Appendices

Appendix 1

List of Existing Equipment

List of Existing Equipment

1) Thuwunna Central Training Center (Thuwunna CTC)

2) Department of Bridges (DOB)

3) Department of Building (DOBi)

4) Department of Highways (DOH)

5) Department of Rural Road Development (DRRD)

1) Thuwunna Central Training Center (Thuwunna CTC)

No.	Name of Equipment	Quantity	Status/Remarks
1	Total Station	2	working, Japan
2	Electric Drill	5	working, Japan
3	Table Electric Saw	1	working, Japan
4	Electric Planer	5	working, Japan
5	Carpenter's Tool	20	working, Japan
6	Concrete Vibrator	5	working, Japan
7	High frequency Generator	1	working, Japan
8	Concrete Mixer	1	working, Japan
9	Asphalt Cutter	1	working, Japan
10	Asphalt Hand Sprayer	1	working, Japan
11	Plate Compactor	2	working, Japan
12	Road safety Facilities	1	working, Japan
13	Bar Bending Machine	2	working, Japan
14	Bar Cutting Machine	2	working, Japan
15	Frame Scaffolding	1	working, Japan
16	Pipe Scaffolding	1	working, Japan
17	Travelling Scaffolding	1	working, Japan
18	Scaffolding Tools	20	working, Japan
19	PPE	34	working, Japan

2) Department of Bridges (DOB)

(1) Rebar Testing

No.	Name of Equipment	Quantity	Status/Remarks
1	Tensile Machine	1	working, Italy
2	Tensile Machine with Extensometer	1	working, Italy

(2) Non Destructive Testing (NDT)

No.	Name of Equipment	Quantity	Status/Remarks
1	Stress-Strain Measuring Instrument	1	working, Korea
2	Stress-Strain Measuring Instrument	1	working, China
3	Magnetic Particle Test	2	working, Japan
4	Profoscope	2	working, Switzerland
5	Pundit Ultrasonic Pulse Velocity	2	working, Switzerland
6	Canin^{+}	1	working, Switzerland
7	Echo-Sounder (River Surveyor)	1	working, U.S.A
8	Profometer (PM-650)	2	working, Switzerland
9	Profometer Corrosion	2	working, Switzerland
10	Pundit Ultrasonic Pulse Echo	2	working, Switzerland
11	Digital Theodolite	4	working, Japan
12	Trimble Total Station	4	working, Japan
13	Nikon Total Station	2	working, Japan
14	Portable Depth Sounder	4	working, Japan
15	Photometer	1	working, Switzerland
16	Auto Level B2	2	working, Japan
17	Auto Level B3	2	working, Japan
18	Auto Level B4	1	working, Japan
19	Aqua Map Sounder 80xs	1	working, Taiwan
20	12 Volt Dry Cell with Adaptor	1	working, China
21	Distance meter	2	working, Germany
22	Core Drilling	1	working, Myanmar
23	Universal Electric Core Drilling Machine	1	working, Germany
24	Digital Water Analyzer	1	working, Japan
25	Hardness Tester Equotip Bambino	2	working, Switzerland
26	Thermometer	1	-
27	Telescopic	1	-
28	ELTECH-4HC Temperature & Humidity Digital Data Logger Recorder	8	working, Taiwan
29	Endoscopic	3	-

(3) Soil Testing

No.	Name of Equipment	Quantity	Status/Remarks
1	Consolidation (3 Units)	1	working, Italy
2	Consolidation (1 Unit)	1	working, Italy
3	Consolidation (4 Units)	1	working, Japan
4	U.C.S Machine	2	working, Italy
5	U.C.S Machine	2	working, U.S.A

6	U.C.S Machine	1	England
7	Direct Shear Machine	4	U.S.A, England, Japan, Italy
8	Triaxial Apparatus	2	Japan,Italy
9	Oven	3	not working, Thailand, Japan
10	Fine-Grained Seives 4,10,20,40,60,100, 200, Pan & Cover	18	working, U.S.A
11	Sieve Shaker with Set of Sieve for Soil	2	working, U.S.A
12	Horizontal Sample Ejector	1	working, U.S.A
13	Stiring Machine	1	working, Italy
14	Soil Dispersion Mixer	1	working, U.S.A
15	Soil Grider	2	working, U.S.A
16	Harvard Miniature Compaction Apparatus	1	working, U.S.A
17	Compaction Mould	1	-
18	Liquid limit Apparatus with grooving tools	4	Japan, U.S.A,ELE
19	Liquid limit Apparatus	1	working, U.S.A
20	Filter for Triaxial Apparatus	1	-
21	Cone Penetrometer Test	2	working, Italy, U.S.A
22	Point Load Tester	1	working, Italy
23	Hydrometer Appartus	2	working, Italy
24	ASTM M Sieves (4,10,20,40,60,100,200 & Pan,cover)	9	working, Japan
25	Plastic Limit Roller	2	working, Italy
26	Plastic Limit Set	1	working, U.S.A
27	Pocket Penetrometer	2	working, Italy
28	Highland Portable Precision Balance	4	working, U.S.A
29	Portable Precision Balance (OHAUS)	1	working, U.S.A
30	Digital Balance	1	not working, China
31	Digital Balance	1	working, Italy
32	Digital Thermometer	2	working, Italy
33	Vernial Caliper	2	working, U.S.A
34	Wire Saw	1	working, Japan
35	Desicator	6	working, Italy
36	Tray	14	working, Italy
37	Measuring Cylinder	15	working, U.S.A
38	Jack	2	working, China

(4) Concrete Testing

No.	Name of Equipment	Quantity	Status/Remarks
1	Abrasion	1	working, Japan
2	Air Entrained Meter (7litre Capacity)	2	working, U.S.A
3	Automatic Vicat Machine	2	working, U.S.A
4	Balance (60kg)	3	working, China
5	Balance (30kg)	8	working, China
6	Bentonite Test Apparatus	2	working, U.S.A
7	Bulk density and voids Measure	2	working, Italy
9	Beaker (1L)	46	working, Myanmar
10	Beaker (500ml)	30	working, Myanmar
11	Beaker (250ml)	30	working, Myanmar
12	Cube Mould (6"x6"x6")	114	working, Thailand
13	Cube Temper	16	working, Thailand
14	Capper for Cylinder	8	working, U.S.A
15	Crushing Value Apparatus	1	working, Thailand
16	Capping Pad (Rubber Pad) Econ-0	70	working, U.S.A
17	Cylinder Mould (6"x12")	186	working, Thailand
18	Coarse Aggregate Sieve Set	6	working, U.S.A
19	Compression Machine (China)	2	working, China
20	Compression Machine(Italy)	2	not working, Italy
21	Compression Machine (ELE) Mortor	1	working, England
22	Compression Machine (MATEST) 1000KN	1	working, Italy
23	Cart	2	working, Myanmar
24	Cent-O-Gram Balance(OHAUS)	2	not working, -
25	Concrete Thermometer	30	working, China
26	Cement Cube Mould (70x70x70 mm)	2	1 not working, Thailand
27	Cement Cube Mould (50x50x50 mm)	44	working, U.S.A
28	Digital Thermometer	2	working, U.S.A
29	Density Basket	2	not working, -
30	Digital Balance (1000g)	2	working, U.S.A
31	2"Diameter Moisture container (Steel)	30	working, Myanmar
32	6"Diameter Steel Plate	30	working, Myanmar
33	Fine Aggregate Sieve Set	6	working, U.S.A
34	Fiber Tank (1'x1'x1')	10	working, Myanmar
35	Glass Tank (2'x1'x1')	10	not working, Myanmar
36	Geological Hammer	1	working, Japan
37	Heavy Duty Balance (20kg)	3	working, China
38	High Land Portable Balance (USA)	1	working, U.S.A

39	Iron Ball	12	working, Japan
40	Load Cell (Matest)	2	working, Italy
41	Load Cell (Matest)	2	working, Italy
42	7/5 Mixer	1	not working, Italy
43	Mortor Mixer (Matest)	1	working, Italy
44	Measuring Cylinder (500ml)	30	workinmg, Myanmar
45	Pan Type Mixer	1	working, Italy
46	PH Meter	3	working, Singapore
47	Slump Cone	47	1 not working, USA
48	Scoop,Stainless Steel	18	working, U.S.A
49	Sand Absorption & Cone Tamper	2	working, U.S.A
50	Specific Gravity Bench Set	1	working, Italy
51	Sieve (No.170)	5	not working, USA
52	Sieve (No.20)	2	working, U.S.A
53	Sieve (No.12)	1	working, U.S.A
54	Standard Sieve (No.20,30)	2	working, U.S.A
55	Sieve Shaker USA	1	working, U.S.A
56	Tamping Rod for Slump & Cylinder	26	working, Thailand
57	Triple Beam Balance (2610gm)	5	working, China
58	Tray (2'x2'x4")	20	working, U.S.A
59	Tray (9"x9"x4")	15	working, U.S.A
60	Vicat	5	not working, USA
61	Vernier Caliper	1	working, Switzerland
62	Compression Machine (ELE) Manual	1	working, England
63	Moisture Digital Microwave Portable Meter	2	working, Taiwan
64	Neoprene	2	working, U.S.A
65	Mortor Mixer	1	working, Korea
66	Pan Type Mixer	1	working, Japan
67	Load Cell	1	working, Japan
68	Specific Gravity Apparatus	1	working, Japan
69	Oven	2	working, Japan
70	3000KN (Italy) Compression Machine	1	working, Italy
71	100KN (Italy) Flexure Machine	1	working, Italy
72	Load Cell (3000KN) (Italy)	1	working, Italy
73	Photometer(original)	2	working, U.S.A
74	Rebound Hammer	4	working, England
75	Silver Schmidt Hammer (Digital)	1	Switzerland
76	Soundness	7	working, U.S.A
77	Salinity Meter	4	working, U.S.A

78	Compression Machine (SHIDMAZU) (computer + colour printer)	2	working, Japan
79	Un bonded capping	5	working, U.S.A
80	Digital Vernier Caliper	1	-

3) Department of Building (DOBi)

No.	Name of Equipment	Quantity	Status/Remarks
1	200T Hydraulic Compression Machine	1	not working
2	2000kN Compression Machine (Digital)	1	working
3	Compression Machine (2000kN)	2	working
4	Compression Machine (1500kN)	5	working
5	Hydraulic Compression Machine	2	working
6	Flexural Testing Machine for Concrete	1	working
7	Ultrasonic Pulse Echo	1	working
8	Core Drilling Machine	1	working
9	Silver Shmidt Rebound Hammer	6	working
10	Pundit Ultrasonic Pulse Velocity	3	working
11	Concrete Test Hammer	1	not working
12	Vibrating Table	1	not working
13	Concrete Mixer Pan Type	2	working
14	Concrete Penetrometer	1	working
15	Melting Pot for Capping Compound	2	working
16	Cube Mould	53	working
17	Cylinder Mould	8	working
18	Cylinder Mould	12	working
19	Capping Mould	1	working
20	4" Size Steel Mould	12	working
21	Slump Cone	2	working
22	Profometer	2	working
23	Accessories for Ultrasonic Pulse Velocity	1	working
24	Profometer	2	working
25	Measurement Ruler	1	working
26	Compressive Strength Testing for Cement	2	working
27	Cement Morter Vibrating Machine	1	working
28	Moter Mixer	1	working
29	Le Chatelier Water Bath	1	working
30	Vicat Apparatus	3	working
31	Blaine Air Permeability Test	3	working
32	Cement Morter Standard Mould	3	not working
33	Le Chatelier's Flask	3	working

34	Le Chatelier's Mould	3	working
35	Water Bath	1	not working
36	50 mm Cube Mould for Cement Morter Test	1	working
37	Cement Setting Time Apparatus	1	not working
38	Setting Time Test	1	not working
39	Soundness	1	not working
40	Timer	1	working
41	Vernier Caliper	1	working
42	Cement Tamper	1	working
43	Sand Absorption Cone and Temper	2	working
44	Sand Organic Impurities Test Set	1	working
45	Sieve for Fine Aggregate Test	2	working
46	Fine Aggregate Specfic Gravity	1	working
47	Water Absorption	1	working
48	Unit Weight Test	1	working
49	Sieve Analysis Test	1	working
50	Five Cycle Soundness Test	1	working
51	Material Finer than 0.075 mm	1	not working
52	Clay Lump	1	working
53	Organic Impurities test	1	not working
54	Los Angels Abrasion Machine	1	working
55	Aggregate Crushing Value Apparatus	1	not working
56	Specific Gravity Flame	1	working
57	Density Container	2	working
58	Aggregate Impact Value Apparatus	1	not working
59	Flakiness/Thickness Gauge	1	not working
60	Sieve Analysis for Coarse Aggregate	3	working
61	Unit Weight Test	1	not working
62	Coarse Aggregate Specific Gravity Test	1	working
63	Water Absorption	1	working
64	Sieve Analysis	1	not working
65	Material Finer than 0.075 mm	1	not working
66	Clay Lump	1	not working
67	Abrasion Test	1	working
68	Determination of Flakiness Index and ElongationTest	1	not working
69	Impact Value	1	not working
70	Hand Scoop	1	not working
71	Andreasen Pipette	1	working
72	Oven	1	working

73	Density Container	2	working
74	Test Sieves	1	working
75	Chapman Flask	1	not working
76	Test Sieves	1	working
77	Volumteric Flask	2	not working
78	Desicator	2	not working
79	Hand Scoop	3	not working
80	Hand Scoop	3	working
81	Bulk Denstiy and Voids Measures	4	working
82	Volumeter for Aggregates	1	not working
83	Specific Gravity Bottle	4	working
84	Steel Cylindrical Measuring Box	1	working
85	Stainless Steel Scoop	1	not working
86	Graduated Cylinder	2	not working
87	Measuring Cylinder	3	not working
88	Graduated Volumetric Cylinder	10	not working

4) Department of Highways (DOH)

Lab-1: Aspahalt Concrete & Bitumen Testing

No.	Name of Equipment	Quantity	Status/Remarks
1	Penetrometer (Digital)	1	Working
2	Penetrometer (Manual)	1	Working
3	Hot Plate (Ring and Ball)	1	Working
4	Ductility	1	Working
5	Thin Flim Oven	1	Not still Working
6	Flash Point	1	Working
7	Loss on Heating oven	1	Working
8	Saybolt Furol Viscometer	1	Working
9	Abrasion Machine	1	Working
10	Compaction pedestal	1	Working
11	Marshall Testing Machine(New)	1	Working
12	Marshall Testing Machine(Old)	1	Working
13	Marshall Testing Machine (Digital,Motorized)	1	Working
14	Centrifuge Extractor	1	Working
15	Roller Compactor	1	Working
16	Hamburg Wheel Tracker	1	Working
17	Oven	1	Working
18	Oven	1	Working
19	Oven	1	Working

20	Balance (20kg)	1	Working
21	Buoyancy Balance (22kg)	1	Working
22	Balance (2610g)	1	Working
23	Balance (20kg)(Old)	1	Working
24	Water Bath	4	Working

Lab-2: Concrete, Cement and Aggregates Testing

No.	Name of Equipment	Quantity	Status/Remarks
1	Soil Automatics Compaction Apparatus	1	working
2	California Bearing Ratio Testing Machine (screw jack type)	1	working
3	Impact Testing Machine	1	working
4	Los Angeles Abrasion Machine	1	working
5	Los Angeles Abrasion Machine	1	not working
6	Aggregate Crushing Machine	1	working
7	Concrete Compressive Machine (ELE)	1	working
8	Concrete Compressive Machine (Japan)	1	working
9	Concrete Compressive Machine (Italy)	2	working
10	Compressive/Mortar Strength Machine(Italy)	1	working
11	Flexural Strength Machine	1	working
12	Oven (Old)	1	not working
13	Oven (Medium)	1	not working
14	Oven (Hambolt) H-30145	1	working
15	Oven (Small) ELE	1	working
16	Oven (New)(Despath)(LBB2-27-2)	1	not working because of factory error
17	Buoyancy Balance (Digital)	1	working
18	Platform Balance	1	working

Lab-3: Soil Testing

R-2 Automatic Equipment Control

No.	Name of Equipment	Quantity	Status/Remarks
1	Direct Shear Machine	1	working
2	Oedometer(Consolidation)	1	working
3	Permeability Test Set	1	working
4	Pinhole Device	1	working
5	Automatic CBR Machine	1	working
6	Automatic UCS Machine	1	working
7	Crushing Machine	1	working

R-3 CBR-UCS Testing Room

No.	Name of Equipment	Quantity	Status/Remarks
1	Digital CBR Machine	2	working
2	Manual CBR Machine	1	working
3	Digital UCS Machine	1	working
4	Manual UCS Machine	2	working

R-4 Grain Size & Liquid Limit Room

No.	Name of Equipment	Quantity	Status/Remarks
1	Buoyancy Balance	1	working
2	Hydrometer Water Bath	1	working
3	Sedimentation Cylinder	10	working
4	Mechanical Stirrer	1	working
5	Liquid Limit Device	1	working
6	Plastic Limit Device	1	working
7	Crushing Machine	1	working

R-5 Triaxial Controlled Room

No.	Name of Equipment	Quantity	Status/Remarks
1	Triaxial Machine Test Set	1	working

Oven & Sample Dried Area

No.	Name of Equipment	Quantity	Status/Remarks
1	Drying Oven (Big)	1	working
2	Drying Oven (Small)	1	working
3	Sample Extruder	1	working
5	Crushing Machine	1	not run yet
6	Direct Shear Machine	1	not working

5) Department of Rural Road Development (DRRD)

No.	Name of Equipment	Quantity	Status/Remarks
1	Sieve No. 200 (0.0751run)	3	working
2	Sieve No. 170 (0.09mm)	1	working
3	Sieve No. 140 (0.106mm)	1	working
4	Sieve No. 100 (0.15mm)	3	working
5	Sieve No. 70 (0.212mm)	2	working
6	Sieve No. 60 (0.25nun)	1	working
7	Sieve No. 50 (0.30mm)	3	working
8	Sieve No. 40 (0.425mm)	2	working
9	Sieve No. 30 (0.60nun)	2	working
10	Sieve No. 16 (1.18n皿)	3	working
11	Sieve No. 12 (1.70mm)	2	working

12	Sieve No. 10 (2.00mm)	2	working
13	Sieve No. 8 (2.36mm)	2	working
14	Sieve No. 4 (4.75mm)	3	working
15	Sieve No. - (9.50nm1)	3	working
16	Sieve No. - (12.5mm)	2	working
17	Sieve No. - (19.0nm1)	3	working
18	Sieve No. - (25.0irun)	1	working
19	Sieve No. - (37.Snun)	1	working
20	Pan	1	working
21	Cover	1	working
22	Oven	3	working
23	CBR Mould	2	working
24	Compaction Mould	2	working
25	Compaction Rod	2	working
26	Soil Mixer	1	working
27	Atterberg Limit	1	working
28	Plastic cylinder(1000ml)	5	working
29	Plastic cylinder (500ml)	5	working
30	Plastic cylinder (250ml)	5	working
31	Plastic cylinder (50ml)	1	working
32	Glass cylinder(l 000ml)	1	working
33	Plastic Beaker (5000ml)	1	working
34	Plastic Beaker (1000ml)	1	working
35	Plastic Beaker (500ml)	5	working
36	Glass Beaker (400ml)	5	working
37	Glass Beaker (100ml)	4	working
38	Steel Pestle	1	working
39	Pestle	3	1 Damaged
40	Sample container	21	working
41	CBR Test Master Loader	1	working
42	Triaxial l Machine (1 cell)	1	working
43	Balance (max: 30kg)	1	working
44	Buoyancy Balance(max:2.2kg)	1	working
45	Abrasion Machine	1	working
46	Impact Mould	1	working
47	Crushing Mould	1	working
48	Flakiness	1	working
49	Elongation	1	working
50	Balance (max: 600g)	1	working

51	Density Mould (big)	1	working
52	Density Mould (small)	1	working
53	Density Rod	2	working
54	Specific gravity bottle (100ml)	7	working
55	Specific gravity bottle (250ml)	1	working
56	Specific gravity bottle (200ml)	1	working
57	Specific gravity bottle (25 ml)	1	working
58	Washing bottle	2	working
59	Setting Time Testing	1	working
60	Vicat	1	working
61	Cement Mould	2	working
62	Cube Mould	16	working
63	Compressive Machine	1	working
64	Concrete Mixer	1	working
65	Concrete Rod	2	working
66	Slump Cone	1	working
67	Hydrometer	1	working

Appendix 2

Similar Facilities Survey

Appendix 2-1

Similar Facilities Survey -1

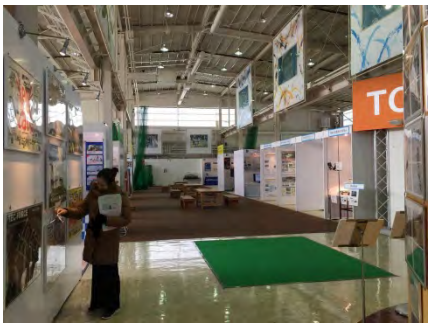
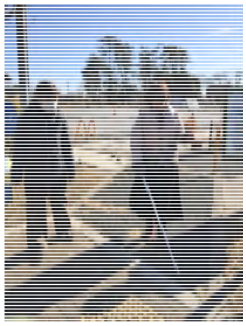
<table>
<tr><td>Name</td><td colspan="2">Construction Technology Pavilion (Ministry of Land, Infrastructure, Transport and Tourism, Kanto Regional Development Bureau, Kanto Technical Office)</td></tr>
<tr><td>Location</td><td colspan="2">6-12-1 Gokonishi, Matsudo City, Chiba Prefecture 270-2218 Japan</td></tr>
<tr><td>Facility Information</td><td colspan="2">• Established in 1999, for the purpose of promoting new technologies and enlightenment of construction business for society.
• This facility targeted at from construction engineers in government offices and private companies to citizens and students etc., and provides basic knowledge of construction technology to new technology. In addition to regular exhibitions, it is an experience-based facility that can be touched and learned.
• This facility consists of indoor exhibition hall, outdoor exhibition area, barrier-free experience area, specialized vehicle storage, Environmental pavement testing area, etc.
• The contents of the exhibition will be renewed once every two years.</td></tr>
<tr><td>Date</td><td colspan="2">January 11th, 2019　11:00 - 12:30</td></tr>
<tr><td rowspan="4">Photo</td><td>  </td><td>  </td></tr>
<tr><td>1) Exhibition Hall</td><td>2) Exhibition Hall (Reception)</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>3) Indoor exhibition hall</td><td>4) Indoor exhibition hall (Training Area)</td></tr>
</table>

Photo		
	5) Indoor exhibition hall (Multipurpose hall)	6) Indoor exhibition hall ("Touch and learn" area)
		
	7) Outdoor exhibition area (Sample of the bridge column)	7) Outdoor exhibition area (Sample of RCT beam section)
		
	9) Outdoor exhibition area (Construction process introduction area)	10) Barrier-free experience area (wheelchair)
		
	11) Barrier-free experience area (white cane for blindness)	12) Specialized vehicle storage

Appendix 2-2

Similar Facilities Survey -2

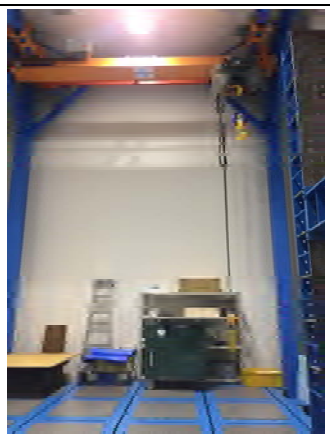
<table>
<tr><td>Name</td><td colspan="2">Japan Testing Center for Construction Materials, Central Test Laboratory</td></tr>
<tr><td>Location</td><td colspan="2">5-21-20 Inari, Soka City, Saitama Prefecture 340-0003 Japan</td></tr>
<tr><td>Facility Information</td><td colspan="2">• Established in 1967, third-party testing and evaluation agency mainly in the field of construction and civil engineering.
• Various tests and evaluations have been conducted to verify the required performance for materials, construction members, doors and windows, and equipment used in buildings and civil engineering structures.
• Tests are conducted in four groups: material test, structural test, fireproof test, environmental test.
• The center is composed of office administration building, material testing building, furniture and material testing building, alkali aggregate testing building, aggregate testing building, acoustic testing building, heat insulation and corrosion testing building, multipurpose testing building, structural and dynamic wind pressure testing building, fire protection structural testing building, and fire protection material test building. Some buildings are currently under consideration for rebuilding. Some buildings are currently under consideration for rebuild.</td></tr>
<tr><td>Date</td><td colspan="2">March 20th , 2019　13:30-16:30</td></tr>
<tr><td rowspan="4">Photo</td><td>  </td><td>  </td></tr>
<tr><td>1) Structural and Dynamic Wind Pressure Testing Building (Structural Testing Room)</td><td>2) Structural and Dynamic Wind Pressure Testing Building (Constant Temperature and Humidity Room)</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>3) Structural and Dynamic Wind Pressure Testing Building (Dynamic Wind Pressure Tests Room)</td><td>4) Structural and Dynamic Wind Pressure Testing Building (Large-size blast and watering test room)</td></tr>
</table>

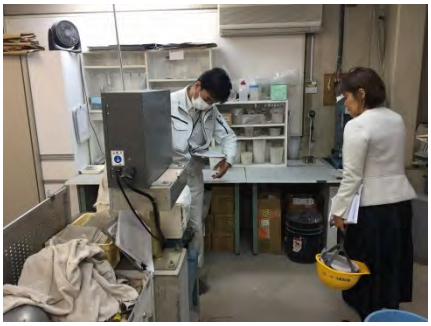
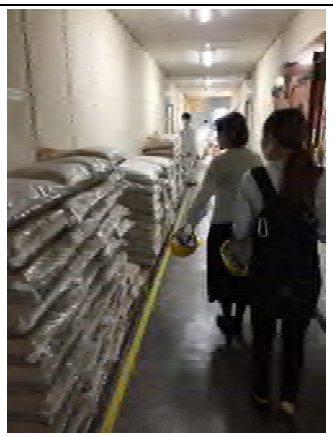
Photo		
	5) Aggregate Testing Building (Testing Laboratory	6) Aggregate Testing Building (Test Sample Storage Area)
		
	7) Gravel Storage Area	8) Alkali Aggregate Testing Room (Preparation area, Crushing etc.)
		
	9) Alkali Aggregate Testing (Testing Laboratory	10) Material Testing Building (Standard Testing Room, Temp. 20°C, Humidity 80%)
		
	11) Material Testing Building (Corridor, Storage of Test Materials)	12) Material Testing Building (Curing Room for Test Piece)

Photo		
	13) Material Testing Building (Universal Testing Machine (500kN)	14) Material Testing Building (Preparation Room)
		
	15) Material Testing Building (Microbiology Laboratory)	16) Material Testing Building (Abrasion Test Room)
		
	17) Fireproof Structure Test Building	18) Fireproof Structure Test Building

Similar Facilities Survey -3

<table>
<tr><td>Name</td><td colspan="2">Japan Road Contractors Association Laboratory</td></tr>
<tr><td>Location</td><td colspan="2">552 Higashi-asakawamachi, Hachioji City, Tokyo Prefecture 193-0834 Japan</td></tr>
<tr><td>Facility Information</td><td colspan="2">• Established as a subsidiary organization of the Japan Road Contractors Association in 1967, commissioning of management tests necessary for construction, investigation and research for the effective use of construction materials, and trainings are conducted.
• A number of quality control tests are conducted for soil related tests, concrete related tests, aggregate related tests, asphalt related tests, field tests, etc., but no evaluation has been made on new materials.
• This facility is designated as a designated testing organization for the asphalt mix pre-examination system in Kanto.
• Reception (general affairs) and various testing laboratories are on the first floor of the main Building, and office, conference room, library, and chemical testing room etc. are on the second floor. Cutter room and crusher room which should make consideration the sound from equipment, sample storage area and drying area which are required for large spaces, and pressure resistance test room are located on the separated single story building from the main building.</td></tr>
<tr><td>Date</td><td colspan="2">March 27th, 2019 10:00-11:30</td></tr>
<tr><td rowspan="4">Photo</td><td>  </td><td>  </td></tr>
<tr><td>1) Separate Building (Pressure Resistance Test Room)</td><td>2) Separate Building (Sample Storage Area and Drying Area)</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>3) Separate Building (Front: Crusher Room, Back: Abrasion Test)</td><td>4) Separate Building (Cutter Room)</td></tr>
</table>

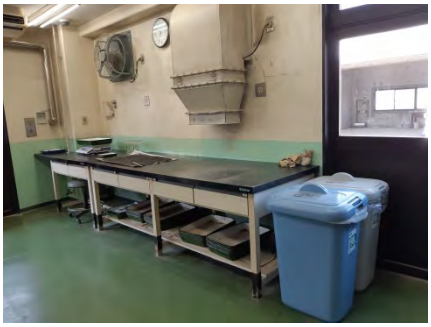
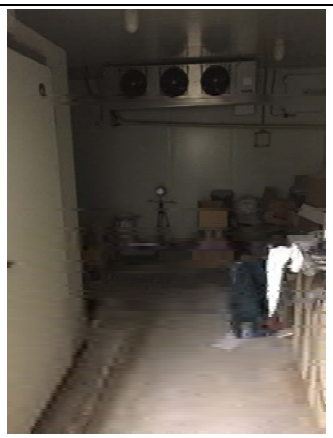
Photo		
	5) Main Building (Concrete Testing Room)	6) Main Building (Aggregate Testing Room)
		
	7) Main Building (Low Temperature Room)	8) Main Building (Constant Humidity Room)
		
	9) Main Building (Soil Testing Room)	10) Main Building (Soil Testing Room, Temperature Regulated Curing Tank)
		
	11) Main Building (Asphalt Mix Testing Room)	12) Main Building (Asphalt Physics Laboratory)

写真		
	13) Main Building (Asphalt Testing Preparation Room)	14) Main Building (Asphalt Extraction Test)
		
	15) Main Building(Wheel Tracking Testing Room)	16) Main Building (Chemical Testing Room)
		
	17) Main Building (Library)	18) Outside (Waste Materials Storage)

Appendix 3

List of Equipment Selection Results

List of Equipment Selection Results

1) Thuwunna Central Training Center (Thuwunna CTC)
2) Department of Bridges (DOB)
3) Department of Building (DOBi)
4) Department of Highways (DOH)
5) Department of Rural Road Development (DRRD)
6) Furniture

Conditions

1. To prioritize essential items to training or to performing ASTM tests
2. Should meet the technical level of engineers/technicians of the target facility
3. Should be possible to secure maintenance services provided by local agents
4. To prioritize items of precision and of high accuracy or items of which quantity is too many to procure by annual development plan
5. Should be items to increase numbers as a supplement to meet the future demands of use

Legend

Conditions: ✓ : meet the condition
× : not meet the condition
Judgement: ✓ : covered by the plan to procure
× : not covered by this plan

1) Thuwunna Central Training Center (Thuwunna CTC)

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Cutting machine for brick	10	✓	✓	✓	✓	✓	✓
2	Cutting machine for tile	10	✓	✓	✓	×	✓	×
3	Bending machine for rebar	8	✓	✓	✓	✓	✓	✓
4	Cutting machine for rebar	8	✓	✓	✓	✓	✓	✓
5	Tying machine for rebar	8	✓	✓	✓	✓	✓	✓
6	Moisture meter for painter	10	✓	✓	✓	✓	✓	✓
7	Total station	10	✓	✓	✓	✓	✓	✓
8	Theodolite	10	✓	✓	✓	✓	✓	✓
9	Level	10	✓	✓	✓	✓	✓	✓
10	Concrete mixer	5	✓	✓	✓	✓	✓	✓
11	Vibrator	5	✓	✓	✓	×	✓	×
12	Los Angles abrasion machine	1	✓	✓	✓	✓	✓	✓
13	Concrete compression machine	1	✓	✓	✓	✓	✓	✓
14	Desktop computer	10	✓	✓	✓	✓	✓	✓
15	Laptop computer	10	✓	✓	✓	✓	✓	✓
16	Printer colour	10	✓	✓	✓	✓	✓	✓
17	Copier medium	10	✓	✓	✓	✓	✓	✓
18	Projector	10	✓	✓	✓	✓	✓	✓
19	Plate Compactor	10	✓	✓	✓	✓	✓	✓
20	Recessed screens	10	✓	✓	✓	✓	✓	✓

2) Department of Bridges (DOB)

(1) Soil Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Thin wall shelby Tube (Sampler complete)	20	✓	✓	✓	×	✓	×
2	Diamond Core Bit	10	✓	✓	✓	×	✓	×
3	Double Tube Core Barrel Complete Assembly	5	✓	✓	✓	✓	✓	✓
4	Diamond Casing Shose	10	✓	✓	✓	×	✓	×
5	Core lifter (spare part)	10	✓	✓	✓	×	✓	×
6	Core litter Case (Spare part)	10	✓	✓	✓	×	✓	×
7	Diamond Reamming Shell	5	✓	✓	✓	×	✓	×
8	Bit Tube (Double core barrel Assembly)	10	✓	✓	✓	×	✓	×
9	Inner extension (Double core barrel Assembly)	10	✓	✓	✓	×	✓	×
10	Outer extension(Double core barrel Assembly)	10	✓	✓	✓	×	✓	×
11	Soil Drilling Machine With accessories complete set	1	✓	✓	✓	×	×	×
12	Consolidation Test Apparatus	2	✓	✓	✓	✓	✓	✓
13	Dial Guage for consolidation test	3	✓	✓	✓	×	✓	×
14	Oven	1	✓	✓	✓	✓	✓	✓

(2) Concrete Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Flow Table Test (Flow of hydraulic cement Mortars and cement pastes) Apparatus	1	✓	✓	✓	✓	✓	✓
2	Turbidimeter Test Apparatus with accessories	1	✓	✓	✓	✓	✓	✓
3	Blaine Air Permeability Test Apparatus with accessories	1	✓	✓	✓	×	✓	×
4	Soundness Test (Autoclave) Apparatus with accessories	1	✓	✓	✓	✓	✓	✓
5	Compressive Strength Test	1	✓	✓	✓	✓	✓	✓
6	Setting Time Test (Gillmore) Apparatus	1	✓	✓	✓	×	✓	×
7	Setting Time Test (Vicat) Apparatus	1	✓	✓	✓	×	✓	×
8	Balance	1	✓	✓	✓	×	✓	×
9	Unit Weight Measure	1	✓	✓	✓	×	✓	×
10	Sieve Brush	1	✓	✓	✓	×	✓	×
11	Aggregate Washer	1	✓	✓	✓	×	✓	×
12	Brass Frame Sieve-stainless	1	✓	✓	✓	×	✓	×
13	Brass Pan	1	✓	✓	✓	×	✓	×
14	Sample Drying Pan	1	✓	✓	✓	×	✓	×
15	Brass Frame Sieve-200ss mesh	1	✓	✓	✓	×	✓	×

3) Department of Building (DOBi)

(1) Concrete Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Vicat Appalatus	2	✓	✓	✓	×	✓	×
2	Initial Needle	10	✓	✓	✓	×	✓	×
3	Automatic Vicat Apparatus	1	✓	✓	✓	×	✓	×
4	Specimen Moulds	6	✓	✓	✓	×	✓	×
5	Tamper	3	✓	✓	✓	×	✓	×
6	Mortar Mixer	3	✓	✓	✓	✓	✓	✓
7-1	Glass Graduates	3	✓	✓	✓	×	✓	×
7-2	Glass Graduates	2	✓	✓	✓	×	✓	×
8	Blaine Air Permeability Apparatus (Conform to C204)	1	✓	✓	✓	×	✓	×
9	Automatic Blaine Fineness Apparatus	1	✓	✓	✓	✓	✓	✓
10	Timer	4	✓	✓	✓	×	✓	×
11	Digital Vernier Clipper	3	✓	✓	✓	×	✓	×
12	Electronic Analytical balance	3	✓	✓	✓	✓	✓	✓
13	Autoclave Expansion	3	✓	✓	✓	×	✓	×
14	Flat Trowel	5	✓	✓	✓	×	✓	×
15	Curing Bench	1	✓	✓	✓	✓	✓	✓
16	Le Chatelier mould	10	✓	✓	✓	×	✓	×
17	Flow Tables Machine	2	✓	✓	✓	✓	✓	✓
18	Length comparator	3	✓	✓	✓	×	✓	×
19	Temperature Recorder	5	✓	✓	✓	×	✓	×
20	Organic Impurities Test Set	2	✓	✓	✓	×	✓	×
21	Warm air drier	1	✓	✓	✓	×	✓	×
22	Sieves (8" diameter)	1	✓	✓	✓	×	✓	×
23	12" diameter 25mm (1in) square opening sieve	2	✓	✓	✓	×	✓	×
24	12" diameter 25mm (½in) square opening sieve	2	✓	✓	✓	×	✓	×
25	Weithting Device (Balance) Capacity:200 kg	1	✓	✓	✓	×	✓	×
26	Weithing Device (Balance) Capacity:30 kg	1	✓	✓	✓	×	✓	×
27	Concrete curing specimens tank	2	✓	✓	✓	✓	✓	✓
28	S.I.T (Sonic Integrity Test)	1	✓	✓	✓	✓	✓	✓
29	Cap Retainer 4"x8"	2	✓	✓	✓	×	✓	×
30	Neoprene pad 6" x 12"	4	✓	✓	✓	×	✓	×
31	Neoprene pad 6" x 12"	4	✓	✓	✓	×	✓	×
32	Standard concrete cube moulds	18	✓	✓	✓	×	✓	×
33	Neoprene pad 4"x8"	2	✓	✓	✓	×	✓	×
34	Neoprene pad 4"x8"	2	✓	✓	✓	×	✓	×
35	Cap retainer 6"x12"	2	✓	✓	✓	×	✓	×
36	Anvil (Proceq)	1	✓	✓	✓	×	✓	×
37	Rebound Proceq Spare parts (Springs and Plunger)	2	✓	✓	✓	×	✓	×

38	Concrete Mixer (Drum Type) Mixer	1	✓	✓	✓	×	✓	×
39	Concrete Flow Table	1	✓	✓	✓	×	✓	×
40	Hand Drilling Machine	2	✓	✓	✓	×	✓	×
41	Concrete Test Hammer	2	✓	✓	✓	×	✓	×
42	Digital Concrete Test Hammer	1	✓	✓	✓	×	✓	×
43	Ultrasonic Pulse Velocity Tester	1	✓	✓	✓	✓	✓	✓
44	Pluse Echo Foundation Teater	1	✓	✓	✓	✓	✓	✓
45	Flat Jacks	1	✓	✓	✓	✓	✓	✓
46	Vicat Mould	2	✓	✓	✓	×	✓	×
47	Plane non- obsorptive plate	2	✓	✓	✓	×	✓	×
48	Test Sieves	2	✓	✓	✓	×	✓	×
49	Graduated Impurities Test Bottle-1	2	✓	✓	✓	×	✓	×
50	Graduated Impurities Test Bottle-2	3	✓	✓	✓	×	✓	×
54	Laboratory Ovens	1	✓	✓	✓	✓	✓	✓
55	Electromagnetic Sieves Shaker	1	✓	✓	✓	✓	✓	✓
57	Rotary Automatic scales	3	✓	✓	✓	✓	✓	✓
58	Semi-automatic zero-centring balance	1	✓	✓	✓	×	✓	×
59	Standard Calibration Weight	1	✓	✓	✓	×	✓	×
60	Thermohygrograph (Humidity Recorder)	1	✓	✓	✓	×	✓	×
61	Perfect Timing Device	3	✓	✓	✓	×	✓	×
62	Neoplane Gloves	20	✓	✓	✓	×	✓	×
63	Heat Resistence Gloves	20	✓	✓	✓	×	✓	×
64	Digital Vernier Caliper	5	✓	✓	✓	×	✓	×
65	Laboratory trolley	3	✓	✓	✓	×	✓	×
66	Shovel with handle	5	✓	✓	✓	×	✓	×
67-1	Pans Aluminium-1	4	✓	✓	✓	×	✓	×
67-2	Pans Aluminium-2	4	✓	✓	✓	×	✓	×
67-3	Pans Aluminium-3	4	✓	✓	✓	×	✓	×
68	Water Stills	2	✓	✓	✓	✓	✓	✓
69	Waterproof Stem Thermometer	3	✓	✓	✓	×	✓	×
70	Three gang cube mould	5	✓	✓	✓	×	✓	×
71	Pulse Echo Foundation Tester	1	✓	✓	✓	✓	✓	✓
72	Cross Hole Ultrasonic Monitor	1	✓	✓	✓	✓	✓	✓
73	Crack width gauge for corners	1	✓	✓	✓	×	✓	×
74	Compression Machine 3000 KN	2	✓	✓	✓	✓	✓	✓
75	Lechetelier Moulds	20	✓	✓	✓	×	✓	×
76	Setra Balance (30kg)	1	✓	✓	✓	×	✓	×

(2) Soil Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
51	Direct Shear Test Apparatus C/W All Accessories	1	✓	✓	✓	✓	✓	✓
52	Horizontal Sample Ejector	1	✓	✓	✓	✓	✓	✓
53	Moist Cabinet	1	✓	✓	✓	✓	✓	✓
54	Glass Tank	1	✓	✓	✓	×	✓	×
55	Heater	1	✓	✓	✓	×	✓	×
56	Thermometer Subdiv 0.5ºC	2	✓	✓	✓	×	✓	×
57	Soil Hydrometer	2	✓	✓	✓	×	✓	×
58	Destersion Mixer	1	✓	✓	✓	×	✓	×

(3) Rebar Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Universal Tensile Testing Machine (1000 kN)	1	✓	✓	✓	✓	✓	✓
2	Cold Bend Testing Machine	1	✓	✓	✓	✓	✓	✓
3	Floorstanding Optical Emission Spectromerters	1	✓	✓	✓	✓	✓	✓
4	Electronic Precision Top Loading & Platform Balance (30kg)	1	✓	✓	✓	×	✓	×
5	Vernier Clipper	1	✓	✓	✓	×	✓	×

(4) Office Equipment

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Copier	5	✓	✓	✓	✓	✓	✓
2	Computer (Laptop)	11	✓	✓	✓	✓	✓	✓
3	Printer (A3)	5	✓	✓	✓	✓	✓	✓
4	Computer (desktop)w/ desk	3	✓	✓	✓	✓	✓	✓

4) Department of Highways (DOH)

(1) Lab-1: Bitumen Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Gyratory Compactor	1	✓	✓	✓	✓	✓	✓
2	Laboratory Saw	1	✓	✓	✓	✓	✓	✓
3	Pycmeter(S.G for Fine Aggregate)	1	✓	✓	✓	×	✓	×
4	Pycmeter(S.G for Bitumen)	1	✓	✓	✓	×	✓	×
5	Large Vacuum Pykmeter	1	✓	✓	✓	×	✓	×
6	Universal Core Drill for AC	1	✓	✓	✓	✓	✓	✓
7	Standard Rotational Viscometer	1	✓	✓	✓	✓	✓	✓
8	Oven (0-120^{o} C)	1	✓	✓	✓	✓	✓	✓
9	Automatic Asphalt Extraction Appratus	1	✓	✓	✓	✓	✓	✓
11	Safety Cabinet	3	✓	✓	✓	✓	✓	✓
12	Electromagnetic Sieves shaker	1	✓	✓	✓	✓	✓	✓

(2) Lab-2: Fine and Coarse Aggregate Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Los Angels Machine	1	✓	✓	✓	✓	✓	✓
2	Set of 12 Abrasive Charges	1	✓	✓	✓	×	✓	×
3	Aggregate Crushing Value Apparatus-1	1	✓	✓	✓	×	✓	×
4	Aggregate Crushing Value Apparatus-2	1	✓	✓	✓	×	✓	×
5	Specific Gravity frame	1	✓	✓	✓	×	✓	×
6	Density Basket	1	✓	✓	✓	×	✓	×
7	Electronic Balance	1	✓	✓	✓	×	✓	×
8	Flakiness Sieves	2	✓	✓	✓	×	✓	×
9	Sand Absoration Cone & Tamper	1	✓	✓	✓	×	✓	×
10	Pilot Compact-line	1	✓	✓	✓	✓	✓	✓
11-13	Distance Piece	1	✓	✓	✓	×	✓	×
14	Bulk Density Measure	1	✓	✓	✓	×	✓	×
15-22	203 mm dia ASTM Sieves Set	8	✓	✓	✓	×	✓	×
23	Electromagnetic Sieve Shaker	1	✓	✓	✓	✓	✓	✓

(3) Lab-2: Cement Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Vicat Test Set ASTM Method	1	✓	✓	✓	×	✓	×
2	Stainless Steel Final Needle with Special Foot	1	✓	✓	✓	×	✓	×
3	High Pressure Cement Autoclave	1	✓	✓	✓	✓	✓	✓
4	Two Gang Prism Mould	1	✓	✓	✓	×	✓	×
5	Spare Contact Points	1	✓	✓	✓	×	✓	×
6	Length Comparator-1	1	✓	✓	✓	×	✓	×
7	Length Comparator-2	1	✓	✓	✓	×	✓	×
8	Three Gang Cube Mould	18	✓	✓	✓	×	✓	×
9	Wooden Tamping Lod	2	✓	✓	✓	×	✓	×
10	Automatic Digital mortar Mixer	1	✓	✓	✓	✓	✓	✓
11	Second Steel Filling Hopper	1	✓	✓	✓	×	✓	×
12	Tube Sampler fro Packaged Cement	1	✓	✓	✓	×	✓	×
13	Sampler for Bulk Cement	1	✓	✓	✓	×	✓	×
14	Digital Balance	1	✓	✓	✓	×	✓	×
15	Vibrating Machine	1	✓	✓	✓	×	✓	×
16	Mould	1	✓	✓	✓	×	✓	×
17	Temperature and Humidity Controlled Cabinet	1	✓	✓	✓	✓	✓	✓
18	Accessories for the above	1	✓	✓	✓	✓	✓	✓
19	Motor Operated Flow Table	1	✓	✓	✓	×	✓	×
20	Flow Clipper	1	✓	✓	✓	×	✓	×
21	Le Chatelier Flask	1	✓	✓	✓	×	✓	×

(4) Lab-2: Concrete Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Cylinder Mould	9	✓	✓	✓	×	✓	×
2	Pan-type Mixer	1	✓	✓	✓	✓	✓	✓
3	Accessories for Pan-type Mixer	1	✓	✓	✓	✓	✓	✓
4	Slump Cone Set	1	✓	✓	✓	×	✓	×
5	Capping Retainer	2	✓	✓	✓	×	✓	×
6	Neprene Pads	2	✓	✓	✓	×	✓	×

(5) Lab-3: Soil Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Resistance R-value and Expansion Pressure of Comapcted Soils	1	✓	✓	✓	×	✓	×
2	Specific Gravity Test	1	✓	✓	✓	×	✓	×
3	Wetting and Drying Test of Compacted Soil-Cement Mixture	1	✓	✓	✓	×	✓	×
4	Lime Content of Uncured Soil-Lime Mixtures1	1	✓	✓	✓	×	✓	×
5	Standard Consistency of Lime Putty	1	✓	✓	✓	×	✓	×
6	Plasticity of Lime Putty	1	✓	✓	✓	×	✓	×
7	Autoclave Expansion of Hydrated Lime	1	✓	✓	✓	×	✓	×
8	Slaking Rate of Quicklime	1	✓	✓	✓	×	✓	×
9	Apparent Loose Density of Hydrated Lime, Pulverized Quicklime, and Limestone	1	✓	✓	✓	×	✓	×
10	Fineness of Pulverized Quicklime and Hydrated Lime by Air Permeability	1	✓	✓	✓	×	✓	×
11	Specific Gravity of Hydrated Lime Products	1	✓	✓	✓	×	✓	×
12	Moisture-Density Relation of Soil-Cement	1	✓	✓	✓	×	✓	×
13	Sand Equivalent Method	1	✓	✓	✓	×	✓	×
14	Aggregate Durability Index Test	1	✓	✓	✓	×	✓	×
15	Cement Content of Hardened Soil-Cement Mixture	1	✓	✓	✓	×	✓	×
16	Density of Cement	1	✓	✓	✓	×	✓	×
17	Sp.gr of fine Aggregate	1	✓	✓	✓	×	✓	×
18	Los-Angels Abrasion Test	1	✓	✓	✓	✓	✓	✓
19	Triaxial Compression Test	1	✓	✓	✓	✓	✓	✓

5) Department of Rural Road Development (DRRD)

(1) Soil Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Laboratory Bench Oven	2	✓	✓	✓	×	✓	×
2	Portable Precision Balance (1000g)	2	✓	✓	✓	×	✓	×
3	Portable Precision Balance (600g)	2	✓	✓	✓	×	✓	×
4	CBR Apparatus	3	✓	✓	✓	✓	✓	✓
5	Sieve (200mm)	44	✓	✓	✓	×	✓	×
6	Mixing Bowl	3	✓	✓	✓	×	✓	×
7	Manual Liquid Limit Device	1	✓	✓	✓	×	✓	×
8	Soil Dispersion Mixer	2	✓	✓	✓	×	✓	×
9	Liquid Linut Machine with Counter	3	✓	✓	✓	×	✓	×
10	Plastic Limit Set	5	✓	✓	✓	×	✓	×
11	Shrinkage Limit Set	4	✓	✓	✓	×	✓	×
12	Unconfined Soil Tester	2	✓	✓	✓	×	✓	×
13	Direct Shear Test Equipment	1	✓	✓	✓	✓	✓	✓
14	ASTM Test Sieves	2	✓	✓	✓	×	×	×
15	Moisture Tester	2	✓	✓	✓	✓	✓	✓
16	Consolidation Test Equipment	1	✓	✓	✓	✓	✓	✓
17	Oven 100 Liter	1	✓	✓	✓	✓	✓	✓

(2) Aggregate Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
34	Triple Beam Balance	3	✓	✓	✓	×	✓	×
35	Compressive Testing Machine	3	✓	✓	✓	✓	✓	✓
36	Wet Washing Sieve	2	✓	✓	✓	×	✓	×
37	Buoyance Balance	3	✓	✓	✓	×	✓	×
38	Digital Balance	3	✓	✓	✓	×	✓	×
39	Aggregate Crushing Value	1	✓	✓	✓	×	✓	×
40	Aggregate Impact Tester	2	✓	✓	✓	×	✓	×
41	Heavy-Duty Solution Balance	2	✓	✓	✓	×	✓	×
42	Los Angels Abrasion testing machine	1	✓	✓	✓	✓	✓	✓
43	Specific Gravity Bench Set Shipping	1	✓	✓	✓	×	✓	×

(3) Field Survey/Testing

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
1	Cone Penetrometer	4	✓	✓	✓	×	✓	×
2	Digital Balance	1	✓	✓	✓	×	✓	×
3	Falling Weight Deflectometer Sys:	2	✓	✓	✓	×	✓	×
4	Concrete Test Hammer	4	✓	✓	✓	×	✓	×
5	Electrical Density Gauge Power	2	✓	✓	✓	×	✓	×
6	Plate Bearing/ Plate Load Test Apparatus	1	✓	✓	✓	×	✓	×
7	Long Tape	3	✓	✓	✓	×	✓	×
8	Total Station	2	✓	✓	✓	✓	✓	✓
9	Level (Geomax)	1	✓	✓	✓	✓	✓	✓
10	Plate Bearing/Plate Load Test	1	✓	✓	✓	×	✓	×
11	SIT(Sonic Integrity Testing) Leng:2m-l 9m,	1	✓	✓	✓	✓	✓	✓
12	Theodolite	1	✓	✓	✓	✓	✓	✓
13	Press-Ur-Meter with plastic case	1	✓	✓	✓	×	✓	×
14	Penetration Equipment	1	✓	✓	✓	×	✓	×
15	Hand Auger (5/9"thread)	2	✓	✓	✓	×	✓	×

6) Furniture

No.	Description	Q'ty	Conditions					Judgement
			1	2	3	4	5	
5	Lab Table-1	27	✓	✓	✓	✓	✓	✓
6	Lab Table-2	19	✓	✓	✓	✓	✓	✓
7	Lab Table-3	38	✓	✓	✓	✓	✓	✓
8	Lab Table-4	32	✓	✓	✓	✓	✓	✓
9	Lab Table-5	21	✓	✓	✓	✓	✓	✓
10	Lab Sink-1	42	✓	✓	✓	✓	✓	✓
11	Lab Sink-2	21	✓	✓	✓	✓	✓	✓

Appendix 4

Report on Topographical Survey

The Topographical and River Survey Works

for

Preparatory Survey for the East-West Economic Corridor Improvement Project (Phase 2)

(THUWUNNA CENTERAL TRAINING CENTER)

Final Report

Asia Air Survey Myanmar Co., Ltd.

January, 2019

MYANMAR

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1. Survey Background

The topographic survey works for the Thuwunna Central Training Center (hereinafter referred to as “the Work”) is a part of the Preparatory Survey for the East-West Economic Corridor Improvement Project (Phase 2). The purpose of the Work is to carry out topographical survey works in order to collect terrain information for preliminary study of Thuwunna Central Training Center and rough cost estimation for the Project. The project area is in and around the candidate sites of Thuwunna Central Training Center.

2. Scope of Work

Table-1 shows the Scope of the Work for Topographic survey and mapping.

Table-1 Scope of the Work for Topographic Survey and Mapping

	▪ **Topographic Survey and Mapping**		
1	Benchmark Installation	1 point	Details of all benchmarks shall be reported. -Coordinates -Elevation -Measured date -And other description
2	Installation of GPS Base Station for UAV	5 points	Necessary number of GPS Base Station for UAV, in order to adjust/confirm Orthophoto production work after the data acquisition by UAV.
3	Aerial Photo Acquisition by UAV	0.37 km^2	Aerial Photograph acquisition was conducted to take aerial photographs to create 1:500 Digital Terrain Models (DTMs) and Orthophoto based on the following specifications. Area: 0.37km^2, Overlap: 80±5%, Side-lap: 40 ±5%
4	Digital Terrain Model (DTM)	1 set	DTM based on the following specifications. - A vertical accuracy should be STD 1.5m - Post (resolution) of 10m -TM will be generated from stereo matching points and topographic break lines.
5	Orthophoto	1 set	-Seamless color mosaic map -Geo TIFF with world file format -Horizontal accuracy of at least 60cm -GSD is within 1.5m
6	Detail Digital Mapping	1 set	Digital topographic map drawing (1:500 scale) by UAV. All natural and artificial terrain features shall be interpreted and plotted.

3. Work Area (Project Location)

The work area of this project is about 0.37 km^2 (a range marked in red) shown in Figure-1.

Source: Google Earth

Figure-1 Project Location

4. Work Schedule

The work schedule for Topographic Survey and Mapping is shown in Figure-2.

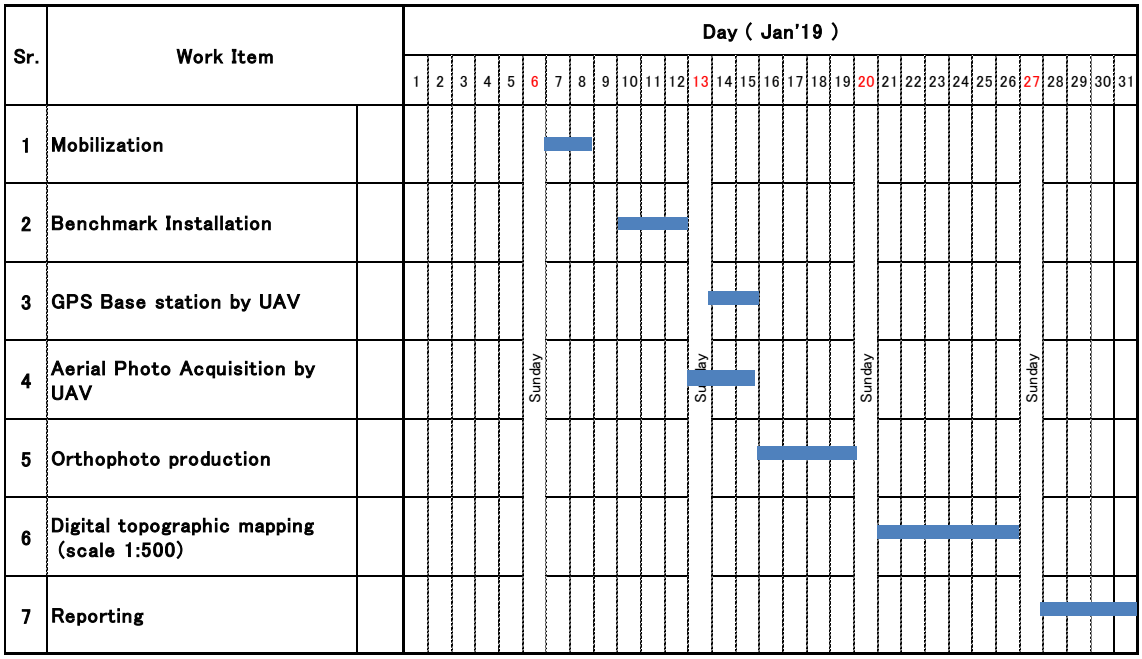

Figure-2 Work Schedule for Topographic Survey and Mapping

5. Topographical Survey acquired data by UAV

5.1 Installation of GPS Base Station for UAV

(1) Coordinate Reference System

In this project, the reference coordinate system used for national surveys in the current Union of Myanmar (Table-2) was applied to all the survey results.

Table-2 Coordinate Reference System Used in This Project

Ellipsoid	: WGS84 (World Geodetic System 1984)
Projection	: Universal Transverse Mercator (UTM) Projection
Zone	: Zone number N47
Central Meridian origin	: 99 degrees east of Meridian international
Latitude origin	: Equator
Scale factor at origin	: 0.9996
False Easting	: (0,500,000) at equator
Vertical Datum	: BM height adopted by Myanmar Survey Department
Unit of measurement	: Meter
EPSG	: 3247 (WGS84 UTM coordinates.47)

(2) Installation of Target for triangulation

Targets for aerial triangulation were installed at the locations shown in the Figure-3 before taking aerial photography with UAV. Coordinate of these 5 targets was observed by GPS.

Source: Google Earth

Figure-3 Target Plan

(3) GPS Survey

Table-3 shows the Coordinates of the Control Points Obtained in GPS Survey. The detail of GCP report shown in the Appendix A

Table-3 Coordinates of the Control Points Obtained in GPS Survey

Pt Ref.	Longitude(E)	Latitude(N)	Easting (m)	Northing (m)	MSL (m)
GCP-01	96° 12′ 37.68″	16° 49′ 8.47″	202690.945	1861629.593	3.751
TWN-01	96° 12′ 30.08″	16° 49′ 13.97″	202468.201	1861801.964	3.433
TWN-02	96° 12′ 40.03″	16° 49′ 17.26″	202764.645	1861898.939	3.918
TWN-03	96° 12′ 41.36″	16° 49′ 1.27″	202796.949	1861406.683	3.469
TWN-04	96° 12′ 45.37″	16° 49′ 7.97″	202918.536	1861610.935	3.509

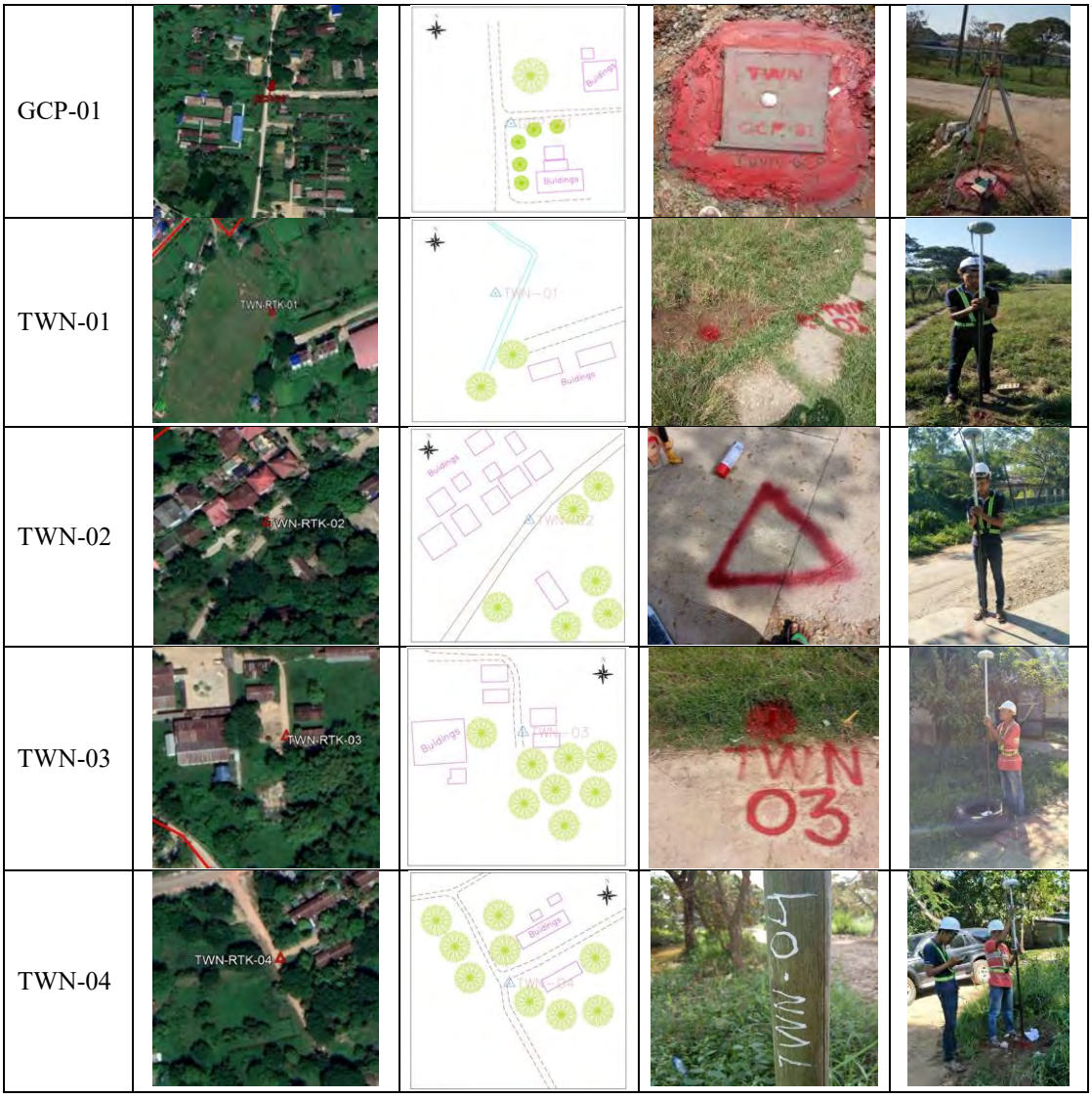

Figure-4 GPS station point

5.2 Aerial Photo Acquisition by UAV

(1) Specification of UAV

The aerial photo acquisition by UAV was carried out according to the flight plan created based on the following specifications.

- Total area: about 0.37km^2
- Flight Height: 50m
- Overlap: 80%±5%
- Side-lap: 40%±5%
- UAV & Camera: DJI Phantom4 & Pro (Model – FC-6310) (Figure-5)
- Number of flight line: See Figure-6

Figure-5 UAV used in this project (Phantom4 Pro)

(2) Flight Plan

The area to be covered with aerial photo is approximately 0.37km^2. Figure-6 shows flight plan of UAV. There are 23 strips.

Source: Google Earth

Figure-6 Flight Plan of UAV

The shooting information of aerial photos taken by UAV is shown in the table-4. Figure-7 shows the sample of photos taken by UAV

Table-4 Shooting information of aerial photos taken by UAV

Date	January 13, 2019
Strip and Number of Photos	Strip-1 to Strip-23 1,373 Photos (1,356 adjusted photos and 17 eliminated photos)
Ground sampling Distance	GSD is 0.0189 m
Evaluation	Overlap: OK, Cloudy: OK, Shadow: OK, Smoke: OK

Figure-7 Sample of photos taken by UAV
(No.553-564 of Strip-10)

6. Aerial Triangulation

The aerial triangulation was conducted to calculate the exterior orientation of photo center (hereinafter EO parameter) which is X, Y, Z, Omega, Phi, Kappa. Advanced photogrammetric software package, which can provide the means for automatic tie and pass point, which will enhance the accuracy and robustness of the bundle adjustment is used. Table-5 shows the ground control point residuals.

Table-5 Ground control point residuals (given – adjusted)

ID	Fold	X [m]	Y [m]	Z [m]	Total [m]	Remark
GCP-01	10	0.0462	0.0730	0.0004	0.0863	
TWN-01	11	-0.0222	-0.0025	-0.0011	0.0224	
TWN-02	16	-0.0054	-0.0252	0.0016	0.0259	
TWN-03	13	0.0110	-0.0363	0.0011	0.0379	
TWN-04	15	-0.0296	-0.0090	-0.0020	0.0309	
Maximum		0.0462	0.0730	-0.0020		
Mean		-0.0000	-0.0000	0.0000		
Sigma		0.0302	0.0429	0.0015		
RMSE(x,y,z)		0.0270	0.0384	0.0013		
RMSEr		0.0469	SQRT(RMSEx * RMSEx + RMSEy * RMSEy)			
ACCr (at 95% Confidence Level)		0.0812	RMSEr * 1.7308			
ACCz (at 95% Confidence Level)		0.0026	RMSEz * 1.9600			

7. Digital Topographic Mapping

7.1 Digital Terrain Model

Figure-7 shows digital terrain model. DTM was constructed by the following procedure.

- Create DSM with auto matching method,
- Correct DSM to DTM by using topographic break lines.
- Generate grid data model as shown Feagure-8

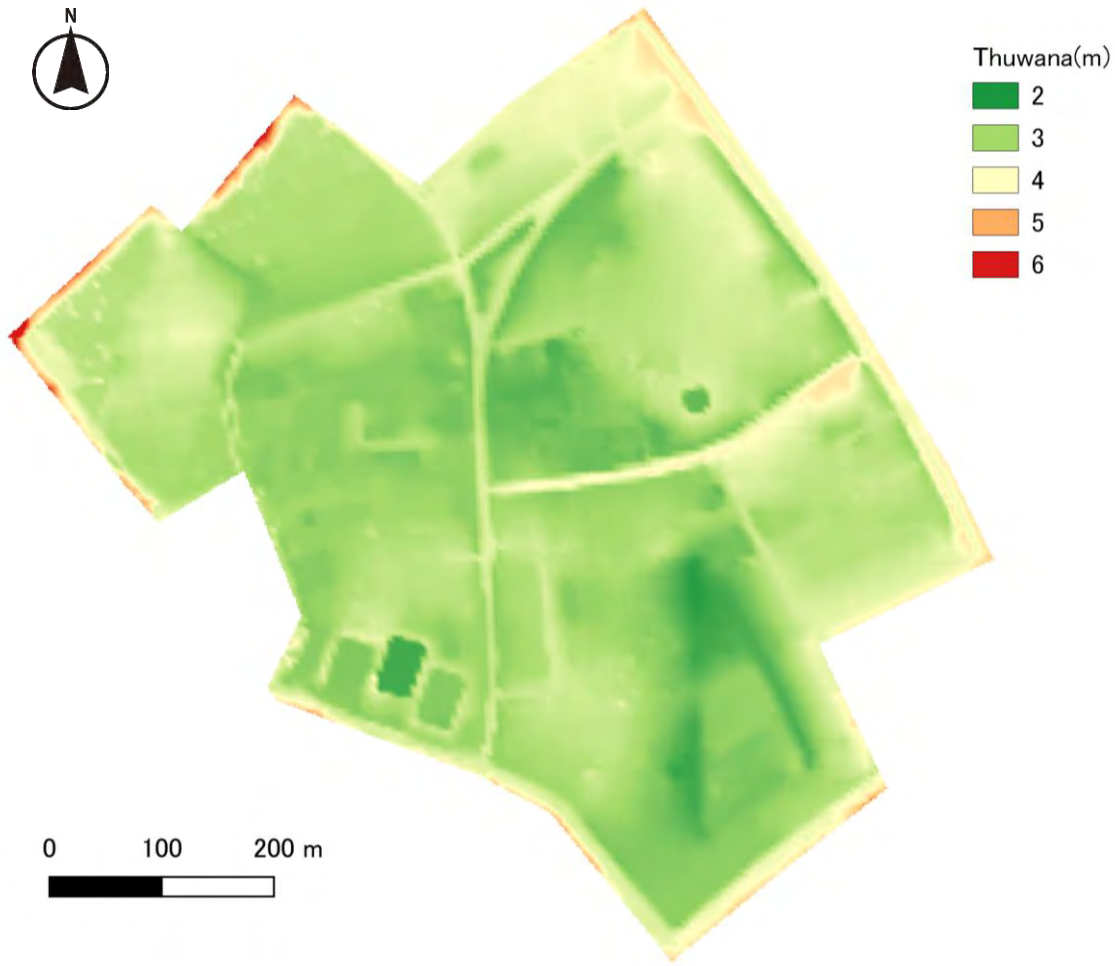

Figure-8 Digital Terrain Model

7.2 Orthophoto

Each aerial photograph converted to Orthophoto using DTM. And generate ortho mosaic imagery with mosaic datasets as shown Figure-9.

Evaluation of aerial photographs taken by UAV was conducted by using mosaicked aerial photograph. Evaluation Items are as follows.

- Overlap: must be overlapped with two or more pictures
- Cloudy: cloud does not exist in the mosaic picture.
- Shadow: shadow does not exist in the mosaic picture.
- Smoke: smoke does not exist in the mosaic picture.

Effective of the Clouds, Shadow and Smoke could not be seen over the principle point of any Photograph.

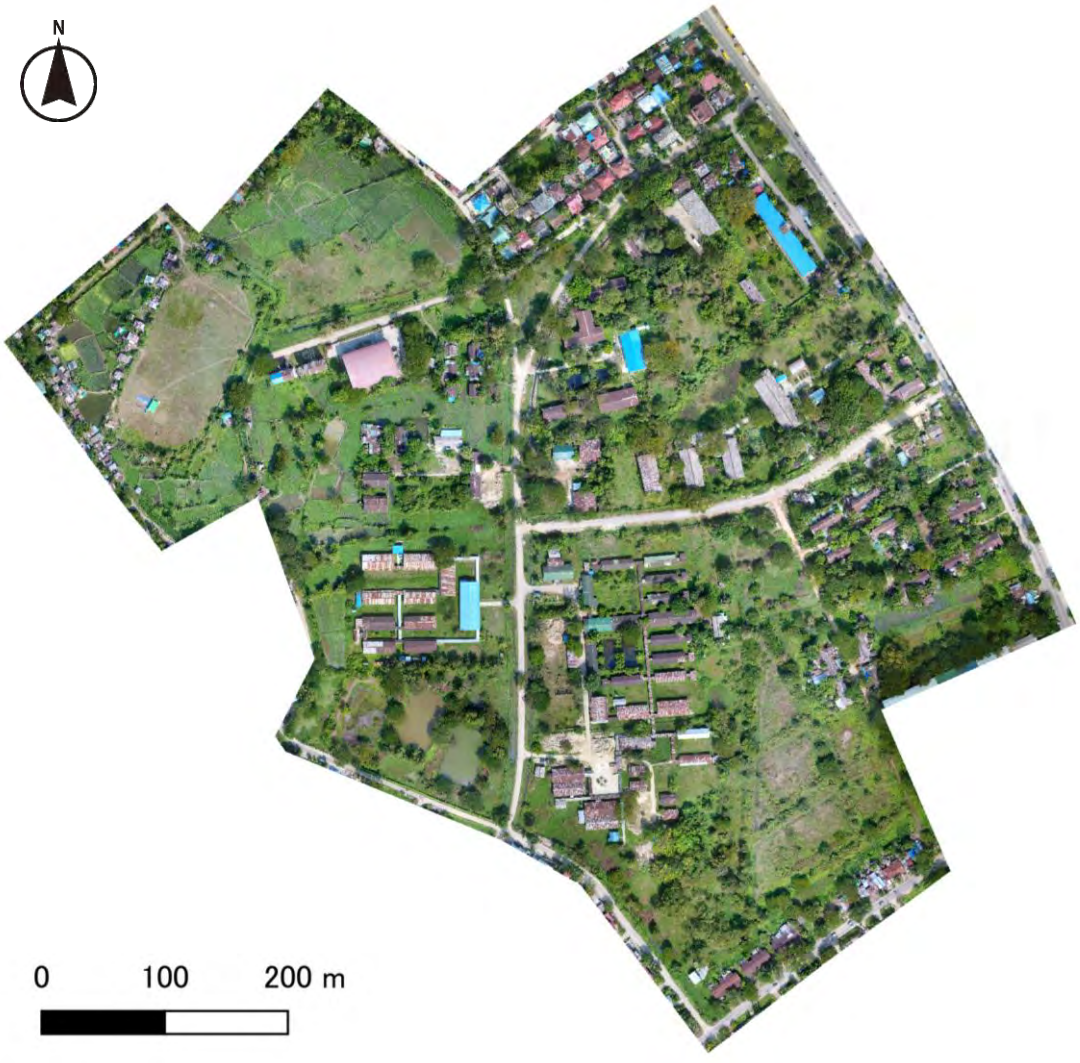

Figure-9 Mosaicked Aerial Photographs

7.3 Detail Digital Mapping

All natural and artificial terrain features such as rivers, forests, monumental trees (together with the name of trees); paddy field, farms, plantation, roads, paths, houses, schools, public buildings, cemeteries, etc. interpreted and plotted by the stereo model after aerial triangulation. The drawn features are classified into layers in AUTOCAD file according to the map symbol specification. The topographic map of each area printed out the PDFs of A0 size. Figure-10 shows topographic map symbol specification adopted in this project. And a part of the topographic map is shown in Figure-11.

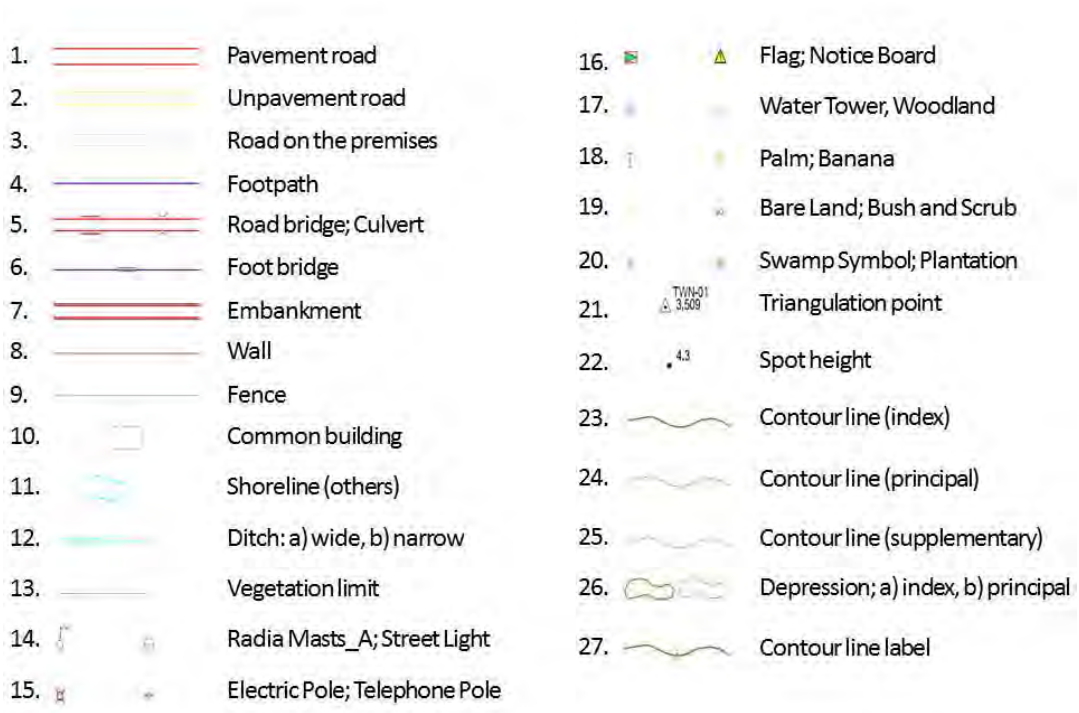

Figure-10 Symbols of Topographic Map

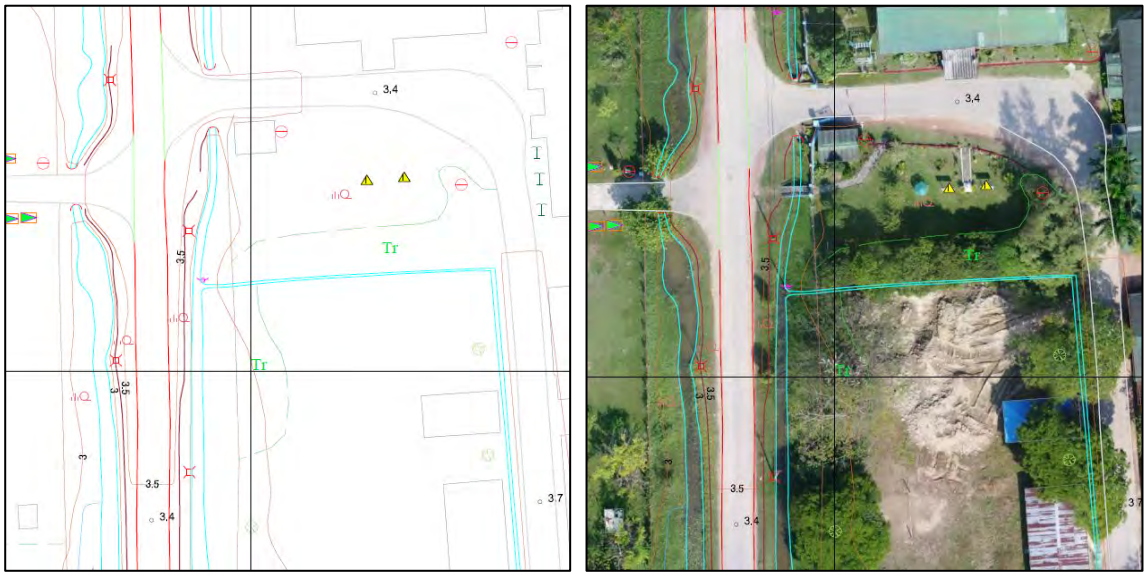

Figure-11 Part of Topographic Map (right: overlay Orthophoto)

8. Outputs & Deliverables

The tangible outputs of this project were delivered as shown in Tables-5.

Table-6 List of the Outputs of the Survey data

No.	Delivered Goods		Amount	Description
1	Digital topographic map data	1:500	2set	DWG, PDF
2	Digital topographic map	1:500	2set	Print manuscripts in A0 sheets
3	Orthophoto map data	1:500	2 set	DVD, A0 plots
4	DTM data	-	2 set	DVD

9. List of Figure

10. List of Table

11. Appendix

-Appendix A – Thuwunna Tsp GCP Report

Appendix A

Thuwunna Tsp GCP Report

ASIA AIR SURVEY MYANMAR CO., LTD.

MYANMAR

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Pyay Road, Kamaryut Township, Yangon, Myanmar
•Telephone:+95 1 501380 •Facsimile:+95 1 501380

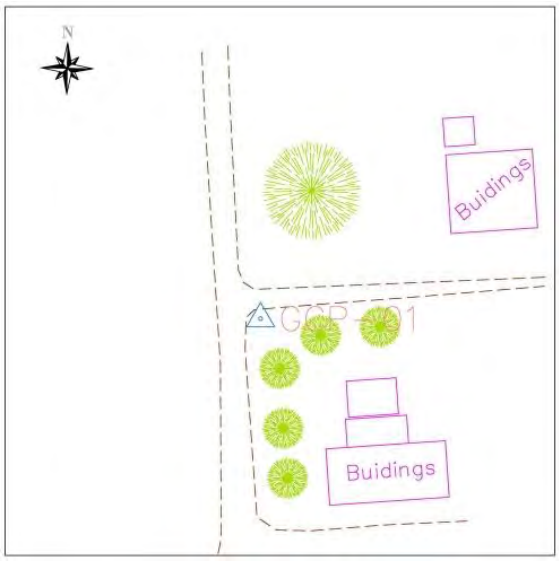
(GCP-01)

STATION DESCRIPTION				Surveyor:	U Than Htwe Aung
Station Name	**GCP-01**			Date of Survey:	14- January-2019
Purpose	**Permanent Pillar with centering nail (Concrete BM)**			Method:	Static
Area:	**Thuwunna Township, Yangon. Union of Myanmar.**			Instrument:	CHC GPS

STATION	Coordinate System: Lat, Long, WGS 84							Coordinate System: UTM, Zone 47 (N)		
	Longitude (E)			Latitude (N)			Ellip Ht	Easting	Northing	Mean Sea Level
	D	M	S	D	M	S	M	M	M	M
GCP-01	96	12	37.68	16	49	8.47	-	202690.9446	1861629.593	3.751

Description and Access Remarks: Point is surveyed on the center mark of GCP-01.

Sketch of Site Plan



Site Photo

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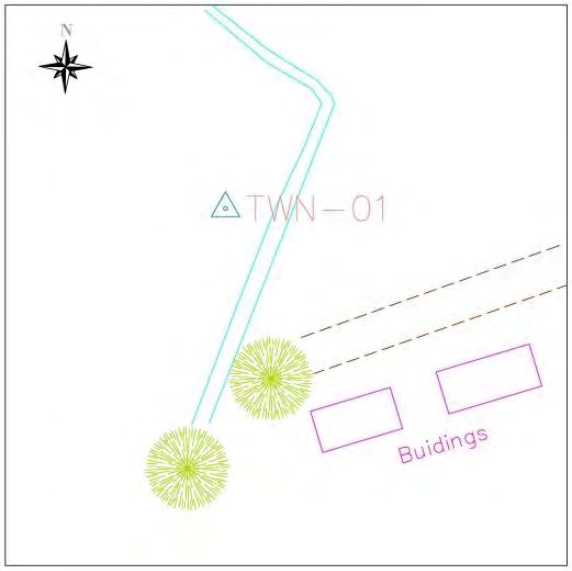
(TWN-01)

STATION DESCRIPTION		Surveyor:	U Than Htwe Aung
Station Name	**TWN-01**	Date of Survey:	14- January-2019
Purpose	**Permanent Pillar with centering nail (Concrete BM)**	Method:	Static
Area:	**Thuwunna Township, Yangon. Union of Myanmar.**	Instrument:	CHC GPS

STATION	Coordinate System: Lat, Long, WGS 84							Coordinate System: UTM, Zone 47 (N)		
	Longitude (E)			Latitude (N)			Ellip Ht	Easting	Northing	Mean Sea Level
	D	M	S	D	M	S	M	M	M	M
GCP-01	96	12	30.08	16	49	13.97	-	202468.2006	1861801.964	3.433

Description and Access Remarks: Point is surveyed on the center mark of TWN-01.

Sketch of Site Plan



Site Photo

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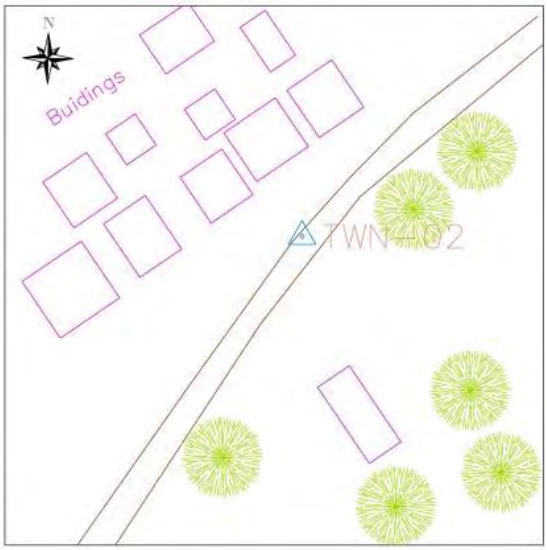
(TWN-02)

STATION DESCRIPTION								Surveyor:	U Than Htwe Aung	
Station Name	**TWN-02**							Date of Survey:	14- January-2019	
Purpose	**Permanent Pillar with centering nail (Concrete BM)**							Method:	Static	
Area:	**Thuwunna Township, Yangon. Union of Myanmar.**							Instrument:	CHC GPS	
STATION	Coordinate System: Lat, Long, WGS 84							Coordinate System: UTM, Zone 47 (N)		
	Longitude (E)			Latitude (N)			Ellip Ht	Easting	Northing	Mean Sea Level
	D	M	S	D	M	S	M	M	M	M
TWN-02	96	12	40.03	16	49	17.26	-	202764.6446	1861898.939	3.918

Description and Access Remarks: Point is surveyed on the center mark of TWN-02.

Sketch of Site Plan



Site Photo

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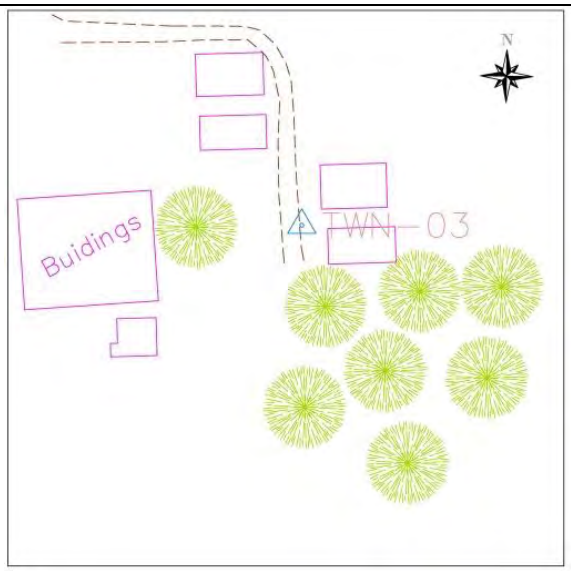
(TWN-03)

STATION DESCRIPTION										Surveyor:	U Than Htwe Aung
Station Name	**TWN-03**									Date of Survey:	14- January-2019
Purpose	**Permanent Pillar with centering nail (Concrete BM)**									Method:	Static
Area:	**Thuwunna Township, Yangon. Union of Myanmar.**									Instrument:	CHC GPS
STATION	Coordinate System: Lat, Long, WGS 84							Coordinate System: UTM, Zone 47 (N)			
	Longitude (E)			Latitude (N)			Ellip Ht	Easting	Northing	Mean Sea Level	
	D	M	S	D	M	S	M	M	M	M	
TWN-03	96	12	41.36	16	49	1.27	-	202796.9486	1861406.683	3.469	

Description and Access Remarks: Point is surveyed on the center mark of TWN-03.

Sketch of Site Plan



Site Photo

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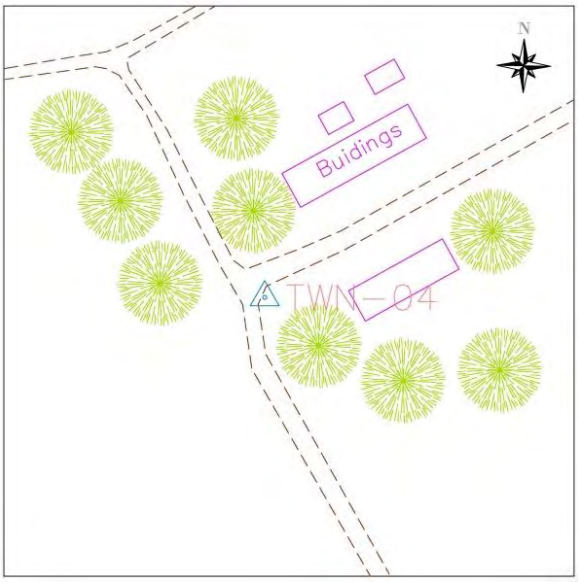
(TWN-04)

STATION DESCRIPTION								Surveyor:	U Than Htwe Aung	
Station Name	**TWN-04**							Date of Survey:	14- January-2019	
Purpose	**Permanent Pillar with centering nail (Concrete BM)**							Method:	Static	
Area:	**Thuwunna Township, Yangon. Union of Myanmar.**							Instrument:	CHC GPS	
STATION	Coordinate System: Lat, Long, WGS 84							Coordinate System: UTM, Zone 47 (N)		
	Longitude (E)			Latitude (N)			Ellip Ht	Easting	Northing	Mean Sea Level
	D	M	S	D	M	S	M	M	M	M
TWN-04	96	12	45.37	16	49	7.97	-	202918.5356	1861610.935	3.509

Description and Access Remarks: Point is surveyed on the center mark of TWN-04.

Sketch of Site Plan



Site Photo

Appendix 5
Report on Geological Survey

REPORT

ON

GEOLOGICAL SURVEY

FOR

PREPARATORY SURVEY FOR THE EAST-WEST ECONMIC CORRODOR IMPROVEMENT PROJECT (PHASE 2)

(DATA COLLECTION SURVEY FOR THUWUNNA CTC)

IN

THE REPUBLIC OF THE UNION OF MYANMAR

THINGANGYUN TOWNSHIP, YANGON REGION

ORIENTAL CONSULTANT GLOBAL CO., LTD.

FKYB- SI –253/2018-032

FEBRUARY, 2019

Submitted by;

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REPORT

ON

GEOLOGICAL SURVEY

FOR

PREPARATORY SURVEY FOR THE EAST-WEST ECONOMIC CORRIDOR IMPROVEMENT PROJECT (PHASE 2)

(DATA COLLECTION SURVEY FOR THUWUNNA CTC)

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FKYB - SI –253/2018-032

FEBRUARY, 2019

Submitted by:
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PREPARATORY SURVEY FOR THE EAST-WEST ECONOMIC CORRIDOR IMPROVEMENT PROJECT (PHASE 2)
OF
(DATA COLLECTION SURVEY FOR THUWUNNA CTC)

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, ports & jetties to be constructed and needs proper design of required structures. ORIENTAL CONSULTANT GLOBAL CO., LTD is planning to construct the Central Training Centre at the compound of Thuwunna CTC and Thuwunna department of bridge and quality control, Thingangyun Township, Yangon 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-

To understand the distribution condition of stratum in this project area
To recognize the physical and mechanical properties of soil
To evaluate the appropriate soil design parameter for construction design process
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 three boring points and the total depth of investigation for three boreholes is 128.0 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 all 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.

(1) Field Works

Boring works by TOHO-D1 Drilling Machines.

- Standard Penetration Test
- Soil Disturbed Sampling
- Soil Undisturbed Sampling
- Water Level Measuring and Sampling

(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 at compound of Thuwunna CTC and Thuwunna department of bridge and quality control, Thingangyun Township, Yangon Region. The detailed location of project area is indicated as a google map in Figure-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 of Junction of No.3 Main Road and No.3 Set Thwe Road, Mingalardon Township. The field investigation works were started from 14th January, 2019 and completed all boreholes on 29th January, 2019. The laboratory tests were carried out after field work and completed on 14 February, 2019.

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 Demobilization of Equipment

Table - 1.1 Actual Working Schedule of Geotechnical Investigation Works

Description	January-2019																			February-2019												
	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	2	4	6	8	10	12	14	16	18	20	22	24	26	28
Preparation																																		
Mobilization																																		
Field Investigation																																		
Machine-1				BH-01																														
											BH-02																							
															BH-03																			
De-mobilization																																		
Laboratory Testing																																		
Report Preparation																																		
Final Report Submission																																		

Mobilization the drilling machine from Office store to site

De-mobilization the drilling machine from site to Office store

Shifting the machine from BH to BH

Holiday

Stand by

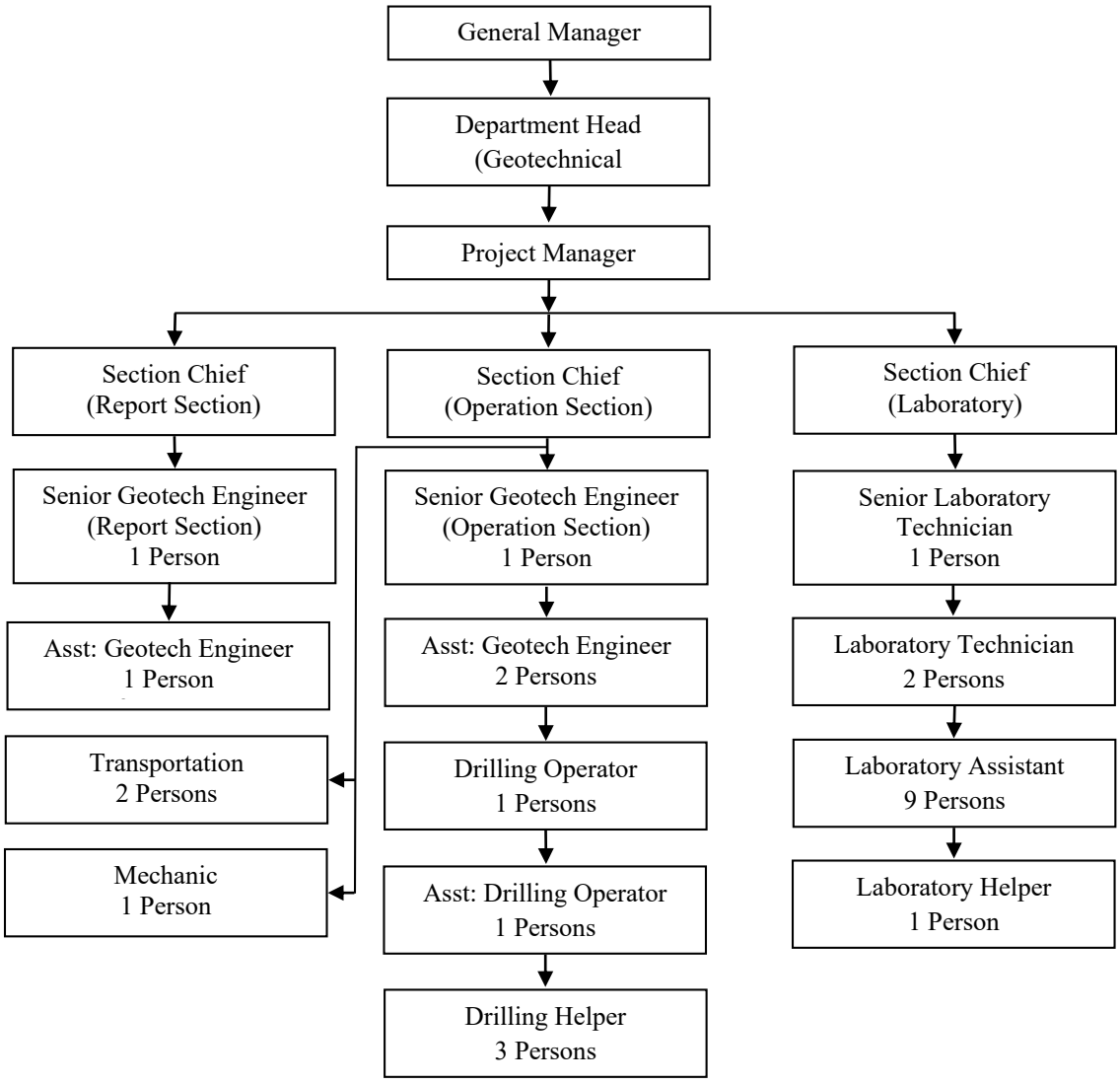


Figure - 1.2 Organization Chart of the works

1.5 Equipment Applied in the Project

1.5.1 Boring Equipment

The boring equipment, TOHO-D2 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 - 1.5 TOHO-D1 Drilling Machine

Table - 1.2 Specification of Boring Equiment

Parts of Equipment	Particulars
Brand of Boring machine	TOHO-"D2"
Boring Type	Oil-hydraulic feed system, Spindle type
Feeding Type	Hydraulic Feed Type
Drilling Capacity	200m
Angle Range	360º
Revolving Speed of Spindle	60 : 180 : 355 Reverse – 65 rpm
Hoisting Speed	10~59m/min
Net Weight	900kgf
Oil-Hydraulic	
Type	Constant delivery, gear type pump
Delivery Capacity	20 l/min at 1600 rpm
Max. Pressure	7.4 MPa (75kg/cm2)
Attached Water Pump Type	Toho "BG-3B"
Discharge Capacity	54 l/min
Working Pressure	15 kgf/cm2
Dimension (LxWxH)	1700 x 110 x 160 mm (without oil-hydraluic chuck)
Engine	Yanmar Engine 110
Power	11.0 HP

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's Limit Test Apparatus	MARUI 1115013
Sieve Test Equipment	TOKYO SAITAMA (JIS Z 8801)
Unconfined Compression Test Machine	MARUI 19047
Consolidation Test ApparatusYF-WG-1B	YF-WG-1B

Photo - 1.6 Drying Oven

Photo - 1.7 Electrical Balance

Photo - 1.8 Atterberg's Limits Apparatus

Photo - 1.9 Sieve Test Equipment

Photo - 1.10 Unconfined Compression Test Machine

Photo - 1.11 Pycnometer for Specific Gravity Test

Photo - 1.12 Consolidation Test Apparatus

2 SITE CHARACTERIZATION

In this chapter, it would be included about the topography, regional geologic setting and geology of the project area in Thingangyun Township of Yangon region.

2.1 Topography

As the project area is located at the western flank of Bago Yoma Range, the original topography of the area is undulated flat low-lying land, small hills and small valleys. The Bago Yoma is trending north to south, and end up south of Shwedagon Hill. At the present time, the proposed site areas are covered with existing buildings, short grass, small bushes and medium trees. Now a day, the topography of the project area is modified several times for being development of urbanization of Yangon City. The drainage pattern also has been modified from original position to urban drain. Panoramic view of project area is shown in below.

Photo - 2.1 View of Project Area

Refer to the geological map from Geology of Burma, published by Friedrich Bender in 1983, the project site and surrounding area is lied on the southwest end of Inner-Burma Tertiary Basin, especially located in back arc basin. In this basin, the sediments are of Miocene, Oligocene, Eocene and small amount of Paleocene. The overburden soil layer of the project site is Quaternary Alluvial deposit (Q2).

By boring results of soil investigation, the project area is made up of alluvial deposit of CLAY and Silty SAND. According to the geological map, the regional geological setting of the stratigraphic succession of project area is as follow-

Description	**Symbols**	**Age**
Alluvium	Q2	Quaternary
Irrawaddy Formation	Tm-Tp	Miocene – Pliocene
Upper Pegu Group	Tm	Miocene

Alluvium

The top soil layer is clayey soil layers, and the colors of these layers are brownish gray to gray in color. The thickness of these clayey soil layers is a minimum 6.0m and a maximum 14.0m. The plasticity of it is medium to plasticity. And then yellowish brown color and gray color of fine to medium grained sandy soil layer is well observed in this project area.

Irrawaddy Formation

This formation is yellowish fine sandstone or sand-rock of the Irrawaddian Group. The outcropping areas can be seen in the left bank of Yangon-Thanlyin crossing of Pegu River. It is characterized by loosely cemented sandstone with trace grit.

Pegu Group

This formation is mainly composed of sand and shale inter-beds. The outcropping area is found along anticlinal ridge of the Thanlyin area. The upper part of Peguan sandstone is altered as by weathering as reddish brown oxidized lateritic soil.

Geological Structure

In the north east part of the project site, the Danyin Gone area, the anticlinal ridge is located. In the eastern part of this area, there has a fault named Danyin Gone Fault the position in parallel with anticline axis. The axis of the anticline is trending in the N–S direction. Regional geological study of project area was made by Friedrich Bender (1983) and geological map is shown in Figure-2.1.

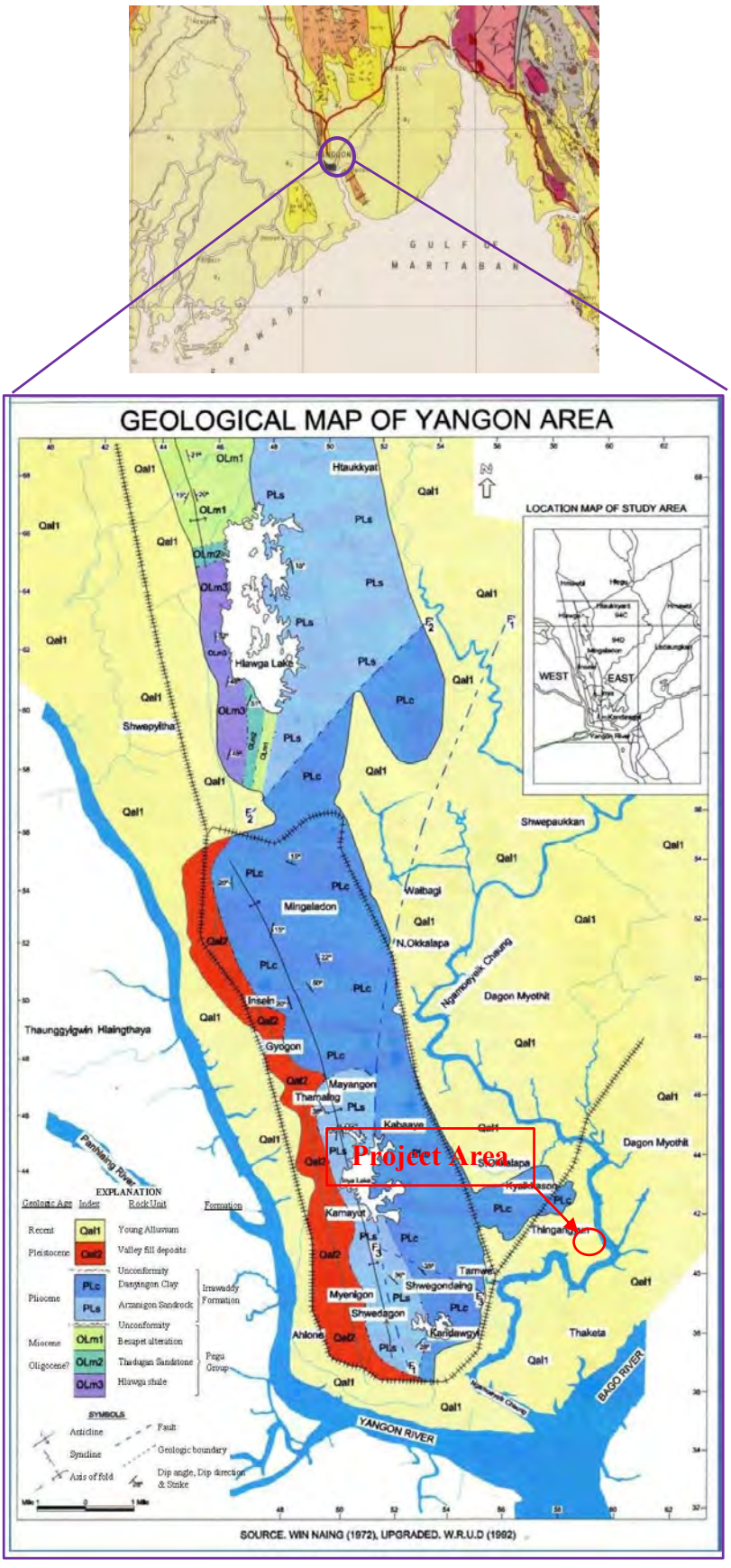


Figure - 2.1 Geological Map of Project Area

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 three boring points were 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 130.0m 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)
		Ø 112 mm	Ø 64 mm	Total			
1	BH-01	1.0	49.0	50.0	44	6	1
2	BH-02	1.0	44.0	45.0	39	4	1
3	BH-03	1.0	34.0	35.0	31	4	1
Total		**3.0**	**127.0**	**130.0**	**114**	**14**	**3**

3.2 Location of Boring Points

The locations of investigated points were designated by client. The plan map showing geotechnical investigated points are indicated in Figure-3.1. The coordinate and elevation of all borehole points are shown in Table-3.2. The coordinate of all investigated points were measured by Hand GPS, and the elevations of all investigated points were measured by Auto level from Control Point (CP-03) which is locating at near the site compound. Photo-3.1 is shown the leveling process and Control Point (CP-03).

Photo - 3.1 Leveling Process and Control Point (GCP-01)

Figure - 3.1 Location of Investigated Points

Table - 3.2 Coordinates and Boring Ponts

No.	BH No.	Easting (E)	Northing (N)	Elevation EL: (m)
1	BH-01	202843.000	1861640.000	+2.91
2	BH-02	202906.000	1861773.000	+3.38
3	BH-03	202713.000	1861526.000	+3.27
4	GCP-01	202690.944	1861629.590	+3.75

Photographs showing location of boring points

Photo - 3.2 View of BH-01

Photo - 3.3 View of BH-02

Photo - 3.4 View of BH-03

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.

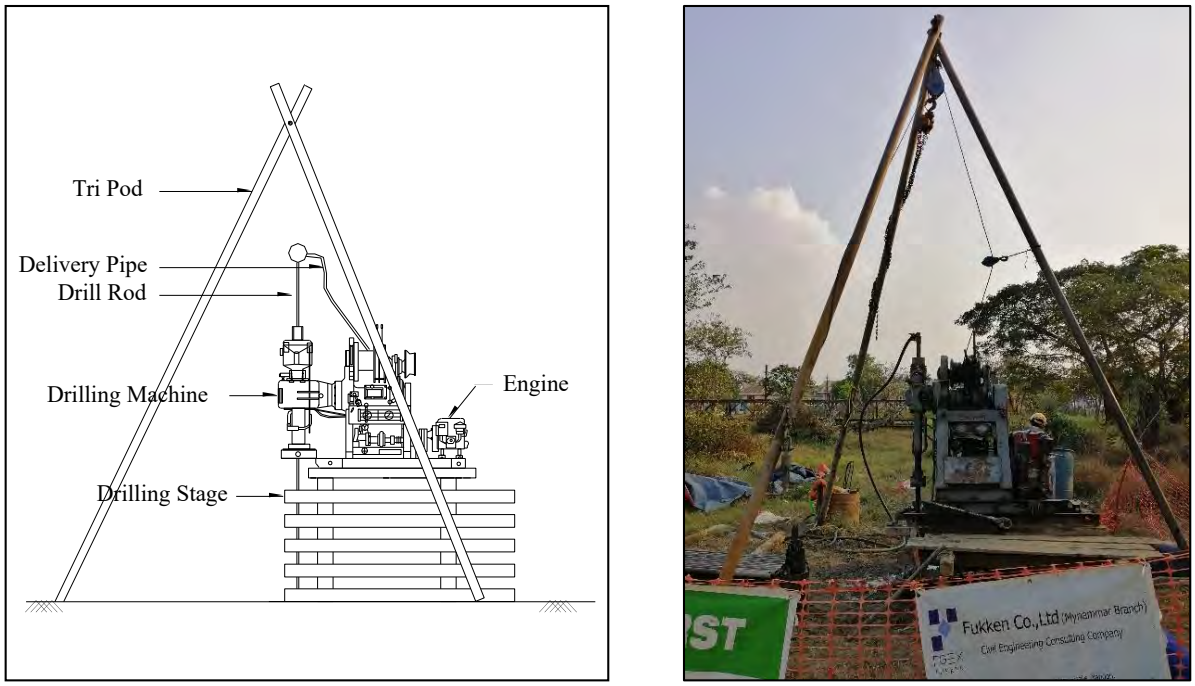


Figure - 3.2 Schematic View of Drilling Machine setting

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-3.3 indicates the procedure and apparatus of standard penetration test. The distribution of N-value for each stratum is summarized in Figure-3.4.

Photo - 3.5 View of Standard Penetration Test and SPT Sample

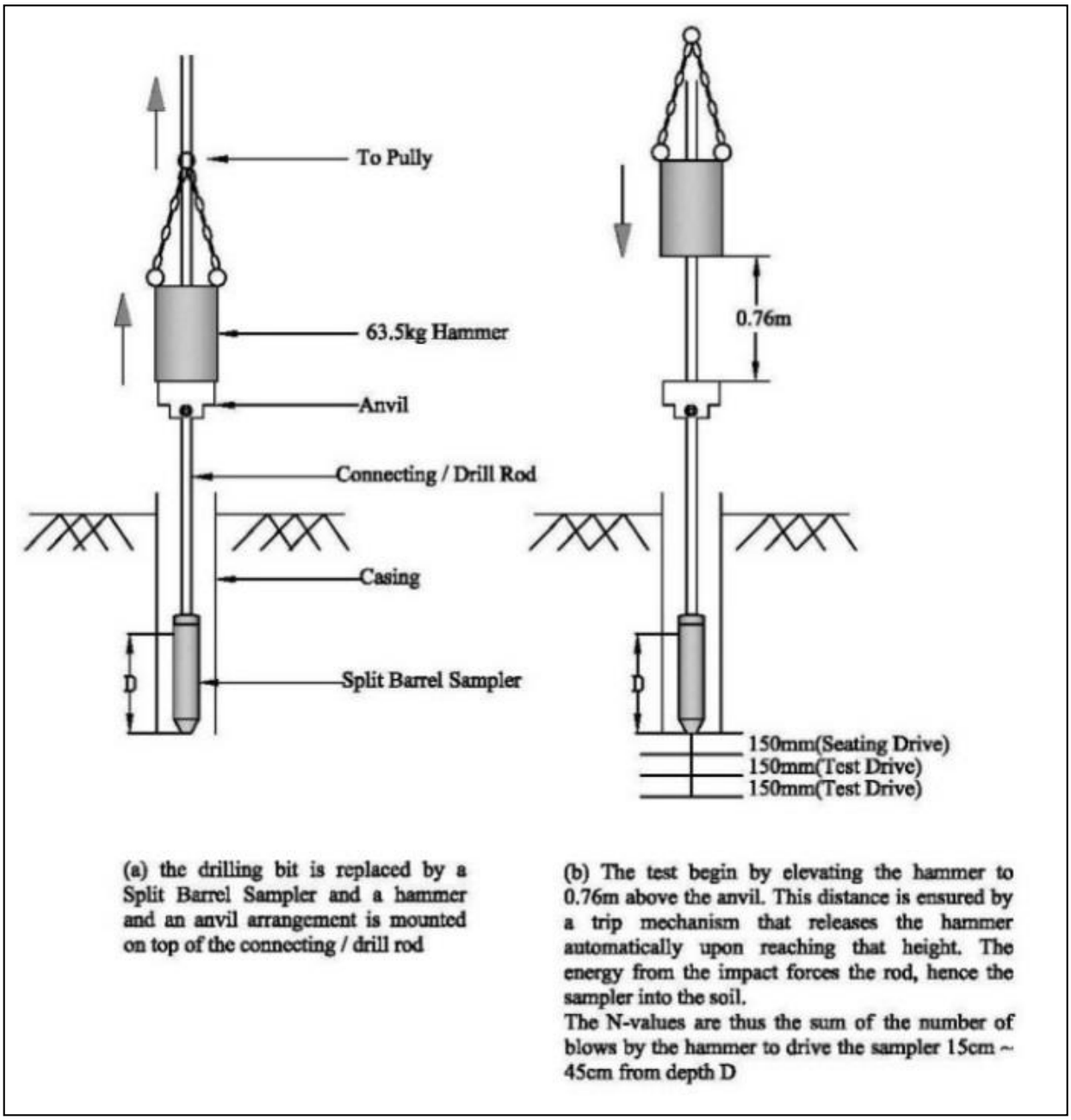


Figure - 3.3 Procedure and Apparatus of Standard Penetration Test

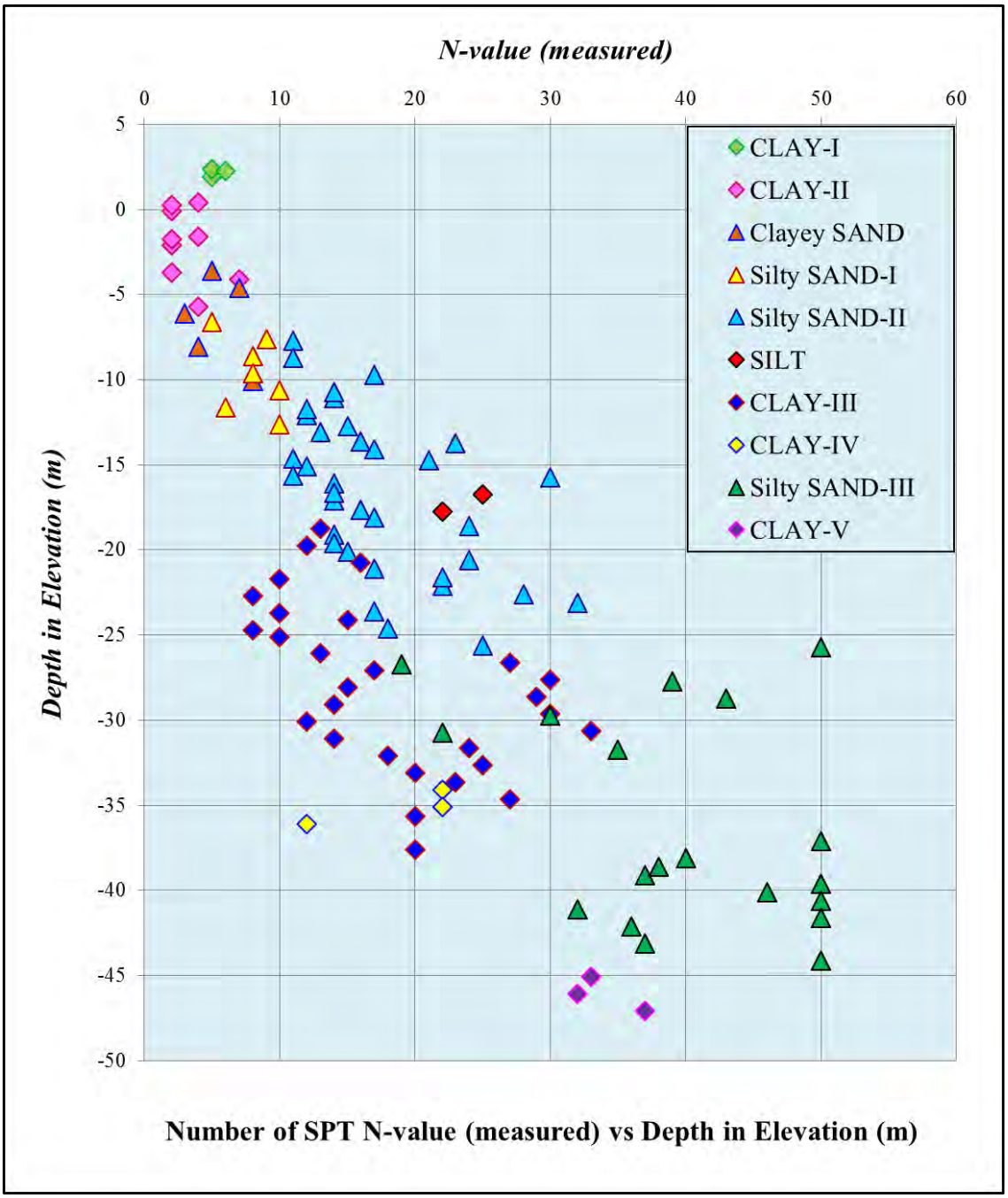


Figure - 3.4 Number of N-Value (measured) vs Depth in Elevation (m)

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-3.5) are used to take as undisturbed sample in the layer of N-value below 5 and Denison samplers (Figure-3.6) are used in the layer of N-value between 5 and 12 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.

If the Denison samplers are applied, the borehole is flushed with water to remove the remnants left at the bottom of the borehole. The sampler tube ahead of the outer rotating barrel is manually adjusted before commencement of sampling operation, rather than spring-controlled during sample penetration. The basic components of the sampler are an outer rotating tube with carbide metal crown bit and an inner stationary sampling tube with a cutting shoe. When sampler put down to the bottom of the borehole, firstly sampler tube was pressed to penetrate about 4 cm in the fresh soil. At the same time, outer soil portion was cut and flushed by metal crown bit with rotation. In that way drilling with sampling is progressed until 0.80m full recovery. When sampler tube was brought on to the surface, some soil was removed from each end and molten paraffin was applied to form as seal. As a result of this, losing natural water content can be surely prevented.

In this project, total (14) numbers of undisturbed samples were carried out in clayey soil layers by using Denison 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	15.01.19	D-1	2.00 ~ 2.80	CLAY	100%	Denison Sampler
2		15.01.19	T-1	4.00 ~ 4.70	CLAY	88%	Piston Sampler
3		15.01.19	D-2	6.00 ~ 6.50	CLAY	63%	Denison Sampler
4		15.01.19	D-3	8.00 ~ 8.50	Clayey SAND	63%	Denison Sampler
5		15.01.19	T-2	10.00 ~ 10.80	CLAY	100%	Piston Sampler
6		15.01.19	T-3	12.00 ~ 12.65	Clayey SAND	81%	Piston Sampler
7	BH-02	22.01.19	D-1	2.00 ~ 2.80	CLAY	100%	Denison Sampler
8		22.01.19	T-1	4.00 ~ 4.65	CLAY	81%	Piston Sampler
9		22.01.19	D-2	6.00 ~ 6.75	Clayey SAND	94%	Denison Sampler
10		22.01.19	D-3	9.00 ~ 9.50	Clayey SAND	63%	Denison Sampler
11	BH-03	26.01.19	D-1	2.00 ~ 2.50	CLAY	63%	Denison Sampler
12		28.01.19	T-1	4.00 ~ 4.70	CLAY	88%	Piston Sampler
13		28.01.19	T-2	6.00 ~ 6.80	CLAY	100%	Piston Sampler
14		28.01.19	T-3	8.00 ~ 8.80	CLAY	100%	Piston Sampler

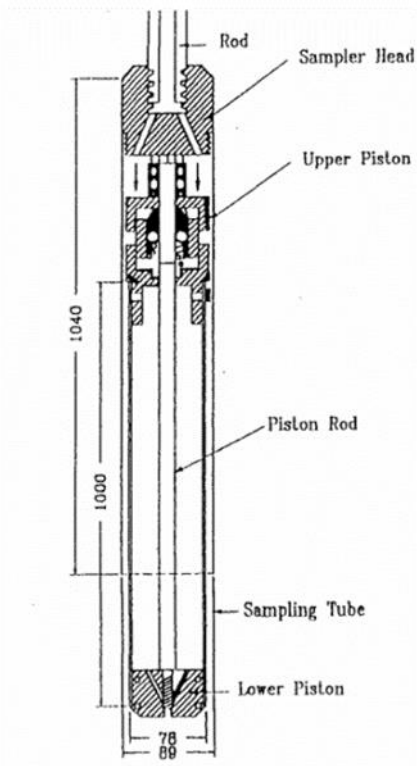


Figure - 3.5 Thin wall tube attached to Fixed-Piston (undisturbed soil) sampler

Photo - 3.6 Taking Undisturbed Sampling

Photo - 3.7 After taking Undisturbed Sample

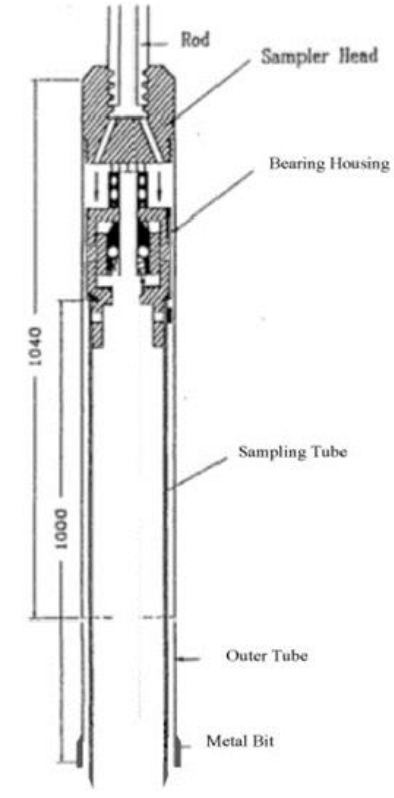


Figure - 3.6 Thin wall tube attached to Denison (undisturbed soil) sampler

Photo - 3.8 Taking Undisturbed Sampling

Photo - 3.9 After taking Undisturbed Sample

3.6 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 between GL-5.00m in minimum and 6.00m in maximum (see Boring Logs in Appendix-A). Groundwater level that confirmed at the boring points through project area during 18th January, 2019 to 29th January, 2019 are shown in Table-3.5.

Table - 3.4 Groundwater level of investigation points through project area

No.	BH-No.	BH EL - (m)	Groundwater Level		Measured Date
			GL - (m)	EL - (m)	
1	BH-01	+2.91	-3.10	-0.19	18.01.2019
2	BH-02	+3.38	-2.50	+0.88	24.01.2019
3	BH-03	+3.27	-3.00	+0.27	29.01.2019

- It is considered that groundwater level in the boreholes may not be precise due to remnant of drilling slurry at the time of measuring.

3.7 Characteristics of Soil Strata Relying on Field Test

There are three numbers of boreholes, the depth of boreholes is a minimum 35.0m and a maximum 50.0m from ground level with the performance of Standard Penetration Test. In this operation, total ten numbers of different layers have been recognized. The soil layers are classified in accordance with their physical properties and/or their relative density. The ten different layers observed in project area are described from top to bottom as follows.

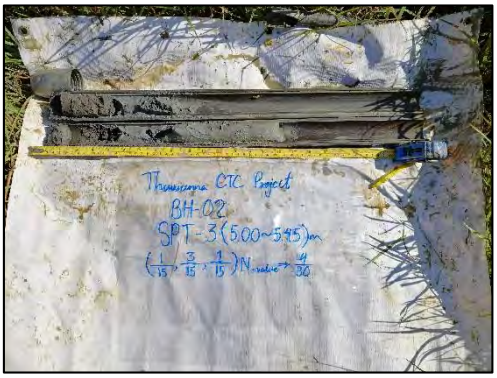
1. CLAY-I
2. CLAY-II
3. Clayey SAND
4. Silty SAND-I
5. Silty SAND-II
6. SILT
7. CLAY-III
8. CLAY-IV
9. Silty SAND-III
10. CLAY-V

3.7.1 CLAY-I

According to the investigation results, the upper most layer is CLAY-I layer. This layer is well observed in all investigated holes. The thickness of this layer is about 3.0m. The color of this layer is brownish gray color. The plasticity of this layer is medium to high plasticity and the water content is moist. SPT N-value range of this layer is 5/30 to 6/30 blows, and it can be described as firm in consistency.

3.7.2 CLAY-II

The second sub-soil layer CLAY-II layer. This layer is also well observed in all investigation hole. The thickness of this layer is a minimum 3.0m and a maximum 7.0m. The color of this layer is gray color. The plasticity of this layer is medium to high plasticity and the water content is moist. SPT N-value range of this layer is 2/30 to 7/30 blows, and it can be described as soft to firm in consistency.



3.7.3 Clayey SAND

This layer is observed only at BH-01 and BH-02. The thickness of it is a minimum 4.0m and a maximum 6.0m. The color of it is mottled gray and yellowish brown, and the water content is moist. The plasticity of clay is low plasticity and the grained size of sand is fine grained. SPT N-value range is varying from 3/30 to 8/30 blows, and it can be described as loose in relative density.

3.7.4 Silty SAND-I

The fourth sub-soil layer is Silty SAND-I. This layer is observed only at BH-02. The thickness of this layer is 7.0m. The color of it is yellowish brown and the water content is moist. The grained size of sand is fine grained. SPT N-value range is varying from 5/30 to 10/30 blows, and it can be described as loose to medium dense in relative density.

3.7.5 Silty SAND-II

This layer is also well observed in all investigated holes. The thickness of it is a minimum 10.0m and a maximum 13.0m. The color of it is yellowish brown and the water content is moist. The grained size of sand is fine grained. Moreover, trace of fine gravel is including in some depth in this layer. SPT N-value range is varying from 11/30 to 34/30 blows, and it can be described as medium dense to dense in relative density.

3.7.6 SILT

According to the investigation results, this SILT layer is observed only at BH-03. The thickness of this layer is about 2.0m. The color of this layer is gray. The plasticity of this layer is low to medium plasticity and the water content is moist. Moreover, trace of clay is including in this layer. SPT N-value range of this layer is 22/30 to 25/30 blows, and it can be described as hard in consistency.

3.7.7 CLAY-III

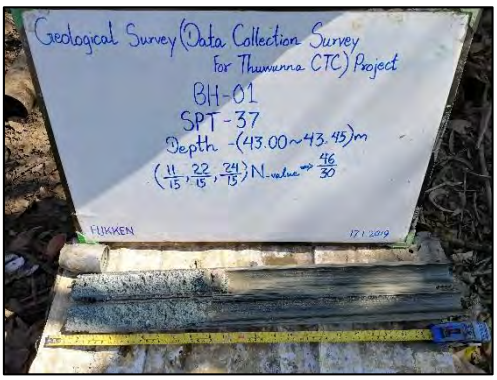
The sixth sub-soil layer is CLAY-III layer. This layer is also well observed in all investigated holes. The thickness of this layer is a minimum 7.0m and a maximum 12.0m. The color of this layer is gray color. The plasticity of this layer is medium to high plasticity and the water content is moist. SPT N-value range of this layer is 8/30 to 33/30 blows, and it can be described as firm to hard in consistency.

3.7.8 CLAY-IV

According to the investigation results, this layer is observed only at BH-01. The thickness of it is about 3.0m. The color of it is gray color and the water content is moist. The plasticity of clay is low to medium plasticity. SPT N-value range is varying from 12/30 to 22/30 blows, and it can be described as stiff to very stiff in consistency.

3.7.9 Silty SAND-III

According to the investigation results, the nine sub-soil layer is Silty SAND-III layer. This layer is the last sub-soil layer of BH-02 and BH-03. The thickness of this layer is cannot be estimated at BH-02 and BH-03 because the two BH-02 and BH-03 is terminated in this layer. But, the thickness of this layer is about 8.0m at BH-01. The color of this layer is gray and the water content is moist. The grained size of sand is fine to medium grained. Moreover, trace of fine gravel is including in this layer. SPT N-value range of this layer is 19/30 to 50/30 blows, and it can be described as medium dene to very dense in relative density.



3.7.10 CLAY-V

This layer is the last sub-soil layer of BH-01. The thickness of this layer is cannot be estimated because the BH-01 is terminated in this layer. The color of this layer is gray. The plasticity of this layer is low to medium plasticity and the water content is moist. Moreover, trace of silt is including in this layer. SPT N-value range of this layer is 32/30 to 37/30 blows, and it can be described as hard in consistency.

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. Figure-3.8 shows the soil profile through the project area.

Figure - 3.7 Borehole Location and Soil Profile on Google Map

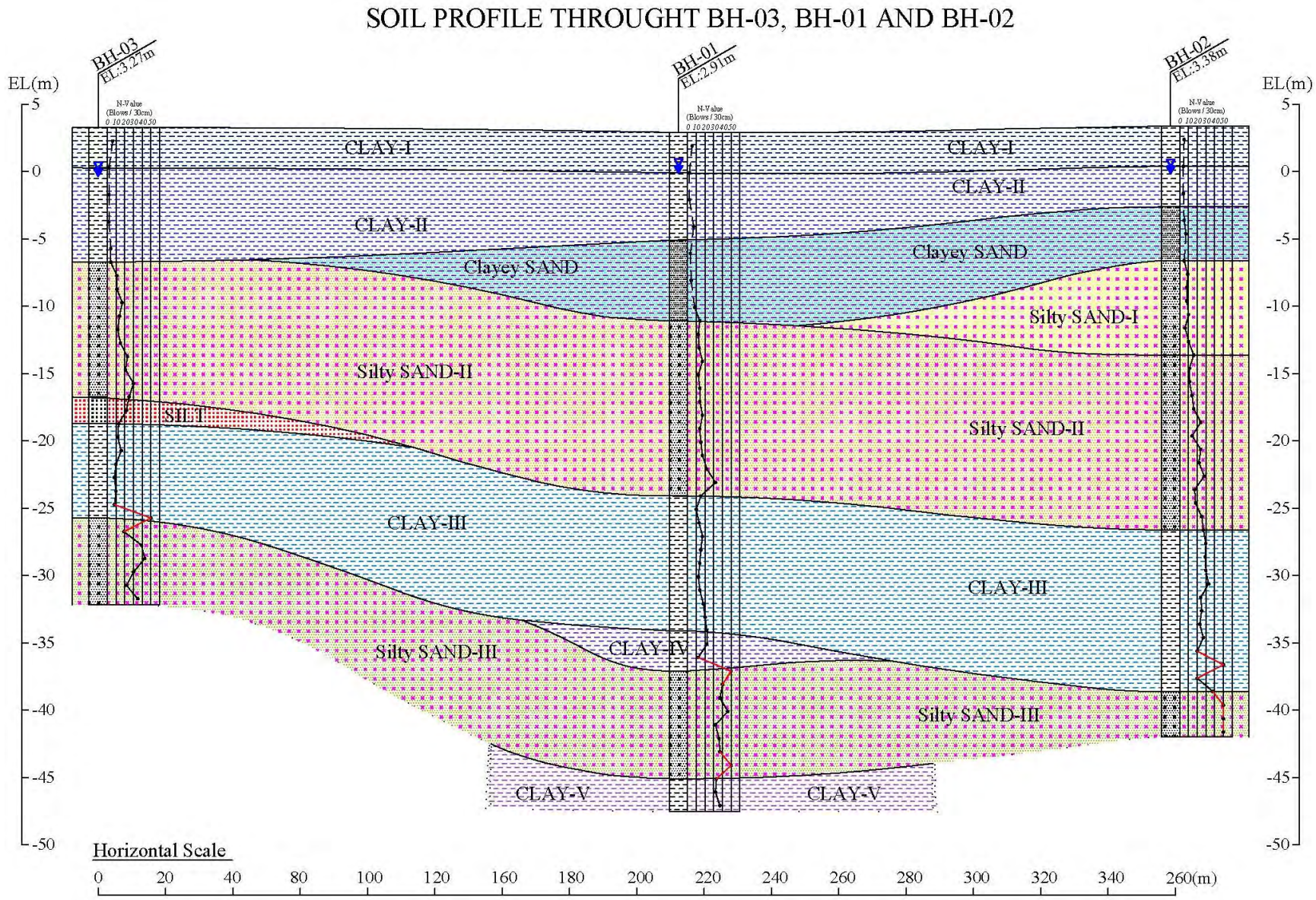


Figure - 3.8 Soil profile through the project area

4 LABORATORY TEST

There have been three numbers of investigation boreholes and total (114) numbers of disturbed samples and (14) numbers of undisturbed samples with Denison sampler and Piston sampler were collected in project site. Some selected numbers of disturbed samples and all 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's Limits Test (ASTM D 4318-05)
  - Liquid Limit Test
  - Plastic Limit Test

The mechanical properties tests include the following items.

- Unconfined Compression Test (ASTM D 2166-06)
- 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	Unconfined Compression Test	One Dimensional Consolidation Test
			Sieve Analysis Test	Hydrometer Analysis Test	Liquid Limit Test	Plastic Limit Test			
BH-01	21	21	21	21	12	12	6	6	3
BH-02	15	15	15	15	8	8	4	4	3
BH-03	10	10	10	10	7	7	4	4	2
Total	**46**	**46**	**46**	**46**	**27**	**27**	**14**	**14**	**8**

Table - 4.2 Summary of Laboratory Test Results

BH No.	Sample No.	Depth		Soil Types	Water Content	Specific Gravity	Grain Size Distribution				Atterberg's Limit			Bulk Density		One Dimensional Consolidation Test			Unconfined Compression Test						Sensitivity Ratio
		GL - (m)	EL; (m)		W (%)	Gs	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	LL (%)	PL (%)	PI (%)	ρ_t g/cm^3		e_o	Py kN/m^2	Cc	qu kN/m^2		ε_f (%)		E_{50} kN/m^2		
BH-01	P-1	1.00	1.91	CH	33.31	2.685	-	0.80	17.20	82.00	79.15	30.41	48.74	-	-	-	-	-	-	-	-	-	-	-	-
	D-1	2.00	0.91	CH	57.22	2.704	-	3.03	52.98	44.00	63.00	29.49	33.51	1.720	1.722	1.450	145.900	0.425	27.2	31.8	4.58	6.35	1602.1	1446.1	-
	T-1	4.00	-1.09	CL	24.93	2.642	-	25.40	36.40	38.20	30.90	14.11	16.79	1.958	1.985	-	-	-	41.5	38.5	7.72	10.74	1502.9	785.6	-
	D-2	6.00	-3.09	CL	22.69	2.695	-	37.14	26.86	36.00	44.40	21.06	23.34	2.005	1.977	0.710	228.700	0.170	58.8	47.9	5.72	5.15	2195.8	1884.9	-
	D-3	8.00	-5.09	SC	23.12	2.649	-	56.45	12.75	30.80	45.90	19.00	26.90	2.026	2.037	-	-	-	31.9	35.3	4.59	3.74	1375.8	1519.9	-
	T-2	10.00	-7.09	CL	41.83	2.687	-	21.88	61.72	16.40	43.55	24.83	18.72	1.889	1.905	1.070	230.200	0.349	94.6	83.3	8.86	9.99	2030.1	1883.6	-
	T-3	12.00	-9.09	SC	30.37	2.670	-	67.90	25.10	7.00	29.00	17.86	11.14	1.870	1.866	-	-	-	109.5	111.7	8.60	7.43	2722.7	3489.9	-
	P-8	14.00	-11.09	SM (or) SC	24.11	2.662	-	79.68	14.12	6.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-10	16.00	-13.09	SM (or) SC	21.84	2.672	0.79	76.33	8.29	14.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-12	18.00	-15.09	SM (or) SC	24.71	2.675	-	73.83	15.87	10.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-14	20.00	-17.09	SM (or) SC	19.15	2.655	-	83.08	11.02	5.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-16	22.00	-19.09	SM (or) SC	18.54	2.665	1.74	79.44	11.61	7.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-18	24.00	-21.09	SM (or) SC	23.13	2.665	-	80.63	12.17	7.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-20	26.00	-23.09	SM (or) SC	20.56	2.685	-	76.81	13.29	9.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-22	28.00	-25.09	CL	37.31	2.703	-	0.25	88.75	11.00	48.65	27.54	21.11	-	-	-	-	-	-	-	-	-	-	-	-
	P-25	31.00	-28.09	CL	32.08	2.691	-	1.53	90.48	8.00	36.30	23.13	13.17	-	-	-	-	-	-	-	-	-	-	-	-
	P-28	34.00	-31.09	CH	39.10	2.606	-	0.35	59.15	40.50	58.50	26.91	31.59	-	-	-	-	-	-	-	-	-	-	-	-
	P-32	38.00	-35.09	CL	27.25	2.675	-	0.72	81.98	17.30	45.65	21.28	24.37	-	-	-	-	-	-	-	-	-	-	-	-
	P-36	42.00	-39.09	SM (or) SC	19.14	2.685	-	80.13	16.37	3.50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-40	46.00	-43.09	SM (or) SC	21.80	2.655	-	73.83	20.97	5.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-43	49.00	-46.09	CH	31.25	2.724	-	0.15	79.15	20.70	58.05	29.37	28.68	-	-	-	-	-	-	-	-	-	-	-	-
BH-02	D-1	2.00	1.38	CH	41.31	2.732	-	0.03	32.08	67.90	75.95	29.56	46.39	1.865	1.904	1.140	317.441	0.375	68.3	73.5	4.57	5.43	3314.9	3791.2	-
	T-1	4.00	-0.62	CH	54.62	2.711	-	3.43	24.68	71.90	66.75	29.97	36.78	1.691	1.677	1.500	102.970	0.415	38.2	39.7	12.48	9.12	1207.8	932.8	-
	D-2	6.00	-2.62	SC	23.86	2.662	-	52.73	18.17	29.10	43.40	17.63	25.77	1.975	1.999	-	-	-	82.7	74.1	5.42	5.12	3306.4	2965.8	-
	P-5	8.00	-4.62	CH	29.46	2.647	-	34.10	30.90	35.00	50.00	20.32	29.68	-	-	-	-	-	-	-	-	-	-	-	-
	D-3	9.00	-5.62	SC	26.05	2.703	-	69.14	21.56	9.30	22.15	14.89	7.26	2.078	1.945	0.870	242.911	0.206	29.6	32.3	6.77	6.90	494.1	498.9	-
	P-7	11.00	-7.62	SM (or) SC	24.21	2.665	-	70.40	18.20	11.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-10	14.00	-10.62	SM (or) SC	22.44	2.660	-	78.13	14.87	7.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-15	19.00	-15.62	SM (or) SC	27.46	2.662	-	76.18	16.42	7.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-19	23.00	-19.62	SM (or) SC	25.24	2.672	-	79.30	13.30	7.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-23	27.00	-23.62	SM (or) SC	29.26	2.713	-	68.50	20.80	10.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-28	32.00	-28.62	CL	31.80	2.731	-	2.00	92.00	6.00	38.65	24.90	13.75	-	-	-	-	-	-	-	-	-	-	-	-
	P-32	36.00	-32.62	ML	31.27	2.714	-	13.38	80.23	6.40	37.00	26.92	10.08	-	-	-	-	-	-	-	-	-	-	-	-
	P-35	39.00	-35.62	CL	36.00	2.733	-	4.33	87.68	8.00	48.00	26.09	21.91	-	-	-	-	-	-	-	-	-	-	-	-
	P-38	42.00	-38.62	SM (or) SC	19.71	2.665	-	73.90	22.40	3.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-40	44.00	-40.62	SM (or) SC	17.20	2.645	-	78.73	18.27	3.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH-03	D-1	2.00	1.27	CH	36.57	2.769	-	0.30	25.40	74.30	70.90	26.73	44.17	1.825	1.844	1.040	315.970	0.302	103.6	109.9	5.97	6.83	2978.0	3456.1	-
	T-1	4.00	-0.73	CH	61.01	2.720	-	2.95	33.25	63.80	61.90	28.26	33.64	1.727	1.734	-	-	-	50.3	53.4	6.00	5.45	1864.6	2224.2	3.0
	T-2	6.00	-2.73	CH	53.69	2.743	-	1.15	26.85	72.00	65.40	29.97	35.43	1.718	1.710	1.460	122.779	0.544	45.3	46.5	9.42	8.87	1077.7	1133.6	2.5
	T-3	8.00	-4.73	CH	31.53	2.698	-	19.55	24.45	56.00	50.10	19.06	31.04	1.972	2.021	-	-	-	57.6	66.4	9.70	14.95	2284.4	1629.6	-
	P-9	13.00	-9.73	SM (or) SC	19.12	2.644	-	82.06	10.74	7.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-13	17.00	-13.73	SM (or) SC	17.55	2.644	-	86.26	8.34	5.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	P-17	21.00	-17.73	ML	25.15	2.705	-	1.60	88.40	10.00	43.15	26.34	16.81	-	-	-	-	-	-	-	-	-	-	-	-
	P-19	23.00	-19.73	CL	35.94	2.711	-	0.13	77.58	22.30	48.05	26.63	21.42	-	-	-	-	-	-	-	-	-	-	-	-
	P-22	26	-22.73	CL	36.63	2.730727	-	0.28	77.43	22.3	48.45	25.68	22.77	-	-	-	-	-	-	-	-	-	-	-	-
	P-29	33.00	-29.73	SM (or) SC	17.33	2.654	2.80	81.70	11.40	4.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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 (46) numbers have been carried out on soil samples for required ten different soil layers at office laboratory in accordance with ASTM Standard (ASTM D 2216-05). Table-4.3 illustrates the summary of natural moisture content in each soil layers. The photograph of testing natural moisture content is shown in Photo-4.1 and the variation of moisture content with depth in elevation can be seen in Figure-4.1. The detailed laboratory test results are illustrated in Appendix-C.

Photo - 4.1 Natural Moisture Content Test

Table - 4.3 Summary of Natural Moisture Content of Test Results

No.	Soil Types	Natural Moisture Content (%)
1	CLAY-I	33.31 ~ 57.22
2	CLAY-II	22.69 ~ 61.01
3	Clayey SAND	23.12 ~ 41.83
4	Silty SAND-I	22.44 ~ 24.21
5	Silty SAND-II	17.55 ~ 29.26
6	SILT	25.15*
7	CLAY-III	31.27 ~ 39.10
8	CLAY-IV	27.25*
9	Silty SAND-III	17.20 ~ 21.80
10	CLAY-V	31.25*

*One sample test

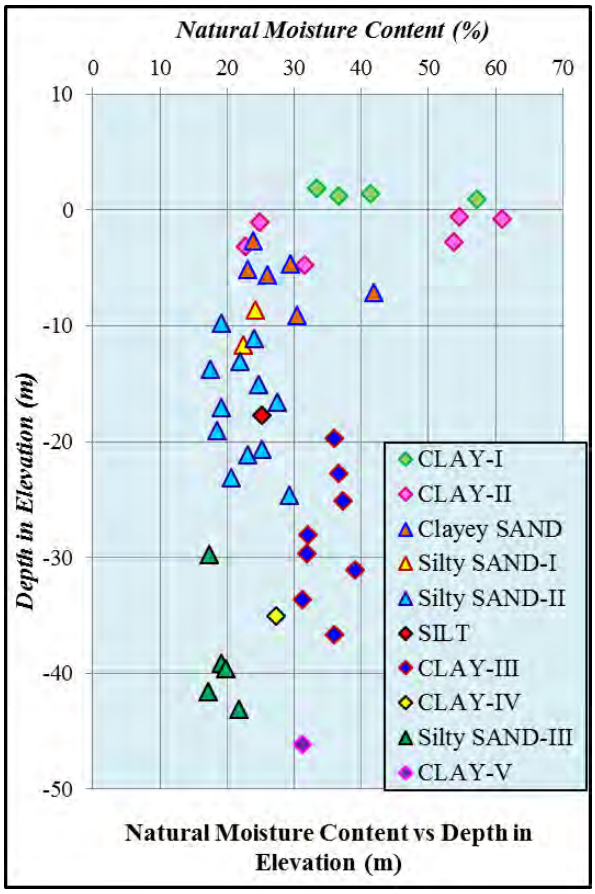


Figure - 4.1 Natural Moisture Content vs Depth in elevation (m)

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 (46) numbers of specific gravity tests. Table-4.4 illustrates the summary of specific gravity for each soil layer. The photograph of specific gravity testing is shown in Photo-4.2 and the relationship between specific gravity and depth in elevation of each soil layer is shown in Figure-4.2. The detailed test results were described in Appendix-C.

Photo - 4.2 Specific Gravity Test

Table - 4.4 Summary of Specific Gravity Test Results

No.	Soil Types	Specific Gravity
1	CLAY-I	2.685 ~ 2.658
2	CLAY-II	2.642 ~ 2.743
3	Clayey SAND	2.647 ~ 2.703
4	Silty SAND-I	2.660 ~ 2.665
5	Silty SAND-II	2.644 ~ 2.713
6	SILT	2.705*
7	CLAY-III	2.606 ~ 2.733
8	CLAY-IV	2.675*
9	Silty SAND-III	2.645 ~ 2.685
10	CLAY-V	2.724*

*One sample test

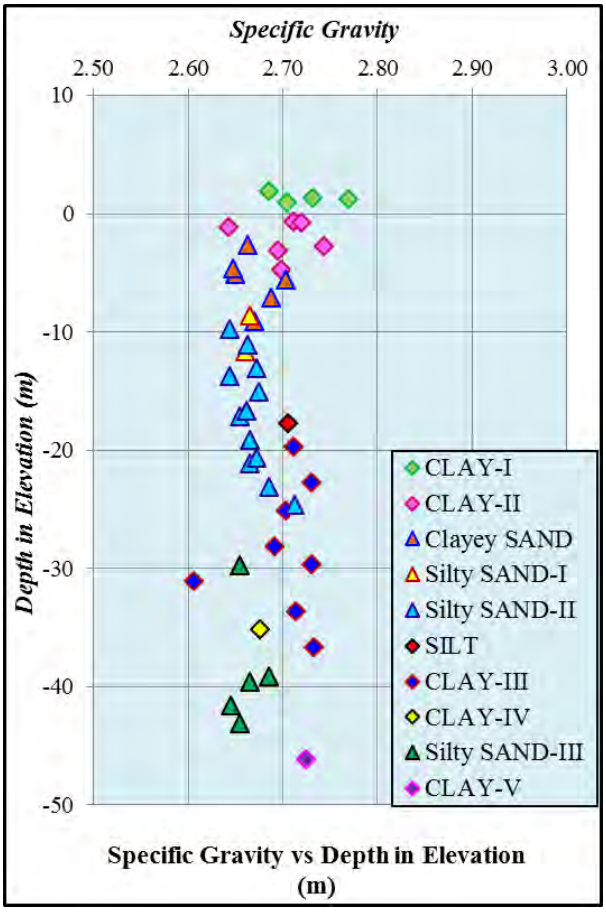


Figure - 4.2 Specific Gravity vs Depth in Elevation (m)

4.1.3 Atterberg's Limit Test

The Atterberg's Limit tests were made on (27) 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 summary of Atterberg's Limit Test results are shown in Table-4.5. Figures-4.3 to 4.5 illustrate the Plastic Limit, Liquid Limit and Plasticity Index of each soil layer versus depth in elevation(m) and Figure-4.6 shows condition of soil in project area by ranges in plasticity chart. The photograph of testing is shown in Photo-4.3. The detailed test results were shown in Appendix-C.

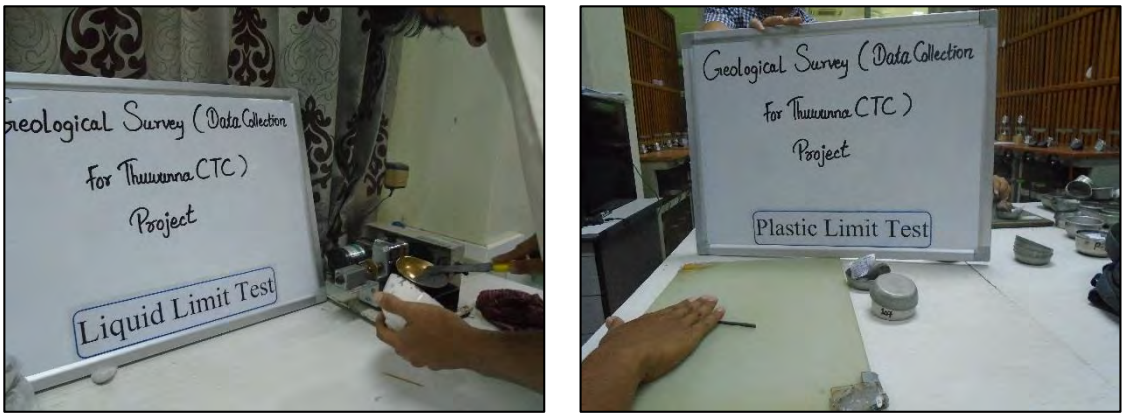


Photo - 4.3 Atterberg's Limit Test (Liquid Limit & Plastic Limit)

Table - 4.5 Summary of Atterberg's Limit Test Results

No.	Soil Types	Liquid Limit (LL) (%)	Plastic Limit (PL) (%)	Plasticity Index (PI)
1	CLAY-I	63.00 ~ 79.15	26.73 ~ 30.41	33.51 ~ 48.74
2	CLAY-II	30.90 ~ 66.75	14.11 ~ 29.97	16.79 ~ 36.78
3	Clayey SAND	22.15 ~ 50.00	14.89 ~ 24.83	7.26 ~ 29.68
	SILT	43.15*	26.34*	16.81*
4	CLAY-III	36.30 ~ 58.50	23.13 ~ 27.54	10.08 ~ 31.59
5	CLAY-IV	45.65*	21.28*	24.37*
6	CLAY-V	58.05*	29.37*	28.68*

*One sample test

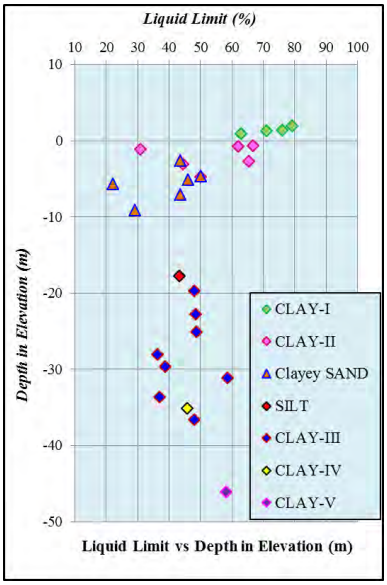


Figure - 4.3 Liquid Limit vs Depth in elevation (m)

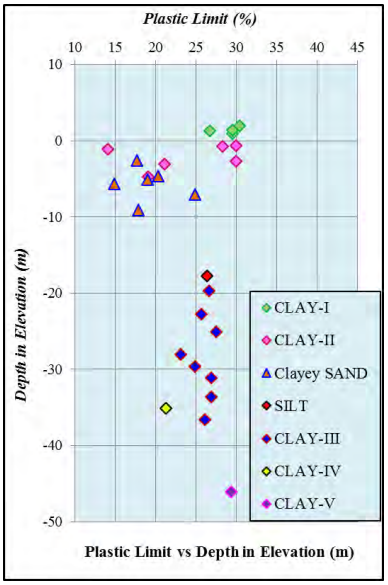


Figure - 4.4 Plastic Limit vs Depth in elevation (m)

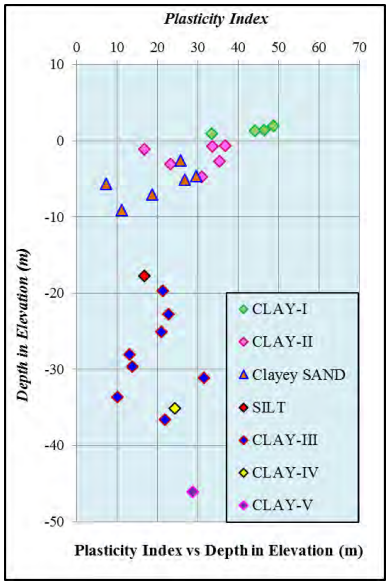


Figure - 4.5 Plasticity Index vs Depth in elevation (m)

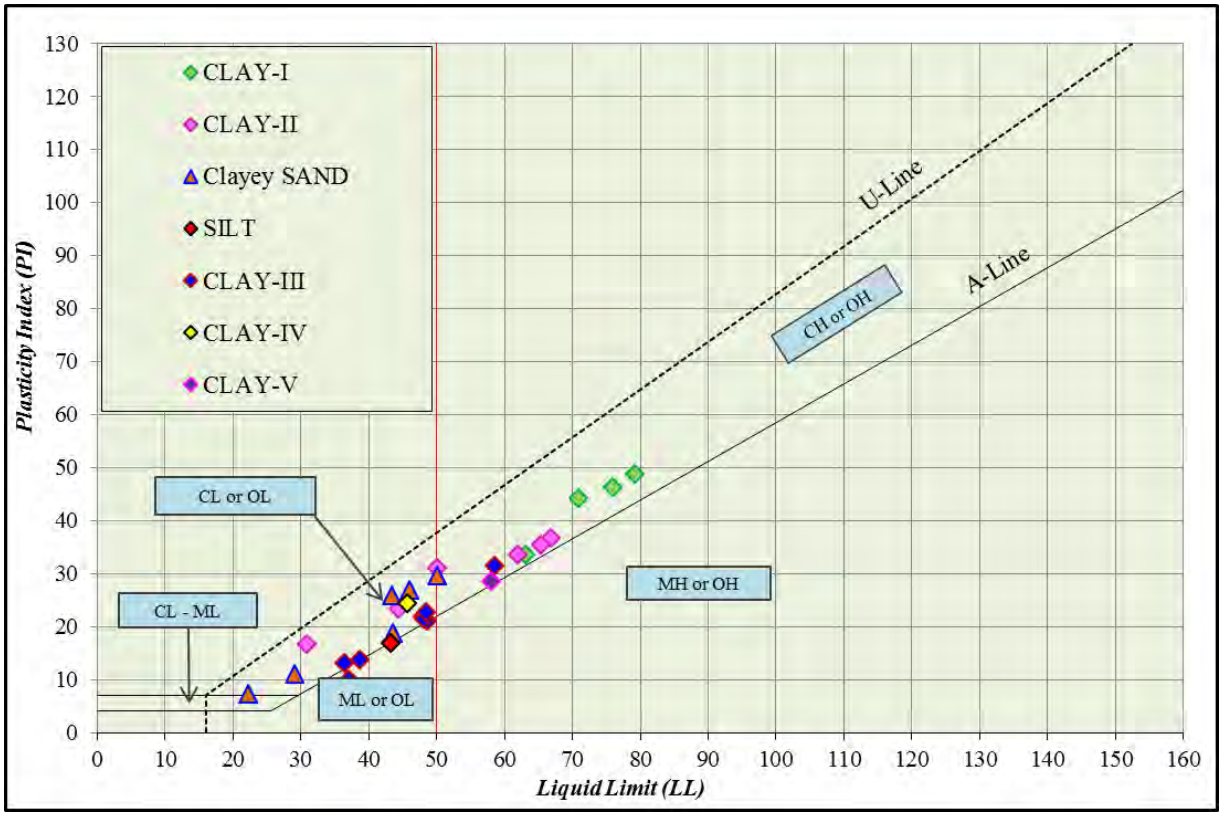


Figure - 4.6 Condition of Atterberg's Limit Test Results

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, (46) 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 Photos-4.4 and 4.5. Figure-4.7 is illustrated the grain size distribution of each soil layer versus depth in elevation. 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

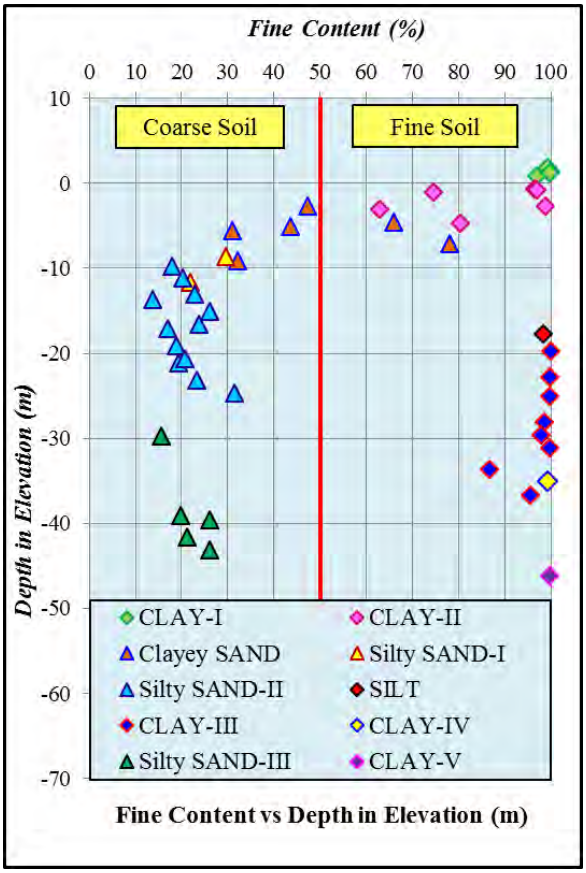


Figure - 4.7 Fine Content vs Depth in Elevation (m)

4.2 Mechanical Properties of Soil

In order to obtain the mechanical properties of soils, (14) numbers of undisturbed soil samples from three boreholes were sent to laboratory for unconfined compression test and one dimensional consolidation test.

4.2.1 Unconfined Compression Test

Total (14) numbers of undisturbed samples were carried out for unconfined compression test at office laboratory in accordance with ASTM Standard (ASTM D 2166-06). Summary of unconfined compression test results are described in Table-4.6. The relationship between the unconfined compressive strength vs their depth in elevation is presented in Figure-4.8 and that of failure strain versus depth in elevation is illustrated in Figure-4.9. Moreover, Figure-4.10 shows the deformation modulus of soil versus depth in elevation, and Figure-4.11 shows the relationship between the bulk density and depth in elevation. The detailed test results are shown in Appendix-C.

Photo - 4.6 Unconfined Compressive Strength Test

Table - 4.6 Summary of Unconfined Compression Test Results

No.	Soil Type	Unconfined Compressive Strength (kN/m^2)	Failure Strain (%)
1	CLAY-I	27.2 ~ 109.9	4.6 ~ 6.8
2	CLAY-II	38.2 ~ 66.4	5.2 ~ 15.0
3	Clayey SAND	29.6 ~ 111.7	3.7 ~ 10.0

Moreover, Deformation Modulus (E50) of soil from unconfined compression test are calculated from following formula in accordance with the standard of Japan Geotechnical Society. The summary of Modulus of Deformation and wet density are shown in Table-4.7.

$$E_{50} = \frac{(\frac{qu}{2})}{\varepsilon_{50}} \times 100$$

Table - 4.7 Summary of Deformation Modulus and Bulk Density

No.	Soil Type	Modulus of Deformation E_{50} (kN/m^2)	Bulk Density (g/cm^3)
1	CLAY-I	1446.1 ~ 3791.2	1.720 ~ 1.904
2	CLAY-II	785.6 ~ 2284.4	1.677 ~ 2.021
3	Clayey SAND	494.1 ~ 3489.9	1.866 ~ 2.078

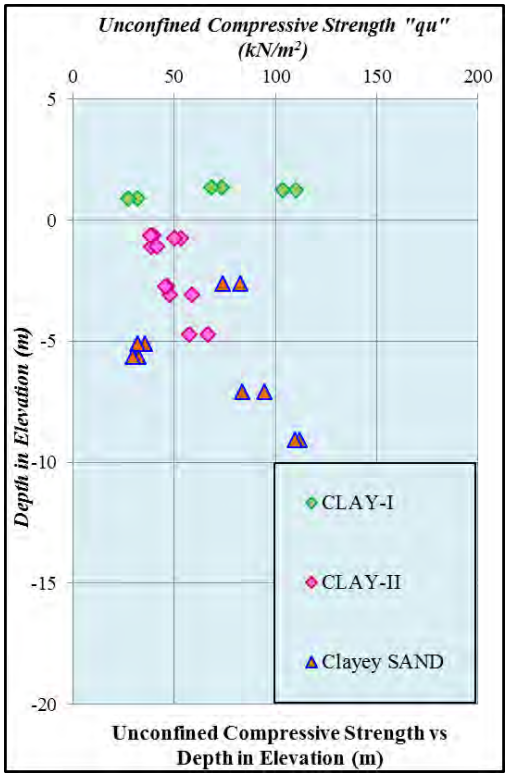


Figure - 4.8 Unconfined Compressive Strength vs Depth in elevation (m)

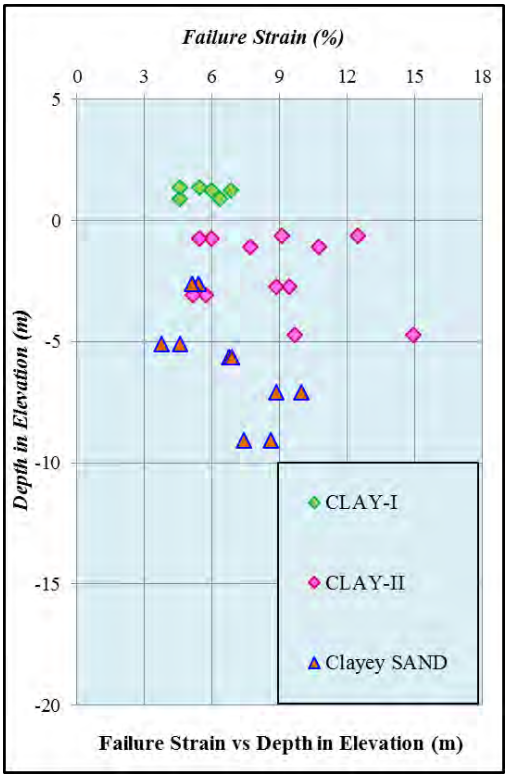


Figure - 4.9 Failure Strain vs Depth in elevation (m)

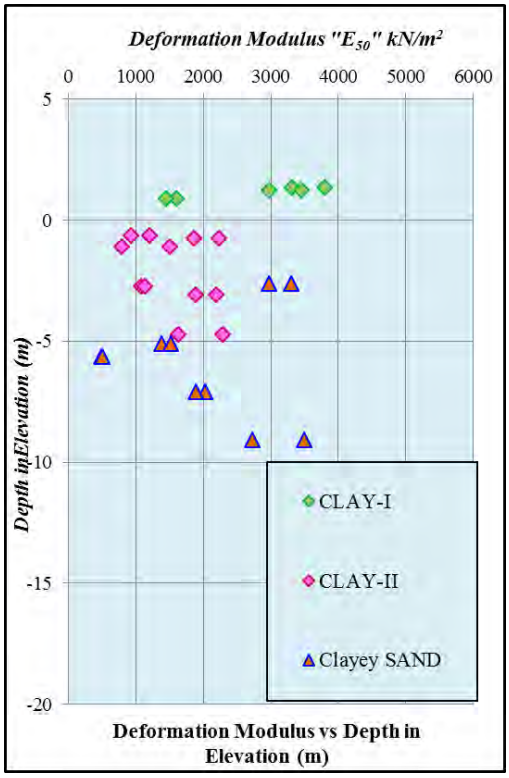


Figure - 4.10 Deformation Modulus vs Depth in elevation (m)

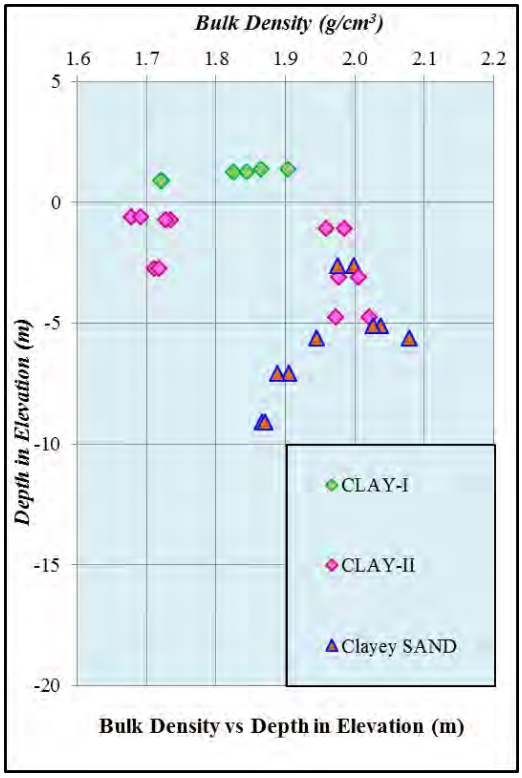


Figure - 4.11 Bulk Density vs Depth in elevation (m)

4.2.2 One Dimensional Consolidation Test

The one dimensional consolidation tests were carried out in undisturbed samples taken from the project area. There are total (8) numbers of one dimensional consolidation test were carried out in accordance with ASTM Standard (ASTM D 2435-04). Table-4.7 summarized some results of one dimensional consolidation test such as initial void ratio (e0), pre-consolidation pressure (Pc) and compression index (Cc). Figure-4.12 to Figure-4.14 indicate the relationship between (e0), (Pc) and (Cc) versus depth in elevation. Moreover, Figure-4.15 to Figure-4.17 show the e-log-P curve results from one dimensional consolidation tests of soil from the investigation area, and Figure-4.18 to Figure-4.20 show the relationship between coefficient of consolidation (Cv) versus mean consolidation pressure of that soil.

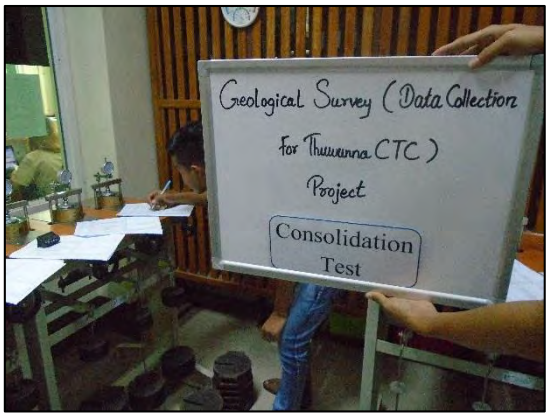


Photo - 4.7 Grain Size Distribution Test

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)
1	CLAY-I	1.040 ~ 1.450	145.9 ~ 317.4	0.302 ~ 0.425
2	CLAY-II	0.710 ~ 1.500	103.0 ~ 228.7	0.170 ~ 0.544
3	Clayey SAND	0.870 ~ 1.070	230.2 ~ 242.9	0.206 ~ 0.349

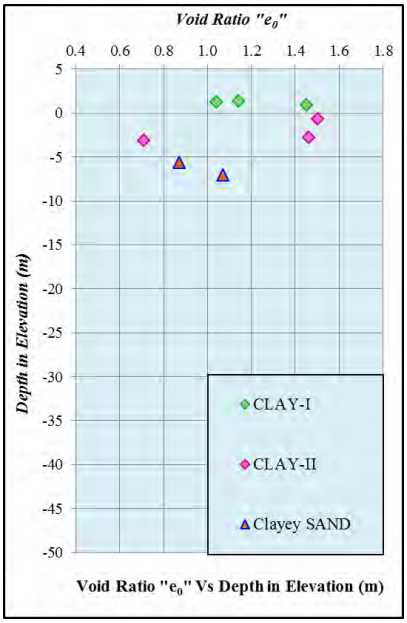


Figure - 4.12 Void Ratio vs Depth in elevation (m)

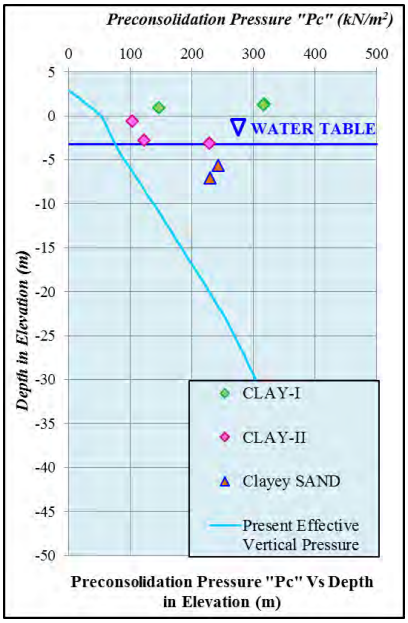


Figure - 4.13 Preconsolidation Pressure vs Depth in elevation (m)

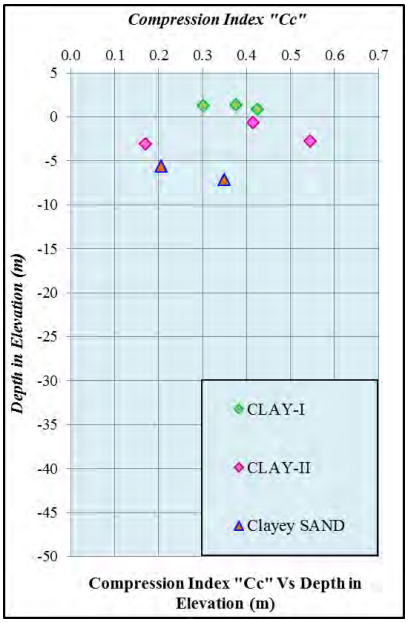


Figure - 4.14 Compression Index "Cc" vs Depth in elevation (m)

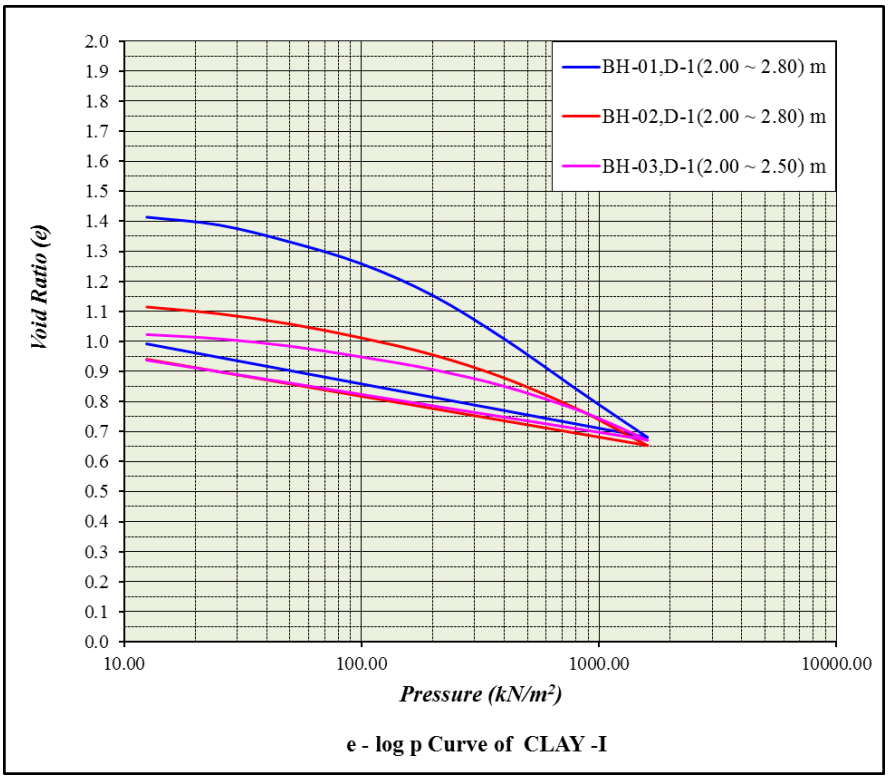


Figure - 4.15 e-log P Curve of CLAY-I

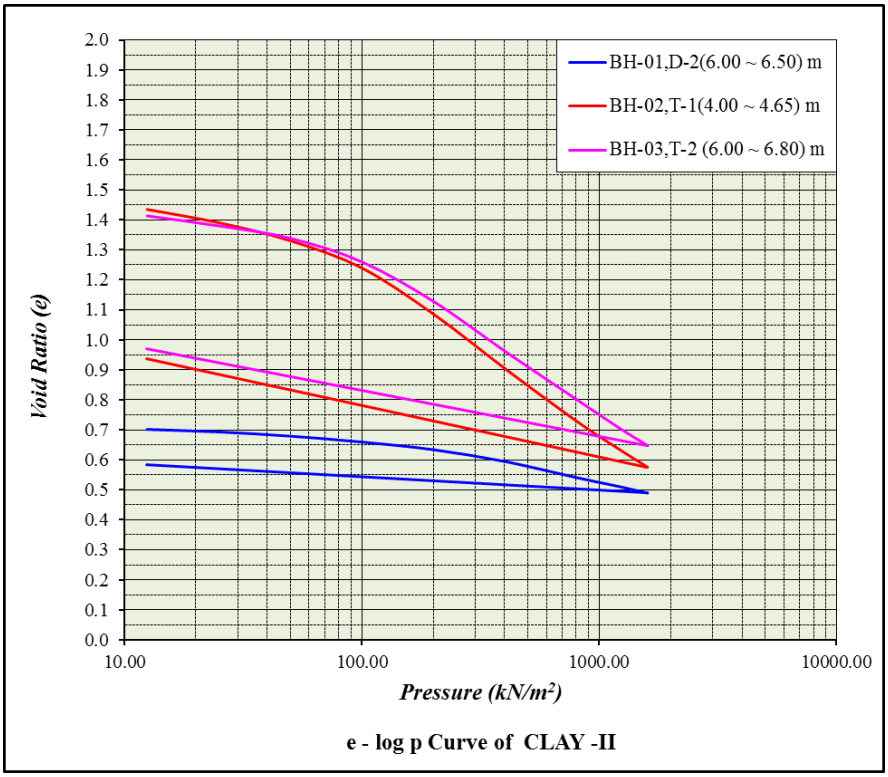


Figure - 4.16 e-log P Curve of CLAY-II

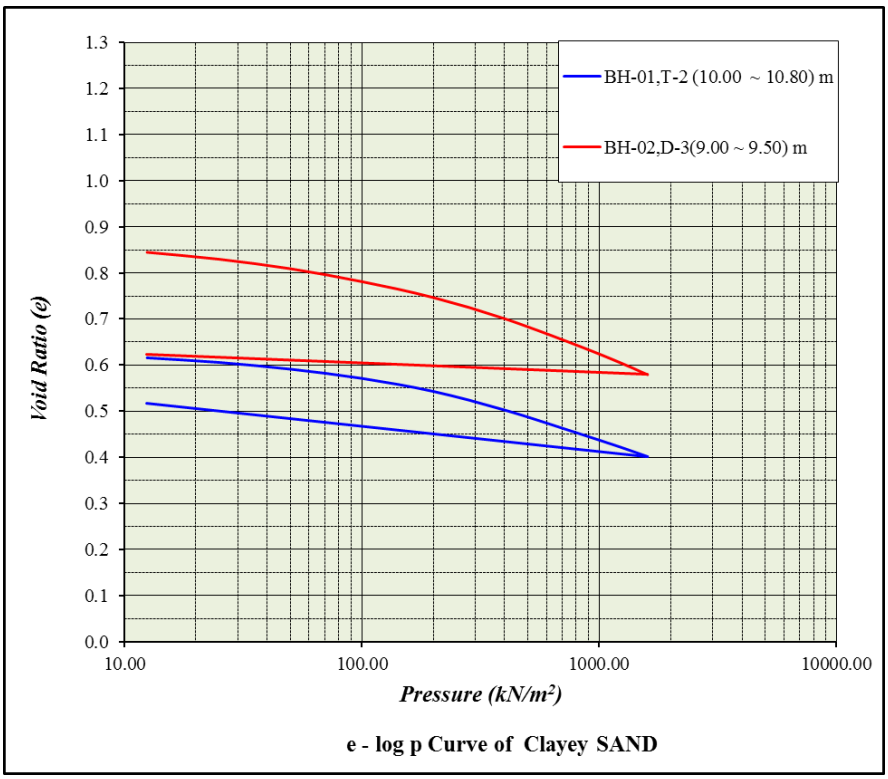


Figure - 4.17 e-log P Curve of Clayey SAND

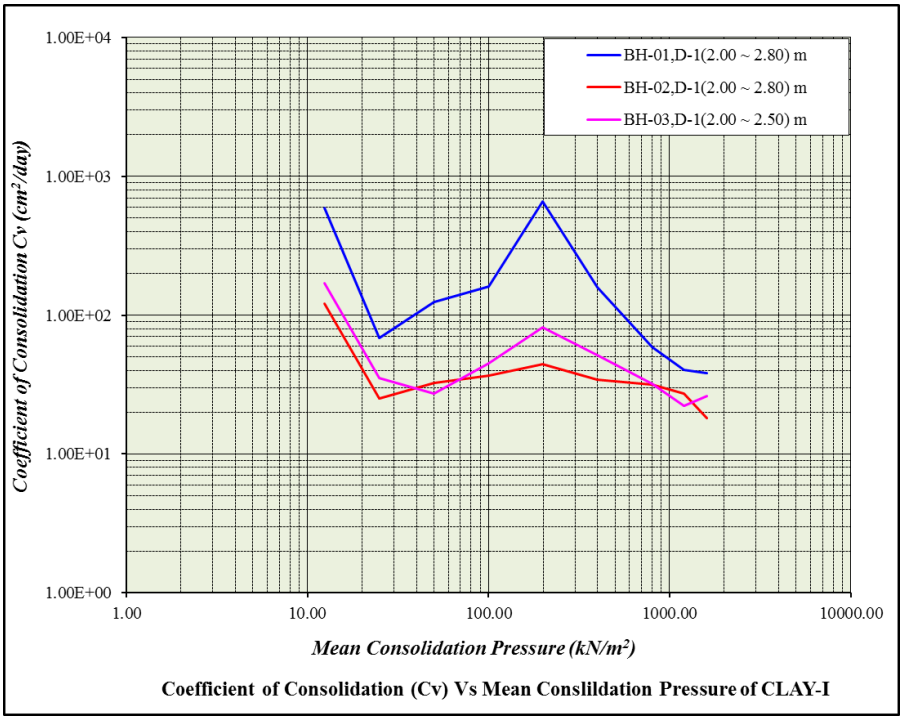


Figure - 4.18 Coefficient of consolidation (Cv) vs mean consolidation pressure of CLAY-I

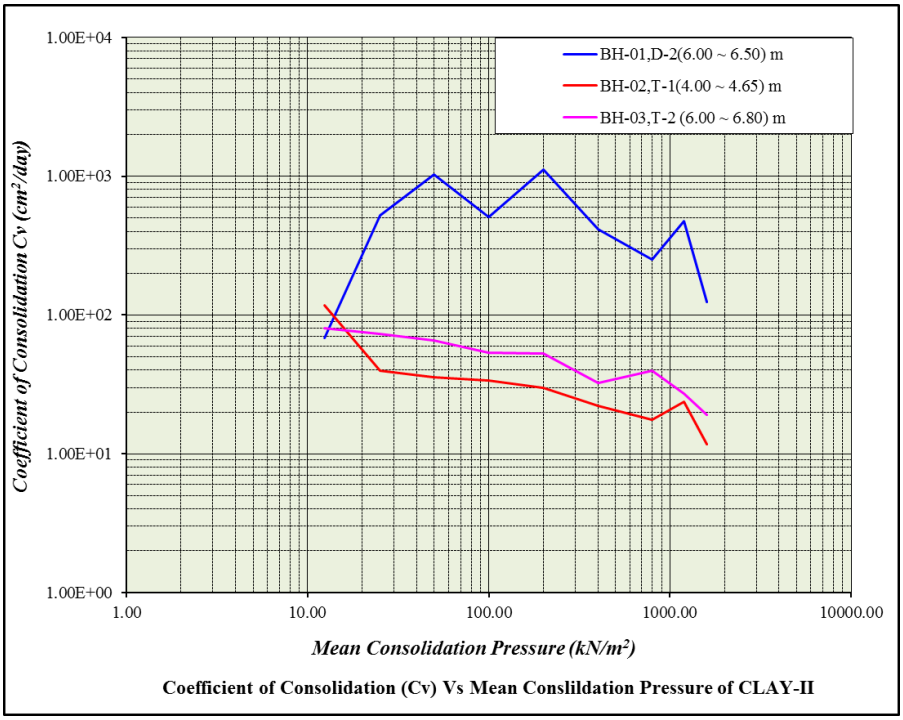


Figure - 4.19 Coefficient of consolidation (Cv) vs mean consolidation pressure of CLAY-II

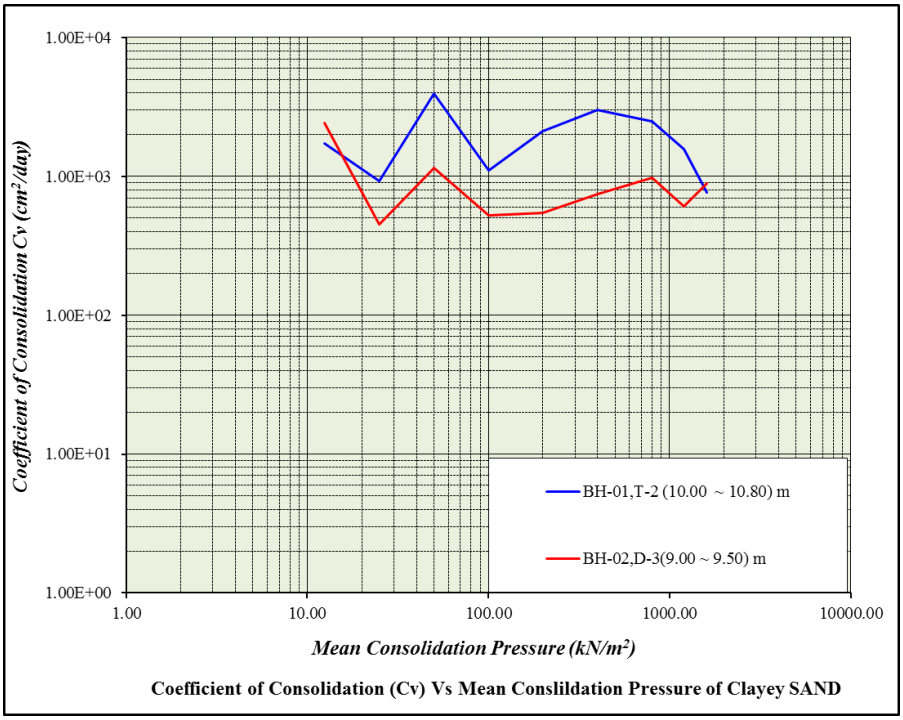


Figure - 4.20 Coefficient of consolidation (Cv) vs mean consolidation pressure of Clayey SAND

5 GEOTECHNICAL ASSESEMENT

5.1 Setting of geotechnical design parameters

The geotechnical parameters are set up by the results of field testing and laboratory testing. Some of the design parameters cannot be evaluated directly neither from field tests nor laboratory tests due to the unfavorable nature of deposits or investigation methods. However, some parameters can be evaluated from the reference formulas by using SPT N-values, and sometimes referred from standard of Nippon Expressway Company Limited (hereinafter called "NEXCO").

(1) Unit weight of soil (γ_t)

Unit weight of soil (γ_t) can be obtained from laboratory test as Bulk density in case of taking undisturbed sample. For the case of non-taking undisturbed sample, unit weight of soil (γ_t) is referred to Table-5.1. Moreover, unit weight of soil (γ_t) can be evaluated from the following formula.-

$\gamma_t = (G_s\gamma_w (1 + w) / (1 + e)$ --- *Braja M. Das, Principles of Foundation Engineering Seventh Edition*

(2) Saturated unit weight of soil (γ_{sat})

Saturated unit weight of soil (γ_{sat}) can be obtained from laboratory test as Bulk density in case of taking undisturbed sample. For the case of non-taking undisturbed sample, saturated weight of soil (γ_{sat}) is referred to Table-5.1 and also can be evaluated from the following formula.-

$\gamma_{sat} = (G_s\gamma_w + e\gamma_w) / (1 + e)$ --- *Braja M. Das, Principles of Foundation Engineering Seventh Edition*

Where- γ_{sat} = saturated unit weight of soil (kN/m^3)

γ_w = unit weight of water (kN/m^3)
G_s = specific gravity of soil
w = water content
e = void ratio of soil (e = wG_s for saturated clayey soil)

Remarks; *This formula can be used only under groundwater level and clayey soil.*
G_s and w can be obtained from laboratory tests results of collected "Disturbed Samples".

(3) Effective unit weight of soil (γ')

The effective unit weight of soil under water table can be evaluated from the equation-

$\gamma' = \gamma_t - \gamma_w$ for Clay/Silt --------- Japanese Code

$\gamma' = \gamma_t - 9.0$ for Sand/Gravel --------- Japanese Code

Where-

γ' = effective unit weight of soil (kN/m^3)
γ_w = unit weight of water (kN/m^3)

Table - 5.1 Recommended Soil Parameter by NEXCO*

Soil Type		Condition of Soil		Bulk Density γt (tf/m^3)	Internal Friction Angle φ (°)	Cohesion Cu (tf/m^2)	Remarks (Soil Name)
Fill Material	Gravel Gravelly Sand	Compacted one.		2.0	40	0	(GW), (GP)
	Sand	Compacted one.	Well graded one.	2.0	35	0	(SW), (SP)
			Poor graded one.	1.9	30	0	
	Silty Sand Clayey Sand	Compacted one.		1.9	25	Less than 3	(SM), (SC)
	Silt, Clay	Compacted one.		1.8	15	Less than 5	(ML), (CL) (MH), (CH)
	Kanto Loam	Compacted one.		1.4	20	Less than 1	(VH)
Natural Ground	Gravel	Dense or Well graded one.		2.0	40	0	(GW), (GP)
		Not dense and Poorly graded one.		1.8	35	0	
	Gravelly Sand	Dense one.		2.1	40	0	(GW), (GP)
		Not dense one.		1.9	35	0	
	Sand	Dense or Well graded one.		2.0	35	0	(SW), (SP)
		Not dense and Poorly graded one.		1.8	30	0	
	Silty Sand Clayey Sand	Dense one.		1.9	30	Less than 3	(SM), (SC)
		Not dense one.		1.7	25	0	
	Sandy Silt Sandy Clay	Stiff one.		1.8	25	Less than 5	(ML), (CL)
		Firm one.		1.7	20	Less than 3	
		Soft one.		1.6	15	Less than 1.5	
	Silt Clay	Stiff one.		1.7	20	Less than 5	(CH), (MH), (ML)
		Firm one.		1.6	15	Less than 3	
		Soft one.		1.4	10	Less than 1.5	
	Kanto Loam	---		1.4	5	Less than 3	(VH)

: Reference value of Silty SAND-I, II, III, and SILT, CLAY-III, IV, V

*Nippon Expressway Company Limited

(4) Cohesion strength (c)

The cohesive strength, also known as undrained shear strength of cohesive soil is normally evaluated from the unconfined compression test. The cohesive strength (c) can be derived from-

$c = q_u / 2$ (kN/m^2) ---- *Braja M. Das, Principles of Foundation Engineering Seventh Edition*

Where-

c = cohesive strength (kN/m^2)

q_u = unconfined compressive strength (kN/m^2)

However, undrained cohesive strength can also be determined from direct shear test (for reference) and unconsolidated undrained triaxial compression test of undisturbed soil samples.

For sandy soil and hard clayey soil, as the undisturbed sample cannot be easily collected, the cohesive strength can be reliably derived from SPT N-value as following equation –

$c = 50N/8$ (kN/m^2) ---------- *(Terzaghi and Peck)*

The relation of SPT N-value and unconfined compressive strength (q_u) is illustrated in Figure-5.1.

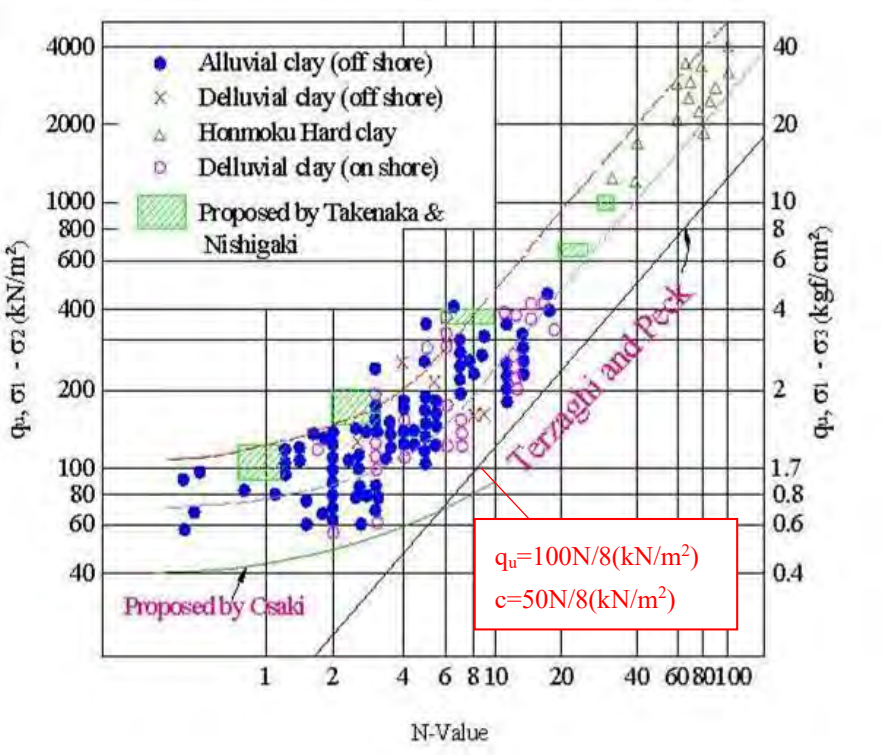


Figure - 5.1 Empirical Relation of N-value and Unconfined Compressive Strength for Clay

(5) Internal friction angle (ϕ)

The internal friction angle of the granular soil can be directly evaluated from the SPT N-value. The internal friction angle of granular soils is evaluated from their average SPT N-value, in accordance with Figure-5.2. The internal friction angle of such deposits can be also evaluated from equation and the recommended design parameters by NEXCO (See Table-5.1). In case of granular soil, the internal friction angle of soil is estimated from following equation- (Refer to Figure-5.2)

$$\emptyset = \sqrt{20N} + 15 \qquad \text{--------- ② } \textit{in Figure: From Osaki, 1979)}$$

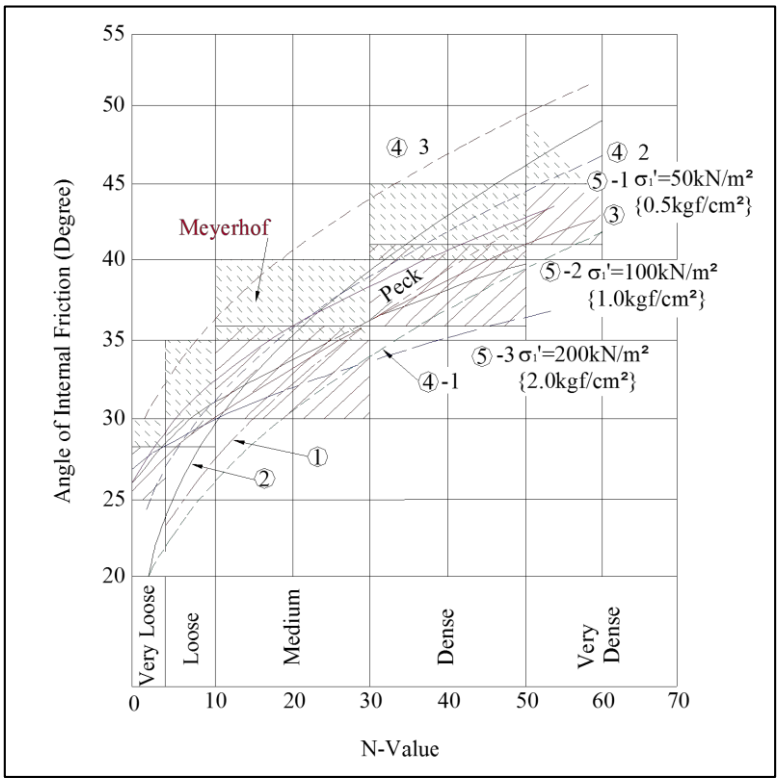


Figure - 5.2 Empirical Relations between N-value and Internal Friction Angle for Sand

(6) Deformation modulus of soil (E)

The deformation modulus of cohesive soil is usually evaluated from the unconfined compression test. For sandy soil and hard clayey soil, as the undisturbed sample cannot be easily taken, the deformation modulus of soil can be evaluated by following equation -

$$E = 700N \text{ (kN/m}^2\text{)} \qquad \text{--------- } \textit{Japanese Code}$$

Where-

E = Deformation modulus of soil (kN/m^2)

N = Number of SPT N-value (measured)

Recommended geotechnical design parameters

Figure-5.3 to Figure-5.6 show the laboratory soil test results and field test results.

Figure-5.7 to Figure-5.12 show the consolidation test results.

Table-5.2 shows the recommended geotechnical design parameters.

Table - 5.2 Recommended geotechnical design parameters

No.	Soil Name	N-Value Average	Unit Weight			Internal Friction Angle	Unconfined Compressive Strength	Cohesive Strength	Deformation Modulus
			γ_t (kN/m^3)	γ_{sat} (kN/m^3)	γ' (kN/m^3)	φ (°)	qu (kN/m^2)	c (kN/m^2)	E_{50} (kN/m^2)
1	CLAY-I	5	18.0[1)]	18.0	8.0	-	70[1)]	35[4)]	3000[1)]
2	CLAY-II	2	17.0[1)]	17.0	7.0	-	50[1)]	25[4)]	1800[1)]
3	Clayey SAND	4	18.5[1)]	19.5	9.5	22[3)]	-	-	2000[1)]
4	Silty SAND-I	8	17.0[2)]	18.0	8.0	27[3)]	-	-	
5	Silty SAND-II	17	18.0[2)]	19.0	9.0	33[3)]	-	-	
6	SILT	22	17.0[2)]	17.0	7.0	-	-	138[3)]	15400[3)]
7	CLAY-III	15	17.0[2)]	17.0	7.0	-	-	90[3)]	10500[3)]
8	CLAY-IV	22	17.0[2)]	17.0	7.0	-	-	137[3)]	15400[3)]
9	Silty SAND-III	50	19.0[2)]	20.0	10.0	45[3)]	-	-	-
10	CLAY-V	16	17.0[2)]	17.0	7.0	-	-	100[3)]	11200[3)]

1) These values were set up by field test or soil laboratory test result.
2) These values were set up by the reference value shown in NEXCO.
3) These values were set up by formula of SPT N-value.
4) These values were set up by formula.

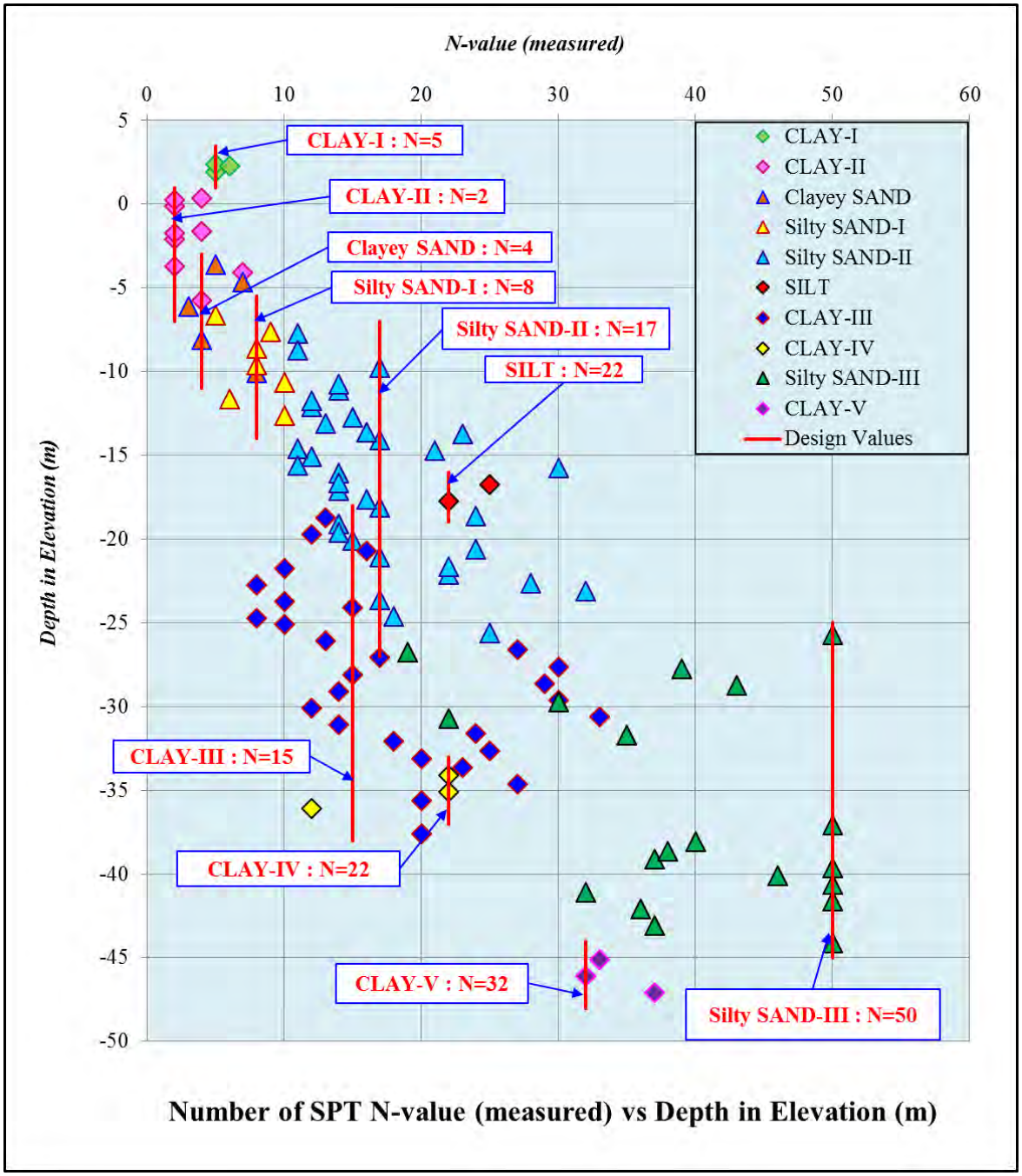


Figure - 5.3 Distribution of SPT N-values

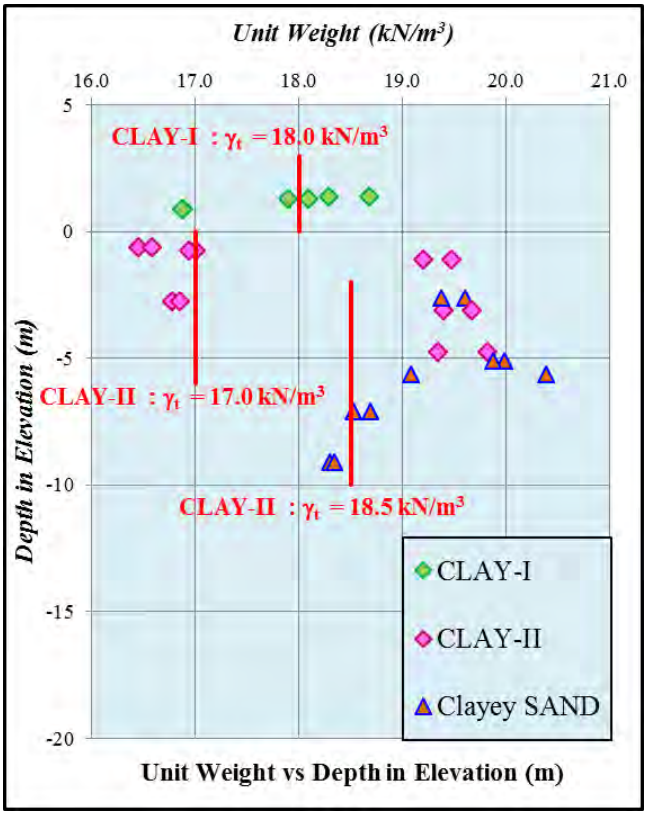


Figure - 5.4 Distribution of Unit Weight

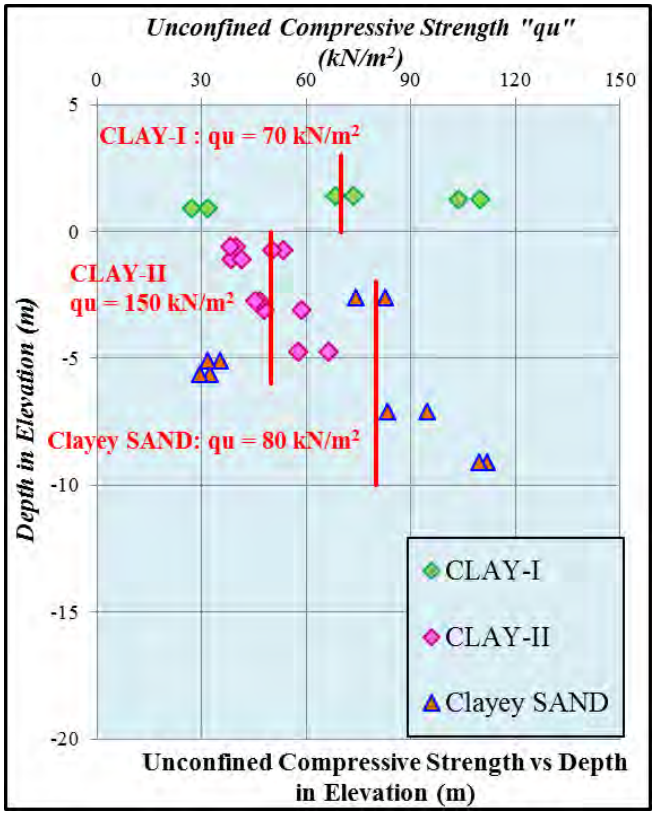


Figure - 5.5 Distribution of Unconfined Compression Strength

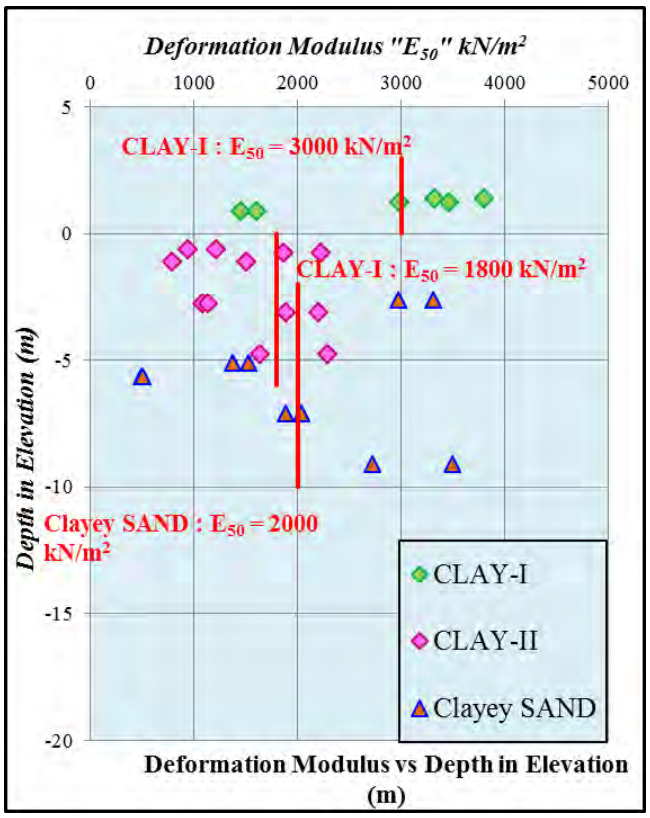


Figure - 5.6 Distribution of Deformation Modulus

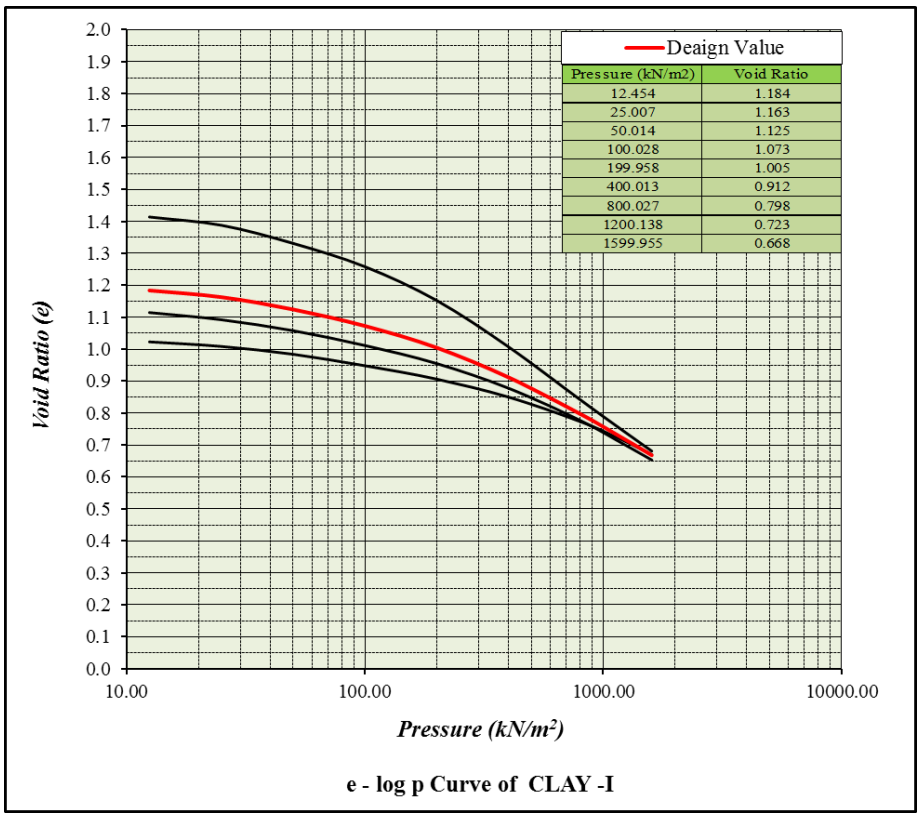


Figure - 5.7 e – log p Curve of CLAY-I Layer

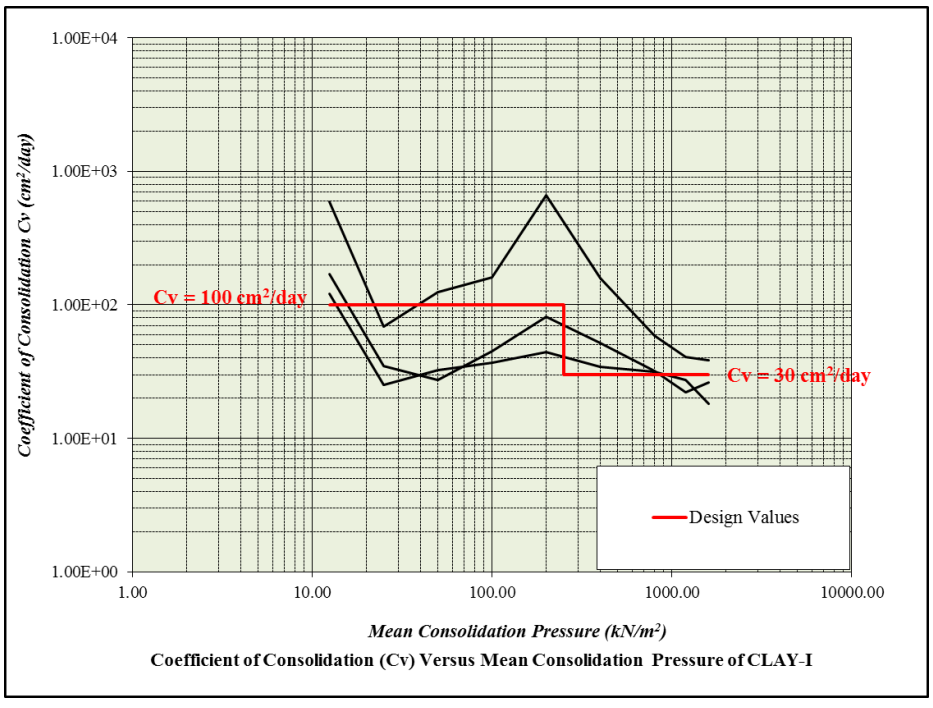


Figure - 5.8 log Cv – log P Curve of CLAY-I Layer

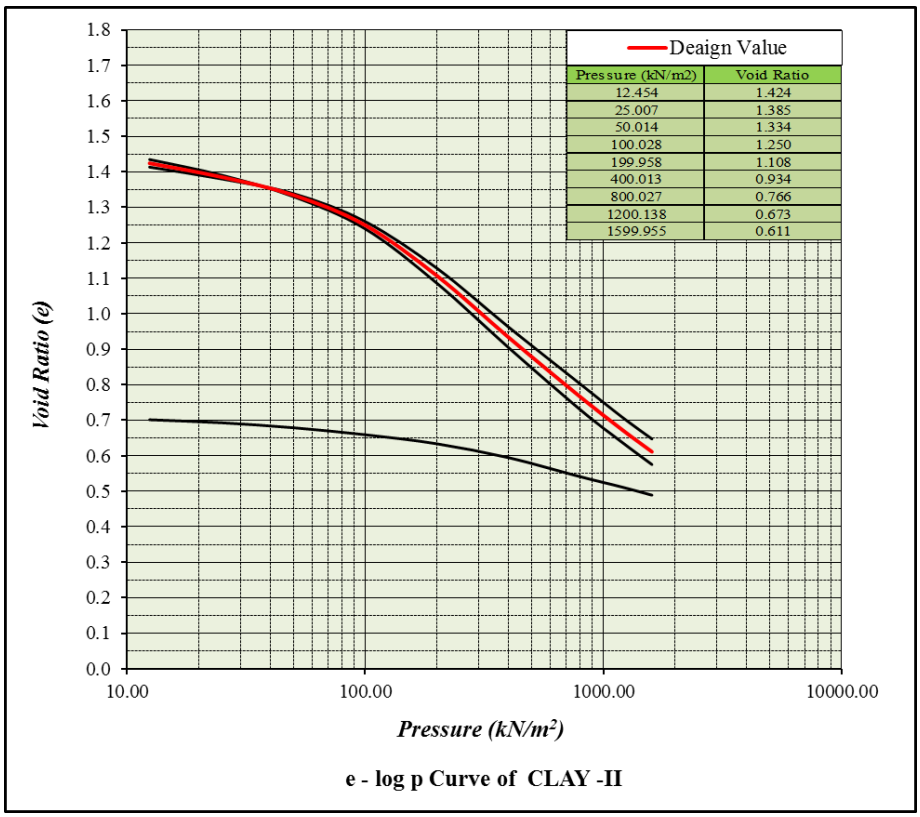


Figure - 5.9 e – log p Curve of CLAY-II Layer

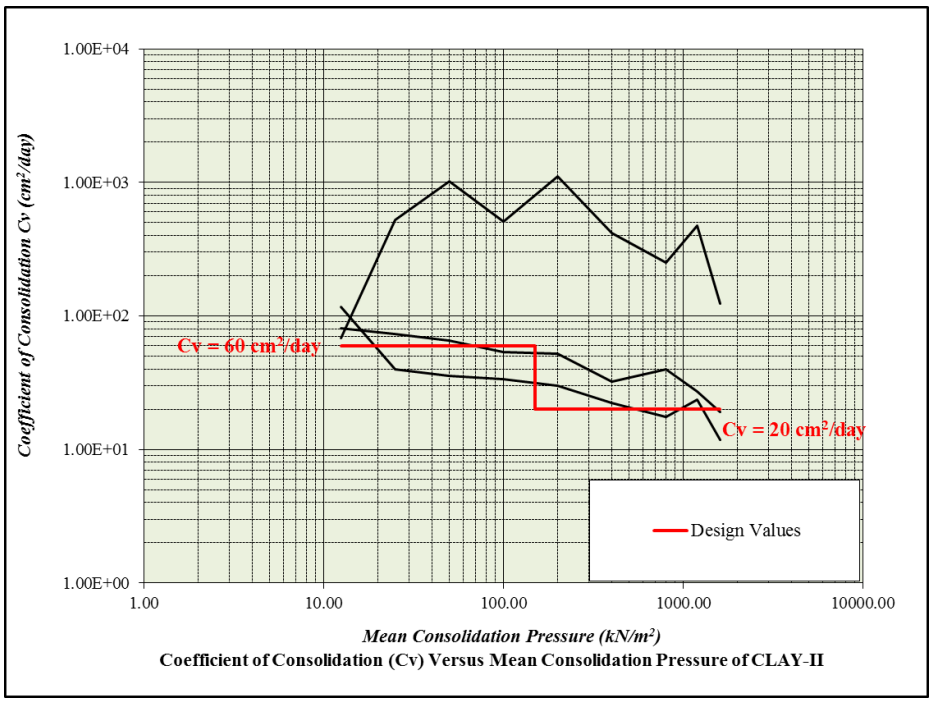


Figure - 5.10 log Cv – log P Curve of CLAY-II Layer

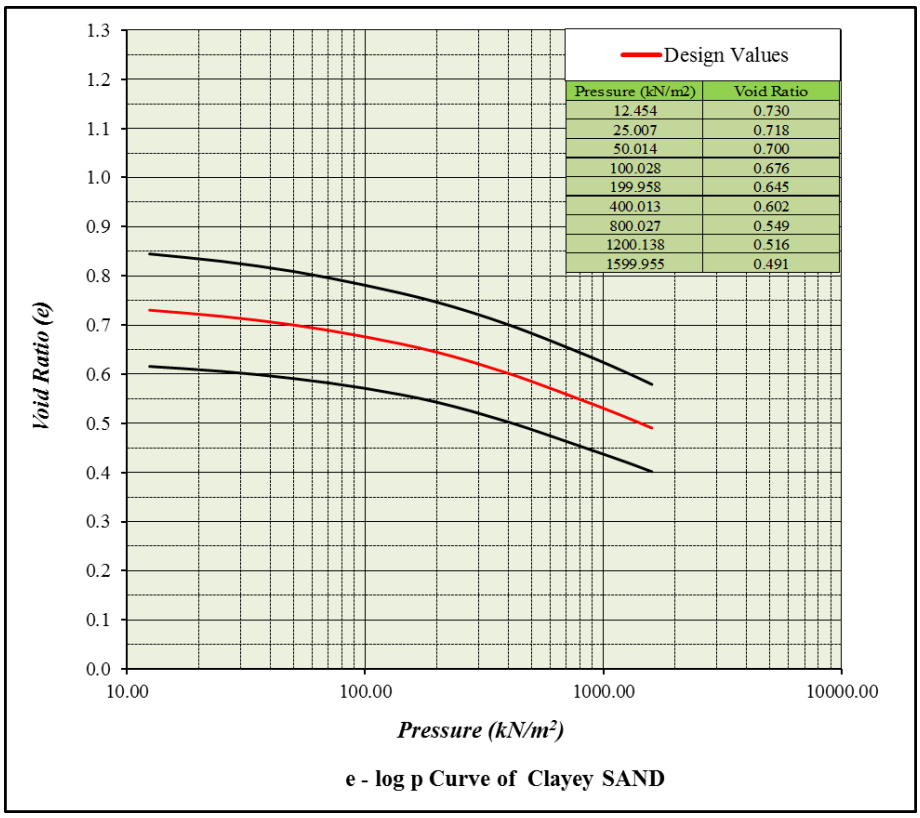


Figure - 5.11 e – log p Curve of CLAY-III Layer

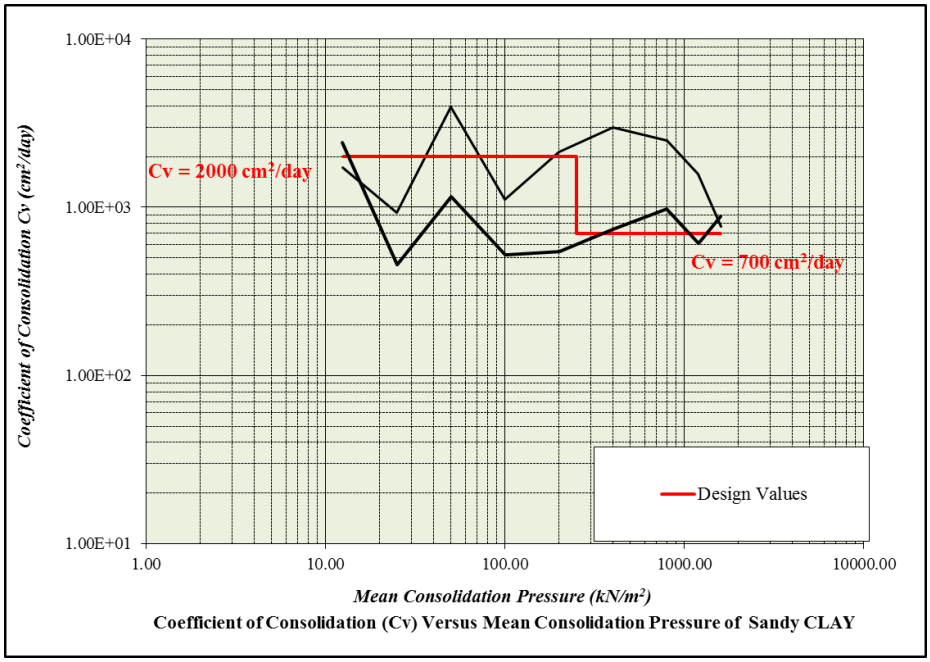


Figure - 5.12 log Cv – log P Curve of CLAY-III Layer

5.2 Examination for Consolidation Settlement

According to the investigation results, clayey soil layers are well observed from the top soil layer and second sub-soil layer in this project area. Therefore, the consolidation settlement should be considered for future construction project. Base on the soil profile, the reference borehole is selected BH-01 at nearly center of the project area. In this calculation, consolidation settlement of embankment is calculated for Clay-I and Clay-II layer. And then, embankment thickness is assumed to be 3 cases, 1.0m, 2.0m and 3.0m.

For (BH-01) Calculation model

The top sub-soil layer is firm CLAY-I layer with the thickness 3.0m. Second sub-soil layer is very soft to firm CLAY-II layer with the thickness 5.0m.

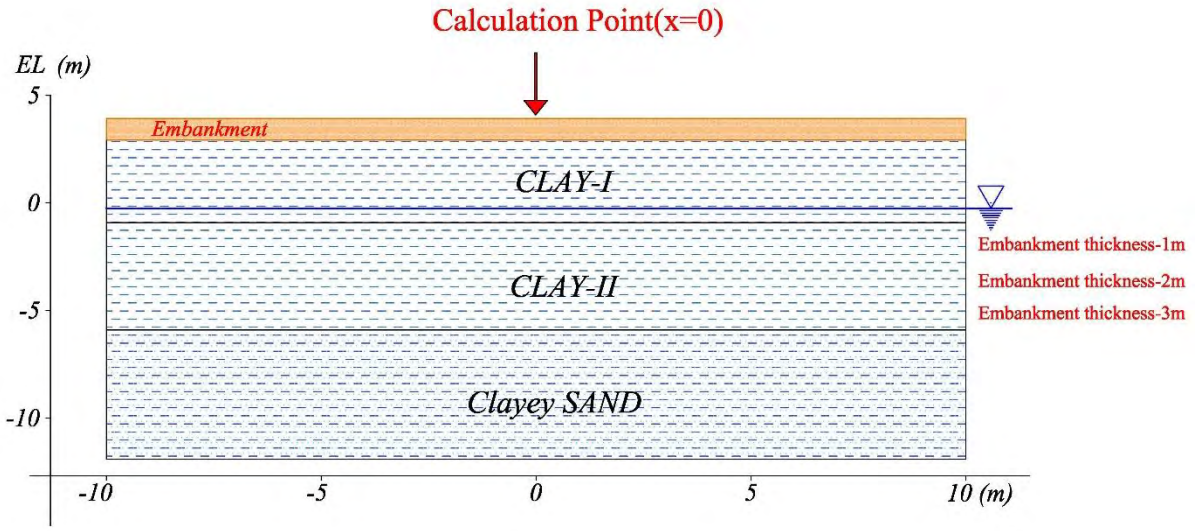


Figure - 5.13 Calculation Model

5.2.1 Calculation Method of Consolidation Settlement

The calculation method of consolidation settlement has the following three kinds;

- e method (Calculation by relationship between void ratio and consolidation pressure)

$$S = \frac{e_0 - e_1}{1 + e_0} \cdot H$$

- Cc method (Calculation by relationship between compression index, initial effective Stress and increasing stress)

$$S = \frac{Cc}{1 + e_0} \cdot log \frac{p_0 + \Delta p}{p_0} \cdot H$$

- m_v method (Calculation by relationship between coefficient of volume compressibility and increasing stress)

$$S = m_v \cdot \Delta p \cdot H$$

Here;

S	: Total Settlement (m)
e_0	: Initial Void Ratio
e_1	: Void Ratio after Increasing Strength
H	: Thickness of Consolidation Layer (m)
Cc	: Compression Index
p_0	: Initial Effective Stress (kN/m^2)
p_1	: Increasing Effective Stress (kN/m^2)
m_v	: Coefficient of Volume Compressibility (m^2/kN)

Since the result of Cc method is influenced by setting of yield stress, this method tends to come out of individual difference. Although mv method can take exact result for small settlement, it tends to take a calculation error in large consolidation settlement. The e method is calculable in consideration of each stress state. Therefore, the e method was selected in this examination.

(1) Calculation for Time and Settlement Relation

It usually takes time for clay layer to dissipate the excess pore water pressure generated with overburden load due to very small permeability. Therefore, the relation between time and consolidation settlement is important to plan the consolidation schedule.

Time and consolidation settlement relation for clay layer are calculated with Terzaghi's theory. In case that there are variation of soil properties with depth in clay layers, it is dealt with as multi-clay layers in settlement calculation.

Terzaghi's one-dimensional consolidation theory is used for the calculation of time and settlement relation as water in clay flows in vertical as shown in Figure-5.14.

Those equations are shown as follows;

$S_t = U \cdot S_f$

$$U = 1 - \frac{8}{\pi^2} \cdot \sum_{n=0}^{\infty} \frac{1}{(2n+1)^2} \cdot \exp\left\{ -\left(\frac{2n+1}{2} \cdot \pi\right)^2 \cdot T_v \right\}$$

$$T_V = \frac{c_v \cdot t}{D^2}$$

Here;

St : Settlement at time t (m)

S_f : Final settlement (m)

U : Cosolidation degree (%)

T_v : Time factor

C_v : Coefficient of consolidation （cm^2/day）

t : Time (day)

D : Length of drainage (cm)

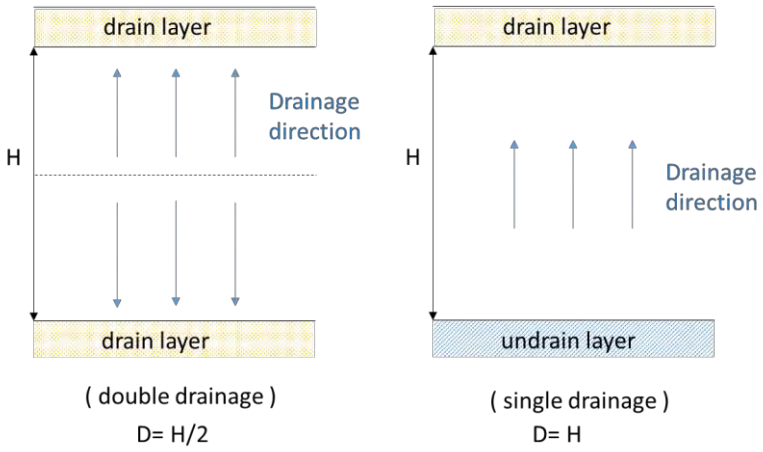


Figure - 5.14 Schematic Diagram of One-dimensional Consolidation

In this calculation for consolidation degree, equivalent layer thickness method is used as follows;

Among the Cvs for clay layers, any C_{V3} is selected as a representative Cv. Then it is dealt with as one clay layer with C_{V3} and thickness of H_0 as shown in the following formula.

$$H_0 = H_1\sqrt{\frac{C_{V3}}{C_{V1}}} + H_2\sqrt{\frac{C_{V3}}{C_{V2}}} + H_3$$

This formula shows a sample case like the clay layers as shown in Figure-5.15.

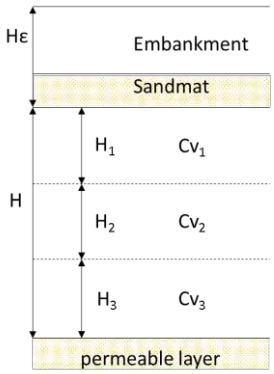


Figure - 5.15 Sample of Clay Layers with Cvi and Hi for Consolidation

5.2.2 Calculation Condition

In this calculation, the e-method is used with parameters of unit weight, e-log P curve and Cv-P curve for each clayey soil layer are necessary. Therefore, the all necessary parameters are described in Section 5.1.

In this calculation, the reference borehole is selected BH-01. The assumed embankment thickness is (1.0m, 2.0m and 3.0m). Moreover, the groundwater level was set EL: +2.91m (Ground water level -3.10m). Figure-5.14 to Figure-5.16 show the calculation model of each embankment thickness.

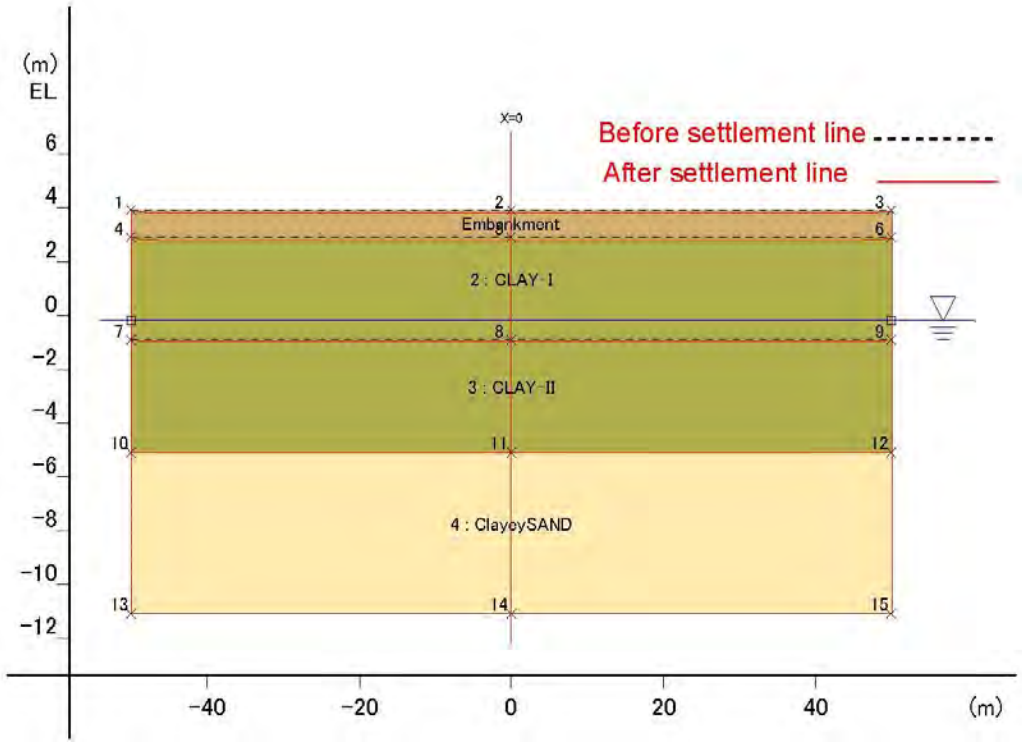


Figure - 5.16 Embankment thickness 1.0m Model

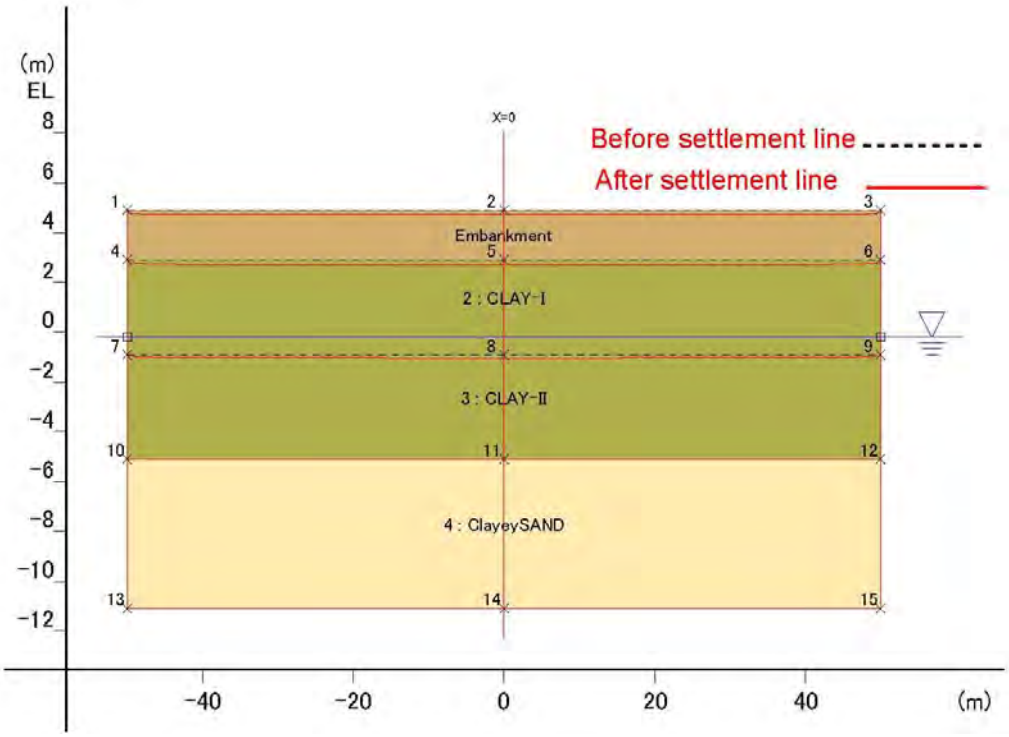


Figure - 5.17 Embankment thickness 2.0m Model

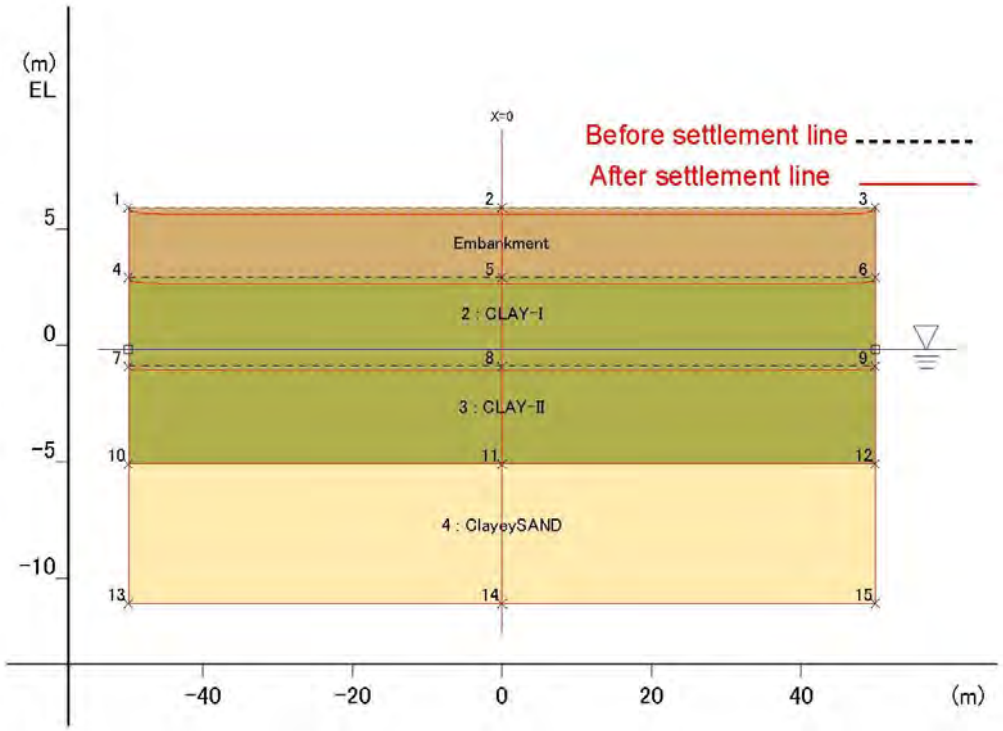


Figure - 5.18 Embankment thickness 3.0m Model

Moreover, stress dispersion was considered in this calculation because embankment is restricted area. Stress dispersion used following formula of Boussinesq;

Formula of stress dispersion for line load:

$$\sigma_y = \frac{3q}{\pi} y^3 \int_0^a \int_0^b \frac{1}{(x^2 + y^2 + z^2)^{3/2}} dxdz$$

$$= \frac{q}{2\pi} \left\{ \frac{aby(a^2 + b^2 + 2y^2)}{(a^2 + y^2) \cdot (b^2 + y^2)\sqrt{a^2 + b^2 + y^2}} + sin^{-1} \frac{ab}{\sqrt{a^2 + y^2}\sqrt{b^2 + y^2}} \right\}$$

$$= \frac{q}{2\pi} \left\{ \frac{mn}{\sqrt{m^2 + n^2 + 1}} \cdot \frac{m^2 + n^2 + 2}{(m^2 + 1)(n^2 + 1)} + sin^{-1} \frac{mn}{\sqrt{(m^2 + 1)(n^2 + 1)}} \right\}$$

where; $m = {}^{a}/_{y}, n = {}^{b}/_{y}$

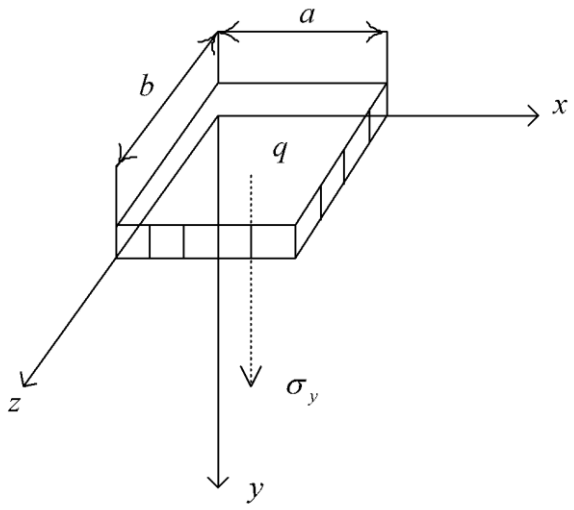


Figure - 5.1 Stress Dispersion of Rectangular Load

5.2.3 Examination Result of Consolidation Settlement

The calculation of consolidation settlement was carried out at the center of the model. The summary total settlement for each thickness of embankment calculation results are shown in Table-5.3. The relationship between settlement and times for each thickness of embankment calculation results are shown in Figure-5.19. The detailed calculation sheets are shown in Appendix-F.

.

Table - 5.3 Summary of consolidation settlements for each Embankment thickness

BH No.	Total Settlement (cm)	Embankment Thickness(m)
BH-01	11.0	1.0
	20.0	2.0
	29.0	3.0

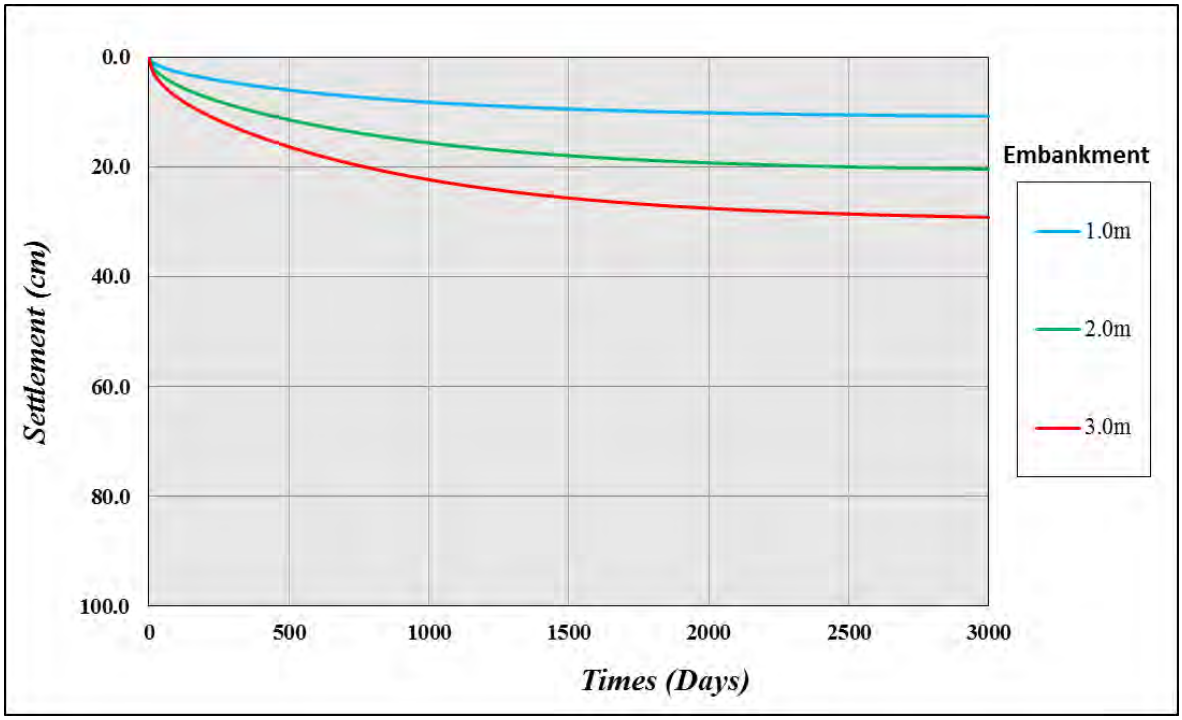


Figure - 5.19 The relationship between settlement and time of each embankment thickness

5.3 Earthquake Consideration

By the global scope of geology, Myanmar lies in one of the great earthquake provinces called the Alpine Earthquake Belt. Therefore, minor to catastrophic earthquakes has occurred many times in the territory of Myanmar since long ago. The central and eastern part of Myanmar lies on the Burma Plate which has a convergent boundary with Indian Plate in the western most part of Myanmar. The Burma Plate has been relatively moving 2 to 3 cm per year to the north. Due to this unstable activity of ground earthquake occurrences can expect at any time in Myanmar.

5.3.1 Earthquake Intensity of Myanmar

The origin and occurrence of earthquakes occurred in Myanmar including Yangon Region; southern part of the country can be interpreted as below.

Earthquake intensity in the area can be seen in Figure-5.20. The map is an earthquake probable intensity zoning map. The approach is mainly empirical and historical in the sense that it makes use of past seismic event and history to make educated guesses about region wide intensities in the future. It is hoped that a probabilistic seismic risk (or earthquake hazard map) on horizontal ground acceleration should be taken into account in the design.

As shown in the map, five seismic zones are demarcated and named (from low to high) Zone I (Low Zone), Zone II (Moderate Zone), Zone III (Strong Zone), Zone IV (Severe Zone), and Zone V (Destructive Zone), mainly following the nomenclature of the European Macro seismic Scale 1992. For each zone, a probable range of ground acceleration in g values and equivalent Modified Mercalli (MM) Scale classes are given. The highest intensity zone designated for Myanmar is the Destructive Zone (with probable intensity range of 0.4-0.5 g) which is equivalent to MM class IX. There are four areas in that zone; namely, Bago-Phyu, Mandalay-Sagaing-Tagaung, Putao-Tanaing, and Kale Myo-Homalin areas. The latter two, however, would not have major earthquake hazards as they are only sparsely populated. Important cities and towns that lie in Zone IV (Severe Zone, with probable intensity range of 0.3-0.4 g) are Taungoo, Taungdwingyi, Bagan-Nyaung-U, Kyaukse, PyinOoLwin, Shwebo, Wuntho, Hkamti, Haka, Myintkyina, Taunggyi, and Kung long. Yangon straddles the boundary between Zone II and Zone III, with old and new satellite towns in the eastern part in Zone III, and the original city in Zone II. Regarding the Modified Mercalli (MM) Scale classes, the level of probable damage and destruction may be summarized as in Table-5.4.

Table - 5.4 The Level of Probable Damage and Destruction

Zone	MM Class	Probable Damage	Examples of Damage
V	IX	Major damage	Considerable damage in specially designed structures Major damage in good RC buildings
IV	VIII-IX	Considerable damage	Considerable damage in good RC buildings Major damage in ordinary brick buildings
III	VIII	Moderate damage	Moderate damage in good RC buildings Considerable damage in ordinary brick buildings
II	VII	Minor damage	Minor damage in good RC buildings Moderate damage in ordinary brick buildings
I	VI	Slight damage	Minor damage in ordinary brick buildings

According to the seismic zone map of Myanmar (after Dr. Maung Thein et.al, 2005 Dec) and records of Meteorology and Hydrology Department (Yangon) the major earthquake intensities around the Yangon area is shown in Table-5.5, Figure-5.20 and Figure-5.21.

Table - 5.5 Records of the major earthquake intensities around the Yangon area

(Meteorology and Hydrology Department)Ygn

Area	**Date**	**Nearest Modified Mercalli (MM)**
Yangon	November 1620	6.0-6.5
Yangon	26 December 1644	5.5
Yangon	6 May 1652	5.0-5.5
Yangon	December 1664	5.5
Yangon	13 June 1768	5.0-5.5
Yangon	23 August 1864	4.5
Yangon	23 July 1884	4.5-5.0
Yangon	10 October 1888	5.5
Yangon	13 December 1894	5.0
Yangon	19 August 1919	5.0
Yangon	10 September 1927	4.0
Yangon	5 May 1930	7.0-7.5
Yangon	9 February 1951	4.0-4.5
Yangon	17 August 1964	4.0
Yangon	9 February 1969	5.0
Yangon	9 September 1970	6.0-6.5
Yangon	1970-1980	4.0-6.5
Yangon	1980-1990	3.5-5.5
Yangon	1990-2000	4.0-5.5
Yangon	2000-2003	4.0-6.0
Yangon	December 2004	5.5
Yangon	2005-2017	<5.0

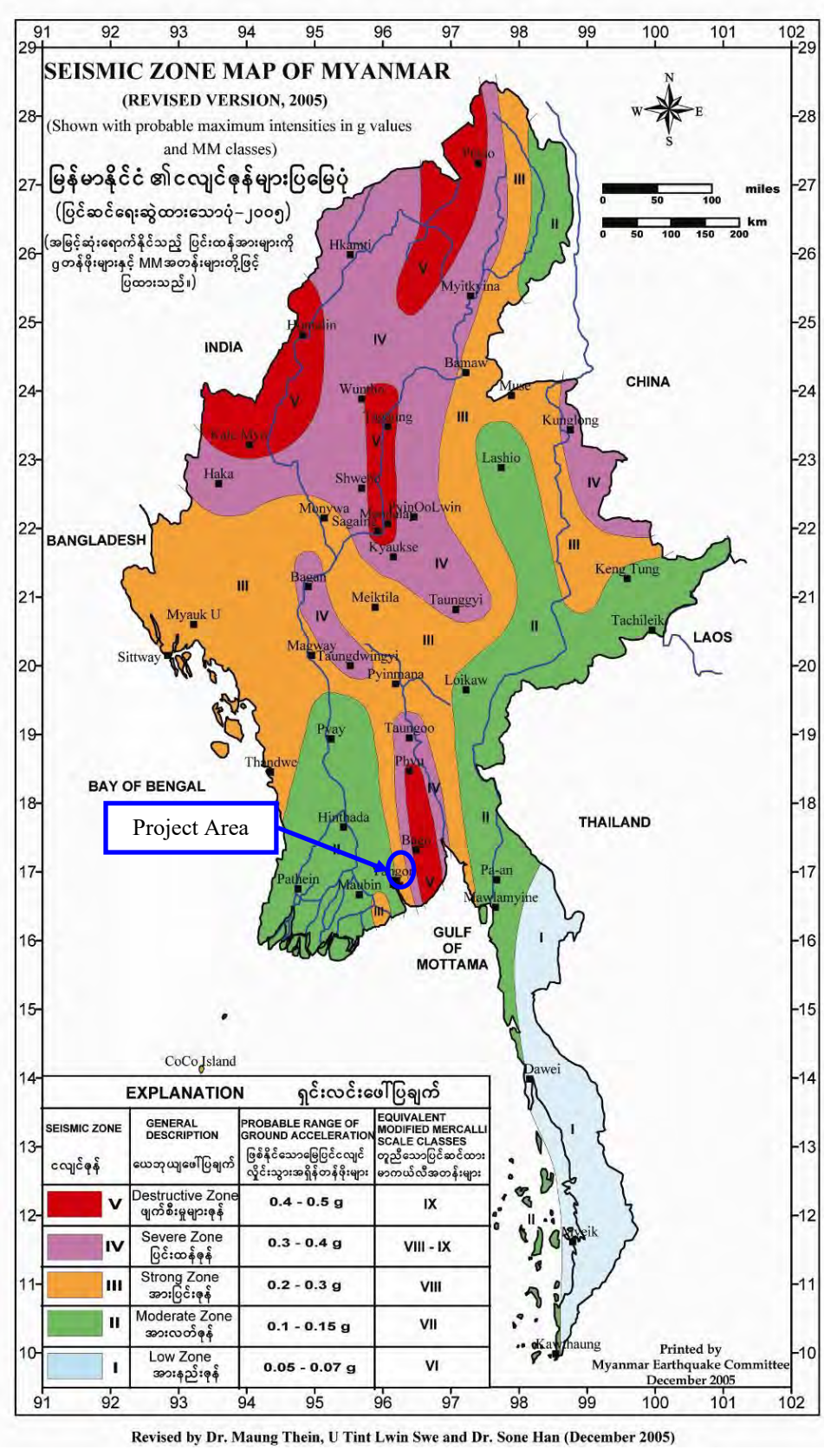
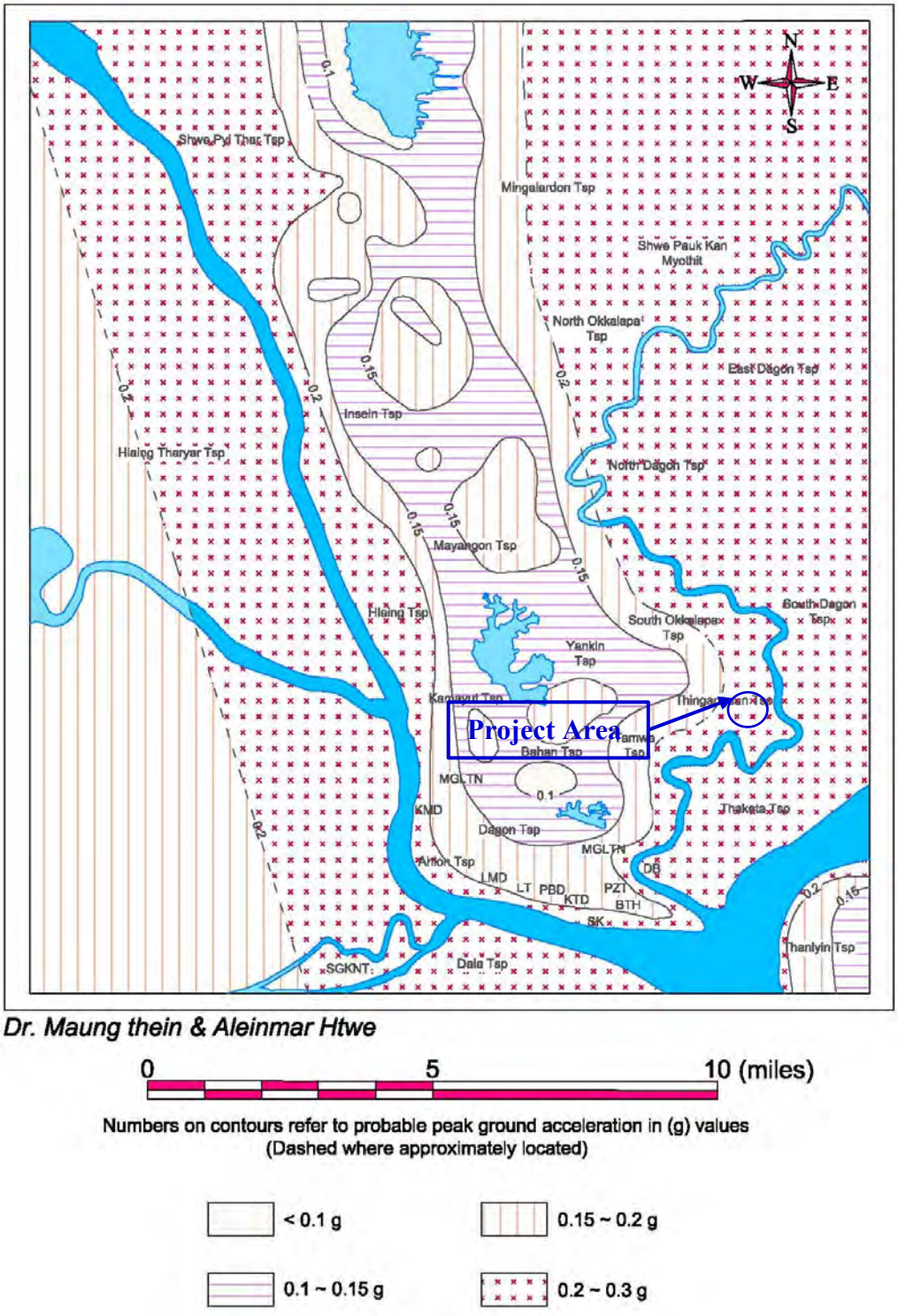


Figure - 5.20 Seismic Zone Map of Myanmar (after Dr. Maung Thein et.al, 2005 Dec)



Dr. Maung thein & Aleinmar Htwe

0 5 10 (miles)

Numbers on contours refer to probable peak ground acceleration in (g) values
(Dashed where approximately located)

< 0.1 g

0.15 ~ 0.2 g

0.1 ~ 0.15 g

0.2 ~ 0.3 g

Figure - 5.21 Earthquake Hazard Map of Yangon Area

5.3.1.1 General

Liquefaction is one of the catastrophic of earthquake related hazards. According to the investigation results, engineering properties of some soil layers have been identified as potential of liquefaction. According to the theoretical research, the quicksand is high potential to liquefaction. The term quicksand (after Terzaghi, 1925) is referred to three conditions. First the sand or silt concerned must be saturated and loosely packed. Second, on disturbance of constituents grains become more closely packed, which leads to an increase in pore water pressure, reducing the forces acting between the grains. This brings about a reduction in strength. The third condition requires that pore water cannot escape readily. This is fulfilled if the sand or silt has a low permeability and/or the seepage path is long. As the above reasons, poorly graded sand of fine to medium grained and silty sand of saturated condition have high potential to liquefaction. Liquefaction of potential quicksand may also be brought about by sudden shocks caused by the action of heavy machinery and blasting.

According to the investigation results for a lot of earthquake experience in the world, it is said that the liquefaction can occur easily under the following condition.

1) Lower fine content of saturated soil (Fine content is meant the size less than 0.07 mm)
2) Lower SPT blow count (N) of saturated soil (SPT N-value < 20 blows per 30 cm)
3) Shallow groundwater table
4) Bigger maximum peak acceleration

5.3.1.2 Liquefaction Analysis Procedure

In this analysis, magnitude of earthquake and peak acceleration at ground surface is assumed as 0.2g, and MM Class is 7.5 in this area. And, water table is actual water level from investigation results.

Liquefaction analysis is performed by the method presented by “Architectural Foundation Design Guideline” (Japan Architectural Association) as follows.

1) Object Soil Layers for Liquefaction Analysis

(a) Depth of Soil Layers : GL ± 0.0 to -20 meters
(b) Fine Content Fc : Fc < 35% (However, even if Fc ≥ 35%, the soil which has Pc ≤ 20% or Ip ≤ 15% is analyzed for Liquefaction.)

2) Calculation of Seismic Stress Ratio (L)

L is induced by the following formula.

$$L = (\tau d)/ (\sigma' z) = \gamma n.(a_{max}/g).(\sigma z/\sigma' z).\gamma d$$

$$\gamma n= 0.1 (M -1)$$

$$\gamma d=1-0.015 z$$

Where-

τd : Amplitude of equivalent constant cyclic shear stress at horizontal phase (tf/m^2)

$\sigma'z$: Vertical effective stress (tf/m^2)

σz : Total vertical stress (tf/m^2)

γn : Correction factor for equivalent repeat number

M : Magnitude of earthquake

a_{max} : Peak acceleration at ground surface

g : Acceleration of gravity

γd : Reduction factor for plastic behavior of ground

Z : Depth from ground surface (GL-m)

3) Calculation of Liquefaction Resistance ratio (R)

Corrected Na is induced by the following formula, and then liquefaction resistance (R) is obtained from Figure-5.23.

$$Na = Nl + \Delta Nf$$

$$Nl = C_N \times N$$

$$CN = \sqrt{(10/\sigma' z)}$$

Na : Corrected N value for fine content of soil, overburden pressure and field testing procedure

Nl : Corrected N value for overburden pressure and field testing procedure

ΔNf : Increment of corrected N value for fine content (It can be obtained by Figure-5.24)

C_N : Correction factor to account overburden pressure

N : N value by Standard Penetration Test (N is corrected by testing procedure, as follows

If test is performed using hook for free fall, correction factor is 1.0.

If using rope connected to weight with pulley, correction factor is 0.8 to 0.9.

4) Calculation of Safety Factor (F_L) against Liquefaction

Safety Factor against Liquefaction (F_L) is induced by the following formula.

$$F_L = (\tau l / \sigma' z)/(\tau d / \sigma' z) = \tau l / \tau d$$

$F_L \leq 1.0$: There is some possibility on occurrence of liquefaction, and if F_L is smaller than, it means higher possibility of liquefaction.

$F_L > 1.0$: There is no possibility on occurrence of liquefaction

However, even if $F_L \leq 1.0$, strain of soil might be within the limit of liquefaction because of the effect of cyclic mobility of soil.

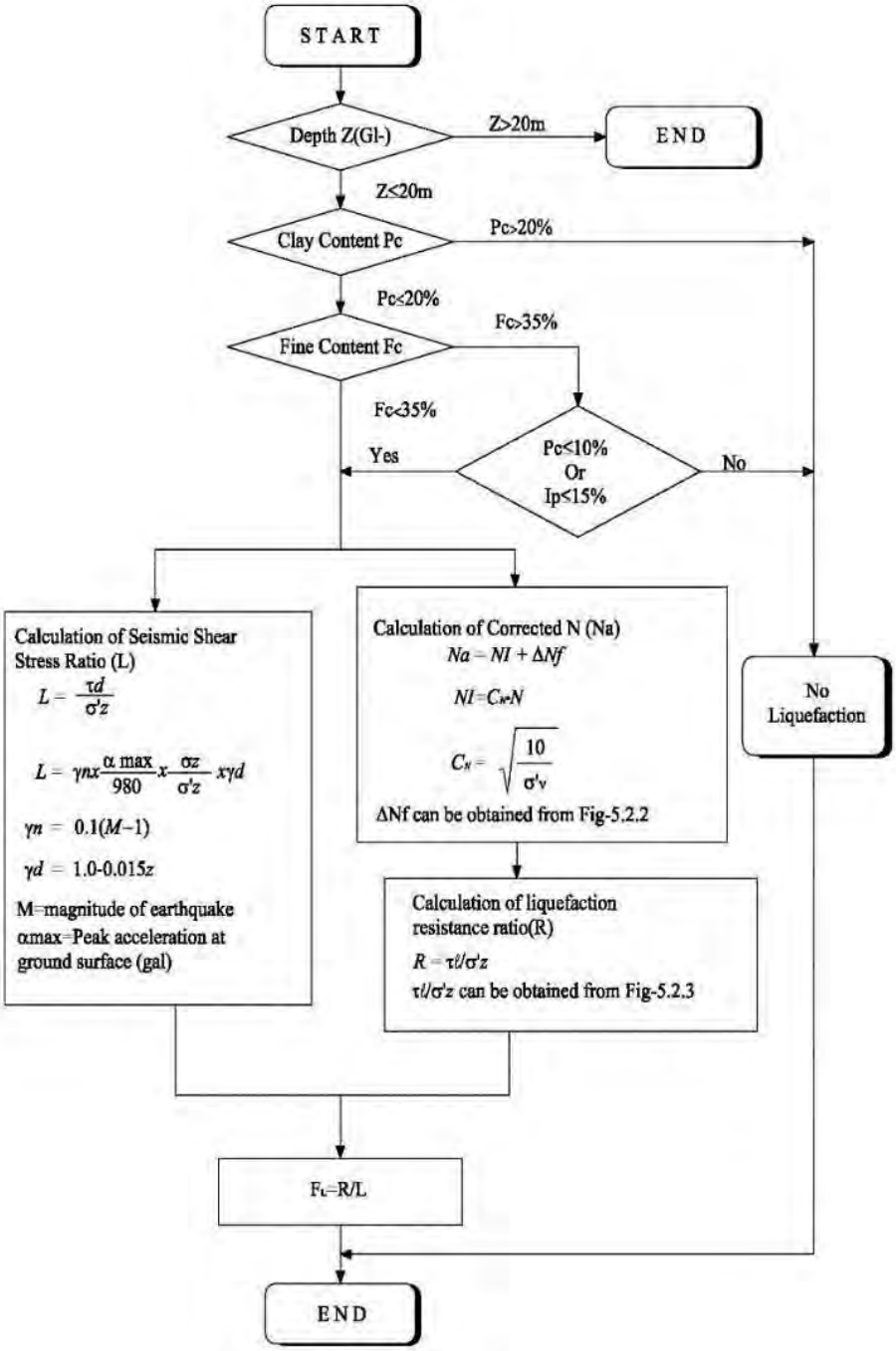


Figure - 5.22 Chart of Liquefaction Analysis Program

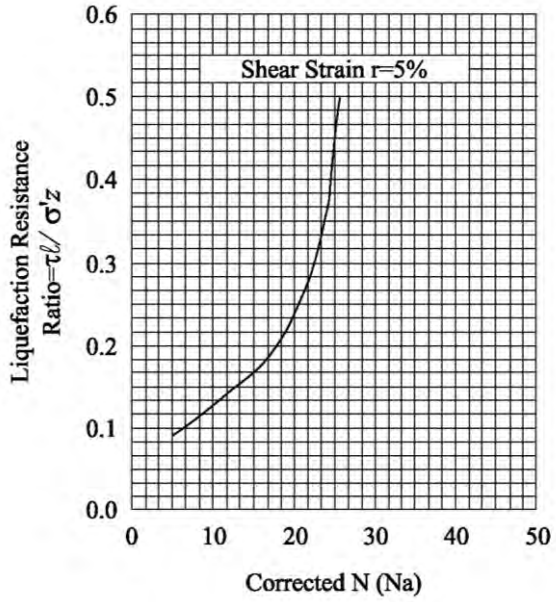


Figure - 5.23 The Relation of corrected N and liquefaction resistant

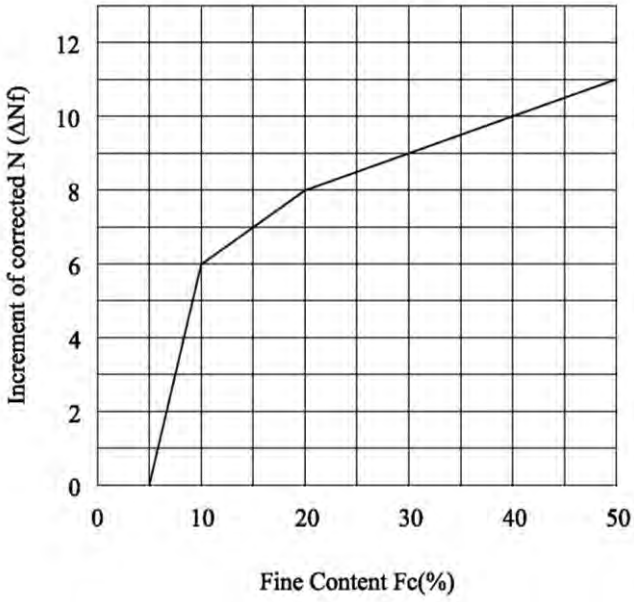


Figure - 5.24 The Relation of fine content and corrected N

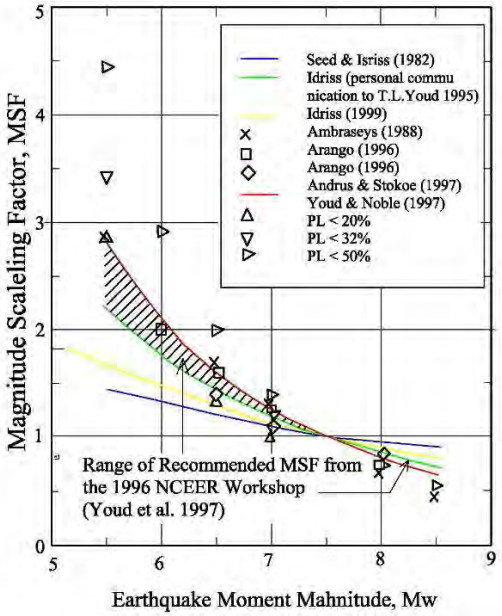


Figure - 5.25 The Magnitude Scaling Factors Derived from Various Investigators

5) Potential of Liquefaction (P_L)

P_L was originally developed in Japan to estimate the potential of liquefaction to cause foundation damage at a site (Iwasaki, 1978). P_L assumes that the severity of liquefaction is proportional to the:

(1) Thickness of the liquefied layer;
(2) Proximity of the liquefied layer to the surface; and
(3) Amount by which the factor of liquefaction (F_L)

The potential of liquefaction can be calculated by following formula;

$$PL = \int_0^{20} (1 - FL)(10 - 0.5z)\, dz$$

Where,

P_L = potential of liquefaction

F_L = factor of liquefaction

z = Depth in meters

Potential of liquefaction condition is shown in Table-5.6.

Table - 5.6 Potential of Liquefaction condition

$15 < P_L$	High Possibility of Liquefaction
$5 < P_L \leq 15$	Possibility of Liquefaction
$0 < P_L \leq 5$	Low Possibility of Liquefaction

5.3.1.3 Except Expected Ground Acceleration at site

According to the seismic zone map of Myanmar, the probable ground peak acceleration when earthquake occur will be 0.2g. In addition, the Modified Mercalli (MM) class of Yangon can be regarded as 7.5.

5.3.2 Liquefaction Analysis Results

Generally, if the earthquake occur in this area, the liquefaction potential will be high in Clayey SAND and Silty SAND-I layers in some depth. According to the liquefaction analysis results, the liquefaction potential is high in sandy soil layers. Because of the water table is shallow (around GL-3.0m from the ground level), and the relative density of sandy soil layer very loose to medium dense. These layers are lying between 6.0m and 21.0m from ground level. Summary of liquefaction analysis results are shown in Table-5.7, and the distribution of liquefaction potential are shown in Figure-5.26 and Figure-5.27. Potential of liquefaction is shown in Table-5.8. The detailed calculation is attached in Appendix-G.

Table - 5.7 Summary of Liquefaction Analysis Results

Depth (m)	BH-01		BH-02		BH-03	
	Soil Layer Name	Possibility of liquefaction	Soil Layer Name	Possibility of liquefaction	Soil Layer Name	Possibility of liquefaction
1.300	CLAY-I	Low	CLAY-I	Low	CLAY-I	Low
2.300	CLAY-I	Low	CLAY-I	Low	CLAY-I	Low
3.300	CLAY-II	Low	CLAY-II	Low	CLAY-II	Low
4.300	CLAY-II	Low	CLAY-II	Low	CLAY-II	Low
5.300	CLAY-II	Low	CLAY-II	Low	CLAY-II	Low
6.300	CLAY-II	Low	Clayey SAND	Low	CLAY-II	Low
7.300	CLAY-II	Low	Clayey SAND	Low	CLAY-II	Low
8.300	Clayey SAND	Low	Clayey SAND	Low	CLAY-II	Low
9.300	Clayey SAND	Low	Clayey SAND	High	CLAY-II	Low
10.300	Clayey SAND	Low	Silty SAND-I	High	Silty SAND-II	High
11.300	Clayey SAND	Low	Silty SAND-I	Low	Silty SAND-II	Low
12.300	Clayey SAND	High	Silty SAND-I	High	Silty SAND-II	Low
13.300	Clayey SAND	High	Silty SAND-I	High	Silty SAND-II	Low
14.300	Silty SAND-II	Low	Silty SAND-II	Low	Silty SAND-II	Low
15.300	Silty SAND-II	Low	Silty SAND-II	High	Silty SAND-II	Low
16.300	Silty SAND-II	Low	Silty SAND-II	High	Silty SAND-II	Low
17.300	Silty SAND-II	Low	Silty SAND-II	Low	Silty SAND-II	Low
18.300	Silty SAND-II	Low	Silty SAND-II	Low	Silty SAND-II	Low
19.300	Silty SAND-II	Low	Silty SAND-II	Low	Silty SAND-II	Low

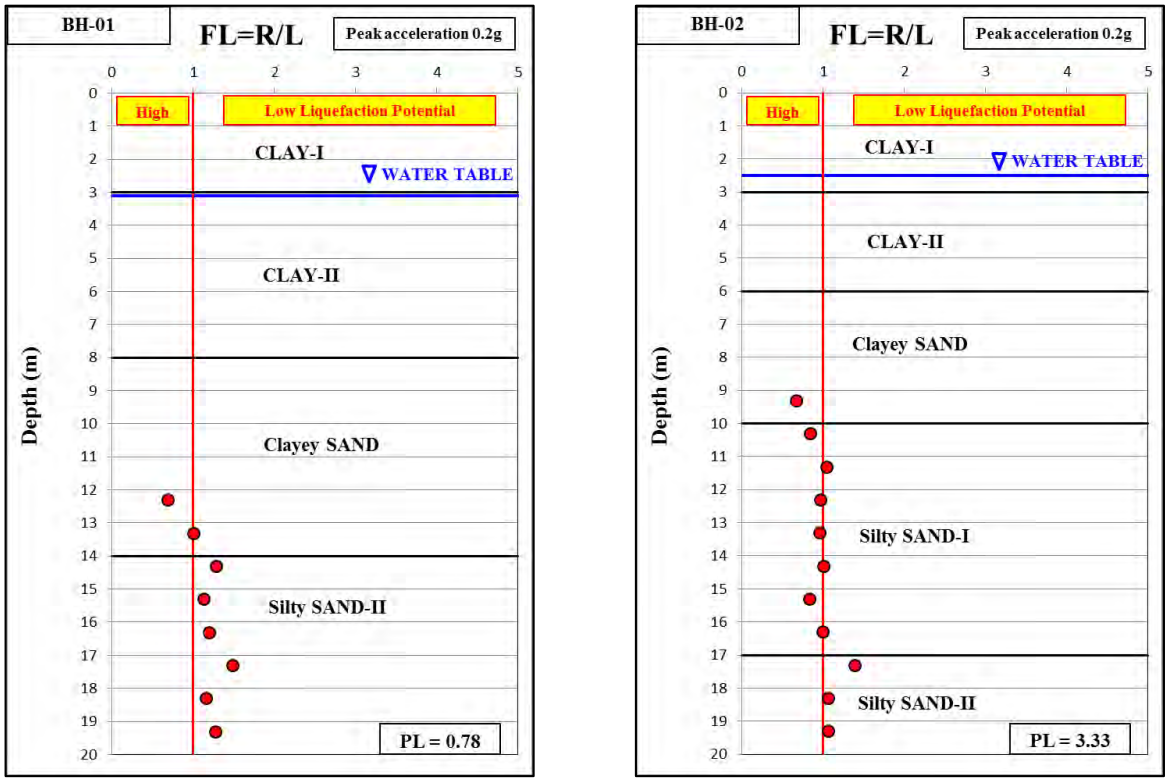


Figure - 5.26 Distribution of liquefaction potential of BH-01 & BH-02

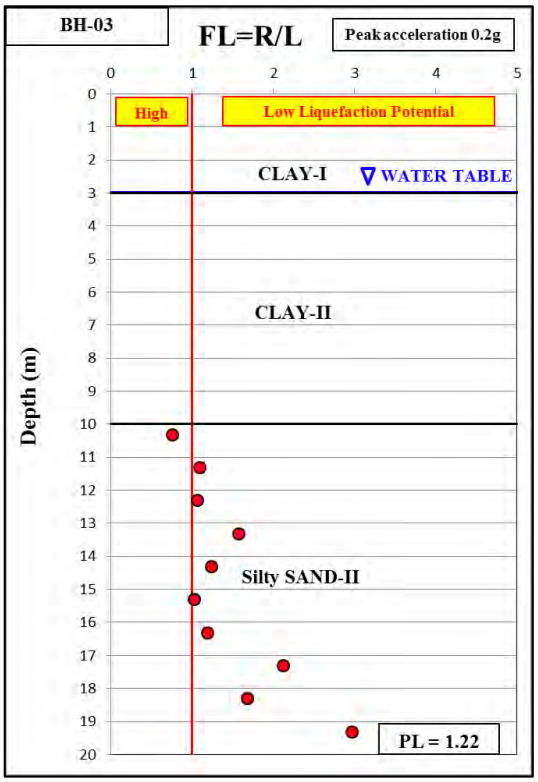


Figure - 5.27 Distribution of liquefaction potential of BH-03

Table - 5.8 PL value of each boreholes

Borehole No.	PL value
BH-01	0.78
BH-02	3.33
BH-03	1.22

6 CONCLUSION AND RECOMMENDATION

6.1 General Information

ORIENTAL CONSULTANTS GLOBAL CO., LTD is planning to construct the Central Training Centre at the compound of Thuwunna CTC and Thuwunna department of bridge and quality control, Thingangyun Township, Yangon Region. Therefore, Fukken Co., Ltd. was assigned to conduct soil investigation works to obtain soil properties of selected locations in the project area. The soil investigation was carried out to obtain the information about the stratigraphic composition at site, the distribution of the reliable bearing layer and geotechnical design parameters. Total three boreholes were carried out on the proposed project area. According to the soil investigation works, three portions are included in this report. There are as follow.

(1) Field Test includes SPT test, Disturbed and Undisturbed Soil Sampling, Water Sampling and Water Level Measuring

(2) Laboratory Test Results (Physical Properties Test, Mechanical Properties Test and Chemical Properties Test for water samples)

(3) Report with geotechnical assessments

6.2 Ground Conditions

According to the investigation results, ten different soil layers are observed in this investigation project. These different layers are described from top to bottom as follows.

(1) CLAY-I
(2) CLAY-II
(3) Clayey SAND
(4) Silty SAND-I
(5) Silty SAND-II
(6) SILT
(7) CLAY-III
(8) CLAY-IV
(9) Silty SAND-III
(10) CLAY-V

According to the Standard Penetration Test “SPT” results, the distribution of SPT N-value for each soil layer is illustrated in Table-6.1 and Figure-6.1. Moreover, soil profile through the project area is shown in Figure-6.2.

Table - 6.1 Distribution of SPT N-value for each soil layer

Sr No.	Soil layer	N-value (Measured) 10 20 30 40 50 60	Minimum	Maximum	Average
1	CLAY-I		5	6	5
2	CLAY-II		2	7	2
3	Clayey SAND		3	8	4
4	Silty SAND-I		5	10	8
5	Silty SAND-II		11	32	17
6	SILT		22	25	22
7	CLAY-III		8	33	15
8	CLAY-IV		12	22	22
9	Silty SAND-III		19	Over 50	50
10	CLAY-V		32	37	32

Average N-value

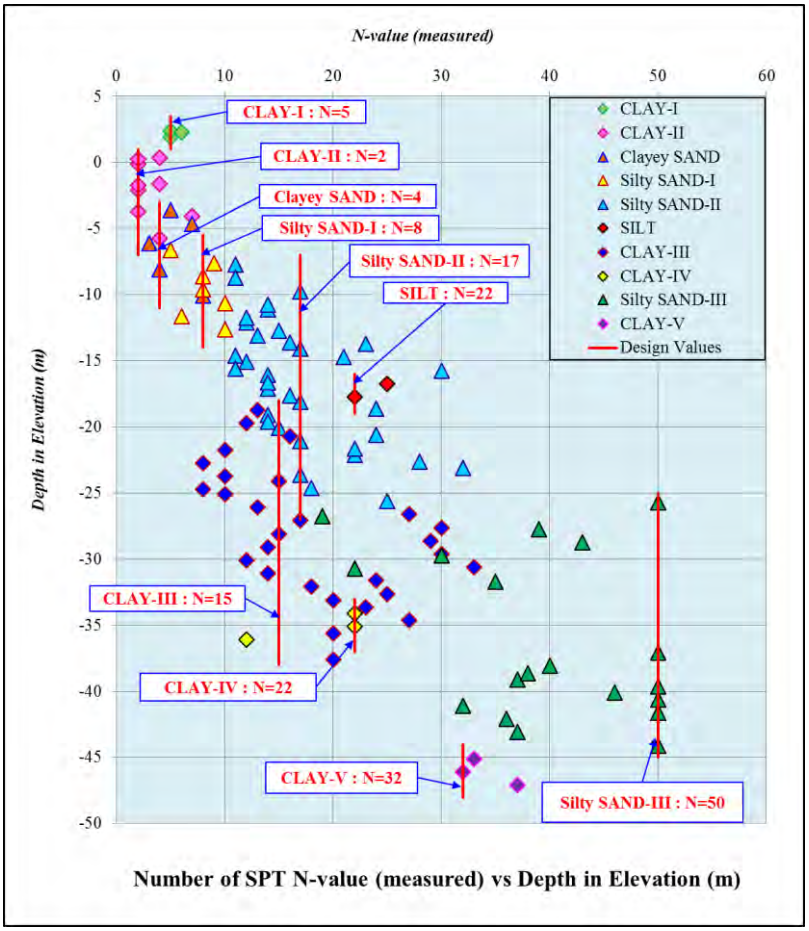


Figure - 6.1 Distribution of SPT N-values of the project area

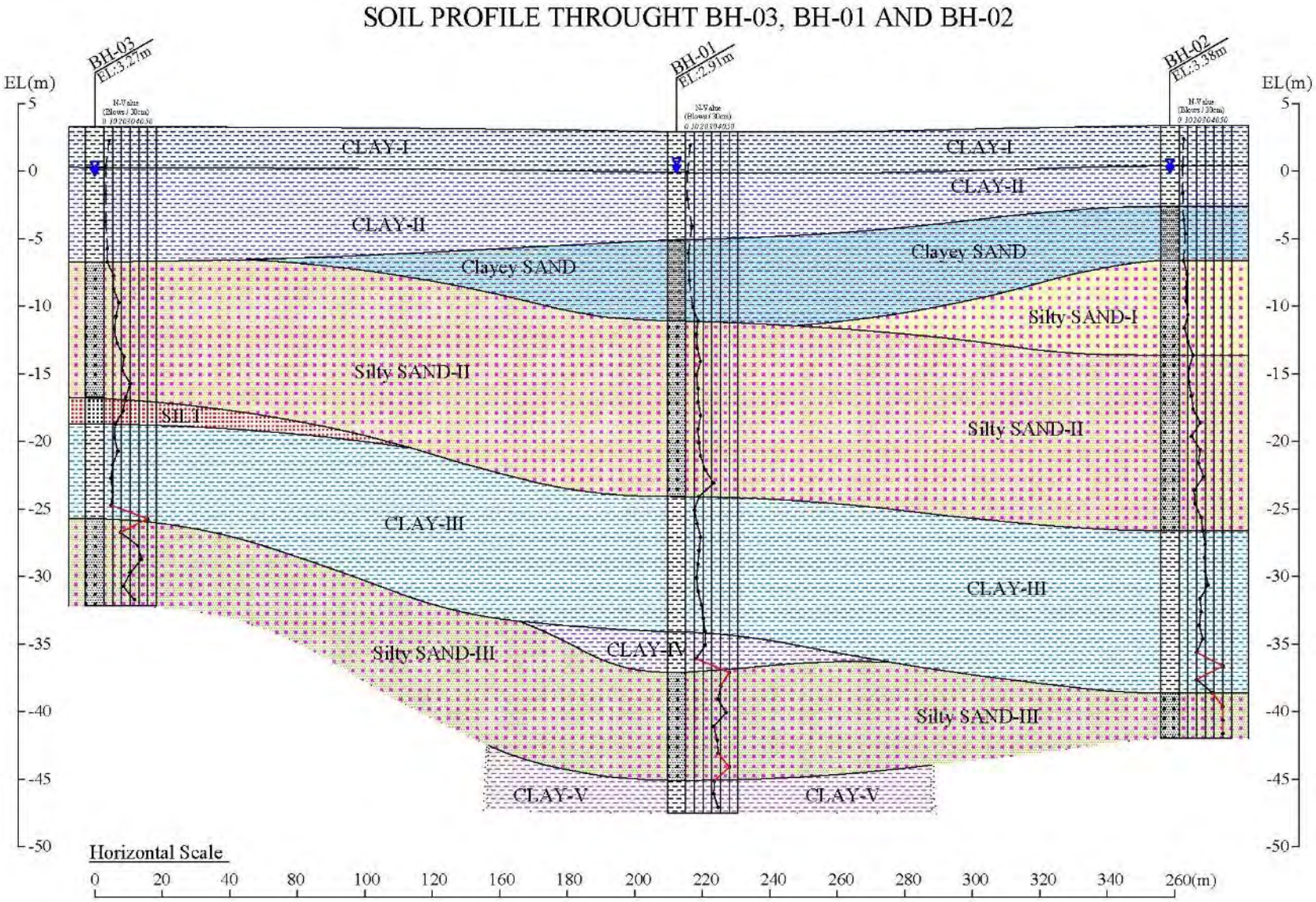


Figure - 6.2 Soil profile through the project area

6.3 Consolidation Settlement

The possible soil layer for consolidation settlement is clayey soil layers. According to the soil investigation results, clayey soil layers are well observed from the top soil layer and second sub-soil layer in this project area. Therefore, the consolidation settlement should be considered for future construction project. Examined point is selected BH-01 at nearly center of the project area. The total settlement of calculation results for each assumed embankment thickness are shown in Table-6.2. The relationship between settlement and time of each embankment thickness calculation results are shown in Figure-6.3.

The estimated total settlement for each assumed embankment thickness is 11cm to 29cm as shown in table-6.2. Most of settlement will be finished around 1 year or 2 year after embankment construction as shown in Figure-6.3. Clay-I and Clay-II, settlement target clay layer are not so soft, and the consolidation characteristic of the target layer is over-consolidated as shown in Figure -6.3. Therefore, expected settlement amount is also small. It means especially measures against settlement are not needed to be considered.

Table - 6.2 Summary of consolidation settlements for each Embankment thickness

BH No.	Total Settlement (cm)	Embankment Thickness(m)
BH-01	11.0	1.0
	20.0	2.0
	29.0	3.0

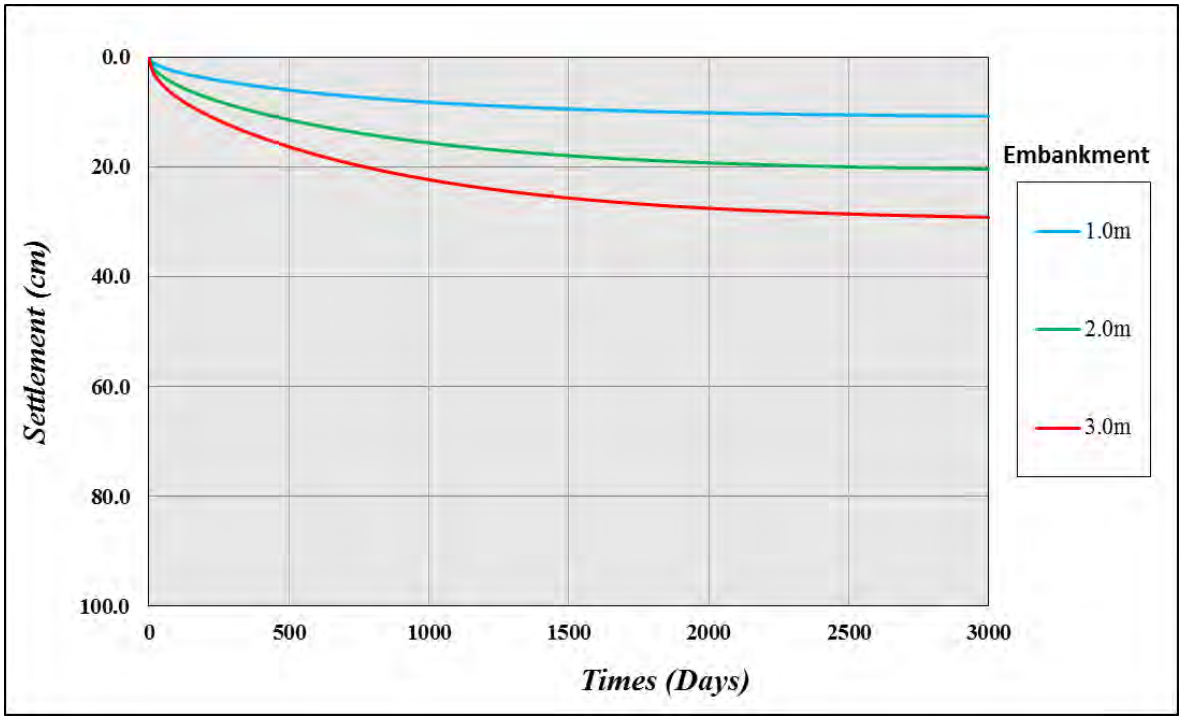


Figure - 6.3 The relationship between settlement and time of each embankment thickness

6.4 Seismic Consideration

The detailed calculation for Liquefaction are presented in Appendix-G. According to the investigation results, the clayey soil layers are well observed in this project area. Generally, the liquefaction potential is high in sandy soil layers. According to the liquefaction analysis results, the liquefaction potential is spotted high in Clayey SAND and Silty SAND-I layer in some depth of each boreholes. However, clay layer is mostly deposited in the project area. Therefore, according to the liquefaction analysis results, the liquefaction potential is mostly low in this project area as shown in Table-6.3.

Table - 6.3 PL value of each boreholes

Borehole No.	PL value
BH-01	0.78
BH-02	3.33
BH-03	1.22

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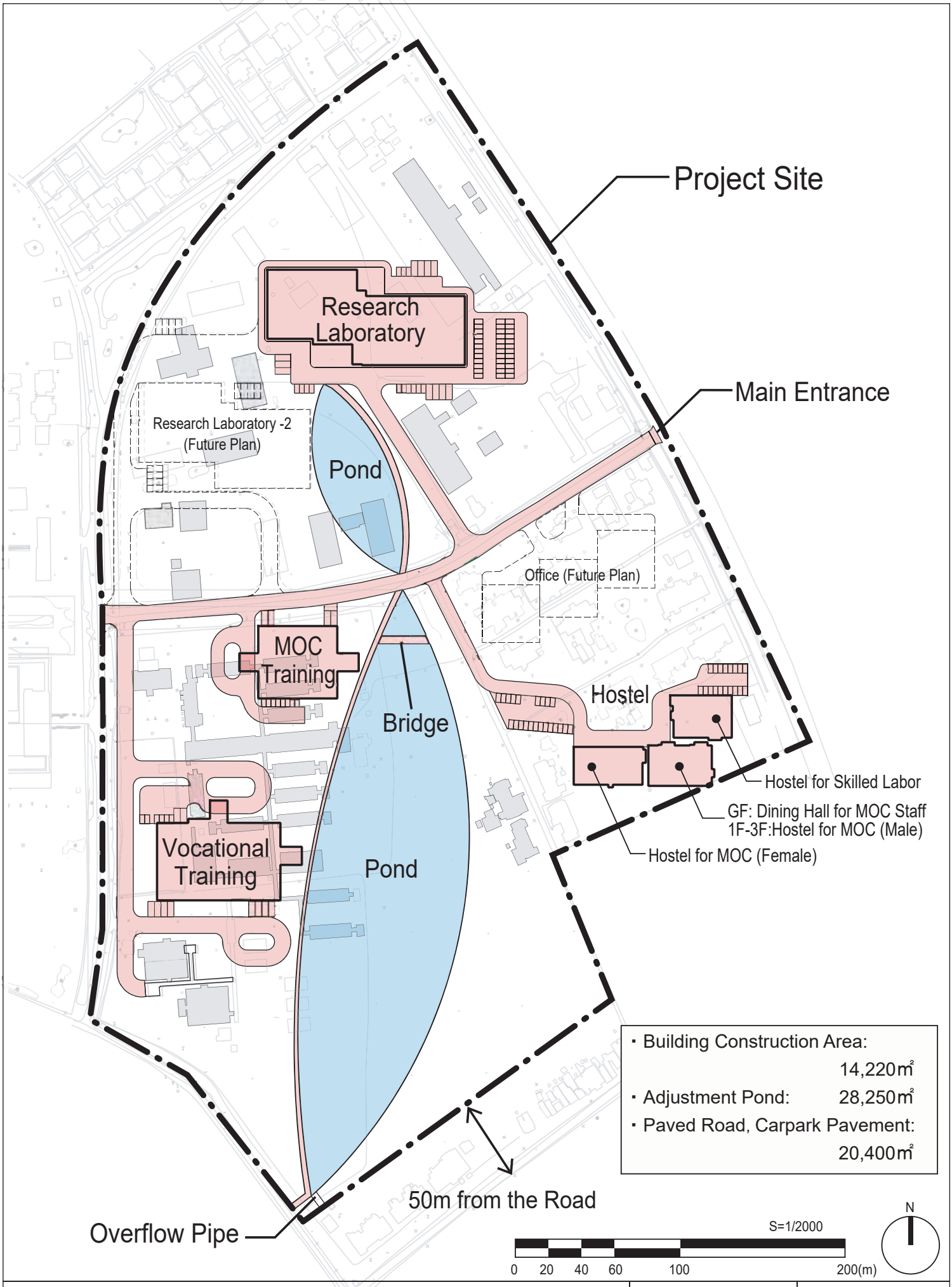
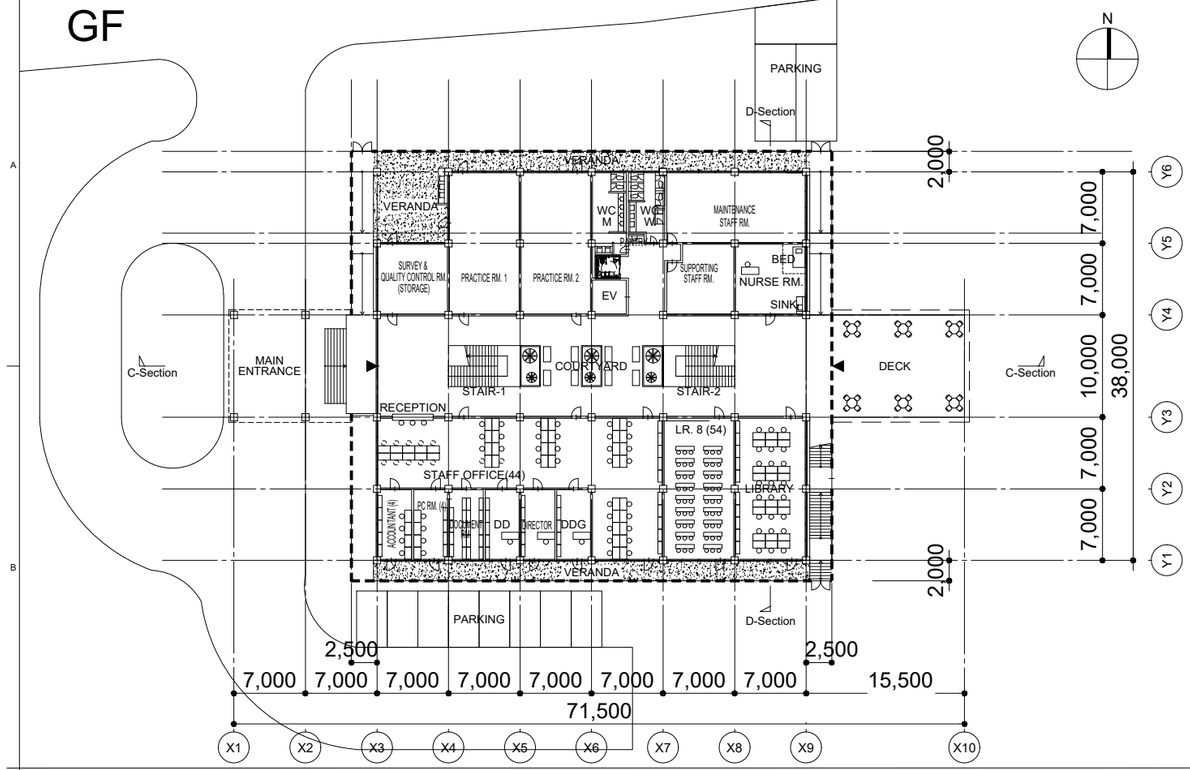
Appendix 6
Preliminary Design Drawings



PROJECT	TITLE	DRAWING NO.
Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) Upgrading of the Thuwunna Research Laboratory and Training Center	LAYOUT PLAN	A-000

GF



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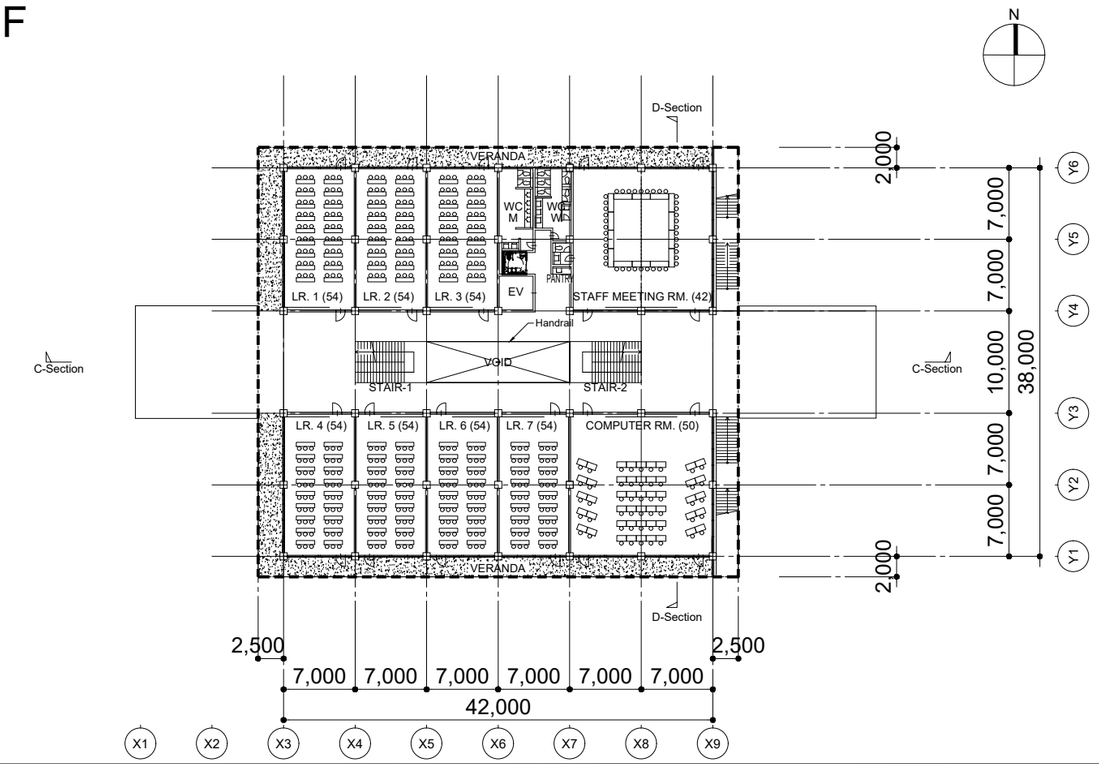

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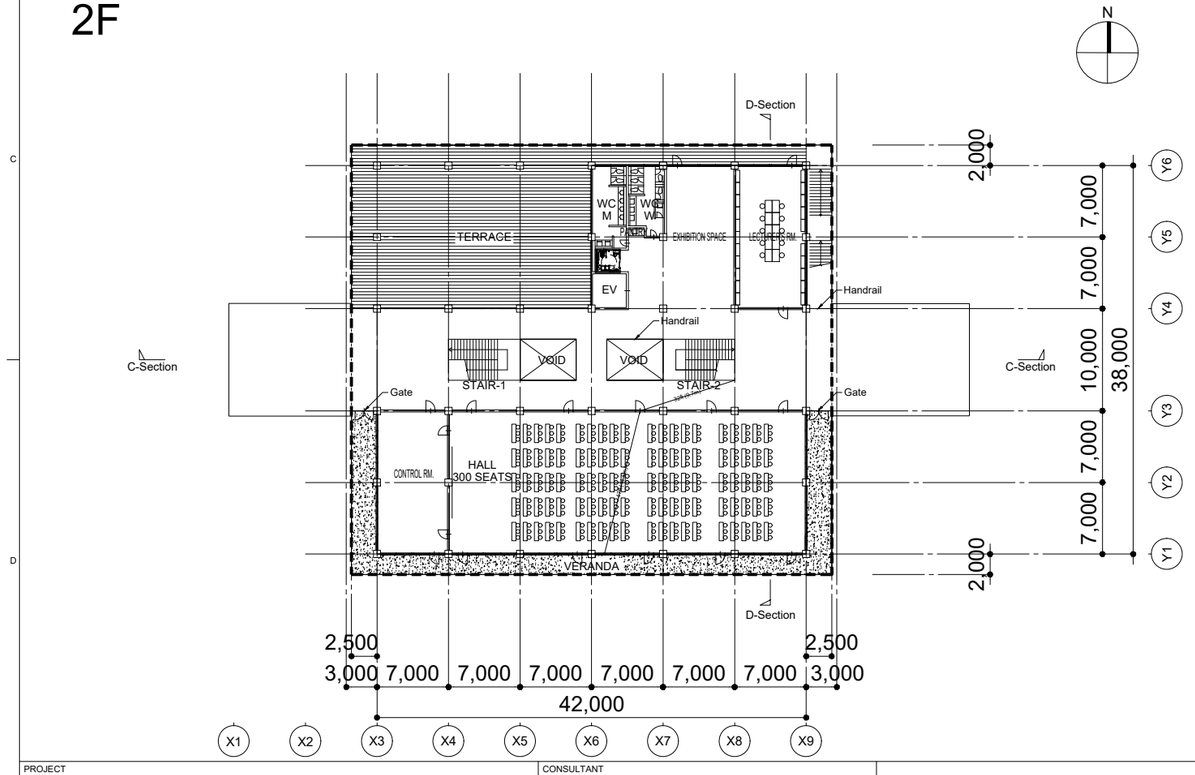

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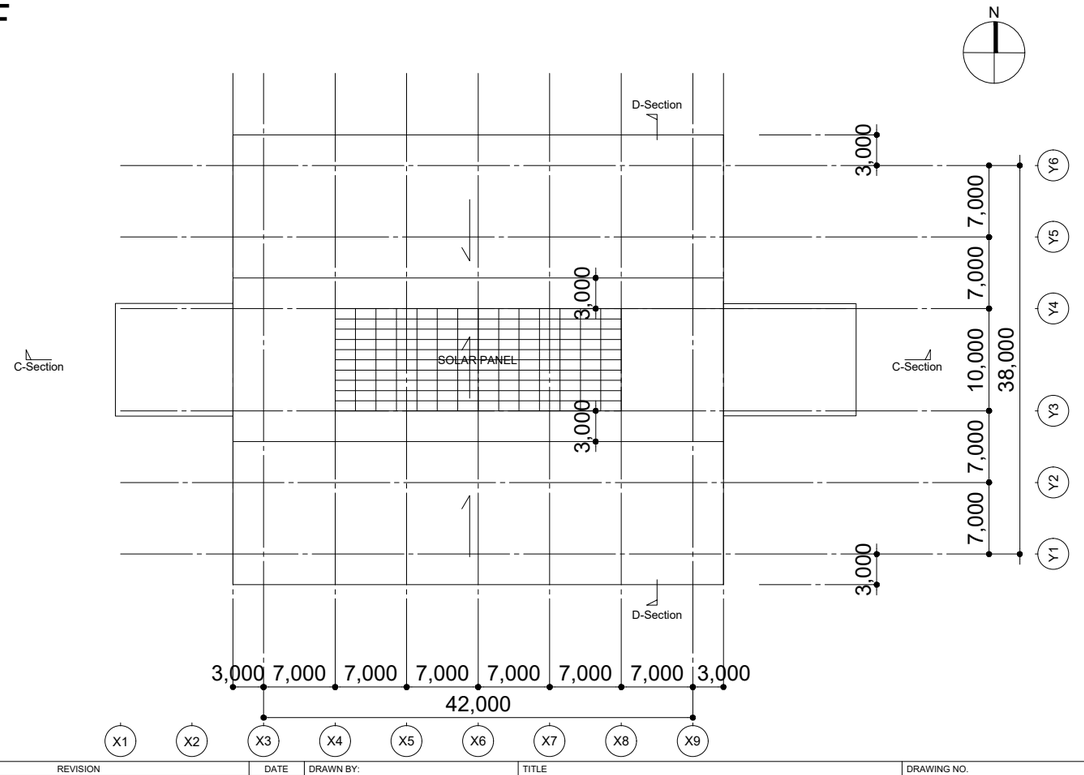


PROJECT

Preparatory Survey for the East-West Economic Corridor Highway Development Project
(New Bago-Kyaikto Highway Section)
Upgrading of the Thuwunna Research Laboratory and Training Center

CONSULTANT

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TOKYO OPERA CITY TOWER 9F,
20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU,
TOKYO 163-1409, JAPAN

* NOT FOR CONSTRUCTION

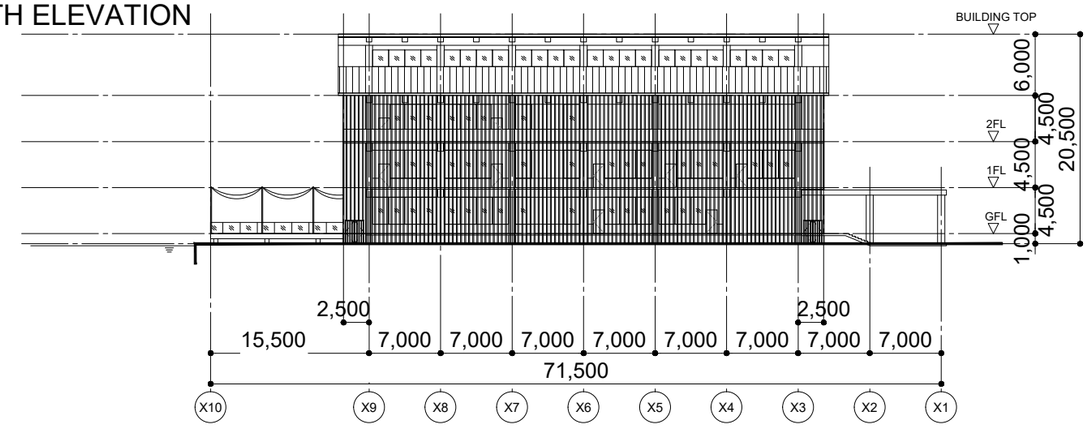
REV.	REVISION	DATE
1	XXXXX	####.##.##

DRAWN BY: OCG
CHECKED BY: XXXXX
APPROVED BY: XXXXX
DATE: DEC. 10, 2019
SHEET SIZE: A3
SCALE: 1:600

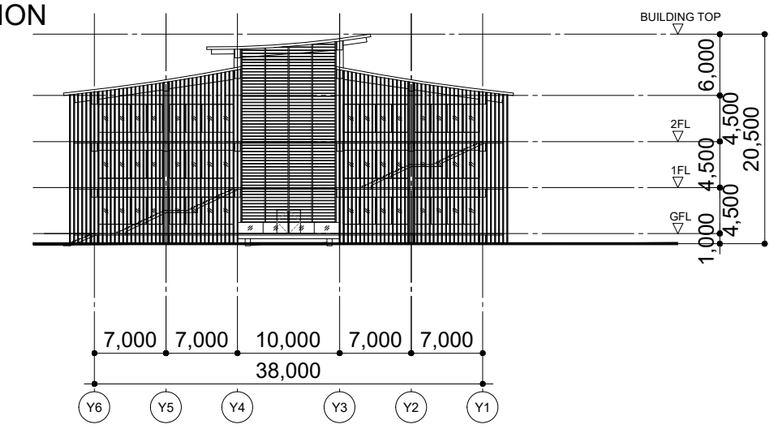
TITLE
PLAN
MOC TRAINING

DRAWING NO.
A-001

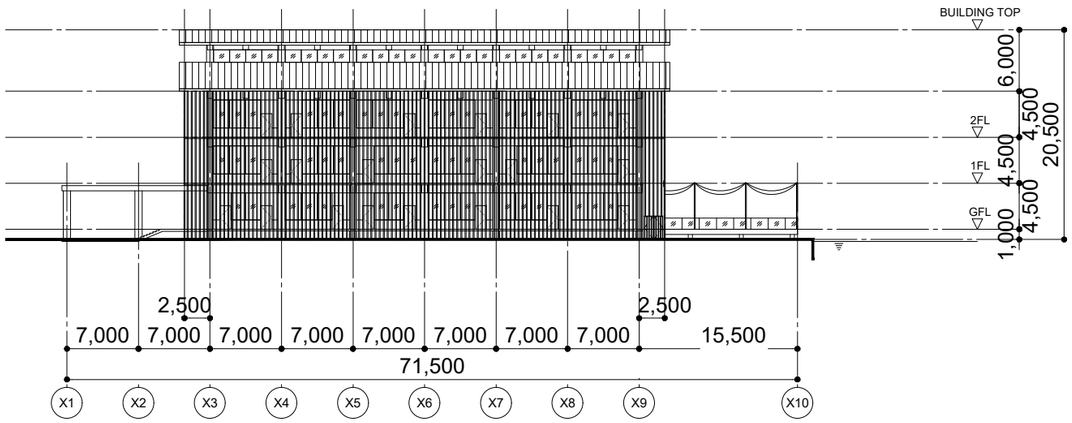
NORTH ELEVATION



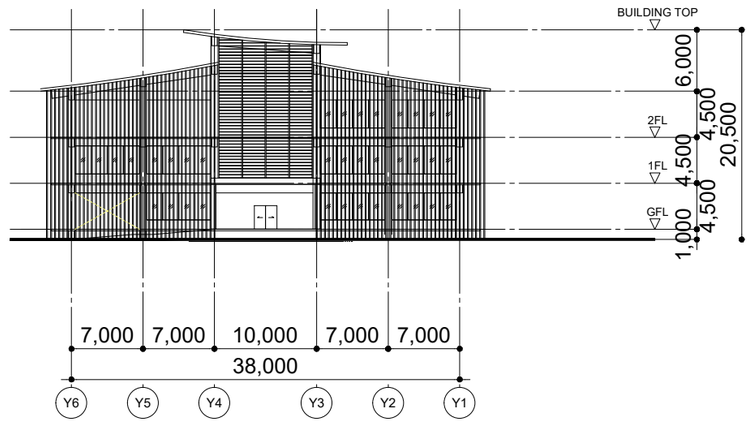
EAST ELEVATION



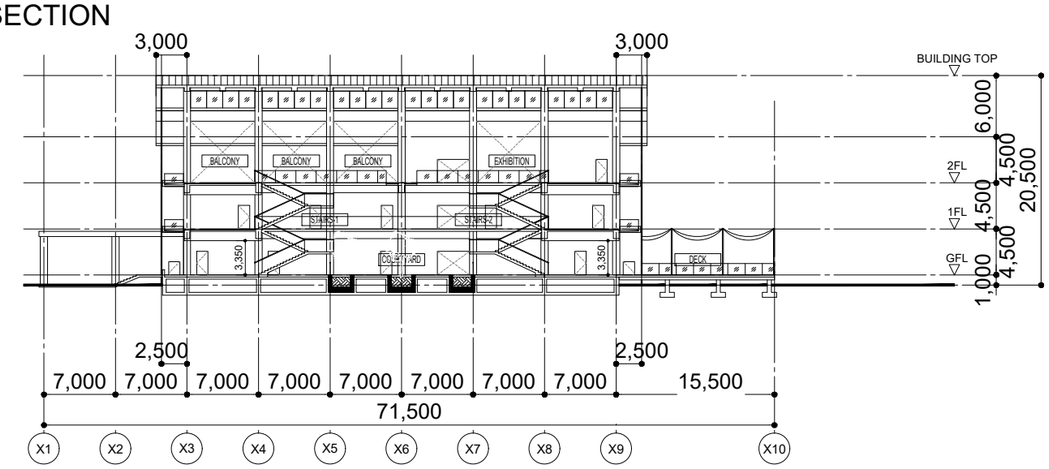
SOUTH ELEVATION



WEST ELEVATION



C-C SECTION



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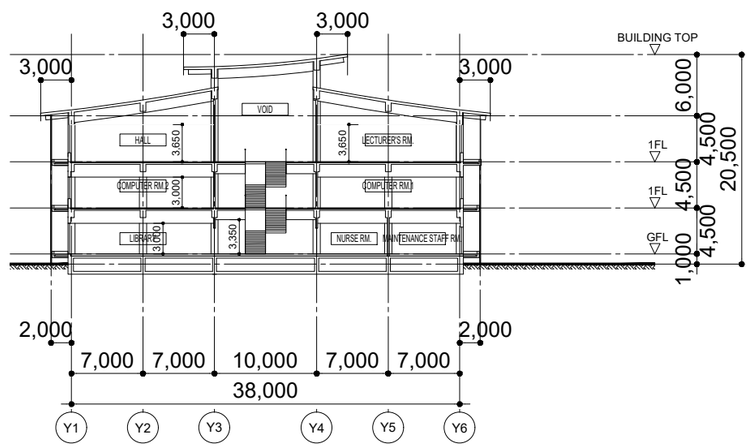
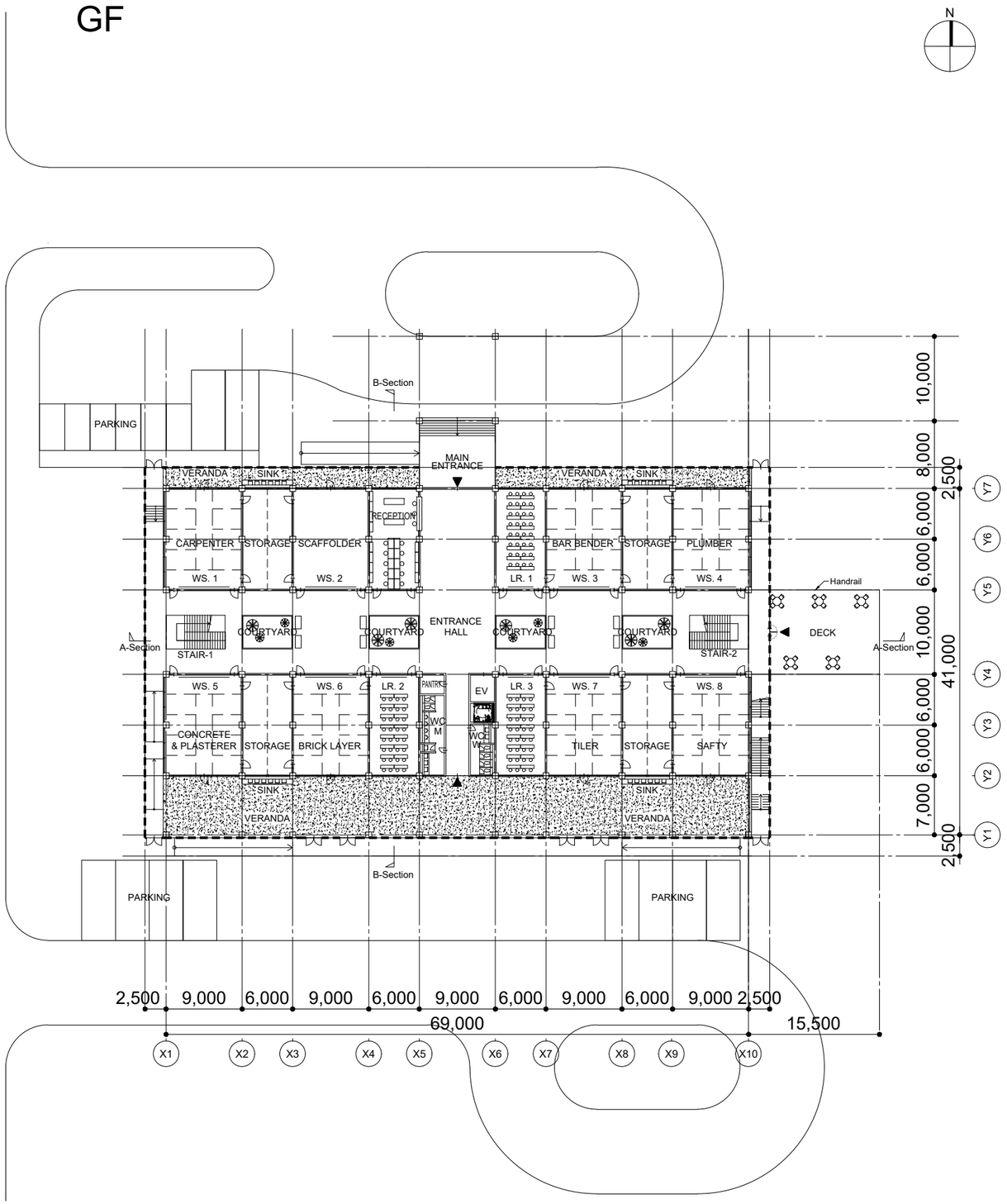


PROJECT	CONSULTANT	
Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) Upgrading of the Thuwunna Research Laboratory and Training Center	ORIENTAL CONSULTANTS GLOBAL CO., LTD. TOKYO OPERA CITY TOWER 9F, 20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU, TOKYO 163-1409, JAPAN	* NOT FOR CONSTRUCTION

REV.	REVISION	DATE
A	XXXXX	####.##.##

DRAWN BY:	Yamaguchi
CHECKED BY:	XXXXX
APPROVED BY:	XXXXX
TITLE	ELEVATION AND SECTION MOC TRAINING
DATE:	JUNE 26, 2019
SHEET SIZE	A3
SCALE	1:600
DRAWING NO.	A-002

GF



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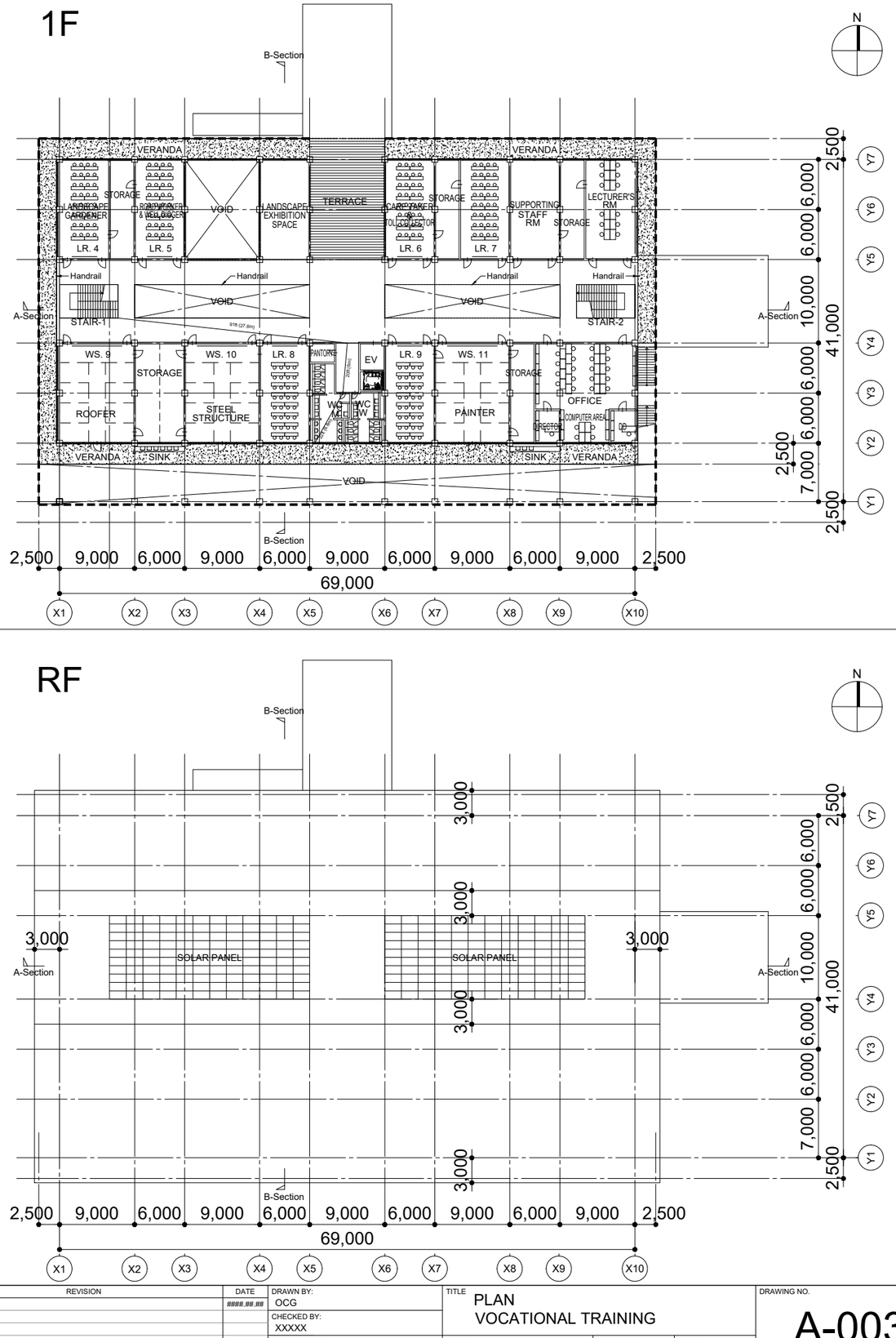


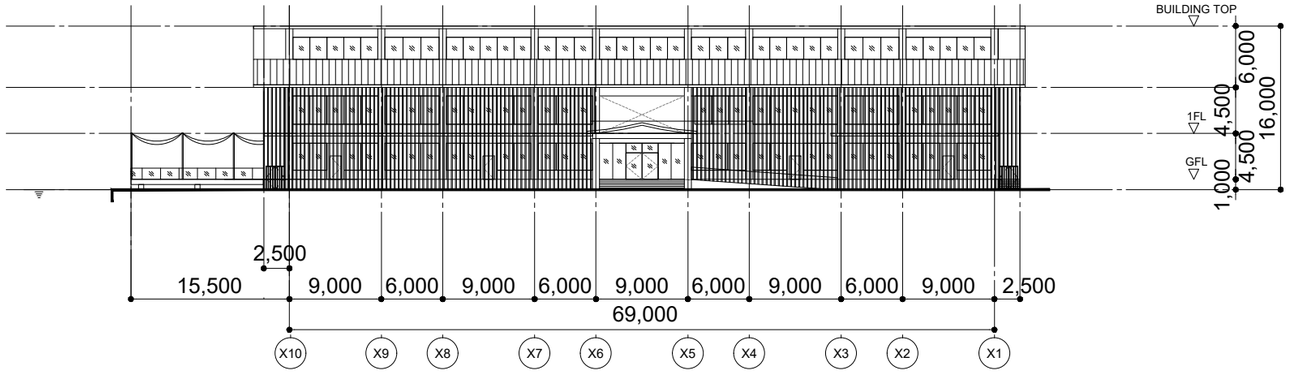
RF

PROJECT	CONSULTANT		
Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) Upgrading of the Thuwunna Research Laboratory and Training Center	ORIENTAL CONSULTANTS GLOBAL CO., LTD. TOKYO OPERA CITY TOWER 9F, 20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU, TOKYO 163-1409, JAPAN	* NOT FOR CONSTRUCTION	

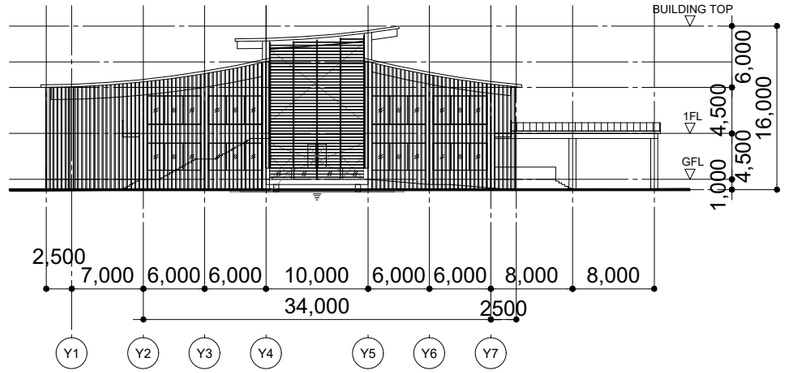
REV.	REVISION	DATE
1	XXXXX	####.##.##

DRAWN BY: OCG	TITLE: PLAN VOCATIONAL TRAINING			DRAWING NO. A-003
CHECKED BY: XXXXX				
APPROVED BY: XXXXX	DATE: DEC. 10, 2019	SHEET SIZE: A3	SCALE: 1:600	

NORTH ELEVATION



EAST ELEVATION



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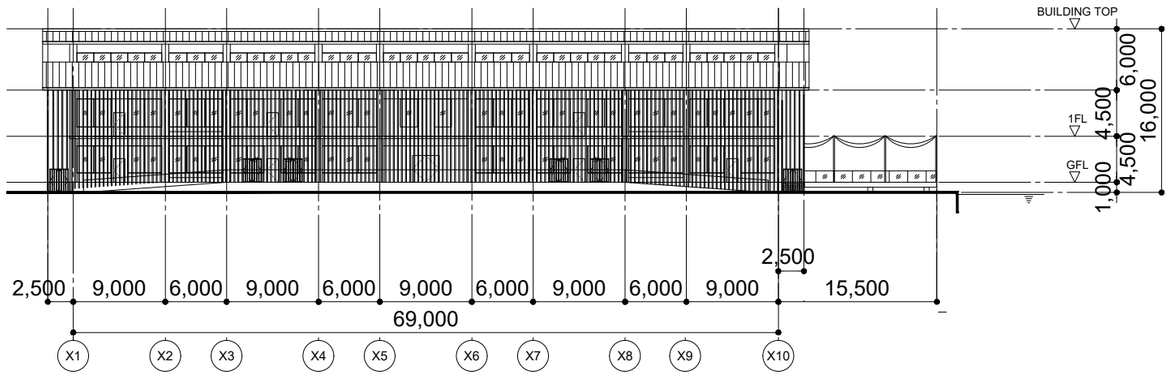
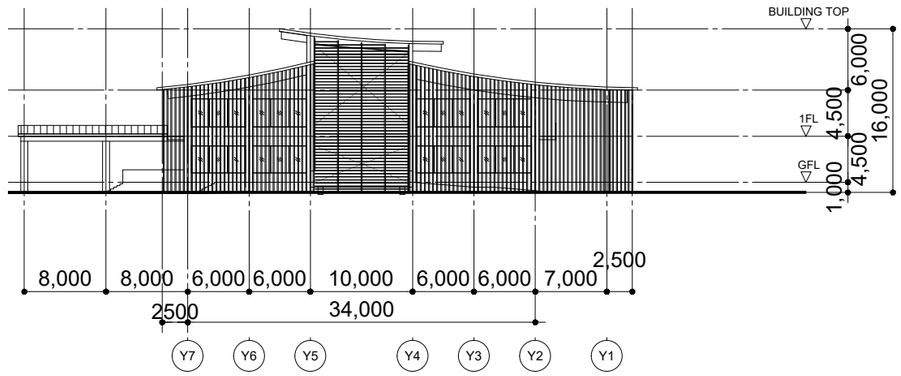
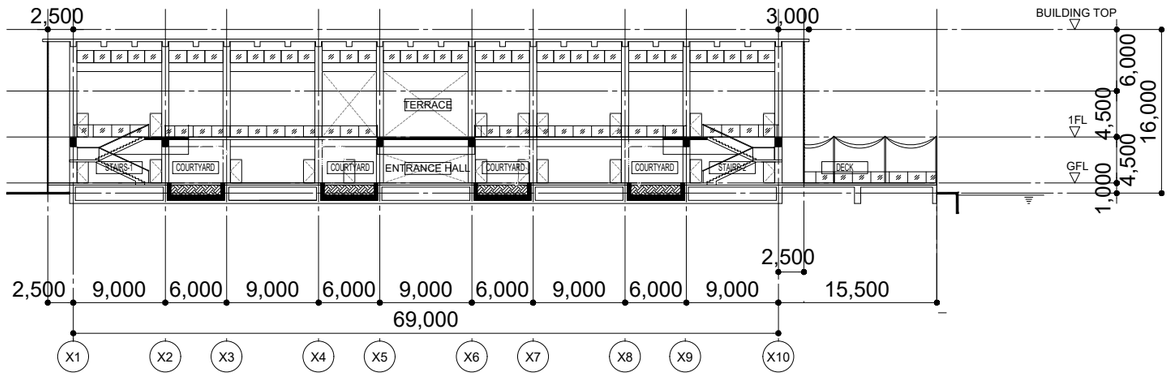


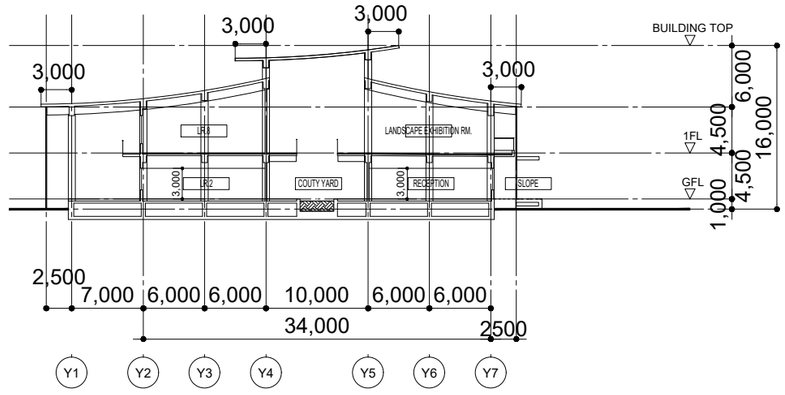
WEST ELEVATION



A-A SECTION

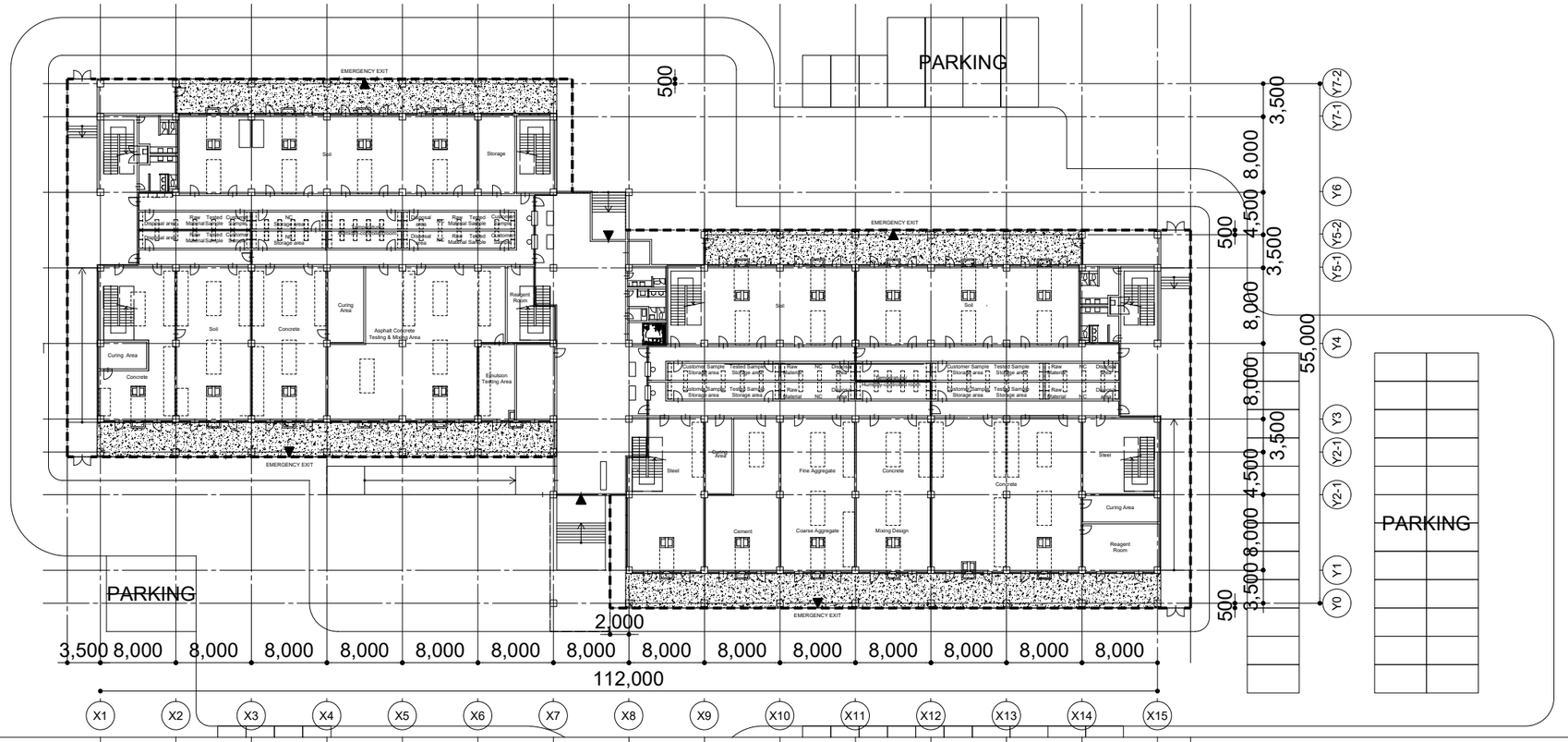


B-B SECTION



PROJECT: Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) Upgrading of the Thuwunna Research Laboratory and Training Center	CONSULTANT: ORIENTAL CONSULTANTS GLOBAL CO., LTD. TOKYO OPERA CITY TOWER 9F, 20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU, TOKYO 163-1409, JAPAN	* NOT FOR CONSTRUCTION	REV. / REVISION / DATE: 2 XXXXX ####.##.##	DRAWN BY: OCG CHECKED BY: XXXXX APPROVED BY: XXXXX
TITLE: ELEVATION AND SECTION VOCATIONAL TRAINING	DATE: OCT. 04, 2019	SHEET SIZE: A3	SCALE: 1:600	DRAWING NO.: A-004

GF



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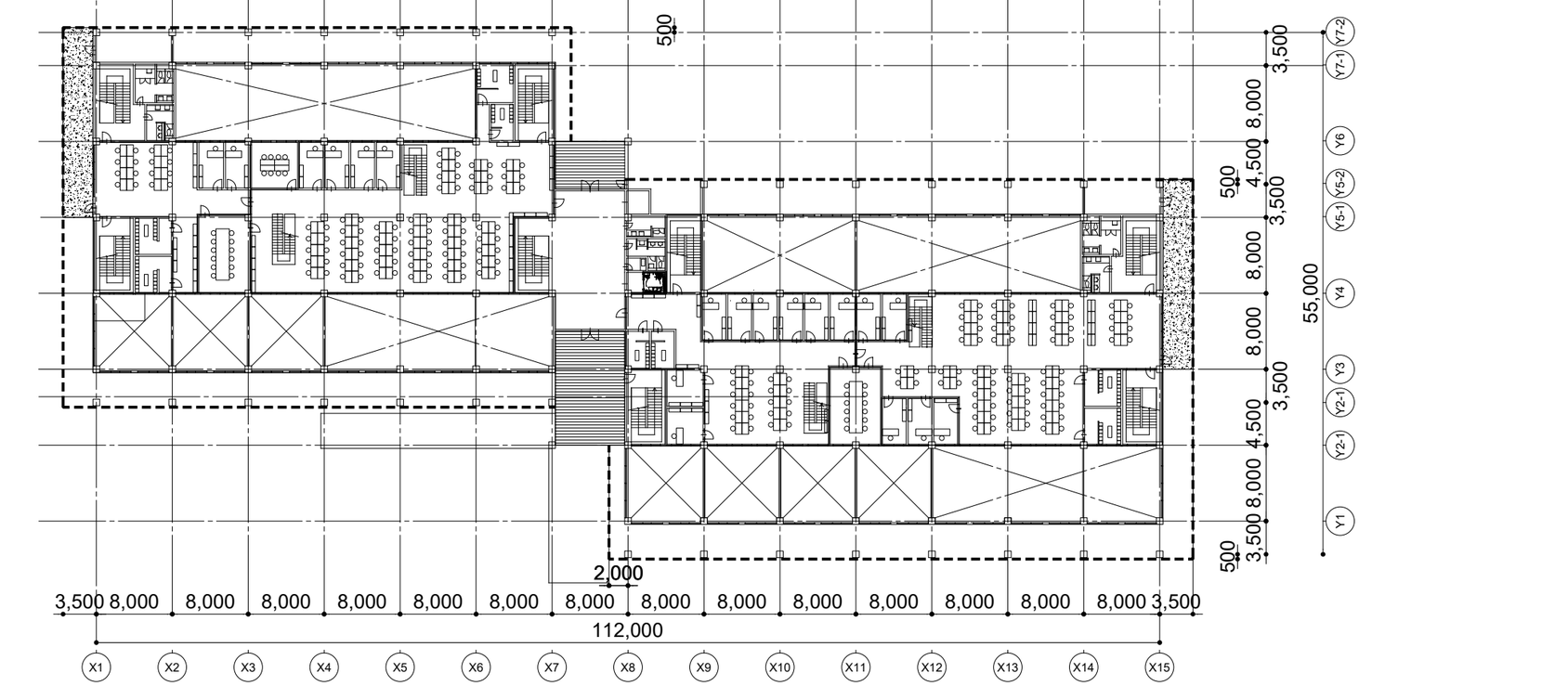
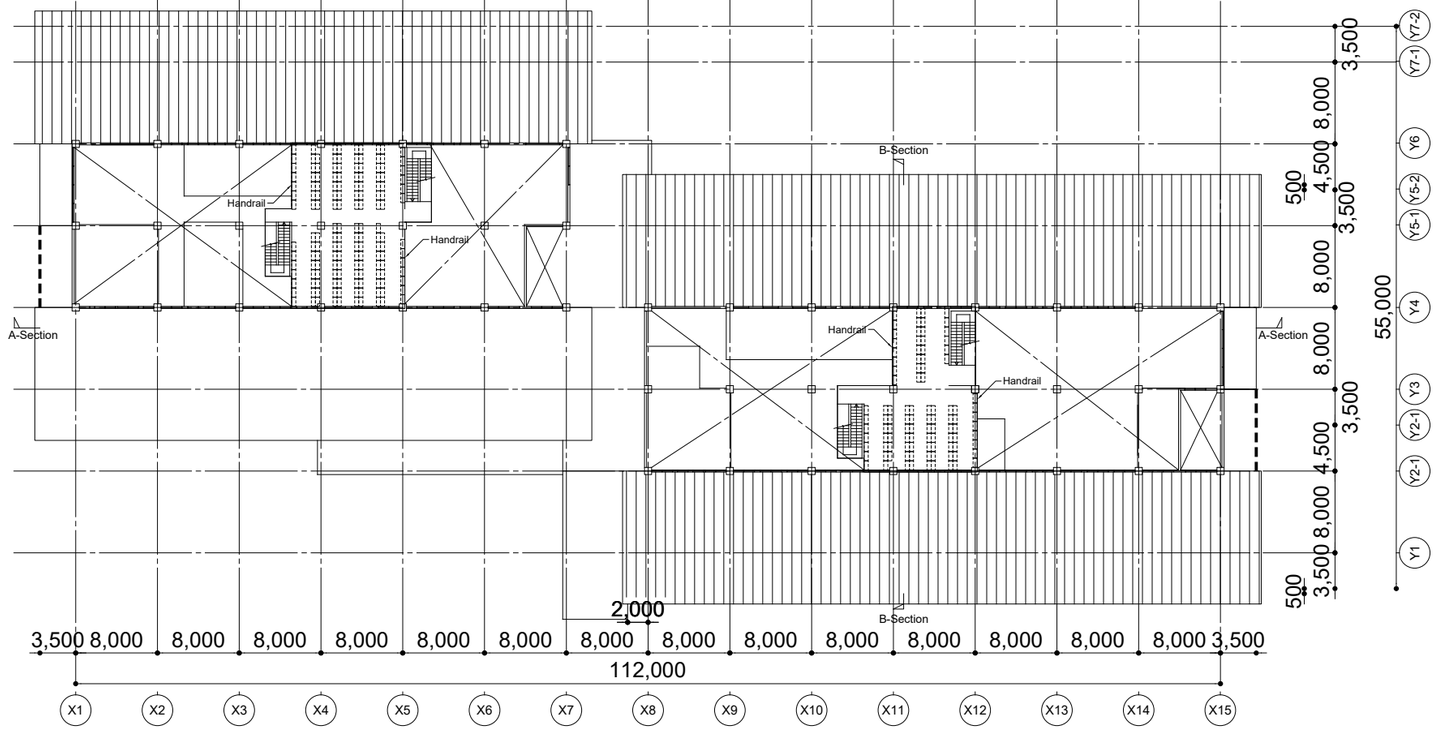
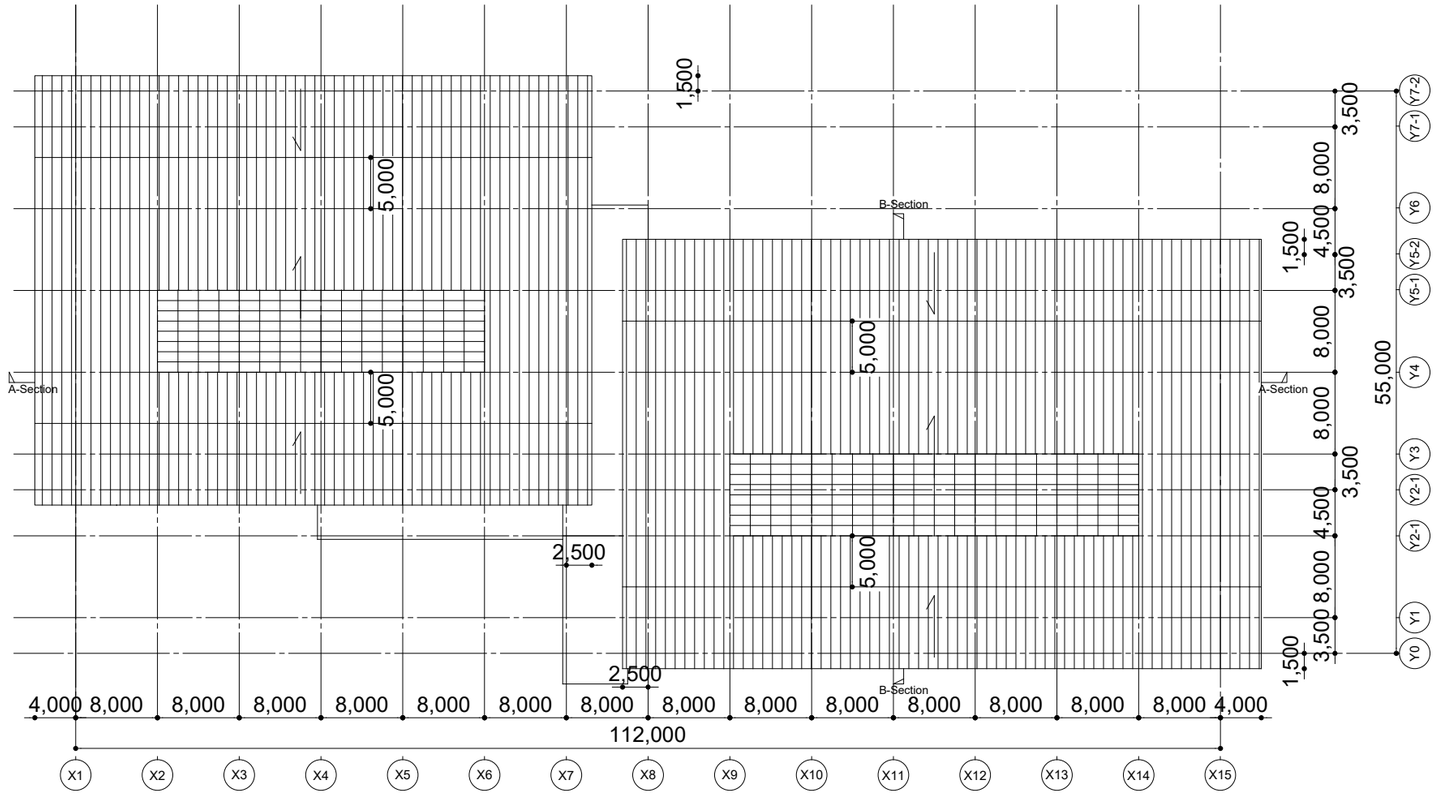


PROJECT: Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) Upgrading of the Thuwunna Research Laboratory and Training Center	CONSULTANT: ORIENTAL CONSULTANTS GLOBAL CO., LTD. TOKYO OPERA CITY TOWER 9F, 20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU, TOKYO 163-1409, JAPAN	* NOT FOR CONSTRUCTION	REV. / REVISION / DATE	DRAWN BY: OC Global; CHECKED BY: XXXXX; APPROVED BY: XXXXX	TITLE: PLAN-1 RESEARCH; DATE: DEC. 23, 2019; SHEET SIZE: A3; SCALE: 1:600	DRAWING NO. A-005

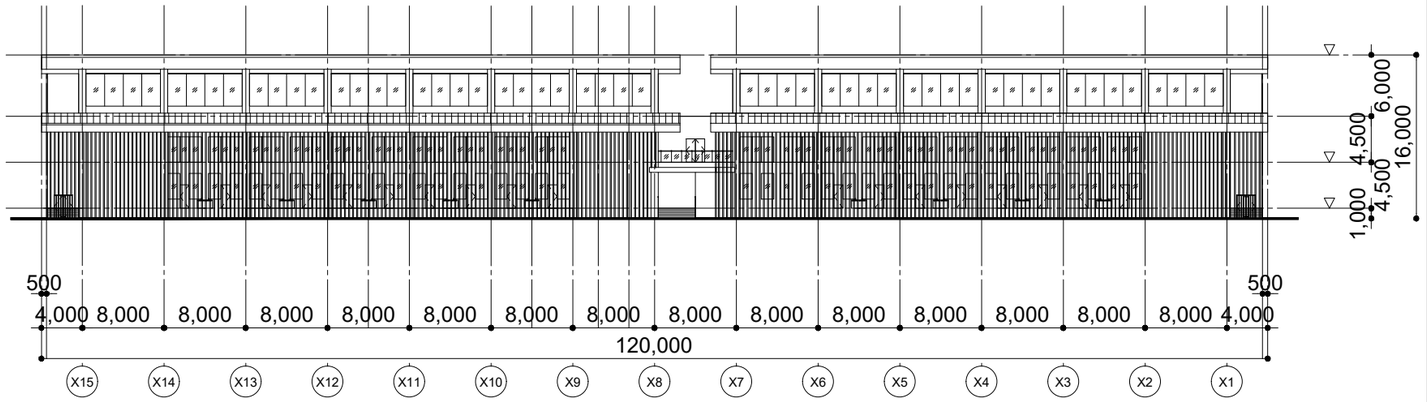
AF

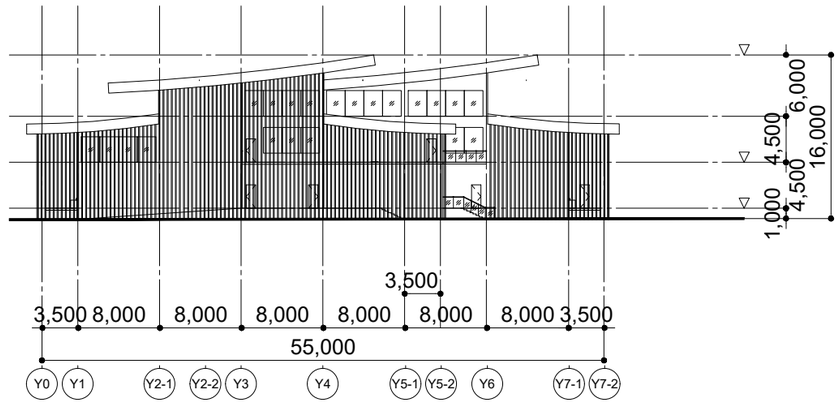


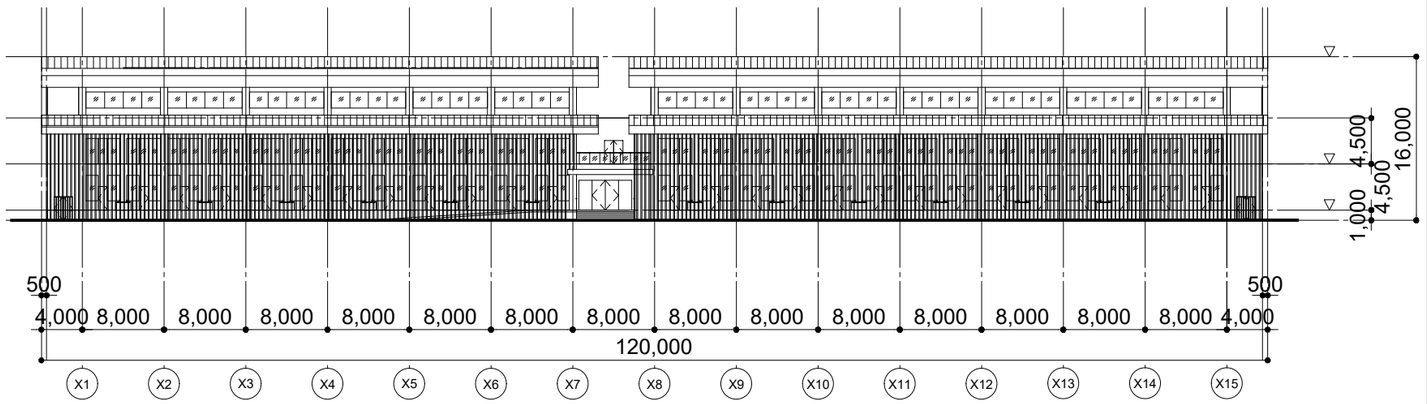
RF

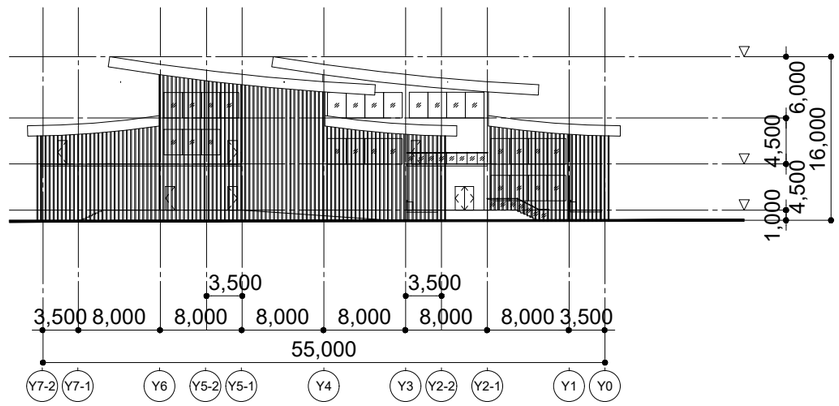


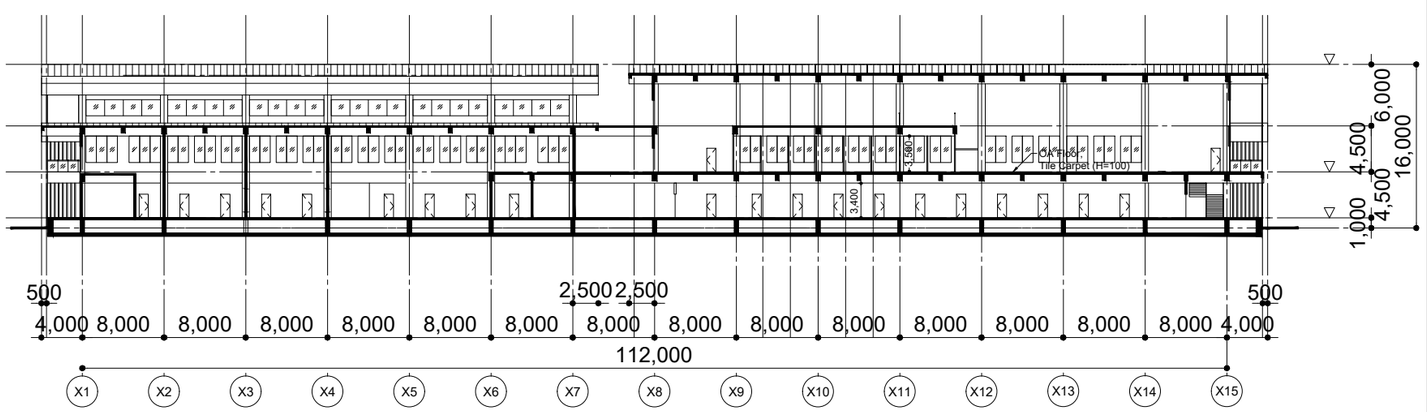
PROJECT Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) Upgrading of the Thuwunna Research Laboratory and Training Center	CONSULTANT ORIENTAL CONSULTANTS GLOBAL CO., LTD. TOKYO OPERA CITY TOWER 9F, 20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU, TOKYO 163-1409, JAPAN	* NOT FOR CONSTRUCTION	REV.	REVISION	DATE	DRAWN BY: OC Global CHECKED BY: XXXXX APPROVED BY: XXXXX	TITLE PLAN-2 RESEARCH DATE: DEC. 23, 2019 / SHEET SIZE: A3 / SCALE: 1:600	DRAWING NO. A-006

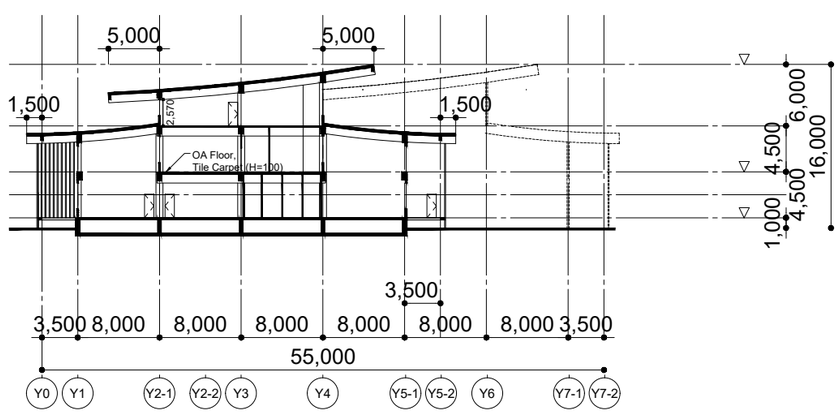






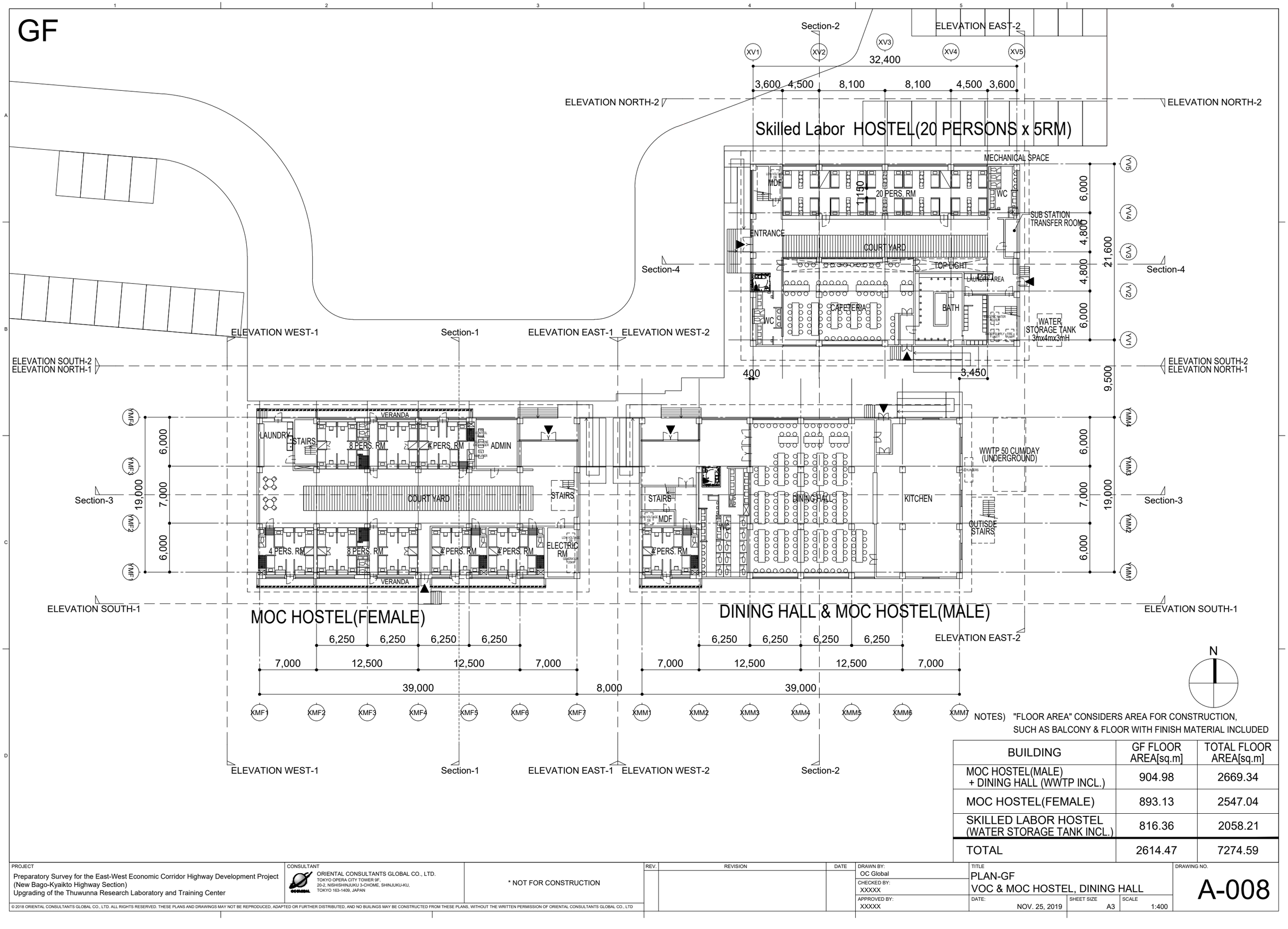






PROJECT: Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) Upgrading of the Thuwunna Research Laboratory and Training Center	CONSULTANT: ORIENTAL CONSULTANTS GLOBAL CO., LTD. TOKYO OPERA CITY TOWER 9F, 20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU, TOKYO 163-1409, JAPAN	* NOT FOR CONSTRUCTION	REV. / REVISION / DATE	DRAWN BY: OC Global; CHECKED BY: XXXXX; APPROVED BY: XXXXX	TITLE: ELEVATION AND SECTION RESEARCH; DATE: OCT. 04, 2019; SHEET SIZE: A3; SCALE: 1:600	DRAWING NO. A-007

GF



NOTES) "FLOOR AREA" CONSIDERS AREA FOR CONSTRUCTION, SUCH AS BALCONY & FLOOR WITH FINISH MATERIAL INCLUDED

BUILDING	GF FLOOR AREA[sq.m]	TOTAL FLOOR AREA[sq.m]
MOC HOSTEL(MALE) + DINING HALL (WWTP INCL.)	904.98	2669.34
MOC HOSTEL(FEMALE)	893.13	2547.04
SKILLED LABOR HOSTEL (WATER STORAGE TANK INCL.)	816.36	2058.21
TOTAL	2614.47	7274.59

PROJECT
Preparatory Survey for the East-West Economic Corridor Highway Development Project
(New Bago-Kyaikto Highway Section)
Upgrading of the Thuwunna Research Laboratory and Training Center

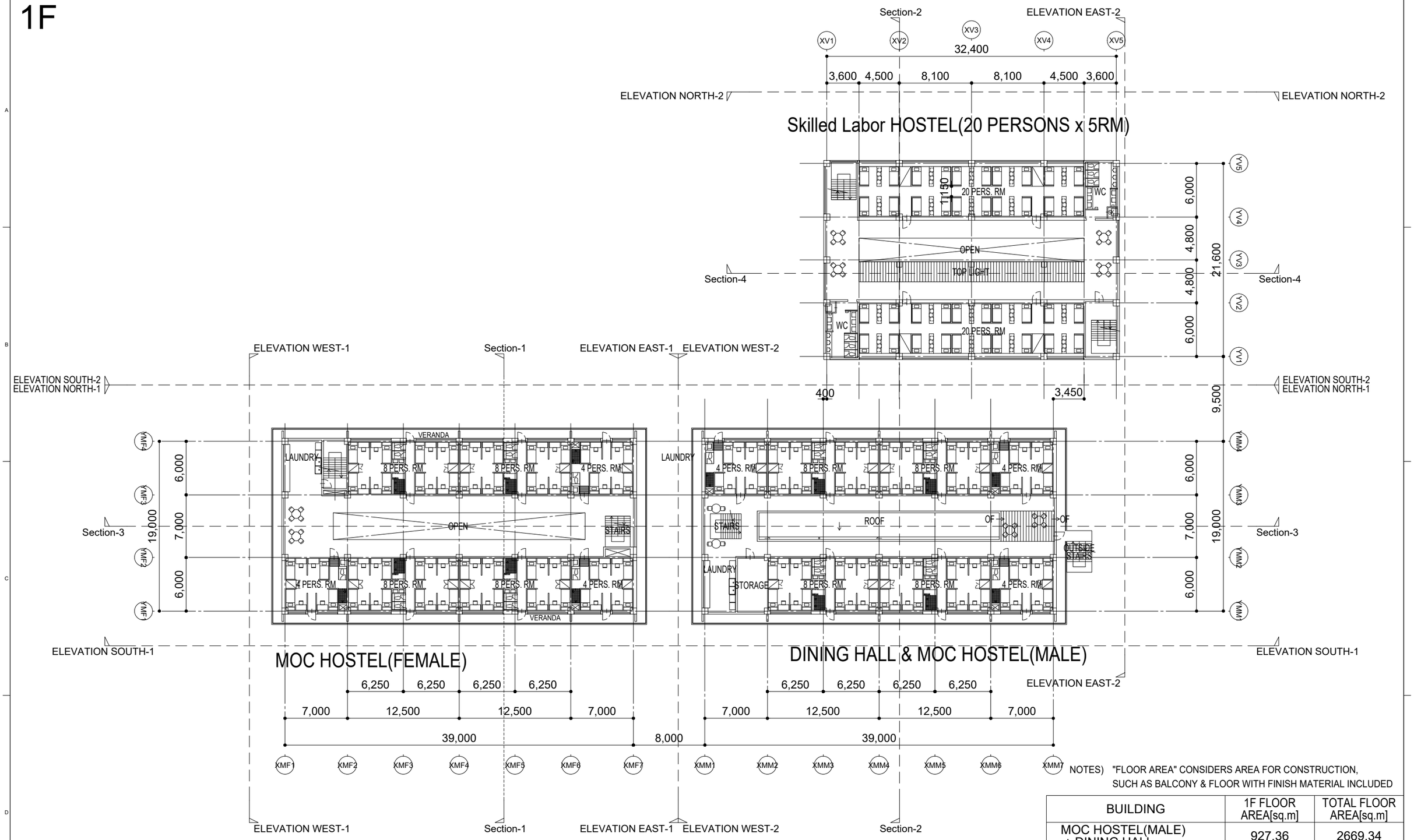
CONSULTANT
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TOKYO OPERA CITY TOWER 9F,
20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU,
TOKYO 163-1409, JAPAN

* NOT FOR CONSTRUCTION

REV.	REVISION	DATE

DRAWN BY: OC Global
CHECKED BY: XXXXX
APPROVED BY: XXXXX
TITLE: PLAN-GF
VOC & MOC HOSTEL, DINING HALL
DATE: NOV. 25, 2019
SHEET SIZE: A3
SCALE: 1:400
DRAWING NO. A-008

1F



NOTES) "FLOOR AREA" CONSIDERS AREA FOR CONSTRUCTION, SUCH AS BALCONY & FLOOR WITH FINISH MATERIAL INCLUDED

BUILDING	1F FLOOR AREA[sq.m]	TOTAL FLOOR AREA[sq.m]
MOC HOSTEL(MALE) + DINING HALL	927.36	2669.34
MOC HOSTEL(FEMALE)	839.41	2547.04
SKILLED LABOR HOSTEL	660.31	2058.21
TOTAL	2427.08	7274.59

PROJECT
Preparatory Survey for the East-West Economic Corridor Highway Development Project
(New Bago-Kyaikto Highway Section)
Upgrading of the Thuwunna Research Laboratory and Training Center

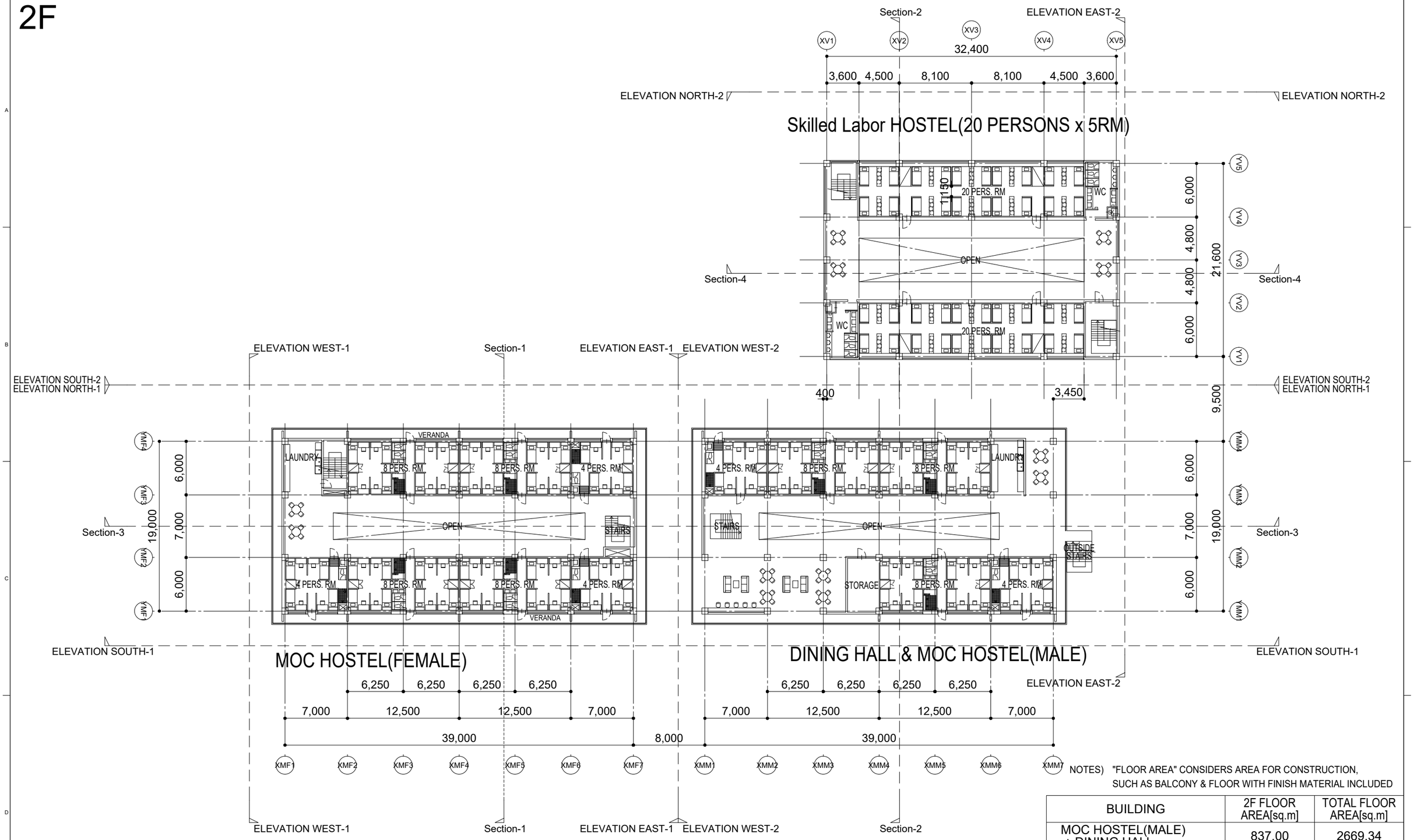
CONSULTANT
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TOKYO OPERA CITY TOWER 9F,
20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU,
TOKYO 163-1409, JAPAN

* NOT FOR CONSTRUCTION

REV.	REVISION	DATE

DRAWN BY: OC Global
CHECKED BY: XXXXX
APPROVED BY: XXXXX
TITLE: PLAN-1F
VOC & MOC HOSTEL, DINING HALL
DATE: NOV. 25, 2019
SHEET SIZE: A3
SCALE: 1:400
DRAWING NO. A-009

2F



NOTES) "FLOOR AREA" CONSIDERS AREA FOR CONSTRUCTION, SUCH AS BALCONY & FLOOR WITH FINISH MATERIAL INCLUDED

BUILDING	2F FLOOR AREA[sq.m]	TOTAL FLOOR AREA[sq.m]
MOC HOSTEL(MALE) + DINING HALL	837.00	2669.34
MOC HOSTEL(FEMALE)	814.50	2547.04
SKILLED LABOR HOSTEL	581.54	2058.21
TOTAL	2233.04	7274.59

PROJECT
Preparatory Survey for the East-West Economic Corridor Highway Development Project
(New Bago-Kyaikto Highway Section)
Upgrading of the Thuwunna Research Laboratory and Training Center

CONSULTANT
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TOKYO OPERA CITY TOWER 9F,
20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU,
TOKYO 163-1409, JAPAN

* NOT FOR CONSTRUCTION

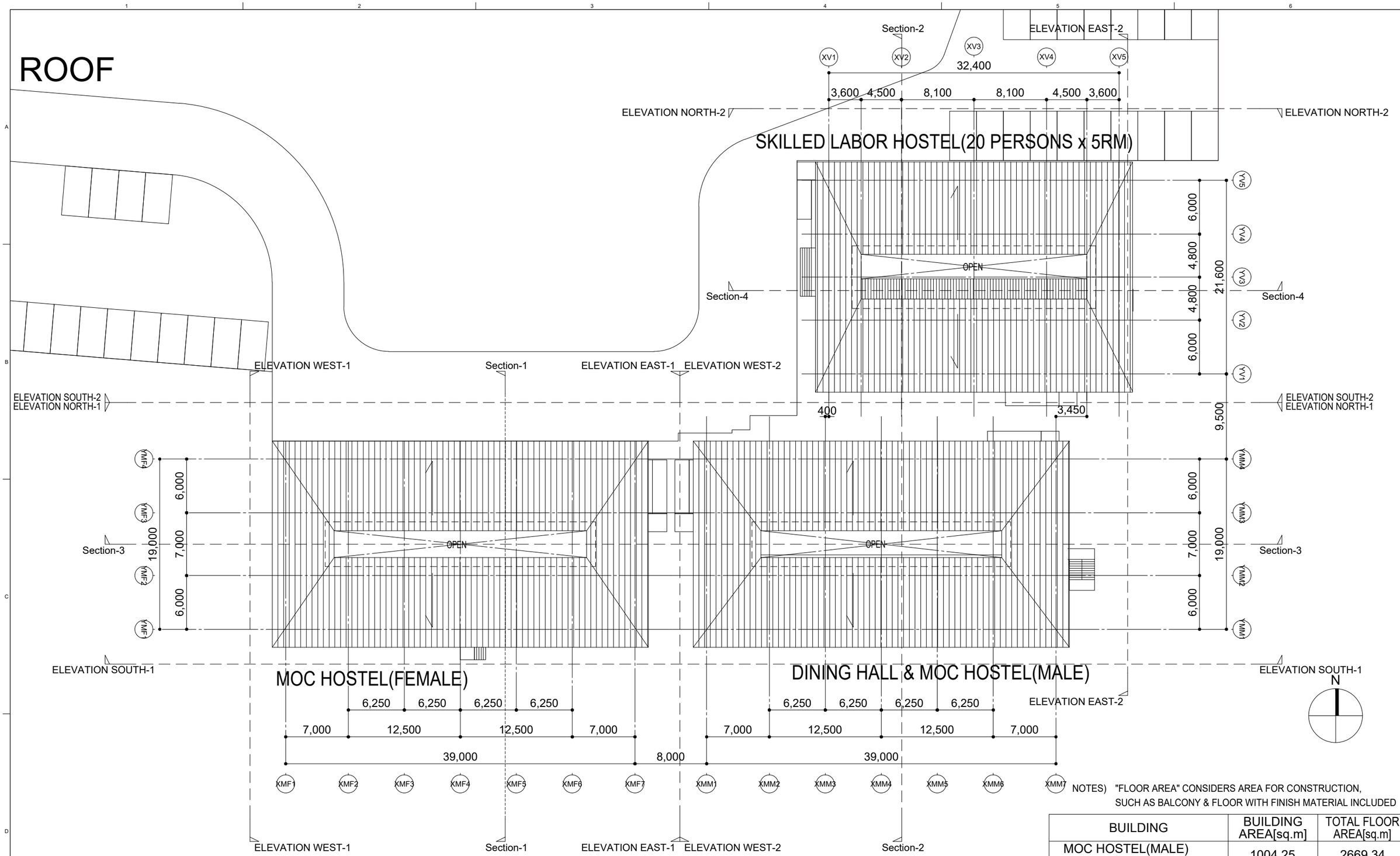
REV.	REVISION	DATE

DRAWN BY: OC Global
CHECKED BY: XXXXX
APPROVED BY: XXXXX
DATE: NOV. 25, 2019
SHEET SIZE: A3
SCALE: 1:400

TITLE
PLAN-2F
VOC & MOC HOSTEL, DINING HALL

DRAWING NO.
A-010

ROOF



NOTES) "FLOOR AREA" CONSIDERS AREA FOR CONSTRUCTION, SUCH AS BALCONY & FLOOR WITH FINISH MATERIAL INCLUDED

BUILDING	BUILDING AREA[sq.m]	TOTAL FLOOR AREA[sq.m]
MOC HOSTEL(MALE) + DINING HALL	1004.25	2669.34
MOC HOSTEL(FEMALE)	901.79	2547.04
SKILLED LABOR HOSTEL	876.20	2058.21
TOTAL	2782.24	7274.59

PROJECT
Preparatory Survey for the East-West Economic Corridor Highway Development Project
(New Bago-Kyaikto Highway Section)
Upgrading of the Thuwunna Research Laboratory and Training Center

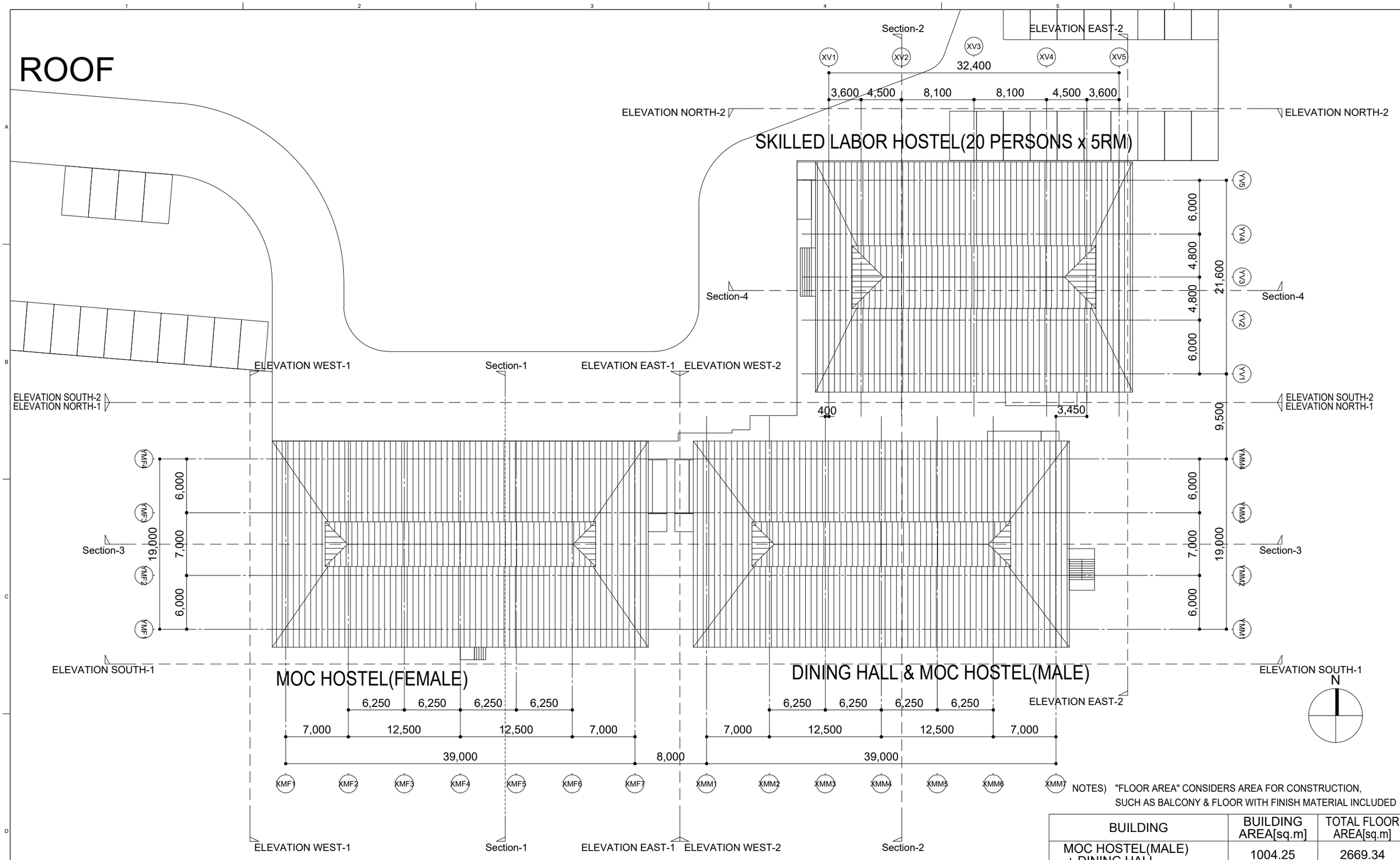
CONSULTANT
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TOKYO OPERA CITY TOWER 9F,
20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU,
TOKYO 163-1409, JAPAN

* NOT FOR CONSTRUCTION

REV.	REVISION	DATE

DRAWN BY: OC Global
CHECKED BY: XXXXX
APPROVED BY: XXXXX
TITLE: PLAN-ROOF
VOC & MOC HOSTEL, DINING HALL
DATE: DEC. 10, 2019
SHEET SIZE: A3
SCALE: 1:400
DRAWING NO. A-011

ROOF



NOTES) "FLOOR AREA" CONSIDERS AREA FOR CONSTRUCTION, SUCH AS BALCONY & FLOOR WITH FINISH MATERIAL INCLUDED

BUILDING	BUILDING AREA[sq.m]	TOTAL FLOOR AREA[sq.m]
MOC HOSTEL(MALE) + DINING HALL	1004.25	2669.34
MOC HOSTEL(FEMALE)	901.79	2547.04
SKILLED LABOR HOSTEL	876.20	2058.21
TOTAL	2782.24	7274.59

PROJECT
Preparatory Survey for the East-West Economic Corridor Highway Development Project
(New Bago-Kyaikto Highway Section)
Upgrading of the Thuwunna Research Laboratory and Training Center

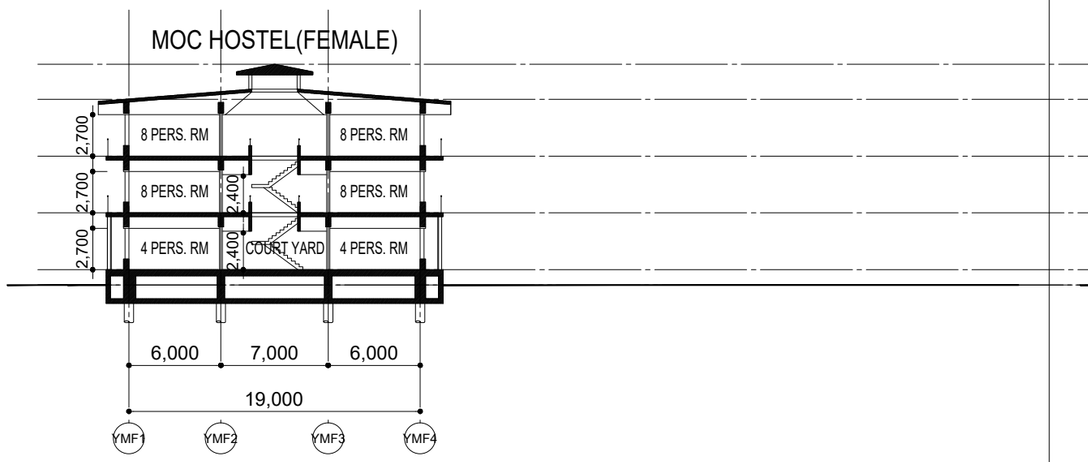
CONSULTANT
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TOKYO OPERA CITY TOWER 9F,
20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU,
TOKYO 163-1409, JAPAN

* NOT FOR CONSTRUCTION

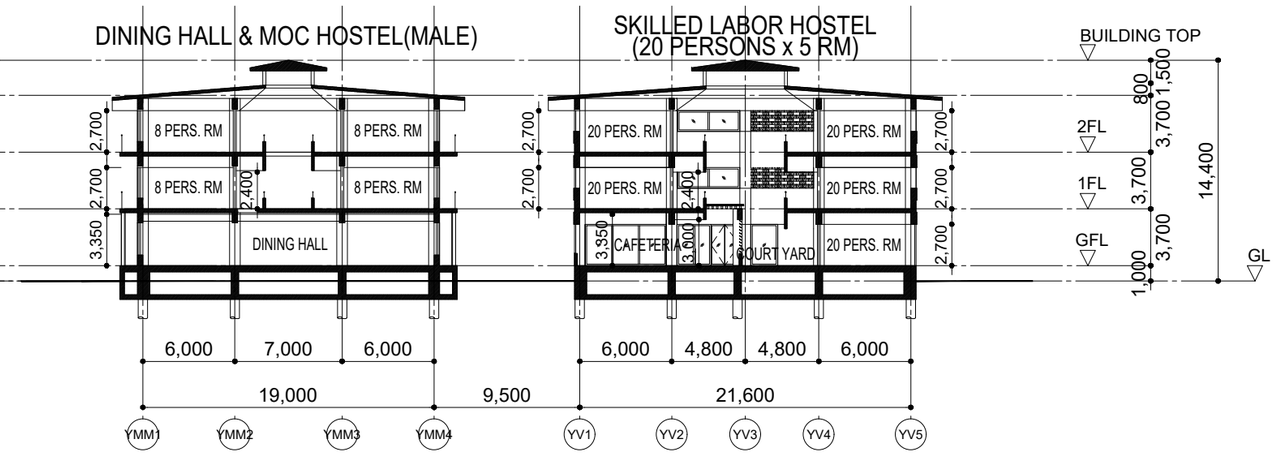
REV.	REVISION	DATE

DRAWN BY: OC Global
CHECKED BY: XXXXX
APPROVED BY: XXXXX
TITLE: PLAN-TOP ROOF
VOC & MOC HOSTEL, DINING HALL
DATE: DEC. 10, 2019
SHEET SIZE: A3
SCALE: 1:400
DRAWING NO. A-012

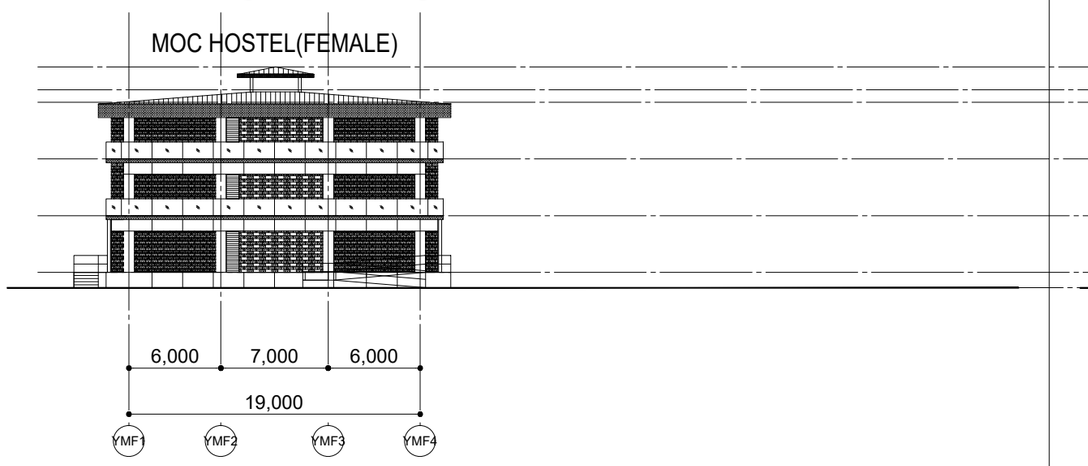
SECTION-1



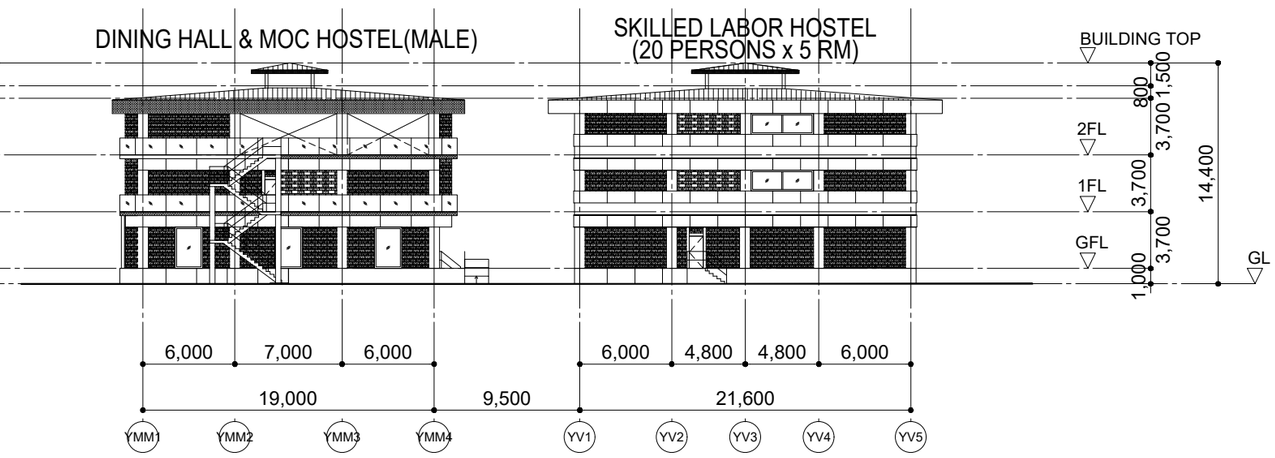
SECTION-2



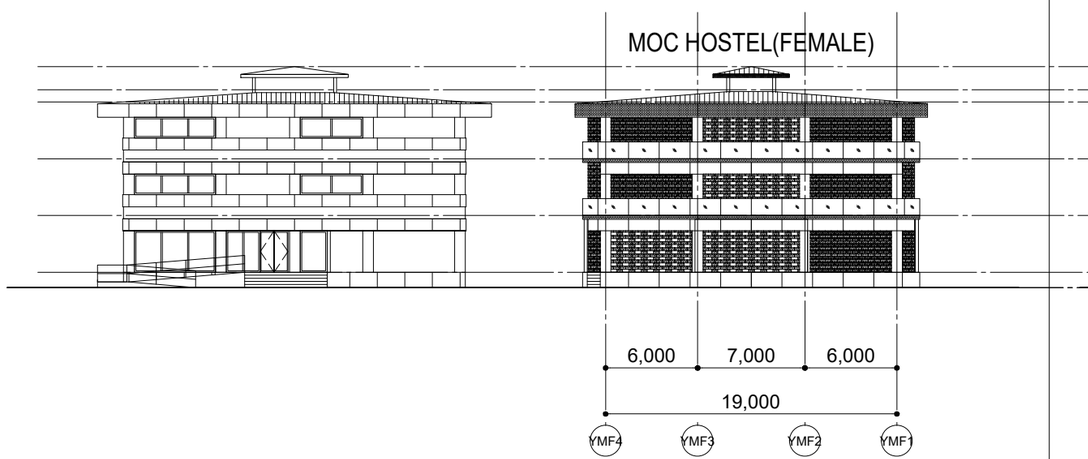
ELEVATION EAST-1



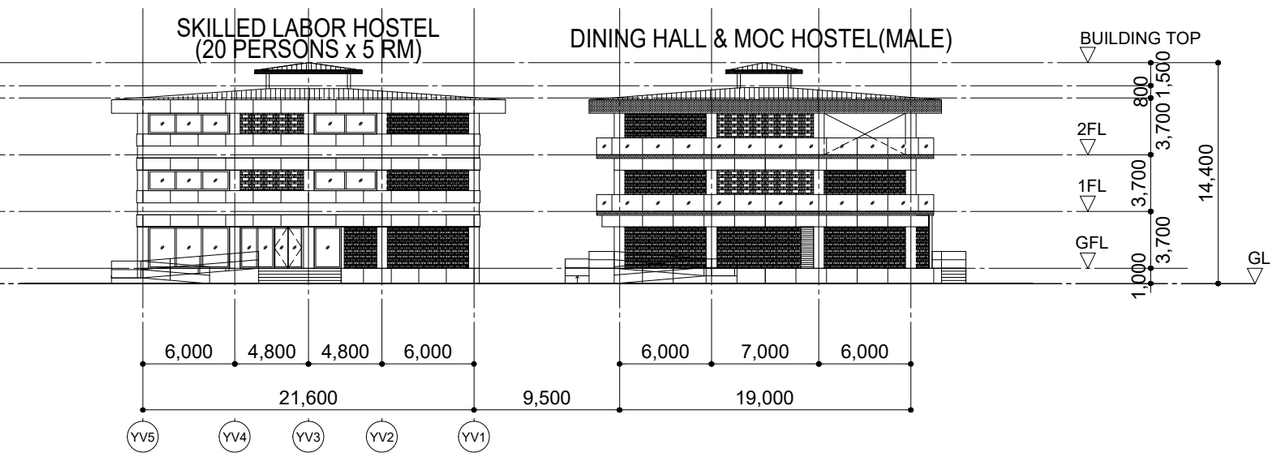
ELEVATION EAST-2



ELEVATION WEST-1

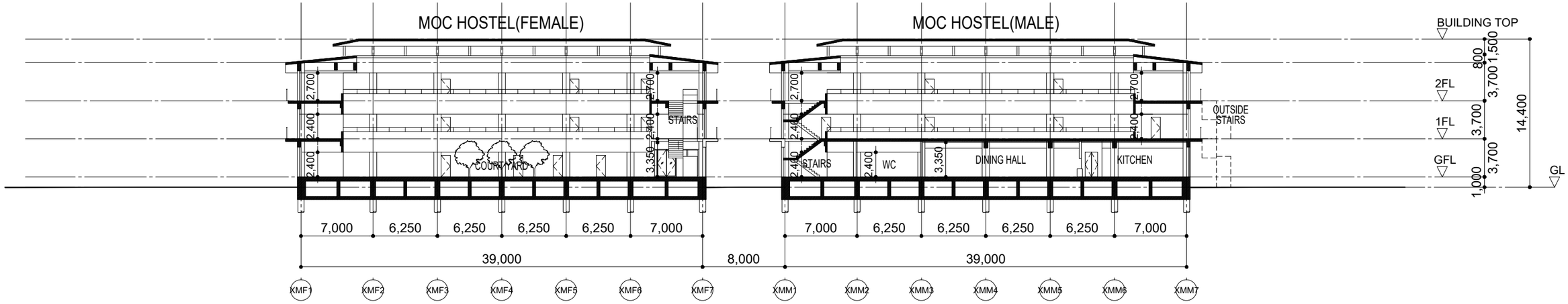


ELEVATION WEST-2

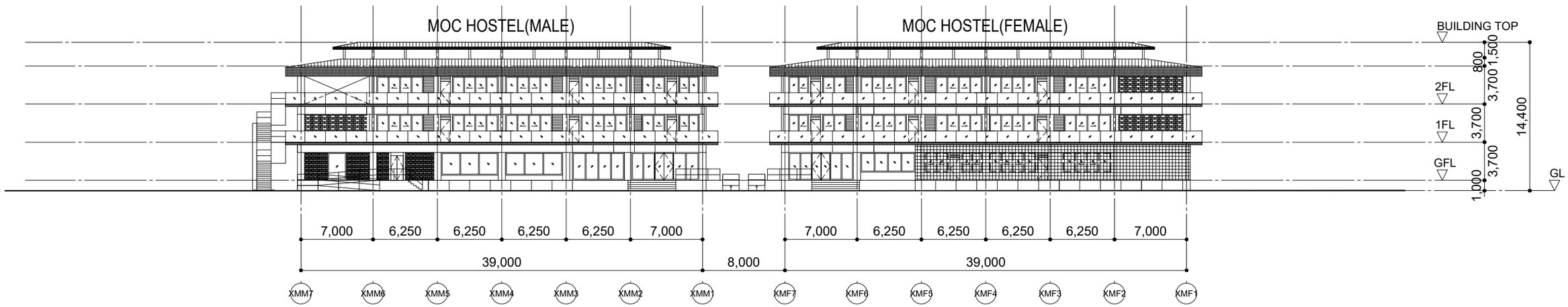


PROJECT: Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) Upgrading of the Thuwunna Research Laboratory and Training Center	CONSULTANT: ORIENTAL CONSULTANTS GLOBAL CO., LTD. TOKYO OPERA CITY TOWER 9F, 20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU, TOKYO 163-1409, JAPAN	* NOT FOR CONSTRUCTION	REV. / REVISION / DATE	DRAWN BY: OC Global CHECKED BY: XXXXX APPROVED BY: XXXXX	TITLE: ELEVATION-1 VOC & MOC HOSTEL, DINING HALL DATE: OCT. 09 , 2019 SHEET SIZE: A3 SCALE: 1:400	DRAWING NO. A-013

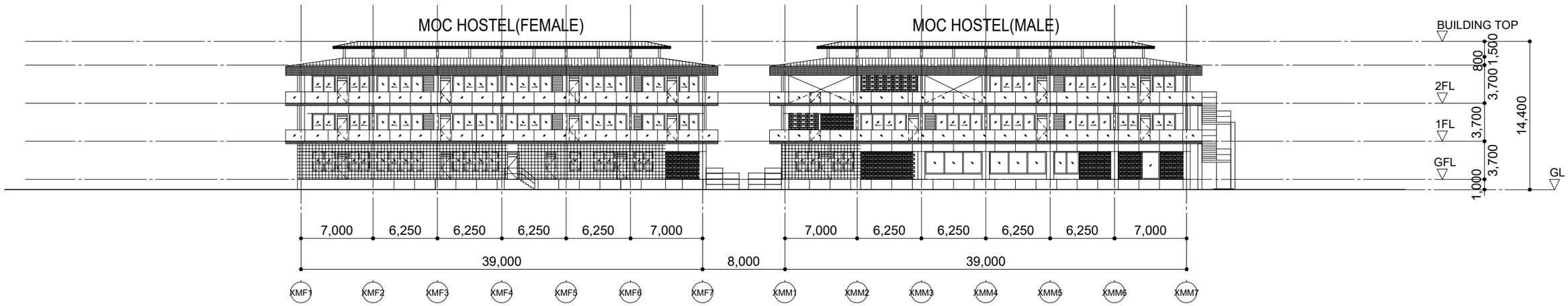
SECTION-3



ELEVATION NORTH-1

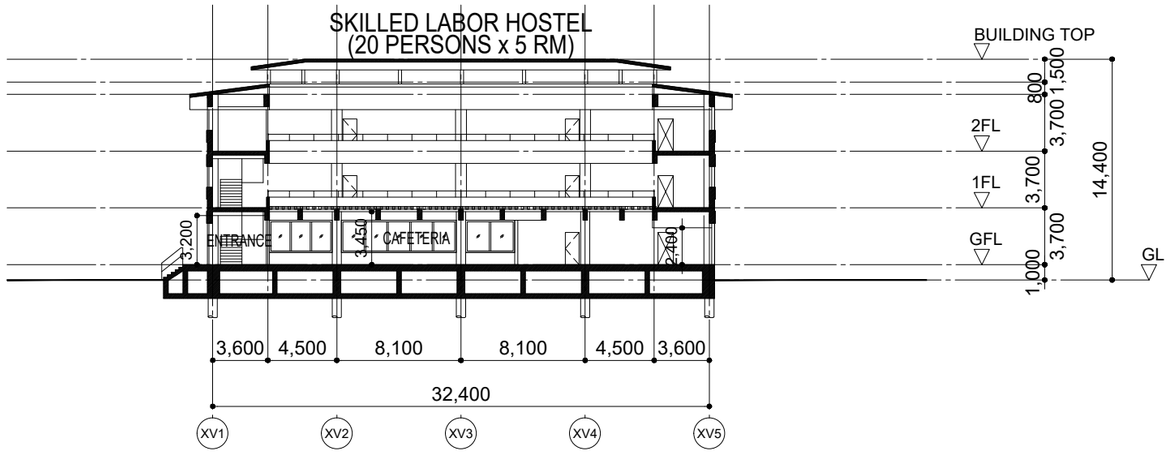


ELEVATION SOUTH-1



PROJECT: Preparatory Survey for the East-West Economic Corridor Highway Development Project (New Bago-Kyaikto Highway Section) Upgrading of the Thuwunna Research Laboratory and Training Center	CONSULTANT: ORIENTAL CONSULTANTS GLOBAL CO., LTD. TOKYO OPERA CITY TOWER 9F, 20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU, TOKYO 163-1409, JAPAN	* NOT FOR CONSTRUCTION	REV. / REVISION / DATE	DRAWN BY: OC Global; CHECKED BY: XXXXX; APPROVED BY: XXXXX	TITLE: ELEVATION-2 VOC & MOC HOSTEL, DINING HALL; DATE: OCT. 09 , 2019; SHEET SIZE: A3; SCALE: 1:400	DRAWING NO. A-014

SECTION-4



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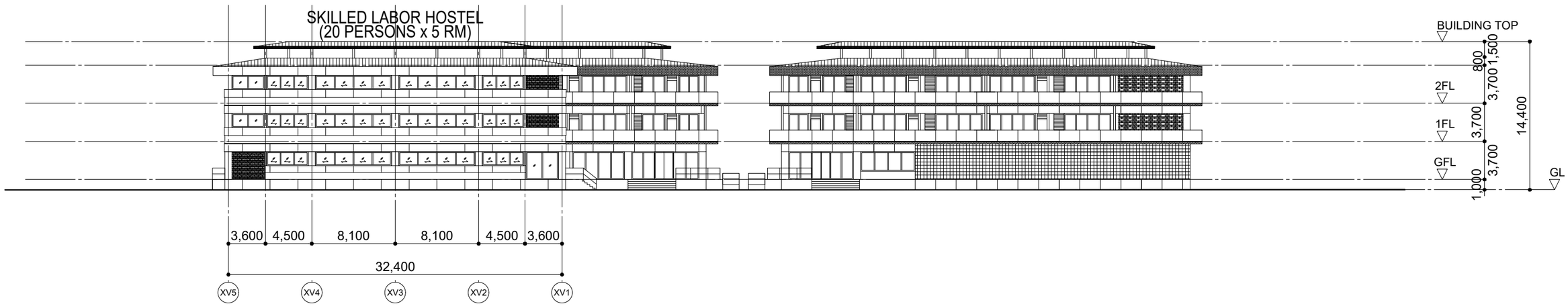

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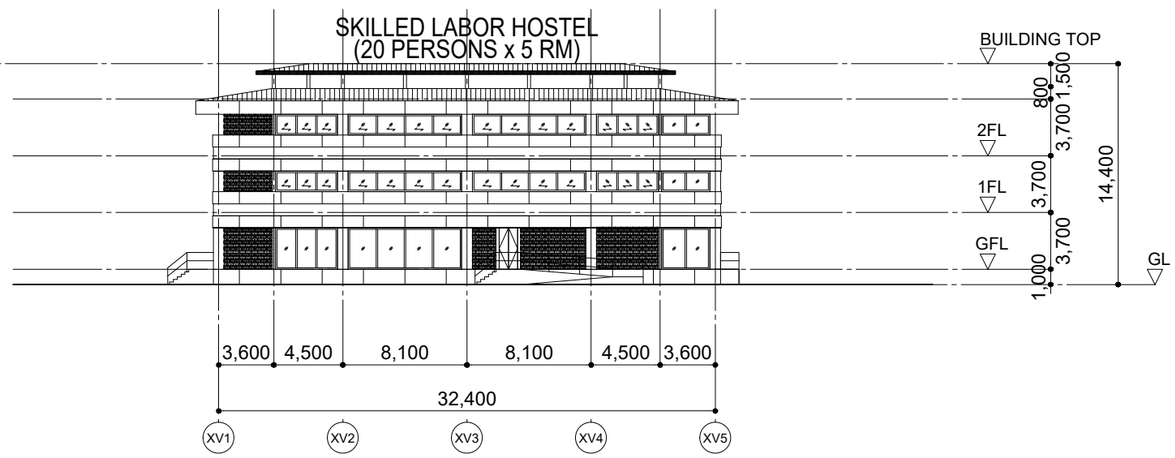

PROJECT
Preparatory Survey for the East-West Economic Corridor Highway Development Project
(New Bago-Kyaikto Highway Section)
Upgrading of the Thuwunna Research Laboratory and Training Center

CONSULTANT
ORIENTAL CONSULTANTS GLOBAL CO., LTD.
TOKYO OPERA CITY TOWER 9F,
20-2, NISHISHINJUKU 3-CHOME, SHINJUKU-KU,
TOKYO 163-1409, JAPAN

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APPROVED BY: XXXXX

TITLE
ELEVATION-3
VOC & MOC HOSTEL, DINING HALL

DATE: OCT. 09 , 2019
SHEET SIZE: A3
SCALE: 1:400

DRAWING NO.
A-015