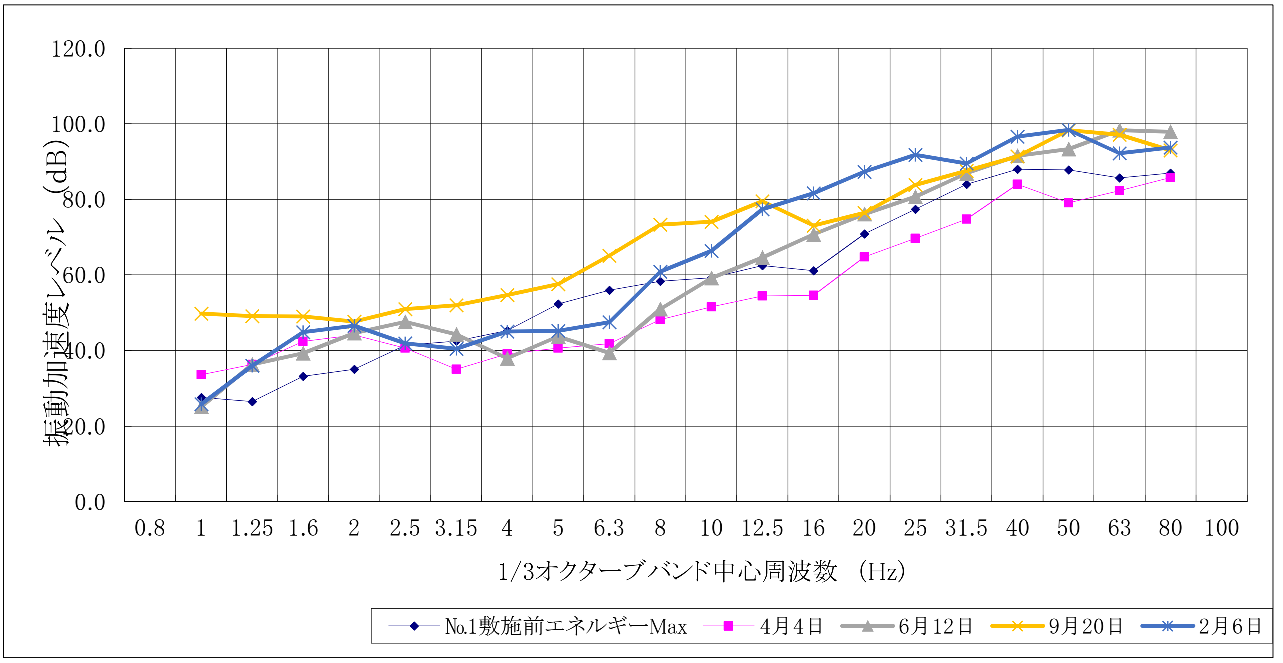
2017年4月4日計測
CH340
Y方向

	№1敷施前エネルギーMax	4月4日	6月12日	9月20日	2月6日
0.8					
1	33.7	26.3	31.5	33.7	29.3
1.25	38.4	34.1	30.7	29.3	35.8
1.6	47.4	37.2	33.6	34.3	37.6
2	54.7	37.3	41.0	40.2	47.0
2.5	54.6	36.8	39.0	36.5	46.8
3.15	49.4	37.0	33.9	37.7	39.0
4	56.8	41.7	39.5	37.8	38.4
5	62.4	41.9	38.4	42.8	47.9
6.3	64.2	42.9	47.1	41.2	53.7
8	64.7	46.4	51.2	51.5	59.4
10	67.5	53.0	53.1	54.6	57.1
12.5	69.3	57.0	63.6	60.2	63.5
16	72.8	58.5	67.2	69.0	72.0
20	75.5	66.7	76.4	76.6	87.2
25	79.6	68.9	84.6	85.0	91.8
31.5	79.4	76.3	85.9	91.1	92.9
40	81.5	84.6	84.0	91.8	96.5
50	81.7	88.0	90.5	94.9	100.3
63	78.7	97.3	94.9	94.6	95.9
80	69.9	97.9	91.7	91.3	95.2
100					



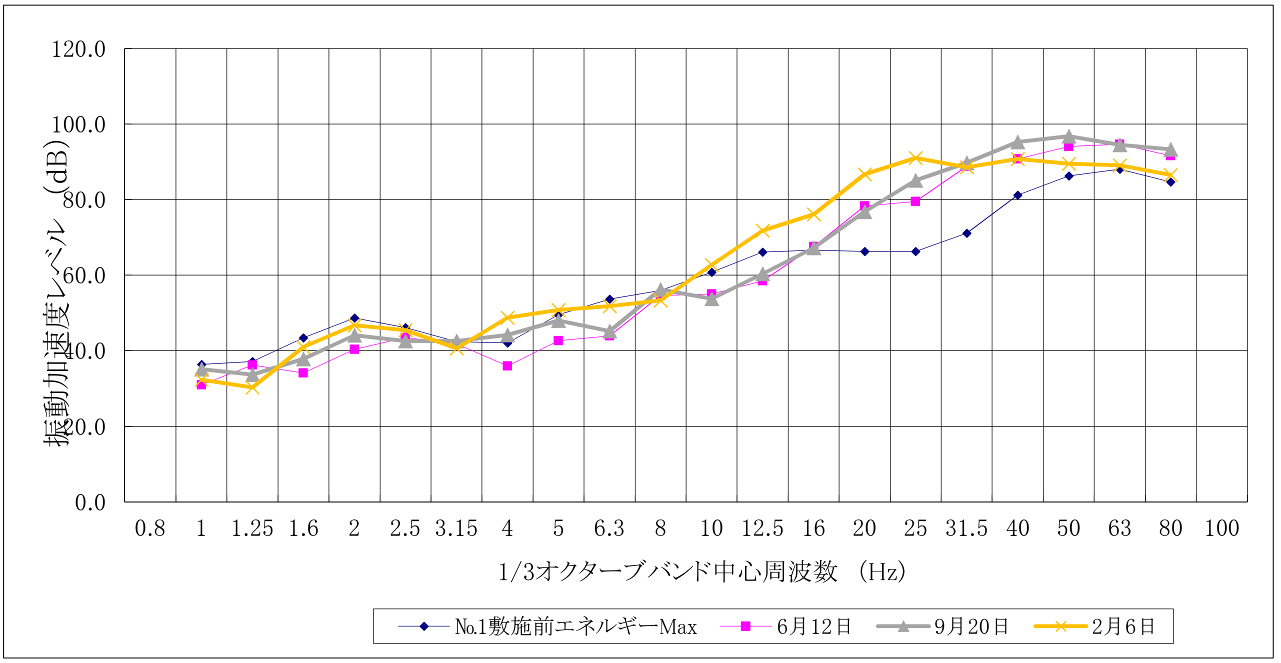
2017年4月4日計測
CH300
Y方向

	No.1敷施前エネルギーMax	4月4日	6月12日	9月20日	2月6日
0.8					
1	27.6	33.6	25.1	49.8	25.8
1.25	26.5	36.3	36.3	49.1	36.0
1.6	33.2	42.4	39.3	49.0	44.9
2	35.0	44.1	44.6	47.7	46.6
2.5	41.4	40.6	47.6	51.0	41.9
3.15	42.5	35.0	44.3	52.0	40.5
4	45.3	39.1	37.9	54.7	45.0
5	52.3	40.6	43.7	57.6	45.2
6.3	56.0	41.8	39.4	65.1	47.5
8	58.3	48.2	51.0	73.3	60.9
10	59.3	51.6	59.2	74.1	66.4
12.5	62.5	54.4	64.6	79.5	77.4
16	61.1	54.6	70.7	73.1	81.6
20	70.9	64.8	76.1	76.5	87.3
25	77.4	69.7	80.7	83.8	91.8
31.5	84.0	74.8	86.9	87.6	89.5
40	88.0	84.0	91.5	91.4	96.6
50	87.8	79.1	93.3	98.3	98.4
63	85.7	82.3	98.3	97.1	92.2
80	87.0	85.8	97.9	93.0	93.7
100					



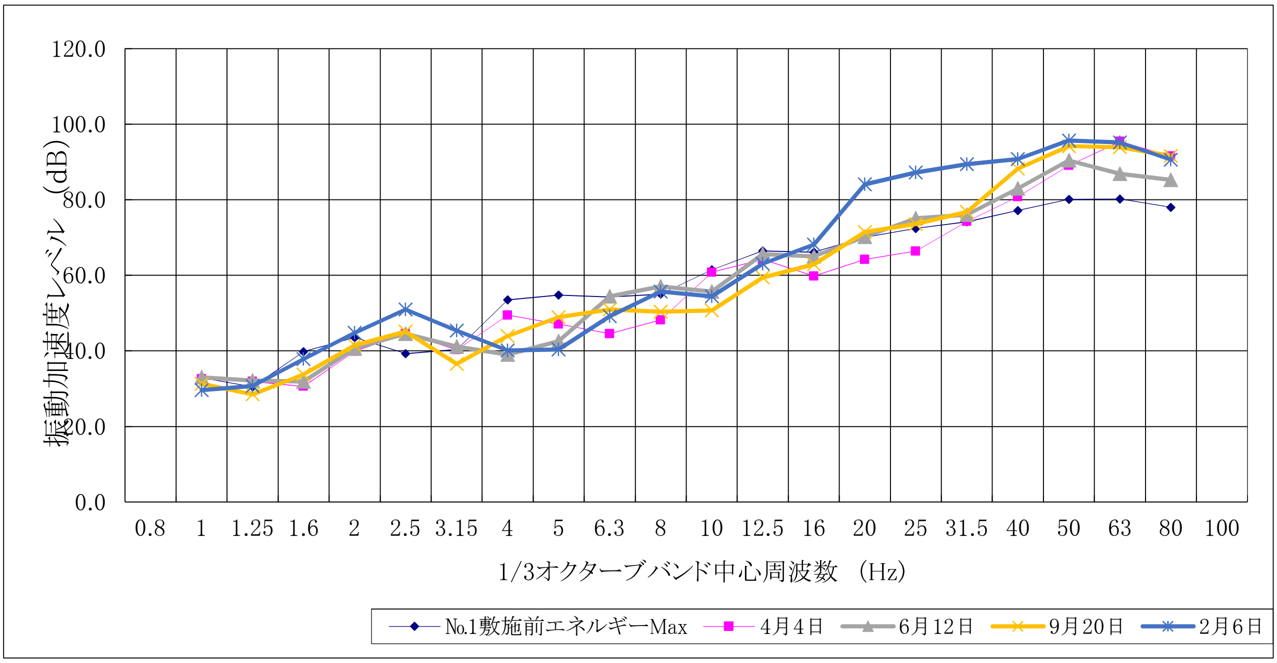
2017年4月4日計測
CH240
Y方向

	№1敷施前エネルギーMax	6月12日	9月20日	2月6日
0.8				
1	36.4	31.0	35.1	32.3
1.25	37.2	36.2	33.7	30.3
1.6	43.4	34.1	37.8	41.0
2	48.7	40.4	44.1	46.7
2.5	46.1	43.5	42.6	45.5
3.15	42.4	41.8	42.6	40.6
4	42.1	36.0	44.2	48.8
5	49.5	42.7	48.0	50.8
6.3	53.7	43.9	45.2	51.8
8	56.0	54.6	56.2	53.3
10	60.8	55.0	53.8	62.7
12.5	66.1	58.5	60.4	71.8
16	66.6	67.6	67.2	76.1
20	66.3	78.3	76.8	86.7
25	66.3	79.5	85.1	91.0
31.5	71.1	88.8	89.8	88.6
40	81.2	90.8	95.3	90.8
50	86.3	94.1	96.8	89.5
63	88.1	94.7	94.5	89.1
80	84.7	91.6	93.3	86.5
100				



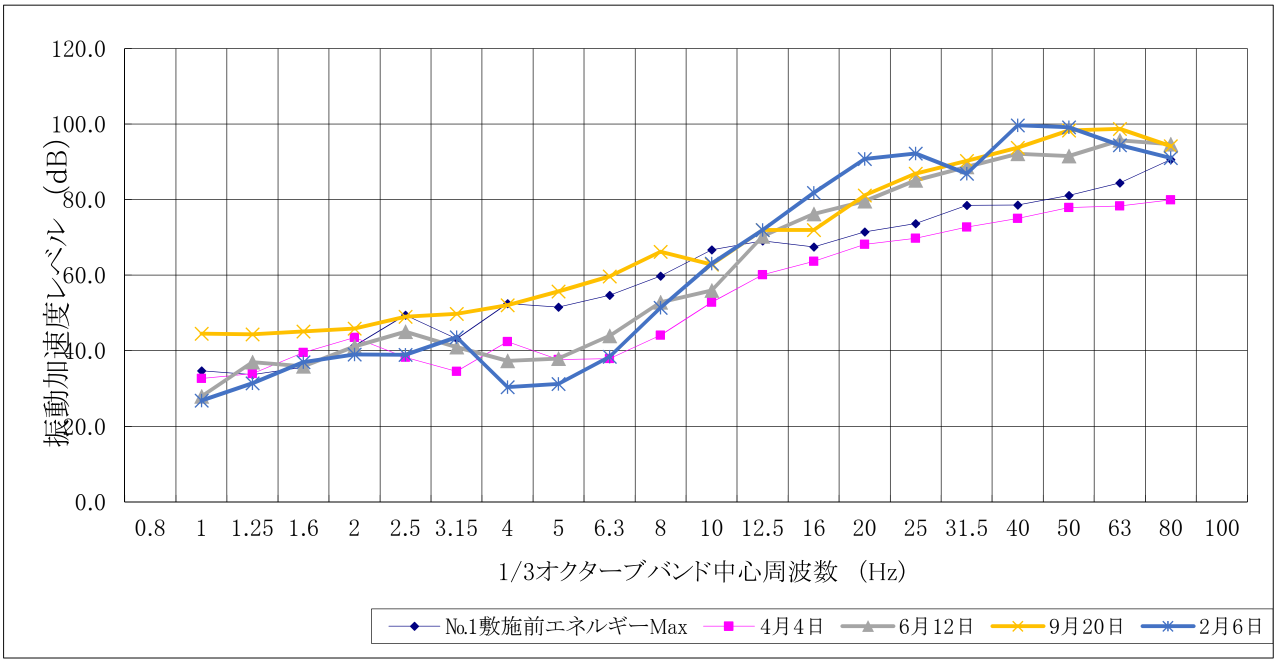
2017年4月4日計測
CH340
Z方向

	No.1敷施前エネルギーMax	4月4日	6月12日	9月20日	2月6日
0.8					
1	32.8	32.6	33.0	31.3	29.6
1.25	30.5	31.9	32.2	28.5	30.7
1.6	39.8	30.6	31.9	33.8	37.8
2	43.5	39.9	40.6	41.5	44.8
2.5	39.3	44.5	44.5	45.1	51.0
3.15	40.4	40.3	41.1	36.6	45.4
4	53.5	49.4	39.0	43.9	40.1
5	54.8	47.1	42.6	48.9	40.4
6.3	54.3	44.5	54.4	51.0	49.2
8	55.0	48.2	57.1	50.4	55.7
10	61.5	60.8	55.7	50.7	54.4
12.5	66.5	64.2	65.6	59.4	63.1
16	66.1	59.8	65.0	62.9	68.2
20	70.0	64.2	70.2	71.5	84.1
25	72.4	66.4	75.1	73.6	87.2
31.5	74.2	74.3	76.0	76.8	89.4
40	77.1	80.8	83.0	88.2	90.8
50	80.1	89.1	90.4	94.2	95.7
63	80.2	95.4	86.9	93.9	95.2
80	78.0	91.5	85.3	91.6	90.6
100					



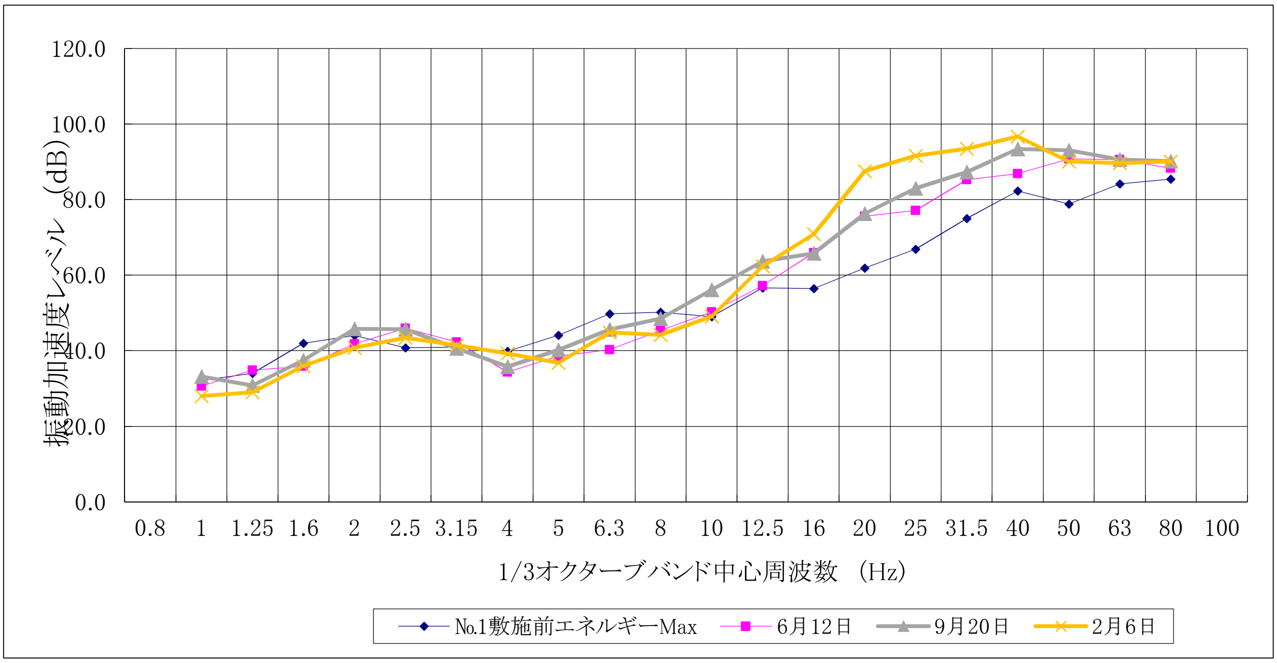
2017年4月4日計測
CH300
Z方向

	No.1敷施前エネルギーMax	4月4日	6月12日	9月20日	2月6日
0.8					
1	34.7	32.7	27.9	44.5	26.8
1.25	33.7	33.9	37.0	44.4	31.4
1.6	35.6	39.5	35.9	45.1	37.0
2	41.3	43.5	41.1	45.9	39.0
2.5	49.4	38.3	45.0	49.0	38.9
3.15	43.2	34.5	41.0	49.8	43.6
4	52.5	42.4	37.3	52.1	30.4
5	51.6	37.7	37.9	55.7	31.2
6.3	54.7	37.9	43.9	59.7	38.4
8	59.8	44.1	52.8	66.2	51.4
10	66.7	52.8	56.0	62.8	63.1
12.5	69.1	60.1	70.3	72.0	72.0
16	67.5	63.7	76.2	72.0	81.8
20	71.5	68.2	79.6	81.1	90.8
25	73.7	69.8	85.1	86.9	92.2
31.5	78.5	72.7	88.7	90.3	86.9
40	78.6	75.0	92.1	93.7	99.7
50	81.1	77.9	91.5	98.3	99.2
63	84.4	78.3	95.7	98.7	94.4
80	90.6	79.9	94.7	94.2	91.0
100					



2017年4月4日計測
CH240
Z方向

	№1敷施前エネルギーMax	6月12日	9月20日	2月6日
0.8				
1	32.2	30.6	33.2	28.0
1.25	34.0	34.9	30.8	29.0
1.6	42.0	35.9	37.5	36.0
2	44.0	41.8	45.8	40.8
2.5	40.8	46.0	45.7	43.4
3.15	41.0	42.3	40.6	41.5
4	39.9	34.4	35.8	39.3
5	44.1	38.6	40.2	36.8
6.3	49.8	40.3	45.6	44.9
8	50.2	45.4	48.5	44.2
10	49.0	50.3	56.1	49.1
12.5	56.6	57.2	63.7	62.4
16	56.5	66.0	65.8	70.9
20	61.9	75.6	76.3	87.6
25	66.9	77.1	83.0	91.6
31.5	75.0	85.3	87.3	93.5
40	82.3	86.9	93.4	96.7
50	78.8	90.8	93.1	90.1
63	84.2	90.6	90.6	89.7
80	85.4	88.3	90.2	90.1
100				



資料-5　斜面補強（D-Box Dam at the Edge of slope）

(1) 斜面補強の概要

鉄道が河川を横断する場合には、橋が設置されており周辺地盤よりも 3m～5m の高さで盛土が必要となり、エーヤワディデルタ地帯では、周囲の軟弱粘土を掘削して盛土を形成している。

この盛土部は、乾季は硬い粘土となり、乾燥収縮により、ところどころにクラックが生じ、雨季にはクラックの隙間から水が浸透し、水分を吸収し軟弱な粘土となる。そのため、Chaungphyar　Bridge 周辺では、1990 年の建設以来、毎年のように軌道部直下の Ballast が噴砂現象により沈下するだけでなく、斜面崩落の補修工事が行なわれて来ている。2017 年 4 月に行なった斜面の形成において法勾配を 1：3 として安定を図ったが、雨季の集中豪雨時には，斜面にクラックが入り、すべりを生じる結果となった（図 5-1 参照）。

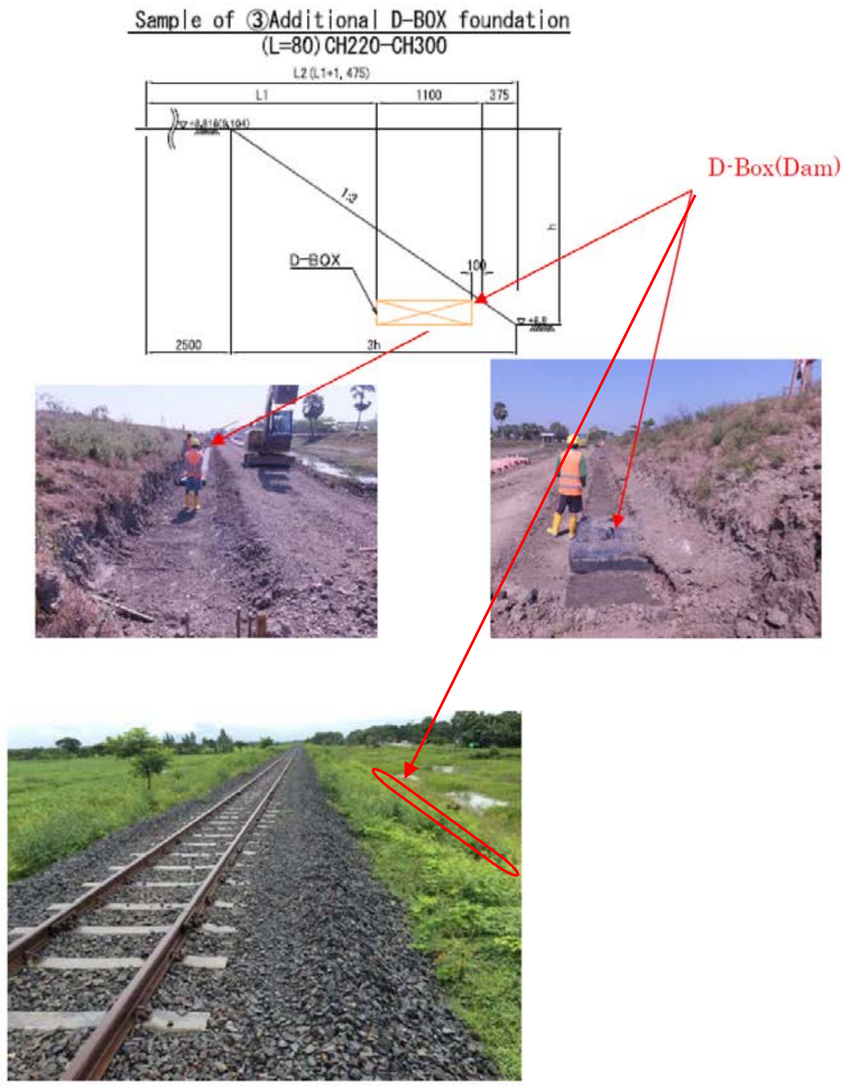
この原因としては、Chaungphyar Site では、乾季に盛土部の粘土が乾燥してひび割れを起こし、その後の雨季の集中豪雨により、ひび割れ部の隙間に水が浸透したことにより、粘土のせん断強度（粘着力）が著しく低下し、斜面崩壊が各所で生じたため斜面の補強を行なった。

斜面補強で効果が高かったものは、図 5-2 に示すように法面の先端にカンシ堤(D-Box Dam)として D-Box を斜面の法先部に延長 80m で設置した区間であり、設置後 1 年以上が経過したが、斜面の崩壊は全く生じていない。

この実績を基に、図 5-3 に示すようにカンシ堤（D-Box Dam）として D-Box を 2 段で埋込む工法を斜面対策としてその他の斜面の補強工法として､約 450 m の法面の補強を行なった。また、一部の擁壁クサビ杭としてＭＲの廃レール（Ｌ＝3m）を 0.5 m～1 m 間隔で打設する工法であった。

Figure 4.6-2　Situation of slope collapse in the construction in Ainme (Sliding occurs even in 1:3 inclination)

図 5-1　斜面の雨季の崩壊状況（2017 年 7 月　法勾配 1：3）



CH220-CH300　Slopes in which D-Box was placed as the Dam are stable.

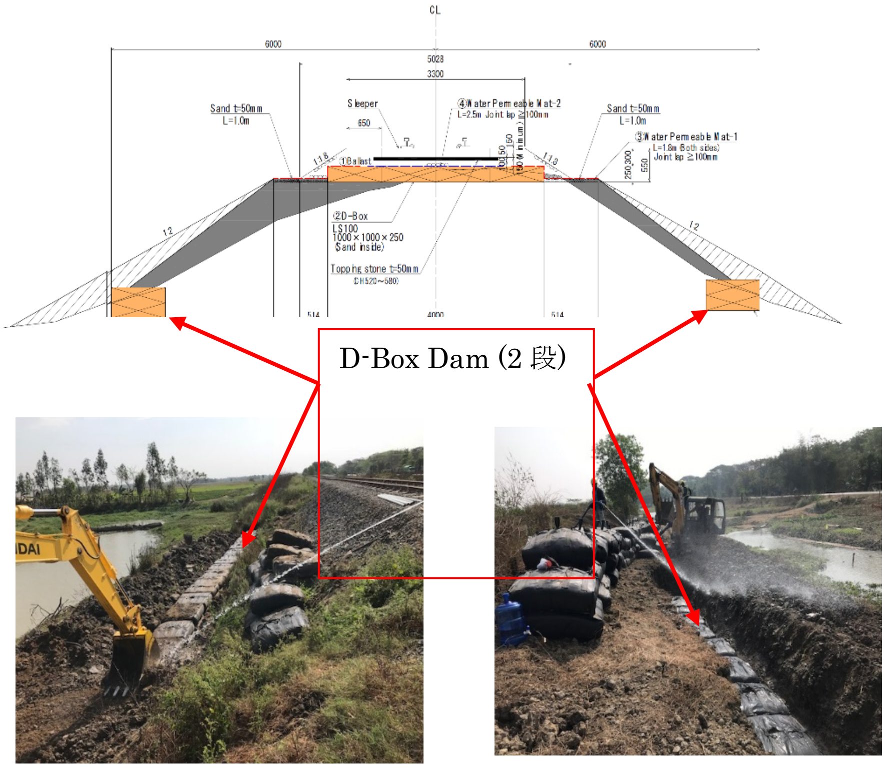
Figure 4.6-1 D-Box Dam at the edge of the slope (CH220-CH300)

図 5-2　D-Box Dam の設置とその後の状況

(2) カンシ堤による斜面補強

D-Box による斜面補強の対策としてのカンシ堤（D-Box Dam）の補強状況を図 5-3 に示す。なお、Retaining Wall の前面には、図 5-4 に示すように rail pile（L＝3m）により斜面のすべり対策を行ない斜面対策としている。

カンシ堤の設置時に地盤が乾燥している場合には、図 5-3 に示すように十分に散水した後にバックホゥによる D-Box への転圧と斜面埋め戻し後の転圧を十分に行なうことが必要である。



D-Box 設置後の散水と転圧

D-Box 及び周辺への散水

D-Box Dam 設置後の backhoe による転圧

D-Box Dam 斜面転圧完了

図 5-3　カンシ堤（D-Box Dam）による斜面補強

図 5-4　rail piles を用いた斜面補強

(3) カンシ堤による Chaungphyar Site の斜面補強の詳細

斜面補強に用いた D-Box カンシ堤（D-Box Dam）の内訳は表 5-1 および図 7.4-5～6 に示すように、延長 487m、追加の D-Box 約 800 袋を用いて 2018 年 2 月に実施した。

なお、D-Box カンシ堤による成果の確認は、2018 年の雨季を待って最終確認する予定である。

表 5-1　D-Box（カンシ堤）の使用数量

NO	Type	Left or Right	Distance from Rail(m)	Start CH	Finish CH	Layer	L(m)	Number of D-Box
L-1	G	L	7	210	406	2	196	392
L-2	G	L	6	393	398	2	5	10
L-3	G	L	6	394	398	3	4	12
L-4	G	L	6	398	406	2	8	16
L-5	G	L	7.6	501.5	510.5	2	9	18
L-6	G	L	10.5	512	524	2	12	24
L-7	G	L	9	525	536	1	11	11
L-8	G	L	6.5	534	536	3	2	6
L-9	G	L	7	536	580	1	44	44
R-1	G	R	7	300	407	2	107	214
R-2	G	R	3	366	382	3	16	48
R-3	G	R	7.3	502.5	517.5	2	15	30
R-4	G	R	6.6	518	547	1	29	29
R-5	G	R	7.3	548	561	1	13	13
R-6	G	R	7.3	562	566	2	4	8
R-7	G	R	7.3	566	578	1	12	12
total							487	887

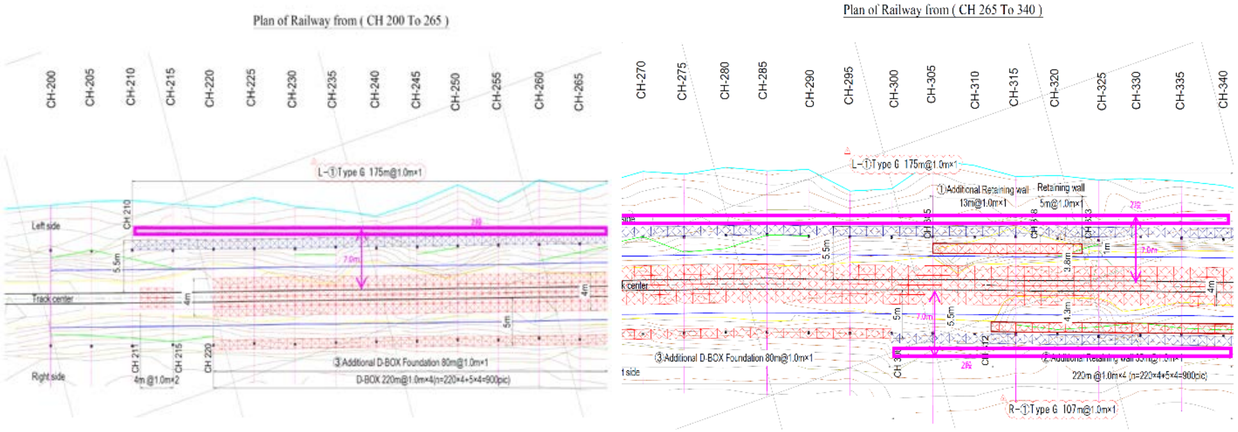


図 5-5　D-Box Dam の位置図（CH210-CH340）

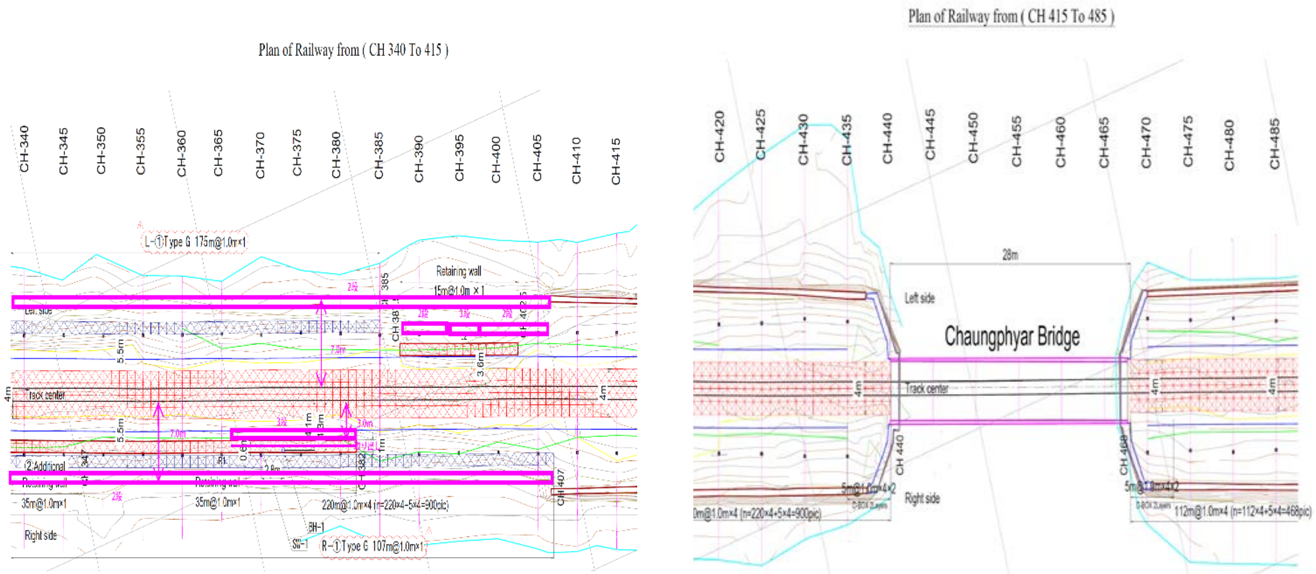


図 5-6　 D-Box Dam の位置図（CH340-C485）

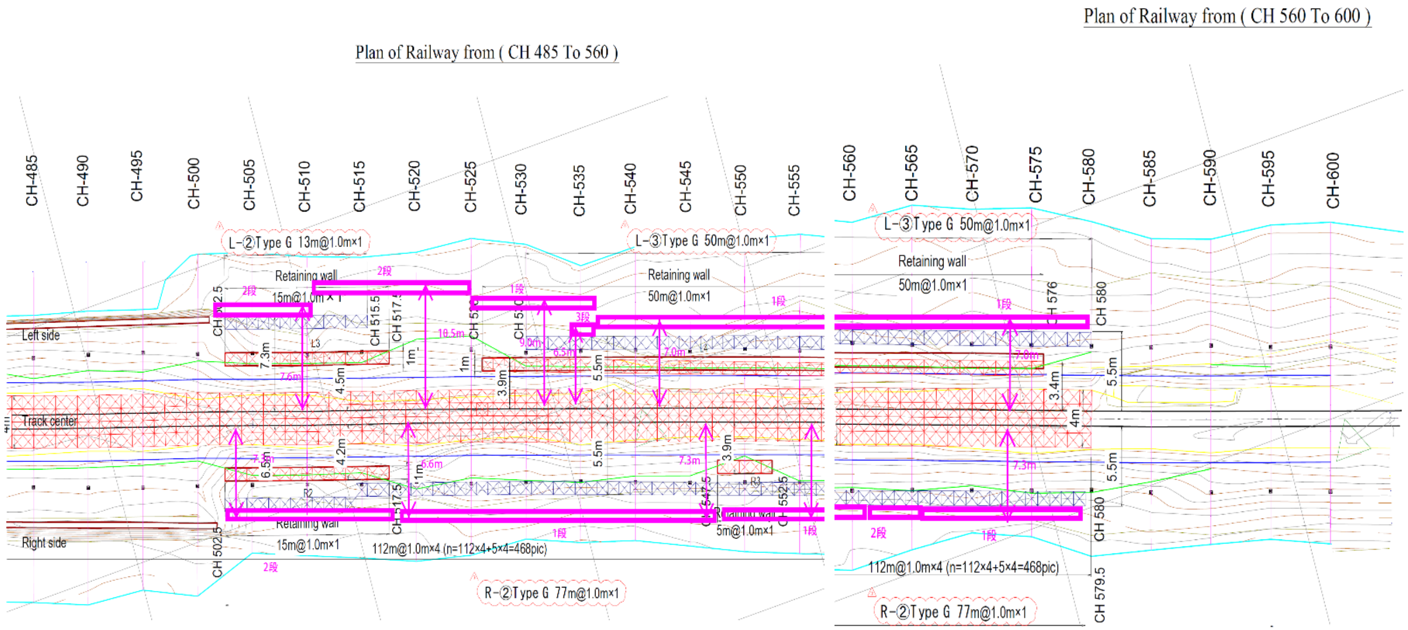


図 5-7　D-Box Dam の位置図（CH4