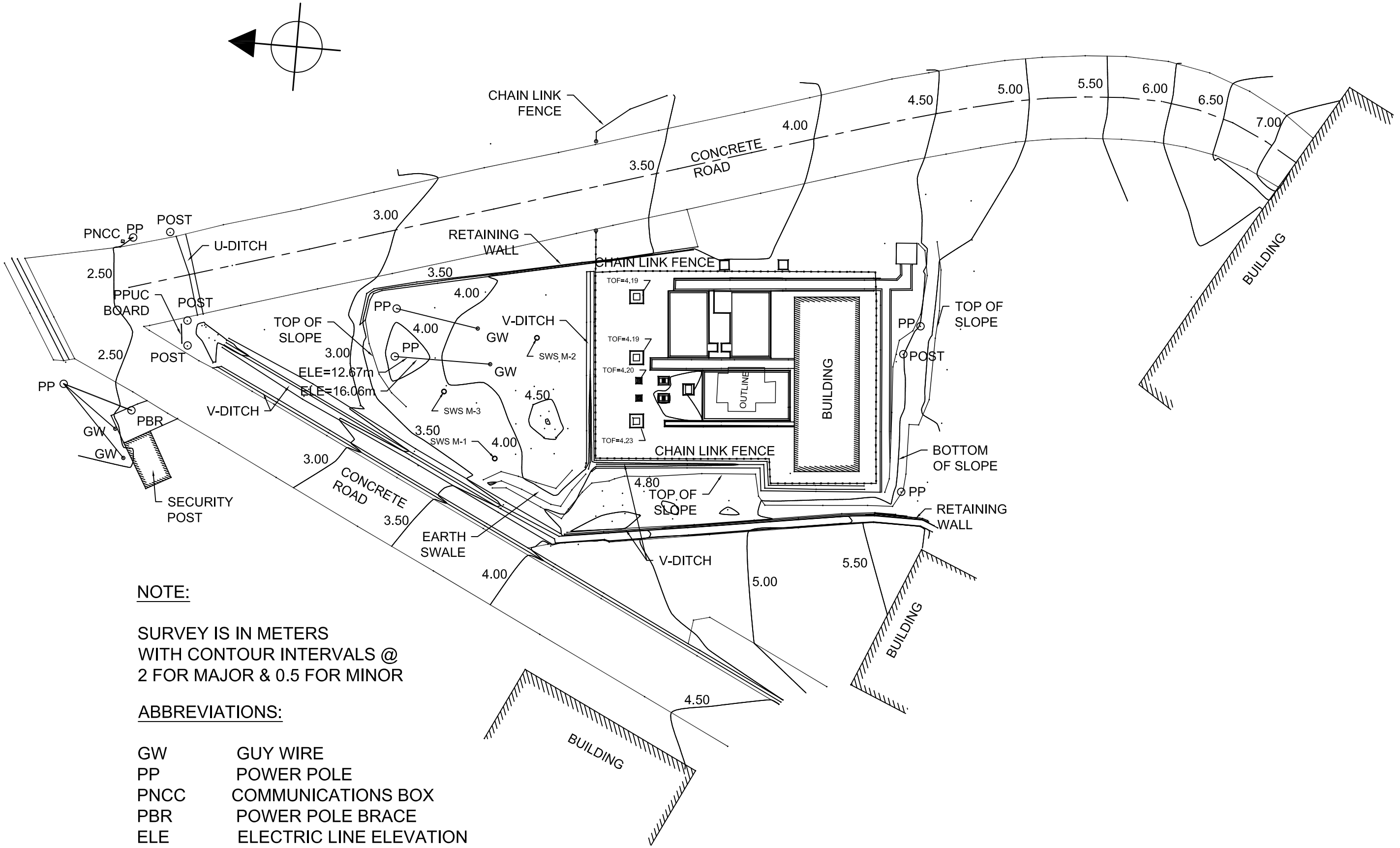
12. 自然条件調査
（地形測量及び地盤・地質調査）報告書
（現地再委託）

Topographical Survey Drawing

Topographical Survey Drawing



NOTE:

SURVEY IS IN METERS
WITH CONTOUR INTERVALS @
2 FOR MAJOR & 0.5 FOR MINOR

ABBREVIATIONS:

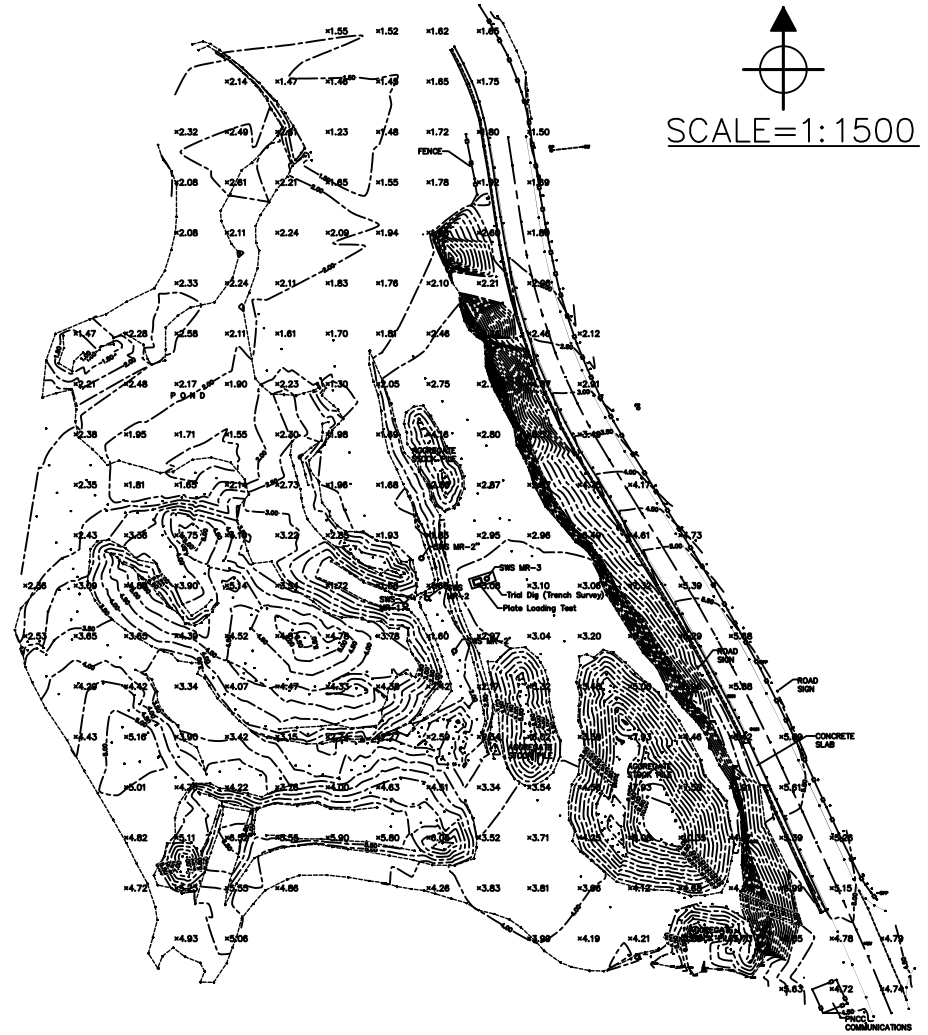
GW	GUY WIRE
PP	POWER POLE
PNCC	COMMUNICATIONS BOX
PBR	POWER POLE BRACE
ELE	ELECTRIC LINE ELEVATION

PROJECT:	LOCATION:	TITLE:	APPROVED BY:	CHECKED BY:	DESIGNED BY:	DATE:	DWG No:
PREPARATORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU	MALAKAL SUBSTATION	TOPOGRAPHIC SURVEY DATA					
			CONSULTANT: Yachiyo Engineering.,Co.LTD Tokyo Japan				SCALE: 1/300

A12-3

SCALE=1:300

SWS MR-2''
SWS MR-3
SWS MR-2
SWS MR-1
Trial Dig (Trench Survey)
Plate Loading Test
SWS MR-2'
ROAD SIGN
MH
AGGREGATE STOCK PILE
AGGREGATE STOCK PILE
P 8.18



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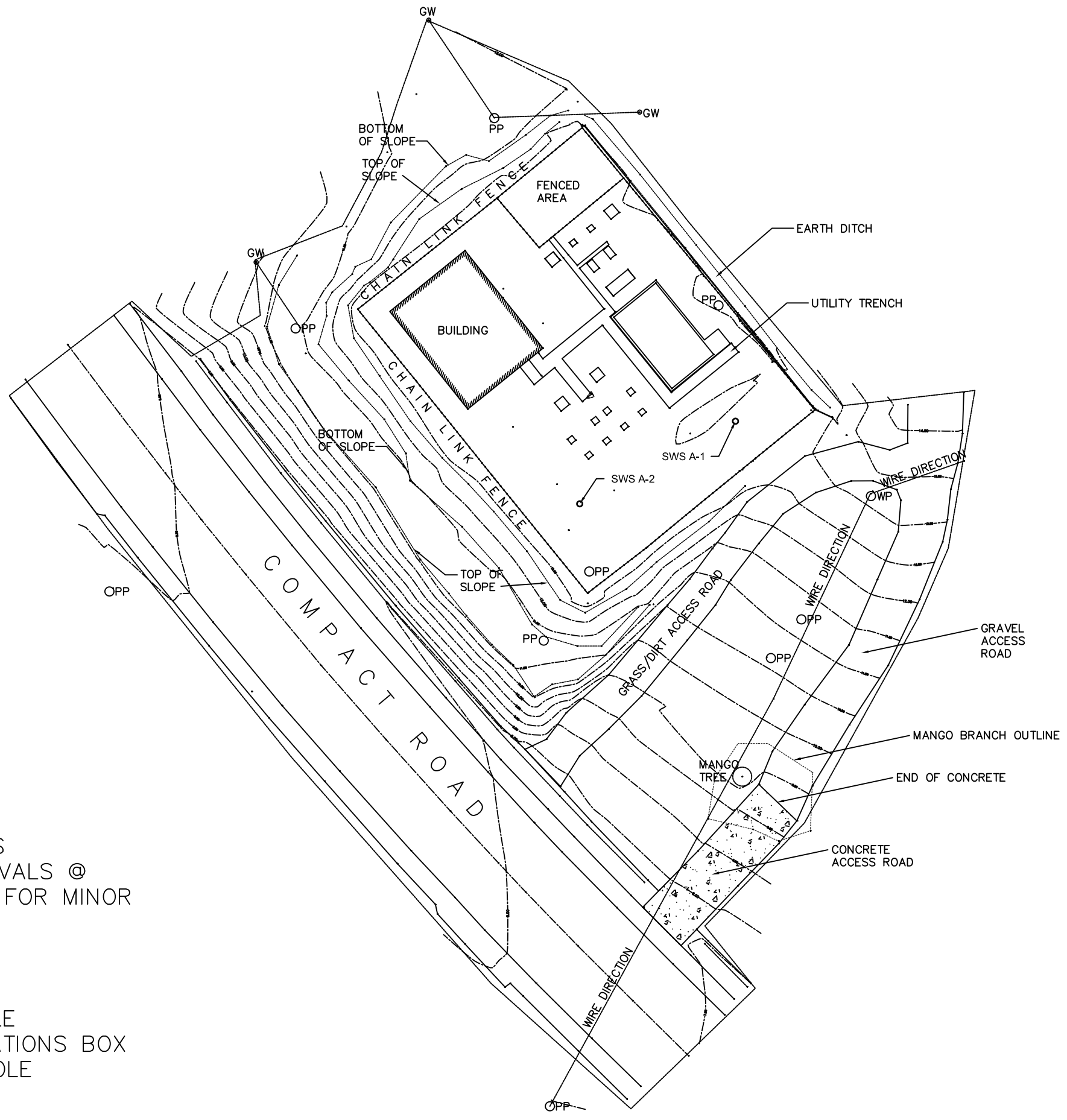
NOTE:

SURVEY IS IN METERS
WITH CONTOUR INTERVALS @
2 FOR MAJOR & 0.5 FOR
MINOR

ABBREVIATIONS:

GW	GUY WIRE
PP	POWER POLE
PNCC BOX	COMMUNICATIONS
PBR	POWER POLE BRACE
WV	WATER VALVE
MH	MAN HOLE

PROJECT:	LOCATION:	TITLE:	APPROVED BY:	CHECKED BY:	DESIGNED BY:	DATE:	DWG No:
PREPARATORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU	TITLE: KOROR SUBSTATION	TOPOGRAPHIC SURVEY DATA	CONSULTANT: Yachiyo Engineering.,Co.LTD Tokyo Japan				SCALE: AS SHOWN



NOTE:

SURVEY IS IN METERS
WITH CONTOUR INTERVALS @
2 FOR MAJOR & 0.5 FOR MINOR

ABBREVIATIONS:

GW	GUY WIRE
PP	POWER POLE
PNCC	COMMUNICATIONS BOX
WP	WOODEN POLE

PROJECT:	LOCATION:	TITLE:	APPROVED BY:	CHECKED BY:	DESIGNED BY:	DATE:	DWG No:
PREPARATORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU	AIRAI SUBSTATION	TOPOGRAPHIC SURVEY DATA	CONSULTANT: Yachiyo Engineering.,Co.LTD Tokyo Japan				SCALE: 1/300

NOTE:

SURVEY IS IN METERS
WITH CONTOUR INTERVALS @
2 FOR MAJOR & 0.5 FOR MINOR

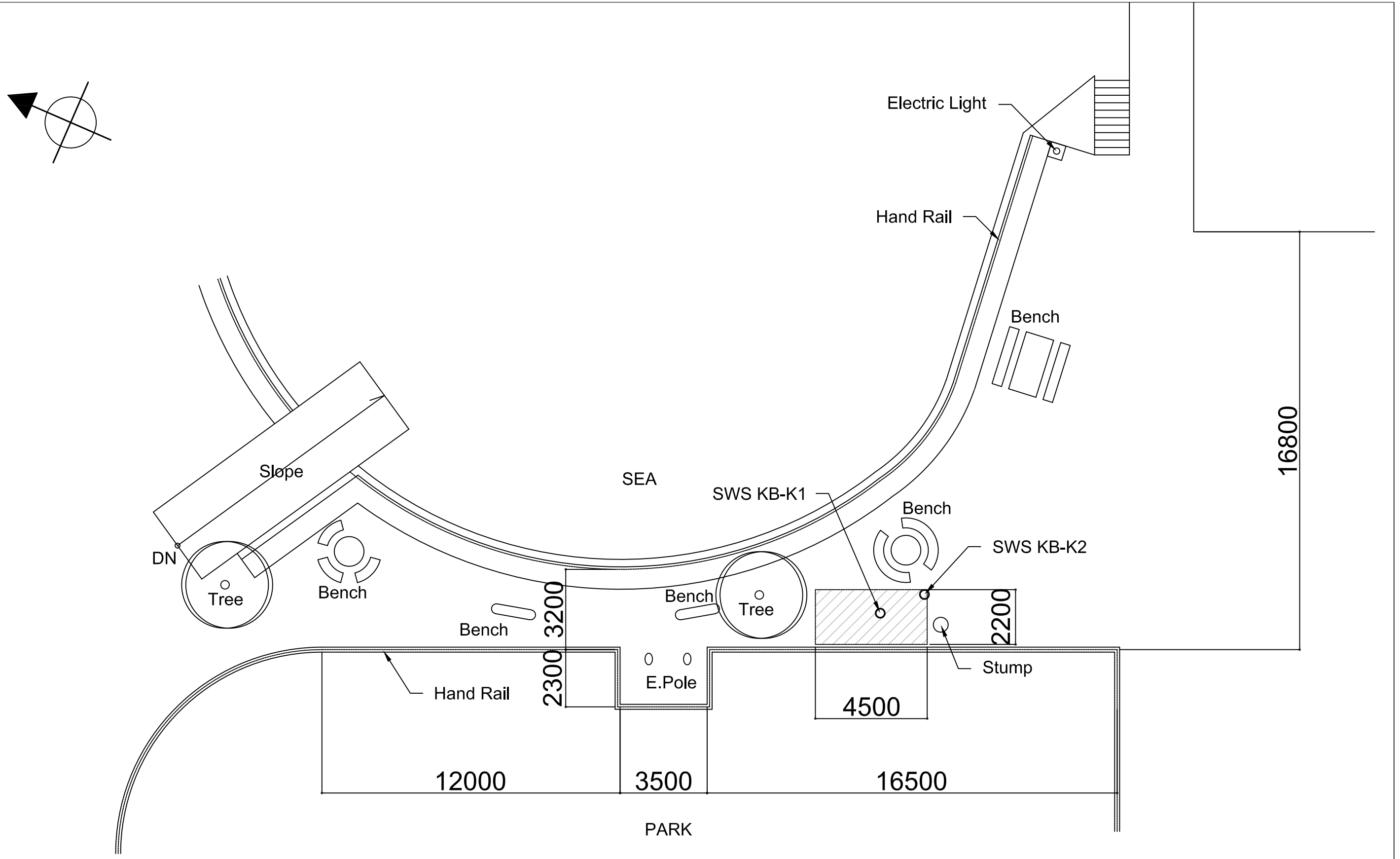
ABBREVIATIONS:

GW	GUY WIRE
PP	POWER POLE
PNCC	COMMUNICATIONS BOX

COMPACT ROAD
ASPHALT ROAD
END OF ASPHALT ROAD
GRAVEL ROAD
SWS K-5
SWS K-6
BOTTOM OF SLOPE
BOTTOM OF SLOPE
TOP OF SLOPE
GW
GW
GW
PP
ELECTRICAL LINE ELEV. =46.58M.
CHAIN LINK FENCE
ELECTRICAL LINE ELEV. =47.70M.
ELECTRICAL LINE ELEV. =46.46M.
POWER LINE DIRECTION
ELECTRICAL LINE ELEV. =50.08M.
ELECTRICAL LINE ELEV. =49.77M.
PP
PP
PP
PP
PP
PP
CHAIN LINK FENCE
CROSS DRAIN OUTLET
ELECTRICAL LINE ELEV. =48.73M.
PNCC
SWS K-4
SWS K-3
SWS K-1
SWS K-2
TOP OF SLOPE
CONCRETE ROAD
BEGINNING OF V-DITCH
SAW CUT
POWER LINE DIRECTION
POWER LINE DIRECTION
ELECTRICAL LINE ELEV. =47.47M.
POWER LINE DIRECTION
ELECTRICAL LINE ELEV. =46.69M.
PP
ELECTRICAL LINE ELEV. =45.84M.
ELECTRICAL LINE ELEV. =48.22M.
POWER LINE DIRECTION
CROSS DRAIN INLET
BEGINNING OF V-DITCH
COMPACT ROAD

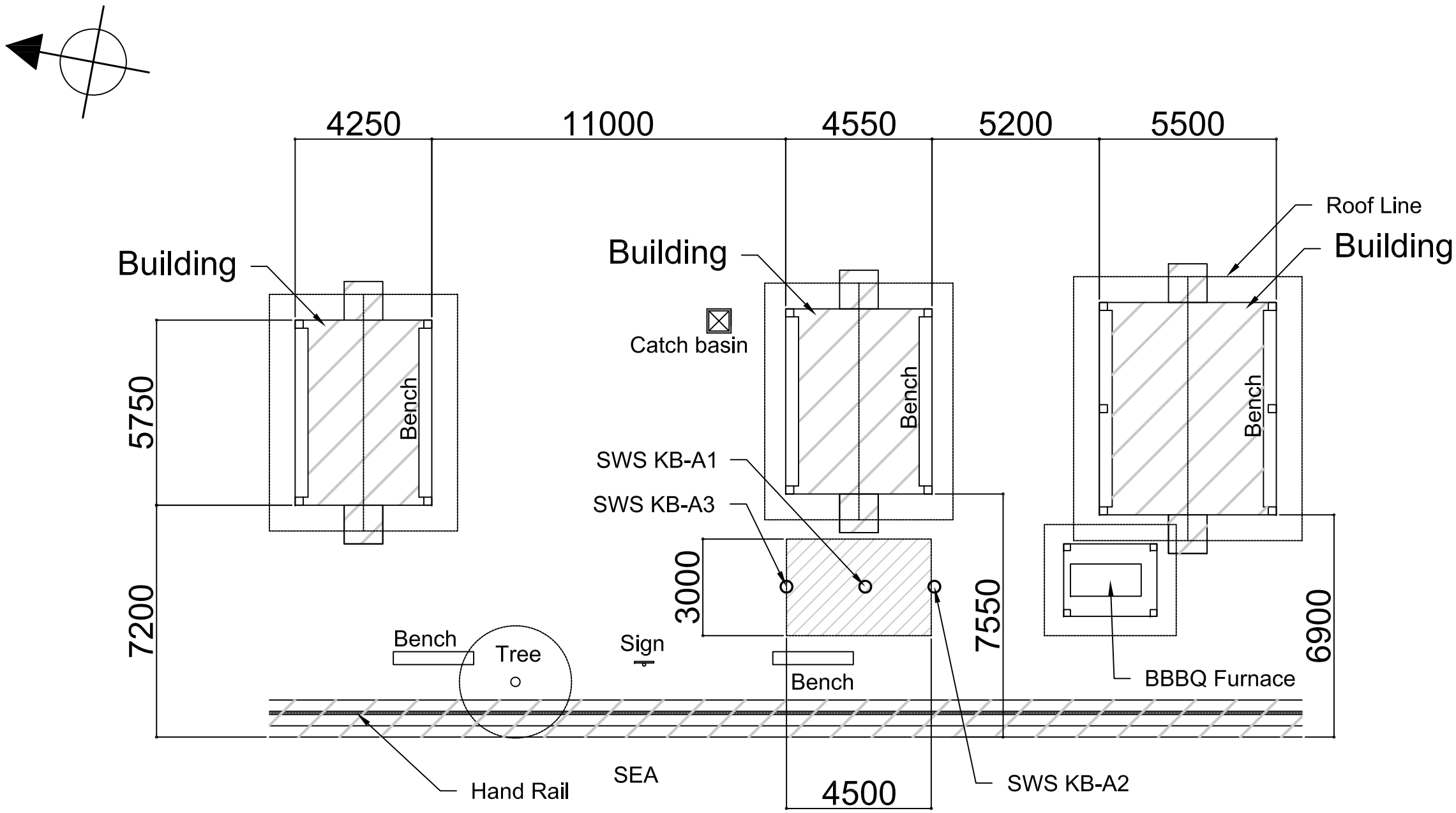
PROJECT:	LOCATION:	TITLE:	APPROVED BY:	CHECKED BY:	DESIGNED BY:	DATE:	DWG No:
PREPARATORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU	KOKUSAI SUBSTATION	TOPOGRAPHIC SURVEY DATA					
			CONSULTANT: Yachiyo Engineering.,Co.LTD Tokyo Japan				SCALE: 1/300

A12-6



A12-7

PROJECT:	LOCATION:	TITLE:	APPROVED BY:	CHECKED BY:	DESIGNED BY:	DATE:	DWG No:
PREPARATORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU	KB BRIDGE - KOROR SIDE -	TOPOGRAPHIC SURVEY DATA	CONSULTANT: Yachiyo Engineering.,Co.LTD Tokyo Japan				SCALE: 1/150



PROJECT:	LOCATION:	TITLE:	APPROVED BY:	CHECKED BY:	DESIGNED BY:	DATE:	DWG No:
PREPARATORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU	KB BRIDGE - AIRAI SIDE -	TOPOGRAPHIC SURVEY DATA	CONSULTANT: Yachiyo Engineering.,Co.LTD Tokyo Japan				SCALE: 1/150

A12-8

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PREPARATORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU

PLATE LOADING TEST REPORT
SOIL LABORATORY TEST REPORT

Submission date: 25th September2021
Surangel and Son's Construction

Signature:

Uchelsung Rdialul
Operations Manager

1. General Information of the Testing

1.1 Name of the Project：

JICA Project:

Preparatory Survey on the Project for Upgrading Power Grid in the Republic of Palau

1.2 Project site:

(1) Koror substation project site (Mason rock area)
(2) Kukusai substation project site

1.3 Expected Items of the construction works by the project

(1) Foundation of the Switchgear Buildings
(2) Foundation of the Transformer and other Equipment

1.4 Items of the tests

(1) Plate loading test
(2) Soil Digging, Collection of soil samples and Laboratory Test

1.5 Testing date

(1) Koror Substation Project Site (Mason Rock Area)
(2) Kokusai Substation Project Site

1.6 Name of the Consultant

Yachiyo Engineering Co.,Ltd.

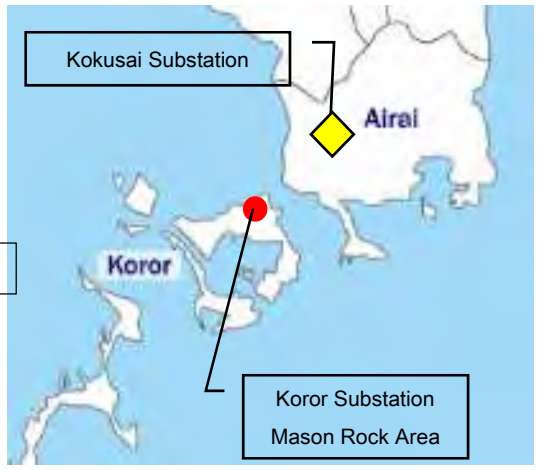
1.7 Name of the Contractor

Surabgel & Son’s Construction

2. Location of the project site

Location of Test /Kokusai Substation

Location of Test/ Mason Rock Area



Location of the Project Sites

3. Method of Testing

3.1 Standards of Plate Loading Test

Test method for bearing capacity of soil for static load and spread footings" specified in ASTM D1194-94 attached herewith

3.2 Testing Load

(1) Expected required bearing capacity for the foundation

1) In case of Transformer foundation

The weight of the Transformer: 300 kN (≒ 30 ton)

The weight of the foundation (3.0m x 7.0m x 2.0m): 600kN (≒60 ton)

Required bearing capacity of the Soil =Total weight / Foundation area = 900kN/ (3x7) ≒43.0 kN/m^2

Testing Load = 43.0 x 3.0 = 129.0 kN/m^2

2) In case of Building foundation

Expected maximum axial force for foundation design≒ 500kN(Include foundation and soil)

Expected dimension of the foundation = 3.5m x 3.5 m

Required bearing capacity of the soil =Total weight / Foundation area = 500kN/ (3.5x3.5) ≒55.6 kN/m^2

Testing load = 55.6 x 3.0 = 166.8 kN/m^2

(2) Therefore, testing load shall more than166.8 kN/m^2

Adopted maximum load pressure for Testing is 11.88 kN

11.88 kN / (0.15x0.15x3.14)= 168.2 kN/m2 > 166.8 kN/m2

3.3 Method of Testing

(1) The loading method implemented this time adopted the 1-cycle method because the purpose of the measurement was to grasp the bearing capacity of the ground

(2) As for the load, the planned maximum load is to be loaded in 8 or more stages in principle, therefore in this Testing, the 9-stage loading method generally adopted in Palau country is applied

(3) Prior to the main loading, preliminary loading is performed for the purpose of confirming whether the displacement meter operates normally and controlling the degree of disturbance of the contact portion between the ground surface and the loading plate. In addition, the load at the time of preliminary loading is, in principle, 1/8 of the planned maximum load and a constant load within the range that does not exceed the load of the first stage, therefore in this test 0.9kN is applied (less than first stage load=1.32kN)

(4) The load speed at each stage of the main loading shall be promptly performed at a constant speed, and the load holding period shall be a fixed time of about 30 minutes. However, at the loading stage, the fixed time is about 5 minutes. In addition, settlement measurement is performed every 0 minutes, 1 minute, 2 minutes, 5 minutes, and every 5 minutes thereafter immediately after the load arrives at each stage

4. Picture of the Testing

4.1 Koror Substation (Mason rock area) : Testing date 07 Sep 2021

Digging Test Pit

Protection from rain and wind

Setting measurement instruments

Measurement and Recording work

4.2 Kokusai Substation : Testing date 20 Sep 2021

Digging of Test Pit

Protection from rain and wind

Setting measurement instrument

5. Attachments

5.1 Results of the Plate loading test

5.2 Results of the Soil laboratory test

5.3 ASTM D-1194-94

MASON'S ROCK PRODUCTS
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PLATE LOAD TEST

ASTM D-1194

Job Name: Koror Sub- Station
Location: MRP Quarry/ Koror
Elevation: 0.5m depth
Date: 07 Sept. 2021
Tested by: RV. Melancio/ Matl's Engr.

Shape of Loading Plate: Disc
Dimension of Loading Plate: 300mm
Area of Loading Plate: 706.5cm^2

Type of Jack: Hydraulic
Design Load: 50 kN
Type of Reactive Devices: Hydraulic Excavator

Loading Method: Staged Loading
9th steps
Actual Loading/Step: 10.6kN/m2
Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
Reserve	0	0	0	0:00	0.00	0.00	0.00	0.00	0.000	0.000
1st	0.90	12.74	1	0:01	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:02	0.00	0.00	0.00	0.00	0.000	0.000
2nd	0	0	1	0:03	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:04	0.00	0.00	0.00	0.00	0.000	0.000
3rd	0.90	12.74	1	0:05	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:06	0.00	0.00	0.00	0.00	0.000	0.000
4th	0	0	1	0:07	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:08	0.00	0.00	0.00	0.00	0.000	0.000
5th	0.90	12.74	1	0:09	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:10	0.00	0.00	0.00	0.00	0.000	0.000
6th	0	0	1	0:11	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:12	0.00	0.00	0.00	0.00	0.000	0.000
1st	1.32	18.68	0	0:12	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:13	0.00	0.00	0.00	0.00	0.000	0.000
			2	0:14	0.00	0.00	0.00	0.00	0.000	0.000
			5	0:17	0.00	0.00	0.00	0.00	0.000	0.000
			10	0:22	0.00	0.00	0.00	0.00	0.000	0.000
			15	0:27	0.00	0.00	0.00	0.00	0.000	0.000
			20	0:32	0.00	0.00	0.00	0.00	0.000	0.000
			25	0:37	0.00	0.00	0.00	0.00	0.000	0.000
			30	0:42	0.00	0.00	0.00	0.00	0.000	0.000
2nd	2.64	37.37	0	0:42	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:43	0.00	0.01	0.00	0.03	0.010	0.010
			2	0:44	0.00	0.01	0.00	0.06	0.018	0.018
			5	0:47	0.00	0.01	0.00	0.10	0.028	0.028
			10	0:52	0.00	0.01	0.00	0.12	0.033	0.033
			15	0:57	0.00	0.01	0.00	0.12	0.033	0.033
			20	1:02	0.00	0.01	0.00	0.12	0.033	0.033
			25	1:07	0.00	0.01	0.00	0.12	0.033	0.033
			30	1:12	0.00	0.01	0.01	0.12	0.035	0.035

MASON'S ROCK PRODUCTS
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PLATE LOAD TEST

ASTM D-1194

Job Name: Koror Sub- Station
Location: MRP Quarry/ Koror
Elevation: 0.5m depth
Date: 07 Sept. 2021
Tested by: RV. Melancio/ Matl's Engr.

Shape of Loading Plate: Disc
Dimension of Loading Plate: 300mm
Area of Loading Plate: 706.5cm^2

Type of Jack: Hydraulic
Design Load: 50 kN
Type of Reactive Devices: Hydraulic Excavator

Loading Method: Staged Loading
9th steps
Actual Loading/Step: 10.6kN/m2
Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
6th	7.92	112.10	0	2:42	0.00	0.01	0.45	0.55	0.253	0.253
			1	2:43	0.00	0.01	0.46	0.56	0.258	0.258
			2	2:44	0.00	0.01	0.57	0.69	0.318	0.318
			5	2:47	0.00	0.01	0.68	0.81	0.375	0.375
			10	2:52	0.00	0.01	0.72	0.85	0.395	0.395
			15	2:57	0.00	0.01	0.73	0.99	0.433	0.433
			20	3:02	0.00	0.01	0.87	0.99	0.468	0.468
			25	3:07	0.00	0.01	0.88	0.99	0.470	0.470
			30	3:12	0.00	0.01	0.88	1.00	0.473	0.473
7th	9.24	130.79	0	3:12	0.00	0.01	0.88	1.03	0.480	0.480
			1	3:13	0.00	0.01	0.88	1.03	0.480	0.480
			2	3:14	0.00	0.01	0.89	1.06	0.490	0.490
			5	3:17	0.01	0.01	0.97	1.17	0.540	0.540
			10	3:22	0.02	0.01	1.01	1.20	0.560	0.560
			15	3:27	0.03	0.01	1.04	1.23	0.578	0.578
			20	3:32	0.05	0.01	1.06	1.25	0.593	0.593
			25	3:37	0.05	0.01	1.07	1.26	0.598	0.598
			30	3:42	0.05	0.01	1.08	1.28	0.605	0.605
8th	10.56	149.47	0	3:42	0.06	0.02	1.11	1.31	0.625	0.625
			1	3:43	0.08	0.04	1.12	1.34	0.645	0.645
			2	3:44	0.10	0.09	1.15	1.37	0.678	0.678
			5	3:47	0.14	0.12	1.20	1.44	0.725	0.725
			10	3:52	0.17	0.15	1.24	1.48	0.760	0.760
			15	3:57	0.19	0.17	1.26	1.50	0.780	0.780
			20	4:02	0.20	0.18	1.26	1.51	0.788	0.788
			25	4:07	0.21	0.19	1.28	1.53	0.803	0.803
			30	4:12	0.22	0.20	1.29	1.54	0.813	0.813

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koror Sub- Station
Location: MRP Quarry/ Koror
Elevation: 0.5m depth
Date: 07 Sept. 2021
Tested by: RV. Melancio/ Matl's Engr.

Shape of Loading Plate: Disc
Dimension of Loading Plate: 300mm
Area of Loading Plate: 706.5cm^2

Type of Jack: Hydraulic
Design Load: 50 kN
Type of Reactive Devices: Hydraulic Excavator

Loading Method: Staged Loading
9th steps
Actual Loading/Step: 10.6kN/m2
Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement	Cumulative Value
					1	2	3	4	(mm)	(mm)
9th	11.88	168.15	0	4:12	0.22	0.20	1.32	1.58	0.830	0.830
			1	4:13	0.22	0.20	1.32	1.58	0.830	0.830
			2	4:14	0.22	0.21	1.32	1.58	0.833	0.833
			5	4:17	0.25	0.27	1.38	1.67	0.893	0.893
			10	4:22	0.29	0.30	1.41	1.70	0.925	0.925
			15	4:27	0.31	0.33	1.43	1.71	0.945	0.945
			20	4:32	0.33	0.35	1.44	1.76	0.970	0.970
			25	4:37	0.35	0.36	1.47	1.77	0.988	0.988
			30	4:42	0.36	0.37	1.48	1.79	1.000	1.000
Unloading	10.56	149.47	0	4:42	0.36	0.37	1.49	1.79	1.003	1.003
1st			5	4:47	0.36	0.37	1.48	1.79	1.000	1.000
2nd	9.24	130.79	0	4:47	0.36	0.37	1.49	1.79	1.003	1.003
			5	4:52	0.36	0.37	1.49	1.79	1.003	1.003
3rd	7.92	112.10	0	4:52	0.36	0.37	1.48	1.78	0.998	0.998
			5	4:57	0.36	0.37	1.48	1.78	0.998	0.998
4th	6.60	93.42	0	4:57	0.36	0.37	1.48	1.78	0.998	0.998
			5	5:02	0.36	0.37	1.48	1.78	0.998	0.998
5th	5.28	74.73	0	5:02	0.36	0.37	1.48	1.78	0.998	0.998
			5	5:07	0.36	0.37	1.48	1.78	0.998	0.998
6th	3.96	56.05	0	5:07	0.36	0.37	1.46	1.74	0.983	0.983
			5	5:12	0.36	0.37	1.46	1.74	0.983	0.983
7th	2.64	37.37	0	5:12	0.36	0.36	1.44	1.71	0.968	0.968
			5	5:17	0.35	0.35	1.43	1.70	0.958	0.958
8th	1.32	18.68	0	5:17	0.33	0.30	1.42	1.69	0.935	0.935
			5	5:22	0.33	0.30	1.42	1.68	0.933	0.933
9th	0.00	0.00	0	5:22	0.16	0.17	1.28	1.52	0.783	0.783
			5	5:27	0.13	0.14	1.25	1.48	0.750	0.750

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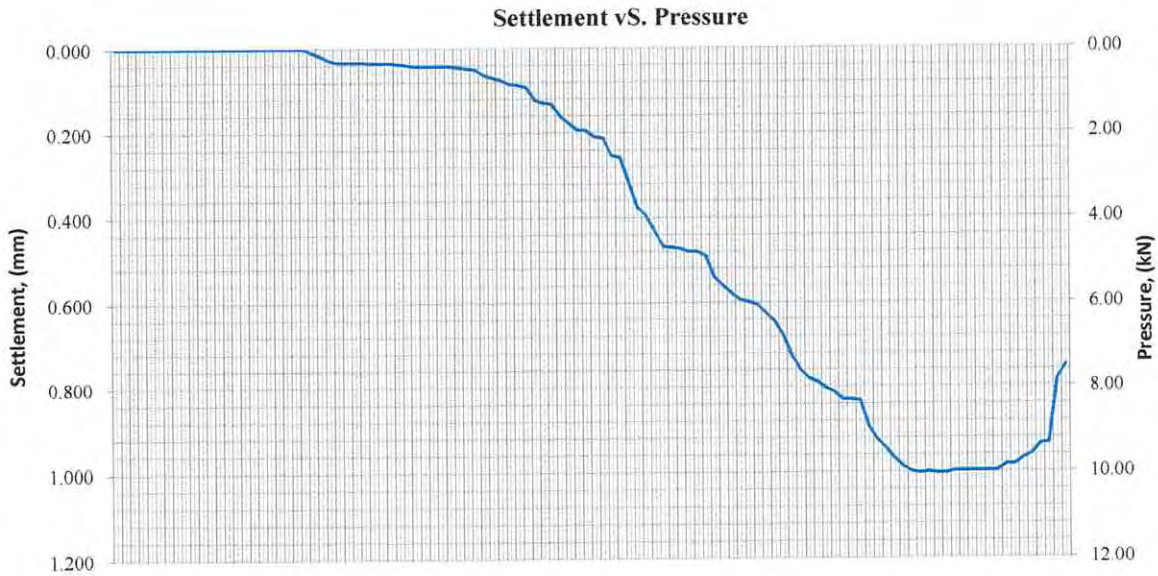
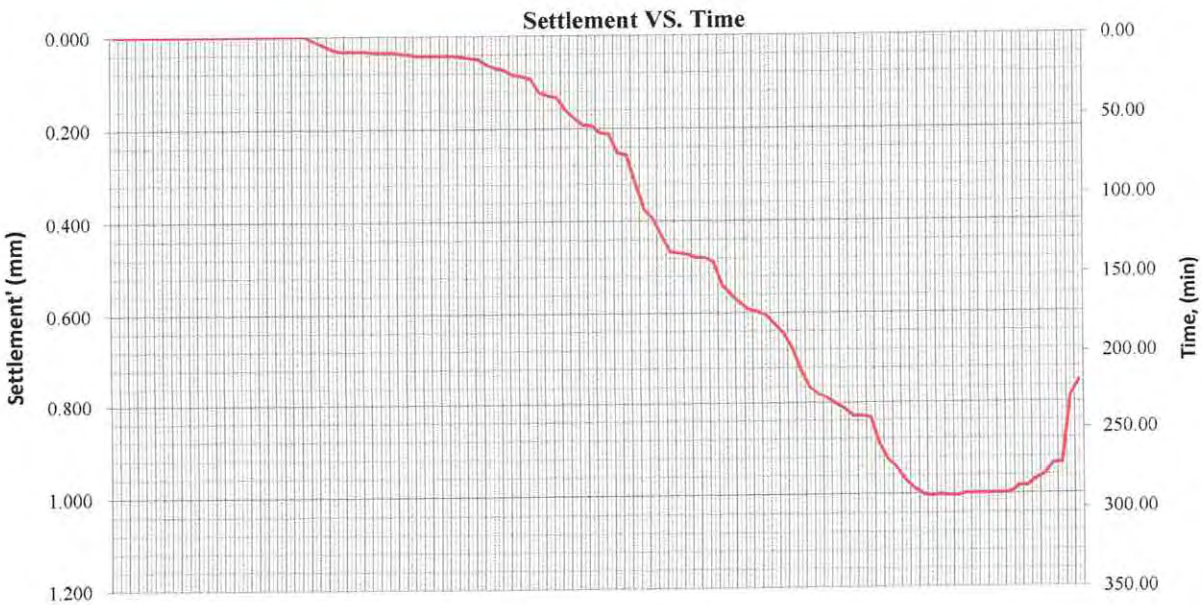
PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 07 Sept. 2021
Location: Ngatpang State	Elevation: 0.5m depth		Tested by: RV. Melancio/ Matl's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading	9th steps	Actual Loading/Step: 10.6kN/m2 Weather: Sunny





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Ph: +680 488-3000 Fx: +680 488-5688 masonsrock@surangel.com

PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 21 Sept. 2021
Location: Ngatpang State	Elevation: NGL(Natural Ground Level)		Tested by: RV. Melancio/ Matl's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading	9th steps	Actual Loading/Step: 10.6kN/m2 Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
Reserve	0	0	0	0:00	0.000	0.000	0.000	0.000	0.000	0.000
1st	0.90	12.74	1	0:01	0.000	0.000	0.020	0.020	0.010	0.010
			1	0:02	0.000	0.000	0.020	0.020	0.010	0.010
2nd	0	0	1	0:03	0.000	0.000	0.020	0.020	0.010	0.010
			1	0:04	0.000	0.000	0.020	0.020	0.010	0.010
3rd	0.90	12.74	1	0:05	0.000	0.000	0.025	0.030	0.014	0.014
			1	0:06	0.000	0.000	0.025	0.030	0.014	0.014
4th	0	0	1	0:07	0.000	0.000	0.030	0.040	0.018	0.018
			1	0:08	0.000	0.000	0.030	0.040	0.018	0.018
5th	0.90	12.74	1	0:09	0.000	0.000	0.035	0.045	0.020	0.020
			1	0:10	0.000	0.000	0.035	0.045	0.020	0.020
6th	0	0	1	0:11	0.000	0.000	0.035	0.045	0.020	0.020
			1	0:12	0.000	0.000	0.035	0.045	0.020	0.020
1st	1.32	18.68	0	0:12	0.000	0.000	0.040	0.050	0.023	0.023
			1	0:13	0.000	0.010	0.060	0.080	0.038	0.038
			2	0:14	0.000	0.010	0.060	0.080	0.038	0.038
			5	0:17	0.090	0.000	0.015	0.080	0.046	0.046
			10	0:22	0.000	0.020	0.100	0.130	0.063	0.063
			15	0:27	0.000	0.030	0.100	0.140	0.068	0.068
			20	0:32	0.000	0.040	0.100	0.145	0.071	0.071
			25	0:37	0.000	0.040	0.120	0.160	0.080	0.080
			30	0:42	0.000	0.040	0.120	0.160	0.080	0.080
2nd	2.64	37.37	0	0:42	0.020	0.160	0.210	0.360	0.188	0.188
			1	0:43	0.020	0.170	0.210	0.360	0.190	0.190
			2	0:44	0.020	0.170	0.220	0.360	0.193	0.193
			5	0:47	0.055	0.230	0.265	0.425	0.244	0.244
			10	0:52	0.070	0.280	0.310	0.490	0.288	0.288
			15	0:57	0.080	0.290	0.320	0.520	0.303	0.303
			20	1:02	0.080	0.290	0.320	0.520	0.303	0.303
			25	1:07	0.085	0.300	0.320	0.520	0.306	0.306
			30	1:12	0.085	0.300	0.320	0.520	0.306	0.306

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 21 Sept. 2021
Location: Ngatpang State	Elevation: NGL(Natural Ground Level)		Tested by: RV. Melancio/ Matl's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading 9th steps	Actual Loading/Step: 10.6kN/m2	Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
3rd	3.96	56.05	0	1:12	0.125	0.400	0.410	0.660	0.399	0.399
			1	1:13	0.125	0.400	0.410	0.660	0.399	0.399
			2	1:14	0.150	0.440	0.430	0.700	0.430	0.430
			5	1:17	0.165	0.470	0.450	0.730	0.454	0.454
			10	1:22	0.180	0.500	0.465	0.760	0.476	0.476
			15	1:27	0.190	0.520	0.490	0.790	0.498	0.498
			20	1:32	0.205	0.540	0.500	0.810	0.514	0.514
			25	1:37	0.210	0.550	0.500	0.810	0.518	0.518
			30	1:42	0.210	0.550	0.515	0.830	0.526	0.526
4th	5.28	74.73	0	1:42	0.320	0.720	0.660	1.020	0.680	0.680
			1	1:43	0.345	0.760	0.680	1.050	0.709	0.709
			2	1:44	0.370	0.780	0.700	1.070	0.730	0.730
			5	1:47	0.385	0.800	0.705	1.095	0.746	0.746
			10	1:52	0.400	0.820	0.720	1.120	0.765	0.765
			15	1:57	0.410	0.840	0.745	1.140	0.784	0.784
			20	2:02	0.430	0.855	0.745	1.140	0.793	0.793
			25	2:07	0.440	0.875	0.770	1.170	0.814	0.814
			30	2:12	0.440	0.875	0.770	1.170	0.814	0.814
5th	6.60	93.42	0	2:12	0.480	0.920	0.820	1.230	0.863	0.863
			1	2:13	0.480	0.925	0.840	1.250	0.874	0.874
			2	2:14	0.480	0.935	0.850	1.270	0.884	0.884
			5	2:17	0.490	0.950	0.860	1.290	0.898	0.898
			10	2:22	0.510	0.980	0.880	1.315	0.921	0.921
			15	2:27	0.530	1.000	0.900	1.340	0.943	0.943
			20	2:32	0.530	1.005	0.900	1.340	0.944	0.944
			25	2:37	0.540	1.020	0.900	1.355	0.954	0.954
			30	2:42	0.560	1.040	0.910	1.355	0.966	0.966

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 21 Sept. 2021
Location: Ngatpang State	Elevation: NGL(Natural Ground Level)		Tested by: RV. Melancio/ Matl's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading 9th steps	Actual Loading/Step: 10.6kN/m2	Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
6th	7.92	112.10	0	2:42	0.590	1.100	0.960	1.430	1.020	1.020
			1	2:43	0.620	1.120	0.980	1.460	1.045	1.045
			2	2:44	0.635	1.155	1.005	1.490	1.071	1.071
			5	2:47	0.645	1.170	1.020	1.505	1.085	1.085
			10	2:52	0.665	1.195	1.030	1.520	1.103	1.103
			15	2:57	0.685	1.220	1.050	1.550	1.126	1.126
			20	3:02	0.700	1.250	1.060	1.560	1.143	1.143
			25	3:07	0.710	1.260	1.080	1.590	1.160	1.160
			30	3:12	0.710	1.260	1.080	1.590	1.160	1.160
7th	9.24	130.79	0	3:12	0.750	1.310	1.110	1.630	1.200	1.200
			1	3:13	0.760	1.320	1.120	1.640	1.210	1.210
			2	3:14	0.780	1.380	1.155	1.690	1.251	1.251
			5	3:17	0.800	1.380	1.155	1.690	1.256	1.256
			10	3:22	0.815	1.400	1.180	1.715	1.278	1.278
			15	3:27	0.840	1.420	1.190	1.740	1.298	1.298
			20	3:32	0.850	1.435	1.190	1.740	1.304	1.304
			25	3:37	0.865	1.450	1.200	1.760	1.319	1.319
			30	3:42	0.865	1.450	1.210	1.765	1.323	1.323
8th	10.56	149.47	0	3:42	0.900	1.510	1.260	1.810	1.370	1.370
			1	3:43	0.960	1.550	1.270	1.840	1.405	1.405
			2	3:44	0.970	1.585	1.310	1.880	1.436	1.436
			5	3:47	1.000	1.625	1.320	1.910	1.464	1.464
			10	3:52	1.020	1.640	1.340	1.920	1.480	1.480
			15	3:57	1.020	1.640	1.345	1.930	1.484	1.484
			20	4:02	1.085	1.710	1.360	1.960	1.529	1.529
			25	4:07	1.090	1.720	1.350	1.970	1.533	1.533
			30	4:12	1.090	1.720	1.370	1.970	1.538	1.538

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 21 Sept. 2021
Location: Ngatpang State	Elevation: NGL(Natural Ground Level)		Tested by: RV. Melancio/ Matl's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading	9th steps	Actual Loading/Step: 10.6kN/m2 Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
9th	11.88	168.15	0	4:12	1.110	1.750	1.390	1.990	1.560	1.560
			1	4:13	1.110	1.755	1.400	2.000	1.566	1.566
			2	4:14	1.130	1.755	1.400	2.015	1.575	1.575
			5	4:17	1.150	1.800	1.420	2.040	1.603	1.603
			10	4:22	1.170	1.830	1.430	2.060	1.623	1.623
			15	4:27	1.180	1.840	1.455	2.085	1.640	1.640
			20	4:32	1.195	1.860	1.460	2.095	1.653	1.653
			25	4:37	1.210	1.880	1.485	2.120	1.674	1.674
			30	4:42	1.215	1.900	1.490	2.130	1.684	1.684
Unloading	10.56	149.47	0	4:42	1.210	1.900	1.490	2.130	1.683	1.683
1st			5	4:47	1.210	1.900	1.490	2.130	1.683	1.683
2nd	9.24	130.79	0	4:47	1.210	1.900	1.490	2.130	1.683	1.683
			5	4:52	1.210	1.900	1.490	2.130	1.683	1.683
3rd	7.92	112.10	0	4:52	1.210	1.900	1.490	2.130	1.683	1.683
			5	4:57	1.210	1.900	1.490	2.130	1.683	1.683
4th	6.60	93.42	0	4:57	1.210	1.900	1.490	2.130	1.683	1.683
			5	5:02	1.210	1.900	1.490	2.130	1.683	1.683
5th	5.28	74.73	0	5:02	1.150	1.830	1.470	2.110	1.640	1.640
			5	5:07	1.150	1.830	1.470	2.110	1.640	1.640
6th	3.96	56.05	0	5:07	1.120	1.825	1.400	2.040	1.596	1.596
			5	5:12	1.120	1.825	1.400	2.040	1.596	1.596
7th	2.64	37.37	0	5:12	1.080	1.770	1.350	1.990	1.548	1.548
			5	5:17	1.060	1.745	1.340	1.960	1.526	1.526
8th	1.32	18.68	0	5:17	1.000	1.690	1.280	1.910	1.470	1.470
			5	5:22	0.990	1.680	1.280	1.900	1.463	1.463
9th	0.00	0.00	0	5:22	0.920	1.590	1.220	1.820	1.388	1.388
			5	5:27	0.890	1.550	1.200	1.800	1.360	1.360

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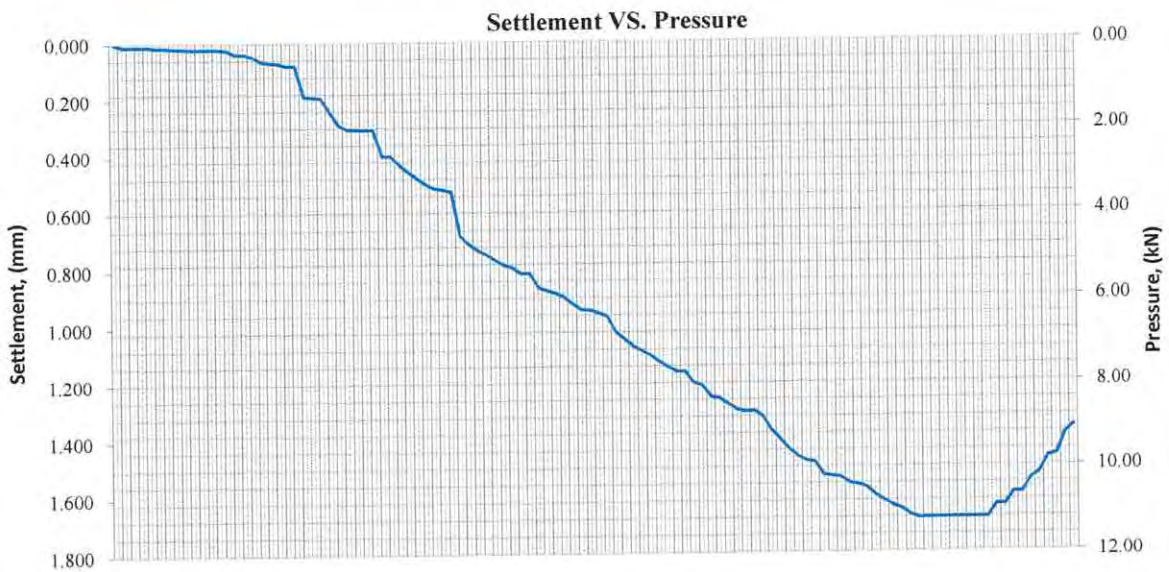
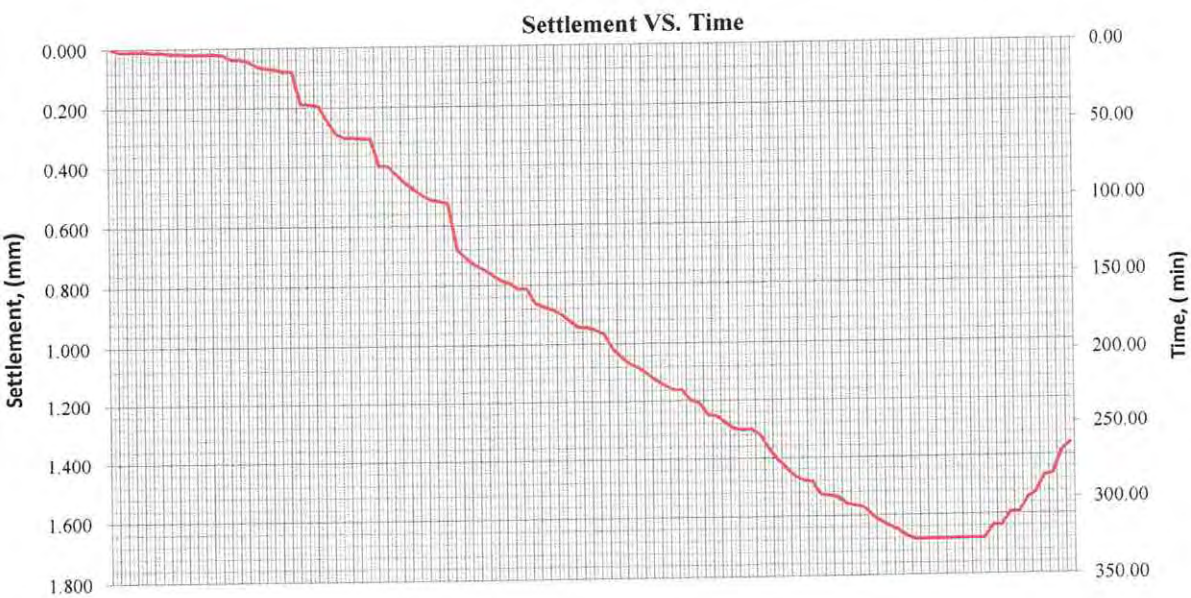
PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 21 Sept. 2021
Location: Ngatpang State	Elevation: NGL(Natural Ground Level)		Tested by: RV. Melancio/ Matl's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading	9th steps	Actual Loading/Step: 10.6kN/m2 Weather: Sunny





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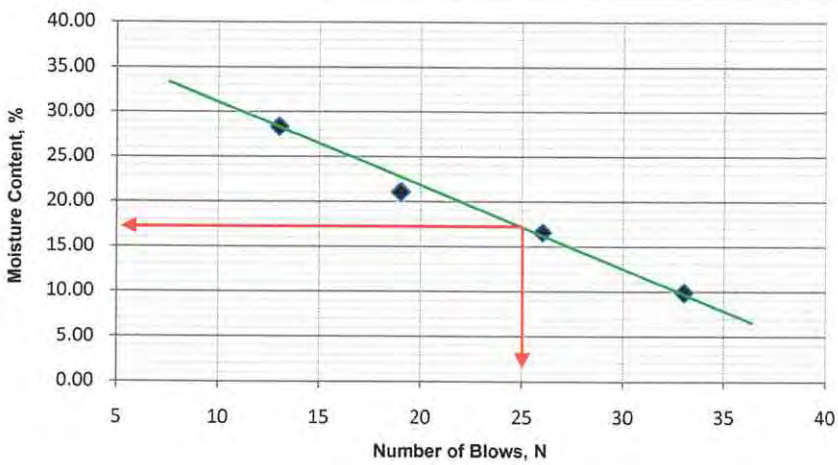
Atterberg Limits Determination
ASTM D-4318

Project	: Koror Sub-Station	Date sampled :	Sept. 14, 2021
Location	: MRP Quarry/Koror	Date Tested :	Sept.16, 2021
Sample Description	: SC-R (Depth 0.3m)	Tested by :	RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No. :	

Can No.	C	F	G	E
Wt. of wet soil + can	59.2	56.4	28.4	26.8
Wt. of dry soil + can	53.0	52.0	26.0	25.4
Wt. of can	31.1	31.1	11.5	11.2
Wt. of dry soil	21.9	20.9	14.5	14.2
Wt. of moisture	6.2	4.4	2.4	1.4
Water Content, w%	28.31	21.05	16.55	9.86
No. of Blows, N	13	19	26	33



Liquid Limit, LL = 17.0

Plastic Limit, PL = NP

Plasticity Index, PI = –

PLASTIC LIMIT DETERMINATION

Can No.				
Wt. of wet soil + can				
Wt. of dry soil + can				
Wt. of can		NON- PLASTIC		
Wt. of dry soil				
Wt. of moisture				
Water Content, w%				

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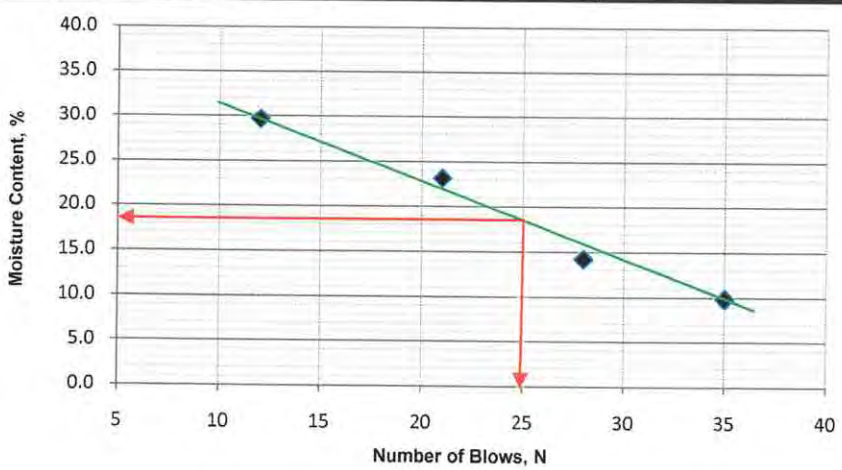
Atterberg Limits Determination
ASTM D-4318

Project	: Koror Sub-Station	Date sampled :	Sept. 14, 2021
Location	: MRP Quarry	Date Tested :	Sept.16, 2021
Sample Description	: SC-1 (Depth 0.5m)	Tested by :	RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No. :	

Can No.	C	E	F	B
Wt. of wet soil + can	53.4	26.1	32.4	48.9
Wt. of dry soil + can	48.3	23.3	29.8	47.3
Wt. of can	31.1	11.2	11.5	31.0
Wt. of dry soil	17.2	12.1	18.3	16.3
Wt. of moisture	5.1	2.8	2.6	1.6
Water Content, w%	29.7	23.1	14.2	9.8
No. of Blows, N	12	21	28	35



Liquid Limit, LL = 18.5

Plastic Limit, PL = 17.1

Plasticity Index, PI = 1.4

PLASTIC LIMIT DETERMINATION

Can No.	F	C		
Wt. of wet soil + can	19.9	42.4		
Wt. of dry soil + can	18.7	40.8		
Wt. of can	11.5	31.7		
Wt. of dry soil	7.2	9.1		
Wt. of moisture	1.2	1.6		
Water Content, w%	16.7	17.6		

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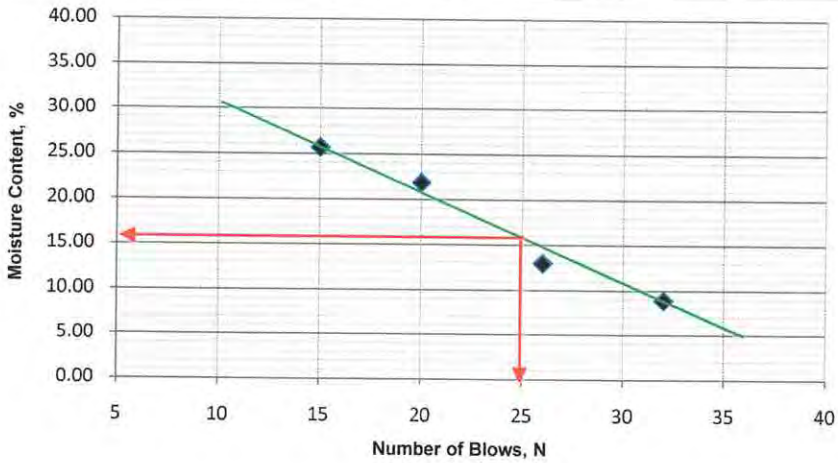
Atterberg Limits Determination
ASTM D-4318

Project	: Koror Sub-Station	Date sampled :	Sept. 14, 2021
Location	: MRP Quarry	Date Tested :	Sept.16, 2021
Sample Description	: SC-2 (Depth 1.0m)	Tested by :	RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No. :	

Can No.	F	C	B	E
Wt. of wet soil + can	35.0	61.8	53.7	28.4
Wt. of dry soil + can	30.2	56.3	51.1	27.0
Wt. of can	11.5	31.1	31.0	11.2
Wt. of dry soil	18.7	25.2	20.1	15.8
Wt. of moisture	4.8	5.5	2.6	1.4
Water Content, w%	25.67	21.83	12.94	8.86
No. of Blows, N	15	20	26	32



Liquid Limit, LL = 15.9

Plastic Limit, PL = NP

Plasticity Index, PI = –

PLASTIC LIMIT DETERMINATION

Can No.				
Wt. of wet soil + can				
Wt. of dry soil + can				
Wt. of can				
Wt. of dry soil				
Wt. of moisture				
Water Content, w%				

NON- PLASTIC

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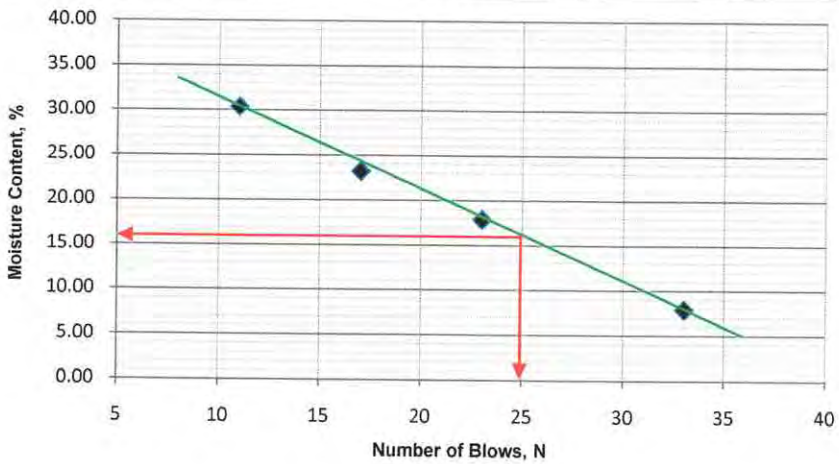
Atterberg Limits Determination
ASTM D-4318

Project	: Koror Sub-Station	Date sampled :	Sept. 14, 2021
Location	: MRP Quarry	Date Tested :	Sept.16, 2021
Sample Description	: SC-3 (Depth 1.5m)	Tested by :	RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No. :	

Can No.	A	B	G	F
Wt. of wet soil + can	24.5	61.8	26.0	58.4
Wt. of dry soil + can	21.4	56.0	23.8	56.4
Wt. of can	11.2	31.0	11.5	31.1
Wt. of dry soil	10.2	25.0	12.3	25.3
Wt. of moisture	3.1	5.8	2.2	2.0
Water Content, w%	30.39	23.20	17.89	7.91
No. of Blows, N	11	17	23	33



Liquid Limit, LL = 16.0

Plastic Limit, PL = NP

Plasticity Index, PI = —

PLASTIC LIMIT DETERMINATION

Can No.				
Wt. of wet soil + can				
Wt. of dry soil + can				
Wt. of can				
Wt. of dry soil				
Wt. of moisture				
Water Content, w%				

NON- PLASTIC

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Particles Sizes Analysis of Soils

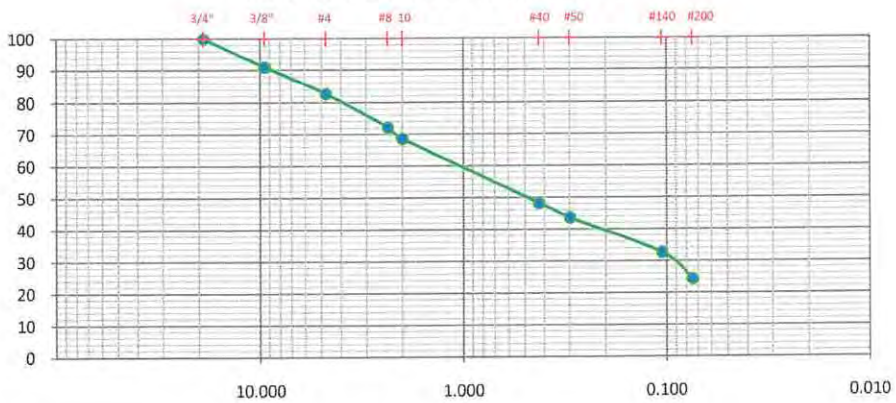
ASTM C-422

Project	: Koror Sub-Station	Date sampled	: Sept. 08 2021
Location	: MRP Quarry	Date Tested	: Sept. 10 2021
Sample Description	: SC- R (0.3m Depth)	Tested by	: RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No.	:

Original Wt. : 1630 g. Oven Dry Wt. : 1392 g. Wash Oven Dry Wt. : 1080.0 g.

Sieve Size		Wt. Retained (gm)	Cum. Wt. Ret. (gm)	% Retained	% Passing	Remarks
(in.)	(mm)					
2"	50.00					
1½"	37.50	0	0		100	
1"	25.00	0.0	0.0	0	100	
¾"	19.00	4.0	4.0	0	100	
3/8"	9.50	125.0	129.0	9	91	
# 4	4.75	111.0	240.0	17	83	
# 8	2.36	146.0	386.0	28	72	
# 10	2.00	51.0	437.0	31	69	
# 20	0.850	-	-	-	-	
# 40	0.425	284.0	721.0	52	48	
# 50	0.300	65.0	786.0	56	44	
# 140	0.106	151.0	937.0	67	33	
# 200	0.075	116.0	1053.0	76	24.4	
Pan		27.0				
Total		1080.0				

Particle- Size Distribution Curve



Remarks: UCS: SM (Silty sand)
AASHTO: A-1-b (Stone fragments, gravel & sand)

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P.O. Box 8065, Koror, PW 96940, Republic of Palau
Ph: +680 488-3000 Fx: +680 488-5688 masonsrock@surangel.com

Particles Sizes Analysis of Soils

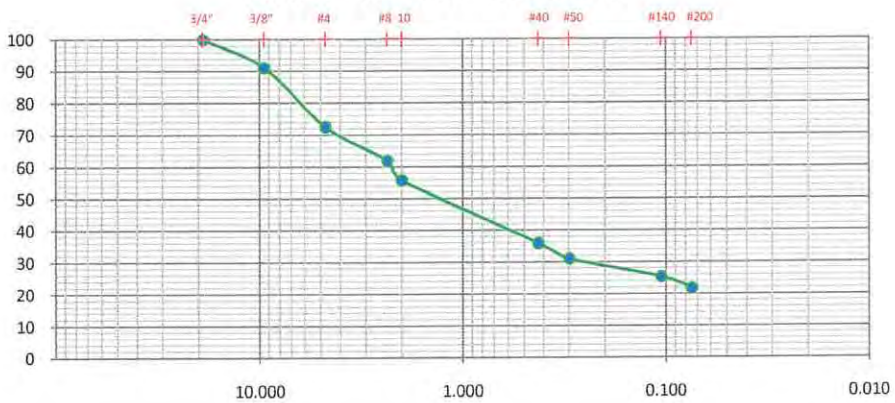
ASTM C-422

Project	: Koror Sub-Station	Date sampled	: Sept. 08 2021
Location	: MRP Quarry	Date Tested	: Sept. 10 2021
Sample Description	: SC- 1 (0.5m Depth)	Tested by	: RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No.	:

Original Wt. : 1686 g. Oven Dry Wt. : 1577 g. Wash Oven Dry Wt. : 1255.0 g.

Sieve Size		Wt. Retained (gm)	Cum. Wt. Ret. (gm)	% Retained	% Passing	Remarks
(in.)	(mm)					
2"	50.00					
1½"	37.50	0	0		100	
1"	25.00	29.0	29.0	2	100	
¾"	19.00	16.0	45.0	3	100	
3/8"	9.50	205.0	250.0	16	84	
# 4	4.75	185.0	435.0	28	72	
# 8	2.36	165.0	600.0	38	62	
# 10	2.00	98.0	698.0	44	56	
# 20	0.850	-	-	-	-	
# 40	0.425	314.0	1012.0	64	36	
# 50	0.300	76.0	1088.0	69	31	
# 140	0.106	88.0	1176.0	75	25	
# 200	0.075	56.0	1232.0	78	21.9	
Pan		23.0				
Total		1255.0				

Particle- Size Distribution Curve



Remarks: UCS: SM (Silty sand)
AASHTO: A-1-b (Stone fragments, gravel & sand)

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Particles Sizes Analysis of Soils

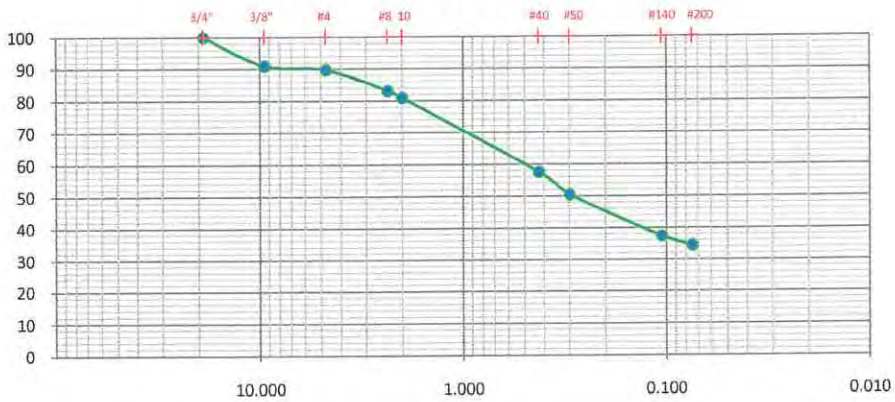
ASTM C-422

Project	: Koror Sub-Station	Date sampled	: Sept. 08 2021
Location	: MRP Quarry	Date Tested	: Sept. 10 2021
Sample Description	: SC- 2 (1.0m Depth)	Tested by	: RV. Melancio/ M.E
Source of Sample	: in- placed	Lab. No.	:

Original Wt. : 1453 g. Oven Dry Wt. : 1327 g. Wash Oven Dry Wt. : 876.0 g.

Sieve Size (in.)	Sieve Size (mm)	Wt. Retained (gm)	Cum. Wt. Ret. (gm)	% Retained	% Passing	Remarks
2"	50.00					
1½"	37.50					
1"	25.00	0.0	0.0	0	100	
¾"	19.00	0.0	0.0	0	100	
3/8"	9.50	62.0	62.0	5	95	
# 4	4.75	75.0	137.0	10	90	
# 8	2.36	87.0	224.0	17	83	
# 10	2.00	29.0	253.0	19	81	
# 20	0.850	-	-	-	-	
# 40	0.425	311.0	564.0	43	57	
# 50	0.300	93.0	657.0	50	50	
# 140	0.106	173.0	830.0	63	37	
# 200	0.075	39.0	869.0	65	34.5	
Pan		27.0				
Total		896.0				

Particle- Size Distribution Curve



Remarks: UCS: SM (Silty sand)
AASHTO: A-2-4 (Silty or clayey gravel and sand)

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Particles Sizes Analysis of Soils

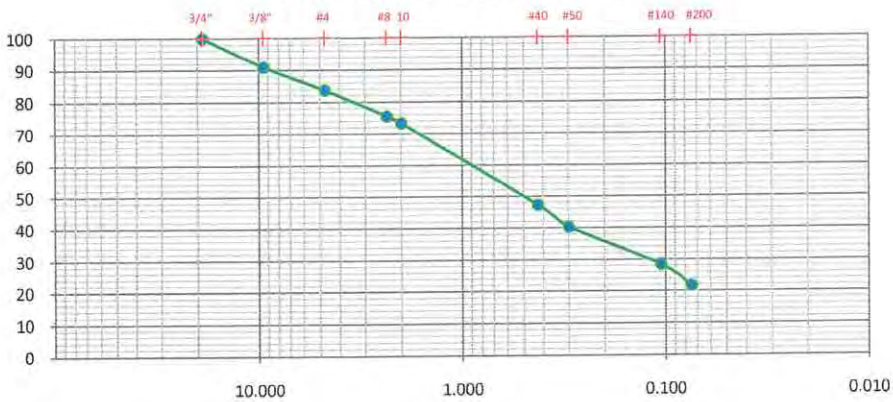
ASTM C-422

Project	: Koror Sub-Station	Date sampled	: Sept. 08 2021
Location	: MRP Quarry	Date Tested	: Sept. 10 2021
Sample Description	: SC- 3 (1.5m Depth)	Tested by	: RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No.	:

Original Wt. : 1334 g. Oven Dry Wt. : 1200 g. Wash Oven Dry Wt. : 964.0 g.

Sieve Size (in.)	Sieve Size (mm)	Wt. Retained (gm)	Cum. Wt. Ret. (gm)	% Retained	% Passing	Remarks
2"	50.00					
1½"	37.50					
1"	25.00	0.0	0.0	0	100	
¾"	19.00	21.0	21.0	2	100	
3/8"	9.50	84.0	105.0	9	91	
# 4	4.75	92.0	197.0	16	84	
# 8	2.36	98.0	295.0	25	75	
# 10	2.00	26.0	321.0	27	73	
# 20	0.850	-	-	-	-	
# 40	0.425	314.0	635.0	53	47	
# 50	0.300	82.0	717.0	60	40	
# 140	0.106	143.0	860.0	72	28	
# 200	0.075	80.0	940.0	78	21.7	
Pan		24.0				
Total		964.0				

Particle- Size Distribution Curve



Remarks: UCS: SM (Silty sand)
AASHTO: A-1-b (Stone fragments, gravel & sand)

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Specific Gravity of Soil

ASTM D 854-00

Project	: Koror Sub-Station	Date sampled	: Sept. 14 2021
Location	: MRP Quarry/Koror	Date Tested	: Sept. 16 2021
Sample Description	: N/A	Tested By	: RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No.	:

Observation No.		SC-R (0.3m depth)	SC-1 (0.5m depth)	SC-2 (1.0m depth)	SC-3 (1.5m depth)
Wt. of empty pycnometer	W_1 (g.)	383.8	383.8	383.8	383.8
Wt of pycnometer + dry sample	W_2 (g.)	584.1	582.4	584.7	587.3
Wt of pycnometer + dry sample + water	W_3 (g.)	988.0	987.6	989.0	991.5
Wt of pycnometer + water	W_4 (g.)	863.7	863.7	863.7	863.7
Specific Gravity	$\frac{W_2-W_1}{(W_4-W_1)-(W_3-W_2)}$	2.636	2.659	2.657	2.688
Ave. Specific Gravity		2.660			

Remarks: _____

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Ph: +680 488-3000 Fx: +680 488-5688 masonsrock@surangel.com

Determination of Water (Moisture) Content of Soil & Rocks

ASTM D2216-19

Project : Koror Sub-Station
Location : MRP Quarry
Sample Description : N/A
Source of Sample : in- placed

Date sampled : Sept. 08, 2021
Date Tested : Sept. 09, 2021
Tested by : RV. Melancio/ M.E
Lab. No. :

Determination No.	SC-R (D= 0.3m)	SC-1 (D= 0.5m)	SC-2 (D=1.0m)	SC-3 (D=1.5m)
Can No.	-	-	-	-
Wt. of wet soil + can	1971	2027	1794	1675
Wt. of dry soil + can	1733	1918	1668	1541
Wt. of can	341	341	341	341
Wt. of dry soil	1392	1577	1327	1200
Wt. of moisture	238	109	126	134
Water Content, w%	17.1	6.9	9.5	11.2
Ave. Water Content, W%	11.2			

Checked/Reviewed by:
RV. Melancio, MRP
Materials Engineer

13. 自然条件調査ならびに現地地質調査結果報告書

パラオ国「送電網整備計画準備調査」

第一次現地調査

＜地質調査部門＞

自然条件調査ならびに現地地質調査結果　報告書

調査期間:8 月 30 日～9 月 20 日

目 次

第１章 自然条件（地形・地質概要）

パラオ共和国（Republic of Palau）は、図 1.1.1 に示すように北緯 2 度から 8 度、東経 131 度から 135 度の太平洋西部の北半球側、ミクロネシア、キャロライン諸島の西端に位置する。国土面積は 444km²で、北端のカヤンゲル島から南部のアンガウル島までは東北から南西方向に連なる約 150km のパラオ群島となっている。

北部のバベルダオブ島が国土面積の 89.2%（396km²）を占める。バベルダオブ島とそのすぐ南に位置するコロール島、マラカル島、アラカベサン島は火山起源、それ以外は石灰岩の隆起珊瑚礁である。国土の最高地点はバベルダオブ島北部のゲ レラウース山の海抜 242m である。

パラオの気候は熱帯雨林気候（Af）に分類され、図 1.1.2 に示すように、年中多雨で気温の年較差が少ない。月平均雨量は 200～400mm と年間を通して多い。パラオは通常の台風のルートより南に位置するため台風の来襲は稀だと言われてきたが、2012 年以降、ほぼ毎年一本のペースで台風の被害が発生している。

パラオはフィリピン海プレートと太平洋プレートの境界に位置し、海洋域には地震多発地帯があるものの、パラオでの地震発生は小規模である（図 1.1.2）。

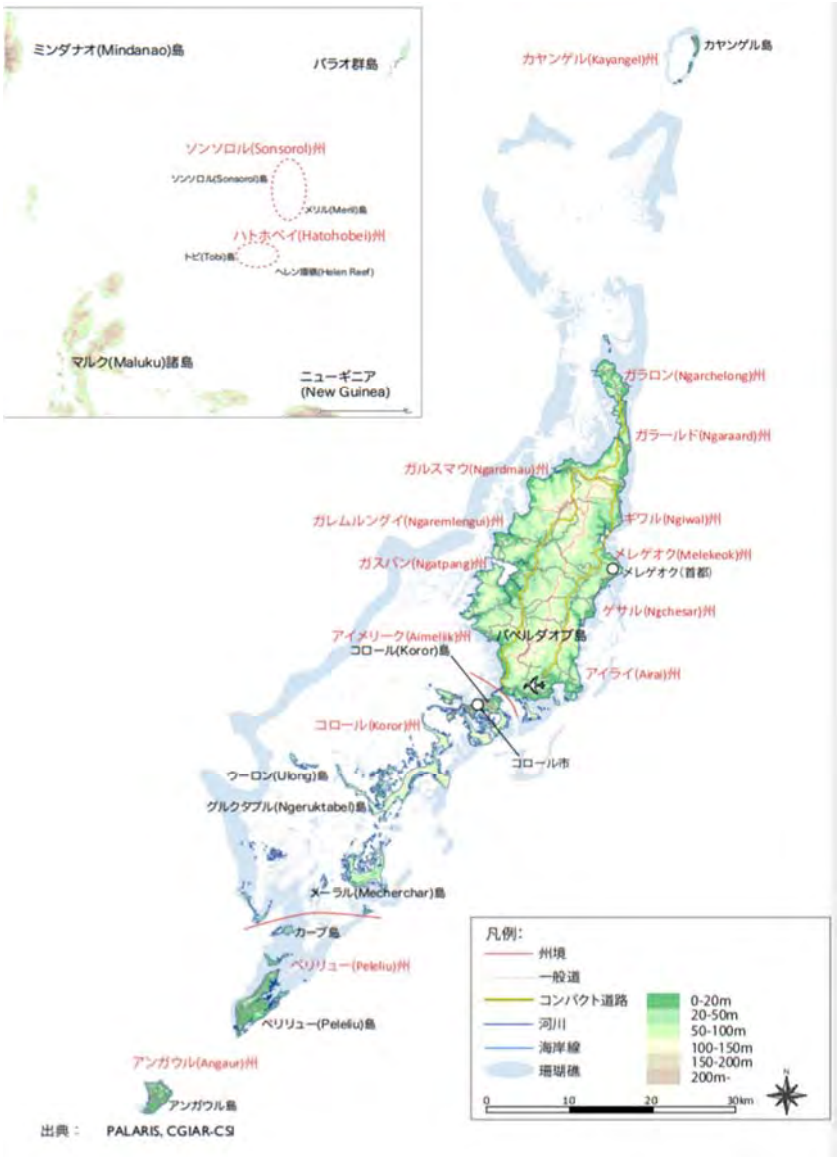


図 1.1.1 パラオ共和国

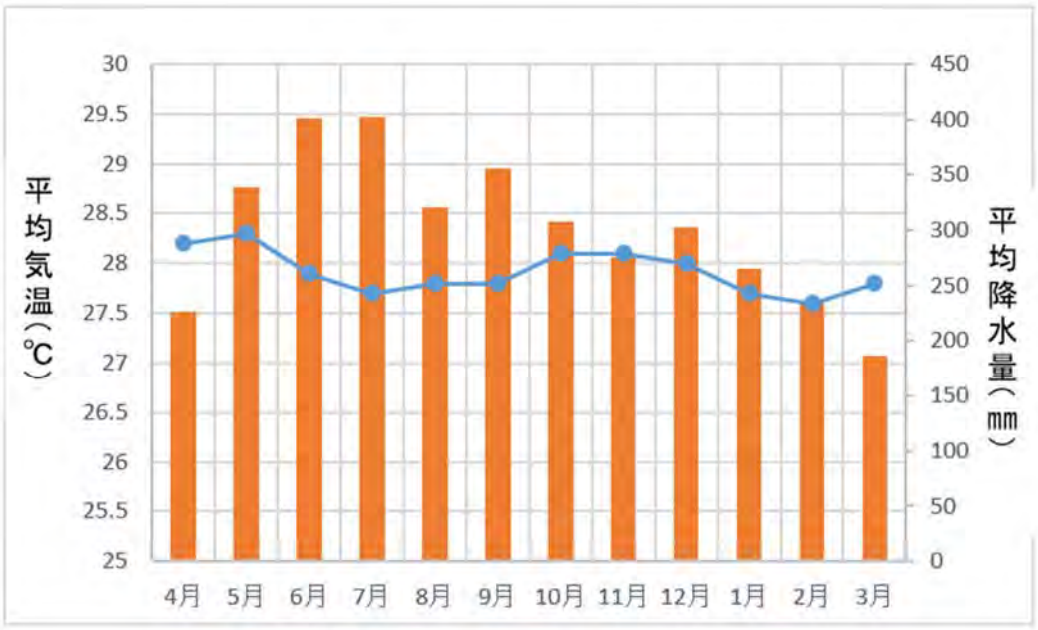


図 1.1.2 パラオ国の気象(1991～2020 の平均データ)
下記のデータを基にグラフ化したもの
http://www.data.jma.go.jp/gmd/cpd/monitor/climatview/graph_mkhtml.php?&n=91408&p=12&s=3&r=1&y=2020&m=3&e=0&k=0&d=0

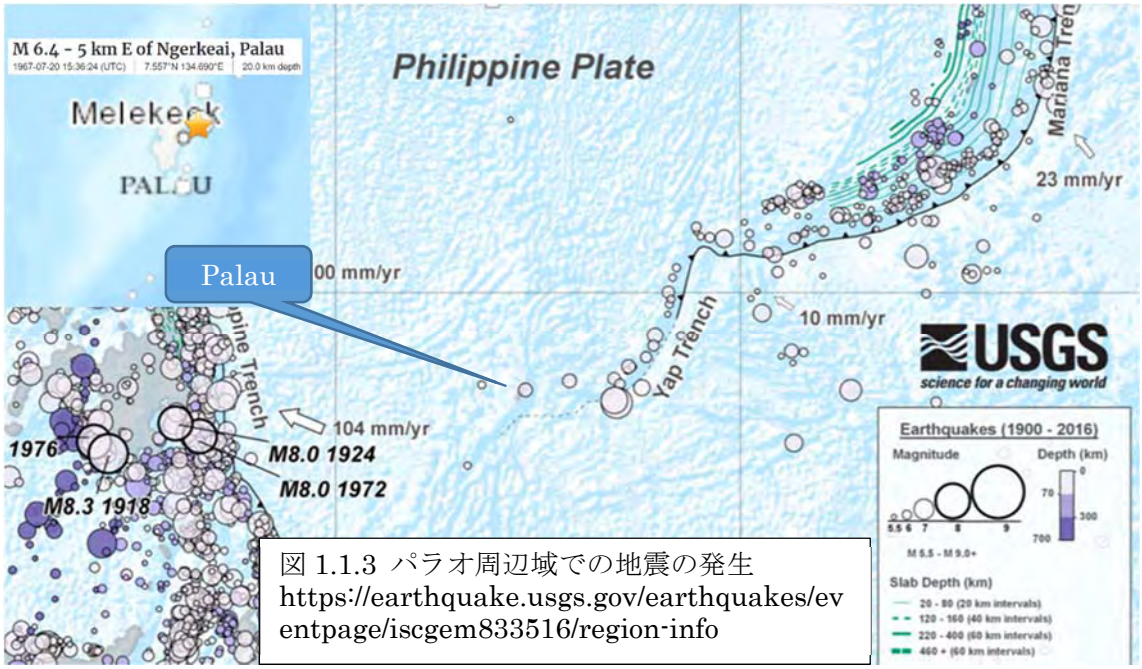


図 1.1.3 パラオ周辺域での地震の発生
https://earthquake.usgs.gov/earthquakes/eventpage/iscgem833516/region-info

1. 地形地質概要

1.1 地形概要

変電所ならびに送電線が計画されているバベルダオブ島、コロール島およびマラカル島の地形は起伏に富み、区間ごとに特徴を有する。送電線ルートを以下の 5 区間に区分し、その地形的特徴を説明する。

（１） バベルダオブ島中部（コクサイ～三叉路）
（２） バベルダオブ島中東部（三叉路～空港北部）
（３） バベルダオブ島南部（空港北部～アイライ発電所付近）
（４） コロール島内
（５） マラカル島内

図 1.1.4　地形の特徴による地域区分

（１） バベルダオブ島中部（コクサイ～三叉路）

全体には丘陵性の山地地形からなり、道路沿い（送電線ルート）の多くは標高 30～150m の尾根部に位置する。

この区間の西側と東側を比べると、西側は起伏が少なく単調で、東側は谷の横断多く、起伏（アップダウン）がある（図 1.1.5 参照）。

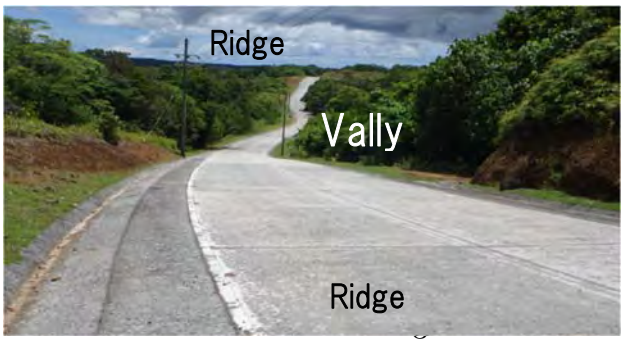


図 1.1.5
アップダウンの地形の様子

（尾根部は切土、谷部は盛土からなる）

Kokusai　Substation から 3.9km の地点

（２） バベルダオブ島中部（三叉路～空港北部）

この区間はほぼ南北方向の道路となる。尾根部は少なく、標高 50～100m の山地斜面部を通過するため、切土が多く、谷部（沢）の埋め土も少なくない。特に切土は高さ 5m 以上の長大法面も見られ、斜面崩壊や地すべりが確認される。この区間は 30 ㎞の送電線ルートの中で最も注意すべき区間である。

（３） バベルダオブ島南部（空港北部～アイライ変電所付近）

開析された丘陵地をとおる。この区間は切土が少なく、あっても 2m 未満と小規模で、規模の大きな不安定斜面は無い。ただし、風化の進行により小規模な切土でも崩壊しやすい箇所があり、表層すべりや小崩壊がみられる。

（４） コロール島内

多くは標高 10～60m の丘陵地で、繁華街、住宅街を通る。切土もほぼ安定している。

（５） マラカル島内

標高 0～15m の低標高を通る。切土はほとんどなく、地形的に安定している。

1.2 地質概要

地質層序表を表 1.1.1 に示す。新生代古第三紀始新世（34 百万～56 百万年前）の集塊岩類（主に玄武岩質安山岩からなる火山礫凝灰岩、自破砕状溶岩、溶岩）が広く分布する。アイライ挟亜炭層の分布は限定的で、道路沿い切土でわずかに確認される。海岸沿いには更新世（0.01～2.6 百万年前）の石灰岩（日本の琉球石灰岩相当）が数 m の小崖をなして分布する。海岸低地には隆起サンゴ礁、サンゴ礁砂ならびに現世サンゴが分布する。

Table 1.2.1 Stratigraphic correlation in Palau Islands

	TAYAMA (1952)	COMENTS
Holocene	Coral reef Garkyoku limestone Uplift layer	Manly distribution on the beach
Pleistocene	Peleliu Limestone Palau Limestone Terrace deposits	Mainly distributed in Koror Island and Malakal Island Ilai Substation is a terrace deposit, Coror Substation is a quarry of Palau Limestone
Pliocene	Airai Lignite	Distribution on the road of north of the air port
Miocene		
Oligocene-Eocene	volcanic rocks	autobrecciated lava and lava) and is distributed all over the island as the foundation of Palau Island. Foundation of Malakal Substation The foundation of the Kokusai Substation is an embankment made of weathered soil of this rock

図 1.2.1 玄武岩質安山岩類　（左は新鮮部　右は風化部）

図 1.2.2 アイライ挟亜炭層

図 1.2.3 パラオ石灰岩

図 1.2.4 コクサイ変電所基礎の盛土
（風化した火山岩土壌が盛土材）

図 1.2.5 コロール変電所の盛土
（採石した石灰岩礫と砂が盛土材）

図 1.2.6 アイライ変電所基礎部の段丘堆積物（径 5 ㎝ほどの円礫を含む）

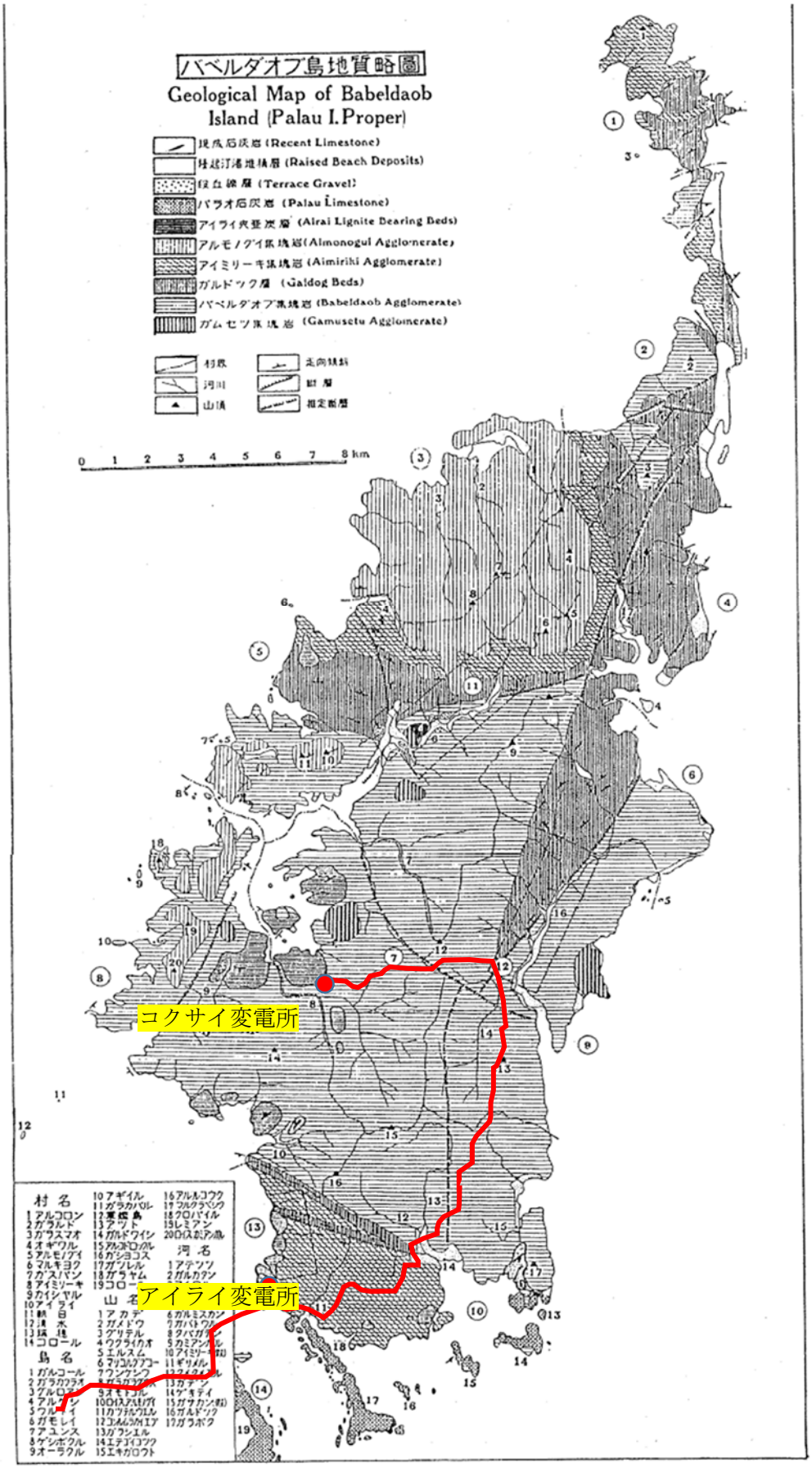


図 1.2.7　　バベルダオブ島の地質図（田山，1939a）

図 1.2.8　土壌分類図と各施設

2 各地質の工学的性質

(1) 玄武岩質安山岩（集塊岩）の地質工学的特徴

バベルダオブ島では風化により褐色化した切土が多いが、三叉路から南下する道路沿い（図 1.1.3 の（2）バベルダオブ島中部）は切土が多く、多くは下部（道路面付近）が黒灰色の新鮮岩～中風化岩、上部が風化岩から構成されている。上部の風化部は軟質で比較的透水性も高い一方、下部の新鮮部は硬質緻密で透水性が小さい。この強度と透水性の違いを素因とする大規模な崩壊が確認される。

マラカル島もこの岩種で構成されるが、高台においても新鮮硬質の岩盤が露出する。マラカル変電所周辺においてもほぼ新鮮岩が分布している。

地盤強度は既往調査においてアイメーク変電所の調査で、深度 3m において N 値 30 以上、長期許容支持力 150KN/m^{2}の結果を得ている。また、マラカル変電所で今回実施した SWS 試験でも N 値 50 以上相当を確認している。

風化部も送電線電柱ならびに変電所基礎として十分な強度を有する。ただし、送電線電柱の位置は、大規模崩壊地、地すべり地を避ける必要がある。

(2) 石灰岩の地質工学的特徴

コロール島とマラカル島の標高 10m 以下の地域に分布し、道路沿いでは高さ 3m 以上の急崖も確認される。岩片は硬質であるが、溶食空洞が見られる。この岩種が基礎となる変電所は無い。

(3) 盛土・埋め土の地質工学的特徴

コロール（メイソン ロック）変電所は石灰岩の砕石を材料にした盛土を基礎とする。

コクサイ変電所は火山岩類の風化土壌を材料にした盛土を基礎とする。

JP橋の基礎のある公園も盛土が施工されている。

石灰岩の砕石を基礎としたコロール（メイソン ロック）変電所で実施した。
N 値 50 以上、極限支持力は 300KN/m²を示した。

火山岩の風化土壌を材料にしたコクサイ変電所で実施した N 値 3～5 相当、平板載荷試験極限支持力は 168KN/m²以上を示した。

JP橋の盛土は良く締め固めた礫混じり粘土からなり、N 値 10～50 相当を示した。

第2章 送電線ルートの崩壊地調査

計画されている約 30 ㎞の送電線沿いには、地すべりや規模の大きな崩壊地形が点在し、送電線電柱の設置位置はこれらを避ける必要がある。本調査は、地すべりなどの不安定斜面の分布を把握することを目的に、送電ルート沿いを踏査したものである。

1.崩壊様式の分類

送電線沿いにおいて課題となる不安定斜面は、その特徴により下記の 4 種類に分類できる。これらのうち、①と②は特に崩壊の危険度が高い地点である。

① 地すべり地（記号Ｌ）・・・・・・・・・・規模大、活動性大
② 新しい大規模崩壊（記号 Cs）・・・・・・ 規模大、活動性大
③ 新しい小規模崩壊（記号 RCs）・・・・・・規模小、活動性大
④ 古い切土崩壊（記号 OC） ・・・・・・・ 規模大、活動性小

2.崩壊地の概要

下記、ならびに図 2.1.1 に示す区間ごとに崩壊地の分布と特徴を示す。

（１） バベルダオブ島中部（コクサイ～三叉路）
（２） バベルダオブ島中東部（三叉路～空港北部）
（３） バベルダオブ島南部（空港北部～アイライ発電所付近）
（４） コロール島内
（５） マラカル島内

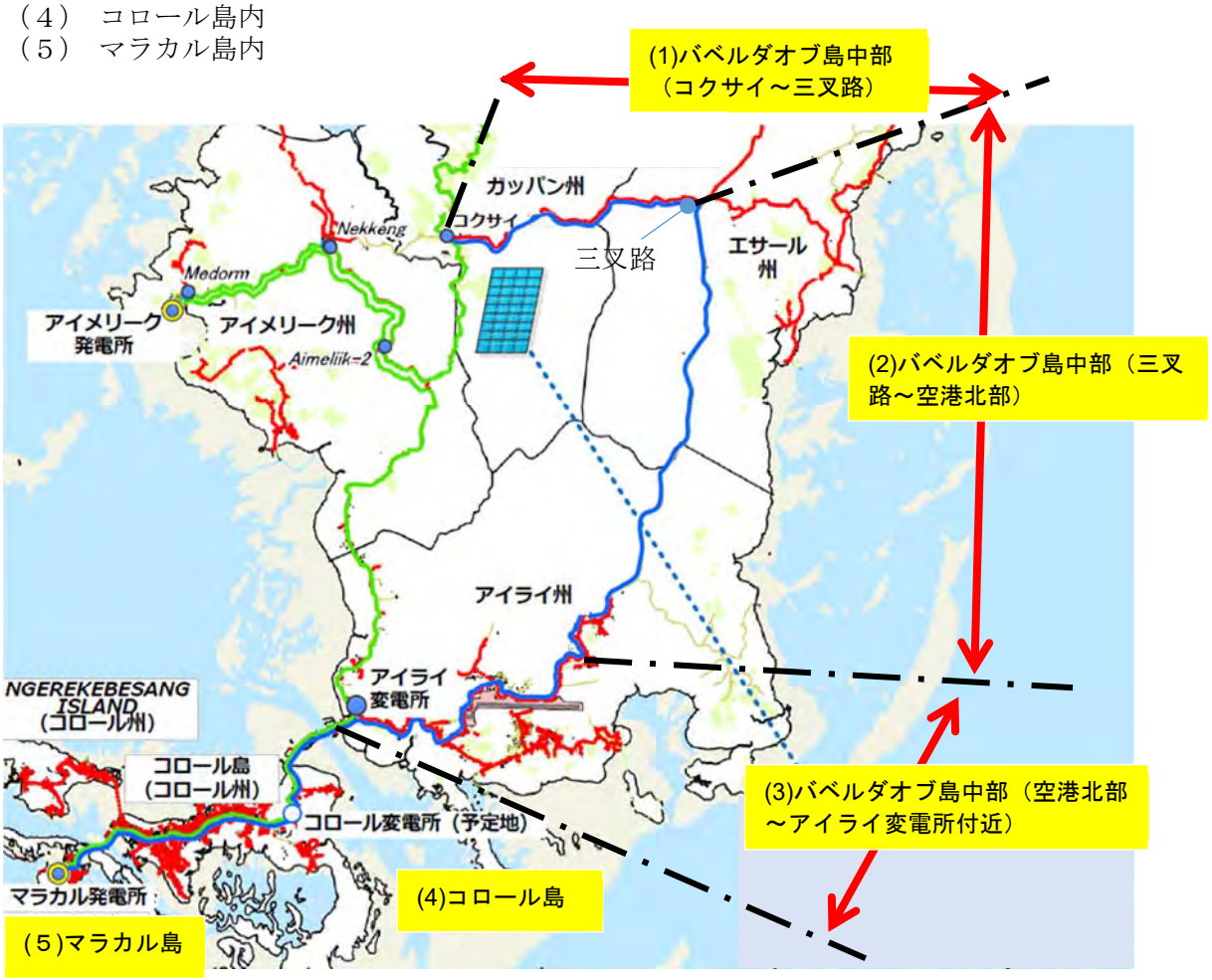


図 2.1.1　ルート区分

（１）バベルダオブ島中部（コクサイ～三叉路）
・小崩壊が２箇所（RCs-1　RCs-2）、表層地すべりが１箇所（L-1）

表層地すべり L-1 はガリー浸食がすすんだルーズな土砂が層厚 30～40 ㎝程度と分布する。集水地形を呈することから、大雨時に流水とともに表層土砂が流される。既存の電柱はこの不安定斜面を避けて設置されている。

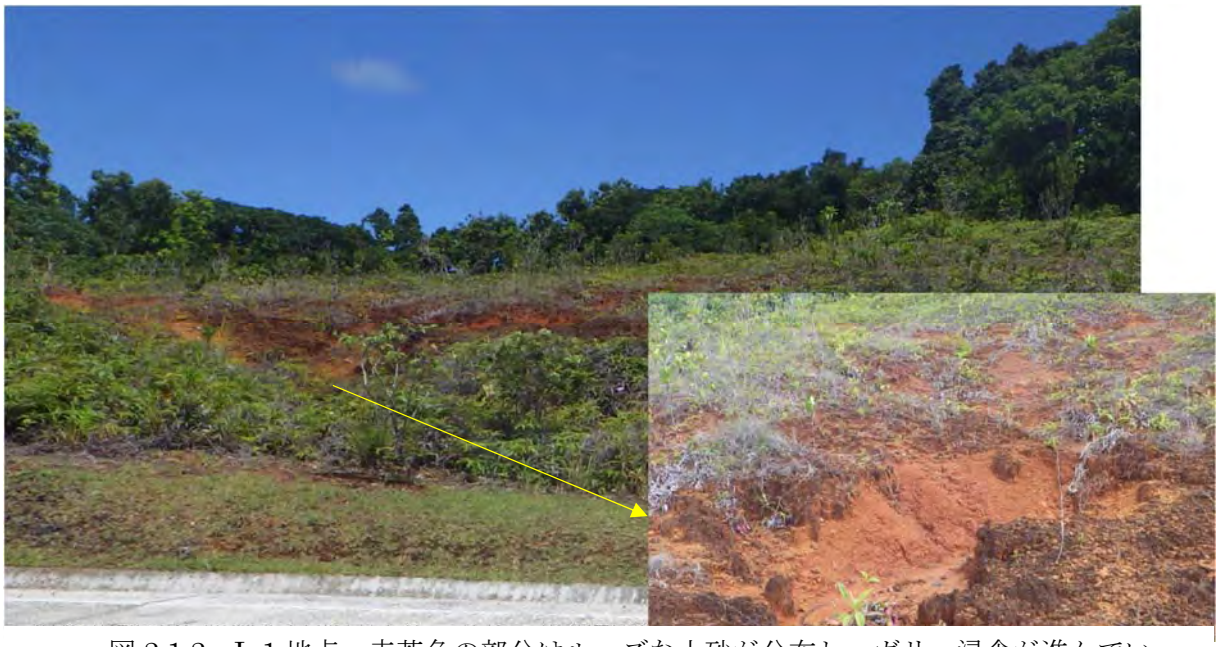


図 2.1.2　L-1 地点　赤茶色の部分はルーズな土砂が分布し、ガリー浸食が進んでいる。風化土壌が流出しやすい状況にある（表層地すべり）

他に、幅数 m の小崩壊が２か所に確認される（SC-1、SC-2）。いずれも既存電柱はこれを避けて設置されている。

（２）バベルダオブ島中部（三叉路～空港北部）
・崩壊地が多い。

崩壊・地すべりを以下に示す。
①　地すべり地（記号Ｌ）が２箇所（L-2 、L-3）
②　新しい大規模崩壊（記号 RC）が２箇所（RC-1、RC-2）
③　新しい小規模崩壊（記号 RCs）が１箇所（RC s -2、RCs-3）
④　古い切土崩壊（記号 OC）が８箇所（OC-1～OC-8）

代表的な現場写真を次頁に示す。

① 地すべり地（2 箇所、L-2、L-3）

図 2.1.3 地すべり地（写真は L-2） 電柱は反対側に設置する

図 2.1.4 地すべり地（写真は L-3） 電柱は反対側に設置する

② 新しい切土崩壊（RC）
基盤岩や土壌がむき出しになり、脆く崩れやすい。

図 2.1.5 新しい崩壊地（RC） 植生が無く進行性の崩壊
この崩壊が分布する法面は全体に不安定であるため、電柱は反対側に設置する

③ 古い切土崩壊（OLC）
崩壊地形であるが周囲と同様の植生を有し赤土などの新たな崩壊跡が見られない。切土工事時に発生したものと推定され、現在は安定している。

図 2.1.6 古い崩壊地跡（OC） 集水地形であること、再び崩壊する可能性が否定できないことから、直下部への電柱設置は避ける

・その他の留意点
幅数 m 程度の小崩壊が確認される（SC-3、SC-4）。いずれもこれを避けて設置することは可能であるが、崩壊地が集中する法面部分はまとめて避けるようにする。
道路が沢を横断する部分では盛土が施工されている。道路や路肩に変状が無いことから安定していると思われる。ただ、斜面近くでは十分な転圧がなされていない可能性もあり、斜面への設置は避けた方が良い。

（３）バベルダオブ島南部（空港北部～アイライ変電所付近）
・ほぼ安定している。地すべりは３箇所である。

住宅街をとおり、日本パラオ友好の橋に至る区間である。この地域の不安定斜面は下記のとおりである。

① 地すべり地（記号Ｌ）が３箇所（L-4 、L-5、L-6 ）
② 新しい小規模崩壊（記号 RCs）が１箇所（RC s -4）

L-4 は復旧工事中で終了すれば問題なくなる。
L-5 は地すべりが懸念される地点であり、古い電柱は傾いているので、新しい電柱は反対側に設置する。
L-6 は特に危険である。現在 30 ㎝以上の変位が生じていて、路面の開口割れ目は補強が間に合っておらず、活動的な地すべり地である。電柱の設置場所は反対側となるが、崩壊時に因果関係が疑われないように出来るだけ離れた地点に電柱を設置したほうが良い。

・その他の留意点
空港北側から道路に開口亀裂が目立つようになり、原因は施工不良である。本計画には直接関係しないが、道路の維持管理の視点から道路カルテ点検が必要と思われる。

3. 崩壊地分布のまとめ

表 3.1.1 に崩壊地一覧を示し、崩壊地の位置を図 3.1.1 に示す。
表 3.1.1 の黄色で塗色した部分が注意すべき崩壊地である。

表 3.1.1 送電線ルート沿いの斜面リスク一覧表

【要約】
・崩壊規模、活動度により 4 分類した（小崩壊、新しい大崩壊、大規模な崩壊地跡、地すべり）.このうち**大崩壊、地すべりに特に留意が必要**である。
・危険度が高い区間は「道路区間（2）地点番号 6～10、地点番号 11～14」である。
・電柱が設置できない場所は無く、道路反対側への設置、電柱間隔を長くとった配置で対応することとした。

地点番号	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
道路区間	（1）	（1）	（1）	（1）	（2）	（2）	（2）	（2）	（2）	（2）	（2）	（2）	（2）	（2）	（2）	（2）	（2）	（3）	（3）	（3）	（3）
地点記号	CRs-1	CRs-2		L-1	OC-1	OC-2	OC-3	RC-1	L-2	OC-4	RC-2	OC-5	OC-6	L-3	OC-7	OC-8	CRs-3	L-4	L-5	CRs-4	L-6
種類	小崩壊	小崩壊	（穴）	地すべり	崩壊跡	崩壊跡	崩壊跡	崩壊	地すべり	崩壊跡	崩壊	崩壊跡	崩壊跡	地すべり	崩壊跡	崩壊跡	小崩壊	地すべり	地すべり	小崩壊	地すべり
活動度	有り	有り		有り	無し	無し	無し	有り	有り	無し	有り	無し	無し	有り	無し	無し	有り	有り	無し	有り	有り
影響度	小	小	なし	中	中	中	大	大	大	大	中	大	中	大	中	小	小	大	大	小	大
規模(m)																					
幅	5	5	1～2	30	30	30	50	20+α	30	50	20	50	50	100～150	30	10	5	50	100	5	40
高さ	4	4	深さ1.5	7	20	10	20	20	30	20	15	10	10	20	20	10	4	10	20	4	5
奥行	1	1		30	2	2	5	5	60	5	10	2	2	60	2	1	1	5	50	1	10
GPS																					
緯度	7.457987	7.465511	7.465539	7.465012	7.449254	7.444635	7.443758	7.443925	7.442015	7.441403	7.432292	7.432224	7.434504	7.431425	7.418737	7.404106	7.38324	7.369212	7.370755	7.367124	7.361112
経度	134.540029	134.562149	134.564394	134.568155	134.579307	134.57936	134.579429	134.578978	134.579424	134.579483	134.575362	134.575134	134.576198	134.575534	134.575494	134.567016	134.55506	134.539634	134.535596	134.533511	134.530368
記事	切土の小崩壊	切土の小崩壊	電柱立替時に古い電柱跡の埋め残しと思われる	表層はガリー浸食がすすみ、流水による浸食が著しい。	植生に覆われており、初期(工事時)のもの。 集水地形をしているため、直下への設置は避けた方が無難	植生に覆われており、初期(工事時)のもの。 集水地形をしているため、直下への設置は避けた方が無難	植生に覆われており、初期(工事時)のもの。 集水地形をしているため、直下への設置は避けた方が無難	周囲にも小崩壊があり、この崩壊地を含む法面は出来るだけ飛ばした方が良い	進行性の地滑りで、範囲が広がる可能性あり。	植生に覆われており、初期(工事時)のもの。 集水地形をしているため、直下への設置は避けた方が無難	滑落崖が新しく、崩積土が残留	植生に覆われており、初期(工事時)のもの。 集水地形をしているため、直下への設置は避けた方が無難	植生に覆われており、初期(工事時)のもの。 集水地形をしているため、直下への設置は避けた方が無難	進行性の地滑りで、範囲が広がる可能性あり。	植生に覆われており、初期(工事時)のもの。 集水地形をしているため、直下への設置は避けた方が無難	植生に覆われており、初期(工事時)のもの。 集水地形をしているため、直下への設置は避けた方が無難	切土の小崩壊	対策工事中	緩斜面の地域で、小段が斜面内にある。道路横の電柱の傾動と土砂の押出し、染み出しがる。	盛土の小崩壊	道路面に開口クラック、西側に30cmほど陥没。路盤下部に数cmの空洞があり、道路として危険度が高い。
対応策	直下への設置を避ける	直下への設置を避ける	放置しておいても影響はないが、埋めた方が良い	既存の電柱も崩壊範囲を飛ばして設置している。 同様の対応	崩壊跡地を避けた設置、もしくは反対側への設置	崩壊跡地を避けた設置、もしくは反対側への設置	崩壊地を避けて設置、あるいは反対側への設置	道路反対側への設置あるいは、電柱間距離を広く取り、崩壊地を避ける	道路反対側への設置	崩壊跡地を避けた設置、もしくは反対側への設置	崩壊地を避けた設置、もしくは反対側への設置	崩壊地を避けた設置、もしくは反対側への設置	崩壊地を避けた設置、もしくは反対側への設置	道路反対側への設置	崩壊跡地を避けた設置、もしくは反対側への設置	道路面は安定しているため、脇か、反対側が良い	直下への設置を避ける	対策工事をしており、設置位置はこの区間を避ける	新しい電柱は反対側に設置している	直下への設置を避ける	電柱は反対側に設置 （道路斜面部に抑止杭を施工、片側路面を取り除き、ジオテキスタイル等で補修）

道路区間

（1）	バベルダオブ島中部（コクサイ～三叉路）
（2）	バベルダオブ島中東部（三叉路～空港北部）
（3）	バベルダオブ島南部（空港北部～アイライ発電所付近）
（4）	コロール島内
（5）	マラカル島内

活動度

有り	次の大雨時に被害を及ぼす可能性あり
無し	現在は安定している

影響度(電柱設置時に留意すべき事項)

大	幅50m以上の崩壊
中	幅10～50mの崩壊
小	幅10m未満の崩壊

崩壊区分と記号　　（黄色は要注意箇所）
①　地すべり地・・・・・・（記号Ｌ）
②　大規模な新しい切土崩壊・・・（記号RC）
③　規模の小さな崩壊・・・・（記号RCs）
④　古い切土崩壊・・・・・（記号OC）

1 小崩壊　CRs-1

2 小崩壊　CRs-2

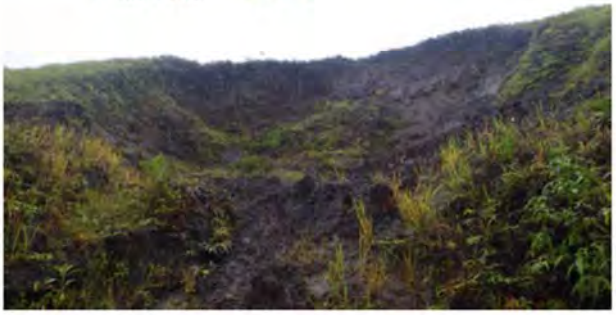
3　穴

4 地すべり　L-1

5 崩壊跡　OC-1

6 崩壊跡　OC-2

7 崩壊跡　OC-3



8 崩壊　RC-1

9 地すべり　L-2

10 崩壊跡　OC-4

11 崩壊　RC-2

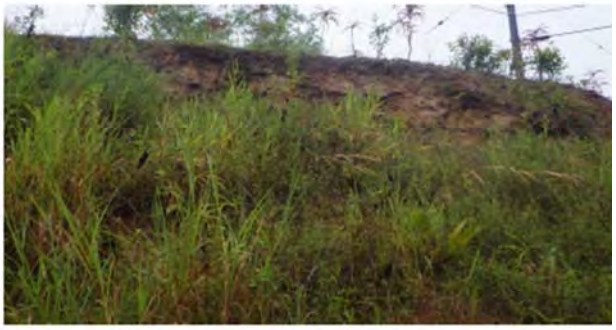
12 崩壊跡　OC-5

13 崩壊跡　OC-6

14 地すべり　L-3

15 崩壊跡　OC-7

16 崩壊跡　OC-8



17 小崩壊　CRs-3

18 対策工事中　L-4

19 地すべり　L-5

20 小崩壊　CRs-4

21 地すべり L-6

図 3.1.1 崩壊地位置図(1)

図 3.1.1 崩壊地位置図 (2)

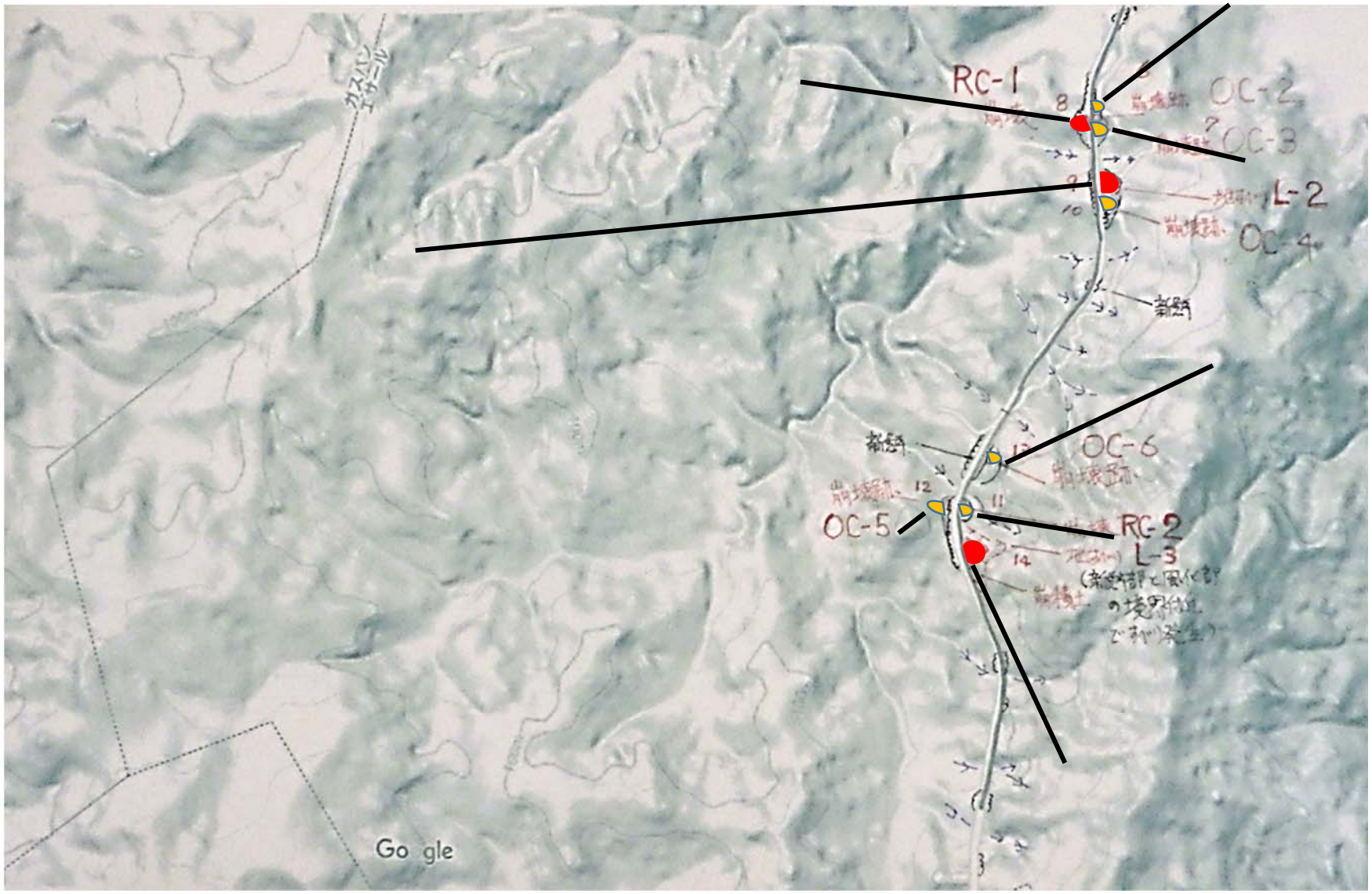


図 3.1.1 崩壊地位置図 (3)

第 3 章. 変電所基礎調査

変電所基礎調査として、スウェーデン式貫入試験（以下 SWS 試験と略す）ならびに平板載荷試験を実施した。以下にこれらの結果を示す。

1 試験概要

1.1 実施数量

表 1.1.1 変電所基礎調査数量

変電所	SWS 試験	平板載荷試験
Malakal Substation	3 箇所	—
Kokusai Substation	4 箇所	1
Koror Substation (Mason’s rock)	8 箇所（地表面での実施 5 地点） （トレンチ個所での実施 3 深度）	1 (d=0.5m)
合計	15 箇所	2

1.2 SWS 試験方法

JIS A 1221:2020（スクリューウエイト貫入試方法）に準じて実施した。実施手順を以下に示す

① 長さ 0.8m のロッド先端にスクリューポイントを取り付ける。
② 掲載用クランプ、重さ５ｋｇを固定し、調査地点上に鉛直に立てる。
③ このままの状態でロッドが地中に貫入するかどうか確認する。
④ 貫入する場合は、荷重に対する貫入量を記録する
⑤ 荷重を載荷用クランプに円筒形のおもりを１枚ずつ順次載荷（5kg⇒15kg⇒25kg⇒50kg⇒75kg⇒100kg）
⑥ 荷重に対する貫入量を記録する。

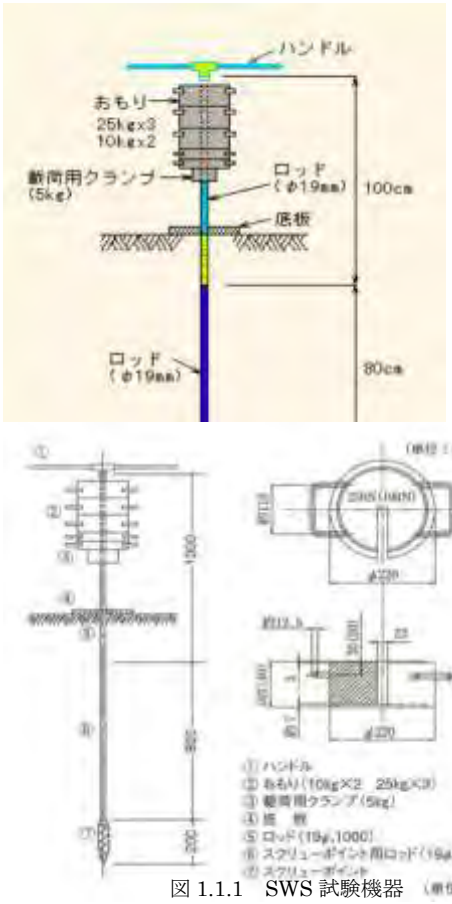


図 1.1.1 SWS 試験機器 （単位:mm）

⑦ 載荷荷重 100kg 後は、ロッドにハンドルを取り付け、右回りに回転させ、ロッドが 25cm 貫入させるのに要する半回転数を記録する。

⑧ ハンドルの回転数は、**180 度（半回転）を 1 回**とする。
⑨ 深度を増やす場合はロッド（長さ１ｍ）を継ぎ足す。
⑩ 測定終了基準
・スクリューポイントが硬い層に達した場合、あるいは貫入量 25cm 当たりの半回転数が 50 回以上となる場合、空転する場合、貫入深度が 10m に達した場合とする。

＜強度の換算＞

換算 N 値

砂質土・礫質土 粘性土 N= 2Wsw+0.067Nsw

粘性土 N= 3Wsw+0.050Nsw

Wsw ： 載荷荷重（kN）

Nsw ： SWS 試験における 1.00m あたりの半回転数（回）

長期許容支持力（kN/m2）

（建築物の構造関係技術基準解説書:国土交通省住宅局他監修）

qa=30Wsw+0.6Nsw

1.3 平板載荷試験方法

ASTM D1194-94 に準じて実施した。この基準に基づく試験計画を以下に示す。

(1) 試験位置の決定および地盤の整形

試験地盤面は載荷板の中心から載荷板直径の 3 倍以上の範囲を水平に整地し、試験面は地盤表層の乱れを避けるために試験直前に仕上げ整形した。

(2) 載荷板の設置

試験地盤面に水平で一様に密着するように載荷板（直径 300mm、厚さ 25mm）を設置した。

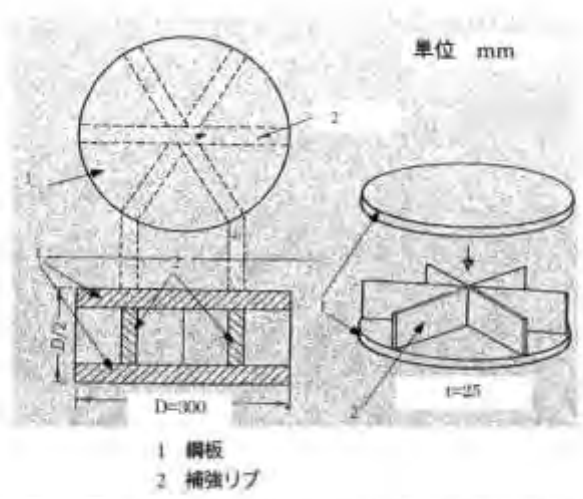


図 3.1.1 載荷板の例（載荷板直径 300mm，鋼板厚さ 25mm の場合）

(3) 載荷装置

ジャッキ・支柱・載荷ばり・反力装置（重機など）から構成され、計画最大荷重に対し 1.2 倍以上の載荷能力を持つ構造とする。載荷板に偏心荷重が加わらないように組立てる。(設置事例参照)

載荷方法には段階式載荷（1 サイクル）を実施した。

(4) 載荷試験計画

① 予備載荷

速繰り返しによる予備載荷を 5 分間程度行い、1 段階荷重を超えない範囲でその都度荷重と沈下を測定した。この試験で載荷装置全体の垂直性、安全性及び正確な動作を確認するとともに、4 個の変位計（ダイヤルゲージ）が正常に作動することを確認し、地盤の表面と載荷板との接触部分の乱れが無いことを確認した。

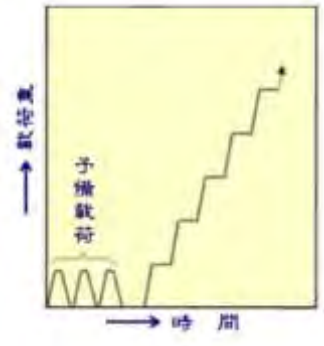


図 3.1.2 予備載荷

② 本載荷と計測

i. 荷重を戻しダイヤルゲージの目盛をゼロに修正

ii. 各荷重段階において所定の荷重に達した後、原則として経過時間 0 分、1 分、2 分、5 分、10 分、15 分、20 分、25 分、30 分で沈下を測定。

iii. 最大荷重載荷後は、5 分間隔で各荷重を段階ごとに順次減圧して荷重の戻しに対する沈下量の復元を測定。

iv. 沈下量は 4 個のダイヤルゲージによって測定し、それぞれの 1／100mm 単位まで読みの平均値を沈下量とした。

v. 最大荷重載荷後は、5 分間隔で各荷重を段階ごとに順次減圧して荷重の戻しに対する沈下量の復元を測定した。

- 荷重強さ（ｋＮ／㎡）と実荷重（ｋＮ）

直径 30cm の円形載荷板の接地面積は A=0.15×0.15×π＝0.07065 ㎡であることから

実荷重（ｋＮ）＝ 0.07065（㎡）× 荷重強さ（ｋＮ／㎡）により求める

今回実施した載荷計画を図 3.2.3 に示す。

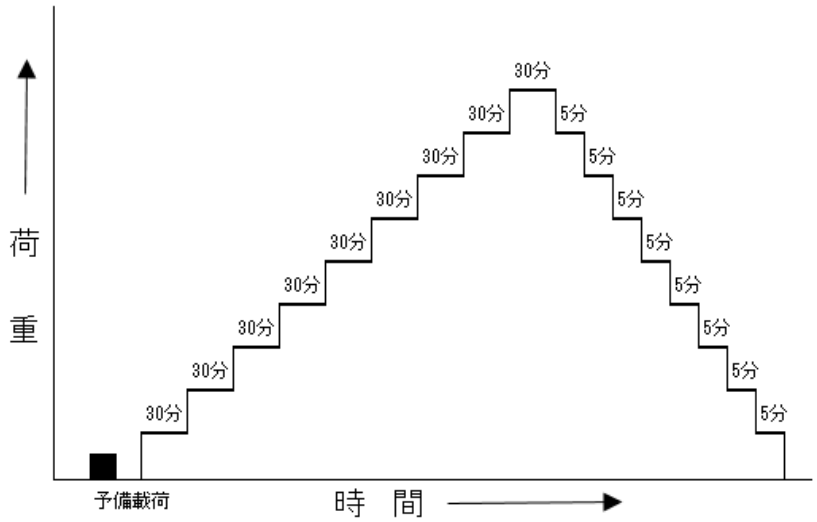


図 3.2.3 載荷試験計画

2 SWS 試験結果
2.1Malakal Substation
(1) 試験位置と数量

図 2.1.1　Malakal Substation　増設予定地

図 2.1.2　SWS 試験位置

図 2.1.3
SWS 試験位置

(2) **Malakal Substation 試験結果**

試験データは巻末資料に、結果の概要を図 2.2.1 に示す。

地表面から 10～30 ㎝程は軟質であるが、これ以深は十分な強度を有する。

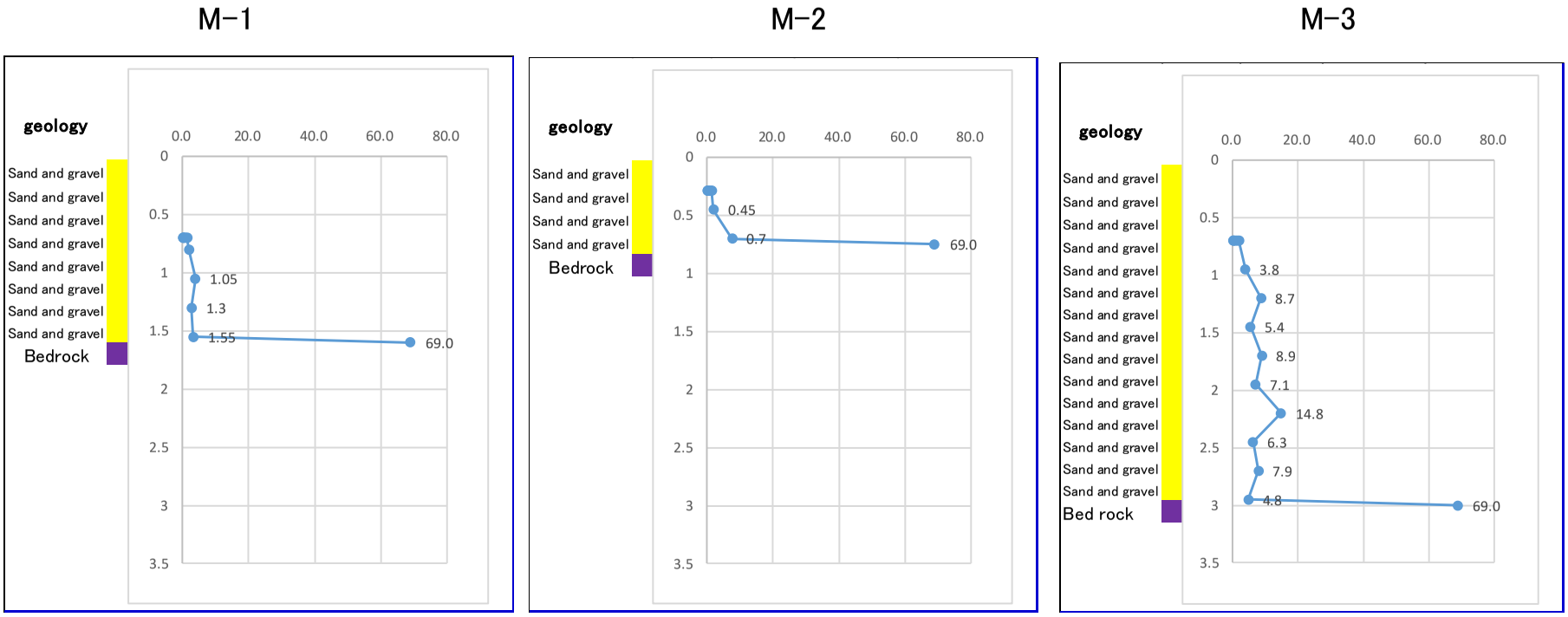


図 2.1.4　試験結果

2.2Kokusai Substation

(1) 試験位置と数量

図 2.2.1(上)は変電施設周辺の盛土・埋土の状況を示した。斜線部分が旧谷地形（谷埋め範囲)、褐色部分が盛土である。埋土と盛土の層厚ならびに強度の把握を詳細に把握する目的で、SWS は 4 箇所で実施し、平板載荷試験を 1 箇所で実施した。

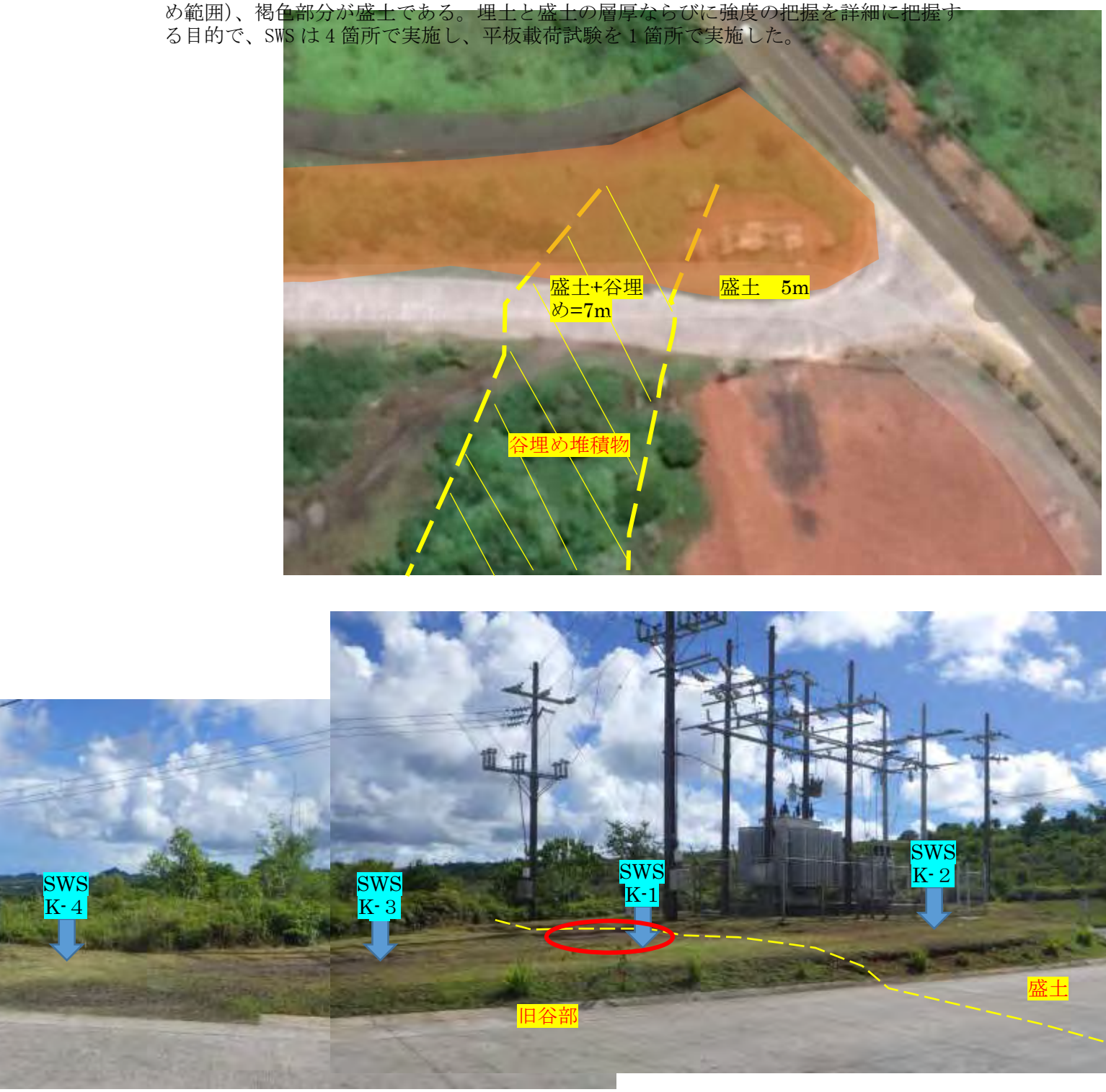


図 2.2.1　Kokusai　Substation　SWS 試験位置（⇩）と平板載荷試験（○）

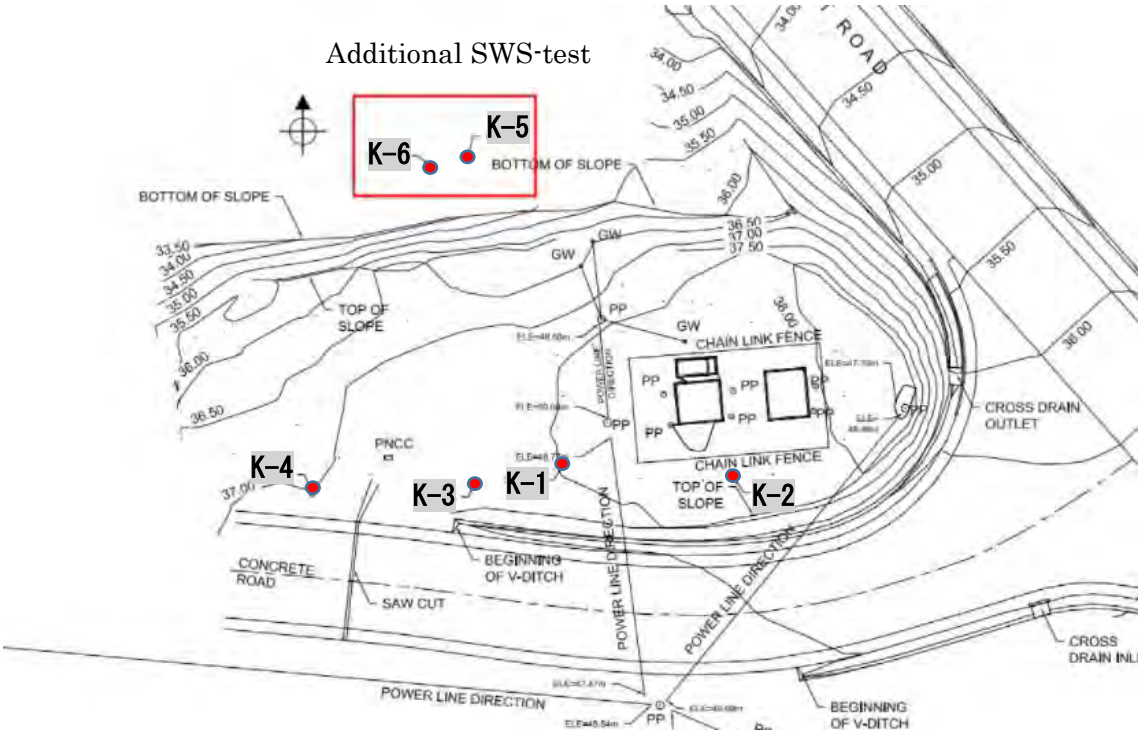


図 2.2.2　SWS 試験位置（●）

(2) 試験結果

試験データは巻末資料に、結果の概要を図 2. 2. 2 に示す。

今回の SWS 試験から、4 地点ともに深度 1m 以浅が換算 N 値 3～5、これ以深に N 値 0～3 のゾーンが確認され、元地盤（N 値 20 以上）は深度 5～7m 以深に分布する。

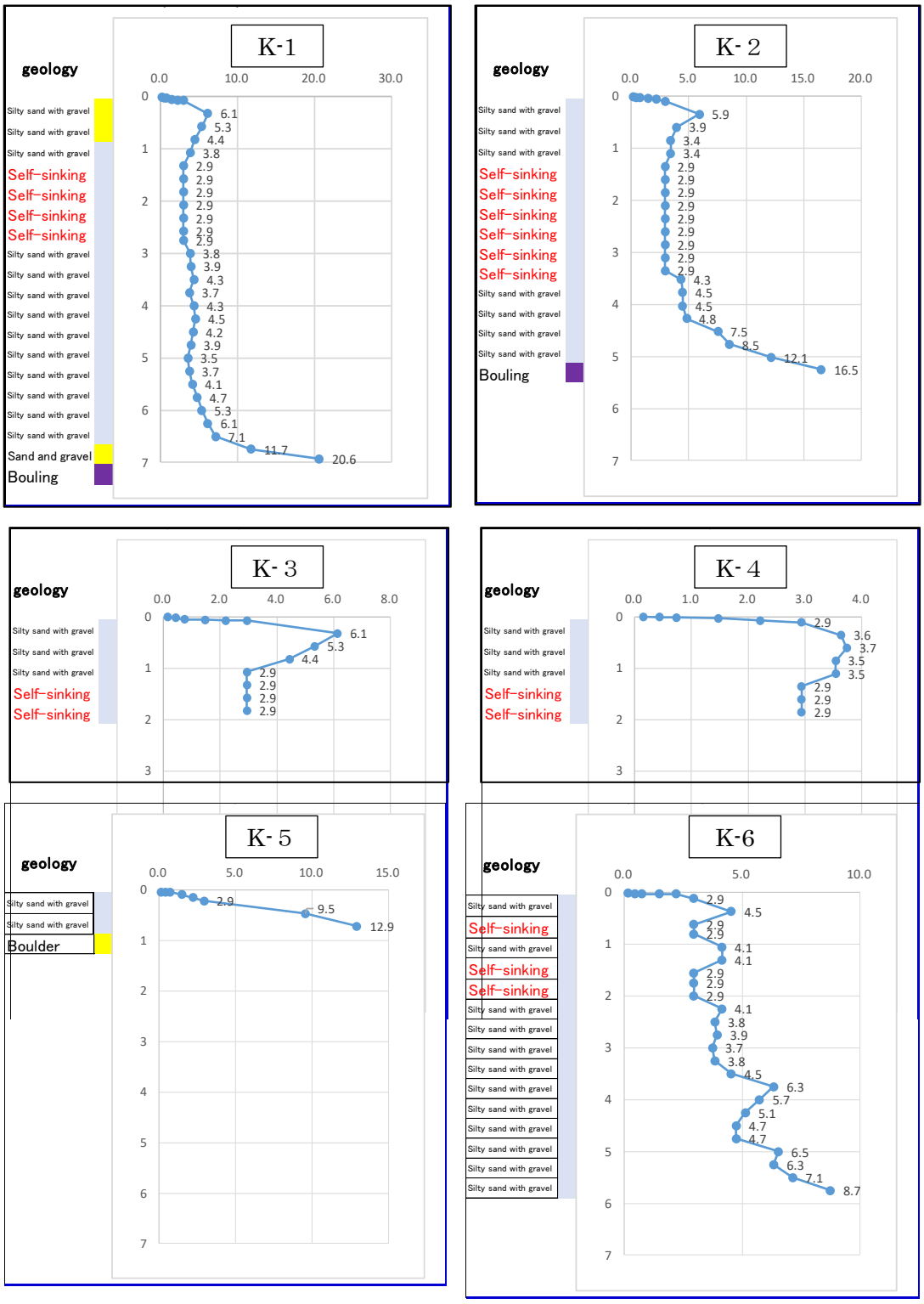


図 2.2.1 Kokusai Substation SWS-test result

(3) 試験結果の考察

図 2.2.2 に試験地点の断面図を示す。

SWS 試験で軟弱地盤の分布が確認された一方で、変電所施設、電柱、道路面に変状が全く無く、矛盾した結果となっている。

道路を含む施設に変状が無い理由としては、下記が考えられる。

・N 値 3～5 のゾーンが盤状に地表面に広がり、この部分で上部構造物を支えている。

以上から、平板載荷試験により地盤強度を評価することとした。

平板載荷試験結果は「3. 平板載荷試験　3.2Kokusai Substation」で述べる。

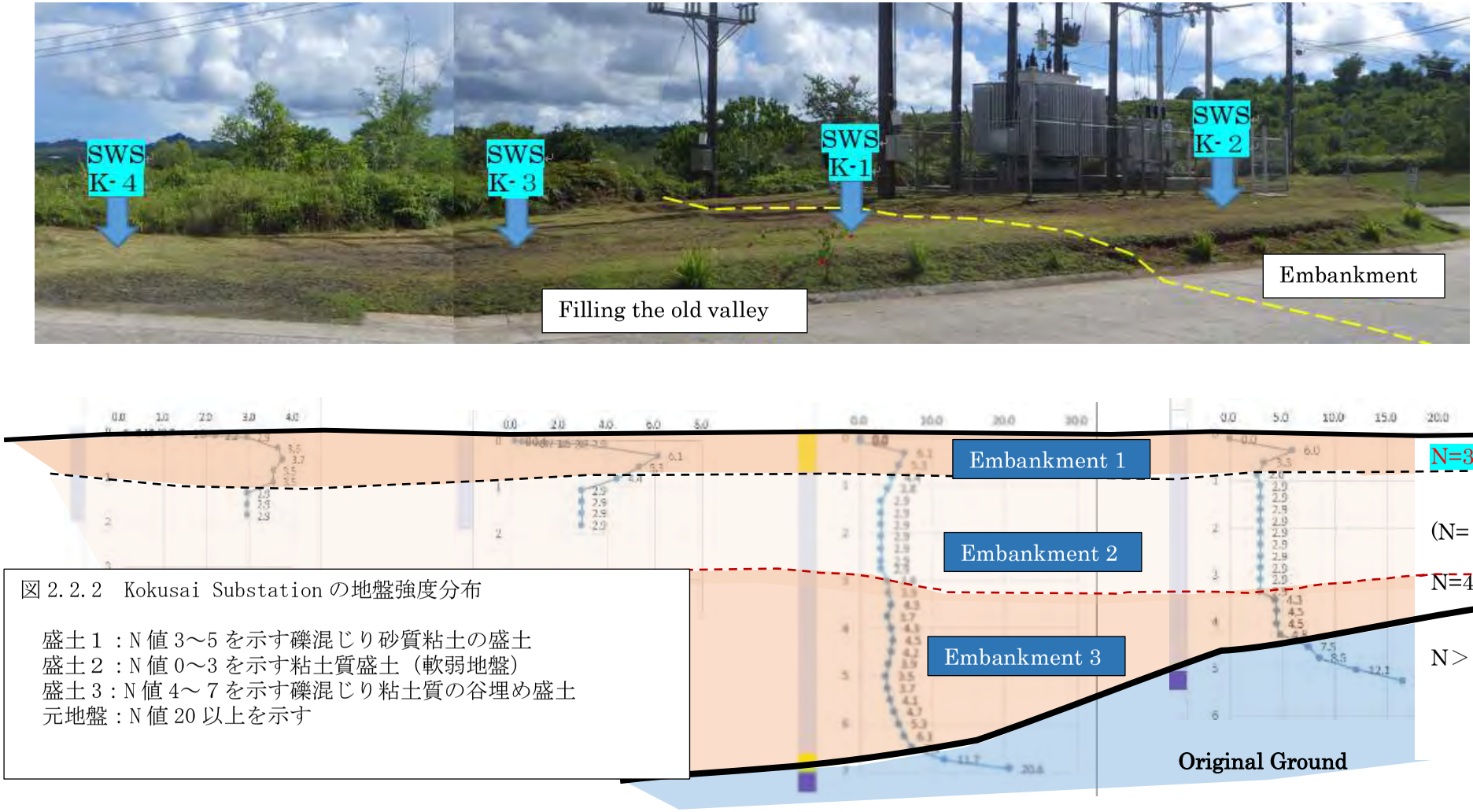


図 2.2.2　Kokusai Substation の地盤強度分布

盛土１：N 値 3～5 を示す礫混じり砂質粘土の盛土
盛土２：N 値 0～3 を示す粘土質盛土（軟弱地盤）
盛土３：N 値 4～７を示す礫混じり粘土質の谷埋め盛土
元地盤：N 値 20 以上を示す

2.3 Koror Substation (Mason's rock)

(1) 試験位置と数量

水路での試験（MR-1)、道路での試験（MR-2, MR-2'、MR-2''）、上部平坦面での試験は（MR-3（0m)）ならびに 3 深度（(MR-3(0.5m)、MR-3（1.0m)、MR-3(1.5m)）をトレンチ掘削とともに実施した。実施位置を図 2.3.1 に示す。深度方向の調査は図 2.2.5 に示す平板載荷試験位置をバックホウで削孔しながら実施した。

表 2.3.1 試験数量一覧

	Waterway	Road	Worksite Flat ground
Point	MR-1	MR-2,MR-2',MR-2"	MR-3(0,0.5,1,1.5)
Number Tested	1	3	4
Remarks	On surface	On surface	d=0m,0.5m,1m,1.5m

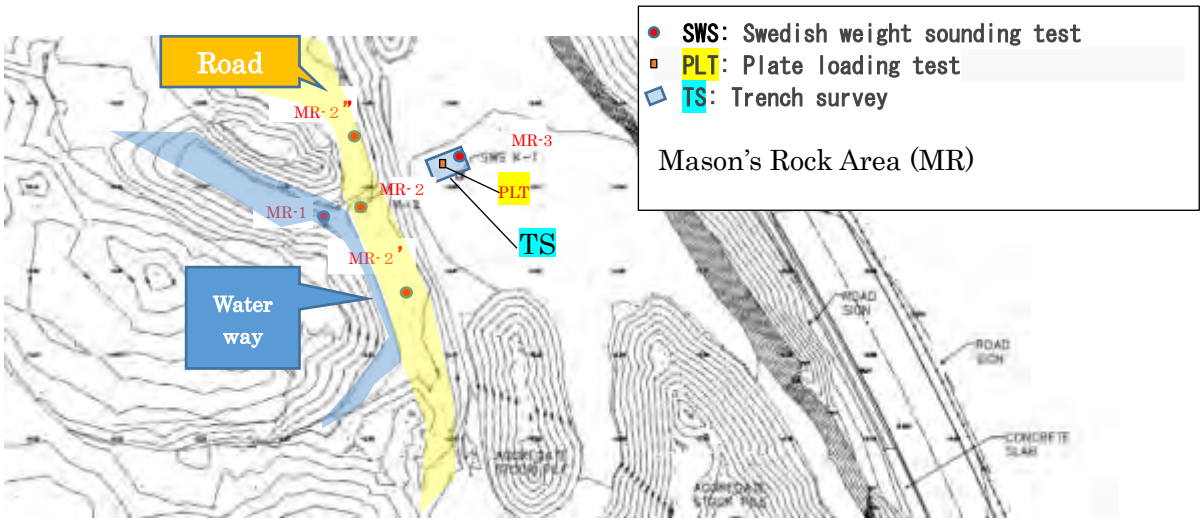


図 2.3.1 In-situ testing points at Mason Rock Area

図 2.3.2 道路と水路

(2) SWS 試験結果

(2) -1 道路面での試験結果

上部平坦面の地表面からの試験結果を表 2.3.1 に、1m 下の道路沿いの試験結果を表 2.3.2 (1) ～ (4) に示す。いずれも採石場から出た砂礫を材料にした盛土からなり、地表面を除き N 値 50 以上である。

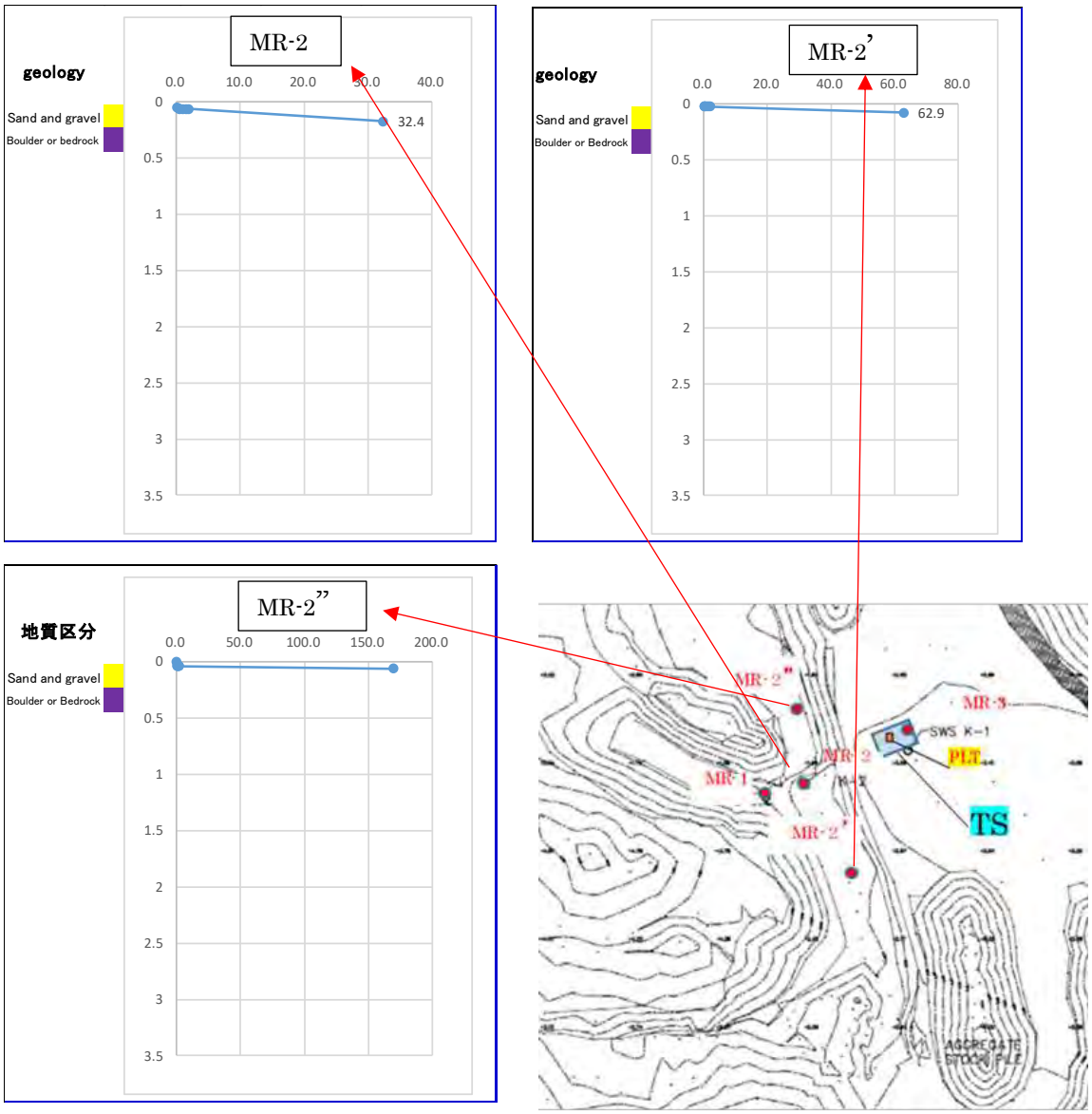


図 2.3.3　SWS 試験結果（上面よりも 1m 下の道路）

(2) -2 水路の試験結果

建設予定地から西に下ったところに水路があり、この部分も変電所建設の敷地である。水路は細粒度混じり砂からなり、含水比が高く、非常に軟質である。この部分の SWS 試験結果を図 2.3.5 に示す。地表から深度 1.5m まではほとんど強度が見込めないことから、重要な建造物の基礎としては不適であることが分かった。

図 2.3.4　水路と SWS 試験位置

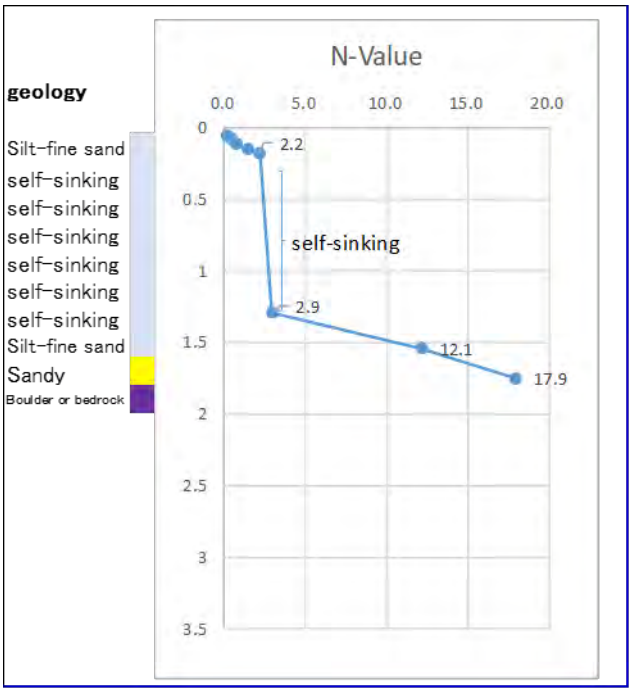


図 2.3.5　水路部での試験結果

(2) -3 トレンチ位置での SWS 試験結果（深度方向の強度分布）

平板載荷試験前に実施した深度 0m の試験に加えて、載荷試験後に深度 0.5m、深度 1.0m、深度 1.5m のトレンチ底面で試験を実施し、深度方向の強度分布を把握した。表 2.2.5 (1) ～ (4) に試験結果を示す。

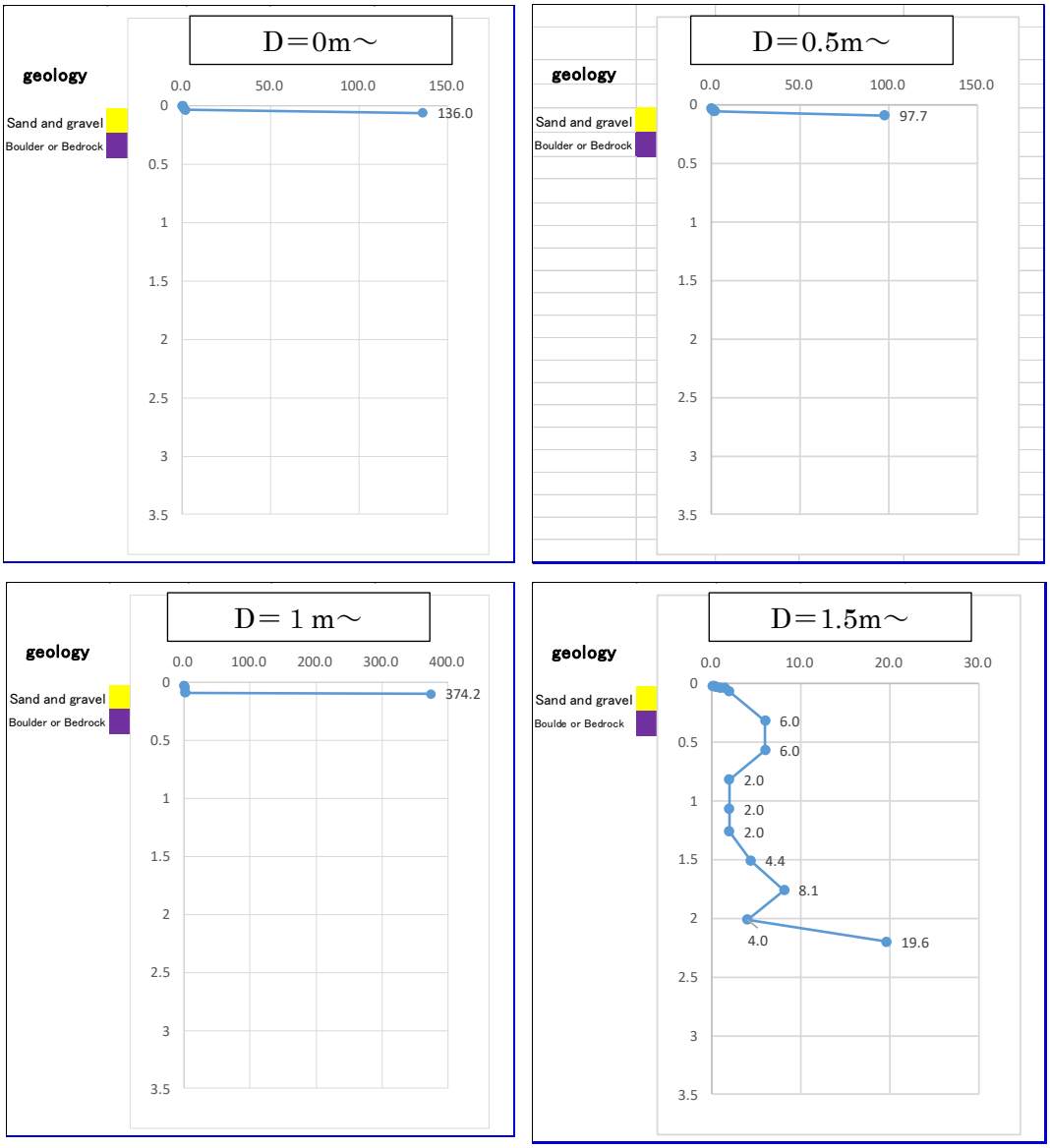


図 2.3.6 トレンチ位置での各深度の試験結果

(3) 考察

上部平坦面（Worksite Flat ground）の深度 0m、深度 0.5m、深度 1.0m、深度 1.5m で実施した試験から、深度 0 ～3.7m 間の強度が把握できた。結果は図 2.3.7 のコンパイル図に示した。このコンパイルは、深度 1.5m～の試験データに、これ以浅の試験データを合算（combine）させて作成した。

≪Koror Substation の土質と強度分布≫

- 地表面 0.1 cm：ルーズな砂礫
- 0.1～1.8m：N 値 50 以上の締め固まった石灰石の盛土（白色）
- 1.8～2.1m：N 値 6 の含礫黒色埋め土
- 2.1～2.8m：N 値 0～ 2 （自沈）層（埋め土）、おそらく粘性土主体
- 2.8～3.5m：N 値 4～8 の含礫黒色埋め土
- 3.5～3.7m：N 値 20 以上の元地盤

2.1～2.8m に軟弱部が介在するが、後述する平板載荷試験結果から十分な地耐力が確認されたことで、変電所基礎として問題ないことを確認した。

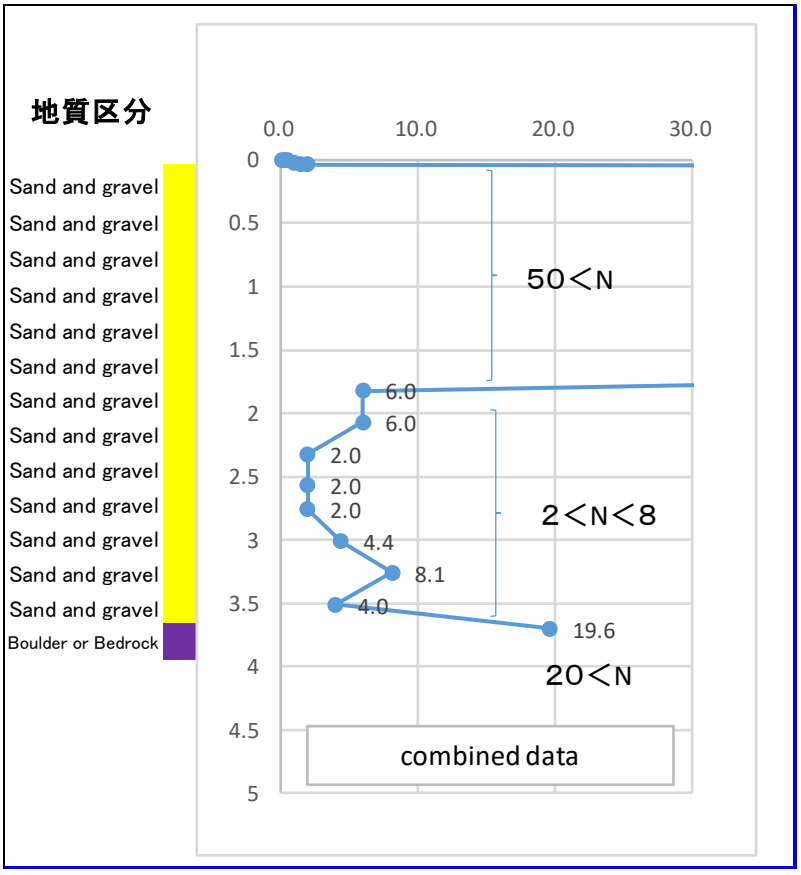


図 2.3.7 深度方向の換算Ｎ値分布

2.4 Airai Substation

(1) 試験位置と数量

表 2.4.1 に実施数量を示す。

表 2.4.1 試験数量一覧

	Substation premises	Substation premises
Point Number	A-1	A-2
Remarks	On surface	On surface

図 2.4.1 Investigation points at airai Substation

(2) 試験結果

試験結果の詳細は巻末に示し、図 2.4.2 および図 2.4.3 に N 値を示す。
A-1 A-2 ともに地表下 50 ㎝より N 値 5 以上を呈する。

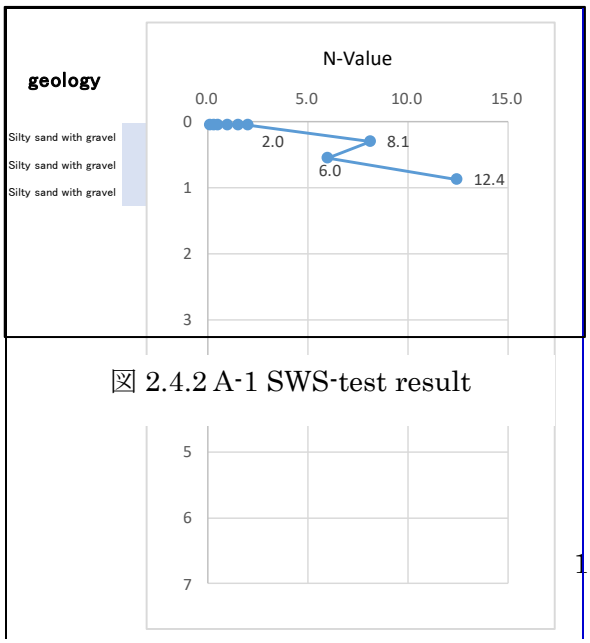


図 2.4.2 A-1 SWS-test result

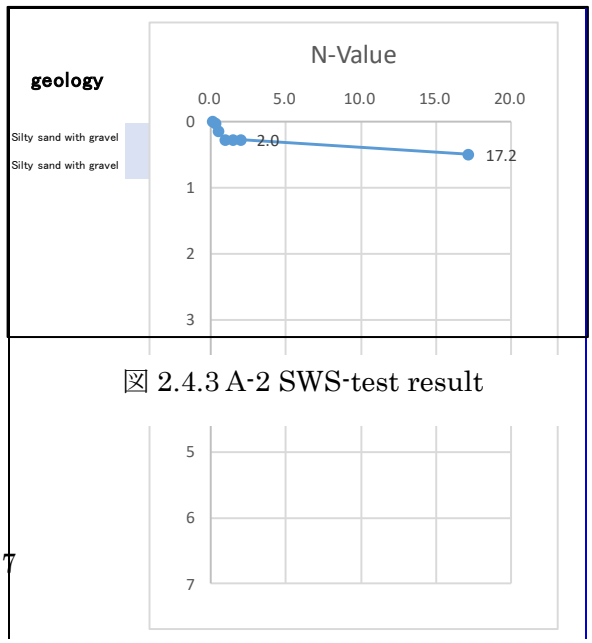


図 2.4.3 A-2 SWS-test result

3 平板載荷試験結果
3.1 Koror Substation (Mason Rock)

試験結果を表 3.1.1 に示す。

表 3.1.1(1) 載荷試験結果(Mason Rock Substation)

Shape of the load plate	Circular steel plate	Diameter and thickness of the load plate	300mm・25mm	Area of the load plate	●m²
Type of jack	Hydraulic jack	Capacity of jack	●KN	Type of reaction force device	
Loading method	Stepped loading (1 cycle)	Correction factor	KN/m²/scale		

Stage	Weingh scale reading	Loading pressure P=KR	time	elapsed time t	Displacement gauge 1/100mm				Average	settlement
	R	KN/m²		min	1	2	3	4	mm	mm
Preliminary loading	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
	0.9	12.676	2	2	0.00	0.00	0.00	0.00	0.00	0.00
	0	0	4	4	0.00	0.00	0.00	0.00	0.00	0.00
	0.9	12.676	6	6	0.00	0.00	0.00	0.00	0.00	0.00
	0	0	8	8	0.00	0.00	0.00	0.00	0.00	0.00
	0.9	12.676	10	10	0.00	0.00	0.00	0.00	0.00	0.00
	0	0	12	12	0.00	0.00	0.00	0.00	0.00	0.00
1	1.32	18.592	0	12	0.00	0.00	0.00	0.00	0.00	0.00
	1.32	18.592	1	13	0.00	0.00	0.00	0.00	0.00	0.00
	1.32	18.592	2	14	0.00	0.00	0.00	0.00	0.00	0.00
	1.32	18.592	5	17	0.00	0.00	0.00	0.00	0.00	0.00
	1.32	18.592	10	22	0.00	0.00	0.00	0.00	0.00	0.00
	1.32	18.592	15	27	0.00	0.00	0.00	0.00	0.00	0.00
	1.32	18.592	20	32	0.00	0.00	0.00	0.00	0.00	0.00
	1.32	18.592	25	37	0.00	0.00	0.00	0.00	0.00	0.00
	1.32	18.592	30	42	0.00	0.00	0.00	0.00	0.00	0.00
2	2.64	37.183	0	42	0.00	0.00	0.00	0.00	0.00	0.00
	2.64	37.183	1	43	0.00	0.00	0.01	0.00	0.00	0.00
	2.64	37.183	2	44	0.00	0.01	0.00	0.06	0.02	0.02
	2.64	37.183	5	47	0.00	0.01	0.00	0.10	0.03	0.03
	2.64	37.183	10	52	0.00	0.01	0.00	0.12	0.03	0.03
	2.64	37.183	15	57	0.00	0.01	0.00	0.12	0.03	0.03
	2.64	37.183	20	62	0.00	0.01	0.00	0.12	0.03	0.03
	2.64	37.183	25	67	0.00	0.01	0.00	0.12	0.03	0.03
	2.64	37.183	30	72	0.00	0.01	0.01	0.12	0.04	0.04
3	3.96	55.775	0	72	0.00	0.01	0.01	0.12	0.04	0.04
	3.96	55.775	1	73	0.00	0.01	0.01	0.12	0.04	0.04
	3.96	55.775	2	74	0.00	0.01	0.02	0.12	0.04	0.04
	3.96	55.775	5	77	0.00	0.01	0.03	0.12	0.04	0.04
	3.96	55.775	10	82	0.00	0.01	0.04	0.12	0.04	0.04
	3.96	55.775	15	87	0.00	0.01	0.04	0.12	0.04	0.04
	3.96	55.775	20	92	0.00	0.01	0.04	0.12	0.04	0.04
	3.96	55.775	25	97	0.00	0.01	0.04	0.12	0.04	0.04
	3.96	55.775	30	102	0.00	0.01	0.04	0.12	0.04	0.04
4	5.24	73.803	0	102	0.00	0.01	0.05	0.12	0.05	0.05
	5.24	73.803	1	103	0.00	0.01	0.06	0.12	0.05	0.05
	5.24	73.803	2	104	0.00	0.01	0.06	0.13	0.05	0.05
	5.24	73.803	5	107	0.00	0.01	0.09	0.15	0.06	0.06
	5.24	73.803	10	112	0.00	0.01	0.11	0.16	0.07	0.07
	5.24	73.803	15	117	0.00	0.01	0.12	0.17	0.08	0.08
	5.24	73.803	20	122	0.00	0.01	0.14	0.19	0.09	0.09
	5.24	73.803	25	127	0.00	0.01	0.15	0.19	0.09	0.09
	5.24	73.803	30	132	0.00	0.01	0.16	0.20	0.09	0.09

表 3.1.1(2) 載荷試験結果（続き）

Stage	weighing scal reading	Loading pressure P=KR	time	elapsed time t	Displacement gauge 1/100mm				Average	settlement
	R	KN/m²		min	1	2	3	4	mm	mm
5	6.6	92.958	0	132	0.00	0.01	0.21	0.27	0.12	0.12
	6.6	92.958	1	133	0.00	0.01	0.23	0.28	0.13	0.13
	6.6	92.958	2	134	0.00	0.01	0.23	0.29	0.13	0.13
	6.6	92.958	5	137	0.00	0.01	0.28	0.35	0.16	0.16
	6.6	92.958	10	142	0.00	0.01	0.32	0.38	0.18	0.18
	6.6	92.958	15	147	0.00	0.01	0.35	0.41	0.19	0.19
	6.6	92.958	20	152	0.00	0.01	0.36	0.41	0.20	0.20
	6.6	92.958	25	157	0.00	0.01	0.38	0.45	0.21	0.21
	6.6	92.958	30	162	0.00	0.01	0.39	0.45	0.21	0.21
6	7.92	111.55	0	162	0.00	0.01	0.45	0.55	0.25	0.25
	7.92	111.55	1	163	0.00	0.01	0.46	0.56	0.26	0.26
	7.92	111.55	2	164	0.00	0.01	0.57	0.69	0.32	0.32
	7.92	111.55	5	167	0.00	0.01	0.68	0.81	0.38	0.38
	7.92	111.55	10	172	0.00	0.01	0.72	0.85	0.40	0.40
	7.92	111.55	15	177	0.00	0.01	0.73	0.99	0.43	0.43
	7.92	111.55	20	182	0.00	0.01	0.87	0.99	0.47	0.47
	7.92	111.55	25	187	0.00	0.01	0.88	0.99	0.47	0.47
	7.92	111.55	30	192	0.00	0.01	0.88	1.00	0.47	0.47
7	9.24	130.14	0	192	0.00	0.01	0.88	1.03	0.48	0.48
	9.24	130.14	1	193	0.00	0.01	0.88	1.03	0.48	0.48
	9.24	130.14	2	194	0.00	0.01	0.88	1.06	0.49	0.49
	9.24	130.14	5	197	0.01	0.01	0.97	1.17	0.54	0.54
	9.24	130.14	10	202	0.02	0.01	1.01	1.20	0.56	0.56
	9.24	130.14	15	207	0.03	0.01	1.04	1.23	0.58	0.58
	9.24	130.14	20	212	0.05	0.01	1.06	1.25	0.59	0.59
	9.24	130.14	25	217	0.05	0.01	1.07	1.26	0.60	0.60
	9.24	130.14	30	222	0.05	0.01	1.08	1.28	0.61	0.61
8	10.56	148.73	0	222	0.06	0.02	1.11	1.31	0.63	0.63
	10.56	148.73	1	223	0.08	0.04	1.12	1.34	0.65	0.65
	10.56	148.73	2	224	0.10	0.09	1.15	1.37	0.68	0.68
	10.56	148.73	5	227	0.14	0.12	1.20	1.44	0.73	0.73
	10.56	148.73	10	232	0.17	0.15	1.24	1.48	0.76	0.76
	10.56	148.73	15	237	0.19	0.17	1.26	1.50	0.78	0.78
	10.56	148.73	20	242	0.20	0.18	1.26	1.51	0.79	0.79
	10.56	148.73	25	247	0.21	0.19	1.28	1.53	0.80	0.80
	10.56	148.73	30	252	0.22	0.20	1.29	1.54	0.81	0.81
9	11.88	167.32	0	252	0.22	0.20	1.32	1.58	0.83	0.83
	11.88	167.32	1	253	0.22	0.20	1.32	1.58	0.83	0.83
	11.88	167.32	2	254	0.22	0.21	1.32	1.58	0.83	0.83
	11.88	167.32	5	257	0.25	0.27	1.38	1.67	0.89	0.89
	11.88	167.32	10	262	0.29	0.30	1.41	1.70	0.93	0.93
	11.88	167.32	15	267	0.31	0.33	1.43	1.71	0.95	0.95
	11.88	167.32	20	272	0.33	0.35	1.44	1.76	0.97	0.97
	11.88	167.32	25	277	0.35	0.36	1.47	1.77	0.99	0.99
	11.88	167.32	30	282	0.36	0.37	1.48	1.79	1.00	1.00

表 3.1.1(3) 載荷試験結果（続き 減圧）

Stage	weighing scal reading	Loading pressure P=KR	time	elapsed time t	Displacement gauge 1/100mm				Average	settlement
	R	KN/m²		min	1	2	3	4	mm	mm
減圧	10.56	148.73	0	282	0.36	0.37	1.49	1.79	1.00	1.00
	10.56	148.73	5	287	0.36	0.37	1.48	1.79	1.00	1.00
	9.24	130.14	0	287	0.36	0.37	1.49	1.79	1.00	1.00
	9.24	130.14	5	292	0.36	0.37	1.49	1.79	1.00	1.00
	7.92	111.55	0	292	0.36	0.37	1.48	1.78	1.00	1.00
	7.92	111.55	5	297	0.36	0.37	1.48	1.78	1.00	1.00
	6.6	92.958	0	297	0.36	0.37	1.48	1.78	1.00	1.00
	6.6	92.958	5	302	0.36	0.37	1.48	1.78	1.00	1.00
	5.24	73.803	0	302	0.36	0.37	1.48	1.78	1.00	1.00
	5.24	73.803	5	307	0.36	0.37	1.48	1.78	1.00	1.00
	3.96	55.775	0	307	0.36	0.37	1.48	1.74	0.99	0.99
	3.96	55.775	5	312	0.36	0.37	1.48	1.74	0.99	0.99
	2.64	37.183	0	312	0.36	0.36	1.44	1.71	0.97	0.97
	2.64	37.183	5	317	0.35	0.35	1.43	1.70	0.96	0.96
	1.32	18.592	0	317	0.33	0.30	1.42	1.69	0.94	0.94
	1.32	18.592	5	322	0.33	0.30	1.42	1.68	0.93	0.93
	0	0	0	322	0.16	0.17	1.28	1.52	0.78	0.78
	0	0	5	327	0.13	0.14	1.25	1.48	0.75	0.75

3.2 Kokusai Substation

試験結果を表 3.2.1 に示す。

表 3.2. 1 (1) 載荷試験結果 (Kokusai Substation)

Location	Kokusai			X=		Y=			
No.	PLT MR-1			Depth	0.5m	Altitude	●m		
Date	7-Sep-21			Weather	cloudy	Tester Name			

Shape of the load plate	Circular steel plate	Diameter and thickness of the load plate	300mm	Area of the load plate	0.07065m²
Type of jack	Hydraulic jack	Capacity of jack	●KN	Type of reaction force device	
Loading method	Stepped loading (1 cycle)	Correction factor	KN/m²/scale		

Stage	Weingh scale reading	Loading pressure P=KR	time	elapsed time t	Displacement gauge 1/100mm				Average	settlement
	R	KN/m²		min	1	2	3	4	mm	mm
Preliminary loading	0	0	0	0	0.000	0.000	0.000	0.000	0.000	0.000
	0.9	12.739	1	1	0.000	0.000	0.020	0.020	0.010	0.010
	0.9	12.739	1	2	0.000	0.000	0.020	0.020	0.010	0.010
	0	0	1	3	0.000	0.000	0.020	0.020	0.010	0.010
	0	0	1	4	0.000	0.000	0.020	0.020	0.010	0.010
	0.9	12.739	1	5	0.000	0.000	0.025	0.030	0.014	0.014
	0.9	12.739	1	6	0.000	0.000	0.025	0.030	0.014	0.014
	0	0	1	7	0.000	0.000	0.030	0.040	0.018	0.018
	0	0	1	8	0.000	0.000	0.030	0.040	0.018	0.018
	0.9	12.739	1	9	0.000	0.000	0.035	0.045	0.020	0.020
	0.9	12.739	1	10	0.000	0.000	0.035	0.045	0.020	0.020
	0	0	1	11	0.000	0.000	0.035	0.045	0.020	0.020
	0	0	1	12	0.000	0.000	0.035	0.045	0.020	0.020
1	1.32	18.684	0	12	0.000	0.000	0.040	0.050	0.023	0.023
	1.32	18.684	1	13	0.000	0.010	0.060	0.080	0.038	0.038
	1.32	18.684	2	15	0.000	0.010	0.060	0.080	0.038	0.038
	1.32	18.684	5	20	0.090	0.000	0.015	0.080	0.046	0.046
	1.32	18.684	10	30	0.000	0.020	0.100	0.130	0.063	0.063
	1.32	18.684	15	45	0.000	0.030	0.100	0.140	0.068	0.068
	1.32	18.684	20	65	0.000	0.040	0.100	0.145	0.071	0.071
	1.32	18.684	25	90	0.000	0.040	0.120	0.160	0.080	0.080
	1.32	18.684	30	120	0.000	0.040	0.120	0.160	0.080	0.080
2	2.64	37.367	0	120	0.020	0.160	0.210	0.360	0.188	0.188
	2.64	37.367	1	121	0.020	0.170	0.210	0.360	0.190	0.190
	2.64	37.367	2	123	0.020	0.170	0.220	0.360	0.193	0.193
	2.64	37.367	5	128	0.055	0.230	0.265	0.425	0.244	0.244
	2.64	37.367	10	138	0.070	0.280	0.310	0.490	0.288	0.288
	2.64	37.367	15	153	0.080	0.290	0.320	0.520	0.303	0.303
	2.64	37.367	20	173	0.080	0.290	0.320	0.520	0.303	0.303
	2.64	37.367	25	198	0.085	0.300	0.320	0.520	0.306	0.306
	2.64	37.367	30	228	0.085	0.300	0.320	0.520	0.306	0.306
3	3.96	56.051	0	228	0.125	0.400	0.410	0.660	0.399	0.399
	3.96	56.051	1	229	0.125	0.400	0.410	0.660	0.399	0.399
	3.96	56.051	2	231	0.150	0.440	0.430	0.700	0.430	0.430
	3.96	56.051	5	236	0.165	0.470	0.450	0.730	0.454	0.454
	3.96	56.051	10	246	0.180	0.500	0.465	0.760	0.476	0.476
	3.96	56.051	15	261	0.190	0.520	0.490	0.790	0.498	0.498
	3.96	56.051	20	281	0.205	0.540	0.500	0.810	0.514	0.514
	3.96	56.051	25	306	0.210	0.550	0.500	0.810	0.518	0.518
	3.96	56.051	30	336	0.210	0.550	0.515	0.830	0.526	0.526
4	5.24	74.168	0	336	0.320	0.720	0.660	1.020	0.680	0.680
	5.24	74.168	1	337	0.345	0.760	0.680	1.050	0.709	0.709
	5.24	74.168	2	339	0.370	0.780	0.700	1.070	0.730	0.730
	5.24	74.168	5	344	0.385	0.800	0.705	1.095	0.746	0.746
	5.24	74.168	10	354	0.400	0.820	0.720	1.120	0.765	0.765
	5.24	74.168	15	369	0.410	0.840	0.745	1.140	0.784	0.784
	5.24	74.168	20	389	0.430	0.855	0.745	1.140	0.793	0.793
	5.24	74.168	25	414	0.440	0.875	0.770	1.170	0.814	0.814
	5.24	74.168	30	444	0.440	0.875	0.770	1.170	0.814	0.814

表 3.2.1(2) 載荷試験結果（続き）

Stage	weighing scal reading	Loading pressure P=KR	time	elapsed time t	Displacement gauge 1/100mm				Average	settlement
	R	KN/m²		min	1	2	3	4	mm	mm
5	6.6	93.418	0	444	0.480	0.920	0.820	1.230	0.863	0.863
	6.6	93.418	1	445	0.480	0.925	0.840	1.250	0.874	0.874
	6.6	93.418	2	447	0.480	0.935	0.850	1.270	0.884	0.884
	6.6	93.418	5	452	0.490	0.950	0.860	1.290	0.898	0.898
	6.6	93.418	10	462	0.510	0.980	0.880	1.315	0.921	0.921
	6.6	93.418	15	477	0.530	1.000	0.900	1.340	0.943	0.943
	6.6	93.418	20	497	0.530	1.005	0.900	1.340	0.944	0.944
	6.6	93.418	25	522	0.540	1.020	0.900	1.355	0.954	0.954
	6.6	93.418	30	552	0.560	1.040	0.910	1.355	0.966	0.966
6	7.92	112.1	0	552	0.590	1.100	0.960	1.430	1.020	1.020
	7.92	112.1	1	553	0.620	1.120	0.980	1.460	1.045	1.045
	7.92	112.1	2	555	0.635	1.155	1.005	1.490	1.071	1.071
	7.92	112.1	5	560	0.645	1.170	1.020	1.505	1.085	1.085
	7.92	112.1	10	570	0.665	1.195	1.030	1.520	1.103	1.103
	7.92	112.1	15	585	0.685	1.220	1.050	1.550	1.126	1.126
	7.92	112.1	20	605	0.700	1.250	1.060	1.560	1.143	1.143
	7.92	112.1	25	630	0.710	1.260	1.080	1.590	1.160	1.160
	7.92	112.1	30	660	0.710	1.260	1.080	1.590	1.160	1.160
7	9.24	130.79	0	660	0.750	1.310	1.110	1.630	1.200	1.200
	9.24	130.79	1	661	0.760	1.320	1.120	1.640	1.210	1.210
	9.24	130.79	2	663	0.780	1.380	1.155	1.690	1.251	1.251
	9.24	130.79	5	668	0.800	1.380	1.155	1.690	1.256	1.256
	9.24	130.79	10	678	0.815	1.400	1.180	1.715	1.278	1.278
	9.24	130.79	15	693	0.840	1.420	1.190	1.740	1.298	1.298
	9.24	130.79	20	713	0.850	1.435	1.190	1.740	1.304	1.304
	9.24	130.79	25	738	0.865	1.450	1.200	1.760	1.319	1.319
	9.24	130.79	30	768	0.865	1.450	1.210	1.765	1.323	1.323
8	10.56	149.47	0	768	0.900	1.510	1.260	1.810	1.370	1.370
	10.56	149.47	1	769	0.960	1.550	1.270	1.840	1.405	1.405
	10.56	149.47	2	771	0.970	1.585	1.310	1.880	1.436	1.436
	10.56	149.47	5	776	1.000	1.625	1.320	1.910	1.464	1.464
	10.56	149.47	10	786	1.020	1.640	1.340	1.920	1.480	1.480
	10.56	149.47	15	801	1.020	1.640	1.345	1.930	1.484	1.484
	10.56	149.47	20	821	1.085	1.710	1.360	1.960	1.529	1.529
	10.56	149.47	25	846	1.090	1.720	1.350	1.970	1.533	1.533
	10.56	149.47	30	876	1.090	1.720	1.370	1.970	1.538	1.538
9	11.88	168.15	0	876	1.110	1.750	1.390	1.900	1.538	1.538
	11.88	168.15	1	877	1.110	1.755	1.400	2.000	1.566	1.566
	11.88	168.15	2	879	1.130	1.755	1.400	2.015	1.575	1.575
	11.88	168.15	5	884	1.150	1.800	1.420	2.040	1.603	1.603
	11.88	168.15	10	894	1.170	1.830	1.430	2.060	1.623	1.623
	11.88	168.15	15	909	1.180	1.840	1.455	2.085	1.640	1.640
	11.88	168.15	20	929	1.195	1.860	1.460	2.095	1.653	1.653
	11.88	168.15	25	954	1.210	1.880	1.485	2.120	1.674	1.674
	11.88	168.15	30	984	1.215	1.900	1.490	2.130	1.684	1.684

表 3.2.1(3) 載荷試験結果（続き 減圧時）

Stage	weighing scal reading	Loading pressure P=KR	time	elapsed time t	Displacement gauge 1/100mm				Average	settlement
	R	KN/m²		min	1	2	3	4	mm	mm
減圧	10.56	149.47	0	984	1.210	1.900	1.490	2.130	1.683	1.683
	10.56	149.47	5	989	1.210	1.900	1.490	2.130	1.683	1.683
	9.24	130.79	0	989	1.210	1.900	1.490	2.130	1.683	1.683
	9.24	130.79	5	994	1.210	1.900	1.490	2.130	1.683	1.683
	7.92	112.1	0	994	1.210	1.900	1.490	2.130	1.683	1.683
	7.92	112.1	5	999	1.210	1.900	1.490	2.130	1.683	1.683
	6.6	93.418	0	999	1.210	1.900	1.490	2.130	1.683	1.683
	6.6	93.418	5	1004	1.210	1.900	1.490	2.130	1.683	1.683
	5.24	74.168	0	1004	1.150	1.830	1.470	2.110	1.640	1.640
	5.24	74.168	5	1009	1.150	1.830	1.470	2.110	1.640	1.640
	3.96	56.051	0	1009	1.120	1.825	1.400	2.040	1.596	1.596
	3.96	56.051	5	1014	1.120	1.825	1.400	2.040	1.596	1.596
	2.64	37.367	0	1014	1.080	1.770	1.350	1.990	1.548	1.548
	2.64	37.367	5	1019	1.060	1.745	1.340	1.960	1.526	1.526
	1.32	18.684	0	1019	1.000	1.690	1.280	1.910	1.470	1.470
	1.32	18.684	5	1024	0.990	1.680	1.280	1.900	1.463	1.463
	0	0	0	1024	0.920	1.590	1.220	1.820	1.388	1.388
	0	0	5	1029	0.890	1.550	1.200	1.800	1.360	1.360

3.3 解析

(1) Mason Rock Substation

時間-沈下量曲線を図 3.3.1 に、荷重-沈下曲線を図 3.3.2 に示す。

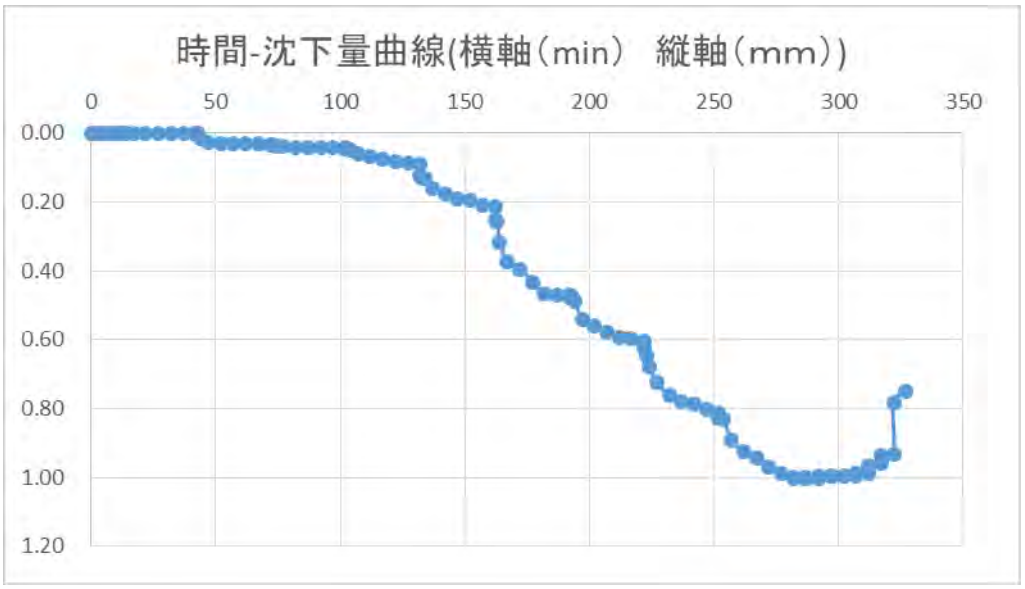


図 3.3.1 時間-沈下量曲線

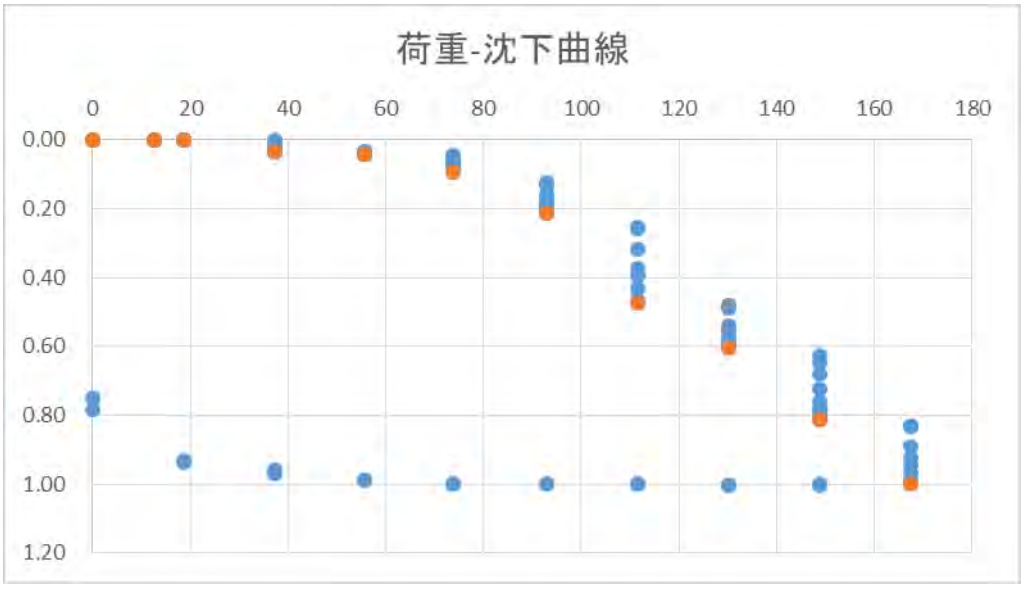


図 3.3.2 荷重-沈下量曲線

(1)-1 変形係数

E＝Is・B・(1－γ²) ×・ΔP／ΔS

Is=	0.79	
B =	0.3	
r =	0.3	
ΔP／ΔS=	218724.1	
E=	20,366	KN/m2

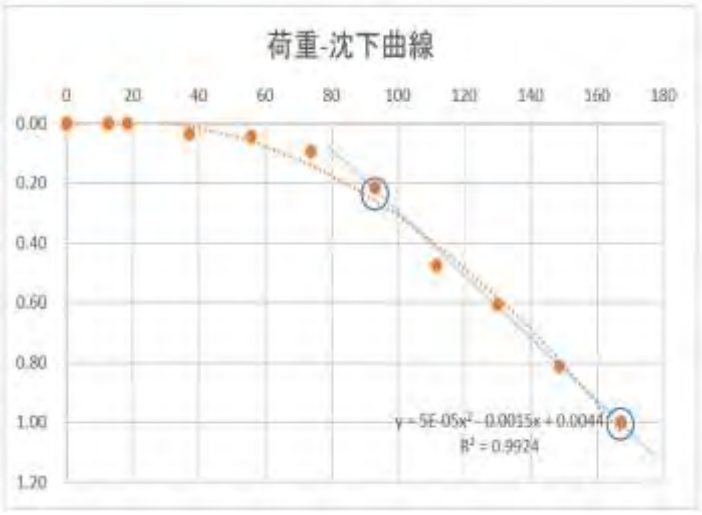
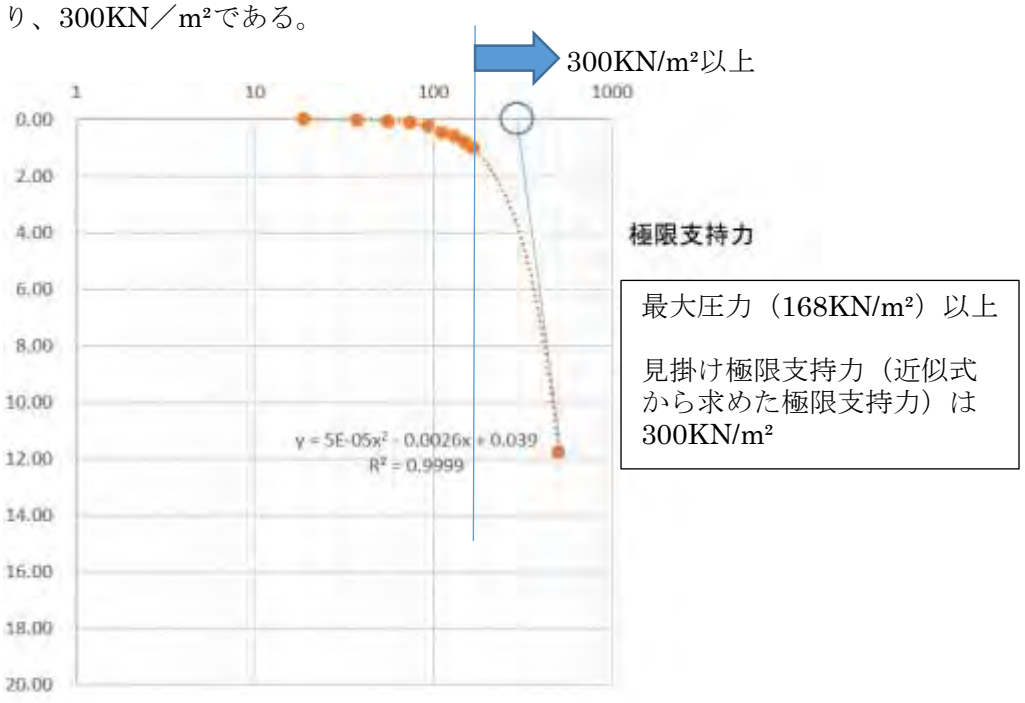


図 3.3.3　変形係数算出の数値選定
（極限支持力値よりも小さい値で、
やや安全側の数値を採用）

(1)-2 極限支持力

図 2.3.8 より、300KN／m²である。



最大圧力（168KN/m²）以上

見掛け極限支持力（近似式から求めた極限支持力）は 300KN/m²

(1)-3　試験間の相関

各係数を表 3.3.1 に示す。

・変形係数 20,360KN/m²は N 値で 30 程度（図 3.3.5 参照）であり、変形係数と N 値はほぼ調和的である

・極限支持力 300KN/m²は N 値で 10～30 程度（表 3.3.2 参照）であり、極限支持力と N 値はほぼ調和的である。

以上から、概ね相関がとれていることを確認した。

表 3.3.1　Mason Rock（採石場跡地）

地質	換算 N 値	E（変形係数）	極限支持力
石灰岩の砕石盛土	平均的な N 値は 20 程度	20,366KN／m²	300KN／m²

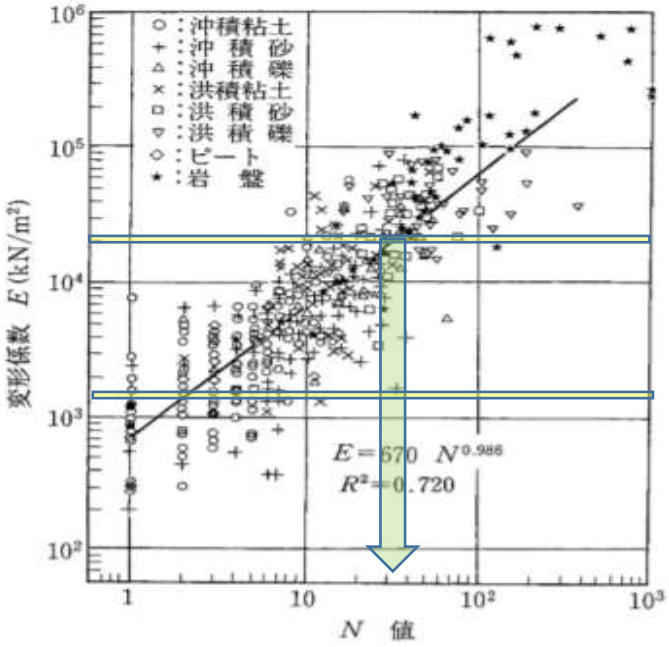


図 3.3.5　変形係数と N 値の関係　（変形係数に相当する N 値は 30 程度）

表 3.3.2 極限支持力と N 値の関係（極限支持力に対応する N 値は 10～30）

	N値	極限支持力	地盤の状態	現場判定法
砂質土	0～5	0kN/m²～100kN/m²	非常にゆるい	φ13%鉄筋が手で容易に貫入する
	5～10	100kN/m²～200kN/m²	ゆるい	スコップで掘削出来る
	10～30	200kN/m²～750kN/m²	普通	φ13%鉄筋を切断ハンマーで容易に打込み可
	30～50	750kN/m²～1,300kN/m²	密な	同上で30cmくらい入る
	50以上	1,300kN/m²以上	非常に密な	同上で5～6cm、打込む時金属音を発す
粘土質	2以下	70kN/m²以下	非常に柔らかい	にぎりこぶしが10cmくらい容易に入る
	2～4	70kN/m²～140kN/m²	柔らかい	親指が10cmくらい容易に入る
	4～8	140kN/m²～280kN/m²	普通	中位の力で親指が10cmくらい入る
	8～15	280kN/m²～570kN/m²	堅い	親指でへこみ、貫入に力が入る
	15～30	570kN/m²～1,140kN/m²	非常に堅い	すきで除去できる
	30以上	1,440kN/m²	固結した	除去するのにつるはしを要す

（東京都交通局データー）

(2) Kokusai

時間-沈下量曲線を図 3.3.6 に、荷重-沈下曲線を図 3.3.7 に示す。

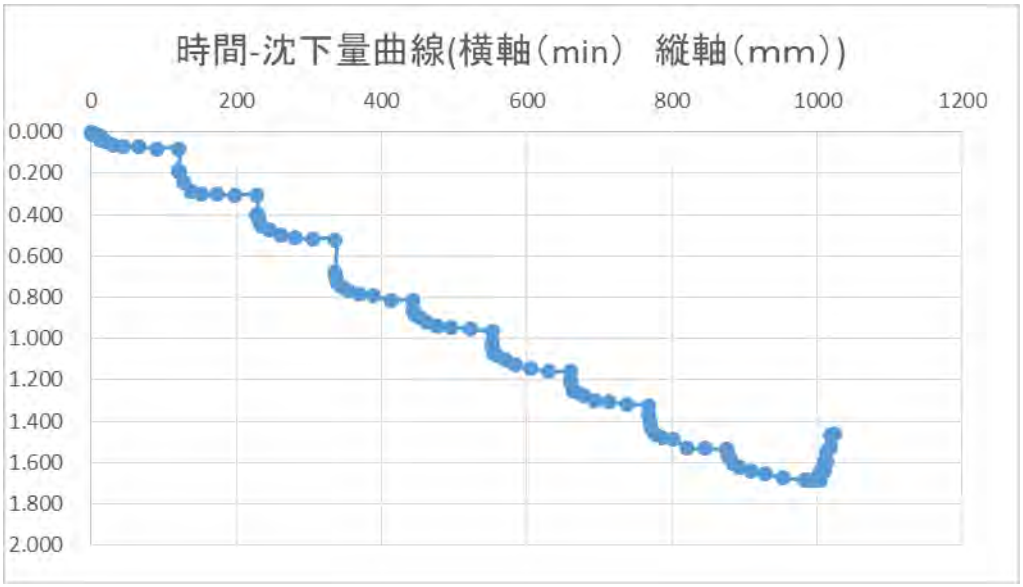


図 3.3.6 時間-沈下量曲線

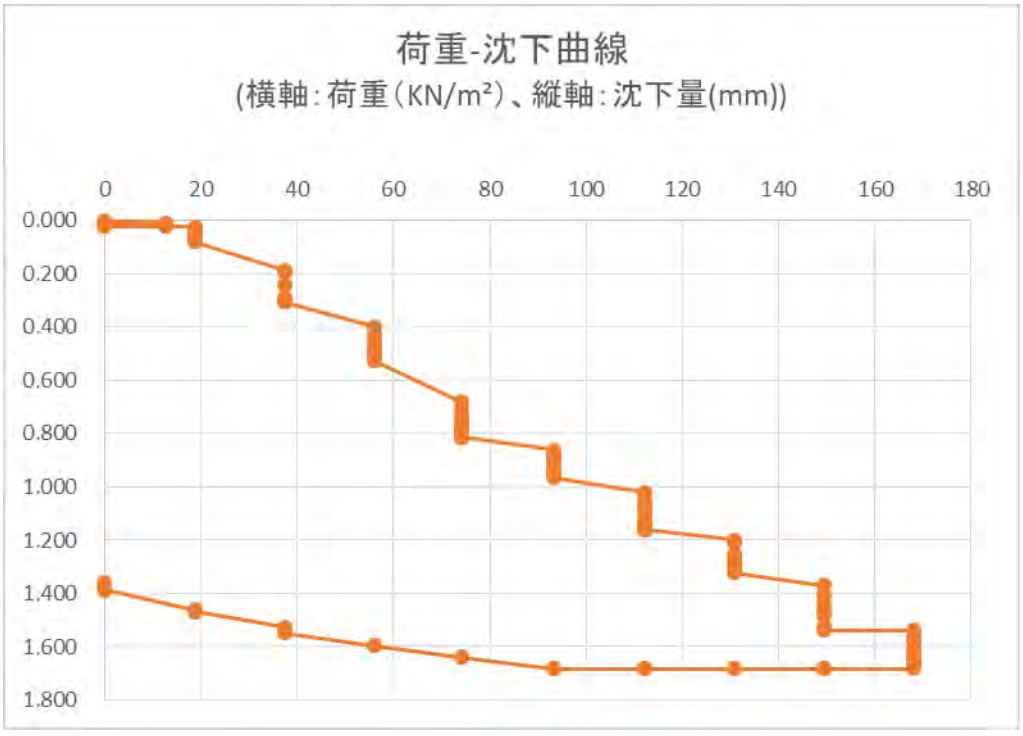


図 3.3.7 荷重-沈下量曲線

(2)-1 変形係数

E＝Is・B・(1－γ²) ×・ΔP／ΔS

Is=	0.79	
B =	0.3	
r =	0.3	
ΔP／ΔS=	83,736	
E=	18,059	kN/m2

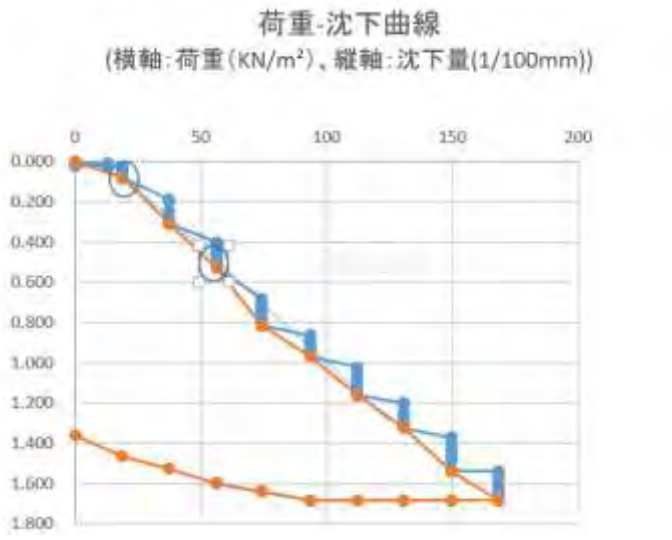


図 3. 3. 8 変形係数算出の数値選定

(2)-2 極限支持力

最大圧力は確認されない、168KN／m²以上である。

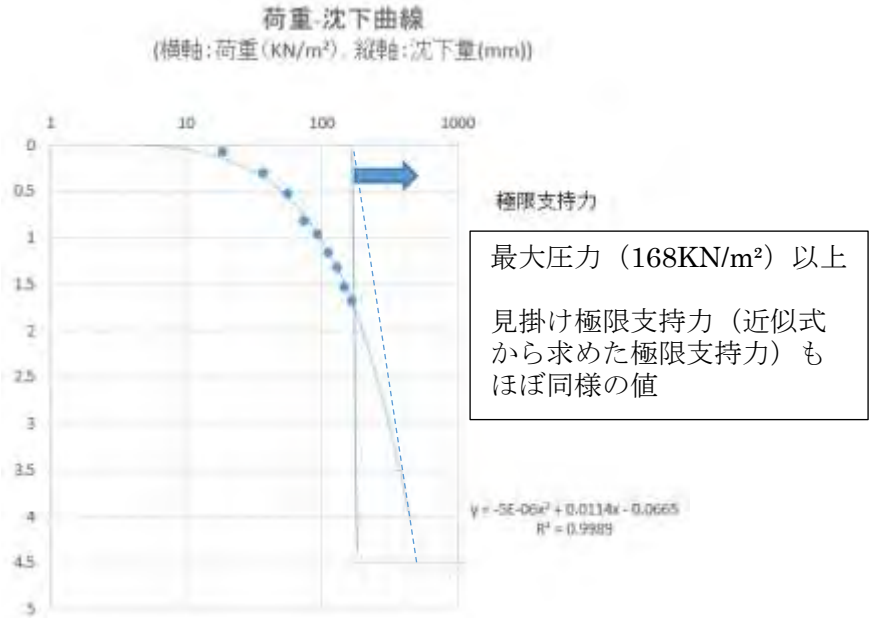


図 3.3.9 極限支持力値の選定

(2)-3 試験間の相関

各係数を表 3.3.3 に示し、相関性を以下に示す。

・極限支持力 168KN/m²は N 値では 4～8 に相当する（表 3.3.4 参照）。このため、試験結果は概ね相関が取れている。
・変形係数 18,059KN/m²は N 値 20 相当（図 3.3.13 の赤矢印参照）であり、調和的でない。変形係数は極限支持力や N 値相当（安全側）の 3,000KN/m²（図 3.3.13 の青矢印参照）を提案する。

表 3.3.3　コクサイ変電所

地質	換算 N 値	E（変形係数）	極限支持力
風化土壌を材料にした盛土	深度 1m 以浅は N 値は平均 4	・平板載荷試験結果は 18,059KN/m²。 ・N 値 4 は 3000KN/m²相当(図 3.3.10 参照)	168KN／m²以上

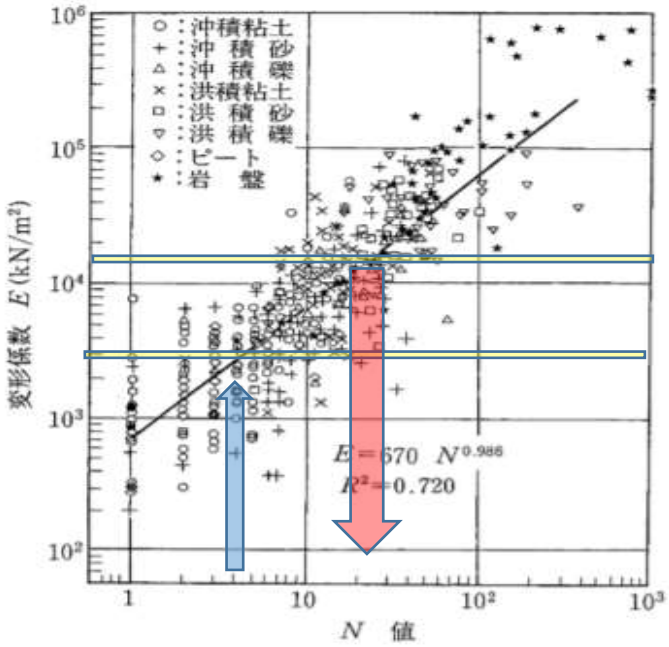


図 3.3.10　変形係数と N 値の関係　（変形係数に相当する N 値は 20～30）

表 3.3.4 極限支持力と N 値の関係（極限支持力に対応する N 値は 10～30）

	N値	極限支持力	粘土の状態	現場判定法
砂質土	0～5	0kN/m²～100kN/m²	非常にゆるい	φ13㎜鉄筋が手で容易に貫入する
	5～10	100kN/m²～200kN/m²	ゆるい	スコップで掘削出来る
	10～30	200kN/m²～750kN/m²	普通	φ13㎜鉄筋を木槌ハンマーで容易に打込み可
	30～50	750kN/m²～1,300kN/m²	密な	同上で30cmくらい入る
	50以上	1,300kN/m²以上	非常に密な	同上で5～6cm、打込む時金属音を発す
粘土質	2以下	70kN/m²以下	非常に柔らかい	にぎりこぶしが10cmくらい容易に入る
	2～4	70kN/m²～140kN/m²	柔らかい	親指が10cmくらい容易に入る
	4～8	140kN/m²～280kN/m²	普通	中位の力で親指が10cmくらい入る
	8～15	280kN/m²～570kN/m²	堅い	親指でへこみ、貫入に力が入る
	15～30	570kN/m²～1,140kN/m²	非常に堅い	すきで除去できる
	30以上	1,440kN/m²	固結した	除去するのにつるはしを要す

（東京都交通局データー）

APPENDIX-1

SWS-test

at

MARACAL SUBSTATION

KOKUSAI SUBSTATION

MASON ROCK SUBSTATION

SWS Test								Date sheet		
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU									
Location	Malakal Substation			X=	7.335026	Y=	134.452995	7.335026,134.452995		
No.	M-1			Depth	0.7m-1.6m			YACHIYO ENGINEERING CO., LTD		
Date	31-Aug-21	13:00～		Wether:	Sunny					

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
0				0.7						
1	5	0.04905	0	0.7	0		1	0.1	1.5	Sand and gravel
2	15	0.14715	0	0.7	0		1	0.3	4.4	Sand and gravel
3	25	0.24525	0	0.7	0		1	0.5	7.4	Sand and gravel
4	50	0.4905	0	0.7	0		1	1.0	14.7	Sand and gravel
5	75	0.73575	0	0.7	0		1	1.5	22.1	Sand and gravel
6	100	0.981	0	0.8	10	0	1	2.0	29.4	Sand and gravel
7	100	0.981	7	1.05	25	28	1	3.8	46.2	Sand and gravel
8	100	0.981	3	1.3	25	12	1	2.8	36.6	Sand and gravel
9	100	0.981	5	1.55	25	20	1	3.3	41.4	Sand and gravel
10	100	0.981	50	1.6	5	1000	1	69.0	629.4	Boulder or bedrock

≪Calculation formula≫

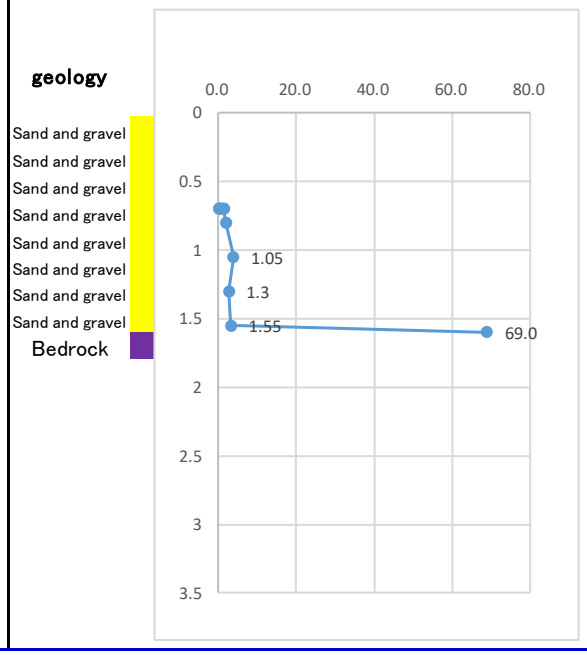
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Malakal Substation			X=	7.335054	Y=	134.453022	7.335054,134.453022	
No.	M-2			Depth	0.25m-0.75m			YACHIYO ENGINEERING CO., LTD	
Date	31-Aug-21	13:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
				0.25						
1	5	0.04905	0	0.29	0		1	0.1	1.5	Sand and gravel
2	15	0.14715	0	0.29	0		1	0.3	4.4	Sand and gravel
3	25	0.24525	0	0.29	0		1	0.5	7.4	Sand and gravel
4	50	0.4905	0	0.29	0		1	1.0	14.7	Sand and gravel
5	75	0.73575	0	0.29	0		1	1.5	22.1	Sand and gravel
6	100	0.981	0	0.45	16	0	1	2.0	29.4	Sand and gravel
7	100	0.981	21	0.7	25	84	1	7.6	79.8	Sand and gravel
8	100	0.981	50	0.75	5	1000	1	69.0	629.4	Boulder or bedrock

≪Calculation formula≫

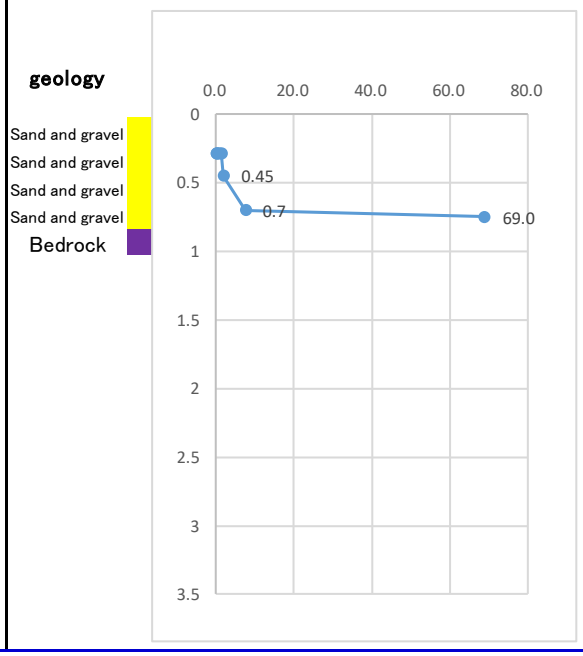
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Malakal Substation			X=	7.335019	Y=	134.453061	7.335019,134.453061	
No.	M-3			Depth		0.6m-3.0m		YACHIYO ENGINEERING CO., LTD	
Date	31-Aug-21	13:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0			0.6						Sand and gravel
1	5	0.04905		0.7	10	0	1	0.1	1.5	Sand and gravel
2	15	0.14715		0.7			1	0.3	4.4	Sand and gravel
3	25	0.24525		0.7			1	0.5	7.4	Sand and gravel
4	50	0.4905		0.7			1	1.0	14.7	Sand and gravel
5	75	0.73575		0.7			1	1.5	22.1	Sand and gravel
6	100	0.981		0.7			1	2.0	29.4	Sand and gravel
7	100	0.981	7	0.95	25	28	1	3.8	46.2	Sand and gravel
8	100	0.981	25	1.2	25	100	1	8.7	89.4	Sand and gravel
9	100	0.981	13	1.45	25	52	1	5.4	60.6	Sand and gravel
10	100	0.981	26	1.7	25	104	1	8.9	91.8	Sand and gravel
11	100	0.981	19	1.95	25	76	1	7.1	75.0	Sand and gravel
12	100	0.981	48	2.2	25	192	1	14.8	144.6	Sand and gravel
13	100	0.981	16	2.45	25	64	1	6.3	67.8	Sand and gravel
14	100	0.981	22	2.7	25	88	1	7.9	82.2	Sand and gravel
15	100	0.981	10.5	2.95	25	42	1	4.8	54.6	Sand and gravel
16	100	0.981	50	3	5	1000	1	69.0	629.4	Boulder or bedrock

≪Calculation formula≫

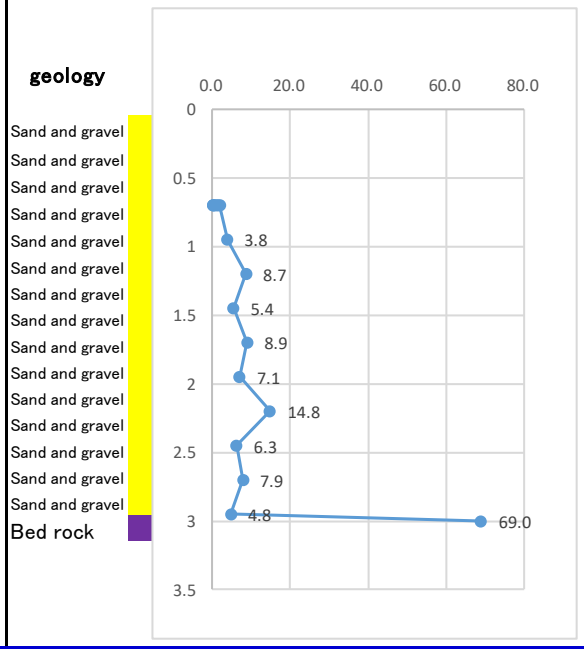
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test									Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU									
Location	Kokusai Susstation			X=	7.458124	Y=	134.528557	7.458124,134.528557		
No.	K-1			Depth	0m-6.93m			YACHIYO ENGINEERING CO., LTD		
Date	3-Sep-21	13:00～		Wether:	Sunny					

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Silty sand with gravel
1	5	0.04905		0.015	1.5	0	2	0.1	1.5	Silty sand with gravel
2	15	0.14715		0.025	1	0	2	0.4	4.4	Silty sand with gravel
3	25	0.24525		0.035	1	0	2	0.7	7.4	Silty sand with gravel
4	50	0.4905		0.06	2.5	0	2	1.5	14.7	Silty sand with gravel
5	75	0.73575		0.075	1.5	0	2	2.2	22.1	Silty sand with gravel
6	100	0.981	0	0.08	0.5	0	2	2.9	29.4	Silty sand with gravel
7	100	0.981	16	0.33	25	64	2	6.1	67.8	Silty sand with gravel
8	100	0.981	12	0.58	25	48	2	5.3	58.2	Silty sand with gravel
9	100	0.981	7.5	0.83	25	30	2	4.4	47.4	Silty sand with gravel
10	100	0.981	4.5	1.08	25	18	2	3.8	40.2	Silty sand with gravel
11	100	0.981	0	1.33	25	0	2	2.9	29.4	Self-sinking
12	100	0.981	0	1.58	25	0	2	2.9	29.4	Self-sinking
13	100	0.981	0	1.83	25	0	2	2.9	29.4	Self-sinking
14	100	0.981	0	2.08	25	0	2	2.9	29.4	Self-sinking
15	100	0.981	0	2.33	25	0	2	2.9	29.4	Self-sinking
16	100	0.981	0	2.58	25	0	2	2.9	29.4	Self-sinking
17	100	0.981	0	2.75	17	0	2	2.9	29.4	Self-sinking
18	100	0.981	4.5	3	25	18	2	3.8	40.2	Silty sand with gravel
19	100	0.981	5	3.25	25	20	2	3.9	41.4	Silty sand with gravel
20	100	0.981	7	3.5	25	28	2	4.3	46.2	Silty sand with gravel
21	100	0.981	4	3.75	25	16	2	3.7	39.0	Silty sand with gravel
22	100	0.981	7	4	25	28	2	4.3	46.2	Silty sand with gravel
23	100	0.981	8	4.25	25	32	2	4.5	48.6	Silty sand with gravel
24	100	0.981	6.5	4.5	25	26	2	4.2	45.0	Silty sand with gravel
25	100	0.981	5	4.75	25	20	2	3.9	41.4	Silty sand with gravel
26	100	0.981	3	5	25	12	2	3.5	36.6	Silty sand with gravel
27	100	0.981	4	5.25	25	16	2	3.7	39.0	Silty sand with gravel
28	100	0.981	6	5.5	25	24	2	4.1	43.8	Silty sand with gravel
29	100	0.981	9	5.75	25	36	2	4.7	51.0	Silty sand with gravel
30	100	0.981	12	6	25	48	2	5.3	58.2	Silty sand with gravel
31	100	0.981	16	6.25	25	64	2	6.1	67.8	Silty sand with gravel
32	100	0.981	21	6.5	25	84	2	7.1	79.8	Silty sand with gravel
33	100	0.981	44	6.75	25	176	2	11.7	135.0	Silty sand with gravel
34	100	0.981	50	6.93	18	278	1	20.6	196.1	Bouling

≪Calculation formula≫

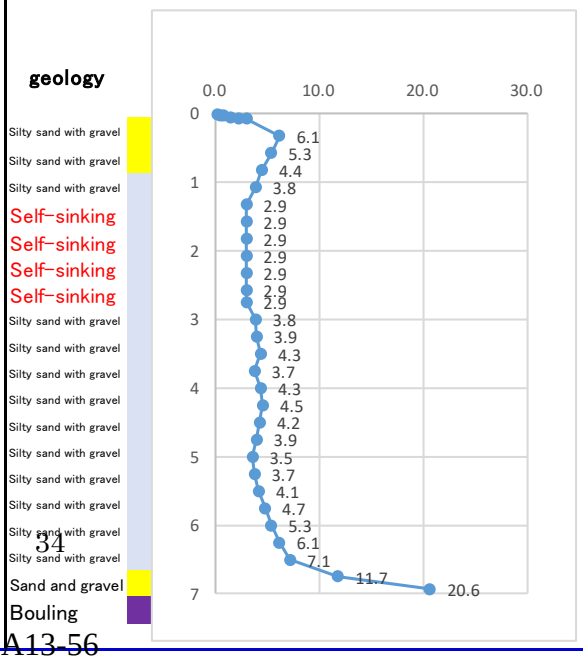
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Kokusai			X=	7.458105	Y=	134.528699	7.458105,134.528699	
No.	K-2			Depth		0m-5.25m		YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	13:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Silty sand with gravel
1	5	0.04905		0.02	2		2	0.1	1.5	Silty sand with gravel
2	15	0.14715		0.03	1		2	0.4	4.4	Silty sand with gravel
3	25	0.24525		0.035	0.5		2	0.7	7.4	Silty sand with gravel
4	50	0.4905		0.05	1.5		2	1.5	14.7	Silty sand with gravel
5	75	0.73575		0.06	1		2	2.2	22.1	Silty sand with gravel
6	100	0.981		0.1	4		2	2.9	29.4	Silty sand with gravel
7	100	0.981	15	0.35	25	60	2	5.9	65.4	Silty sand with gravel
8	100	0.981	5	0.6	25	20	2	3.9	41.4	Silty sand with gravel
9	100	0.981	2.5	0.85	25	10	2	3.4	35.4	Silty sand with gravel
10	100	0.981	2.5	1.1	25	10	2	3.4	35.4	Silty sand with gravel
11	100	0.981	0	1.35	25	0	2	2.9	29.4	self-sinking
12	100	0.981	0	1.6	25	0	2	2.9	29.4	self-sinking
13	100	0.981	0	1.85	25	0	2	2.9	29.4	self-sinking
14	100	0.981	0	2.1	25	0	2	2.9	29.4	self-sinking
15	100	0.981	0	2.35	25	0	2	2.9	29.4	self-sinking
16	100	0.981	0	2.6	25	0	2	2.9	29.4	self-sinking
17	100	0.981	0	2.85	25	0	2	2.9	29.4	self-sinking
18	100	0.981	0	3.1	25	0	2	2.9	29.4	self-sinking
19	100	0.981	0	3.35	25	0	2	2.9	29.4	self-sinking
20	100	0.981	0	3.52	17	0	2	4.3	29.4	self-sinking
21	100	0.981	7	3.77	25	28	2	4.5	46.2	Silty sand with gravel
22	100	0.981	8	4.03	26	31	2	4.5	47.9	Silty sand with gravel
23	100	0.981	9	4.27	24	38	2	4.8	51.9	Silty sand with gravel
24	100	0.981	23	4.52	25	92	2	7.5	84.6	Silty sand with gravel
25	100	0.981	28	4.77	25	112	2	8.5	96.6	Silty sand with gravel
26	100	0.981	46	5.02	25	184	2	12.1	139.8	Silty sand with gravel
27	100	0.981	50	5.25	23	217	1	16.5	159.9	Bouling

≪Calculation formula≫

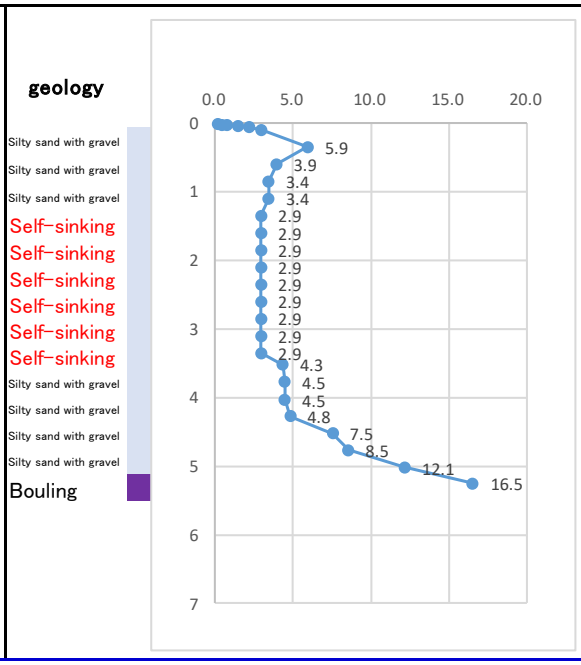
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Kokusai Substation			X=	7.458119	Y=	134.526512	7.458119,134.526512	
No.	K-3			Depth	0m-1.82 m			YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	13:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Silty sand with gravel
1	5	0.04905	0	0	0		2	0.1	1.5	Silty sand with gravel
2	15	0.14715	0	0.02	2		2	0.4	4.4	Silty sand with gravel
3	25	0.24525	0	0.05	3		2	0.7	7.4	Silty sand with gravel
4	50	0.4905	0	0.055	0.5		2	1.5	14.7	Silty sand with gravel
5	75	0.73575	0	0.07	1.5		2	2.2	22.1	Silty sand with gravel
6	100	0.981	0	0.07	0		2	2.9	29.4	Silty sand with gravel
7	100	0.981	16	0.32	25	64	2	6.1	67.8	Silty sand with gravel
8	100	0.981	12	0.57	25	48	2	5.3	58.2	Silty sand with gravel
9	100	0.981	7.5	0.82	25	30	2	4.4	47.4	Silty sand with gravel
10	100	0.981	0	1.07	25	0	2	2.9	29.4	Self-sinking
11	100	0.981	0	1.32	25	0	2	2.9	29.4	Self-sinking
12	100	0.981	0	1.57	25	0	2	2.9	29.4	Self-sinking
13	100	0.981	0	1.82	25	0	2	2.9	29.4	Self-sinking

≪Calculation formula≫

sandy or gravel **N= 2Wsw+0.067Nsw**

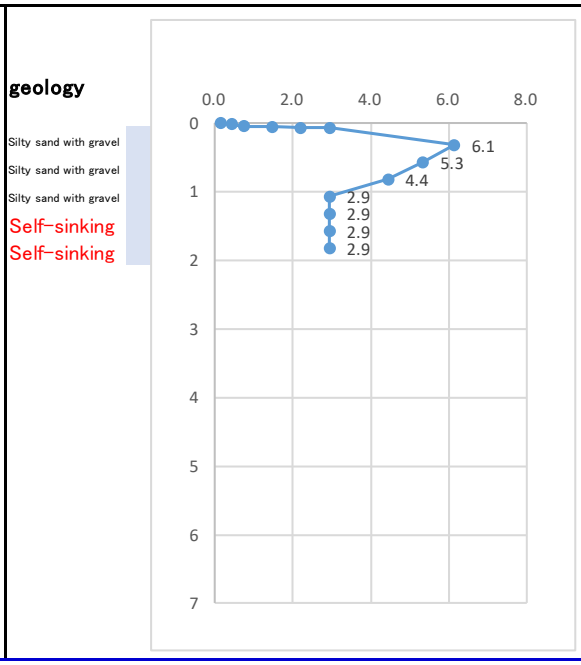
silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw

geology



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Kokusai Susstation			X=	7.458107	Y=	134.528476	7.458107,134.528476	
No.	K-4			Depth	0m-1.855m			YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	13:00～		Wether:	Sunny				

No.	Planned load **Wsw** Kg	Loading pressure **Wsw** Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									
1	5	0.04905	0	0	0		2	0.1	1.5	Silty sand with gravel
2	15	0.14715	0	0.005	0.5		2	0.4	4.4	Silty sand with gravel
3	25	0.24525	0	0.01	0.5		2	0.7	7.4	Silty sand with gravel
4	50	0.4905	0	0.03	2		2	1.5	14.7	Silty sand with gravel
5	75	0.73575	0	0.07	4		2	2.2	22.1	Silty sand with gravel
6	100	0.981	0	0.105	3.5		2	2.9	29.4	Silty sand with gravel
7	100	0.981	3.5	0.355	25	14	2	3.6	37.8	Silty sand with gravel
8	100	0.981	4	0.605	25	16	2	3.7	39.0	Silty sand with gravel
9	100	0.981	3	0.855	25	12	2	3.5	36.6	Silty sand with gravel
10	100	0.981	3	1.105	25	12	2	3.5	36.6	Silty sand with gravel
11	100	0.981	0	1.355	25	0	2	2.9	29.4	Self-sinking
12	100	0.981	0	1.605	25	0	2	2.9	29.4	Self-sinking
13	100	0.981	0	1.855	25	0	2	2.9	29.4	Self-sinking

≪Calculation formula≫

sandy or gravel **N= 2Wsw+0.067Nsw**

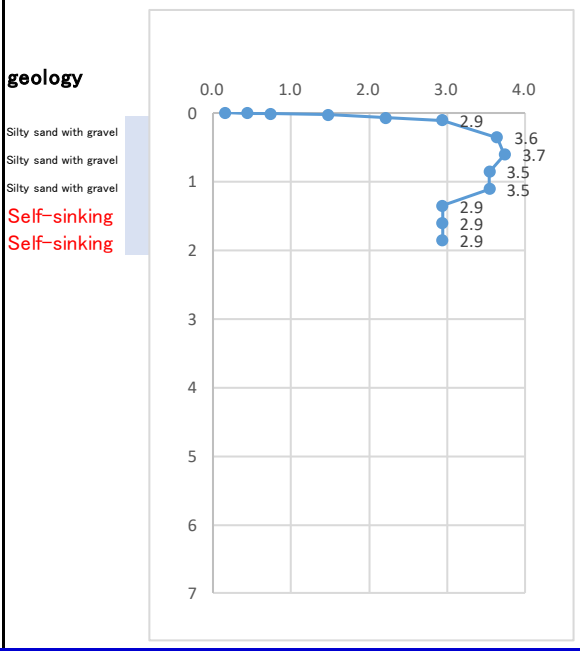
silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw

geology



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Kokusai Susstation			X=	7.458288	Y=	134.52658	7.458288,134.52658	
No.	K-5			Depth	0m-0.72m			YACHIYO ENGINEERING CO., LTD	
Date	21-Sep-21	14:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Silty sand with gravel
1	5	0.04905	0	0.04	4		2	0.1	1.5	Silty sand with gravel
2	15	0.14715	0	0.04	0		2	0.4	4.4	Silty sand with gravel
3	25	0.24525	0	0.04	0		2	0.7	7.4	Silty sand with gravel
4	50	0.4905	0	0.09	5		2	1.5	14.7	Silty sand with gravel
5	75	0.73575	0	0.15	6		2	2.2	22.1	Silty sand with gravel
6	100	0.981	0	0.215	6.5		2	2.9	29.4	Silty sand with gravel
7	100	0.981	33	0.465	25	132	2	9.5	108.6	Silty sand with gravel
8	100	0.981	50	0.715	25	200	2	12.9	149.4	Boulder

≪Calculation formula≫

sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

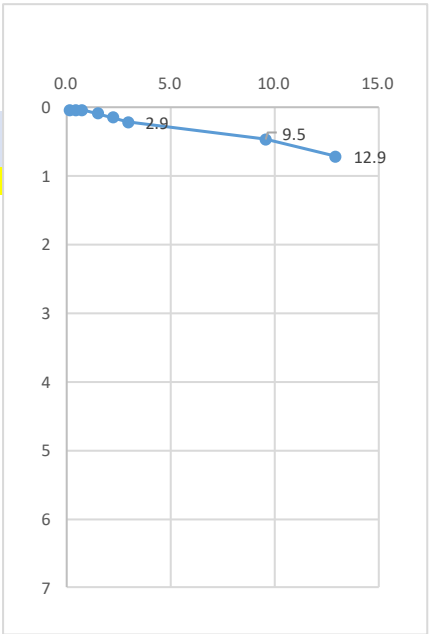
qa=30Wsw+0.6Nsw

geology

Silty sand with gravel

Silty sand with gravel

Boulder



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Kokusai Susstation			X=	7.45828	Y=	134.528547	7.45828,134.528547	
No.	K-6			Depth	0m-5.75m			YACHIYO ENGINEERING CO., LTD	
Date	21-Sep-21	14:00～		Wether:	Sunny				

No.	Planned load **Wsw** Kg	Loading pressure **Wsw** Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Silty sand with gravel
1	5	0.04905	0	0.015	1.5		2	0.1	1.5	Silty sand with gravel
2	15	0.14715	0	0.035	2		2	0.4	4.4	Silty sand with gravel
3	25	0.24525	0	0.035	0		2	0.7	7.4	Silty sand with gravel
4	50	0.4905	0	0.035	0		2	1.5	14.7	Silty sand with gravel
5	75	0.73575	0	0.035	0		2	2.2	22.1	Silty sand with gravel
6	100	0.981	0	0.125	9		2	2.9	29.4	Silty sand with gravel
7	100	0.981	8	0.375	25	32	2	4.5	48.6	Silty sand with gravel
8	100	0.981	0	0.625	25	0	2	2.9	29.4	Self-sinking
9	100	0.981	0	0.81	18.5	0	2	2.9	29.4	Self-sinking
10	100	0.981	6	1.06	25	24	2	4.1	43.8	Silty sand with gravel
11	100	0.981	6	1.31	25	24	2	4.1	43.8	Silty sand with gravel
12	100	0.981	0	1.56	25	0	2	2.9	29.4	Self-sinking
13	100	0.981	0	1.75	19	0	2	2.9	29.4	Self-sinking
14	100	0.981	6	2	25	24	2	2.9	43.8	Silty sand with gravel
15	100	0.981	4.5	2.25	25	18	2	4.1	40.2	Silty sand with gravel
16	100	0.981	5	2.5	25	20	2	3.8	41.4	Silty sand with gravel
17	100	0.981	4	2.75	25	16	2	3.9	39.0	Silty sand with gravel
18	100	0.981	4.5	3	25	18	2	3.7	40.2	Silty sand with gravel
19	100	0.981	8	3.25	25	32	2	3.8	48.6	Silty sand with gravel
20	100	0.981	17	3.5	25	68	2	4.5	70.2	Silty sand with gravel
21	100	0.981	14	3.75	25	56	2	6.3	63.0	Silty sand with gravel
22	100	0.981	11	4	25	44	2	5.7	55.8	Silty sand with gravel
23	100	0.981	9	4.25	25	36	2	5.1	51.0	Silty sand with gravel
24	100	0.981	9	4.5	25	36	2	4.7	51.0	Silty sand with gravel
25	100	0.981	18	4.75	25	72	2	4.7	72.6	Silty sand with gravel
26	100	0.981	17	5	25	68	2	6.5	70.2	Silty sand with gravel
27	100	0.981	21	5.25	25	84	2	6.3	79.8	Silty sand with gravel
28	100	0.981	29	5.5	25	116	2	7.1	99.0	Silty sand with gravel
29	100	0.981	50	5.75	25	200	2	8.7	149.4	Silty sand with gravel

≪Calculation formula≫

sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw

geology

Silty sand with gravel
Self-sinking
Silty sand with gravel
Self-sinking
Self-sinking
Silty sand with gravel
Silty sand with gravel
Silty sand with gravel
Silty sand with gravel
Silty sand with gravel
Silty sand with gravel
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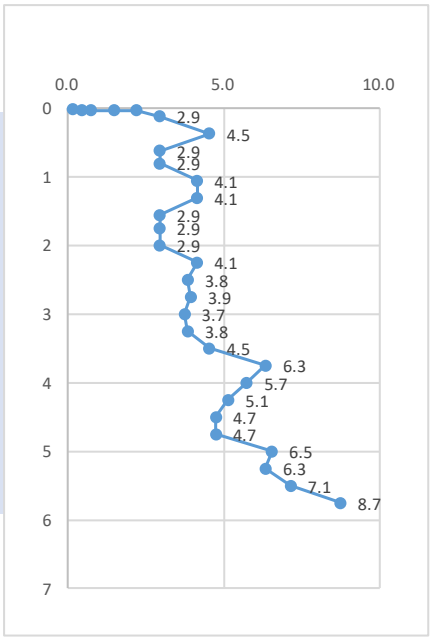
Silty sand with gravel
Silty sand with gravel



Swedish Weight Sounding test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Mason Rock Substation			X=	7.352875	Y=	134.498128	7.352875,134.498128	
No.	MR-1 (river)			Depth	0m-0.08m			YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	14:00～		Wether:	sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Silt-fine sand
1	5	0.04905		0.055	5.5	0	2	0.1	1.5	Silt-fine sand
2	15	0.14715		0.075	2	0	2	0.4	4.4	Silt-fine sand
3	25	0.24525		0.11	3.5	0	2	0.7	7.4	Silt-fine sand
4	50	0.4905		0.15	4	0	2	1.5	14.7	Silt-fine sand
5	75	0.73575		0.18	3	0	2	2.2	22.1	Silt-fine sand
6	100	0.981		1.29	111	0	2	2.9	29.4	self-sinking
7	100	0.981	38	1.54	25	152	1	12.1	120.6	Sandy
8	100	0.981	50	1.75	21	238	1	17.9	172.3	Boulder or Bedrock

≪Calculation formula≫

sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

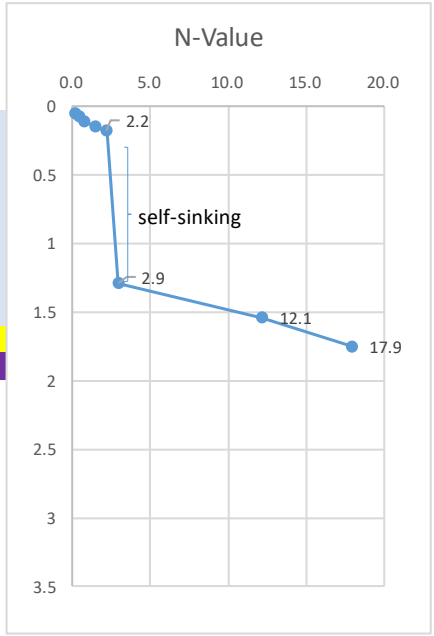
Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw

geology

Silt-fine sand
self-sinking
self-sinking
self-sinking
self-sinking
self-sinking
self-sinking
Silt-fine sand
Sandy
Boulder or bedrock



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Mason Rock Substation			X=	7.3528801	Y=	134.4982928	7.3528801,134.4982928	
No.	MR-2 Lower road surface			Depth	0m-0.175m			YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	14:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Sand and gravel
1	5	0.04905		0.05	5	0	1	0.1	1.5	Sand and gravel
2	15	0.14715		0.06	1	0	1	0.3	4.4	Sand and gravel
3	25	0.24525		0.065	0.5	0	1	0.5	7.4	Sand and gravel
4	50	0.4905		0.065	0		1	1.0	14.7	Sand and gravel
5	75	0.73575		0.065	0		1	1.5	22.1	Sand and gravel
6	100	0.981		0.065	0		1	2.0	29.4	Sand and gravel
7	100	0.981	50	0.175	11	455	1	32.4	302.2	Boulder or bedrock

≪Calculation formula≫

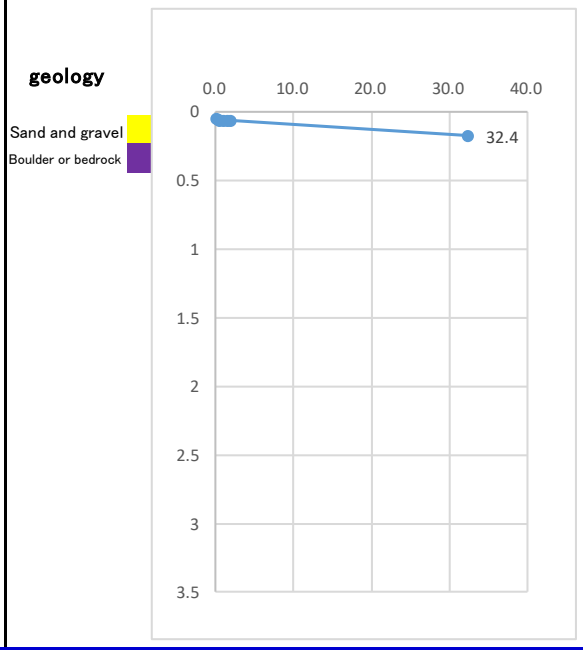
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Mason Rock Substation			X=	7.352765	Y=	134.498253	7.352765,134.498253	
No.	MR-2´ Lower road surface			Depth	0m-0.08m			YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	14:00～		Wether:	Sunny				

No.	Planned load **Wsw** Kg	Loading pressure **Wsw** Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Sand and gravel
1	5	0.04905		0.02	2	0	1	0.1	1.5	Sand and gravel
2	15	0.14715		0.02	0		1	0.3	4.4	Sand and gravel
3	25	0.24525		0.02	0		1	0.5	7.4	Sand and gravel
4	50	0.4905		0.02	0		1	1.0	14.7	Sand and gravel
5	75	0.73575		0.025	0.5	0	1	1.5	22.1	Sand and gravel
6	100	0.981		0.025	0		1	2.0	29.4	Sand and gravel
7	100	0.981	50	0.08	5.5	909	1	62.9	574.9	Boulder or Bedrock

≪Calculation formula≫

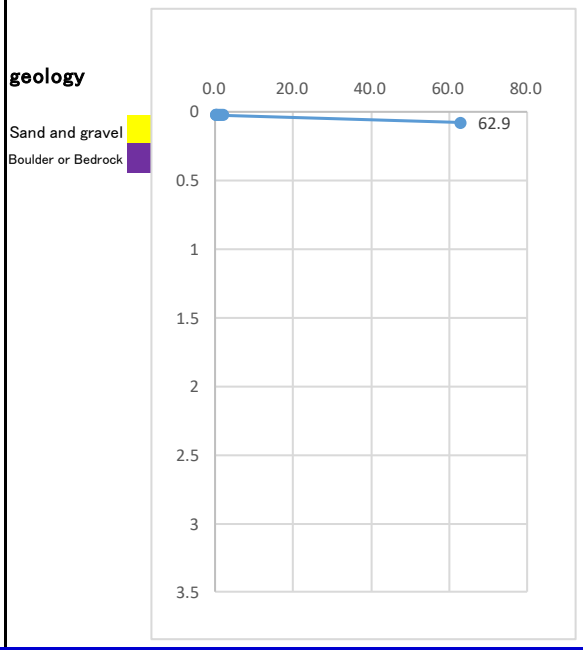
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Mason Rock Substation			X=	7.352934	Y=	134.498169	7.352934,134.498169	
No.	MR-2´´ Lower road surface			Depth	0m-0.08m			YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	14:00～		Wether:	Sunny				

No.	Planned load **Wsw** Kg	Loading pressure **Wsw** Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Sand and gravel
1	5	0.04905		0	0		1	0.1	1.5	Sand and gravel
2	15	0.14715		0.035	3.5	0	1	0.3	4.4	Sand and gravel
3	25	0.24525		0.035	0		1	0.5	7.4	Sand and gravel
4	50	0.4905		0.04	0.5	0	1	1.0	14.7	Sand and gravel
5	75	0.73575		0.04	0		1	1.5	22.1	Sand and gravel
6	100	0.981		0.04	0		1	2.0	29.4	Sand and gravel
7	100	0.981	50	0.06	2	2500	1	169.5	1529.4	Boulder or Bedrock

≪Calculation formula≫

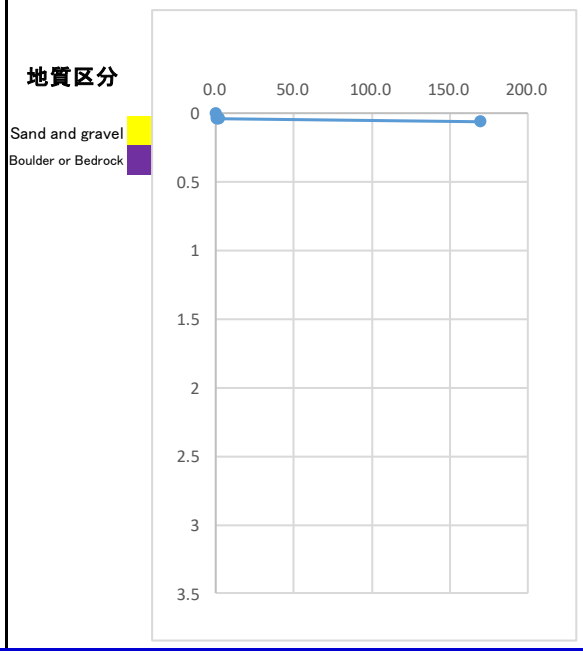
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Mason Rock Substation			X=	7.3528801	Y=	134.4982928	7.3528801,134.4982928	
No.	MR-3 Worksite Flat ground			Depth	0m-0.08m			YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	14:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Sand and gravel
1	5	0.04905	0	0	0		1	0.1	1.5	Sand and gravel
2	15	0.14715	0	0	0		1	0.3	4.4	Sand and gravel
3	25	0.24525	0	0	0		1	0.5	7.4	Sand and gravel
4	50	0.4905	0	0.02	2	0	1	1.0	14.7	Sand and gravel
5	75	0.73575	0	0.03	1	0	1	1.5	22.1	Sand and gravel
6	100	0.981	0	0.035	0.5	0	1	2.0	29.4	Sand and gravel
7	100	0.981	50	0.06	2.5	2000	1	136.0	1229.4	Boulder or Bedrock

≪Calculation formula≫

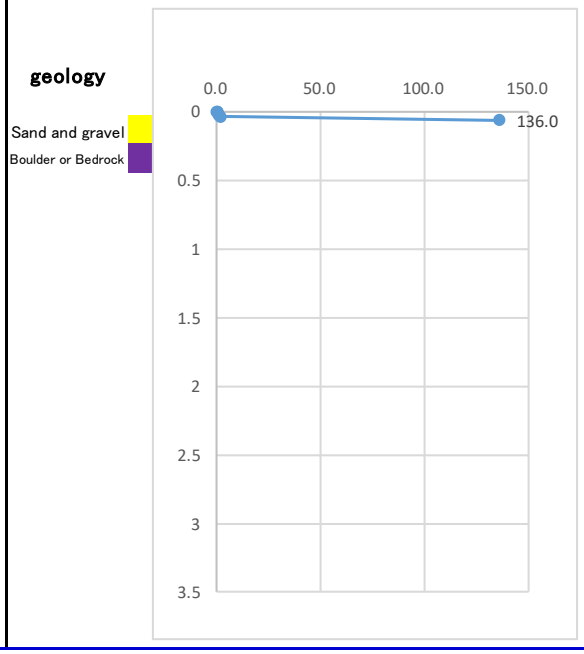
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Mason Rock Substation			X=	7.3528801	Y=	134.4982928	7.3528801,134.4982928	
No.	MR-3 Worksite Flat ground(d=0.5m)			Depth		0m-0.08m		YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	14:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Sand and gravel
1	5	0.04905	0	0.03	3		1	0.1	1.5	Sand and gravel
2	15	0.14715	0	0.035	0.5		1	0.3	4.4	Sand and gravel
3	25	0.24525	0	0.04	0.5		1	0.5	7.4	Sand and gravel
4	50	0.4905	0	0.045	0.5	0	1	1.0	14.7	Sand and gravel
5	75	0.73575	0	0.05	0.5	0	1	1.5	22.1	Sand and gravel
6	100	0.981	0	0.055	0.5	0	1	2.0	29.4	Sand and gravel
7	100	0.981	50	0.09	3.5	1429	1	97.7	886.6	Boulder or Bedrock

≪Calculation formula≫

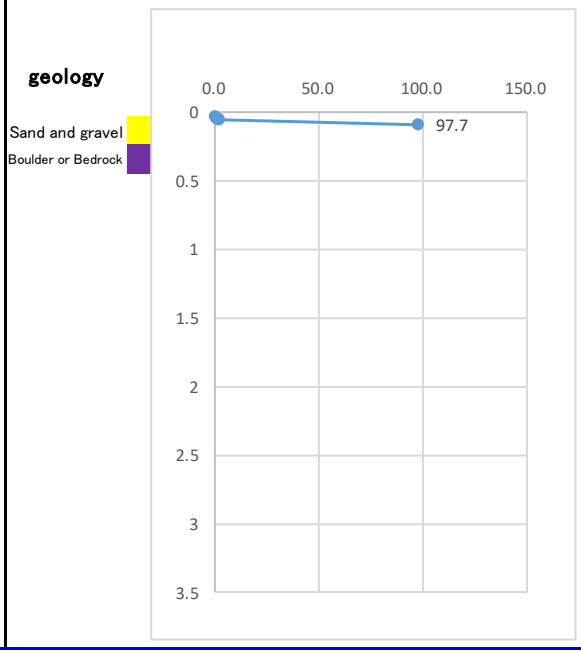
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Mason Rock Substation			X=	7.3528801	Y=	134.4982928	7.3528801,134.4982928	
No.	MR-3 Worksite Flat ground(d=1.0m)			Depth		0m-0.08m		YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	14:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Sand and gravel
1	5	0.04905	0	0.03	3	0	1	0.1	1.5	Sand and gravel
2	15	0.14715	0	0.031	0.1	0	1	0.3	4.4	Sand and gravel
3	25	0.24525	0	0.035	0.4	0	1	0.5	7.4	Sand and gravel
4	50	0.4905	0	0.05	1.5	0	1	1.0	14.7	Sand and gravel
5	75	0.73575	0	0.09	4	0	1	1.5	22.1	Sand and gravel
6	100	0.981	0	0.091	0.1	0	1	2.0	29.4	Sand and gravel
7	100	0.981	50	0.1	0.9	5556	1	374.2	3362.8	Boulder or Bedrock

≪Calculation formula≫

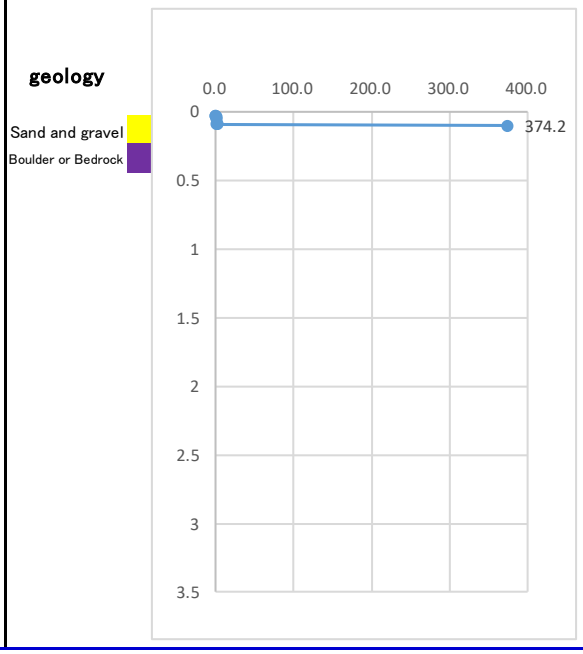
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Mason Rock Substation			X=	7.3528801	Y=	134.4982928	7.3528801,134.4982928	
No.	MR-3 Worksite Flat ground(d=1.5m)			Depth	0m-0.08m			YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	14:00～		Wether:	Sunny				

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
	0									Sand and gravel
1	5	0.04905	0	0.02	2	0	1	0.1	1.5	Sand and gravel
2	15	0.14715	0	0.025	0.5	0	1	0.3	4.4	Sand and gravel
3	25	0.24525	0	0.03	0.5	0	1	0.5	7.4	Sand and gravel
4	50	0.4905	0	0.035	0.5	0	1	1.0	14.7	Sand and gravel
5	75	0.73575	0	0.04	0.5	0	1	1.5	22.1	Sand and gravel
6	100	0.981	0	0.07	3	0	1	2.0	29.4	Sand and gravel
7	100	0.981	15	0.32	25	60	1	6.0	65.4	Sand and gravel
8	100	0.981	15	0.57	25	60	1	6.0	65.4	Sand and gravel
9	100	0.981	0	0.82	25	0	1	2.0	29.4	Sand and gravel
10	100	0.981	0	1.07	25	0	1	2.0	29.4	Sand and gravel
11	100	0.981	0	1.26	19	0	1	2.0	29.4	Sand and gravel
12	100	0.981	9	1.51	25	36	1	4.4	51.0	Sand and gravel
13	100	0.981	23	1.76	25	92	1	8.1	84.6	Sand and gravel
14	100	0.981	7.5	2.01	25	30	1	4.0	47.4	Sand and gravel
15	100	0.981	50	2.2	19	263	1	19.6	187.3	Boulde or Bedrock

≪Calculation formula≫

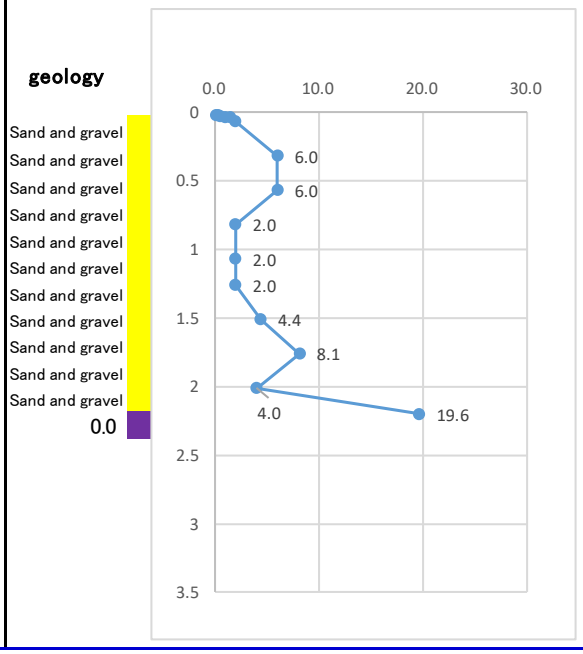
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



SWS Test								Date sheet	
Project Name	PREPARATETORY SURVEY ON THE PROJECT FOR UPGRADING POWER GRID IN THE REPUBLIC OF PALAU								
Location	Mason Rock Substation			X=	7.3528801	Y=	134.4982928	7.3528801,134.4982928	
No.	MR-Combined deta (0-3.7m)			Depth		0-3.7m		YACHIYO ENGINEERING CO., LTD	
Date	3-Sep-21	時刻:14時～		Wether:	Sunny	試験者:	飯島康夫		

No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Number of half-turns per 1m	Soil type 1:sandy/gravelly 2: clayey	N-Value	ultimate bearing capacity qa kN/m2	Geology
MR-3 (深度0mのデータ)	0									Sand and gravel
	5	0.04905	0	0	0		1	0.1	1.5	Sand and gravel
	15	0.14715	0	0	0		1	0.3	4.4	Sand and gravel
	25	0.24525	0	0	0		1	0.5	7.4	Sand and gravel
	50	0.4905	0	0.02	2	0	1	1.0	14.7	Sand and gravel
	75	0.73575	0	0.03	1	0	1	1.5	22.1	Sand and gravel
	100	0.981	0	0.035	0.5	0	1	2.0	29.4	Sand and gravel
	100	0.981	50	0.06	2.5	2000	1	136.0	1229.4	Sand and gravel
深度0.5mのデータ	100	0.981	50	0.59	3.5	1429	1	97.7	886.6	Sand and gravel
深度1mのデータ	100	0.981	50	1.1	0.9	5556	1	374.2	3362.8	Sand and gravel
深度1.5mのデータ	100	0.981	15	1.82	25	60	1	6.0	65.4	Sand and gravel
	100	0.981	15	2.07	25	60	1	6.0	65.4	Sand and gravel
	100	0.981	0	2.32	25	0	1	2.0	29.4	Self-sinking
	100	0.981	0	2.57	25	0	1	2.0	29.4	Self-sinking
	100	0.981	0	2.76	19	0	1	2.0	29.4	Self-sinking
	100	0.981	9	3.01	25	36	1	4.4	51.0	Sand and gravel
	100	0.981	23	3.26	25	92	1	8.1	84.6	Sand and gravel
	100	0.981	7.5	3.51	25	30	1	4.0	47.4	Sand and gravel
	100	0.981	50	3.7	19	263	1	19.6	187.3	Boulder or Bedrock

≪Calculation formula≫

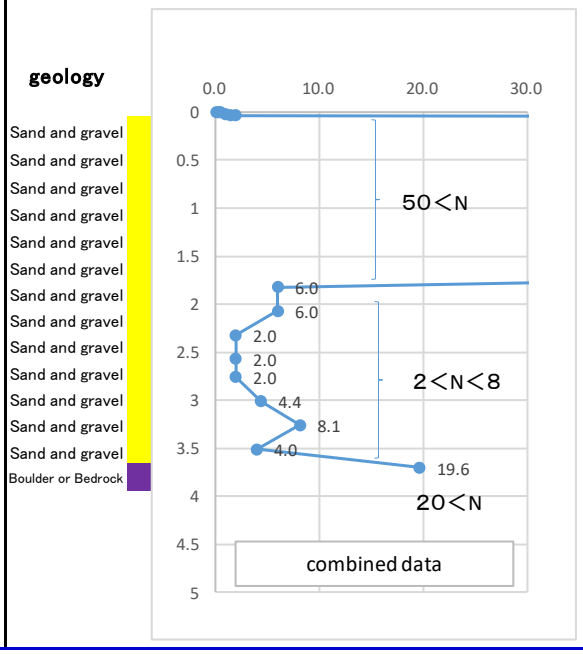
sandy or gravel **N= 2Wsw+0.067Nsw**

silty or clay N= 3Wsw+0.050Nsw

Wsw : loading weight (kN)

Nsw : Number of half-turns per 1m

qa=30Wsw+0.6Nsw



APPENDIX-2

Site Photograph

5. マラカル変電所:SWS 試験
6. コクサイ変電所：SWS 試験・平板載荷試験
7. コロール ロック変電所：SWS 試験・平板載荷試験・サンプリング
8. アイライ変電所：SWS 試験

1. マラカル変電所:SWS 試験

SWS-test M-3

SWS-test M-2

2. コクサイ変電所：SWS 試験・平板載荷試験

SWS-test　K-1

SWS-test　K-2

SWS-test　K-5

平板載荷試験

Digging of Test Pit

Protection from rain and wind

Setting measurement instrument

PLT　Measurement

2. コロール ロック変電所：SWS 試験・平板載荷試験・サンプリング

SWS-test at Mason Rock Substation　M-2

SWS-test at Mason Rock Substation　M-3(d=1.0m)

平板載荷試験：コロール ロック変電所　削孔と試験面の整形

表層から深度 50 ㎝までを掘削

試験面の整形
円が試験面

直径 30 ㎝の円盤とジャッキをセット

平板載荷試験

上部は反力となる重機。試験装置のセット完了

平板載荷試験　計測中

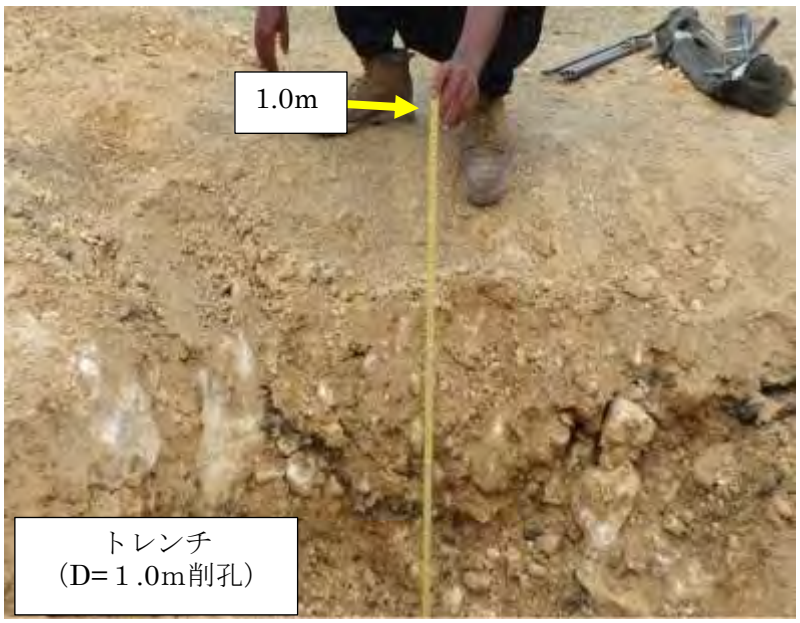
土壌硬度計による計測（新コロール）

６ kg/cm²（600KN／m²）複数回の平均値

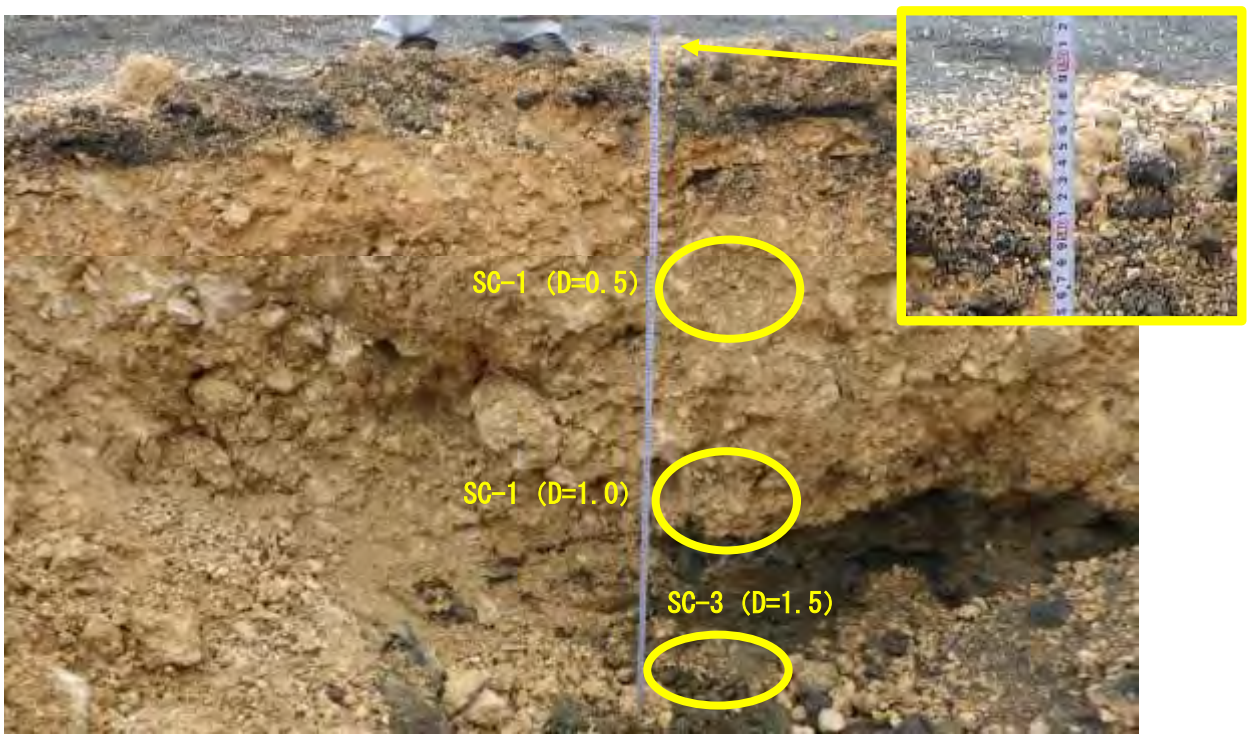
トレンチ調査

トレンチ掘削中

トレンチ掘削中(深度 1.5m)



トレンチとサンプリング位置



深度 1.5m 時の坑壁の状況　○はサンプリング地点

SC-3(D=1.5m)

SC-2(D=1.0m)

SC-1(D=0.5m)

サンプリング試料

SC-1:深度 0.5m 地点：石灰岩の砂礫盛土（砕石盛土の中央部　施設基礎部）

SC-2 深度 1.0m 地点：バックフィル直上の石灰岩礫砕石盛土（混在部）

SC-3 深度 1.5m 地点：黒色粘土まじり礫（バックフィル）

SC-R 水路になっている部分：灰色の細粒分混じり砂：含水比高く軟質

サンプリング状況

SC-1（深度 0.5m）

SC-2 （深度 1m）

SC-3（深度 1.5m）

SC-R（水路になっている部分）

サンプル一式

5. アイライ変電所：SWS 試験

SWS-test at Airai Substation

第４章　JP橋基礎調査

1 調査概要

JP橋は 2002 年に建設されたコロール島とバベルダオブ島を結ぶ全長 413 メートルのコンクリート製の橋で、日本とパラオの友好のシンボルでもあり、観光名所ともなっている。このJP橋に隣接する位置に送電線の鉄塔建設の計画があり、その可能性調査の一環として図 3.1.1に示す赤四角（破線）部分の地盤調査を実施したものである。調査は SWS 試験で、各州が許可した地点で実施した。

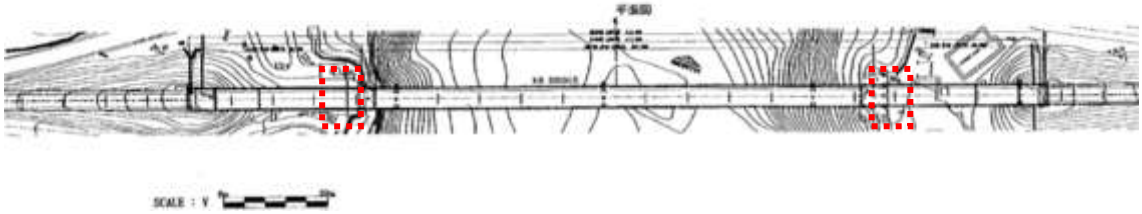


図 1.1.1 調査対象箇所

(1)　基礎岩盤の分布

調査に先立ち、地表踏査により基盤岩の分布状況を確認した。以下に結果を示す。

・コロール側の公園とその周辺：基礎岩盤の露出は確認されない。

・アイライ側の公園とその周辺：公園内の北端にある東屋の下部に玄武岩質安山岩（自破砕状溶岩溶岩）の露岩が確認された（図 1.1.2）。このほか、南側の海岸沿いの一部などに基盤岩が露出している。

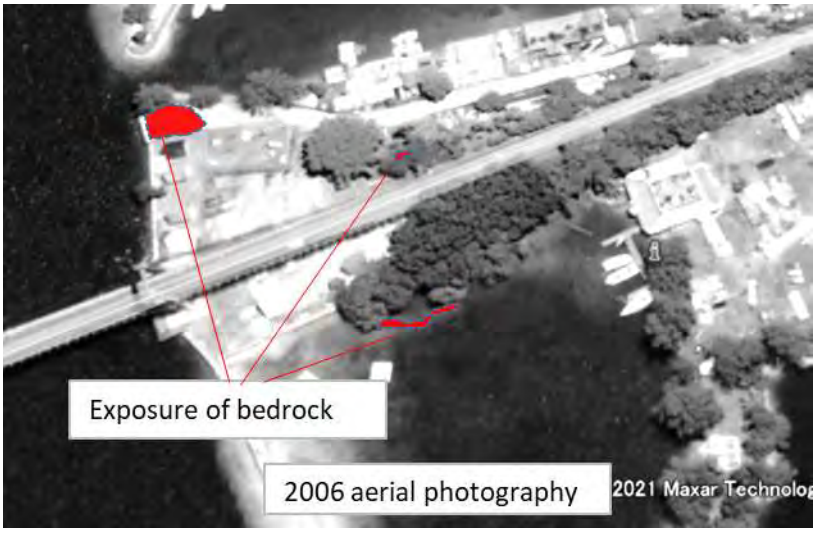


図 1.1.2
基盤岩が確認された位置(赤)
露岩分布から着岩深度は 2m 程度が想定される

図 1.1.3 東屋の下にある基盤岩（赤四角の部分を拡大して図 1.1.4 に示す）

図 1.1.4　東屋基礎部の玄武岩質安山岩（自破砕状溶岩溶岩）

現場にて、建設当時のことを知っている方から下記をレクチャーされた。
・アイライ側は被覆土を掘削し、ほぼ岩盤を露出させた状態で土が盛られた。
・アイライ側の掘削土は、コロール側の盛土に利用された。
・コロール側も被覆層は掘削して、新しく盛られた。
・どちら側も、盛土深さは 2m であった。

信ぴょう性には疑問があるが、本調査結果と調和した内容なので記載しておく。

（2）調査数量と調査位置

調査数量を表 1.1.1 に、調査位置を図 1.1.5 および図 1.1.6 に示す。

表 1.1.1 調査数量ならびに調査結果概要

調査場所	調査数量
コロール側公園	2 地点
アイライ側公園	3 地点

※ N 値が 50 を超えるものは N 値 50 として計算

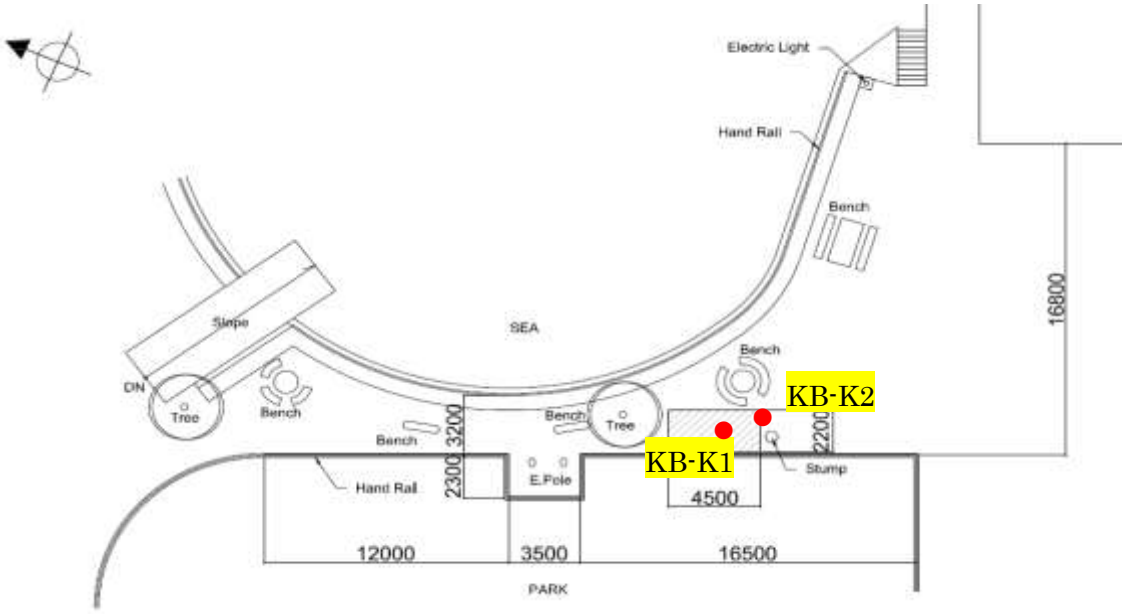


図 1.1.5 コロール側公園での調査位置

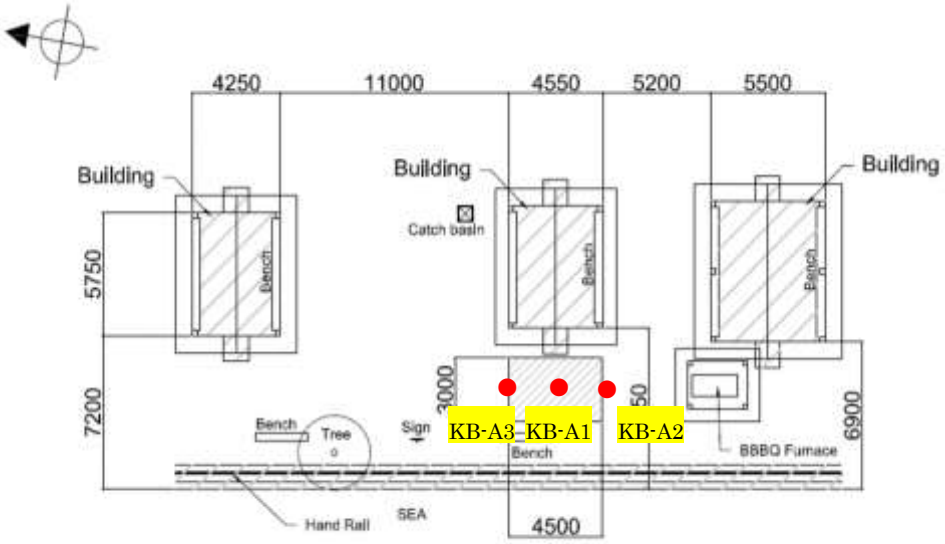


図 1.1.6 アイライ側公園での調査位置

2 試験結果

調査結果の詳細は巻末資料に示し、結果を表 1.2.1 に示す。

表 1.2.1 調査数量ならびに調査結果概要

調査場所	調査数量	調査深度	盛土の種類	盛土の N 値
コロール側公園	2 地点	D＝0～1.5m	粘土混じり砂礫	平均 10
アイライ側公園	3 地点	D＝0～1.4m	砂礫混じり粘土	平均 36※

※ N 値が 50 を超えるものは N 値 50 として計算

2.1 コロール側公園の調査結果

N 値 5～14（平均 10）の良く締め固まった盛土が 1.5m まで分布し、その下部に基盤岩が分布する。2 箇所ともほぼ同じ結果であった。

2.2 アイライ側公園の調査結果

N 値 15 以上（平均 36）の粘着力が強く非常に良く締め固まった盛土が 1.4m まで分布し、その下部に基盤岩が分布する。KB-A1 と A2 はほぼ同じ結果であった。北側の KB-A3 は基盤が浅く、着岩は約 1m であった。A3 の延長には基盤岩の露出することから北側に徐々に基盤が浅くなることを示している。

3.考察

（1）想定断面図

各公園の基礎地盤の状態のイメージを図 3.1.1 に示した。

いずれも良く締め固まった盛土が 1.5m ほどで分布している。基盤岩は直近の露岩から玄武岩質安山岩からなり、岩質から自破砕状溶岩溶岩である（古い文献では集塊岩とされる）。基盤岩は硬質で基礎として十分な強度を有する。

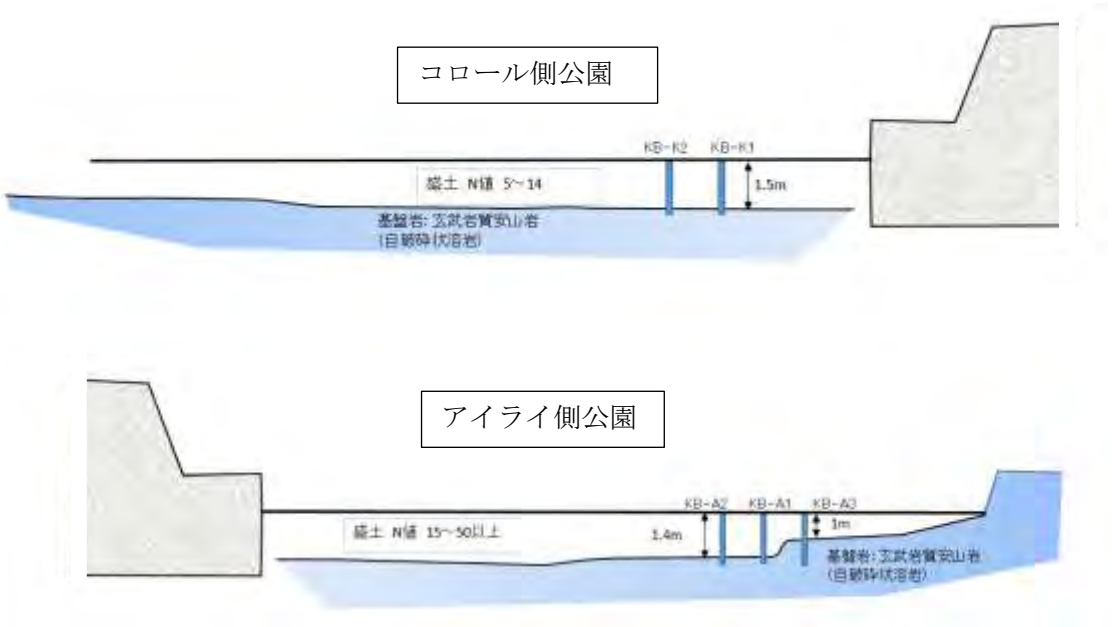


図 3.1.1 南北方向のイメージ断面図

(2)　課題と調査計画

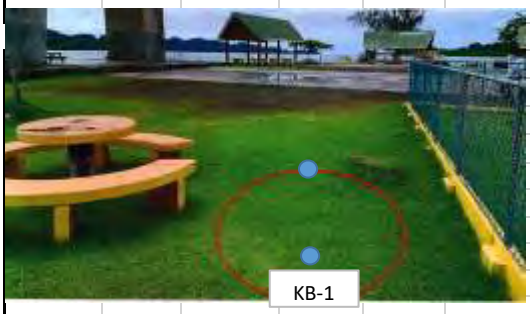
SWS 試験では基盤岩の上面深度の推定はできるが、岩盤の岩相（風化程度、割れ目状態など）は把握できない。複数の試験でほぼ同じ結果を得ているので、基盤岩深度は約 1.5m として良いと判断しているが、着岩深度も正確に把握する必要がある。

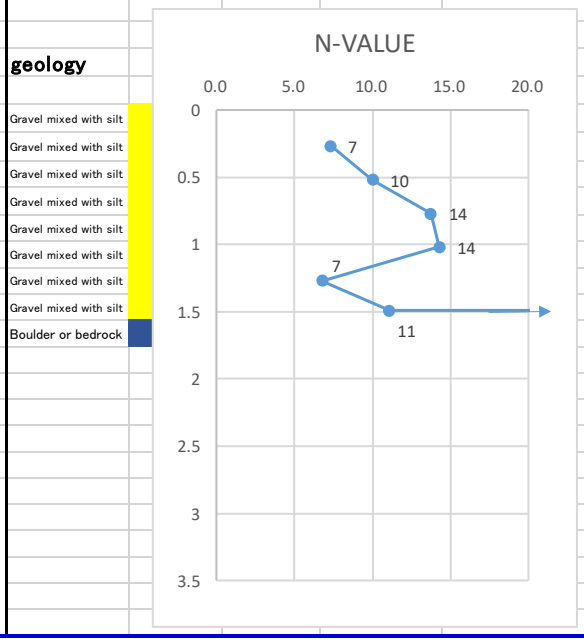
表 3.1.1 追加調査（案）

位置	調査種	調査数量
コロール側公園	SPT（各深度 50 ㎝はコアを採取）	10m・SPT 試験 10 回
アイライ側公園	SPT（各深度 50 ㎝はコアを採取）	10m・SPT 試験 10 回

APPENDIX

SWS test								DATA SEET	
Number	KB-K1 （Koror）			Depth	0m-1.5m			YACHIYO ENGINEERING CO., LTD	
Date	15-Sep-21	10:00～		Temp	Rainy				
No.	Planned load **Wsw** Kg	Loading pressure **Wsw** Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Na*4 **Nsw**	Soil 1: Sandy or gravel 2: Silty	N値	allowable bearing capacity qa kN/m2	comments
	0			0						
1	5	0.04905		0.015	1.5	0	1			
2	15	0.14715		0.015	0		1			
3	25	0.24525		0.015	0		1			
4	50	0.4905		0.015	0		1			
5	75	0.73575		0.015	0		1			
6	100	0.981		0.02	0.5	0	1			
7	100	0.981	20	0.27	25	80	1	7.3	77.4	Gravel mixed with silt
8	100	0.981	30	0.52	25	120	1	10.0	101.4	Gravel mixed with silt
9	100	0.981	44	0.77	25	176	1	13.8	135.0	Gravel mixed with silt
10	100	0.981	46	1.02	25	184	1	14.3	139.8	Gravel mixed with silt
11	100	0.981	18	1.27	25	72	1	6.8	72.6	Gravel mixed with silt
12	100	0.981	30	1.49	22	136	1	11.1	111.2	Gravel mixed with silt
13	100	0.981	50	1.5	1	5000	1	337.0	3029.4	Boulder or bedrock
										Boulder or bedrock



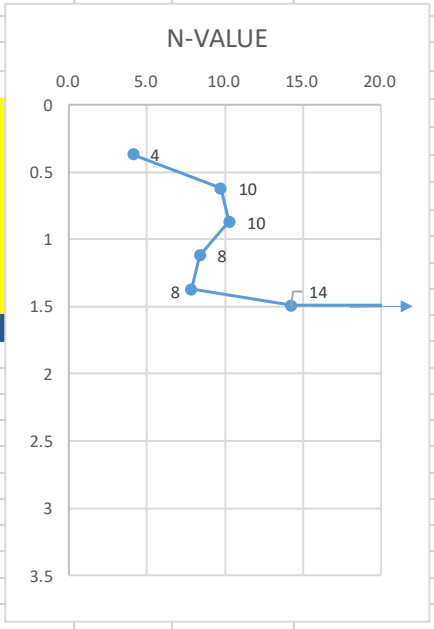


試験結果（KB-K1）

SWS test								DATA SEET		
Number	KB-K2 (Koror)			Depth	0m-1.5m			YACHIYO ENGINEERING CO., LTD		
Date	15-Sep-21	13:00～		Temp	Rainy					
No.	Planned load **Wsw** Kg	Loading pressure **Wsw** Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Na*4 **Nsw**	Soil 1: Sandy or gravel 2: Silty	N値	allowable bearing capacity qa kN/m2	comments
	0			0						
1	5	0.04905		0.02	2		1			
2	15	0.14715		0.03	1		1			
3	25	0.24525		0.06	3		1			
4	50	0.4905		0.08	2		1			
5	75	0.73575		0.1	2		1			
6	100	0.981		0.12	2		1			
7	100	0.981	8	0.37	25	32	1	4.1	48.6	Gravel mixed with silt
8	100	0.981	29	0.62	25	116	1	9.7	99.0	Gravel mixed with silt
9	100	0.981	31	0.87	25	124	1	10.3	103.8	Gravel mixed with silt
10	100	0.981	24	1.12	25	96	1	8.4	87.0	Gravel mixed with silt
11	100	0.981	22	1.37	25	88	1	7.9	82.2	Gravel mixed with silt
12	100	0.981	22	1.49	12	183	1	14.2	139.4	Gravel mixed with silt
13	100	0.981	50	1.5	1	5000	2	252.9	3029.4	Boulder or Bedrock
										Boulder or Bedrock

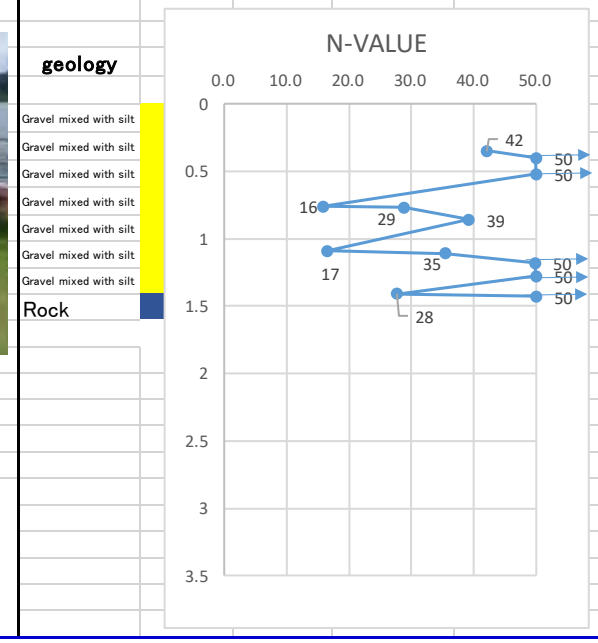
geology

- Gravel mixed with silt
- Gravel mixed with silt
- Gravel mixed with silt
- Gravel mixed with silt
- Gravel mixed with silt
- Gravel mixed with silt
- Gravel mixed with silt
- Gravel mixed with silt
- Boulder or Bedrock



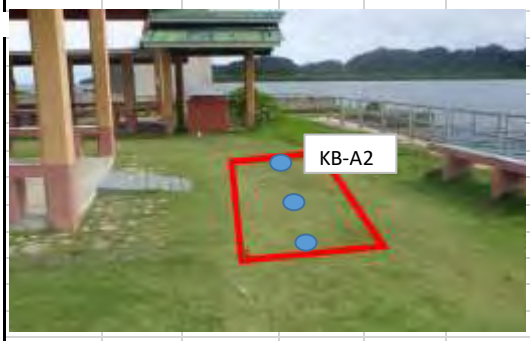
試験結果（KB-K2）

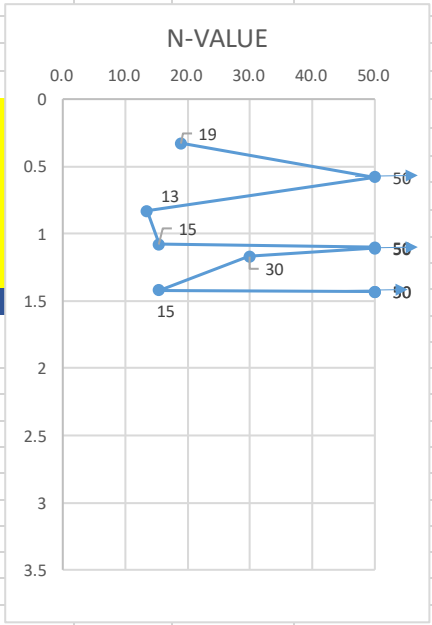
SWS test								resalt		
Number	KB-A1 （Airai）			Depth	0m-1.5m					
Date	16-Sep-21	10:00～		Temp	sunny					
No.	Planned load Wsw Kg	Loading pressure Wsw Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Na*4 Nsw	Soil 1: Sandy or gravel 2: Silty	N-Value	allowable bearing capacity qa kN/m2	comments
	0			0	0					
1	5	0.04905		0	1	0	1			
2	15	0.14715		0.05	4	0	1			Cohesive hard soil
3	25	0.24525		0.06	1	0	1			Cohesive hard soil
4	50	0.4905		0.07	1	0	1			Cohesive hard soil
5	75	0.73575		0.09	2	0	1			Cohesive hard soil
6	100	0.981		0.1	1	0	1			Cohesive hard soil
7	100	0.981	150	0.35	25	600	1	42.2	389.4	Cohesive hard soil
8	100	0.981	80	0.4	5	1600	1	50.0	989.4	Cohesive hard soil
9	100	0.981	150	0.52	12	1250	1	50.0	779.4	Cohesive hard soil
10	100	0.981	50	0.76	24	208	1	15.9	154.4	Cohesive hard soil
11	100	0.981	4	0.77	1	400	1	28.8	269.4	Cohesive hard soil
12	100	0.981	50	0.86	9	556	1	39.2	362.8	Cohesive hard soil
13	100	0.981	50	1.09	23	217	1	16.5	159.9	Cohesive hard soil
14	100	0.981	10	1.11	2	500	1	35.5	329.4	Cohesive hard soil
15	100	0.981	50	1.18	7	714	1	49.8	458.0	Cohesive hard soil
16	100	0.981	100	1.28	10	1000	1	50.0	629.4	Cohesive hard soil
17	100	0.981	50	1.41	13	385	1	27.7	260.2	Cohesive hard soil
18.0	100.0	0.981	50.0	1.43	2.0	2500.0	1	50.0	1529.4	ROCK
19.0										ROCK



試験結果（KB-A1）

SWS test								resalt		
Number	KB-A2 （Airai）			Depth	0m-1.43m					
Date	16-Sep-21		13:00～	Temp	sunny					
No.	Planned load **Wsw** Kg	Loading pressure **Wsw** Kg	Number of half-turns Na	Depth of penetration D （m）	Amount of penetration L （cm）	Na*4 **Nsw**	Soil 1: Sandy or gravel 2: Silty	N-Value	allowable bearing capacity qa kN/m2	comments
	0			0						
1	5	0.04905		0.04	4		1			
2	15	0.14715		0.04	0		1			Cohesive hard soil
3	25	0.24525		0.05	1		1			Cohesive hard soil
4	50	0.4905		0.05	0		1			Cohesive hard soil
5	75	0.73575		0.05	0		1			Cohesive hard soil
6	100	0.981		0.08	3		1			Cohesive hard soil
7	100	0.981	63	0.33	25	252	1	18.8	180.6	Cohesive hard soil
8	100	0.981	420	0.58	25	1680	1	50.0	1037.4	Cohesive hard soil
9	100	0.981	43	0.83	25	172	1	13.5	132.6	Cohesive hard soil
10	100	0.981	50	1.08	25	200	1	15.4	149.4	Cohesive hard soil
11	100	0.981	100	1.1	2	5000	1	50.0	3029.4	Cohesive hard soil
12	100	0.981	150	1.11	1	15000	1	50.0	9029.4	Cohesive hard soil
13	100	0.981	25	1.17	6	417	1	29.9	279.4	Cohesive hard soil
14	100	0.981	50	1.42	25	200	1	15.4	149.4	Cohesive hard soil
15.0	**100.0**	**1.0**	**220.0**	**1.43**	**1.0**	**22000.0**	**1**	**50.0**	**13229.4**	**ROCK**
16.0	**100.0**	**1.0**	**300.0**	**1.43**	**0.5**	**60000.0**	**1.0**	**50.0**	**36029.4**	**ROCK**



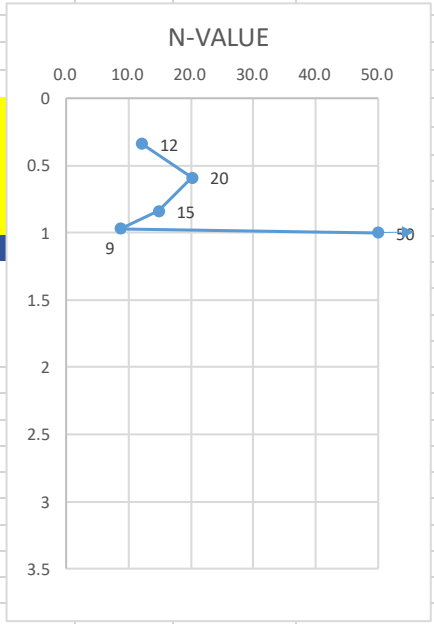


試験結果（KB-A2）

SWS test								resalt		
Number	KB-A3 （Airai）				Depth	0m-1.5m				
Date	16-Sep-21		15:00～		Temp	sunny				
No.	Planned load **Wsw** Kg	Loading pressure **Wsw** Kg	Number of half-turns Na	Depth of penetration D (m)	Amount of penetration L (cm)	Na*4 **Nsw**	Soil 1: Sandy or gravel 2: Silty	N-Value	allowable bearing capacity qa kN/m2	comments
	0			0						
1	5	0.04905		0.03	3		1			
2	15	0.14715		0.03	0		1			Cohesive hard soil
3	25	0.24525		0.04	1		1			Cohesive hard soil
4	50	0.4905		0.05	1		1			Cohesive hard soil
5	75	0.73575		0.05	0		1			Cohesive hard soil
6	100	0.981		0.09	4		1			Cohesive hard soil
7	100	0.981	38	0.34	25	152	1	12.1	120.6	Cohesive hard soil
8	100	0.981	68	0.59	25	272	1	20.2	192.6	Cohesive hard soil
9	100	0.981	48	0.84	25	192	1	14.8	144.6	Cohesive hard soil
10	100	0.981	13	0.97	13	100	1	8.7	89.4	Cohesive hard soil
11	**100**	**1**	**50**	**1**	**3**	**1667**	**1**	**50.0**	**1029.4**	**ROCK**

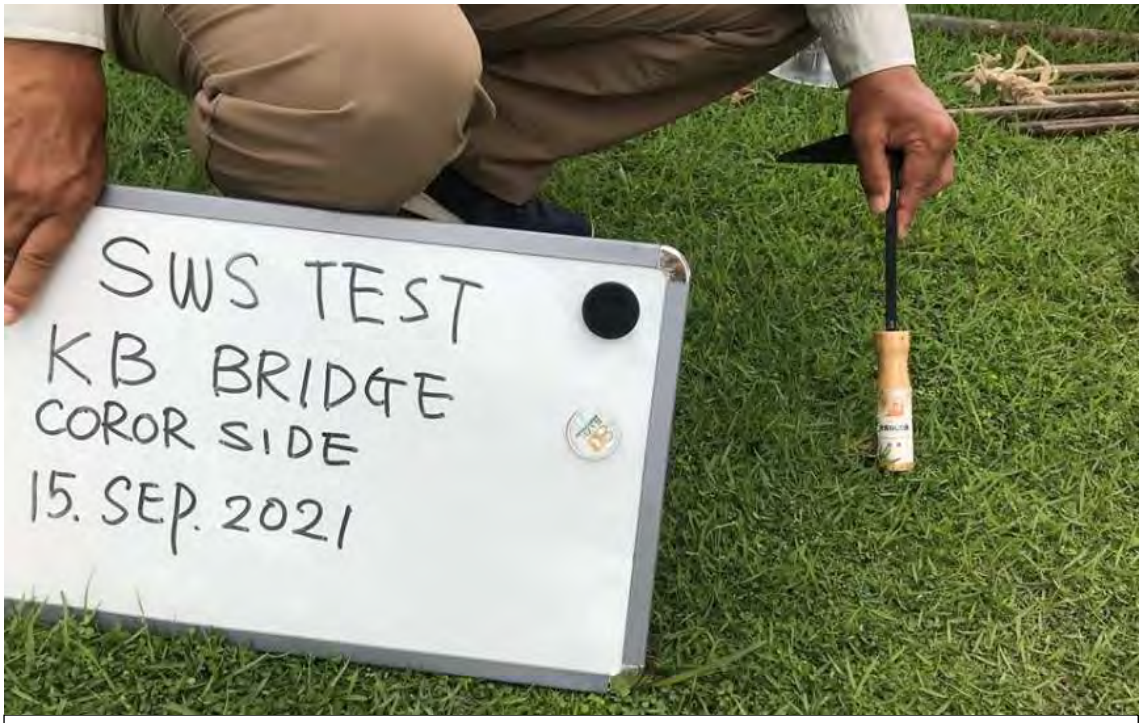
geology

Gravel mixed with silt
Gravel mixed with silt
Gravel mixed with silt
Gravel mixed with silt
Gravel mixed with silt
Rock

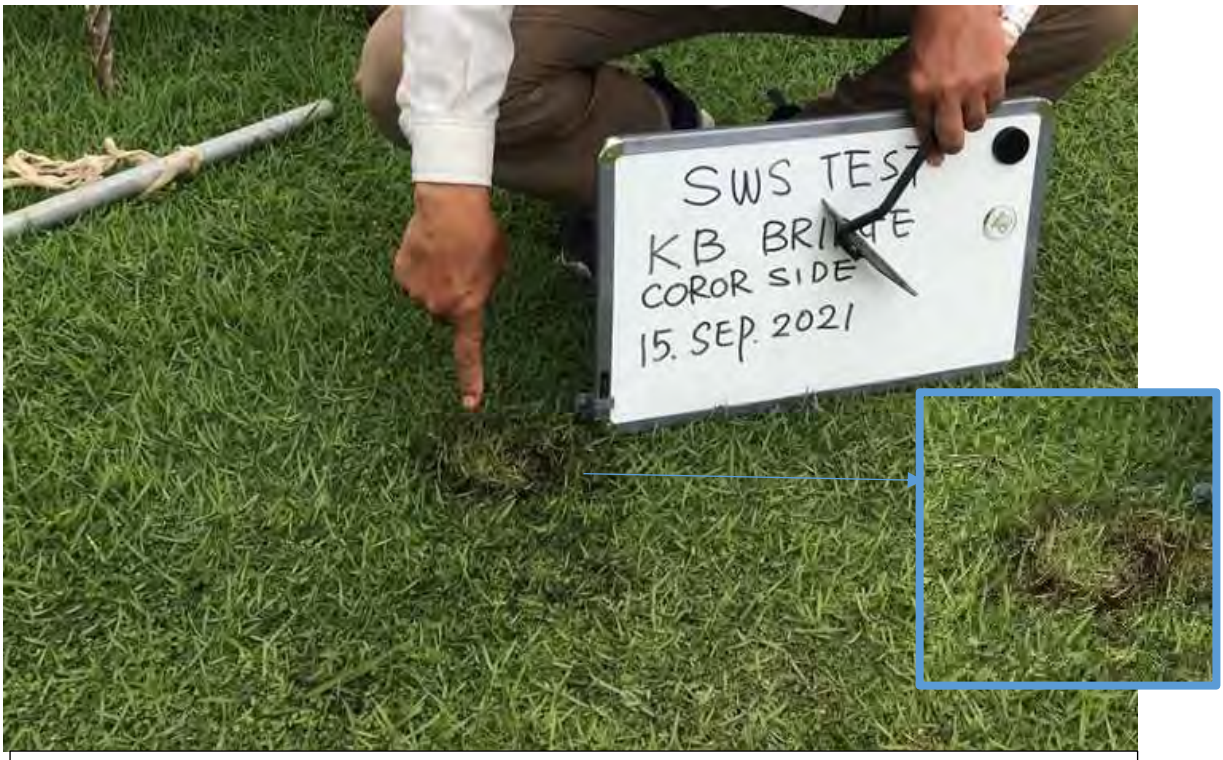


試験結果（KB-A3）

SWS-test at the JP Bridge Koror Park



Before SWS-test (KB-1)



After SWS-test（KB-1）

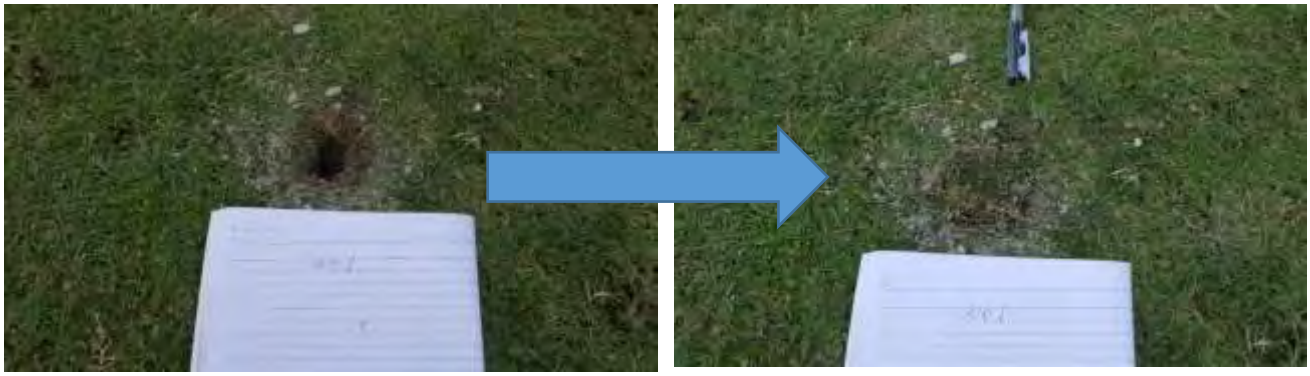
Before SWS-test(KB-1´)

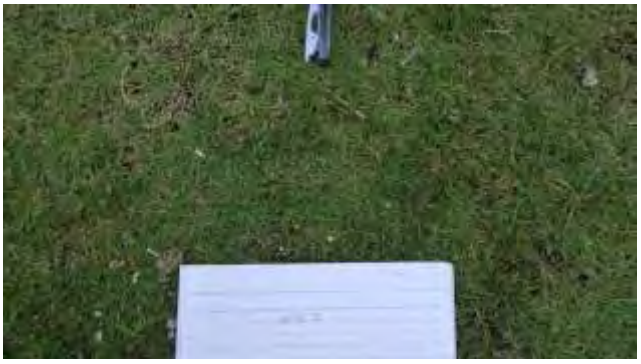
Before SWS-test(KB-1´)

Finished SWS-test at JP Bridge Koror Park

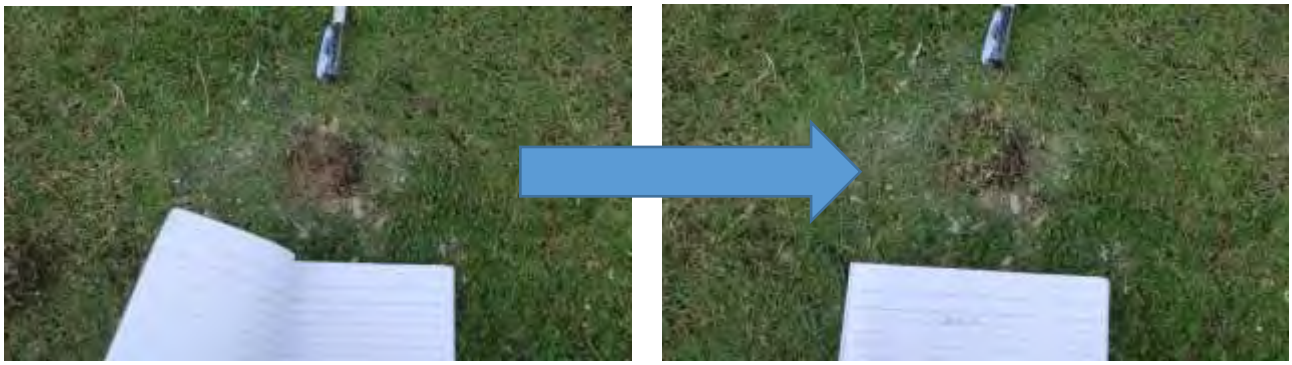
SWS-test at the JP Bridge Airai Park

Before and After SWS-test (KB-A1)

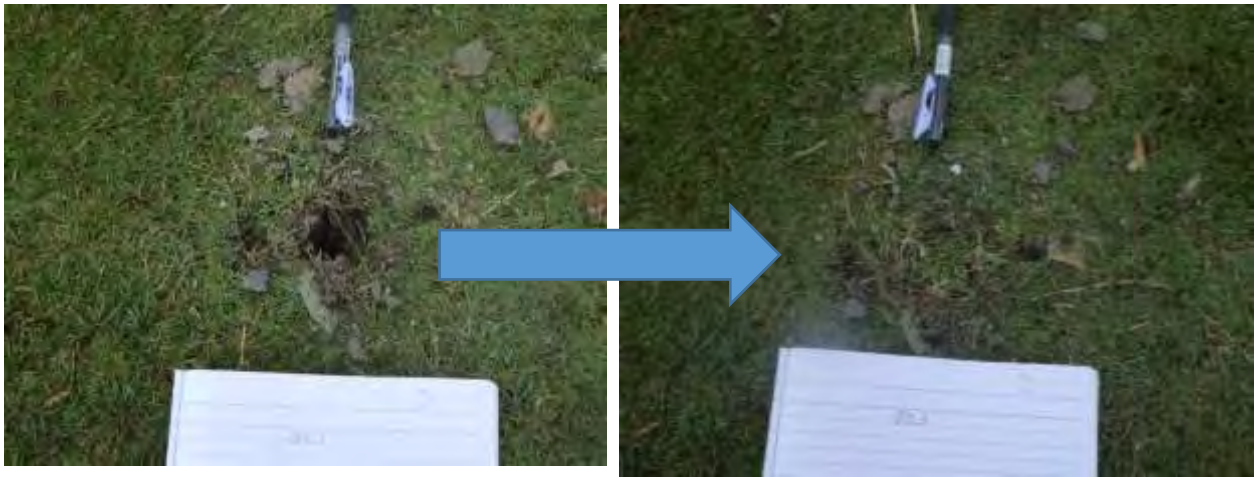




Before and After SWS-test (KB-A2)



Before and After SWS-test (KB-A3)



Under Investigation

Finished SWS-test at JP Bridge Airai Park

第５章 室内土質試験

1.試料採取

Mason Rock Substation計画地であるSurangel Cuary（採石場）より採取した。採取位置と土質状況を以下に示す。

・深度0.5m（SC-1）：平板載荷試験実施位置

・深度1.0m（SC-2）：石灰石の砕石と埋め土の混在部

・深度1.5m（SC-3）：玄武岩質安山岩礫を多く含む黒色埋め土

さらに、変電所敷地の一部となる水路部の軟質な砂まじりシルトを加えて4か所より試料を採取した。

・水路部分（SC-R）：含水比の高い砂まじりシルト

図 1.1.1　Soil materials sampling for laboratory tasting

表1.1.1 採取試料一覧

Sample №	試料採取場所	見た目の土質	N値	Sample
SC-1	深度0.5m	石灰石砕石盛土	＞50	
SC-2	深度1.0m	混在部	＞50	
SC-3	深度1.5m	黒色の埋め土	6～50	
SC-R	水路部	砂混じりシルト	0～2	

2. 試験内容

表2.1.1に試験内容を示す。

表2.1.1 試験内容

Exam name	Number of tests	Standards for Test Methods
Atterberg Limits	4	ASTMD4318
Particles Size Analysis of Soils	4	ASTMC-422
Spesific Gravity of Soil	4	ASTMD854-00
Water Content of soil	4	ASTMD2216-19

3. 試験結果

試験結果の詳細は巻末資料に示し、表3.1.1に結果を示す。

いずれも細粒分質礫質砂（Fine-grained gravel sand）に分類される。SC-Rは直径19mmを超える礫がほとんどなく、含水比が高いものの、砂・細粒分含有量は他の試料とほぼ同じである。

表3.1.1　試験結果

Exam name	SC-1 D=0.5	SC-2 D=1.0	SC-3 D=1.5	SC-R surface
Atterberg Limits				
Liquid Limits	18.5	15.9	16.0	17.0
Plastic Limits	17.1	NP	Np	NP
Plasticity Index	1.4	—	—	—
Particles Size Analysis of Soils				
Gravel fraction (2mm or more)	44%	19%	27%	31%
Sand fraction (2mm～0.074mm)	34%	46%	51%	45%
Fine grain fraction（0.074～)	22%	35%	22%	24%
Classification	細粒分質礫質砂 Fine-grained gravel sand	細粒分質礫質砂 Fine-grained gravel sand	細粒分質礫質砂 Fine-grained gravel sand	細粒分質礫質砂 Fine-grained gravel sand
Specific Gravity of Soil	2.659	2.657	2.688	2.636
Water Content of soil	6.9	9.5	11.2	17.1

APPENDIX

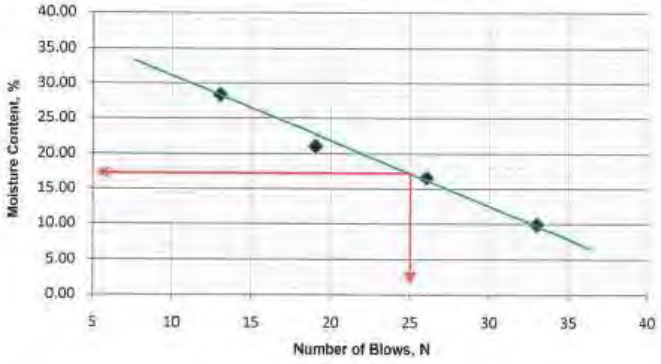
SOIL LABORATRY TEST REPORT

MASON'S ROCK PRODUCTS
P.O. Box 8065, Koror, PW 96940, Republic of Palau
Ph: +680 488-3000 Fx: +680 488-5688 masonsrock@surangel.com

Atterberg Limits Determination
ASTM D-4318

Project	: Koror Sub-Station	Date sampled	: Sept. 14, 2021
Location	: MRP Quarry/Koror	Date Tested	: Sept.16, 2021
Sample Description	: SC-R (Depth 0.3m)	Tested by	: RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No.	:

Can No.	C	F	G	E
Wt. of wet soil + can	59.2	56.4	28.4	26.8
Wt. of dry soil + can	53.0	52.0	26.0	25.4
Wt. of can	31.1	31.1	11.5	11.2
Wt. of dry soil	21.9	20.9	14.5	14.2
Wt. of moisture	6.2	4.4	2.4	1.4
Water Content, w%	28.31	21.05	16.55	9.86
No. of Blows, N	13	19	26	33



Liquid Limit, LL = 17.0

Plastic Limit, PL = NP

Plasticity Index, PI = —

PLASTIC LIMIT DETERMINATION

Can No.				
Wt. of wet soil + can				
Wt. of dry soil + can				
Wt. of can		NON- PLASTIC		
Wt. of dry soil				
Wt. of moisture				
Water Content, w%				

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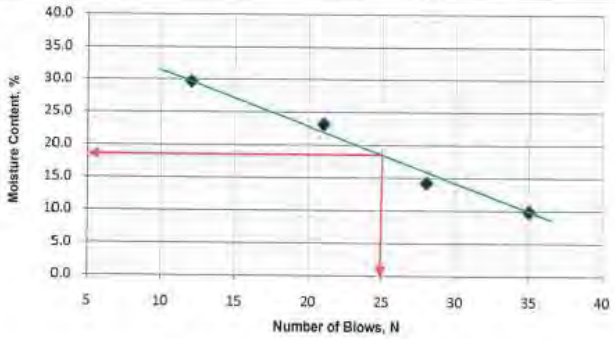
Atterberg Limits Determination
ASTM D-4318

Project	: Koror Sub-Station	Date sampled	: Sept. 14, 2021
Location	: MRP Quarry	Date Tested	: Sept.16, 2021
Sample Description	: SC-1 (Depth 0.5m)	Tested by	: RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No.	:

Can No.	C	E	F	B
Wt. of wet soil + can	53.4	26.1	32.4	48.9
Wt. of dry soil + can	48.3	23.3	29.8	47.3
Wt. of can	31.1	11.2	11.5	31.0
Wt. of dry soil	17.2	12.1	18.3	16.3
Wt. of moisture	5.1	2.8	2.6	1.6
Water Content, w%	29.7	23.1	14.2	9.8
No. of Blows, N	12	21	28	35



Liquid Limit, LL = 18.5

Plastic Limit, PL = 17.1

Plasticity Index, PI = 1.4

PLASTIC LIMIT DETERMINATION

Can No.	F	C		
Wt. of wet soil + can	19.9	42.4		
Wt. of dry soil + can	18.7	40.8		
Wt. of can	11.5	31.7		
Wt. of dry soil	7.2	9.1		
Wt. of moisture	1.2	1.6		
Water Content, w%	16.7	17.6		

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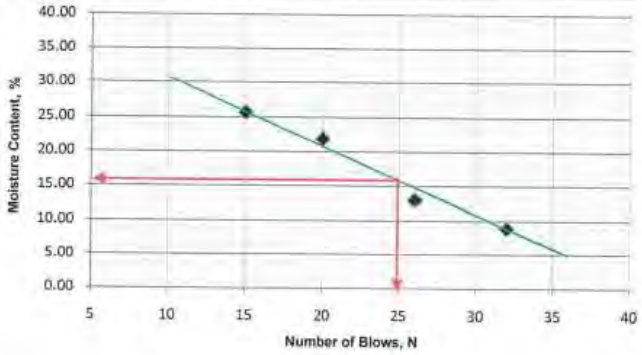
Atterberg Limits Determination
ASTM D-4318

Project	: Koror Sub-Station	Date sampled	: Sept. 14, 2021
Location	: MRP Quarry	Date Tested	: Sept.16, 2021
Sample Description	: SC-2 (Depth 1.0m)	Tested by	: RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No.	:

Can No.	F	C	B	E
Wt. of wet soil + can	35.0	61.8	53.7	28.4
Wt. of dry soil + can	30.2	56.3	51.1	27.0
Wt. of can	11.5	31.1	31.0	11.2
Wt. of dry soil	18.7	25.2	20.1	15.8
Wt. of moisture	4.8	5.5	2.6	1.4
Water Content, w%	25.67	21.83	12.94	8.86
No. of Blows, N	15	20	26	32



Liquid Limit, LL = 15.9

Plastic Limit, PL = NP

Plasticity Index, PI = –

PLASTIC LIMIT DETERMINATION

Can No.				
Wt. of wet soil + can				
Wt. of dry soil + can				
Wt. of can		NON- PLASTIC		
Wt. of dry soil				
Wt. of moisture				
Water Content, w%				

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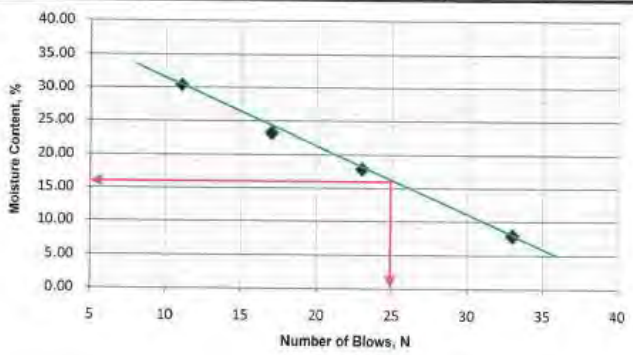
Atterberg Limits Determination
ASTM D-4318

Project	: Koror Sub-Station	Date sampled	: Sept. 14, 2021
Location	: MRP Quarry	Date Tested	: Sept. 16, 2021
Sample Description	: SC-3 (Depth 1.5m)	Tested by	: RV. Melancio/ Mafi's Engr.
Source of Sample	: in- placed	Lab. No.	:

Can No.	A	B	G	F
Wt. of wet soil + can	24.5	61.8	26.0	58.4
Wt. of dry soil + can	21.4	56.0	23.8	56.4
Wt. of can	11.2	31.0	11.5	31.1
Wt. of dry soil	10.2	25.0	12.3	25.3
Wt. of moisture	3.1	5.8	2.2	2.0
Water Content, w%	30.39	23.20	17.89	7.91
No. of Blows, N	11	17	23	33



Liquid Limit, LL = 16.0

Plastic Limit, PL = NP

Plasticity Index, PI = —

PLASTIC LIMIT DETERMINATION

Can No.				
Wt. of wet soil + can				
Wt. of dry soil + can				
Wt. of can				
Wt. of dry soil		NON- PLASTIC		
Wt. of moisture				
Water Content, w%				

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Particles Sizes Analysis of Soils

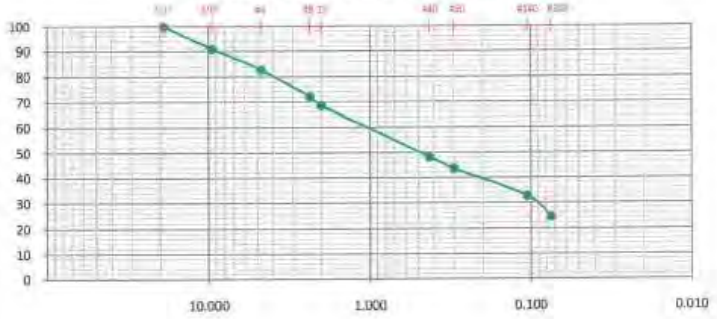
ASTM C-422

Project	: Koror Sub-Station	Date sampled	: Sept. 08 2021
Location	: MRP Quarry	Date Tested	: Sept. 10 2021
Sample Description	: SC- R (0.3m Depth)	Tested by	: RV. Melancio/ Matl's Engr.
Source of Sample	: in- placed	Lab. No	:

Original Wt. : 1630 g. Oven Dry Wt. : 1392 g. Wash Oven Dry Wt. : 1080.0 g.

Sieve Size (in.)	Sieve Size (mm)	Wt. Retained (gm)	Cum. Wt. Ret. (gm)	% Retained	% Passing	Remarks
2"	50.00					
1½"	37.50	0	0		100	
1"	25.00	0.0	0.0	0	100	
¾"	19.00	4.0	4.0	0	100	
3/8"	9.50	125.0	129.0	9	91	
# 4	4.75	111.0	240.0	17	83	
# 8	2.36	146.0	386.0	28	72	
# 10	2.00	51.0	437.0	31	69	
# 20	0.850	-	-	-	-	
# 40	0.425	284.0	721.0	52	48	
# 50	0.300	65.0	786.0	56	44	
# 140	0.106	151.0	937.0	67	33	
# 200	0.075	116.0	1053.0	76	24.4	
Pan		27.0				
Total		1080.0				

Particle- Size Distribution Curve



Remarks: UCS: SM (Silty sand)
AASHTO: A-1-b (Stone fragments, gravel & sand)

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Particles Sizes Analysis of Soils

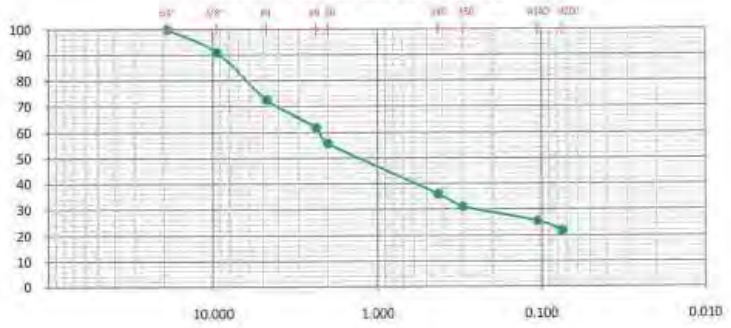
ASTM C-422

Project	Koror Sub-Station	Date sampled	Sept. 08 2021
Location	MRP Quarry	Date Tested	Sept. 10 2021
Sample Description	SC- 1 (0.5m Depth)	Tested by	RV. Melancio/ Matl's Engr.
Source of Sample	in- placed	Lab. No.	

Original Wt. : 1686 g. Oven Dry Wt. : 1577 g. Wash Oven Dry Wt. : 1255.0 g.

Sieve Size (in.)	Sieve Size (mm)	Wt. Retained (gm)	Cum. Wt. Ret. (gm)	% Retained	% Passing	Remarks
2"	50.00					
1½"	37.50	0	0		100	
1"	25.00	29.0	29.0	2	100	
¾"	19.00	16.0	45.0	3	100	
3/8"	9.50	205.0	250.0	16	84	
# 4	4.75	185.0	435.0	28	72	
# 8	2.36	165.0	600.0	38	62	
# 10	2.00	98.0	698.0	44	56	
# 20	0.850	-	-	-	-	
# 40	0.425	314.0	1012.0	64	36	
# 50	0.300	76.0	1088.0	69	31	
# 140	0.106	88.0	1176.0	75	25	
# 200	0.075	56.0	1232.0	78	21.9	
Pan		23.0				
Total		1255.0				

Particle- Size Distribution Curve



Remarks: UCS: SM (Silty sand)
AASHTO: A-1-b (Stone fragments, gravel & sand)

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Particles Sizes Analysis of Soils

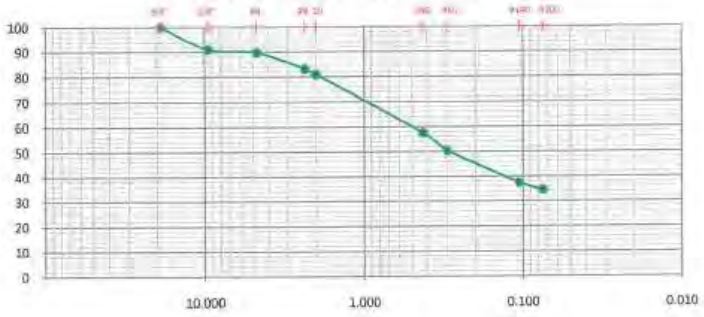
ASTM C-422

Project	Koror Sub-Station	Date sampled	Sept. 08 2021
Location	MRP Quarry	Date Tested	Sept. 10 2021
Sample Description	SC- 2 (1.0m Depth)	Tested by	RV, Melancio/ M.E
Source of Sample	in- placed	Lab. No.	

Original Wt. : 1453 g. Oven Dry Wt. : 1327 g. Wash Oven Dry Wt. : 876.0 g.

Sieve Size (in.)	Sieve Size (mm)	Wt. Retained (gm)	Cum. Wt. Ret. (gm)	% Retained	% Passing	Remarks
2"	50.00					
1½"	37.50					
1"	25.00	0.0	0.0	0	100	
¾"	19.00	0.0	0.0	0	100	
3/8"	9.50	62.0	62.0	5	95	
# 4	4.75	75.0	137.0	10	90	
# 8	2.36	87.0	224.0	17	83	
# 10	2.00	29.0	253.0	19	81	
# 20	0.850	-	-	-	-	
# 40	0.425	311.0	564.0	43	57	
# 50	0.300	93.0	657.0	50	50	
# 140	0.106	173.0	830.0	63	37	
# 200	0.075	39.0	869.0	65	34.5	
Pan		27.0				
Total		896.0				

Particle- Size Distribution Curve



Remarks: UCS: SM (Silty sand)
AASHTO: A-2-4 (Silty or clayey gravel and sand)

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Particles Sizes Analysis of Soils

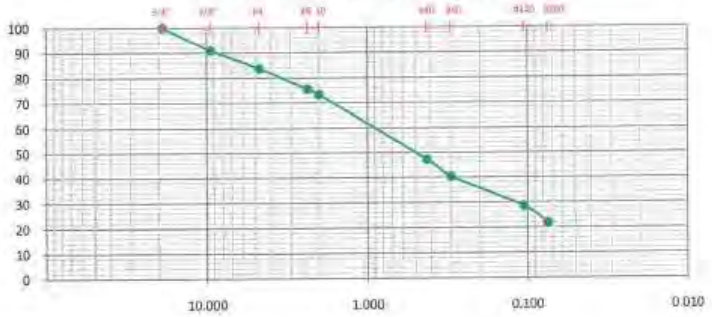
ASTM C-422

Project	Koror Sub-Station	Date sampled	Sept. 08 2021
Location	MRP Quarry	Date Tested	Sept. 10 2021
Sample Description	SC- 3 (1.5m Depth)	Tested by	RV. Melancio/ Mall's Engr.
Source of Sample	in- placed	Lab. No	

Original Wt. : 1334 g. Oven Dry Wt : 1200 g. Wash Oven Dry Wt. : 964.0 g.

Sieve Size (in.)	Sieve Size (mm)	Wt. Retained (gm)	Cum. Wt. Ret. (gm)	% Retained	% Passing	Remarks
2"	50.00					
1½"	37.50					
1"	25.00	0.0	0.0	0	100	
¾"	19.00	21.0	21.0	2	100	
3/8"	9.50	84.0	105.0	9	91	
# 4	4.75	92.0	197.0	16	84	
# 8	2.36	98.0	295.0	25	75	
# 10	2.00	26.0	321.0	27	73	
# 20	0.850	-	-	-	-	
# 40	0.425	314.0	635.0	53	47	
# 50	0.300	82.0	717.0	60	40	
# 140	0.106	143.0	860.0	72	28	
# 200	0.075	80.0	940.0	78	21.7	
Pan		24.0				
Total		964.0				

Particle- Size Distribution Curve



Remarks: UCS: SM (Silty sand)
AASHTO: A-1-b (Stone fragments, gravel & sand)

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Specific Gravity of Soil

ASTM D 854-00

Project	Koror Sub-Station	Date sampled	Sept. 14 2021
Location	MRP Quarry/Koror	Date Tested	Sept. 16 2021
Sample Description	N/A	Tested By	RV. Melancio/ Matl's Engr.
Source of Sample	in- placed	Lab. No.	

Observation No.		SC-R (0.3m depth)	SC-1 (0.5m depth)	SC-2 (1.0m depth)	SC-3 (1.5m depth)
Wt. of empty pycnometer	W_1 (g.)	383.8	383.8	383.8	383.8
Wt of pycnometer + dry sample	W_2 (g.)	584.1	582.4	584.7	587.3
Wt of pycnometer + dry sample + water	W_3 (g.)	988.0	987.6	989.0	991.5
Wt of pycnometer + water	W_4 (g.)	863.7	863.7	863.7	863.7
Specific Gravity	$\frac{W_2-W_1}{(W_4-W_1)-(W_3-W_2)}$	2.636	2.659	2.657	2.688
Ave. Specific Gravity		2.660			

Remarks: _____

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Determination of Water (Moisture) Content of Soil & Rocks

ASTM D2216-19

Project	: Koror Sub-Station	Date sampled	: Sept. 08, 2021
Location	: MRP Quarry	Date Tested	: Sept. 09, 2021
Sample Description	: N/A	Tested by	: RV. Melancio/ M.E
Source of Sample	: in- placed	Lab. No.	:

Determination No.	SC-R (D= 0.3m)	SC-1 (D= 0.5m)	SC-2 (D=1.0m)	SC-3 (D=1.5m)
Can No.	-	-	-	-
Wt. of wet soil + can	1971	2027	1794	1675
Wt. of dry soil + can	1733	1918	1668	1541
Wt. of can	341	341	341	341
Wt. of dry soil	1392	1577	1327	1200
Wt. of moisture	238	109	126	134
Water Content, w%	17.1	6.9	9.5	11.2
Ave. Water Content, W%	11.2			

Checked/Reviewed by: .....
RV. Melancio, MRP
Materials Engineer

APPENDIX

PLATE LOAD TEST REPORT

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koror Sub- Station — Date: 07 Sept. 2021
Location: MRP Quarry/ Koror — Elevation: 0.5m depth — Tested by: RV. Melanecio/ Matl's Engr
Shape of Loading Plate: Disc — Dimension of Loading Plate: 300mm — Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic — Design Load: 50 kN — Type of Reactive Devices: Hydraulic Excavator
Loading Method: Staged Loading — 9th steps — Actual Loading/Step: 10.6kN/m2 — Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement	Cumulative Value
					1	2	3	4	(mm)	(mm)
Reserve	0	0	0	0:00	0.00	0.00	0.00	0.00	0.000	0.000
1st	0.90	12.74	1	0:01	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:02	0.00	0.00	0.00	0.00	0.000	0.000
2nd	0	0	1	0:03	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:04	0.00	0.00	0.00	0.00	0.000	0.000
3rd	0.90	12.74	1	0:05	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:06	0.00	0.00	0.00	0.00	0.000	0.000
4th	0	0	1	0:07	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:08	0.00	0.00	0.00	0.00	0.000	0.000
5th	0.90	12.74	1	0:09	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:10	0.00	0.00	0.00	0.00	0.000	0.000
6th	0	0	1	0:11	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:12	0.00	0.00	0.00	0.00	0.000	0.000
1st	1.32	18.68	0	0:12	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:13	0.00	0.00	0.00	0.00	0.000	0.000
			2	0:14	0.00	0.00	0.00	0.00	0.000	0.000
			5	0:17	0.00	0.00	0.00	0.00	0.000	0.000
			10	0:22	0.00	0.00	0.00	0.00	0.000	0.000
			15	0:27	0.00	0.00	0.00	0.00	0.000	0.000
			20	0:32	0.00	0.00	0.00	0.00	0.000	0.000
			25	0:37	0.00	0.00	0.00	0.00	0.000	0.000
			30	0:42	0.00	0.00	0.00	0.00	0.000	0.000
2nd	2.64	37.37	0	0:42	0.00	0.00	0.00	0.00	0.000	0.000
			1	0:43	0.00	0.01	0.00	0.03	0.010	0.010
			2	0:44	0.00	0.01	0.00	0.06	0.018	0.018
			5	0:47	0.00	0.01	0.00	0.10	0.028	0.028
			10	0:52	0.00	0.01	0.00	0.12	0.033	0.033
			15	0:57	0.00	0.01	0.00	0.12	0.033	0.033
			20	1:02	0.00	0.01	0.00	0.12	0.033	0.033
			25	1:07	0.00	0.01	0.00	0.12	0.033	0.033
			30	1:12	0.00	0.01	0.01	0.12	0.035	0.035

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koror Sub- Station — Date: 07 Sept. 2021
Location: MRP Quarry/ Koror — Elevation: 0.5m depth — Tested by: RV. Melancio/ Mud's Engr.

Shape of Loading Plate: Disc — Dimension of Loading Plate: 300mm — Area of Loading Plate: 706.5cm^2

Type of Jack: Hydraulic — Design Load: 50 kN — Type of Reactive Devices: Hydraulic Excavator

Loading Method: Staged Loading — 9th steps — Actual Loading/Step: 10.6kN/m2 — Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
3rd	3.96	56.05	0	1:12	0.00	0.01	0.01	0.12	0.035	0.035
			1	1:13	0.00	0.01	0.01	0.12	0.035	0.035
			2	1:14	0.00	0.01	0.02	0.12	0.038	0.038
			5	1:17	0.00	0.01	0.03	0.12	0.040	0.040
			10	1:22	0.00	0.01	0.04	0.12	0.043	0.043
			15	1:27	0.00	0.01	0.04	0.12	0.043	0.043
			20	1:32	0.00	0.01	0.04	0.12	0.043	0.043
			25	1:37	0.00	0.01	0.04	0.12	0.043	0.043
			30	1:42	0.00	0.01	0.04	0.12	0.043	0.043
4th	5.28	74.73	0	1:42	0.00	0.01	0.05	0.12	0.045	0.045
			1	1:43	0.00	0.01	0.06	0.12	0.048	0.048
			2	1:44	0.00	0.01	0.06	0.13	0.050	0.050
			5	1:47	0.00	0.01	0.09	0.15	0.063	0.063
			10	1:52	0.00	0.01	0.11	0.16	0.070	0.070
			15	1:57	0.00	0.01	0.12	0.17	0.075	0.075
			20	2:02	0.00	0.01	0.14	0.19	0.085	0.085
			25	2:07	0.00	0.01	0.15	0.19	0.088	0.088
			30	2:12	0.00	0.01	0.16	0.20	0.093	0.093
5th	6.60	93.42	0	2:12	0.00	0.01	0.21	0.27	0.123	0.123
			1	2:13	0.00	0.01	0.23	0.28	0.130	0.130
			2	2:14	0.00	0.01	0.23	0.29	0.133	0.133
			5	2:17	0.00	0.01	0.28	0.35	0.160	0.160
			10	2:22	0.00	0.01	0.32	0.38	0.178	0.178
			15	2:27	0.00	0.01	0.35	0.41	0.193	0.193
			20	2:32	0.00	0.01	0.36	0.41	0.195	0.195
			25	2:37	0.00	0.01	0.38	0.45	0.210	0.210
			30	2:42	0.00	0.01	0.39	0.45	0.213	0.213

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koror Sub- Station			Date: 07 Sept. 2021
Location: MRP Quarry/ Koror	Elevation: 0.5m depth		Tested by: RV Melancon/ Matt Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading 9th steps	Actual Loading/Step: 10.6kN/m2	Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement	Cumulative Value
					1	2	3	4	(mm)	(mm)
6th	7.92	112.16	0	2:42	0.00	0.01	0.45	0.55	0.253	0.253
			1	2:43	0.00	0.01	0.46	0.56	0.258	0.258
			2	2:44	0.00	0.01	0.57	0.69	0.318	0.318
			3	2:47	0.00	0.01	0.68	0.81	0.375	0.375
			10	2:52	0.00	0.01	0.72	0.85	0.395	0.395
			15	2:57	0.00	0.01	0.75	0.99	0.433	0.433
			20	3:02	0.00	0.01	0.87	0.99	0.468	0.468
			25	3:07	0.00	0.01	0.88	0.99	0.470	0.470
			30	3:12	0.00	0.01	0.88	1.00	0.473	0.473
7th	9.24	130.79	0	3:12	0.00	0.01	0.88	1.03	0.480	0.480
			1	3:13	0.00	0.01	0.88	1.03	0.480	0.480
			2	3:14	0.00	0.01	0.89	1.06	0.490	0.490
			5	3:17	0.01	0.01	0.97	1.17	0.540	0.540
			10	3:23	0.02	0.01	1.01	1.20	0.560	0.560
			15	3:27	0.03	0.01	1.04	1.23	0.578	0.578
			20	3:32	0.05	0.01	1.06	1.25	0.593	0.593
			25	3:37	0.05	0.01	1.07	1.26	0.598	0.598
			30	3:42	0.05	0.01	1.08	1.28	0.605	0.605
8th	10.56	149.47	0	3:42	0.06	0.02	1.13	1.31	0.625	0.625
			1	3:43	0.08	0.04	1.12	1.34	0.645	0.645
			2	3:44	0.10	0.09	1.15	1.37	0.678	0.678
			5	3:47	0.14	0.12	1.20	1.44	0.725	0.725
			10	3:52	0.17	0.15	1.24	1.48	0.760	0.760
			15	3:57	0.19	0.17	1.26	1.50	0.780	0.780
			20	4:02	0.20	0.18	1.20	1.51	0.788	0.788
			25	4:07	0.21	0.19	1.28	1.53	0.803	0.803
			30	4:12	0.22	0.20	1.29	1.54	0.813	0.813

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koror Sub- Station
Location: MRP Quarry/ Koror
Elevation: 0.5m depth
Date: 07 Sept. 2021
Tested by: RV. Melancio/ Matl's Engr.

Shape of Loading Plate: Disc
Dimension of Loading Plate: 300mm
Area of Loading Plate: 706.5cm^2

Type of Jack: Hydraulic
Design Load: 50 kN
Type of Reactive Devices: Hydraulic Excavator

Loading Method: Staged Loading
9th steps
Actual Loading/Step: 10.6kN/m2
Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
9th	11.88	168.15	0	4:12	0.22	0.20	1.32	1.58	0.830	0.830
			1	4:13	0.22	0.20	1.32	1.58	0.830	0.830
			2	4:14	0.22	0.21	1.32	1.58	0.833	0.833
			5	4:17	0.25	0.27	1.38	1.67	0.893	0.893
			10	4:22	0.29	0.30	1.41	1.70	0.925	0.925
			15	4:27	0.31	0.33	1.43	1.71	0.945	0.945
			20	4:32	0.33	0.35	1.44	1.76	0.970	0.970
			25	4:37	0.35	0.36	1.47	1.77	0.988	0.988
			30	4:42	0.36	0.37	1.48	1.79	1.000	1.000
Unloading	10.56	149.47	0	4:42	0.36	0.37	1.49	1.79	1.003	1.003
1st			5	4:47	0.36	0.37	1.48	1.79	1.000	1.000
2nd	9.24	130.79	0	4:47	0.36	0.37	1.49	1.79	1.003	1.003
			5	4:52	0.36	0.37	1.49	1.79	1.003	1.003
3rd	7.92	112.10	0	4:52	0.36	0.37	1.48	1.78	0.998	0.998
			5	4:57	0.36	0.37	1.48	1.78	0.998	0.998
4th	6.60	93.42	0	4:57	0.36	0.37	1.48	1.78	0.998	0.998
			5	5:02	0.36	0.37	1.48	1.78	0.998	0.998
5th	5.28	74.73	0	5:02	0.36	0.37	1.48	1.78	0.998	0.998
			5	5:07	0.36	0.37	1.48	1.78	0.998	0.998
6th	3.96	56.05	0	5:07	0.36	0.37	1.46	1.74	0.983	0.983
			5	5:12	0.36	0.37	1.46	1.74	0.983	0.983
7th	2.64	37.37	0	5:12	0.36	0.36	1.44	1.71	0.968	0.968
			5	5:17	0.35	0.35	1.43	1.70	0.958	0.958
8th	1.32	18.68	0	5:17	0.33	0.30	1.42	1.69	0.935	0.935
			5	5:22	0.33	0.30	1.42	1.68	0.933	0.933
9th	0.00	0.00	0	5:22	0.16	0.17	1.28	1.52	0.783	0.783
			5	5:27	0.13	0.14	1.25	1.48	0.750	0.750

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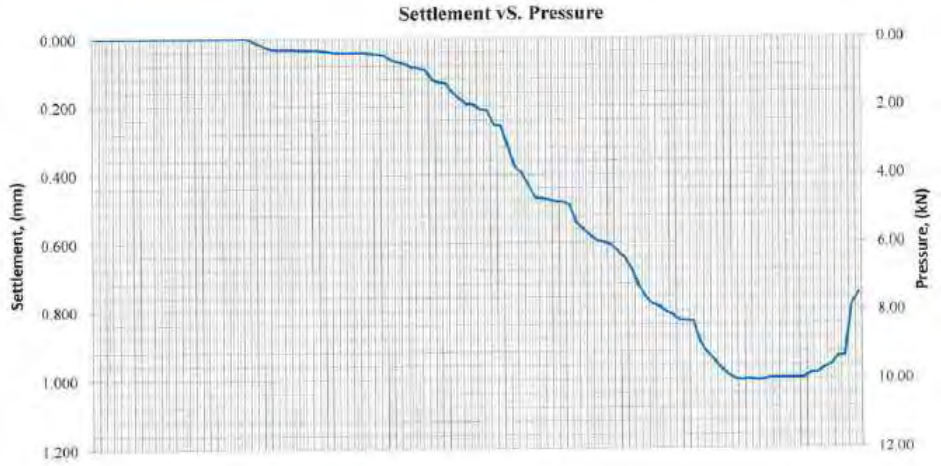
PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 07 Sept. 2021
Location: Ngatpang State	Elevation 0.5m depth		Tested by: RV Melancio/ Matl's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading	9th steps	Actual Loading/Step: 10.6kN/m2 Weather: Sunny



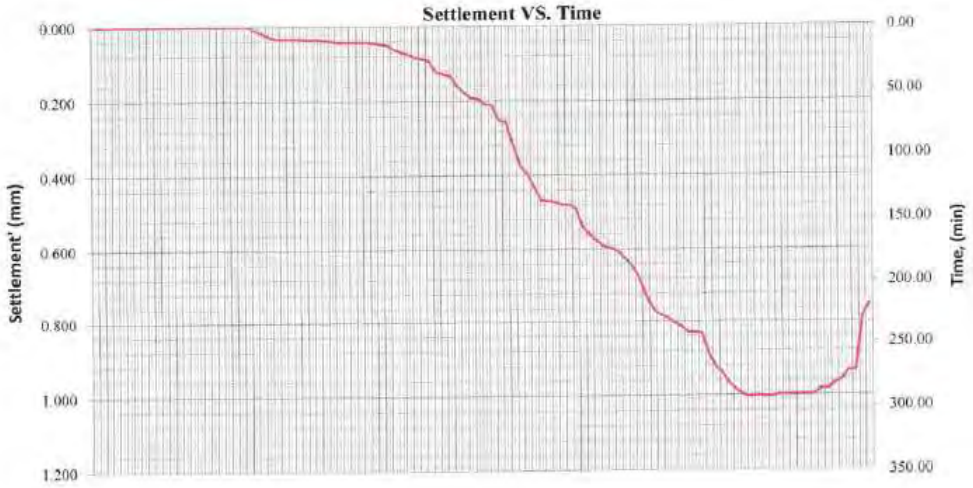


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PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 21 Sept. 2021
Location: Ngatpang State	Elevation: NGL(Natural Ground Level)		Tested by: RV. Melaneio/ Marl's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading 9th steps	Actual Loading/Step: 10.6kN/m2	Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
Reserve	0	0	0	0:00	0.000	0.000	0.000	0.000	0.000	0.000
1st	0.90	12.74	1	0:01	0.000	0.000	0.020	0.020	0.010	0.010
			1	0:02	0.000	0.000	0.020	0.020	0.010	0.010
2nd	0	0	1	0:03	0.000	0.000	0.020	0.020	0.010	0.010
			1	0:04	0.000	0.000	0.020	0.020	0.010	0.010
3rd	0.90	12.74	1	0:05	0.000	0.000	0.025	0.030	0.014	0.014
			1	0:06	0.000	0.000	0.025	0.030	0.014	0.014
4th	0	0	1	0:07	0.000	0.000	0.030	0.040	0.018	0.018
			1	0:08	0.000	0.000	0.030	0.040	0.018	0.018
5th	0.90	12.74	1	0:09	0.000	0.000	0.035	0.045	0.020	0.020
			1	0:10	0.000	0.000	0.035	0.045	0.020	0.020
6th	0	0	1	0:11	0.000	0.000	0.035	0.045	0.020	0.020
			1	0:12	0.000	0.000	0.035	0.045	0.020	0.020
1st	1.32	18.68	0	0:12	0.000	0.000	0.040	0.050	0.023	0.023
			1	0:13	0.000	0.010	0.060	0.080	0.038	0.038
			2	0:14	0.000	0.010	0.060	0.080	0.038	0.038
			5	0:17	0.090	0.000	0.015	0.080	0.046	0.046
			10	0:22	0.000	0.020	0.100	0.130	0.063	0.063
			15	0:27	0.000	0.030	0.100	0.140	0.068	0.068
			20	0:32	0.000	0.040	0.100	0.145	0.071	0.071
			25	0:37	0.000	0.040	0.120	0.160	0.080	0.080
			30	0:42	0.000	0.040	0.120	0.160	0.080	0.080
2nd	2.64	37.37	0	0:42	0.020	0.160	0.210	0.360	0.188	0.188
			1	0:43	0.020	0.170	0.210	0.360	0.190	0.190
			2	0:44	0.020	0.170	0.220	0.360	0.193	0.193
			5	0:47	0.055	0.230	0.265	0.425	0.244	0.244
			10	0:52	0.070	0.280	0.310	0.490	0.288	0.288
			15	0:57	0.080	0.290	0.320	0.520	0.303	0.303
			20	1:02	0.080	0.290	0.320	0.520	0.303	0.303
			25	1:07	0.085	0.300	0.320	0.520	0.306	0.306
			30	1:12	0.085	0.300	0.320	0.520	0.306	0.306

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 21 Sept. 2021
Location: Ngatpang State	Elevation: NGL(Natural Ground Level)		Tested by: RV. Melancio/ Mat'l's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading	9th steps Actual Loading/Step: 10.6kN/m2	Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
3rd	3.96	56.05	0	1:12	0.125	0.400	0.410	0.660	0.399	0.399
			1	1:13	0.125	0.400	0.410	0.660	0.399	0.399
			2	1:14	0.150	0.440	0.430	0.700	0.430	0.430
			5	1:17	0.165	0.470	0.450	0.730	0.454	0.454
			10	1:22	0.180	0.500	0.465	0.760	0.476	0.476
			15	1:27	0.190	0.520	0.490	0.790	0.498	0.498
			20	1:32	0.205	0.540	0.500	0.810	0.514	0.514
			25	1:37	0.210	0.550	0.500	0.810	0.518	0.518
			30	1:42	0.210	0.550	0.515	0.830	0.526	0.526
4th	5.28	74.73	0	1:42	0.320	0.720	0.660	1.020	0.680	0.680
			1	1:43	0.345	0.760	0.680	1.050	0.709	0.709
			2	1:44	0.370	0.780	0.700	1.070	0.730	0.730
			5	1:47	0.385	0.800	0.705	1.095	0.746	0.746
			10	1:52	0.400	0.820	0.720	1.120	0.765	0.765
			15	1:57	0.410	0.840	0.745	1.140	0.784	0.784
			20	2:02	0.430	0.855	0.745	1.140	0.793	0.793
			25	2:07	0.440	0.875	0.770	1.170	0.814	0.814
			30	2:12	0.440	0.875	0.770	1.170	0.814	0.814
5th	6.60	93.42	0	2:12	0.480	0.920	0.820	1.230	0.863	0.863
			1	2:13	0.480	0.925	0.840	1.250	0.874	0.874
			2	2:14	0.480	0.935	0.850	1.270	0.884	0.884
			5	2:17	0.490	0.950	0.860	1.290	0.898	0.898
			10	2:22	0.510	0.980	0.880	1.315	0.921	0.921
			15	2:27	0.530	1.000	0.900	1.340	0.943	0.943
			20	2:32	0.530	1.005	0.900	1.340	0.944	0.944
			25	2:37	0.540	1.020	0.900	1.355	0.954	0.954
			30	2:42	0.560	1.040	0.910	1.355	0.966	0.966

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station
Location: Ngatpang State
Elevation: NGL(Natural Ground Level)
Date: 21 Sept. 2021
Tested by: RV. Melancio/ Mat's Engr.

Shape of Loading Plate: Disc
Dimension of Loading Plate: 300mm
Area of Loading Plate: 706.5cm^2

Type of Jack: Hydraulic
Design Load: 50 kN
Type of Reactive Devices: Hydraulic Excavator

Loading Method: Staged Loading
9th steps
Actual Loading/Step: 10.6kN/m2
Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
6th	7.92	112.10	0	2:42	0.590	1.100	0.960	1.430	1.020	1.020
			1	2:43	0.620	1.120	0.980	1.460	1.045	1.045
			2	2:44	0.635	1.155	1.005	1.490	1.071	1.071
			5	2:47	0.645	1.170	1.020	1.505	1.085	1.085
			10	2:52	0.665	1.195	1.030	1.520	1.103	1.103
			15	2:57	0.685	1.220	1.050	1.550	1.126	1.126
			20	3:02	0.700	1.250	1.060	1.560	1.143	1.143
			25	3:07	0.710	1.260	1.080	1.590	1.160	1.160
			30	3:12	0.710	1.260	1.080	1.590	1.160	1.160
7th	9.24	130.79	0	3:12	0.750	1.310	1.110	1.630	1.200	1.200
			1	3:13	0.760	1.320	1.120	1.640	1.210	1.210
			2	3:14	0.780	1.380	1.155	1.690	1.251	1.251
			5	3:17	0.800	1.380	1.155	1.690	1.256	1.256
			10	3:22	0.815	1.400	1.180	1.715	1.278	1.278
			15	3:27	0.840	1.420	1.190	1.740	1.298	1.298
			20	3:32	0.850	1.435	1.190	1.740	1.304	1.304
			25	3:37	0.865	1.450	1.200	1.760	1.319	1.319
			30	3:42	0.865	1.450	1.210	1.765	1.323	1.323
8th	10.56	149.47	0	3:42	0.900	1.510	1.260	1.810	1.370	1.370
			1	3:43	0.960	1.550	1.270	1.840	1.405	1.405
			2	3:44	0.970	1.585	1.310	1.880	1.436	1.436
			5	3:47	1.000	1.625	1.320	1.910	1.464	1.464
			10	3:52	1.020	1.640	1.340	1.920	1.480	1.480
			15	3:57	1.020	1.640	1.345	1.930	1.484	1.484
			20	4:02	1.085	1.710	1.360	1.960	1.529	1.529
			25	4:07	1.090	1.720	1.350	1.970	1.533	1.533
			30	4:12	1.090	1.720	1.370	1.970	1.538	1.538

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PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 21 Sept. 2021
Location: Ngatpang State	Elevation: NGL(Natural Ground Level)		Tested by: RV. Melancio/ Mati's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading 9th steps	Actual Loading/Step: 10.6kN/m2	Weather: Sunny

Cycle	Load Pressure kN	Actual Load (kN/m^2)	Split Time (Min.)	Elapsed Time	Reading Settlement Value of Dial Gauge (1/100mm)				Average Settlement (mm)	Cumulative Value (mm)
					1	2	3	4		
9th	11.88	168.15	0	4:12	1.110	1.750	1.390	1.990	1.560	1.560
			1	4:13	1.110	1.755	1.400	2.000	1.566	1.566
			2	4:14	1.130	1.755	1.400	2.015	1.575	1.575
			5	4:17	1.150	1.800	1.420	2.040	1.603	1.603
			10	4:22	1.170	1.830	1.430	2.060	1.623	1.623
			15	4:27	1.180	1.840	1.455	2.085	1.640	1.640
			20	4:32	1.195	1.860	1.460	2.095	1.653	1.653
			25	4:37	1.210	1.880	1.485	2.120	1.674	1.674
			30	4:42	1.215	1.900	1.490	2.130	1.684	1.684
Unloading	10.56	149.47	0	4:42	1.210	1.900	1.490	2.130	1.683	1.683
1st			5	4:47	1.210	1.900	1.490	2.130	1.683	1.683
2nd	9.24	130.79	0	4:47	1.210	1.900	1.490	2.130	1.683	1.683
			5	4:52	1.210	1.900	1.490	2.130	1.683	1.683
3rd	7.92	112.10	0	4:52	1.210	1.900	1.490	2.130	1.683	1.683
			5	4:57	1.210	1.900	1.490	2.130	1.683	1.683
4th	6.60	93.42	0	4:57	1.210	1.900	1.490	2.130	1.683	1.683
			5	5:02	1.210	1.900	1.490	2.130	1.683	1.683
5th	5.28	74.73	0	5:02	1.150	1.830	1.470	2.110	1.640	1.640
			5	5:07	1.150	1.830	1.470	2.110	1.640	1.640
6th	3.96	56.05	0	5:07	1.120	1.825	1.400	2.040	1.596	1.596
			5	5:12	1.120	1.825	1.400	2.040	1.596	1.596
7th	2.64	37.37	0	5:12	1.080	1.770	1.350	1.990	1.548	1.548
			5	5:17	1.060	1.745	1.340	1.960	1.526	1.526
8th	1.32	18.68	0	5:17	1.000	1.690	1.280	1.910	1.470	1.470
			5	5:22	0.990	1.680	1.280	1.900	1.463	1.463
9th	0.00	0.00	0	5:22	0.920	1.590	1.220	1.820	1.388	1.388
			5	5:27	0.890	1.550	1.200	1.800	1.360	1.360

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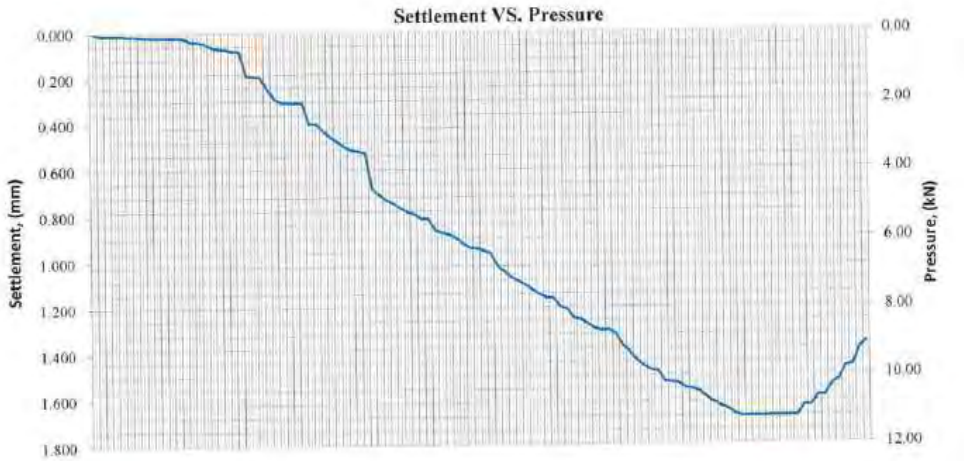
PLATE LOAD TEST

ASTM D-1194

Job Name: Koksai Sub- Station			Date: 21 Sept. 2021
Location: Ngatpang State	Elevation: NGL(Natural Ground Level)		Tested by: RV. Melancio/ Matl's Engr.
Shape of Loading Plate: Disc	Dimension of Loading Plate: 300mm		Area of Loading Plate: 706.5cm^2
Type of Jack: Hydraulic	Design Load: 50 kN		Type of Reactive Devices: Hydraulic Excavator
Loading Method:	Staged Loading	9th steps	Actual Loading/Step: 10.6kN/m2 Weather: Sunny



14. ステークホルダー協議議事録

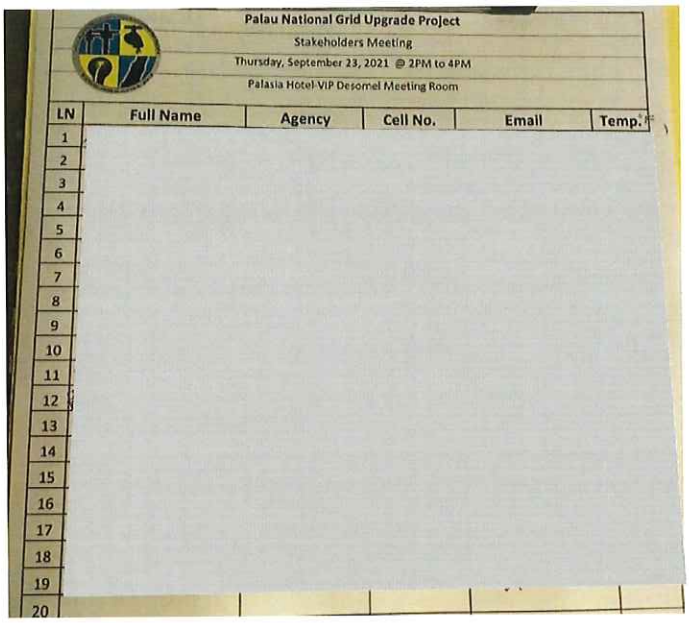
14 ステークホルダー協議議事録

Stakeholder meeting was held at 2 pm on 23rd September 2021.
Participants are 19 persons, who consists of:
PPUC, JICA Preparatory Survey Team, each state government (Koror, Airai, Ngchesar, and Ngatpang), MPII, EQPB, and PEA, to hear opinions to the Project.

Summary is as follows:

- PPUC explained the abstract of the Project.
- Each state government and organizations almost agreed and will provide the necessary support to PPUC and the Team.
- PPUC explained 3 options of transmission method at JP Bridge. 1. Cable in the bridge, 2. Overhead line, 3. Submarine cable, as described in 2.2 (1) f).
  Koror and Airai state government asked for 3. Submarine cable to PPUC and the Team, from the view point of the landscape.
  The Team will consider this opinion, and implement the necessary examination.

Explanation of the Project by PPUC



Palau National Grid Upgrade Project
Stakeholders Meeting
Thursday, September 23, 2021 @ 2PM to 4PM
Palasia Hotel-VIP Desomel Meeting Room

LN	Full Name	Agency	Cell No.	Email	Temp.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

Participant list

Notes:
ASPLA: Airai State Public Land Authority
KSPLA: Koror State Public Land Authority
NSPLA: Ngatpang State Public Land Authority
PEA: Palau Energy Authority

15. 環境モニタリングフォーム

資料-15 環境モニタリングフォーム

MONITORING FORM (Construction Stage)

- The project proponent is required to submit environmental and social monitoring result to JICA by using following monitoring form.

-When monitoring plans including monitoring items, frequencies and methods are adjusted through detailed design, project phase or project life cycle (such as construction phase and operation phase) should be taken into consideration. The project proponent is required to inform any change of monitoring form to JICA if any.

1. The situation of compensation

Monitoring Item	Monitoring Results during Report Period
Check of compensation payment and grievance redress	Monthly report

2. Mitigation Measures

- Air pollution

Monitoring Item	Monitoring Results during Report Period
The condition of the sprinkle The use condition of low emission gas construction vehicles	Once a week

－Water quality

Free of visible floating materials, oils, greases, scum, and other floating matter attributable to human activities

Name of Substation	Item	Standards		Conditions	Remarks
		Turbidity	pH		
Malakal	Visual Check Measure of Turbidity and pH	Not more than 2 NTU	7.7-8.5		1 time per week The nearest ocean from construction sites
Airai		Not more than 5% from natural conditions	6.5-8.5		
Kokusai					

- Noise and vibration

Monitoring Item	Locations	IFC standards	Monitoring Results during Report Period
The condition of noise	Surrounding areas of construction sites	75dB	Once a week

- Protected areas, ecosystem and historical areas

Monitoring Item	Monitoring Results during Report Period
Existence of endangered species Impacts to protected areas, KBA, and historical areas	Once a week

3. Social Environment

－Impact to existing road

Monitoring item	Monitoring results during report periods
Conditions of construction vehicles operation and traffic jams	Visual check Picture Monthly report

－Accident

Monitoring item	Monitoring results during report periods
Safety Meeting	Visual check Picture Monthly report

MONITORING FORM (Operation Stage)

- The project proponent is required to submit environmental and social monitoring result to JICA by using following monitoring form.

-In case monitoring plans including monitoring items, frequencies and methods are adjusted through detailed design, project phase or project life cycle (such as construction phase and operation phase) should be taken into consideration. The project proponent should inform change of monitoring form to JICA if any.

1. Mitigation measures

- Soil pollution

Monitoring Item	**Monitoring Results during Report Period**
The situation of soil pollution	Once a week

2. Social Environment

－Accident

Monitoring items	Monitoring results during report periods
Safety Meeting	Visual check Picture Monthly report

16. 簡易住民移転計画書案

THE PREPARATORY SURVEY

FOR THE

POWER GRID UPGRADE PROJECT

IN

THE REPUBLIC OF PALAU

ABBREVIATED RESETTLEMENT ACTION PLAN (ARAP)

May 2022

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

EXECUTIVE SUMMARY

Japan International Cooperation Agency (JICA) and the Palau Public Utilities Corporation (PPUC) are jointly undertaking a Preparatory Survey for the Power Grid Upgrade in the Republic of Palau. This survey is being financed by JICA.

The objective of this project is to improve the power transmission network of Republic through the following activities:

- Additional transmission lines between the Malakal power station and the Airai substation;
- New transmission lines between the Airai substation and the Kokusai substation along the east side of Babeldaob Island (Airai, Ngchesar and Ngatpang States);
- These new transmission lines will require installation of new power poles at 50 meter intervals; and
- Repair of existing substations in Malakal (Koror), Ngetkib (Airai) and Kokusai (Ngatpang).

This document is an Abbreviated Resettlement Action Plan (ARAP), a planning document that describes what the project implementers will do to address the direct social and economic impacts associated with involuntary displacement as a result of this project. This abbreviated document has been prepared in accordance with the World Bank resettlement policy (OP 4.12), where impacts on the entire displaced population are minor, or fewer than 200 people are displaced.

The ARAP explains the project goals and identification of affected lands, participation and consultation procedures, eligibility criteria for project affected people (PAPs), legal framework and institutional involvement, defines valuation methodology, establishes compensation entitlements and unit rates, and grievance redress mechanism and the project implementation schedule.

There are total of 119 project affected parcels, among them 27 are privately owned land parcels while the remainder are all government (National and State) Lands. The breakdown by state is as follows: 49 properties (10 private) in Koror State, 52 parcels (12 private) in Airai State, 12 parcels (5 private) in Ngchesar State and 6 parcels (2 private) in Ngatpang State.

Regarding crops and plants, multiple fruit trees, coconut trees, betelnut trees and ornamental plants will be affected by the project.

No homes, buildings or other structures are going to be affected and no people are going to be resettled or livelihoods are expected to be impacted from this project.

Table of Contents

INTRODUCTION

1.1 Background

The Japan International Cooperation Agency (JICA) and the Palau Public Utilities Corporation (PPUC) are jointly undertaking a preliminary survey on the upgrade to the power grid in the Republic of Palau. This survey is being financed by JICA and has hired Yachiyo Engineering Co., Ltd., a Japanese firm, to do the initial work.

The objective of this project is to improve the power transmission network of Republic through the following activities:

- Additional transmission lines between the Malakal power station and the Airai substation;
- New transmission lines between the Airai substation and the Kokusai substation along the east side of Babeldaob Island (Airai, Ngchesar and Ngatpang States);
- These new transmission lines will require installation of new power poles at 50 meter intervals; and
- Repair of existing substations in Malakal (Koror), Ngetkib (Airai) and Kokusai (Ngatpang).

The installation of the new power poles and overhead transmission lines will impact numerous properties along the entire utility corridor. Around 119 individual properties will be affected by this proposed project. Impacted lots include approximately 29 private properties while the rest are government-owned.

1.2 Legal Basis of the Land Acquisition

Palau has legal basis for land acquisition for public purpose under the Palau Constitution. There are also Statues (Palau National Code Title 35), agency rules and regulations, and previous court rulings that contain detailed provisions concerning eminent domain and related concepts and procedures.

Further explanation of this subject is detailed in Section 3.1

1.3 Objectives of RAP

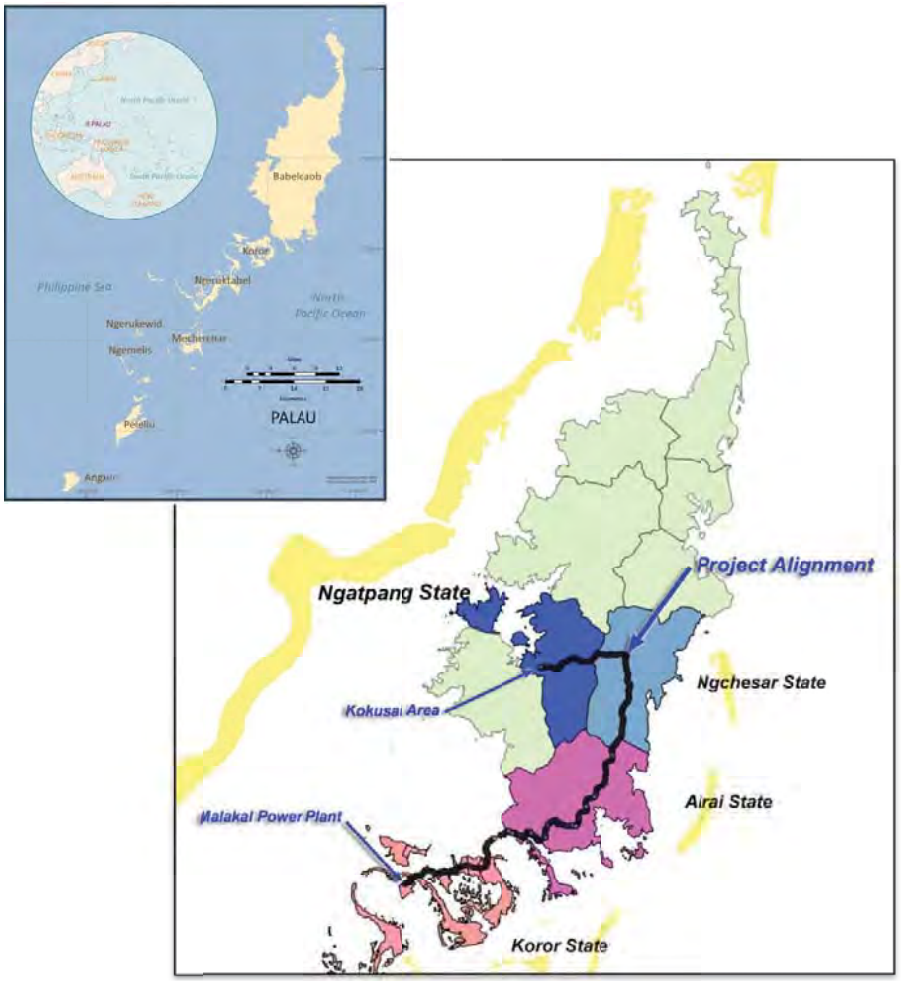
This document is an Abbreviated Resettlement Action Plan (ARAP), a planning document that describes what the project implementers will do to address the direct social and economic impacts associated with involuntary displacement as a result of this project.

The main objective of this ARAP is to ensure that the following land acquisition issues, all persons affected by it are properly consulted, made available to affordable and accessible grievance mechanisms and compensated at replacement cost or market value (which ever higher) for their losses. They will also be provided with rehabilitation measures so that they are at least as well off as they would have been in the absence of this proposed project.

This abbreviated document has been prepared in accordance with the World Bank resettlement policy (OP 4.12), where impacts on the entire displaced population are minor, or fewer than 200 people are displaced.

1.4 Project Location and Impact Area

The project location extends from the Malakal Power Station on Malakal Island through Koror Island to Airai, Ngchesar and Ngatpang States on Babeldaob Island. Refer to the figure below for the entire project alignment.



1.5 Status of the Land Acquisition

The process for land acquisition for the proposed power upgrade project is in its early stages. Private landowners are being consulted about the project and the impacts to their properties. The process will be based on voluntary sales agreements with each landowner. However, because majority of the impacted properties are fairly small and the project only impacts a small portion of these properties, compensation of utility easements may be an option that the landowners may be more open to, rather than giving up or selling their land. Refer to Section 2.1 for additional information.

The consultation process was performed by PPUC staff through meetings with the individual land owners to discuss the anticipated impacts to their properties and their initial thoughts on the project. They were informed that there will be later consultations to discuss potential compensation, if necessary, for the impacts to their properties. The compensation meetings with landowners will be scheduled at a later date to be determined by PPUC.

The compensation policy in JICA's Guidelines for Environmental and Social Considerations is to compensate at full replacement cost for the loss of affected assets. In order to comply with the Guidelines, the agreed compensation amount needs to be comparable with the replacement cost. The replacement cost is described in Section 3.6.

2. Census Survey Results

2.1 Affected Land Use and Landowners

The proposed construction of new power poles and transmission lines will impact lands that are adjacent to the main roadways that used for school grounds, businesses, farms, residential and vacant/unimproved lots.

According to the Bureau of Lands and Survey, there are total of 119 project affected parcels, with 29 being privately owned land parcels while the remainder are all government (National and State) Lands.

Government properties affected by this project are mostly lands leased for business and residential use. PPUC will work with the State Governments to secure utility easements in these affected properties for the project. There may be leased lands in Koror that will have issues with power poles and overhead transmission lines. This is further discussed in Section 2.5, below.

The areas in the following tables below shows the estimated areas within each impacted private lot that falls under the overhead transmission lines and power poles. The area is calculated using the length of the overhead line and a 2.44-meter (8 ft.) wide corridor. The 2.44-meter wide utility corridor was proposed by PPUC as a minimum area for the overhead transmission lines and thus minimizing the loss of available land on the affected properties as they are fairly small in size. Since the overhead transmission lines will be adjacent to the main roads, PPUC is able to use the road and shoulders to gain access to the power poles and transmission lines for maintenance purposes.

2.1.1 Koror State

	Cadastral Lot No.	Owner	Land Use	Zoning	Area (m^2)
1	062 B 04	Private	Elementary School	Residential/Commercial	190.86
2	030 B 17	Private	Business	Residential/Commercial	54.90
3	030 B 18	Private	Business	Residential/Commercial	57.72
4	030 B 24	Private	Elementary & High School	Residential	338.63
5	092 B 01	Private	Residential	Residential/Commercial	264.56
6	022 B 07	Private	Business	Residential/Commercial	56.76
7	022 B 12	Private	Business	Residential/Commercial	203.02
8	021 B 08	Private	Farm land/Vacant	Residential/Commercial	109.32
9	055 B 02	Private	Farm	Residential/Commercial	469.74
10	055 B 01	Private	Farm/Business	Residential/Commercial	393.52
				Total	**2,139.03**

2.1.2 Airai State

	Cadastral Lot No.	Owner	Land Use	Zoning	Area (m^2)
1	024 N 14	Private	Business	Residential/Commercial	181.46
2	024 N 12	Private	Community/Church	Residential/Commercial	50.49
3	069 N 01	Private	Community facility	Residential/Commercial	102.39
4	024 N 15	Private	Residential	Residential/Commercial	83.14
5	025 N 10	Private	Business/Residential	Residential/Commercial	276.40
6	025 N 09	Private	Residential	Residential/Commercial	268.85
7	025 N 08	Private	Business	Residential/Commercial	99.43
8	009 N 01	Private	Residential	Residential/Commercial	413.85
9	009 N 03	Private	Residential	Residential/Commercial	128.85
10	009 N 20	Private	Residential	Residential/Commercial	117.49
11	002 N 01	Private	Church/Residential	Residential/Commercial	40.23
12	059 N 01	Private	School/Business	Residential/Commercial	137.54
				Total	**1,900.12**

2.1.3 Ngchesar State

	Cadastral Lot No.	Owner	Land Use	Area (m^2)
1	064 P 18	Private	Business	147.99
2	045 P 09	Private	Vacant/Unimproved	407.46
3	059 P 01	Private	Vacant/Unimproved	97.16
4	069 P 04	Private	Vacant/Unimproved	217.66
5	069 P 03	Private	Vacant/Unimproved	169.19
			Total	**1,039.46**

Ngchesar State does not have Zoning laws.

2.1.4 Ngatpang State

	Cadastral Lot No.	Owner	Land Use	Area (m^2)
1	024 P 18	Private	Vacant/Unimproved	122.84
2	023 L 03	Private	Vacant/Unimproved	225.45
			Total	**348.29**

Ngatpang State does not have Zoning laws.

2.2 Types of the Affected Land

As stated in Section 2.1 above, impacted lands from the proposed project are adjacent to the main road and include lands used for school grounds, businesses, farms, residential and vacant/unimproved lots. Majority of the affected lands in Koror and Airai are in residential, business and school use. Affected areas in Ngchesar and Ngatpang are mainly vacant and unimproved properties.

2.3 Economic Condition of Landowners

A total of 101 people are affected by the proposed new power pole installations. In addition to the landowners who reside on their land with their families, there are 43 tenants renting units in rental buildings. These rental properties are all located in Koror.

Out of the 6 power pole-affected private properties with residential dwellings, 5 of these properties are in Airai and are owned by family clans. Adult individuals in these households are employed while others earn their livelihood through other occupation such as small-scale farming. Number of the household members range between 3 and 10.

Table 2-1: Age and Gender Structure of PAPs and Percentage of PAPs in each Age Category

Age	Male	Female	Total	Percentage
0-9	2	1	3	2.9%
10-19	0	1	1	0.9%
20-29	5	2	7	6.9%
30-39	33	10	43	42.6%
40-49	5	8	13	12.9%
50-59	14	4	18	17.8%
60-69	7	7	14	13.9%
70 +	2	0	2	1.9%
Total	**68**	**33**	**101**	**100%**

In regards to income, a majority of the PAPs are earning the minimum wage of $3.50/hr in their jobs. The highest earners are the landowners that are either renting out housing units on their properties, have on-site commercial buildings, or have businesses elsewhere. The table below shows a simple breakdown of the income for the project-affected people:

Table 2-2: Monthly Income of PAPs and Percentage of PAPs in each Income Category

Monthly Income of PAPs		
Category (USD)	No. of PAPs	Percentage
<300	16	15.84%
300-599	57	56.44%
600-999	8	7.92%
1000-1499	8	7.92%
1500-2500	2	1.98%
>2500	10	9.90%
Total	**101**	**100.00%**

Impacted commercial/business properties are mainly owned by local businessmen. Some properties include multiple buildings that include homes, rental units and commercial buildings. The impacted school properties in Koror belong to the Catholic Mission. Impacted community facilities in Airai State include a community meeting facility and a basketball court.

Land uses for the affected properties include the following:

Uses of Affected Properties	
Residence	6
Rental Housing	5
Commercial Retail/Service/Office Building	9
Community/School Facilities	5
Farm	2
Undeveloped	3

2.4 Stakeholder Engagement

Engagement with the affected landowners were initially conducted though individual meetings to introduce the project and its anticipated impacts to their properties. Personnel from PPUC led the meetings. Discussions on land acquisition or other possible options were considered. A description of the project and an initial reaction from the landowner was noted. The landowner was informed that a subsequent meeting will be held to discuss compensation, if necessary, for the impact to their property once the project timeline has been confirmed.

2.5 Results of the Consultation with the Affected Private Landowners

	State	Hamlet	Lot No.	Owner	Comments
1	Koror	Ngerkesoaol	062 B 04		Support the proposed project. However wants to see the exact location of power poles to ensure that they do not interfere with student access and pedestrian walkway.
2	Koror	Ngerkesoaol	030 B 17		No problems with the proposed project. However wants PPUC assurance that there will be no lateral power lines over his property to inhibit future development of his lot.
3	Koror	Ngerkesoaol	030 B 24		Same as #1
4	Koror	Ngerkesoaol	092 B 01		No issues with the proposed project.
5	Koror	Ngerkesoaol	022 B 07		No issues if the power pole does not affect access to his property. *Note: possible relocation of the power pole may avoid impact to this property.*
6	Koror	Ngerkesoaol	022 B 12		No problem with the proposed project. Just move the power pole location several meters to avoid existing driveway.
7	Koror	Ngerchemai	021 B 08		No problem with the proposed project. However wants to see the actual locations to ensure it does not interfere with future development.
8	Koror	Ngerchemai	055 B 02		Proposed power poles and lines will interfere with planned development of his properties and result in the loss of more than 50 trees. Mature trees may be worth $1,000. May reconsider if Gov't can provide land as compensation. Also, if the transmission line is put underground, he may be more open to this idea.
9	Koror	Ngerchemai	055 B 01		Same as #8
10	Airai	Ngeruluobel	024 N 14		No issue with the proposed project. Just ensure power pole location does not impact existing trees and driveway.
11	Airai	Ngeruluobel	024 N 12		No problem with the proposed project. Just ensure power pole location does not impact the driveway access.
12	Airai	Ngerusar	024 N 15		No issue with the proposed project. Just ensure power pole location does not impact existing coconut trees.
13	Airai	Ngerusar	025 N 10		No problem with the proposed project. Just ensure power pole location does not impact the driveway access.
14	Airai	Ngerusar	025 N 09		No problem with the proposed project. Asked project proponent to reconsider reducing the number of poles along the property. *Note: Project will utilize existing poles with only one additional pole proposed on the eastern boundary of the property.*
15	Airai	Ngerusar	025 N 08		No problem with the proposed project. Just ensure power pole location does not impact the driveway access.
16	Airai	Ngerusar	009 N 01		No problem with the proposed project. Just ensure power pole location does not impact proposed driveway.
17	Airai	Ngerusar	009 N 03		Proposed project will use existing pole location. No additional poles needed therefore no additional impact.
18	Airai	Ngerusar	009 N 20		No issue with the proposed project.
19	Airai	Ngerusar	002 N 01		No issue with the proposed project. Just ensure power pole location does not impact existing driveway access.
20	Airai	Ngerusar	059 N 01		No issue with the proposed project. Just

					ensure power pole location does not impact existing driveway access.
21	Ngchesar	Simizu	064 P 18		No issue with the proposed project.
22	Ngchesar	Ngersuul	045 P 09		No problem with the proposed project. Just ensure power pole location does not impact their planned future access.
23	Ngchesar	Ngersuul	059 P 01		No issue with the proposed project.
24	Ngchesar	Simizu	069 P 04		No problem with the proposed project.
25	Ngchesar	Ngersuul	069 P 03		No issue with the proposed project.
26	Ngatpang	Teluol Lius	024 L 18		No owner determined at the moment.
27	Ngatpang	Teluol Lius	023 L 03		No issue with the proposed project.

It should be noted that there may be leaseholders in Koror State that will have issues if the power poles are placed within their leased lands. While the majority of the alignment within Koror is along the main road, there are a couple of known instances that will cause difficulties to the leaseholder. One instance is the Palau Community College (PCC) campus. A recent conversation with the PPC President indicated that PCC has spent large amount of resources to place all the utilities underground to improve the campus infrastructure and aesthetics. New poles and transmission lines in front of the campus will not be appreciated. Placing the transmission line underground or overhead transmission lines across the street would be PCC's preference.

Another instance is the large lot across the National Congress building that is the planned future site of a Sheraton Hotel. The project proponent has asked PPUC to relocate the existing power poles and transmission lines to the other side of the street to avoid interference with the planned development.

2.6 Perspectives on the Project

All but one impacted private landowners that were consulted were agreeable with the project, however the majority of landowners wanted to know the exact location of the power poles to ensure that it does not affect existing or proposed future access and structures within their properties.

For the Koror and Airai states' leased lots, there may be instances that the proposed alignment of the new transmission line to be reconsidered based on individual circumstances of the lessees of the lands. PPUC should work further with the public land authorities of the respective states to address such situations.

The existing Airai substation will be improved and used for this project. There was an plan to construct a new substation in Koror near the Ngesaol area but was rejected due to future development plans at one site and construction cost at the other. One of these possible locations was an existing quarry site, however future planned development at this site, after the quarrying activities were completed, would not allow for a power substation. The other site is a submerged piece of land which would result in a substantial cost for reclamation of the site for construction of a new power substation.

3 Policy of the Acquisition

3.1 Palau's Legal Authority for Land Acquisition

As stated in Section 1.2, Palau has legal basis for land acquisition for public purpose under the Palau Constitution. Article IV, Section 6 of the Constitution states that, "the government shall take no . . . property without due process of law nor shall private property be taken except for a recognized public use and for just compensation in money or in kind." Furthermore, Article VIII, Section 7 provides that, "[t]he national government shall have the power to take property for public use upon payment of just compensation. The state government shall have the power to take private property for public use upon payment of just compensation. No property shall be taken by the national government without prior consultation with the government of the state in which the property is located. This power shall not be used for the benefit of a foreign entity. This power shall be used sparingly and only as a final resort after all means of good faith negotiation with the land owner have been exhausted." Please refer to **Attachment 1** for legal documentation on land dealings in the Republic of Palau.

There are also Statues (Palau National Code Title 35), agency rules and regulations, and previous court rulings that contain detailed provisions concerning eminent domain and related concepts and procedures.

There are also provisions in the lease agreements of State lands that reserve rights of way and easements for public use such as needed utility corridors. Koror, Airai and Ngchesar have such provisions in their lease agreements. Ngatpang State has not developed a formal lease agreement.

3.2 Comparative Analysis with JICA's Guidelines and World Bank's Safeguard Policy

This section compares Palau's land acquisition procedure with JICA's Guidelines for Environmental and Social Considerations. For the items which have inconsistencies, the measures in Table 3-1 shall be applied to make the procedure conform to JICA's Guidelines.

Table 3-1 Comparative Analysis with JICA's Guidelines

	Item	JICA's Guidelines	Current Procedure	Measures for correcting Inconsistencies
1	Approval of compensation recipients	All affected people are approved as candidate recipients of compensation regardless of their status as legal/ illegal dwellers	Since the process is for private land acquisition, compensation has only been considered for private landowners.	Lessees of government lands are eligible to request compensation if they are affected.
2	Enhancement of public participation in planning and implementation of the ARAP	Appropriate participation by the affected people and their communities should be promoted in planning, implementation and	Opportunities of public participation have not been prepared since the acquisition is based on the individual agreement.	Consultation meetings were held between January and March 2022 with the affected landowners.

		monitoring during the project period		
3	Grievance redress mechanism	Grievance redress system must be formulated and must function appropriately	Grievance redress mechanism will be established prior to the acquisition of lands needed for the project.	Grievance redress process is prepared.
4	Compensation rate	Replacement cost should be applied.	Market price is applied based on the appraisal results.	Appraised market value is used as the replacement cost.

3.3 Entitlement Matrix

Entitlement for each type of loss of this project is presented in Table 3-2.

Table 3-2 Entitlement Matrix

	Type of loss	Eligible persons	Entitlements	Remarks
1	Loss of Land	Land owners affected by the proposed project.	Compensation based on the replacement cost.	
2	Loss of Structures	Owners of structures potentially impacted by proposed project. (There are no structures anticipated to be impacted by the project.)	Compensation based on the replacement cost.	Compensation shall be made at the same time as the land acquisition because the owner of structure is the same as the landowner.
3	Loss of Trees	Owners of trees impacted by the proposed project.	Compensation based on the replacement cost. Other options may be considered such as trimming or transplant.	Compensation shall be made at the same time as the land acquisition because owner of tree is the same as the landowner.
4	Loss of Crops	Owners of crops impacted by the proposed project.	Owners are allowed to harvest the crops prior to the construction.	After the date of the agreement, planting/seeding of crops is prohibited. In the case of an easement, certain crops may be allowed.

3.4 Cut-off Date

Cut-off date is established to decide the eligibility of the affected persons. According to the World Bank's safeguard policy, persons who encroach onto the project area after the cut-off date are not entitled to compensation or any other form of resettlement assistance.

For this project, the cut-off date is June 30, 2022, which is the date after the formal survey has been completed. After the cut-off date, persons who encroach on the area are not entitled to any assistance described in this RAP.

3.5 Replacement Cost

It is the policy stated in JICA's Guidelines to compensate the loss of assets at full replacement cost. As the replacement cost needs to be based on fair market value, the current market price of the affected properties in their respective areas is presented in Table 3-3. The price was determined by a licensed land appraiser. The land values shall ensure that the acquisition of land for this project will comply with JICA's Guidelines.

Table 3-3 Fair Market Assessed Valuation of Lands and Trees

Item		Unit	Unit Price (USD)
Land	Koror		
	Commercial	m^2	200
	Residential/Commercial	m^2	120
	Residential	m^2	90
	Airai		
	Commercial	m^2	70
	Residential/Commercial	m^2	26
	Residential and Farm Land	m^2	10
	Ngchesar		
	Vacant (no zoning)	m^2	9.40*
	Ngatpang		
	Vacant (no zoning)	m^2	6.60*
Trees	Coconut (full grown and fruiting)	each	300
	Coconut (small)	each	150
	Fruit trees (large)	each	300
	Medium trees (fruit/ornamental)	each	150

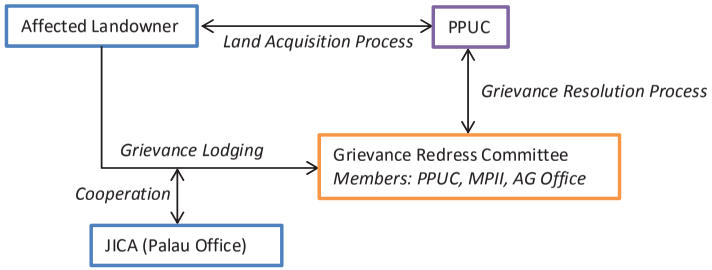
* *Land values based on highest appraised cost for Ngchesar & Ngatpang*

In regards to potentially impacted trees and other crops, an alternative redress option is to offer technical mitigation measures to prevent the loss of the tree/plant within the utility corridor. If it is feasible, trimming or transplantation of the tree/plant may be possible mitigative actions. A detailed list of potentially impacted trees in included as **Appendix 2.**

A potential structural interference may exist in Koror. The existing roof of the Palau Central Hotel may pose an obstruction with the proposed new transmission line alignment. This potential issue should be investigated and addressed.

4 Institutional Responsibility for Implementation

PPUC has overall responsibility for the implementation of the land acquisition as the executing agency of the project. The Palau's Ministry of Public Infrastructure and Industries (MPII) and the office of the Attorney General (AG) shall help the procedure in cases where grievance resolution is required as members of the Grievance Redress Committee. The JICA Palau office in shall also assist in the grievance resolution process as needed.



5 Grievance Redress Process

The grievance redress process is established with the main consideration of the possible impacts on individual's living standards and vulnerable households as part of this proposed project.

In the grievance mechanism, affected persons can request assistance or lodge a complaint in the case of the following:

- In the event that the living standards become worse due to the land acquisition, affected persons can request PPUC to provide opportunities for restoring and improving their living standards; for example, providing employment opportunity and job training at PPUC if they are able and qualified.
- In the event that the affected persons are identified as a socially vulnerable household such as low-income, elderly and/or female head of household, the affected persons can request PPUC to provide special considerations appropriate to the situation, to improve living standards diminished due to the land acquisition.
- In the event of any other issues related to the land acquisition, affected persons can lodge the complaint to PPUC/Grievance Redress Committee to discuss the solution.

Three stages are established to discuss the submitted request and/or complaint, including court proceeding as a last resort. PPUC will be liable for all administrative and legal fees that will be required through the resolution process.

1. First Stage: Initial Meeting with PPUC

2. Second Stage: Request/Complaint with Grievance Redress Committee

3. Third Stage: Court Proceedings

6 Monitoring and Evaluation

Monitoring will be conducted to ensure effective and reasonable implementation the project through the following indicators:

- Progress of the acquisition, and
- Grievances and requests from the project affected persons and the solutions.

The results of these indicators will be prepared by PPUC and reported to JICA.

7 Implementation Schedule

Expected time schedule of implementation of RAP is presented in Table 7-1. The land acquisitions by PPUC will be initiated after the RAP is approved by JICA. The grievances redress mechanism shall be prepared by the time the land acquisition process begins. Monitoring will be also be implemented after the acquisition process begins on a quarterly basis.

The schedule may be adjusted in the next phase after the preparatory survey.

Table 7-1 Tentative Schedule of RAP Implementation

		2021					2022											2023											
		8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Preparation of Draft ARAP																													
2	Meetings With Affected Landowners																													
3	ARAP Finalization and Approval by JICA																													
4	Organizational Preparations (PPUC)																													
5	Land Acquisition (Including Payments)																													
6	Grievance Redress Mechanism																													
7	Monitoring																													
	Overall Project Schedule																													
8	Preparatory Survey (JICA)																													
9	Funding Agreement																													
10	Formal Survey (final location of power poles)																													
11	Detailed Design																													
12	Construction																													

8 Cost and Budget

The cost for the land acquisition is estimated in Table 8-1, below. The areas of each private property to be acquired include the power pole location and an 8-foot (2.44 m) wide utility easement under the transmission line.

Since the exact location of the power poles needs to be determined by a licensed surveyor, the final size of the areas to be acquired shall be updated and the budget adjusted based on the survey results.

The number of trees to be removed includes trees on private and leased lands. The types of trees included fruit trees or species that are commercially valuable such as coconuts, fruit trees, betelnut and mahogany. There were no cultivated trees that will be potentially impacted within the project limits in the states of Ngchesar and Ngatpang.

As stated in Section 3.5, alternative methods to minimize the removal of affected trees may be implemented on a case-by-case basis.

The budget will be updated by PPUC.

Table 8-1 Cost Estimation for Implementing RAP

Item		Quantity	Unit	Unit Price (USD)	Amount (USD)
Acquisition of land	Koror	2,139.03	m^2	varies ($120/$90)	246,525.15
	Airai	1,900.12	m^2	$26/$m^2$	49,403.15
	Ngchesar	1,039.46	m^2	$9.40/$m^2$*	9,770.90
	Ngatpang	348.29	m^2	$6.60/$m^2$*	2,298.69
Acquisition of trees		387	each	varies	112,200.00
Contingency Cost		10	%	-	42,019.79
Grand Total					**$ 462,217.68**

* *Land values based on highest appraised cost for Ngchesar & Ngatpang*

A16-9

ATTACHMENT 1

LEGAL DOCUMENTATION

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A16-10

Subj: Legal Authorities Pertaining to Lands Contemplated for Use by the Government to Improve the Electrical Grid from Koror to Ngatpang

This legal report is made based on the following general scenario: replacing, improving, or supplementing the existing electrical grid from Koror State to Ngatpang State along the eastern portion of the Compact Road.

What follows is an overview of the various legal authorities pertaining to land acquisition for public use as they exist on November 8, 2021. Exactly how each legal requirement applies or dictates in any given situation is dependent on the facts, especially on the issue of who owns the land in each instance. For the states of Koror and Airai, ownership of most lands should already be determined and finalized but there is the possibility that ownership of some other lands are still undergoing adjudication and registration with the Land Court.[1] Wherever the planned grid is to be situated should reveal the lands at issue for which the ownership status can be investigated at the Bureau of Lands & Surveys and the Land Court.

Unless and until specific facts are presented to the undersigned attorney as to a particular land—e.g., who is the owner; is the owner an individual or a group; is the owner a lineage or a clan or a public land authority; or if ownership is not yet determined then who are the land claimants—an analysis including possible legal outcomes, options, and recommendations as to that particular land cannot be put forth.

Accordingly, the following rules are presented with the expectation that they would be reviewed first and then questions can be generated for further legal analysis as to each particular land for which there are more questions than answers.

[1] This statement as to the status of land ownership is made based on the experienced of the undersigned as former Senior Judge of the Land Court from 2007-2018.

The following rules generally follow the hierarchy of laws in Palau, starting with the Constitution being the Supreme Law of the Land and ending with leases which are contracts enforceable only between persons and entities.

1. **The Palau Constitution**

   a. Article IV, Section 6 provides in pertinent part that, "the government shall take no . . . property without due process of law nor shall private property be taken except for a recognized public use and for just compensation in money or in kind."

   b. Article XIII, Section 7 provides that, "[t]he national government shall have the power to take property for public use upon payment of just compensation. The state government shall have the power to take private property for public use upon payment of just compensation. No property shall be taken by the national government without prior consultation with the government of the state in which the property is located. This power shall not be used for the benefit of a foreign entity. This power shall be used sparingly and only as a final resort after all means of good faith negotiation with the land owner have been exhausted."

   c. Caselaw interpreting Article XIII, Section 7

      i. Several cases have interpreted Article XIII, Section 7 but probably the most relevant for present purposes is the case of *Airai State Gov't v. Ngkekiil Clan*, 11 ROP 261 (Tr. Div. 2004) (see Attachment 1). In this case, the Trial Division held that Airai State cannot use its eminent domain power to take private property to benefit a foreign entity being a foreign golf course business. Thus, for the present electrical grid project, if a foreign entity is involved in any work on the land and the power of eminent domain is to be invoked, the Government must first take the land by eminent domain for the benefit of Palauans only and not for the benefit of foreigners. Alternatively, the government can obtain easements which are not government takings because they are entered into by consensus. Easements should not trigger the bar on foreign interests accommodated by eminent domain. Easements was what the Palau Government generally used to obtain rights of way along the Compact Road.

2. **Palau's Statutes**

   a. Title 35 of the Palau National Code contains the detailed provisions concerning eminent domain and related concepts and procedures. The relevant provisions (§ 301 to § 410) are attached as Attachment 2.

3. **Agency Rules and Regulations**

   a. If only portions of lands are to be taken by eminent domain or through easements or other use rights, they should be surveyed to obtain a legal description (metes

and bounds or a cadastral lot with clear dimensions and area size). The Bureau of Lands and Surveys has its rules and regulations concerning such surveys. If this is a government project, it is to be expected that cooperation from the Bureau of Lands and Surveys will be forthcoming as to these surveying requirements.

4. Court Rules

a. If the land belongs to a lineage or clan and will be purchased by the Government with the cooperation of the lineage or clan then such a transaction has to be consented to by all senior strong members of the lineage or clan. Such a sale should undergo the public notice requirements set forth under Rule 24 of the Rules and Regulations of the Land Court, as amended by Order dated October 8, 2001 (copy attached as Attachment 3). If public notices are issued then anyone who had notice but did not file an objection within the 30-day window should be barred from later raising objections to undo the transaction.

b. If the land belongs to a lineage or clan and will be utilized under a lease, easement, public dedication, or some other form of use right, consent of the senior strong members of the clan is also required. *See generally, Demei v. Sugiyama*, 2021 Palau 2 (holding that leasing of clan lands to non-clan members requires the consent of all senior strong members of the clan) (attached as Attachment 4); public notices should also be issued pursuant to Rule 24 of the Rules and Regulations of the Land Court, as amended by Order dated October 8, 2001 (copy attached as Attachment 3).

5. Leases of Public Lands

a. Reservations for Rights of Way: most public land leases in Koror and possibly Airai contain provisions reserving rights of way and easements. A sample page (pg. 9 of 17) from one such lease with the Koror State Public Lands Authority is attached as Attachment 5 page 1. If the land at issue is a public land subject to a leasehold and is covered by such a provision then the issue is clearer as to what can be done as to the electrical grid.

b. Eminent Domain: Most public land leases in Koror and possibly Airai also contain provisions recognizing the possibility of eminent domain action. A sample page from one such lease with the Koror State Public Lands Authority is attached as Attachment 5. If the land at issue is a public land subject to a leasehold and is covered by such a provision then the issue is clearer as to what can be done as to the electrical grid. That is, the Lessee will have acknowledged ahead of time that their lease or a portion thereof can be taken by eminent domain for public use.

6. Private Leases

If the land at issue is privately-owned but has been leased by the owner to a lessee then the terms of such lease should be reviewed with respect to any reservations for public utilities. If no such provisions exist then consent by the Lessee and the Lessor should be obtained for the electrical grid requirements otherwise eminent domain may have to be exercised. END.

Sincerely,

C. Quay Polloi, Esq.

ATTACHMENT 1

AIRAI STATE GOVERNMENT,
Plaintiff,

v.

NGKEKIIL CLAN,
Defendant.

CIVIL ACTION NO. 03-207

Supreme Court, Trial Division
Republic of Palau

Decided: August 3, 2004
⊥262
ARTHUR NGIRAKLSONG, Chief Justice:

BACKGROUND

At issue in this case is land located in Oikull Hamlet in Airai State, listed as Lots N-153 and N-091, which both sides agree is owned by Defendant in fee simple. The disputed property is part of a larger tract of land upon which Plaintiff hopes a golf course will be built. To that end, the Airai State Public Lands Authority (hereinafter "ASPLA") has entered into a lease agreement with Resort Trust, Inc. (hereinafter "RTI"), a Japanese corporation established under the laws of Japan with its principal place of business at Nagoya, Japan.

Pursuant to the terms of the agreement between ASPLA and RTI, the lands authority will lease 120 hectares of land referred to as Olsiukl, including the property as issue in this case, to RTI for 25 years for the purpose of "any lawful business, including but not limited to construction and operation of a golf course, hotel(s) and condominium(s), and assorted facilities." RTI Palau, a wholly-owned subsidiary of RTI, has been granted a Foreign Investment Approval Certificate for the operation of the golf course and accompanying facilities.

After Defendant was judicially determined to own the disputed property, the Clan rejected ASPLA's offer to lease the land. Plaintiff brought this action seeking to use its power of eminent domain to condemn the disputed property. Defendant has moved for summary judgment.

DISCUSSION

Article X, Section 2 of the Airai State Constitution provides in relevant part: "The State Government shall have the power to take private property for public use upon payment of just compensation. . . . This power shall not be used for the benefit of a foreign entity . . . ."[1]

[1]The Palau Constitution also prohibits the use of the power of eminent domain "for the benefit of a foreign entity." Palau Const, art. XIII, § 7. The recently passed Airai State Public Law No. A-3-15-01, however, prohibits the use of the eminent domain power only when it is used "for the *sole* benefit of a foreign entity" (emphasis added). To the extent that A-3-15-01 purports to give the State a broader power of eminent domain than it has under either the State or national Constitution, the law is invalid. *See* Airai Const. art. II, § 2 ("Any law or act of the Government of the State of Airai which conflicts with this Constitution shall be invalid to the extent of such conflict."); Palau Const. art II, § 1 ("This Constitution is the supreme law of the land."). Consequently, it is only necessary to determine whether Airai State's attempted condemnation violates the state Constitution.

Defendant argues that Article X, Section 2 prohibits the proposed condemnation here because Airai State wants to use its eminent domain power for the benefit of RTI, a foreign entity. Plaintiff claims that the true beneficiaries would be the citizens of Airai, who would benefit from the money the Airai State Government stands to make in the transaction.

Even if Plaintiff's argument is correct, the Airai Constitution on its face prohibits the use of the eminent domain power because the ⊥263 condemnation would be for the benefit of a foreign entity. The Constitution does not require the foreign entity to be the "sole" beneficiary, and it does not include an exception for situations in which the citizens of Airai might also benefit. Very simply, it prohibits the use of the power "for the benefit of a foreign entity," which is exactly what the proposed condemnation would be.

From its inception, the Court has held that, where the language of a Constitution or statute is clear, that is the end of the inquiry. *Tellames v. Congressional Reapportionment Comm'n*, 8 ROP Intrm. 142, 143 (2000) ("When constitutional language is clear and unambiguous, we must apply its plain meaning."); *The Senate v. Nakamura*, 7 ROP 212, 217 (1999) ("We have stated time and again that courts must presume that a legislature says in a statute what it means and means in a statute what it says there. When the words of a statute are unambiguous, then, this first canon is also the last: 'judicial inquiry is complete.'") (quoting *Conn. Nat'l Bank v. Germain*, 112 S. Ct. 1146, 1149 (1992); *Ngiradilubech v. Nabeyama*, 5 ROP Intrm. 117, 119-20 (1995). ("Where the language of a statute is plain and admits of no more than one meaning, the language of the statute controls without resort to other materials."); *Yano v. Kadoi*, 3 ROP Intrm. 174, 182 (1992) "([W]here the language in a statute is unambiguous, courts are to find legislative intent in the ordinary meaning of the language alone."); *Remeliik v. The Senate*, 1 ROP Intrm. 1 (Tr. Div. 1981) ("[I]t is a cardinal rule of constitutional construction, that if a constitutional provision is positive and free from all ambiguity, it must be accepted by the courts as it is written.").

Even assuming there are ambiguities in the words "benefit" or "foreign entity" or in how the condemnation provision of the Airai Constitution is read, the guiding principle of constitutional construction is that the intent of the framers must be given effect. *Remeliik*, 1 ROP Intrm. at 5; *Palau Chamber of Commerce v. Ucherbelau*, 5 ROP Intrm. 300, 302 (Tr. Div. 1995). Although the plain language of Article X, Section 2 of the Airai Constitution is sufficient for this Court to decide the constitutionality of this condemnation proceeding,[2] a look at the history of the identical language in the national constitution, as discussed in *Gibbons v. Salii*, 1 ROP Intrm.

[2]*See Ngeremlengui State Council of Chiefs v. Ngeremlengui State Gov't*, 8 ROP Intrm. 178, 181 (2000) ("[T]he courts are required to give effect to the intent of the framers as expressed in the plain meaning of the language used in the constitution."); *The Senate,* 7 ROP Intrm. at 214 ("In determining the framers' intent, we look first to the language chosen.").

333 (1986), confirms that the framers intended to prohibit the use of the power of eminent domain in situations such as this one.[3] On the question of what constitutes a "foreign entity," the Constitutional Convention's Committee on General Provisions defined "foreign entity" to include "any entity whether a person, a ⊥264 government, a corporation, or other association or group, which is neither a citizen of Belau nor totally owned by citizens of Belau." SCR No. 30 (March 4, 1979). Since RTI is a Japanese company and RTI Palau is a wholly-owned subsidiary of RTI, both clearly are foreign entities.

As for the question of what constitutes a "benefit," the history of the constitutional provision shows that Article XIII, Section 7 prohibits the use of the power of eminent domain for the benefit of a foreign entity even if the Palauan people might also benefit. The 1979 Rosenblatt cable seeking changes in the proposed constitution to avoid conflicts with the Compact of Free Association warned that the proposed text, "*public use* does not include use by a foreign entity" might "be inconsistent with the U.S. responsibility for and authority in the defense of Palau under the Compact" (emphasis added), putting the Compact at risk. Instead of abandoning the sentence, however, the framers decided to amend it in a way that makes it clear that it applies to situations such as the one here, settling on the current language that the "[eminent domain] power shall not be used for the benefit of a foreign entity." The limit on the power of eminent domain remained even after the Drafting Commission proposed deleting the sentence from Article XIII, Section 7 because keeping the provision "would seriously undermine the ability of the constitutional government of Palau to fulfill its obligations under a compact of free association and thus close the door to a political relationship of free association." *Report to the Palau Legislature from the Palau Constitutional Drafting Commission*, at 6 (Aug. 21, 1979).

Thus, the framers risked losing the Compact and the benefits it would bring to the people of Palau in order to protect a citizen's right not to have his property taken by the government. Therefore, the history of the provision at issue shows that the framers wanted to preclude the use of the power of eminent domain for the benefit of a foreign entity, even if the people would also benefit.

The Appellate Division reached the same conclusion in *Gibbons*, which considered the constitutionality of a provision of the Compact of Free Association and Military Use and Operating Rights Agreement that obligated Palau to make available land and water areas designated by the United States for use by the United States military. *Gibbons*, 1 ROP Intrm. at 333. After finding that the United States qualified as a "foreign entity," the Court rejected the Republic of Palau's claim that the benefit to the United States was not relevant because the Compact would also benefit the people of Palau.

This reasoning would render meaningless the constitutional position against

[3]Although this case arises out of the Airai Constitution, it is appropriate to look at the history of the national Constitution in order to interpret the relevant language. *See, e.g.*, *Gotina v. ROP*, 8 ROP Intrm. 65 (1999) (looking to United States case law because Palau's consitutional prohibition against excessive fines is derived from a comparable clause in the U.S. Constitution); *State v. Ramirez* , 597 N.W.2d 795 (Iowa 1999) (noting the propriety of looking to the United States Constitution in order to interpret a provision of the Iowa State Constitution because the Iowa Constitution took the language of the provision at issue directly from the United States Constitution).

> exercise of eminent domain for the benefit of a foreign entity. Eminent domain is the power exercised by the Executive Branch and the "benefit" language is obviously intended as a curb upon the powers of that branch. Surely the government would only invoke the power of eminent domain after concluding that exercise of the power would be beneficial to the people of Palau. The government's position is, in essence, that the eminent domain clause prevents the government from exercising such powers to provide land for a foreign entity, except when the ⊥265 government has decided that it would be good to do so. That is not what Article XIII, Section 7 says.
>
> The clause unambiguously prohibits the use of the power of eminent domain for a foreign entity. At the very least, this means that if the land in question is to be used by a foreign nation the government of the Republic of Palau has an extremely heavy burden of showing extraordinary circumstances which establish that the particular use is for the sole benefit of Palauan persons or entities.

Gibbons, 1 ROP Intrm. at 354-55.

Plaintiff in this case observes that the United States would have had the right to select the sites to be condemned in *Gibbons*, while the site here has already been determined. Airai also notes that *Gibbons* involved a foreign nation, while the beneficiary here would be a foreign corporation; that if RTI decides not to pursue the golf course project, the state will search for another developer; and that the land will be returned to its rightful owners when the lease expires in 25 years. But the State fails to explain why any of these minor distinctions should change the analysis or the outcome. The fact remains that, as in *Gibbons*, a foreign entity will benefit from the condemnation, leaving Airai State with "an extremely heavy burden of showing extraordinary circumstances which establish that the particular use is for the sole benefit of Palauan persons or entities." If the millions of dollars and national defense benefits that would have gone to the people of Palau from the Compact did not qualify as "extraordinary circumstances," then the generation of revenue for Plaintiff–the stated purpose of the proposed condemnation–cannot qualify, either.

Defendant has also filed motion seeking attorney's fees. Although Plaintiff's argument is not a winning one, it is not groundless, frivolous, or brought in bad faith as required for sanctions under ROP R. Civ. P. 11 or 14 PNC § 702. Accordingly, Defendant's motion for an award of attorney's fees is denied.

CONCLUSION

For the foregoing reasons, Defendant's motion for summary judgment is granted. Article X, Section 2 of the Airai State Constitution on its face clearly prohibits the use of eminent domain for the benefit of a foreign entity. The *Gibbons* Court reading of the identical provision in the National Constitution is consistent with the plain meaning of the Airai State Constitution. Hence, this condemnation proceeding is hereby declared unconstitutional.

ATTACHMENT 2

Chapter 3
Eminent Domain

Subchapter I
General Provisions

§ 301. Purpose.

It is the purpose of this chapter to set up procedures to be followed by the national government in the exercise of its inherent power to acquire real property by eminent domain.

Source
(Code 1966, § 1301; Code 1970, tit. 10, § 1.) 10 TTC § 1, modified.

Cross-reference
ROP Const., Art. XIII, § 7.

Notes
Wally v. ROP, 16 ROP 19, 23 (2008).
Ngiralois v. Trust Territory, 4 TTR 517 (App. Div. 1969).
In re Ngiralois, 3 TTR 303 (1967).

§ 302. Private corporations not to have right of eminent domain.

No private corporation except as may be authorized by the Olbiil Era Kelulau shall have the right of eminent domain in the Republic.

Source
(Code 1966, § 1303; Code 1970, title 10, § 2; Department of Interior Order No. 2969, § 8(a).) 10 TTC § 2, modified.

Notes
Wally v. ROP, 16 ROP 19, 23 (2008).

§ 303. Definitions.

In this chapter:

(a) "Eminent domain" means the right of the national government to condemn property for public use or purposes and to appropriate the ownership and possession of such property for such public use upon paying the owner a just compensation to be ascertained according to the law.

(b) "Public use" shall be construed to cover any use determined by the President to be a public use.

Source
(Code 1966, § 1302; Code 1970, title 10, § 3; Department of Interior Order No. 2969, § 8(b).) 10 TTC § 3, modified.

Notes
Wally v. ROP, 16 ROP 19, 23 (2008).
Ngiralois v. Trust Territory, 4 TTR 517 (App. Div. 1969).
In re Ngiralois, 3 TTR 303 (1967).

Subchapter II
Procedure

§ 311. Complaint.

A complaint must be brought in the Trial Division of the Supreme Court in the name of and on behalf of the national government as plaintiff by the Attorney General. The complaint must contain:

(a) the names of all owners and claimants of the property, if known, or a statement that they are unknown, who must be called defendants.

(b) a statement of the right or authority of the plaintiff.

(c) a description of each parcel of land to be acquired and a statement of what interest in the land is desired by the plaintiff.

(d) a general statement of the purpose of the taking.

Source
(Code 1966, § 1304; Code 1970, title 10, § 51.) 10 TTC § 51, modified.

Notes
Wally v. Republic of Palau, 17 ROP 109, 110 (2010).
Wally v. ROP, 16 ROP 19, 23 (2008).
In re Kabua, (App. Div. June 1978).

§ 312. Failure of parties to appear at proceedings.

In the event of the failure of any of the parties specified in section 311 of this title to appear in the proceedings, the court shall, nevertheless, proceed to fix the amount of compensation and order that the amount be paid by the national government, without interest, to the rightful claimants on demand at any time within seven years from the date of the final judgment.

Source
(Code 1966, § 1311; Code 1970, title 10, § 52.) 10 TTC § 52, modified.

Notes
Wally v. Republic of Palau, 17 ROP 109, 110 (2010).
Wally v. ROP, 16 ROP 19, 23 (2008).

§ 313. Issuance of summons; contents.

The Clerk of Courts shall issue a summons which shall contain:

(a) the names of the parties;

(b) a general description of the whole property, or a reference to the complaint for the description of the land; and

(c) a notice to the defendants to appear in the proceedings.

Source
(Code 1966, § 1305.) 10 TTC § 53(1), first sentence, modified.

Notes
Wally v. Republic of Palau, 17 ROP 109, 110 (2010).
Wally v. ROP, 16 ROP 19, 23 (2008).

§ 314. Service of summons and complaint; posting.

(a) When the defendants are known the summons shall be served by delivering to them a copy thereof along with a copy of the complaint.

(b) If the defendants, whether known or unknown, cannot be found, then a copy of the summons and complaint shall be posted as follows:

(1) on the property;

(2) at the courthouse;

(3) at a public place in a village located near the property; and

(4) by delivering one copy of the summons and complaint to the chief executive officer of the state in which the property is situated.

(c) The service of the summons and the complaint or the posting thereof as provided herein shall be sufficient to give the Trial Division of the Supreme Court jurisdiction to proceed with and finally determine the case.

Source
(Code 1966, § 1305.) 10 TTC § 53(1) (except first sentence) and (2), modified.

Notes
Wally v. Republic of Palau, 17 ROP 109, 110 (2010).
Wally v. ROP, 16 ROP 19, 23 (2008).

§ 315. Establishment of value of land; assessors.

(a) Upon a prima facie showing by the Attorney General that the property desired to be purchased by the national government is for public use, the court must hear the parties, and establish a fair value for the land.

(b) The court may appoint three assessors to assist in the proceedings and perform such functions as the court may direct.

(c) In the event assessors are appointed by the court, they shall take and subscribe an oath before the judge or justice that they will faithfully perform their duties as assessors.

Source
(Code 1966, § 1306.) 10 TTC § 54, modified.

Notes
Wally v. Republic of Palau, 17 ROP 109, 110 (2010).
Wally v. ROP, 16 ROP 19, 23 (2008).
In re Ngiralois, 3 TTR 303 (1967).

§ 316. Determination of ownership in event of dispute.

In the event there is a dispute over the ownership of the property which is the subject of an eminent domain proceeding, the court shall adjudicate and determine the ownership of the property as part of the proceedings.

Source
(Code 1966, § 1307.) 10 TTC § 55.

Notes
Wally v. Republic of Palau, 17 ROP 109, 110 (2010).
Wally v. ROP, 16 ROP 19, 23 (2008).

§ 317. Final judgment; certificate of title.

(a) The record of the final judgment in the proceedings shall state the particular land or interest in land which the national government has acquired and the compensation to be paid to the defendants.

(b) The Clerk of Courts shall issue a certificate of title in accordance with the judgment.

Source
(Code 1966, § 1308.) 10 TTC § 56, modified.

Notes
Wally v. Republic of Palau, 17 ROP 109, 110 (2010).
Wally v. ROP, 16 ROP 19, 23 (2008).

§ 318. Immediate possession; procedure generally.

(a) In the event the national government desires to enter into immediate possession of the property, it shall file a declaration of taking and pay a sum of money which is considered to be the fair value of the property to the Clerk of Courts.

(b) In addition to the requirements set out in section 313 of this title, the summons shall state the following:

(1) that the plaintiff requires immediate possession of the property;

(2) that a sum of money which is considered to be the fair value of the property has been paid to the Clerk of Courts, which sum shall draw interest at the rate of three percent per annum from the date of the summons until claimed by the defendant or ordered paid to the defendant by the court;

(3) that the defendant may at any time claim and receive the money which has been deposited with the Clerk of Courts upon the execution of a quitclaim deed in favor of the plaintiff.

(c) Payment to the Clerk of Courts in accordance with this section shall entitle the national government to take immediate possession of the land.

Source
(Code 1966, § 1309.) 10 TTC § 57, modified.

Notes
Wally v. Republic of Palau, 17 ROP 109, 110, 111, 112, 113, 114 (2010).
Wally v. ROP, 16 ROP 19, 21, 23, 24, 25 (2008).
In re Kabua, (App. Div. June 1978).

§ 319. Same; possession after proceedings commenced.

(a) In the event the national government determines that it requires immediate possession of the property after eminent domain proceedings have been commenced, but before the rights of the parties and the amount of compensation are determined, a declaration of taking shall be filed in the court and a sum of money which is considered to be the fair value of the land shall be paid to the Clerk of Courts.

(b) A summons shall be issued and served in the same manner as the summons in

sections 313 and 314 of this title. The summons shall refer to the original summons already served on the defendants, and shall otherwise conform to the requirements set out in section 318 of this title.

Source
(Code 1966, § 1310.) 10 TTC § 58, modified.

Notes
Wally v. Republic of Palau, 17 ROP 109, 110 (2010).
Wally v. ROP, 16 ROP 19, 23 (2008).
In re Kabua, (App. Div. June 1978).

§ 320. Costs of proceedings.

The costs in all cases brought under this chapter shall be paid by the plaintiff.

Source
(Code 1966, § 1312.) 10 TTC § 59.

Notes
Wally v. ROP, 16 ROP 19, 23 (2008).

Chapter 4
Land Acquisition

§ 401. Application of chapter.

This chapter shall be applicable to the acquisition of real property under the laws of the Republic for use in any project or program of the national government, a state government, or any agency of such government.

Source
(P.L. No. 6-71, § 1.) 67 TTC § 451, modified.

§ 402. "Government" defined.

In this chapter, "government" means the national government, a state government, or any agency of such government.

Source
35 PNC § 402.

§ 403. Procedure generally; government conduct encouraged or required.

(a) In acquiring real property the government will, to the greatest extent practicable:

(1) make every reasonable effort to acquire real property expeditiously through negotiation.

(2) before the initiation of negotiations, have the real property appraised and give the owner or his representative an opportunity to accompany the appraiser during the inspection of the property.

(3) before the initiation of negotiations, establish an amount which is believed to be just compensation for the real property, and make a prompt written offer to acquire the property for that amount.

(A) In no event will the just compensation offered be less than the government's approved appraisal of the fair market value of such property.

(B) At the time the government makes an offer to purchase real property, the owner of that property will be provided with a written statement of the basis for the amount estimated to be just compensation.

(C) In determining just compensation for the property, any increase or decrease of the fair market value caused by the public improvement for which the property is acquired prior to the date of valuation will be disregarded (other than that caused by physical deterioration).

(4) if interest in the real property is to be acquired by exercise of the power of eminent domain, institute formal condemnation proceedings and not intentionally make it necessary for the owner to institute legal proceedings to prove the fact of the taking of the real property.

(5) if the acquisition of only part of the property will leave its owner with an uneconomic remnant, offer to acquire that remnant.

(b) Before requiring any owner to surrender possession of any real property, the government will:

(1) pay the agreed purchase price; or

(2) deposit with the court, for the benefit of the owner, an amount not less than the government's approved appraisal of the fair market value of the property; or

(3) pay the amount of the award of compensation in condemnation proceedings for the property.

Source
67 TTC § 452(1), modified.

§ 404. Same; government conduct discouraged.

In acquiring real property, to the greatest extent practicable the government will not:

(a) schedule construction or development of a public improvement that will require any person lawfully occupying real property to move from a dwelling, or move his business or farm operation, without giving that person at least 90 days' written notice of the date he is required to move.

(b) if acquired property is rented to the former owner or tenant for a short term or subject to termination by the government on short notice, charge a rent that is more than the fair rental value of the property to a short term occupant.

(c) advance the time of condemnation.

(d) defer negotiations, condemnation or deposit of funds in court for use of the owner.

(e) take any course of action to compel an owner to agree to a price for his property.

Source
67 TTC § 452(2), modified.

§ 405. Unauthorized or inverse condemnation; litigation expenses to owner.

Should a court determine condemnation was unauthorized or should the property owner obtain a judgment in the nature of inverse condemnation, then the owner shall be reimbursed for reasonable expenses of litigation, in line with section 304 of the United States' Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970.

Source
67 TTC § 452(3), modified.

Commission Comment
Section 304 of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646) is found at 42 U.S.C. § 4654.

§ 406. Donation by owner allowed.

Nothing in sections 403 through 405 should be construed to preclude a donation by an owner after his property has been appraised and the full amount of the estimated just compensation has been tendered to him.

Source
67 TTC § 452(4), modified.

§ 407. Interest in improvements.

In acquiring any interest in real property the government will acquire at least an equal interest in all building structures or other improvements located on that real property which will be removed or which will be adversely affected by the completed project.

Source
(P.L. No. 6-71, § 1.) 67 TTC § 453.

§ 408. Payments for improvements by tenants.

(a) In the case of a building structure or other improvements owned by the tenant on real property acquired for a project to which this chapter applies, the government will, subject to subsection (c) of this section, pay the tenant the larger of:

(1) the fair market value of the improvement (as established by the government's appraiser), assuming its removal from the property; or

(2) the enhancement to the fair market value of the real property.

(b) Payments will also be made for improvements that are damaged as well as those which must be removed.

(c) A payment may not be made to a tenant under subsection (a) of this section unless:

(1) the tenant, in consideration for the payment, assigns, transfers and releases to the government all his rights, title and interest in the improvements;

(2) the owner of the land involved disclaims any interest in the

improvements; or

(3) the payment is not duplicated by any payment otherwise authorized by law or regulation.

Source
(P.L. No. 6-71, § 1.) 67 TTC § 454, modified.

§ 409. Expenses incidental to transfer of title.

As soon as possible after real property has been acquired, the government shall reimburse the owner for:

(a) recording fees, taxes and similar expenses incidental to conveying the real property to the agency; and

(b) the penalty cost for prepayment of any pre-existing recorded mortgage entered into in good faith and encumbering the real property.

Source
(P.L. No. 6-71, § 1.) 67 TTC § 455.

§ 410. Authority of President to promulgate regulations.

The President shall have authority to issue regulations to implement this chapter.

Source
(P.L. No. 6-71, § 1.) 67 TTC § 456, modified.

ATTACHMENT 3

IN THE
SUPREME COURT OF THE REPUBLIC OF PALAU

IN RE AMENDMENT NO. 1 TO RULES AND REGULATIONS OF THE LAND COURT	)))	ORDER

Pursuant to the rule-making power vested in the Supreme Court, in consultation with the Land Court, by 35 PNC § 1316, Article X, § 14 of the Constitution, and 4 PNC § 101,

Rule 24 of the RULES AND REGULATIONS OF THE LAND COURT, promulgated on October 15, 1996 to take effect on October 18, 1996, is amended as follows:

"(A) Transfers of Land Owned by Persons or Entities other than Clans or Lineages. When transfer of title or interest in registered land occurs, the Senior Land Court Judge shall cancel the certificate and issue a new certificate of title to the transferee. If only a part of the land is transferred, the Land Court shall require the certificate holder to have the area to be transferred surveyed at his own expense, and a map thereof submitted to the Senior Land Court Judge. If satisfactory to the Senior Judge, a new certificate of title shall then be issued for each part of the land covered by the former certificate.

Upon receiving a request for or notice of transfer, the Senior Land Court Judge must determine that the document of transfer is properly executed and properly describes the land before canceling the existing certificate and issuing a new certificate of title. In doing so, the Senior Judge may order such notice and hearing as deemed appropriate.

The owner's duplicate certificate must be submitted for proper cancellation upon a request for or notice of transfer. If the owner's duplicate certificate has been lost, destroyed or is otherwise unavailable, the new owner may request the Land Court to issue a replacement duplicate certificate. Such request shall be by petition under oath. The replacement certificate shall include a statement that it is issued in place of a lost or destroyed certificate.

(B) Transfers of Land Owned by a Clan or Lineage. The procedures for transferring land owned by a clan or lineage shall be governed by section (A) except that no certificate of title based on a transfer of such land shall issue unless notice has been given that any strong senior member of the lineage or clan may object to the transfer by filing an objection with the Land Court by a specified date which is 30 days after notice is posted as required by section (B)(1). The notice shall describe the land to be transferred and shall indicate the identity of the transferee and the persons acting for the clan or lineage in the transfer. Notice shall be given as follows:

(1) by posting notice for at least 30 days in both English and the principal local language of the state in which the land is located at the Post Office, the Office of the Clerk of the Supreme Court in Koror, the Land Court, and in the state office and the principal meeting place in the village in which or nearest to which the land is located; and

(2) by placing an advertisement to appear within the 30 days specified in section (B)(1) and in the languages specified in section (B)(1) on a local Koror radio station and in a local newspaper.

(C) Transfers of Land by Will or Inheritance. Transfers of interests in land by will or by inheritance shall be determined by the Trial Division of the Supreme Court. Upon determination by the Trial Division of the proper devisee or heir, the Trial Division shall order the Land Court to cancel the decedent's duplicate certificate and the original certificate bound in the permanent register and to issue a new original certificate and duplicate certificate in favor of the devisee or heir.

The Land Court may establish a fee schedule and charge for issuance of new or replacement certificates."

SO ORDERED THIS 8th DAY OF October, 2001

ARTHUR NGIRAKLSONG
Chief Justice

LARRY W. MILLER
Associate Justice

R. BARRIE MICHELSEN
Associate Justice

KATHLEEN M. SALII
Associate Justice

A16-21

ATTACHMENT 4

IN THE SUPREME COURT OF THE REPUBLIC OF PALAU APPELLATE DIVISION

ROBAT DEMEI and NGEDIKES GIBBONS,
Appellants/Cross-Appellees,
v.
MARY HIROKO SUGIYAMA, BONICACIO EBERDONG, UODELCHAD INES SANTOS, DIRCHOLSUCHEL MARY THING, and KEKEREI EL TECHEDIB TIMOTHY NGIRDIMAU,[1]
Appellees/Cross-Appellants.

Cite as: 2021 Palau 2
Civil Appeal No. 19-019
Appeal from Civil Action No. 18-077

Argued: November 2, 2020
Decided: January 14, 2021

Counsel for Appellants ..... J. Uduch Sengebau Senior
Counsel for Appellees ..... Johnson Toribiong

BEFORE: GREGORY DOLIN, Associate Justice
KATHERINE A. MARAMAN, Associate Justice
DENNIS K. YAMASE, Associate Justice

Appeal from the Trial Division, the Honorable Oldiais Ngiraikelau, Presiding Justice, presiding.

OPINION

MARAMAN, Associate Justice:

[¶ 1] This matter arose after Ngeribkal Clan prevailed in its return of public lands claim against Koror State Public Lands Authority ("KSPLA")[2]

[1] Because certain clan titles, and therefore the ability to bring suit on behalf of the clan, are disputed in this case, we have altered the caption to remove Ngeribkal Clan and all disputed clan titles. *See Etpison v. Obichang*, 2020 Palau 8 n.1.

[2] The land returned to the Clan is referred to as *Bkulatiull* and is located in Ngerbeched.

and Appellant Robat Demei, acting as the Clan's chief, began entering into new leases with individuals who were up until that point KSPLA's tenants, some of whom are not Clan members. The parties dispute whether Demei had the authority to enter into these leases. The trial court concluded that although a clan's chief has authority to manage land within the clan, in order to alienate property (including by lease) in favor of non-clan members, the consent of all senior strong members is required. The trial court further concluded that because such consent was not obtained in the present case, none of the litigants had the authority to unilaterally enter into the leases. Finally, the trial court held that Demei holds the Clan's male chief title but that none of the parties demonstrated that she holds the female chief title. Because we discern no error in the trial court's factual findings or application of the law, we **AFFIRM**.

BACKGROUND

[¶ 2] We here sketch the basic factual background and provide some additional details as necessary in the analysis below. Ngeribkal Clan has three lineages started by three sisters, Ewalech, Saulwai, and Kiklang. The highest male title is *Ngiribkal* and the highest female title is *Dirribkal*. It is undisputed that Rengulbai Ngirdimau was *Ngiribkal* at the time the Clan filed its return of public lands claim. The last uncontested *Dirribkal* was a woman named Tolilang, who passed away in 2013. It is also undisputed that individuals on both sides of this dispute are *ochell* members of Ngeribkal Clan. In addition, the trial court specifically found, and the parties do not challenge, that there are senior strong members on both sides: Appellants Demei and Ngedikes Gibbons, and Appellees Mary Hiroko Sugiyama and Ines Santos.

[¶ 3] Appellees sought a declaratory judgment that, among other things, (1) Demei and Gibbons have no authority to negotiate or execute the leases; (2) Appellee Bonicacio Eberdong is *Ngiribkal*; and (3) Sugiyama is *Dirribkal*. Appellants counterclaimed seeking a mirror image declaration that (1) Demei is *Ngiribkal*; (2) Gibbons is *Dirribkal*; and (3) Eberdong and Sugiyama have no authority to enter into the leases. In their closing argument at trial, Appellees urged the court to refrain from deciding the title disputes and instead to base its judgment as to Sugiyama's authority to administer the land on the fact that she was chosen by the then-*Ngiribkal* to represent the Clan in court during its return of public lands claim. According to Appellees, this appointment is binding on the other Clan members, and the authority to

administer the successfully reclaimed land was inherent in her appointment, especially in light of the fact that she spent considerable time and personal resources in the reclamation process.

[¶ 4] On August 9, 2019, the trial court concluded, in its Findings of Fact and Conclusions of Law, that Demei is the male titleholder. However, the court also concluded that, as a matter of customary law, Demei cannot grant leases or use rights to non-clan members without the consent of the senior strong members of the Clan. Because the trial court found that Appellees include such members, it held that leases entered into by Demei are invalid. Next, the trial court held that there was insufficient evidence to conclude that either Gibbons or Sugiyama is the Clan's female titleholder, and therefore the court declined to enter judgment in favor of either party on this issue. Finally, the court rejected Sugiyama's argument that she had the authority to enter into the leases on the basis of her prior representation of the Clan in the return of public lands process.

[¶ 5] Both sides timely appealed. Appellants object to the finding that there is insufficient evidence that Gibbons is the female titleholder, whereas Appellees challenge the finding that Demei is the male titleholder, the finding of insufficient evidence to establish that Sugiyama is the female titleholder, and the trial court's conclusion that Sugiyama's representation of the Clan in the return of public lands process did not vest her with the authority to administer the land following its return.

STANDARD OF REVIEW

[¶ 6] We review a trial court's legal conclusions, including its application of customary law, de novo, and its findings of fact for clear error. *Etpison v. Ngeruluobel Hamlet*, 2020 Palau 10 ¶ 16; *Beouch v. Sasao*, 20 ROP 41, 50 (2013).

DISCUSSION

[¶ 7] Appellants/Cross-Appellees argue that Demei's testimony that "when Tolilang passed away . . . Ngerair was one of those who appointed Ngedikes to be Dirribkal," Trial Tr. at 135:11-13, and Demei's identification of Ngerair as a child of Lucy Orrukem combined with evidence that Orrukem previously held the *Dirribkal* title, undermines the trial court's conclusion that "there was

a complete lack of evidence on the identity of the people who [allegedly] appointed" Gibbons to be *Dirribkal*. Findings of Fact and Conclusions of Law (Aug. 9, 2019) at 12. Although we agree with Appellants that the evidence of Gibbons' appointment as *Dirribkal* is more substantial than the trial court's decision would lead one to believe, we conclude that the trial court's statement about a lack of evidence does nothing to undermine its ultimate conclusion. It is well established "that the ourrot of all lineages of a clan must reach a consensus" regarding the appointment of the female titleholder in order for it to be valid. *Ngirmang v. Orrukem*, 3 ROP Intrm. 91, 95 (1992). In contrast, the testimony Appellants proffered at trial and point to on appeal merely establishes that one individual, who may or may not have been an *ourrot* member of the Clan at the time, participated in the appointment. Thus, although there may have been an attempt by some individuals to install Gibbons as *Dirribkal*, the evidence is insufficient to establish, by a preponderance of the evidence, that Gibbons was appointed by consensus of the *ourrot* of all three lineages of the Clan. *See Sungino v. Benhart*, 20 ROP 215, 217 (2013) ("The burden of proof . . . belongs to the individual or group seeking to establish their status within the clan."). Therefore, the trial court's misdescription of the state of the evidence was harmless. Because the "mistake did not affect the outcome, it would be senseless to vacate and remand for reconsideration." *Sea "B" Mining Co. v. Addison*, 831 F.3d 244, 253 (4th Cir. 2016); s*ee also Ngiraiwet v. Telungalek ra Emadaob*, 16 ROP 163, 165 (2009) ("Harmless errors are those that do not prejudice a particular party's case."). This Court "will not reverse a lower court decision due to an error where that error is harmless." *Ngiraiwet*, 16 ROP at 165.

[¶ 8] Appellees/Cross-Appellants raise three issues on appeal. First, they argue that Sugiyama must be the female titleholder because she was appointed by women from all three lineages of the Clan.[3] The trial court agreed with the basic legal proposition that appointment of a female titleholder must involve *ourrot* from all lineages of a clan. Applying the law to the facts before it, however, the court concluded that there was insufficient evidence that Sugiyama was properly appointed. Although one woman from each lineage

[3] Before the trial court, Appellees contended that a resolution of the disputed titles was unnecessary, but, as previously described, the court rejected this argument and made a ruling regarding the disputed female title.

may have participated in the appointment, there was, in the court's view, insufficient evidence that two of them, Appellee Mary Thing and Karen Kohama, were *ourrot*.[4] Neither Thing nor Kohama testified, and Appellees' briefs do not point to anything in the record that demonstrates their services to and status in the Clan. "It is not the Court's duty to . . . scour the record for any facts to which [an] argument might apply." *Idid Clan v. Demei*, 17 ROP 221, 229 n.4 (2010). Because Appellees fail to point this Court to any evidence that Thing and Kohama were *ourrot*, we cannot hold that the trial court's finding regarding the lack of evidence on this point was clearly erroneous. *See Rudimch v. Rebluud*, 21 ROP 44, 46 (2014) ("[T]he burden of demonstrating error on the part of a lower court is on the Appellant.").

[¶ 9] Second, Appellees challenge the trial court's finding that Demei, rather than Eberdong, is *Ngiribkal*. The trial court found that Demei was properly appointed to hold the title in 2004 because the women who appointed him included the contemporaneous holder of the female title, his mother, Dirramekar. *See Kebliil ra Uchelkeyukl v. Ngiraingas*, 2018 Palau 15 ¶ 11 ("This court has previously recognized that it is the female chief title holder who ultimately chooses the male chief title holder."). Appellees' argument that Demei does not hold the title rests almost entirely on their contention that Demei improperly leased the Clan's land.[5] However, Appellees do not cite (and our own research has failed to reveal) any customary law or other basis to support the proposition that one's mishandling of clan lands has any direct effect on that individual's status as the clan's titleholder. To the contrary, once a titleholder is properly installed, customary law requirements must be met in order to remove him, even where the titleholder acts beyond his authority. *See Filibert v. Ngirmang*, 8 ROP Intrm. 273, 275-77 (2001) (discussing the procedure for removing a titleholder); *Espangel v. Diaz*, 3 ROP Intrm. 240, 246

[4] The trial court declined to rule that Thing and Kohama are not *ourrot*. The court also noted that Gibbons was clearly a senior strong member of the Clan and did not participate in the appointment.

[5] In the fact section of their brief, Appellees cite Sugiyama's testimony that Clan members never gathered to appoint Demei, but the trial court was free to credit this testimony or the conflicting testimony in favor of Appellants' position, and we will not overturn credibility determinations on appeal absent extraordinary circumstances. *See, e.g.*, *Ngermengiau Lineage v. Estate of Isaol*, 20 ROP 68, 71 (2013).

(1992) ("The removal of the title [] from appellee amounts to a deprivation of a vested right."). Accordingly, we discern no error by the trial court.

[¶ 10] Appellees also contend that the trial court should have found that Eberdong was the titleholder "because the majority of the *ourrot* representing the consensus of the lineages . . . support him." Appellees' Opening Br. at 23. However, the only individuals who claim to have appointed Eberdong are Sugiyama, Kohama, and Santos, as well as Agatha Eberdong, Demei's sister. As already discussed, there was no evidence that Kohama was an *ourrot* member of the Clan, nor do Appellees point to any such evidence regarding Agatha Eberdong. Perhaps most fundamentally, according to Appellees' own argument, Eberdong was appointed in 2015, *i.e.*, eleven years after Demei was appointed to hold the title. As there is no evidence that Demei's title was revoked, it follows that Eberdong's appointment was a legal nullity. *See Filibert*, 8 ROP Intrm. at 275-77; *Espangel*, 3 ROP Intrm. at 246. Even assuming that Eberdong's alleged appointment could, in theory, be viewed as an act that somehow removed Demei from his position, on appeal, we "may not reweigh the evidence, test the credibility of witnesses, or draw inferences from the evidence." *Seventh Day Adventist Mission of Palau, Inc. v. Elsau Clan*, 11 ROP 191, 195 (2004) (internal quotation marks omitted). Therefore, where, as here, "there are two permissible views of the evidence, the fact finder's choice between them cannot be clearly erroneous." *Id.* In sum, we discern no clear error in the trial court's factual findings regarding the *Ngiribkal* title.

[¶ 11] Lastly, Appellees contend that as a result of Sugiyama's appointment to represent the Clan in its return of public lands claim against KSPLA, she was conferred authority to administer the Clan's returned land. We agree with the trial court that this argument finds no support in Palauan customary law, our precedent, or the nature of Sugiyama's appointment by the then-chief of the Clan. It is well settled that "clan or lineage land is administered by the strongest male member, normally the title bearer." *Ngirudelsang v. Etibek*, 6 TTR 235, 239 (Palau Tr. Div. 1973). Although a clan can, by consensus among the senior strong members, choose to forgo traditional arrangements and select who will serve as a trustee of its land, *see, e.g.*, *Elbelau v. Beouch*, 3 ROP Intrm. 328, 331 (1993), the record is devoid of evidence that Ngeribkal Clan's custom differs from the traditional method of administering clan land, or that

it chose to deviate from its custom. We also discern no error, let alone clear error, in the trial court's factual finding that, despite Sugiyama's selection to be the Clan's "voice[,] and eyes[,] and ears," during the return of public lands process, *see* Trial Tr. at 56:19, and the undisputed fact that Sugiyama largely financed the return of lands proceeding out of her own pocket, "[s]he was only appointed to represent the clan in court and she did," Findings of Fact and Conclusions of Law at 17. Appellees have not pointed to any basis in the record or in customary law for interpreting Sugiyama's appointment more broadly. Nor do Appellees' remaining (and underdeveloped) arguments about equitable estoppel, waiver, and ratification undermine the trial court's conclusion regarding the specific and limited scope of Sugiyama's appointment.

CONCLUSION

[¶ 12] In summary, the trial court's findings that none of the litigants proved they were properly appointed *Dirribkal*, and that Demei is *Ngiribkal* but lacks authority to unilaterally lease the Clan's lands to non-clan members, are **AFFIRMED** in their entirety.[6]

[6] As we have recently noted, the parties had the right to seek declaratory relief in the Trial Division regarding their dispute over clan titles. *See Lakobong v. Blesam*, 2020 Palau 28 ¶ 7 n.3; *see also* 14 PNC § 1001 ("In a case of actual controversy within its jurisdiction, any appropriate court of the Republic, upon the filing of an appropriate pleading, may declare the rights and other legal relations of any interested party seeking such declaration, whether or not further relief is or could be sought."); *Kiuluul v. Elilai Clan*, 2017 Palau 14 ¶¶ 10-15. However, once the trial court determined that neither Demei nor Sugiyama had the authority to execute the leases on the land, the title disputes became untethered from any discrete, real-world dispute over the exercise of legal authority. Furthermore, according to the parties at oral argument, the resolution of the title disputes by the trial court or this Court will do little to quell the internecine conflicts that are roiling the Clan and its surrounding community. As we stated in *Lakobong*, the time may be ripe for this Court to reassert, as a prudential matter, its ability to decline to determine those internal clan title disputes that are not connected to specific disputes over land or an exercise of legal authority, and which cannot be satisfactorily resolved through litigation. *See* 2020 Palau 28 ¶ 7 n.3; *Matlab v. Melimarang*, 9 ROP 93, 97 (2002) (suggesting that "the issuance of declaratory relief concerning the seating of a title holder is at odds with this Court's repeated insistence that the selection of a title bearer is not the courts' responsibility"), *overruled on other grounds by Kiuluul*, 2017 Palau 14 ¶ 6.

DOLIN, Associate Justice, concurring *dubitante*:

[¶ 13] I join the Court's judgment insofar as it affirms the trial court's conclusion that neither Demei nor Sugiyama has the authority to unilaterally lease the Clan land to non-clan members. I am also constrained to say that, under the current governing caselaw, and applying the clear error standard of review, the Court's resolution of the issues regarding Clan titles is correct. However, I hesitate to fully endorse that part of the opinion because I have grown increasingly skeptical of the wisdom of this Court adjudicating intra-clan title disputes that are untethered to any dispute over land or other legal right.

[¶ 14] On the one hand, we have held not only that the courts have jurisdiction over customary law disputes, *see, e.g.*, *Espangel v. Diaz*, 3 ROP Intrm. 240, 245 (1992), but that to the extent we have "jurisdiction over a dispute[, we] should usually exercise it," *Koror State Legislature v. KSPLA*, 2017 Palau 28 ¶ 16. On the other hand, we have repeatedly and consistently said that "[t]he selection of a title bearer is the Clan's responsibility, not the Court's." *Lakobong v. Blesam*, 2020 Palau 28 ¶ 7 (quoting *Sato v. Ngerchelong State Assembly*, 7 ROP Intrm. 79, 81 (1998)); *see also Matlab v. Melimarang*, 9 ROP 93, 97 (2002), *overruled on other grounds by Kiuluul v. Elilai Clan*, 2017 Palau 14 ¶ 6; *Filibert v. Ngirmang*, 8 ROP Intrm. 273, 276 (2001). Although these directions may seem inconsistent, upon a careful reading of our precedent, it becomes apparent that they are not. Thus, *Kiuluul* did not *require* courts to exercise jurisdiction over title disputes governed by customary law; rather, it reaffirmed that "the decision whether to entertain claims for declaratory relief is 'committed to the sound discretion of the trial court.'" 2017 Palau 14 ¶ 5 (quoting *Filibert*, 8 ROP Intrm. at 276); *see also id.* ¶ 7 ("noting that nothing in the language of [ROP] Rule [of Civil Procedure] 57 purports to create an absolute right in any party to [] a declaration[,]" but that "under its plain language, it places discretion in the trial court, creating an opportunity—not a duty—to grant relief to qualifying litigants"). Similarly, although the *Koror State Legislature* Court reversed the Trial Division's *constitutional* holding, which concluded that the Palauan Constitution, like the U.S. one, imposes a standing requirement for the court to exercise jurisdiction, 2017 Palau 28 ¶ 22, it endorsed the notion that, as a *prudential* matter, cases

over which this Court has jurisdiction may nevertheless be non-justiciable, *id.* ¶¶ 23-24. In my view, over the past several years our courts have adjudicated intra-clan disputes without sufficiently considering whether, as a prudential matter, these contests "may be inappropriate for consideration for other [than constitutional] reasons." *Id.* ¶ 23 (quoting *PCSPP v. Udui*, 22 ROP 11, 14-15 (2014)).

[¶ 15] Because "the decision whether to entertain claims for declaratory relief is 'committed to the sound discretion of the trial court,'" *Kiuluul*, 2017 Palau 14 ¶ 5 (quoting *Filibert*, 8 ROP Intrm. at 276), I cannot be sure (certainly not without the benefit of briefing and argument on the issue) that the decision to adjudicate the title disputes in the present case was erroneous. Because I cannot be certain of the error, I concur in the Court's judgment on these issues. However, because discretion merely "denotes the absence of a hard and fast rule," and must be "exercised not arbitrarily or willfully, but with regard to what is right and equitable under the circumstances and the law," *Etpison v. Obichang*, 2020 Palau 8 ¶ 40 (Dolin, J., concurring) (quoting *Langnes v. Green*, 282 U.S. 531, 541 (1931)), we should take the earliest possible opportunity to authoritatively set forth the factors that would militate for or against the exercise of jurisdiction in such disputes.

[¶ 16] At the end of the day, disputes over clan titles that are untethered to disputes over land or other legal rights are mostly disputes about the status and respect accorded to the claimant within a clan. Such respect is not conferred by judicial decree but is earned over years, if not decades, of providing services to a clan and building strong bonds within it. For this reason, though the Constitution and the Declaratory Judgment Act grant us the power to resolve such intra-clan disputes, in my view this power should be exercised rarely and gingerly. *Cf. Aitaro v. Koror State Gov't*, 15 ROP 175, 179 (Tr. Div. 2008) ("When title or customary disputes are resolved through traditional means, such resolutions can only strengthen traditions and customs."). I look forward to the day when the Court clarifies this area of the law and reinvigorates the prudential justiciability doctrine as it applies to "naked" title disputes.

Section 13.2. Roads and Drainage. The KSPLA reserves the right and easement to construct and maintain on the Property boundaries, roads and related drainage. The KSPLA shall have reasonable discretion to decide the matter of where such boundaries, roads and related drainage shall be situated, but the roads and drainage shall take into account the existence of improvements situated on the property.

Section 13.3. Right to Remove. This reservation of Rights of Way and Easements shall include the right to remove trees, vegetation, signage and other obstructions which may, in the KSPLA's sole discretion, need to be removed in order to carry out the purposes of this section; said removal shall be without compensation to the Lessee.

SECTION 14. LIENS, TAXES & ASSESSMENTS.

Section 14.1. Tax Liens. Lessee shall keep the Property and all improvements thereon free and clear of liens, taxes, encumbrances and other charges. Lessee shall immediately pay any such lien, tax, encumbrance or charge that is reduced to judgment.

Section 14.2. Taxes. Lessee shall promptly pay all taxes, licenses, fees, assessments and other charges levied upon the Property (or any interest in the Property) as they become due, and upon request shall provide KSPLA with proof of such payment.

Section 14.3. Indemnification. Lessee shall protect, indemnify and hold harmless the KSPLA, the Lease and the Property (and all KSPLA interest therein and improvements thereupon) from all claims, tax assessments and other charges, and from all costs, including attorneys, court and expert witness fees, in connection therewith.

SECTION 15. EMINENT DOMAIN.

Section 15.1. Complete Taking. If during this Lease the entire Property is taken by eminent domain, then Lessee' entire leasehold interest and all other Lessee' rights hereunder shall terminate on the actual date of such taking and the KSPLA shall refund any excess rent paid by Lessee. In any condemnation proceeding that may be brought pertaining to the Property, Lessee shall be entitled to file and to prosecute a claim against the condemnor for the value of its leasehold interest in the Property and for the value of its interest in the improvements and the KSPLA shall be entitled to pursue a claim against the condemnor for the full value of its interest in the Property and the Property improvements.

Section 15.2. Partial Taking. In the event of a partial taking by eminent domain, this Lease shall remain in effect covering the property not taken, except that the annual Base Rent shall be reduced by an amount equivalent to the square meter area taken multiplied by the per-square-meter Base Rent rate in effect at the time of the taking.

Section 15.3. Award Apportionment. All compensation awarded by reason of such taking shall be divided between Lessee and the KSPLA according to their respective interests in the Lease, the Property, the Property's improvements, and in the remainder at the time of such taking.

Initials: W.C

A16-26

ATTACHMENT 2

DETAILED LIST OF IMPACTED TREES

KOROR STATE
Potential Tree Impact Survey

NO.	LOT NO	LOCATION	OWNER/LEASEE	Type	Medium Size	Large Size
1	098 B 001	MALAKAL	Customs & PPUC Offices (KSPLA)	Coconut		4
2	098 B 001	MALAKAL	Koror State Public Works (KSPLA)	Coconut		4
3	098 B 001	MALAKAL	Koror State Public Works (KSPLA)	Mango		1
4	098 B 001	MALAKAL	Koror State Public Works (KSPLA)	Mahogany		1
5	098 B 001	MALAKAL	Koror State Public Works KSPLA)	Ficus		2
6	098 B 001	MALAKAL	Kione Isechal (KSPLA)	Coconut		2
7	098 B 001	MALAKAL	Kione Isechal (KSPLA)	Mango	1	
8	098 B 005	MALAKAL	Ephram Policarp/Me So Hungry (KSPLA)	Coconut		2
9	None	MALAKAL	Fish n Fins/Bilung Building	Mahogany	1	
10	None	MALAKAL	Fish n Fins/Bilung Building	Tropical Almond (miich)		1
11	128 B 003	MEDALAII	Chinese Restaurant/Palau Ocean Divers	Coconut		2
12	128 B 004	MEDALAII	Temmy Shmull	Coconut	1	
13	127 B 001	MEDALAII	Inaria Tomei	Betelnut		21
14	127 B 001	MEDALAII	Former Kosiil Nightclub (Hiromi Nabeyama)	Mango	1	
15	127 B 001	MEDALAII	Trebkul Bedor	Coconut		1
16	127 B 001	MEDALAII	Dianne Delutaoch	Coconut		1
17	127 B 001	MEDALAII	IA Building	Ornamental		1
18	127 B 001	MEDALAII	Lily Nakamura/King Palace Rstaurant	Mahogany		1
19	127 B 001	MEDALAII	Former Surangel Headquarters	Coconut	2	
20	127 B 001	MEDALAII	Elma Oiterong	Coconut	1	
21	None	MEDALAII	PNCC Future Office	Mango		1
22	None	MEDALAII	PNCC Future Office	Bamboo		1
23	None	MEDALAII	NECO Plaza	Mahogany		5
24	None	MEDALAII	NECO Plaza	Mango		1
25	109 B 008	MEDALAII	PCC (KSPLA)	Tropical Almond (miich)		2
26	109 B 008	MEDALAII	PCC (KSPLA)	Coconut		6
27	109 B 008	MEDALAII	PCC (KSPLA)	Mango	2	
28	None	MEDALAII	OEK	Coconut		14
29	044 B 004	IKELAU	Palau Central Hotel (Harry jr. & Dallas Rengii)	Top of Building		
30	043 B 005	MEKETII	Blai ra Meketii (Ibedul)	Coconut		8
31	039 B 006	MEKETII	Itungelbai Lineage	Coconut		3
32	039 B 006	MEKETII	Itungelbai Lineage	Betelnut		2
33	039 B 010	MEKETII	Bem Tuchakl (Ngirmidor Clan)	Betelnut		6
34	039 B 010	MEKETII	Bem Tuchakl (Ngirmidor Clan)	Mango	1	
35	040 B 006	MEKETII	HE Budget Mart 1 (Tkel & Tatsuo Ada)	Coconut		1
36	None	MEKETII	Across Pin An Hardware	Mountain Apple (Rebotel)		3
37	062 B 04	NGERKESOWAOL	Catholic Mission	Mango		1
38	062 B 04	NGERKESOWAOL	Catholic Mission	Betelnut		15
39	062 B 04	NGERKESOWAOL	Catholic Mission	Coconut		1
40	030 B 018	NGERKESOWAOL	Society of St. Francis Xavier Member	Mango		1
41	123 B 001	NGERKESOWAOL	Watanabe Residence (KSPLA)	Mango		1
42	116 B 002	NGERKESOWAOL	Tmetbab Clan (Clara Residence)	Tropical Almond (miich)		5
43	023 B 004	NGERKESOWAOL	George Rechucher (corner of Ngerkesowaol entrance)	Mahogany	1	
44	023 B 004	NGERKESOWAOL	George Rechucher (corner of Ngerkesowaol entrance)	Coconut		1
45	134 B 009/015	NGERKESOWAOL	Before PIDC	Mahogany		12
46	134 B 009/015	NGERKESOWAOL	Before PIDC	Avocado		1
47	134 B 009/015	NGERKESOWAOL	Before PIDC	Mango		1
48	Road ROW	NGERKESOWAOL	Fronting PIDC	Bamboo		1
49	141 B 001	NGERKESOWAOL	CJ Ngirakelsong (KSPLA)	Coconut		1
50	141 B 001	NGERKESOWAOL	Lily Nakamura (KSPLA)	Coconut		7
51	021 B 026	NGERCHEMAI	Before Katey's/Melwert Tmetuchl	Ukall		4
52	021 B 021	NGERCHEMAI	Katey's/Melwert Tmetuchl	Coconut		9
53	021 B 021	NGERCHEMAI	Katey's/Melwert Tmetuchl	Mahogany		7
54	021 B 021	NGERCHEMAI	Katey's/Melwert Tmetuchl	Betelnut		4
55	055 B 02	NGERCHEMAI	George Rechucher	Coconut		29
56	055 B 01	NGERCHEMAI	George & Cindy Rechucher	Mahogany		1
57	055 B 01	NGERCHEMAI	George & Cindy Rechucher	Mango		1
58	055 B 01	NGERCHEMAI	George & Cindy Rechucher	Coconut		37
					11	237

Total Tree Count:	248

Medium Tree Price: $150.00
Large Tree Price: $300.00

$1,650.00	$71,100.00	**Total Tree Price:**	**$72,750.00**

Koror & Airai Total Trees:	387
Koror & Airai Total Cost:	**$112,200.00**

AIRAI STATE
Potential Tree Impact Survey

NO.	LOT NO	LOCATION	OWNER/LEASEE	Type	Medium Size	Large Size
1	ASPLA	NGETKIB	Surangel & Sons Company	Tropical Almond (Miich)	1	
2	ASPLA	NGETKIB	Surangel & Sons Company	Coconut	2	
3	027 N 002	NGETKIB	Kukumai Rudimch	Coconut		27
4	097 N 008	NGETKIB	Simeon Eberdong (Eisei)	Coconut		6
5	097 N 008	NGETKIB	Simeon Eberdong (Eisei)	Mango		1
6	097 N 008	NGETKIB	Simeon Eberdong (Eisei)	Betelnut		8
7	097 N 011	NGETKIB	Unknown (after Eisei)	Mahogany		2
8	029 N 004	NGETKIB	Ngermellong Clan	Betelnut		10
9	029 N 004	NGETKIB	Ngermellong Clan	Breadfruit		1
10	029 N 009	NGETKIB	Betty Salvador residence	Mountain Apple (Rebotel)		1
11	028 N 012	NGERULOBEL	Airai Water Paradise & Spa	Coconut		13
12	ASPLA	NGERULOBEL	Tmetuchl Annex	Tropical Almond (Miich)	1	
13	ASPLA	NGERULOBEL	Tmetuchl Annex	Coconut		4
14	ASPLA	NGERULOBEL	Tmetuchl Annex	mango	1	
15	ASPLA	NGERULOBEL	Tmetuchl Annex	Betelnut		3
16	ASPLA	NGERULOBEL	High Speed Auto Repair	Coconut		2
17	ASPLA	NGERULOBEL	High Speed Auto Repair	Tropical Almond (Miich)		1
18	024 N 014	NGERULOBEL	Ghandi Baules	Coconut		1
19	024 N 014	NGERULOBEL	Ghandi Baules	Mango		1
20	024 N 013	NGERULOBEL	Roman Tmetuchl Family Trust	Coconut		1
21	ASPLA	NGERULOBEL	Kelib Telei	Btaches	1	
22	ASPLA	NGERULOBEL	Kelib Telei	Coconut	4	
23	024 N 015	NGERULOBEL	Ngeruluobel Hamlet/Techur Rengulbai	Coconut		2
24	009 N 01	NGERUSAR	Irikl Clan	Coconut		2
25	009 N 01	NGERUSAR	Irikl Clan	Betelnut		6
26	009 N 01	NGERUSAR	Irikl Clan	Mango	1	
27	None	NGERIKIIL	Olidiil Store/John Oiph	Mango	1	
28	None	NGERIKIIL	Olidiil Store/John Oiph	Coconut		2
29	None	NGERIKIIL	Dr. Yano	Mango	1	
30	None	NGERIKIIL	Dr. Yano	Coconut		2
31	None	NGERIKIIL	Dr. Yano	Mahogany	2	
32	None	NGERIKIIL	Dr. Yano	Betelnut		4
33	None	NGERIKIIL	Dr. Yano	Coconut		6
34	None	NGERIKIIL	Dr. Yano	Monkeypod		2
35	None	NGERIKIIL	Dr. Yano (Elilai Yano residence)	Coconut		4
36	None	NGERIKIIL	Dr. Yano	Coconut		12
					15	124

Total Tree Count:	139
Total Tree Price:	**$39,450.00**

Medium Tree Price: $150.00
Large Tree Price: $300.00

$2,250.00	$37,200.00

A16-27

17. 事故対応に関する提言

17. 事故対応に関する提言（案）

1. 現状の PPUC の事故対応手順

現状、PPUC では、事故対応マニュアルは作成していないが、PPUC へのインタビューを行い、以下の手順で事故対応を行っていることを確認した。図１に現状の事故対応フローを示す。

＜事故対応手順＞

①変電所のリレーにより事故情報を確認

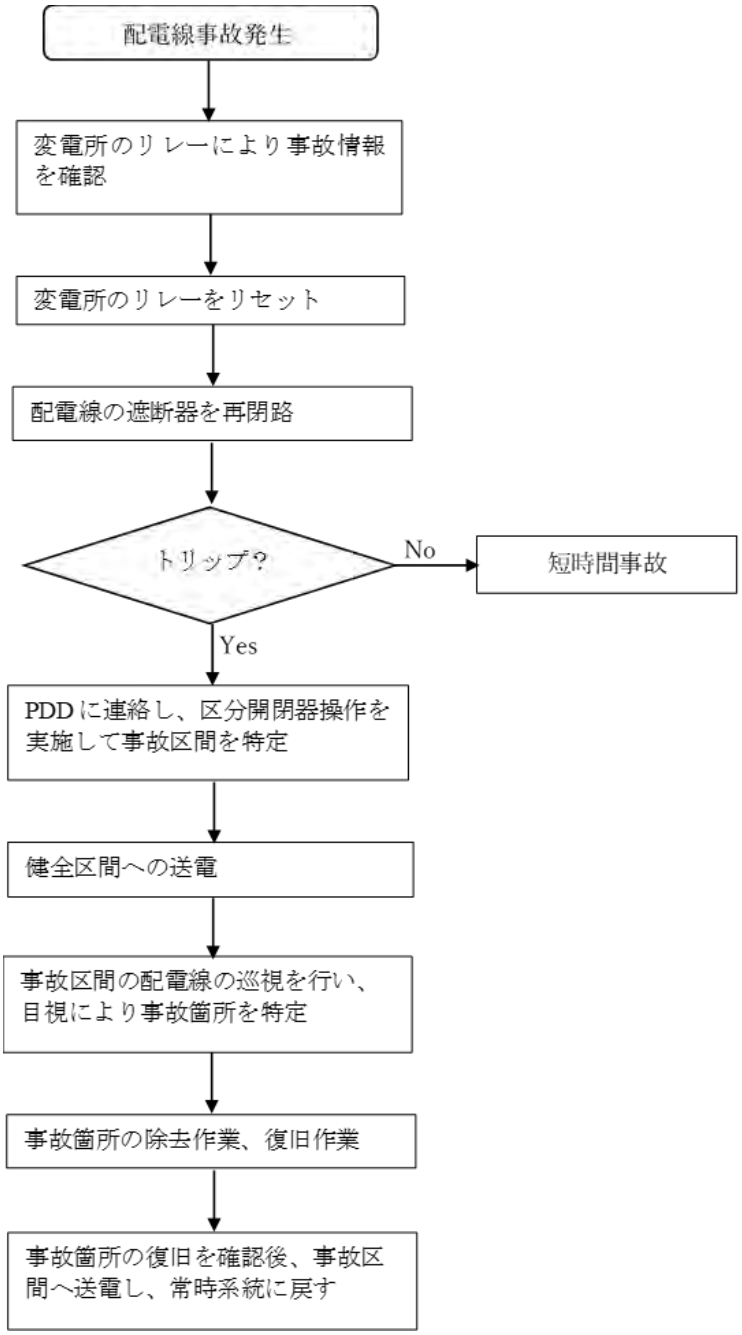
②変電所のリレーをリセット

③変電所の遮断器を再閉路

④再度トリップした場合、PDD（Power Distribution Division）の担当者に連絡し、区分開閉器の操作を実施して、事故区間を特定。(順次電源側から区分開閉器区間ごとに送電し、送電区間に事故箇所がある場合、変電所遮断器がトリップ）健全区間には送電する。

⑤事故区間の配電線の巡視を行い、目視により事故箇所を特定し（メガ―を所有しているが、あまり活用していない)、事故箇所の除去作業、復旧作業を行う。

⑥事故箇所の復旧を確認後、事故区間へ送電し、常時系統に戻す。



出典：PPUC 資料を元に調査団作成

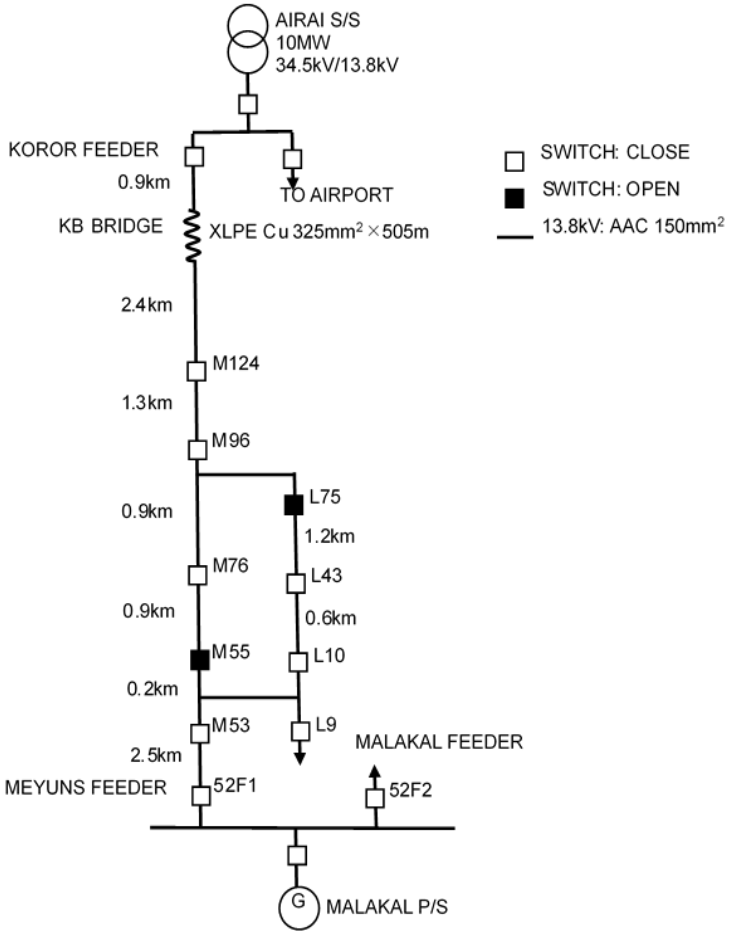
図 1　現状の事故対応フロー

2. コロール線の運用に関する課題と対策

アイライ変電所のコロール線及びマラカル発電所のミユンズ線の常時 13.8kV 幹線系統図を図 2 に示す。ミユンズ線で配電線事故が発生し、コロール市街地が停電し M53～M55 開閉器間が健全区間の場合、PPUC は M53 開閉器を「切」、M55 開閉器を「入」としてコロール市街地へコロール線で供給する運用を行っている。

なお、M53 開閉器～M55 開閉器の間で国立総合病院（Belau National Hospital）に供給しているが、同病院は自家用発電設備を所有しており、燃料補給をしない場合、8 時間まで運転可能である。

今後の需要増加を考慮すると、コロール変電所の建設が最善の解決策であるが、それまでの暫定的な運用では、更に電圧降下対策（自動電圧調整器（SVR）、キャパシタバンク等）が必要になる場合もある。



出典：PPUC 資料を元に調査団作成

図 2　13.8kV 幹線系統図
（アイライ変電所～マラカル発電所）

また、PPUC は今年中にコロール線及びミユンズ線の全ての区分開閉器の老朽化による取替を計画している。

3. ミユンズ線の運用に関する課題と対策

ミユンズ線は常時 M55 開閉器まで供給しており、マラカル発電所の運用制約のため常時の配電容量 3.5MW を上限としている。しかし、コロール線で配電線事故が発生し、コロール市街地が停電し M55～M96 開閉器間が健全区間の場合、PPUC は M96 開閉器を「切」、M55 開閉器を「入」としてコロール市街地へミユンズ線で供給する運用を行っている。マラカル発電所の遮断器 52F1 のリレー設定は 7.5MW であり、非常時の 13.8kV 幹線の運用上の配電容量は 5.5MW を上限としており、過負荷にならないよう注意して運用している。

また、メンテナンス等によりアイライ変電所が停電の場合についても、配電容量を超過し

ないよう最大 M124 開閉器までミユンズ線から供給する運用を行っている。コロール線と同様に、今後の需要増加を考慮すると、更に電圧降下対策（自動電圧調整器（SVR）、キャパシタバンク等）が必要になる場合もある。

4. PPUC への提言

現状の PPUC での事故復旧手順、コロール線、ミユンズ線の運用等を踏まえて次の事項について PPUC に提言する。

(1) 事故対応マニュアルの作成

現状、PPUC では、事故対応マニュアルを作成していないとのことであるが、運用ルールを明確にすることで、属人的ではなく組織的な運用が可能となり、信頼度向上、品質向上に資するとともに、ノウハウの継承、対応能力の維持向上に繋がることから、事故対応マニュアルの作成を推奨する。

(2) メガ―等の事故探査装置の活用

PPUC では事故区間の配電線の巡視の際、目視により事故箇所を特定している。（メガ―を所有しているが、あまり活用していない。）夜間は目視による事故箇所の特定が困難であり、昼間でも目視で発見できない場合も想定される。早期復旧、停電時間の短縮に有効であるためメガ―等の事故探査装置の活用を推奨する。

(3) 事故時の過負荷・電圧降下のチェック方法の確立

コロール線、ミユンズ線で配電線事故が発生した場合、双方の健全区間へ送電するため送電容量の過負荷、電圧降下のチェックが必要である。可能な限り停電時間を短縮し、停電区間を極小化するため、あらかじめ曜日・時間帯等により電流、電圧を計算しておき、オペレータが事故時に送電可否を迅速に判断できるようチェック方法を決めておき、事故対応マニュアルに反映することを推奨する。

(4) 事故時の対応に関する訓練

上記、(1)～(3)は策定・導入するだけではなく、訓練等を通じて対応能力を維持向上させることが重要である。定期的な事故時の対応に関する訓練を推奨する。

(5) 事故データの記録、分析、対策策定

PPUC では、事故データを記録し、Excel データで保管しているが、事故データの分析及び対策策定等の対応は未実施である。PPUC にヒアリングしたところ、事故の約 95%は樹木に起因する事故であり、残りの 5%は動物や車両衝突、その他に起因する事故であるとのこと。停電実績と詳細な停電原因等、データ分析に基づいた効果的かつ効率的な対策が重要である。このため、事故分析に必要な情報を記録、収集し、そのデータを分析し、短期及び中長期的な対策を策定・実施する必要がある。

5. 想定事故対応マニュアル（案）

想定される事故対応マニュアル（案）は以下のとおり。

(1) アイライ変電所 34.5/13.8kV 変圧器事故

①アイライ変電所の 13.8kV 側遮断器（コロール線、エアポート線）を「切」とする。

②変圧器 1 次側の復旧作業を実施する。
③コロール線の M76、M96、M124 開閉器のいずれかを「切」、M55 開閉器を「入」とし、ミユンズ線の運用上の配電容量までの電力を送電する。（あらかじめ曜日、時間帯等により電流、電圧を計算しておき、送電できる範囲を決めておく）
④変圧器 1 次側の復旧作業完了後、M55 開閉器を「切」、③の「切」開閉器を「入」とし、常時系統に戻す。
⑤アイライ変電所の 13.8kV 側遮断器（コロール線、エアポート線）を「入」とする。
（注）現状、エアポート線は、逆送可能な 13.8kV 配電線がないが、コロール変電所の建設によりエアポート方面への配電ルートが構築できる。

(2) コロール線事故
①変電所のリレー情報により事故情報を確認
②変電所のリレーをリセット
③変電所の遮断器を再閉路
④再度トリップした場合、PDD（Power Distribution Division）の担当者に連絡し、区分開閉器操作を実施して、事故区間を特定。（順次電源側から区分開閉器「入」操作を実施し、送電区間に事故箇所がある場合、変電所遮断器がトリップ）健全区間には送電する。
⑤ミユンズ線と連系箇所のコロール線が健全区間である場合、コロール線の M76、M96、M124 開閉器のいずれかを「切」、M55 開閉器を「入」とし、ミユンズ線の運用上の配電容量までの電力を送電する。（あらかじめ曜日、時間帯等により電流、電圧を計算しておき、送電可否を判断する）
⑥事故区間の配電線の巡視を行い、目視及びメガ―等の事故探査装置により事故箇所を特定
⑦事故箇所において、公衆安全のための安全措置を行う。
⑧事故箇所の除去作業、復旧作業を行う。
⑨事故箇所の復旧を確認後、事故区間へ送電し、常時系統に戻す。

(3) ミユンズ線事故
①変電所のリレー情報により事故情報を確認
②変電所のリレーをリセット
③変電所の遮断器を再閉路
④再度トリップした場合、PDD（Power Distribution Division）の担当者に連絡し、区分開閉器操作を実施して、事故区間を特定。（順次電源側から区分開閉器「入」操作を実施し、送電区間に事故箇所がある場合、変電所遮断器がトリップ）健全区間には送電する。
⑤M53～M55 開閉器間が健全区間の場合、M53 開閉器を「切」、M55 開閉器を「入」とし、コロール線の運用上の配電容量までの電力を送電する。（あらかじめ曜日、時間帯等により電流、電圧を計算しておき、送電可否を判断する）
⑥事故区間の配電線の巡視を行い、目視及びメガ―等の事故探査装置により事故箇所を特

定

⑦事故箇所において、公衆安全のための安全措置を行う。

⑧事故箇所の除去作業、復旧作業を行う。

⑨事故箇所の復旧を確認後、事故区間へ送電し、常時系統に戻す。

18. 系統解析（コロール変電所建設時）

18. 系統解析（コロール変電所建設時）

1. 需要想定

(1) 需要想定

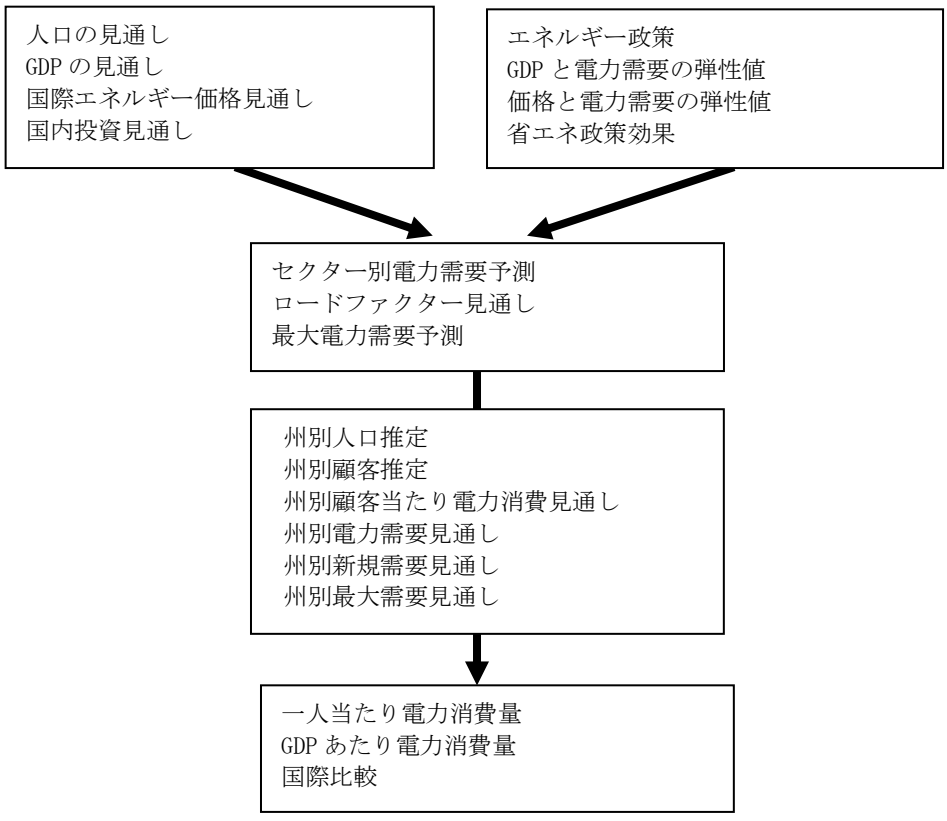
コロール島及びバベルダオブ島の需要は、2019 年に貴機構で実施した「パラオ国送配電システム改善・維持管理強化計画策定プロジェクト」（以下、前回 MP 案件と称す）で想定しており、パラオ側の合意を得ている。

以下に前回 MP 案件時における需要想定の概要について記載したのち、本調査におけるコロール島及びバベルダオブ島の需要想定結果について説明する。

1) 前回 MP 案件時の需要想定

a) 需要予測の手法

需要予測は、セクターごとに電力エネルギー需要を求め、その後、最大需要や発電量を求める。また、送配電計画のために州別の電力需要予測を行う。本モデルフローは図 1.1 のとおりである。



出典：調査団作成

図 1.1 電力需要予測フロー

上記の電力需要予測フローに従い電力需要予測モデルを構築する。

b)　電力需要予測式

計算される電力消費セクターは商業部門・公共部門・家庭部門・送配電ロスである。これら部門の予測値を合計することで PPUC の電力需要量となる。予測の手順を以下に示す。

各セクターは GDP に対する弾性値を過去の推移から計算する。弾性値の計算では、2000 年から 2016 年までの全データを使った長期弾性値と 2010 年から 2016 年までのデータを使った短期弾性値の２つを計算し、今後の弾性値の推移を設定する。

・商業部門と公共部門の場合

Ln（セクター別電力消費）＝a*Ln（セクター別 GDP）- b*Ln（セクター別電力料金）＋c

・家庭部門の場合

Ln（家庭部門での電力消費）＝a*Ln（一人当たり所得）- b*Ln（家庭部門の電力料金）＋c

ここで Ln は自然対数の意、「a」は GDP 弾性値、「b」は価格弾性値となる。

上記の弾性値を使い以下の式で商業部門、公共部門、家庭部門の電力需要を求める。

＜商業部門と公共部門の電力需要予測式＞

Yt ：セクター別電力需要（t 年の MWh）
a　：セクター部門の GDP 弾性値
b　：電気料金弾性値
省エネ率 : 省エネ効果を需要に対する比率で設定、省エネ効果は毎年累積的に効果を発する。

$Yt = Y_{t-1}$*（1 ＋ a*セクター別 GDP 伸び率）*（1 - b*電気料金上昇率）
***（1 - 省エネの効果上昇率/100）**

＜家庭部門の電力需要予測式＞

Yt ：家庭部門の電力需要（ t 年の MWh）
a　：一人当たり所得に対する弾性値
b　：電気料金弾性値
省エネの効果上昇率：省エネ効果を需要に対する比率で設定

$Yt = Y_{t-1}$*（1 ＋ a*一人当たり所得伸び率）*（1 - b*電気料金上昇率）
***（1 - 省エネの効果上昇率/100）**

上記の電力需要予測手法より算出された州別のピーク需要予測及びその構成比を表 1.1 及び表 1.2 に示す。表 1.2 に示すとおり、パラオの人口が集中しているコロール州では、電力需要の大半を消費しており、国全体の約 66%を占めている。なお、その他州においては、アイライ州を除き、それぞれ 5%以下の電力消費となっている。

表 1.1　州別ピーク需要予測（前回 MP 案件時）

単位：kW

	2016	2017	2018	2019	2020	2021	2022	2023	2024
Aimeliik	453	459	470	481	492	505	514	524	533
Airai	2,535	2,587	2,680	2,776	2,909	3,071	3,209	3,351	3,496
Koror	7,985	8,127	8,445	8,775	9,396	9,807	10,176	10,554	10,941
Melekeok	438	445	459	472	487	503	515	668	712
Ngaraard	88	89	93	96	100	104	106	143	157
Ngardmau	37	38	39	40	41	43	44	45	46
Ngaremlengui	100	102	105	108	111	114	116	119	121
Ngatpang	61	62	64	65	67	69	70	72	73
Ngchesar	46	46	48	49	50	52	53	54	55
Ngarchelong	79	80	82	84	87	89	91	104	117
Ngiwal	49	50	52	53	54	56	57	58	60
Total	11,870	12,090	12,530	13,000	13,790	14,410	14,950	15,690	16,310

	2025	2026	2027	2028	2029	2030	2031	2032	2035
Aimeliik	543	551	559	568	570	573	576	578	586
Airiai	3,656	3,745	3,844	3,937	3,997	4,058	4,120	4,182	4,367
Koror	11,395	11,650	11,911	12,178	12,327	12,477	12,628	12,782	13,254
Melekeok	792	841	927	1,031	1,054	1,078	1,090	1,103	1,141
Ngaraard	356	373	427	445	496	510	511	513	519
Ngardmau	47	48	49	50	50	51	52	52	54
Ngaremlengui	124	126	128	131	132	133	134	135	139
Ngatpang	74	76	77	78	79	80	80	81	83
Ngchesar	56	57	58	60	60	61	61	62	64
Ngarchelong	131	145	159	173	186	198	211	224	226
Ngiwal	61	62	63	64	65	65	66	66	68
Total	17,240	17,670	18,200	18,710	19,020	19,280	19,529	19,778	20,501

出典：パラオ国送配電システム改善・維持管理強化計画策定プロジェクト

表 1.2　州別ピーク需要構成比（前回 MP 案件時）

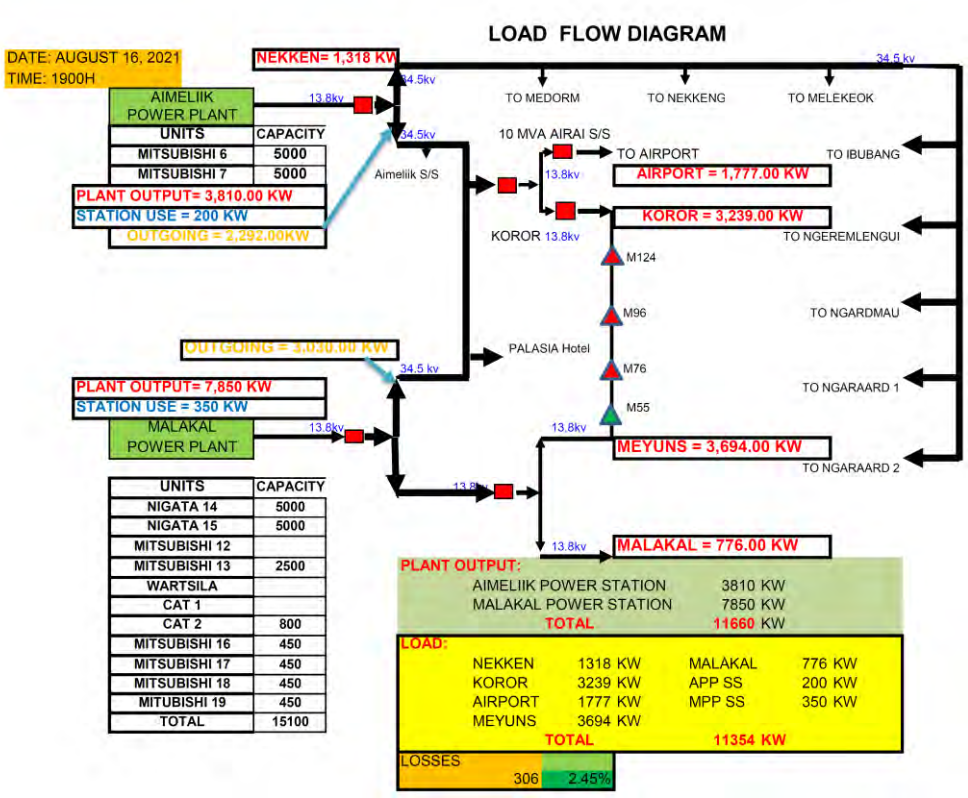
単位：%

	2016	2017	2018	2019	2020	2025	2030	2035
Aimeliik	3.8	3.8	3.7	3.7	3.6	3.2	3.0	2.9
Airai	21.4	21.4	21.4	21.4	21.1	21.2	21.0	21.3
Koror	67.3	67.2	67.4	67.5	68.1	66.1	64.7	64.7
Melekeok	3.7	3.7	3.7	3.6	3.5	4.6	5.6	5.6
Ngaraard	0.7	0.7	0.7	0.7	0.7	2.1	2.6	2.5
Ngardmau	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ngaremlengui	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7
Ngatpang	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4
Ngchesar	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Ngarchelong	0.7	0.7	0.7	0.6	0.6	0.8	1.0	1.1
Ngiwal	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3
Koror+Babeldaob	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

出典：パラオ国送配電システム改善・維持管理強化計画策定プロジェクト

2)　ピーク需要の実績

図 1.2 に調査時点（2021 年 8 月）における最新の実績潮流を示す。ピーク需要は 11.354MW であり、これに対する供給はアイメリーク発電所 3.810MW、マラカル発電所 7.850MW の合計 11.660MW であり、送電損失は 0.306MW で損失率は 2.62%であった。



出典：PPUC

図 1.2　ピーク時実績潮流（2021 年 8 月）

3)　新規の大型電力需要

新規投資による電力需要は、前回 MP 案件時同様、コロール州、アイライ州、マルキョク州、ガラルド州、ガラロン州で新規需要が見込まれる。さらに、本調査にて新たに確認された新規の大型需要家として、アイライ州にて大型商業施設の完工（約 1.0MW）が 2021 年となっている。

また、ケーススタディーを行うにあたって、前回 MP 案件時同様、新規需要が予定通り見込まれる場合を Base ケースとし、High ケースは「新規需要が 2 倍になった場合」、Low ケースは「新規需要がなくなった場合」としてそれぞれ想定する。下表に最大需要時における各ケースの新規需要を示す。

表 1.3　各ケースの新規需要一覧（最大需要時）

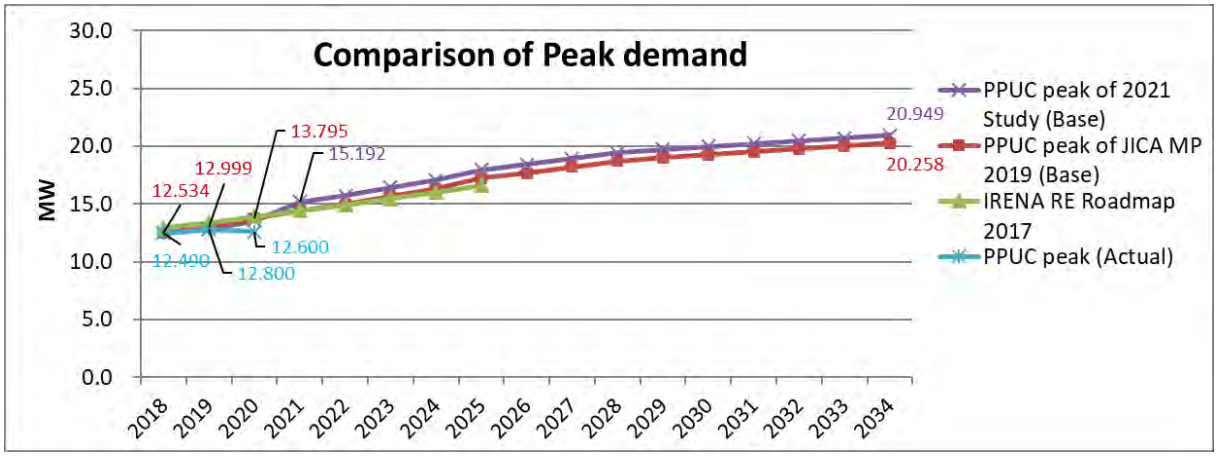
Unit: MW

Case		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
High	今回	0.000	0.546	2.742	3.036	3.655	4.040	4.919	5.026	5.270	5.467	5.614	5.699	5.744	5.790	5.816	5.836
Base	今回	0.000	0.273	1.371	1.518	1.828	2.020	2.460	2.513	2.635	2.734	2.807	2.849	2.872	2.895	2.908	2.918
	前回 (MP)	*0.000*	*0.273*	*0.371*	*0.518*	*0.828*	*1.020*	*1.460*	*1.513*	*1.635*	*1.734*	*1.807*	*1.849*	*1.872*	*1.895*	*1.908*	*1.918*
Low	今回	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

出典：調査団作成

4) コロール島及びバベルダオブ島の需要想定

以上を踏まえ、前回 MP 案件時の電力需要想定をベースに本計画の需要想定を行った。図 1.3 に本計画のピーク需要想定結果と実績値、既存の想定結果の比較を示す。2020 年並びに調査時点（2021 年 8 月）におけるピーク電力においては、昨今のコロナ感染による影響と思われる需要の落ち込みが確認できるため、2019 年の実績データをベースに前回 MP 案件時の電力需要想定をレビューした。2019 年から 2034 年間のピーク需要（MW）の伸び率は 3.3%／年である。



出典：調査団作成

図 1.3　ピーク需要予測と実績値、既存想定との比較

5) ケーススタディー

前述の「3）新規の大型電力需要」のとおり、本調査でも基本的には前回 MP 案件時と同様のケーススタディーとするが、Low ケースについてはさらに COVID-19 の影響による需要の落ち込みも考慮する。同影響に伴う需要の落ち込みの割合としては、直近年である 2020 年の需要の落ち込み率（約 9%）を採用する。

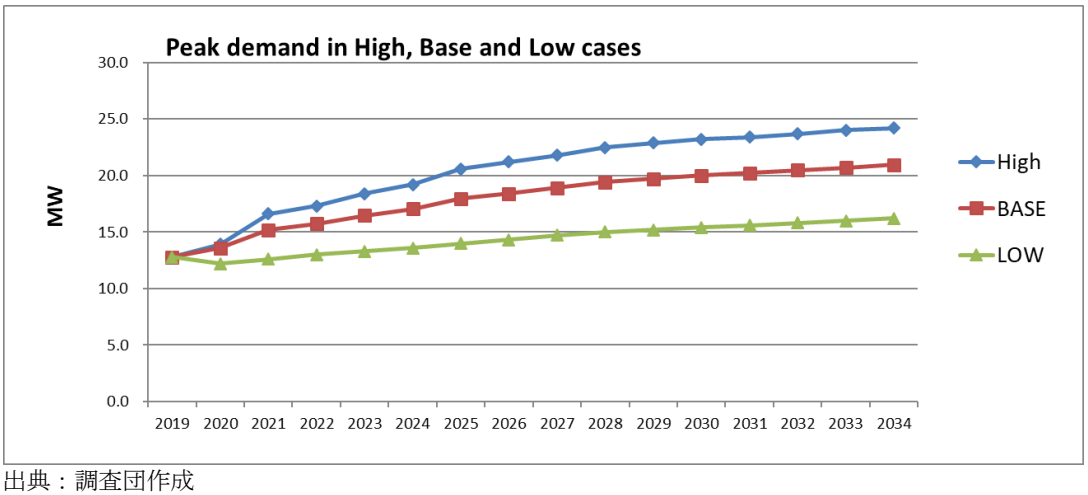
以上の前提で、各ケースの既存需要を含めたピーク需要を計算すると以下の表 1.4 及び図 1.4 となる。

表 1.4　各ケースにおけるピーク需要

Unit: MW

Case	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
High	12.8	13.9	16.6	17.3	18.4	19.2	20.6	21.2	21.8	22.5	22.9	23.2	23.4	23.7	24.0	24.2
Base	12.8	13.6	15.2	15.7	16.5	17.1	18.0	18.4	18.9	19.4	19.7	20.0	20.2	20.5	20.7	20.9
Low	12.8	12.0	12.5	13.0	13.3	13.6	14.0	14.3	14.7	15.0	15.2	15.4	15.6	15.8	16.0	16.2

出典：調査団作成



出典：調査団作成

図 1.4　各ケースにおけるピーク需要

6)　州別電力需要想定

上記 Base ケースにおけるピーク需要をベースに、コロール島及びバベルダオブ島における州別のピーク需要予測の結果を表 1.5 に示す。表 1.5 に示すとおり、パラオの人口が集中しているコロール州では、電力需要の大半を消費しており、国全体の約 60%を占めている。なお、その他州においては、アイライ州を除き、それぞれ約 5%以下の電力消費となっている。

表 1.5　州別のピーク需要予測

Unit: MW

State	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Aimeliik	0.474	0.484	0.497	0.506	0.516	0.525	0.535	0.543	0.550	0.559	0.561	0.564	0.567	0.569	0.572	0.575
	4%	4%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Airiai	2.734	2.864	4.524	4.660	4.800	4.943	5.100	5.188	5.285	5.377	5.436	5.496	5.557	5.618	5.681	5.740
	21.4%	21.1%	29.8%	29.6%	29.2%	29.0%	28.4%	28.2%	27.9%	27.7%	27.6%	27.5%	27.5%	27.4%	27.4%	27.4%
Koror	8.641	9.252	9.157	9.520	9.893	10.274	10.721	10.972	11.229	11.492	11.638	11.786	11.935	12.086	12.240	12.395
	67.5%	68.1%	60.3%	60.6%	60.1%	60.2%	59.7%	59.6%	59.3%	59.1%	59.0%	59.0%	59.0%	59.0%	59.1%	59.2%
Melekeok	0.465	0.480	0.495	0.507	0.658	0.701	0.780	0.828	0.913	1.015	1.038	1.062	1.073	1.086	1.098	1.111
	3.6%	3.5%	3.3%	3.2%	4.0%	4.1%	4.3%	4.5%	4.8%	5.2%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%
Ngaraard	0.095	0.098	0.102	0.104	0.141	0.155	0.351	0.367	0.420	0.438	0.488	0.502	0.503	0.505	0.507	0.509
	0.7%	0.7%	0.7%	0.7%	0.9%	0.9%	2.0%	2.0%	2.2%	2.3%	2.5%	2.5%	2.5%	2.5%	2.4%	2.4%
Ngardmau	0.039	0.040	0.042	0.043	0.044	0.045	0.046	0.047	0.048	0.049	0.049	0.050	0.051	0.051	0.052	0.052
	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.2%	0.3%	0.3%	0.3%	0.3%	0.2%
Ngaremlengui	0.106	0.109	0.112	0.114	0.117	0.119	0.122	0.124	0.126	0.129	0.130	0.131	0.132	0.133	0.134	0.135
	0.8%	0.8%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.6%	0.6%	0.6%
Ngatpang	0.064	0.066	0.068	0.069	0.071	0.072	0.073	0.075	0.076	0.077	0.078	0.079	0.079	0.080	0.080	0.081
	0.5%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Ngchesar	0.048	0.049	0.051	0.052	0.053	0.054	0.055	0.056	0.057	0.059	0.059	0.060	0.060	0.061	0.062	0.063
	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Ngarchelong	0.083	0.086	0.088	0.090	0.102	0.115	0.129	0.143	0.157	0.170	0.183	0.195	0.208	0.221	0.221	0.222
	0.6%	0.6%	0.6%	0.6%	0.6%	0.7%	0.7%	0.8%	0.8%	0.9%	0.9%	1.0%	1.0%	1.1%	1.1%	1.1%
Ngiwal	0.052	0.053	0.055	0.056	0.057	0.059	0.060	0.061	0.062	0.063	0.064	0.064	0.065	0.065	0.066	0.067
	0.4%	0.4%	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Koror+Babeldaob	12.800	13.583	15.192	15.722	16.452	17.061	17.971	18.404	18.924	19.429	19.725	19.989	20.230	20.475	20.713	20.949
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

出典：調査団作成

(2)　配電用変圧器容量

配電線網に配電するためには十分な容量の変圧器が整備されている必要があるが、コロール島及びバベルダオブ島に配電する現状の 34.5/13.8kV 変圧器容量は下表のとおり合計 51.05MVA である。PPUC が管轄する変電所（発電所のローカル供給用変電設備を含む）は 12 箇所であるが、同変電所のうち送電線遮断器を備えているのはアイメリーク変電所、マラカル発電所及びアイライ変電所のみであり、送電線に事故があると事故線路の全区間が停電となる。

表 1.6　34.5/13.8kV 配電用変圧器容量

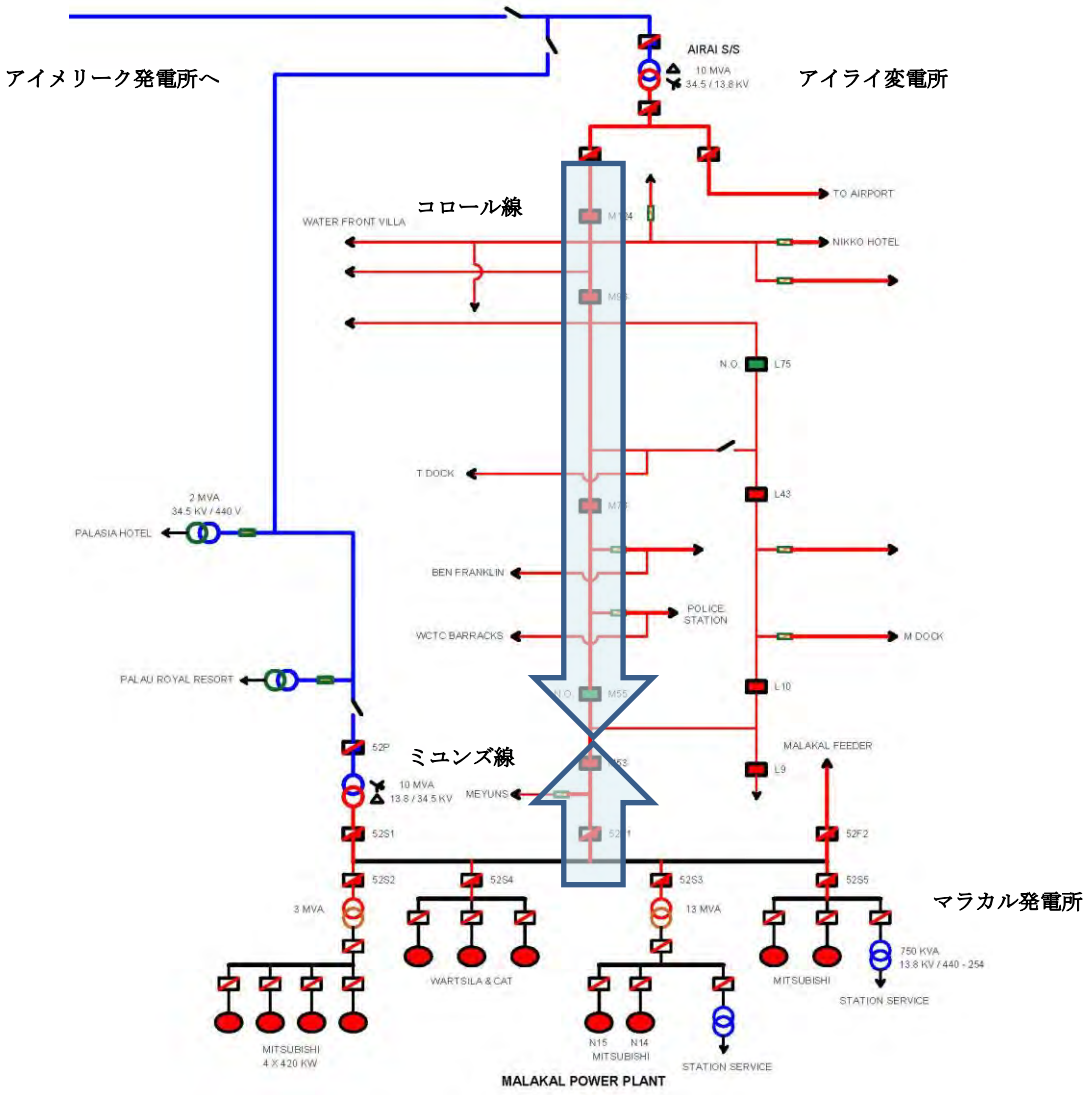
変電所	変圧器容量 (MVA)	数量	変圧器容量合計 (MVA)
Airai Substation	10	1	10
Kokusai Substation	5	1	5
Malakal Power Station	10	3	10
Aimellik 2 (Mogami) Substation	0.75	3	2.25
Aimeliik 1 (Medorm) Substation	1.5	1	1.5
Nekken Substation	0.75	3	2.25
Ibobang Substation	0.25	3	0.75
Ngremlengui (Asahi) Substation	0.30	1	0.30
Ngardmau Substation	0.75	3	2.25
Ngaraard 1 Substation	0.25	3	0.75
Ngaraard 2 Substation	2	1	2
Hotel (Palasia Hotel)*	1	1	1
Hotel (Royal Resort)*	1.5	2	3
Total Capacity			51.05

* プライベート
出典：調査団作成

(3)　各変電所への想定負荷配分

各変電所負荷は、現地調査時（2021 年 8 月）に入手した各発電所の配電線負荷実績及び本計画の需要想定を踏まえ配分した。ここで、PPUC の電力設備には送電線潮流を計測するメータは発電所とアイライ（Airai）変電所のみに設置されているため、その他各変電所の負荷ならびに送電線潮流は正確には把握できない。そのため、系統解析にあたり発電所出口やアイライ変電所の出口で計測された送電線潮流を、その送電線に連系された変電所の変圧器容量で案分するなど、各変電所の負荷を想定した。なお、各変電所への負荷配分における留意事項を下記に示す。

- 既設マラカル変電所は、現在アイライ向け 34.5kV 送電線及びミユンズ（Meyuns）、マラカル向けの計 2 つの 13.8kV 配電線フィーダーを有している。PPUC では、ミユンズ線は既設アイライ変電所のコロール線と系統連系用開閉器（N.O.）を介して接続されているが（下図参照）、新設するコロール変電所に可能な限り負荷をシフトしたいとの PPUC からの要請があったため、2024 年以降におけるミユンズ線の負荷を最大 3.5MW までとし、残りの負荷はコロール変電所にシフトする
- 新規の大型需要家として、アイライ州にて大型商業施設の完工（約 1.0MW）が年内に予定されている。さらに、年内中のコロール州からアイライ州への大規模な住民移転が計画されており、約 0.50MW の電力需要の移設が見込まれている。



出典：PPUC

図 1.5　コロール島及びバベルダオブ島南部における電力系統

以上より、前述の州別のピーク需要負荷を系統解析モデル内に必要な変電所に負荷配分したものを表 1.7 に示す。

表 1.7　需要想定負荷の変電所配分

Unit: MW

Substation	34.5/13.8 kV Transformer (PF 0.90)	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Koror Substation	**10 MVA (9.0 MW)**						**5.128 57.0%**	**5.504 61.2%**	**5.714 63.5%**	**5.930 65.9%**	**6.151 68.3%**	**6.274 69.7%**	**6.398 71.1%**	**6.523 72.5%**	**6.651 73.9%**	**6.780 75.3%**	**6.909 76.8%**
Airai Substation	10 MVA (9.0 MW)	5.828 64.8%	6.178 68.6%	7.803 86.7%	8.069 89.7%	8.342 92.7%	4.943 54.9%	5.100 56.7%	5.188 57.6%	5.285 58.7%	5.377 59.7%	5.436 60.4%	5.496 61.1%	5.557 61.7%	5.618 62.4%	5.681 63.1%	5.740 63.8%
Koror Substation + Airai Substation		*5.828 32%*	*6.178 34%*	*7.803 43%*	*8.069 45%*	*8.342 46%*	*10.071 56%*	*10.604 59%*	*10.902 61%*	*11.215 62%*	*11.528 64%*	*11.710 65%*	*11.894 66%*	*12.080 67%*	*12.269 68%*	*12.461 69%*	*12.650 70%*
Kokusai Substation (Kokusai)	5 MVA (4.5 MW)	0.627 13.94%	0.646 14.35%	0.667 14.83%	0.682 15.16%	0.837 18.59%	0.884 19.64%	0.966 21.46%	1.018 22.62%	1.105 24.56%	1.212 26.92%	1.236 27.47%	1.262 28.04%	1.275 28.32%	1.289 28.65%	1.303 28.96%	0.078 1.74%
Ngchesar Substation (Melekeok+Ngchesar+Ngiwal)	5 MVA (4.5 MW)																1.241 27.6%
Malakal Power Station (Meyuns, Malakal)	10 MVA (9.0 MW)	5.073 56%	5.432 60%	5.376 60%	5.589 62%	5.808 65%	4.583 51%	4.630 51%	4.656 52%	4.683 52%	4.711 52%	4.726 53%	4.742 53%	4.758 53%	4.774 53%	4.790 53%	4.806 53%
Aimeliik 2 (Mogami) Substation	0.75×3 MVA (2.0 MW)	0.309 15.4%	0.316 15.8%	0.324 16.2%	0.330 16.5%	0.337 16.8%	0.342 17.1%	0.349 17.4%	0.354 17.7%	0.359 18.0%	0.365 18.2%	0.366 18.3%	0.368 18.4%	0.370 18.5%	0.371 18.6%	0.373 18.7%	0.375 18.8%
Aimeliik 1 (Medorm) Substation	1.5 MVA (1.35 MW)	0.126 9.3%	0.128 9.5%	0.132 9.8%	0.134 9.9%	0.137 10.1%	0.139 10.3%	0.142 10.5%	0.144 10.7%	0.146 10.8%	0.148 11.0%	0.149 11.0%	0.150 11.1%	0.150 11.1%	0.151 11.2%	0.152 11.2%	0.153 11.3%
Nekken Substation	0.75×3 MVA (2.0 MW)	0.039 2.0%	0.040 2.0%	0.041 2.0%	0.042 2.1%	0.043 2.1%	0.043 2.2%	0.044 2.2%	0.045 2.2%	0.045 2.3%	0.046 2.3%	0.046 2.3%	0.047 2.3%	0.047 2.3%	0.047 2.3%	0.047 2.4%	0.047 2.4%
Ibobang Substation	0.25×3 MVA (0.675 MW)	0.002 0.02%	0.002 0.02%	0.002 0.01%	0.002 0.01%	0.002 0.01%	0.002 0.01%	0.002 0.01%	0.002 0.01%	0.002 0.01%	0.003 0.01%	0.003 0.01%	0.003 0.01%	0.003 0.01%	0.003 0.01%	0.003 0.01%	0.003 0.01%
Ngeremlengui (Asahi) Substation	0.30 MVA (0.27 MW)	0.106 39.4%	0.109 40.5%	0.112 41.6%	0.114 42.3%	0.117 43.4%	0.119 44.1%	0.122 45.2%	0.124 46.0%	0.126 46.7%	0.129 47.8%	0.130 48.1%	0.131 48.5%	0.132 48.9%	0.133 49.2%	0.134 49.6%	0.135 50.0%
Ngardmau Substation	0.75×3 MVA (2.0 MW)	0.039 2.0%	0.040 2.0%	0.042 2.1%	0.043 2.2%	0.044 2.2%	0.045 2.3%	0.046 2.3%	0.047 2.4%	0.048 2.4%	0.049 2.5%	0.049 2.5%	0.050 2.5%	0.051 2.6%	0.051 2.6%	0.052 2.6%	0.052 2.6%
Ngaraard 1 Substation	0.25×3 MVA (0.675 MW)	0.026 3.8%	0.027 4.0%	0.028 4.1%	0.028 4.2%	0.038 5.7%	0.042 6.2%	0.096 14.2%	0.100 14.8%	0.115 17.0%	0.120 17.7%	0.133 19.7%	0.137 20.3%	0.137 20.3%	0.138 20.4%	0.138 20.5%	0.139 20.6%
Ngaraard 2 Substation	2 MVA (1.8 MW)	0.151 8.4%	0.157 8.7%	0.162 9.0%	0.166 9.2%	0.205 11.4%	0.228 12.6%	0.384 21.3%	0.410 22.8%	0.462 25.7%	0.489 27.2%	0.538 29.9%	0.560 31.1%	0.574 31.9%	0.588 32.7%	0.589 32.7%	0.592 32.9%
Hotel (Palasia Hotel)	1 MVA (0.9 MW)	0.118 6.6%	0.127 7.0%	0.125 7.0%	0.130 7.2%	0.136 7.5%	0.141 7.8%	0.147 8.2%	0.150 8.3%	0.154 8.5%	0.157 8.7%	0.159 8.9%	0.161 9.0%	0.163 9.1%	0.166 9.2%	0.168 9.3%	0.170 9.4%
Hotel (Royal Resort)	1.5×2 MVA (2.7 MW)	0.355 19.7%	0.380 21.1%	0.376 20.9%	0.391 21.7%	0.407 22.6%	0.422 23.5%	0.441 24.5%	0.451 25.0%	0.461 25.6%	0.472 26.2%	0.478 26.6%	0.484 26.9%	0.490 27.2%	0.497 27.6%	0.503 27.9%	0.509 28.3%
KB grid	56.05 MVA (50.45 MW)	12.800 27%	13.583 29%	15.192 32%	15.722 34%	16.452 35%	17.061 36%	17.971 38%	18.404 39%	18.924 40%	19.429 41%	19.725 42%	19.989 43%	20.230 43%	20.475 44%	20.713 44%	20.949 45%

出典：調査団作成

現在アイライ州及びコロール州の一部に電力を供給するアイライ変電所の変圧器容量は10MVA であり、力率を 90%と想定すると約 9MW 相当の容量がある。

表 1.8 に示すとおり、同変電所における需要の伸びと比較すると 2024 年（ピーク需要：約10MW）には変圧器容量（約 9MW）の限界を迎えることになり、本計画にて建設されるコロール変電所の建設が不可欠であることが分かる。

表 1.8　本プロジェクトで計画される変電所の変圧器容量

需要地（変電所名）	設備計画の目標年次（2034 年）の需要	変圧器容量	尤度（需要／変圧器容量）
コロール州（コロール変電所）	6.9MW	9MW*（10MVA）	76.7%
アイライ州（アイライ変電所）	5.7MW	9MW*（10MVA）	63.3%

* 力率を 90%と想定する。

出典：調査団作成

2. 系統解析

(1)　系統解析の目的

系統解析の目的は、PPUC による将来の開発計画（IPP 事業含む）についても考慮した上で、通常時や事故時の送電線及び変圧器の電流値、母線電圧が適正範囲内であることを確認すること並びに系統安定度（定態・過渡安定度）解析により下記諸点を確認することである。

- 将来計画を考慮した各設備の主要機器および周辺機器の妥当性
- 事故防止策（N-1 事故）を考慮した各設備の妥当性
- 送電線事故時の潮流解析及び系統の周波数解析

(2)　設備の現状

1)　発電設備

コロール・バベルダオブ電力系統の電源は、コロール島のマラカル発電所とバベルダオブ島のアイメリーク発電所の２箇所である。発電方式は両発電所ともディーゼル発電であり、燃料はディーゼル油である。表 2.1 に発電設備の概要を示す。

表 2.1 発電設備の概要（コロール・バベルダオブ電力系統）

Name of Power Plant	Generator	Output Rating (kW)	Output Voltage (kV)	Rotating speed (rpm)	Year Commissioned
Malakal	Mitsubishi 12	3,400	13.8	720	1997
	Mitsubishi 13	3,400	13.8	720	1997
	Wartsila 1	2,000	13.8	1200	1996
	Caterpillar 1	1,825	0.48	1800	2006
	Caterpillar 2	1,825	0.48	1800	2006
	Niigata 14	5,000	6.6	720	2005
	Niigata 15	5,000	6.6	720	2005
	Mitsubishi 1	500	0.48	1800	2012
	Mitsubishi 2	500	0.48	1800	2012
	Mitsubishi 3	500	0.48	1800	2012
	Mitsubishi 4	500	0.48	1800	2012

Aimeliik	Mitsubishi 6	5,000	13.8	720	2013
	Mitsubishi 7	5,000	13.8	720	2013
	CAT 3516	2,000	0.48	1800	2012
Total		36,450			

出典：PPUC

2) 送電設備

送電設備の現状を表 2.2 に示す。パラオの全ての送電設備は、34.5 kV の 1 回線であり、支持物は殆どがコンクリート柱であり一部にパンザーマストが用いられている。送電線はコロール島とバベルダオブ島を南北に縦貫しており総亘長は約 80 km である。

表 2.2 送電設備の現状（コロール・バベルダオブ電力系統）

Line	Vloltage (kV)	Number of circuits	Length (km)	Conductor	Capacity (A) [(MW) : Power factor 0.9 assumed]
Malakal--Airai	34.5	1	9.184	AAC150mm^2	約 420 A [約 21.5 MW]
Aimeliik--Airai	34.5	1	18.553	AAC150mm^2	約 420 A [約 21.5 MW]
Aimeliik--Nekken	34.5	1	4.287	AAC150mm^2	約 420 A [約 21.5 MW]
Nekken--Kokusai	34.5	1	8.849	AAC150mm^2	約 420 A [約 21.5 MW]
Kokusai--Ngaraard	34.5	1	38.778	AAC150mm^2	約 420 A [約 21.5 MW]
Total			79.651		

出典：PPUC

3) 変電設備

変電設備の現状は前述の表 1.6 を参照。

(3) 系統解析実施の条件

系統解析ソフトウエア利用（PSSE@34.5）による機器仕様の妥当性判断を実施する。具体的には、同ソフトウエアに現地調査で収集したデータを入力しての潮流解析と事故電流解析、系統安定度解析を実施する。

本計画ではコロール変電所を主体とするコンポーネントとなるため、系統解析の対象はコロール島及びバベルダオブ島における 34.5kV 系統（図 2.1 を参照）とする。なお、PPUC が進めている IPP 事業の太陽光発電所建設及び蓄電池導入についても、コロール島及びバベルダオブ島の系統への影響が大きいことから、系統解析に反映する。

解析断面は、供与開始時点の 2024 年、プロジェクト評価の目標年次（供与開始後 3 年）の 2027 年及び設備計画の目標年次（供与開始後 10 年）の 2034 年とする。

系統解析条件を下記に示す。

- コロール島及びバベルダオブ島における 34.5kV 系統にて解析モデルを構築する（図 2.1 を参照）。
- 他ドナー（ADB）で支援実施する IPP 事業 Phase-1 および Phase-2、開閉所（Bus stop junction）は、Phase-1 および開閉所は 2023 年、Phase-2 は 2025 年には運用を開始する。各 Phase における太陽光発電システムの主な構成と仕様を下記に示す。

Phase-1

太陽光発電出力：12.46 MWp ac（15.27 MWp dc）

蓄電池容量　　：8.8 MW ac / 12.906 MWh（太陽光発電設備に隣接）

Phase-2

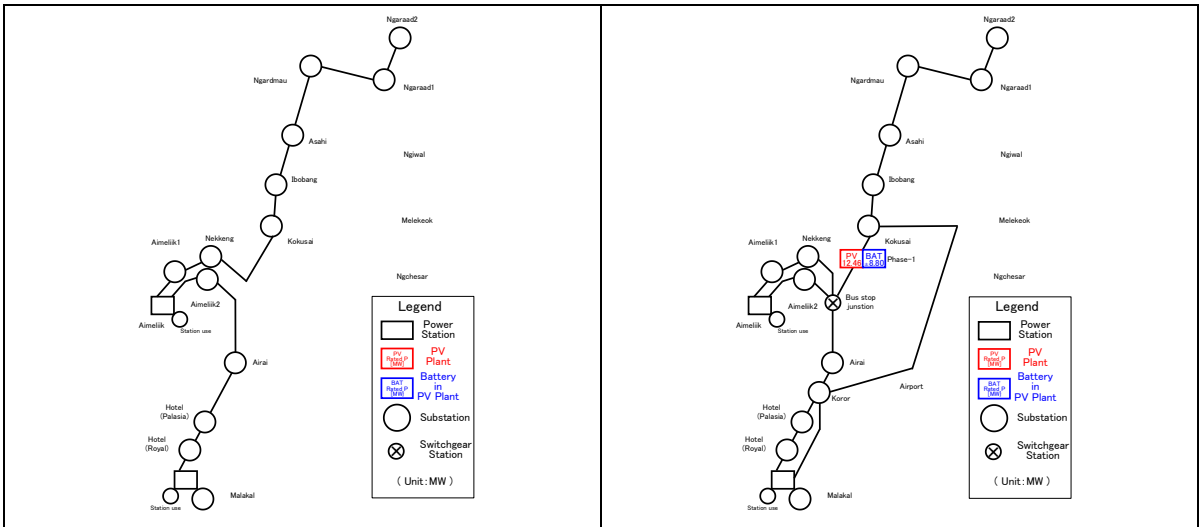
太陽光発電出力：17.96 MWp ac（22 MWp dc）

蓄電池容量　　：8.8 MW ac / 30 MWh（太陽光発電設備に隣接）

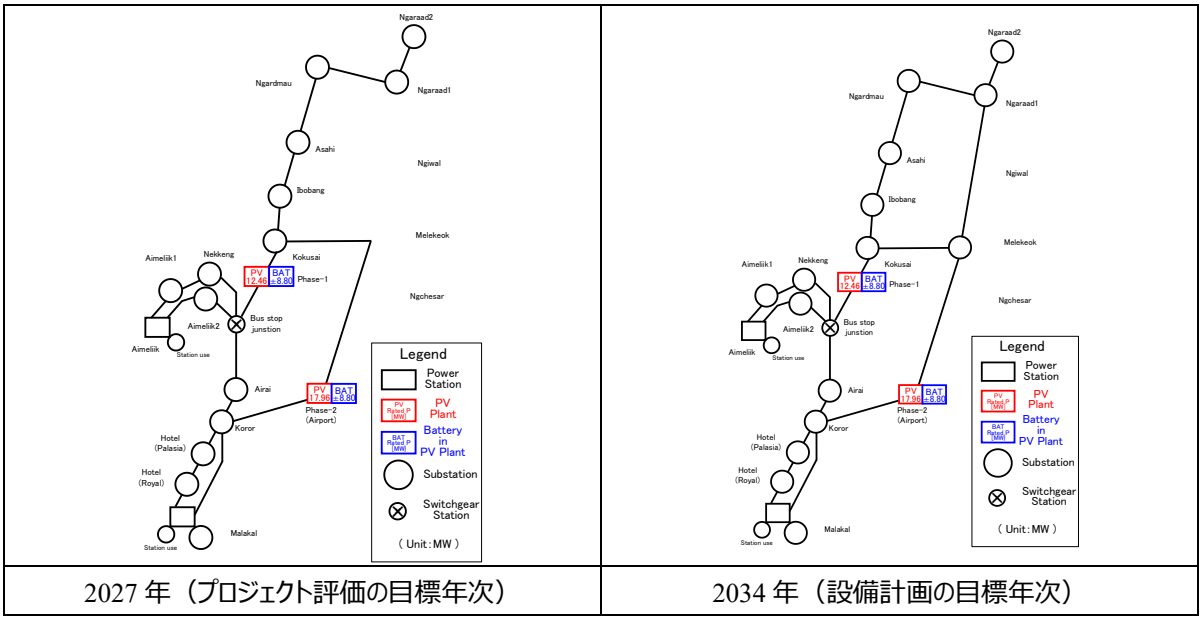
- 系統解析シナリオを下表に示す。（○：系統解析を実施）潮流解析では、解析年の最大需要時（再エネ出力ゼロ）及びオフピーク時（再エネ最大出力）の 2 つのシナリオを主に実施する。なお、各シナリオにおける需要想定は、最大需要時は High ケース、オフピーク時は Low ケースを採用する。（表 1.4 参照）また、事故電流解析（短絡電流計算）では、母線短絡事故時（34.5 k 及び 13.8 kV 系統）における遮断器の遮断容量を確認する。

系統解析	2021 年 （調査時点）	2024 年	2027 年 （評価年次）	2034 年
潮流解析 （健全時：最大需要時およびオフピーク）	○	○	○	○
潮流解析 （事故時：最大需要時およびオフピーク）	-	-	○	○
事故電流解析 （短絡電流計算）	○	-	-	○
潮流解析 （健全時：プロジェクトなし）	-	-	○	-
安定度解析（定態安定度・過渡安定度）	-	-	○	-

- PPUC 系統運用基準に従い、系統電圧における運用範囲は 34.5 kV±5%、系統周波数における運用範囲は 60Hz±0.2Hz を適正範囲とする。
- 負荷の力率は、調査時点（2021 年 8 月）の運用実績を考慮し 90%とする。
- 各発電所及び変電所における母線は、解析対象内の 34.5 kV 及び 13.8 kV 母線までを模擬し、各需要負荷は、配電電圧である 13.8 kV の母線に接続する。



2021 年（現状）　　2024 年（供与開始時点）



2027 年（プロジェクト評価の目標年次）	2034 年（設備計画の目標年次）

出典：調査団作成

図 2.1　系統解析モデル

(4)　系統解析結果

各解析断面における系統解析結果を下記に示す。

1)　現状系統

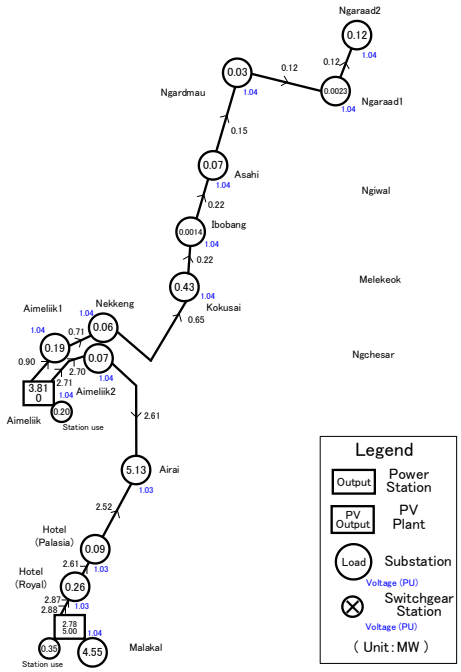
①　対象系統

調査時点（2021 年 8 月）における系統を対象とする。（図 2.1 参照）

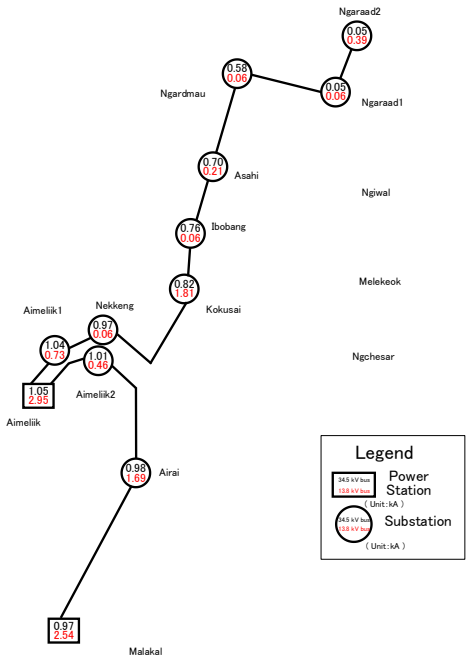
②　潮流解析

PPUC の電力設備には送電線潮流を計測するメータは、発電所とアイライ（Airai）変電所のみに設置されているため、その他各変電所の負荷ならびに送電線潮流は正確には把握できない。このため、系統解析にあたり発電所出口やアイライ変電所の出口で計測された送電線潮流を、その送電線に連系された変電所の変圧器容量で案分するなど各変電所の負荷を想定した。潮流解析結果を図 2.2 に示す。

最大潮流は、最大需要時でマラカル発電所－ホテル（Hotel）線の 2.88MW で送電容量 21.5MW に十分に小であるため、過負荷の恐れはない。電圧面では、最大需要時で 103～104%の範囲にあり適正値（基準電圧 100±5%）を維持している。



潮流解析結果



事故電流解析結果

出典：調査団作成

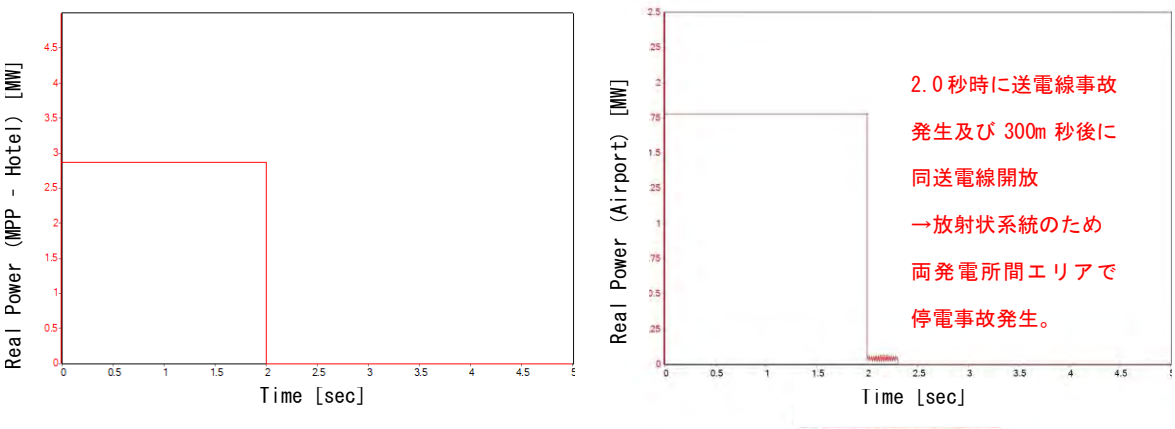
図 2.2　潮流解析結果及び事故電流解析結果（調査時点：2021 年 8 月）

③　事故電流解析

図 2.2 に事故電流解析結果を示す。系統規模が小であり、さらに全ての送電線が 1 回線と系統間の連系が疎であるため、3 相短絡電流の最大値は 34.5kV 系統ではアイメリーク発電所の 1.05kA、13.8kV 系統でも同発電所の 2.95kA となった。したがって、遮断器定格の 12.5kA に対し十分に小であるため、全く問題はない。

④　系統安定度解析

安定度の検討条件は PPUC から聴取した 34.5kV 遮断器の実績遮断時間に基づき、送電線に 3 相短絡事故（2.0 秒時）が発生し、300ms 後に遮断器が動作し当該事故送電線が開放されるものと設定した。潮流が大きい送電線の事故は安定度上厳しいため、マラカル発電所－ホテル線で事故が発生したケースを対象に安定度解析を実施した。その結果を図 2.3 に示す。上記事故により同送電による電力供給が不可能となるため、マラカル発電所及びアイメリーク発電所間の需給バランスが崩れ停電事故が発生する。



送電線負荷（マラカル発電所－ホテル線）　　アイライ変電所負荷（空港線）

出典：調査団作成

図 2.3　過渡安定度解析結果（調査時点：2021 年 8 月）

2)　2024 年系統

①　対象系統

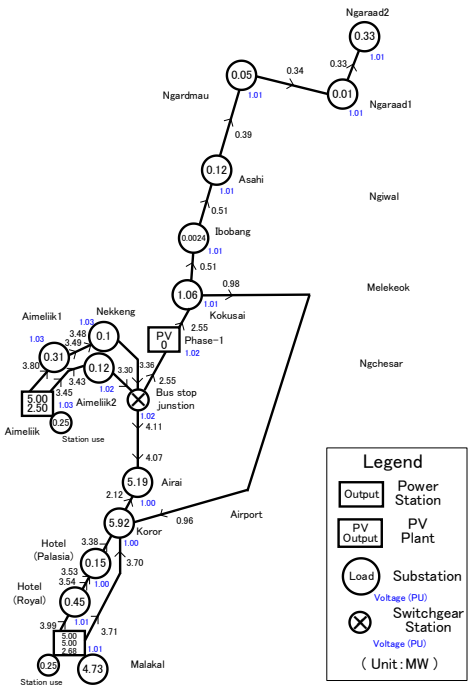
2022 年に Phase-1 及び開閉所（Bus stop junction）が完成し、既設コクサイ（Kokusai）変電所-ネッケン（Nekken）変電所線に連系される。また、2024 年にコロール（Koror）変電所及び 34.5 kV 送電線（コロール変電所－コクサイ変電所及びコロール変電所－マラカル発電所）が新設される。

負荷に供給する発電力は以下の通り仮定し系統的に厳しい条件を設定した。

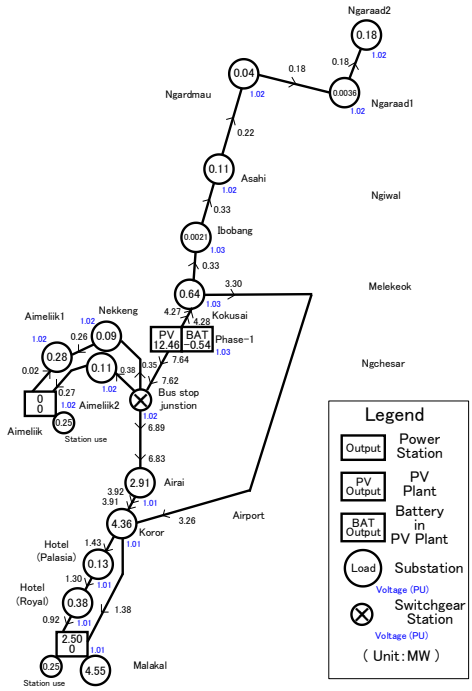
- 最大需要時（再エネ出力ゼロ）：需要ピークは 19 時～20 時頃であり日没後のため PV は発電しておらず、また PV 地点に設置された蓄電池は短周期補償用電池（PV 脱落時補償）であり出力は基本的にゼロであるため、負荷全量に対してはディーゼル発電機のみが供給している。需要は High ケースの 19.2MW とした。ディーゼル発電機の運転台数は 5 台であり、各発電所の運転台数は PPUC の運用方針を踏まえ、アイメリーク発電所 2 台、マラカル発電所 3 台とした。
- オフピーク需要時（再エネ最大出力）時：昼間時間帯のため、Phase-1 の PV は最大出力（12.46MW）で発電しているものとし、需要は Low ケースの 13.6MW とした。ディーゼル発電機の運転台数は PPUC の運用方針を踏まえ、マラカル発電所 1 台（最小負荷率 50%）とした。

②　潮流解析

解析から得られた 34.5kV 系統の潮流解析を図 2.4 に示す。最大潮流は、最大需要時で開閉所－アイライ変電所線の 4.11MW、再エネ出力最大時では Phase-1－開閉所（Bus stop junction）線の 7.64MW で送電容量 21.5MW に十分に小であるため、過負荷の恐れはない。電圧面では、最大需要時で 100～103%、再エネ出力最大時では 101～103%の範囲にあり適正値（基準電圧 100±5%）を維持している。



2024 年 最大需要時（再エネ出力ゼロ）



2024 年 オフピーク需要時（再エネ最大出力）

出典：調査団作成

図 2.4 潮流解析結果（2024 年）

3) 2027 年系統

① 対象系統

2025 年に Phase-2 が完成し、本プロジェクトにより新設されるコロール変電所－コクサイ変電所線に連系される。負荷に供給する発電力は以下の通り仮定し系統的に厳しい条件を設定した。

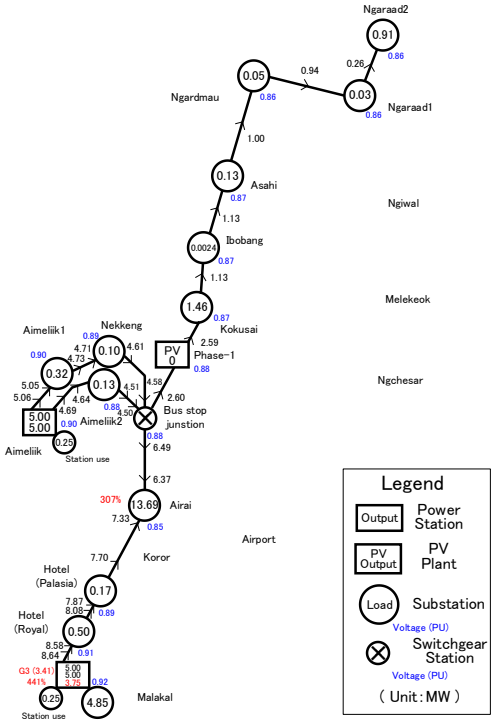
- 最大需要時（再エネ出力ゼロ）：需要ピークは 19 時～20 時頃であり日没後のため PV は発電しておらず、また PV 地点に設置された蓄電池は短周期補償用電池（PV 脱落時補償）であり出力は基本的にゼロであるため、負荷全量に対してはディーゼル発電機のみが供給している。需要は High ケースの 21.8MW とした。ディーゼル発電機の運転台数は 5 台であり、各発電所の運転台数はアイメリーク発電所 2 台、マラカル発電所 3 台とした。
- オフピーク需要時（再エネ最大出力）時：昼間時間帯のため、Phase-1 の PV は最大出力（12.46MW）で発電しているものとし、需要は Low ケースの 14.7MW とした。また、ディーゼル発電機の運転台数はマラカル発電所 1 台（最小負荷率 50%）とした。

② 潮流解析

図 2.5 および図 2.6 にプロジェクトの有無における潮流解析結果を示す。図 2.5 のプロジェクトなし（最大需要時）の場合、全系における電圧は 85%～92%と全体的に適正値を逸脱しており、またアイライ変電所における変圧器が過負荷（約 307%）となるなど健全な運用が実施できない。

一方、図 2.6 のプロジェクトを実施した場合、最大潮流は、最大需要時で開閉所－ア

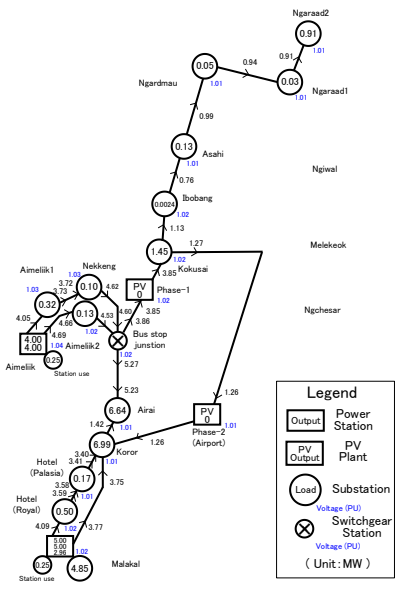
イライ変電所線の 5.27MW、再エネ出力最大時では Phase-2－コロール変電所線の 9.54MW であり送電容量 21.5MW に十分に小であるため、過負荷の恐れはない。電圧面では最大需要時 101～104%、再エネ出力最大時は 104～105%の範囲にあり適正値（基準電圧±5%）を維持している。



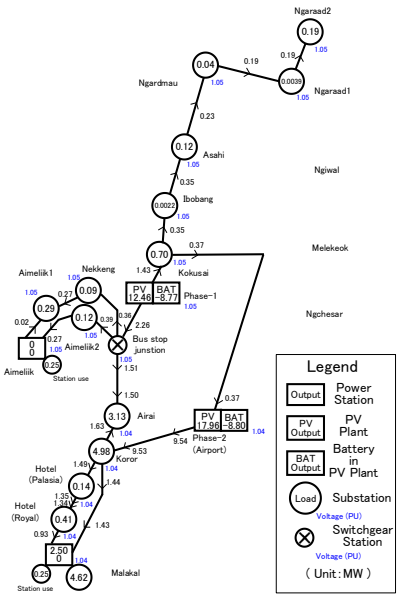
2027 年 最大需要時（再エネ出力ゼロ）

出典：調査団作成

図 2.5 潮流解析解析結果（2027 年、プロジェクトなし）



2027 年 最大需要時（再エネ出力ゼロ）

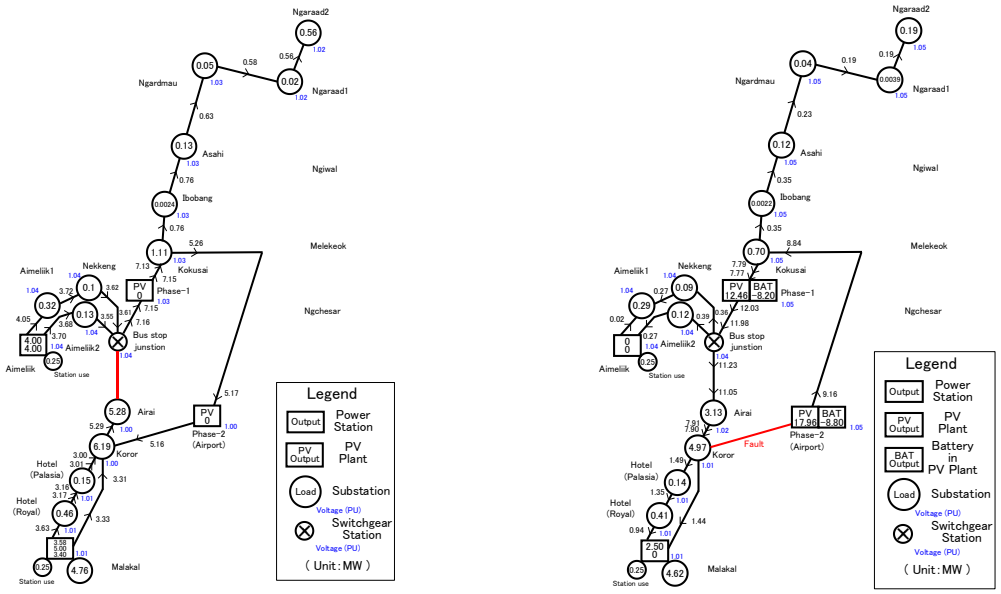


2027 年 オフピーク需要時（再エネ最大出力）

出典：調査団作成

図 2.6 潮流解析結果（2027 年、プロジェクトあり）

また、図 2.7 に上記各シナリオにおける最大潮流送電線にて事故が発生し、同送電線が開放された場合の潮流解析解析結果を示す。図 2.7 より、最大潮流は、最大需要時（開閉所―アイライ線にて送電線事故）で Phase-1－開閉所線の 7.16MW、再エネ出力最大時（Phase-2―コロール変電所線にて送電線事故）においても Phase-1－開閉所線の 12.03MW であり送電容量 21.50MW に十分に小であるため、過負荷の恐れはない。また、電圧面では最大需要時 100～104%、再エネ出力最大時は 101～105%の範囲にあり適正値（基準電圧 100±5%）を維持している。



2027 年 最大需要時（再エネ出力ゼロ）　　2027 年 オフピーク需要時（再エネ最大出力）

出典：調査団作成

図 2.7　潮流解析結果（2027 年、送電線事故時）

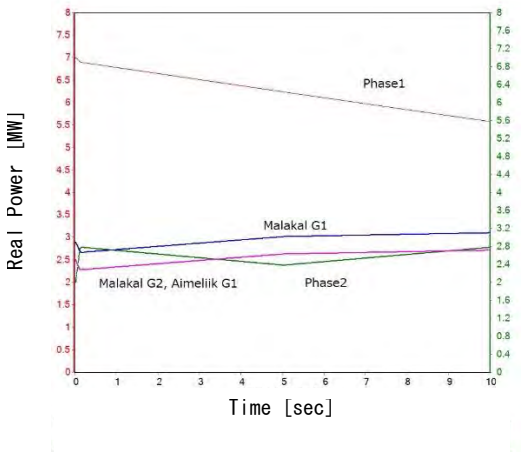
③ 安定度

安定度解析としては、定態安定度および過渡安定度における解析（周波数解析含む）を行い、対象系統はプロジェクト評価の目標年次である 2027 年のオフピーク時とした。

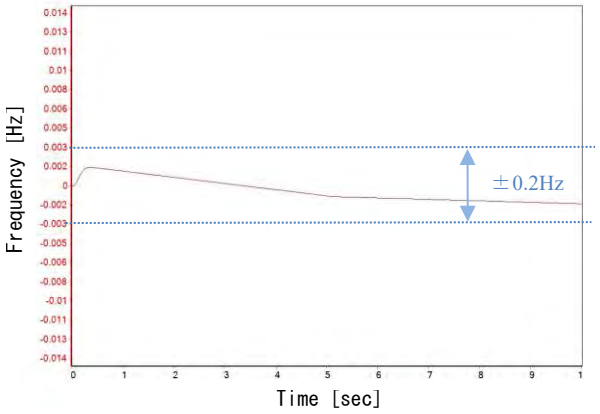
➢ **<u>定態安定度</u>**

定態安定度の検討条件は、出力変動する Phase-1 や Phase-2 の PV 出力に対し、周波数や電圧を許容範囲内に維持するようにディーゼル発電機が動作するものとした。なお、ディーゼル発電機の運転台数は、系統上の慣性を考慮し、マラカル発電所 2 台及びアイメリーク 1 台とした。その結果を図 2.8 に示す。

図 2.8 より、Phase-1 および Phase-2 の PV 出力変動に応じて各ディーゼル発電出力が追従するため、周波数が適正範囲内（基準値±0.1Hz）で維持できていることが確認できる。



発電出力



周波数

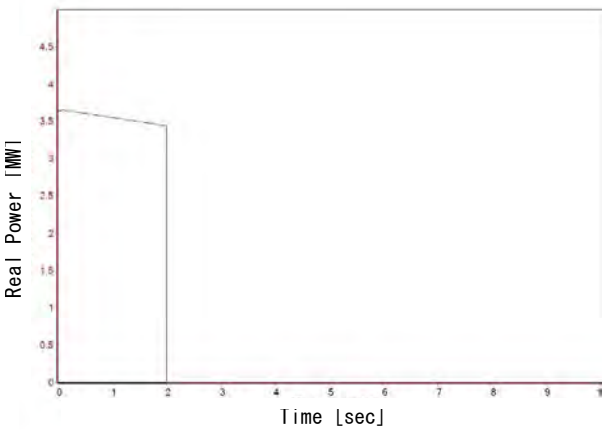
出典：調査団作成

図 2.8　定態安定度解析結果（2027 年）

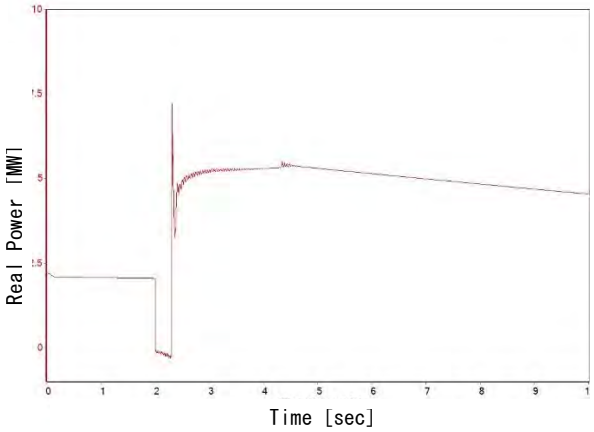
➢ <u>過渡安定度</u>

安定度の検討条件は、PPUC から聴取した 34.5kV 遮断器の実績遮断時間に基づき、送電線に 3 相短絡事故が発生し 300ms 後に遮断器が動作し同送電線が開放されるものと設定した。なお、本プロジェクトによる大規模太陽光発電所（IPP 事業 Phase-1）の供給信頼度向上を検証するため、同発電所付近の既設送電線（Phase-1－開閉所線）で 3 相短絡事故が発生したケースを対象に安定度解析を実施した。その結果を図 2.9 に示す。

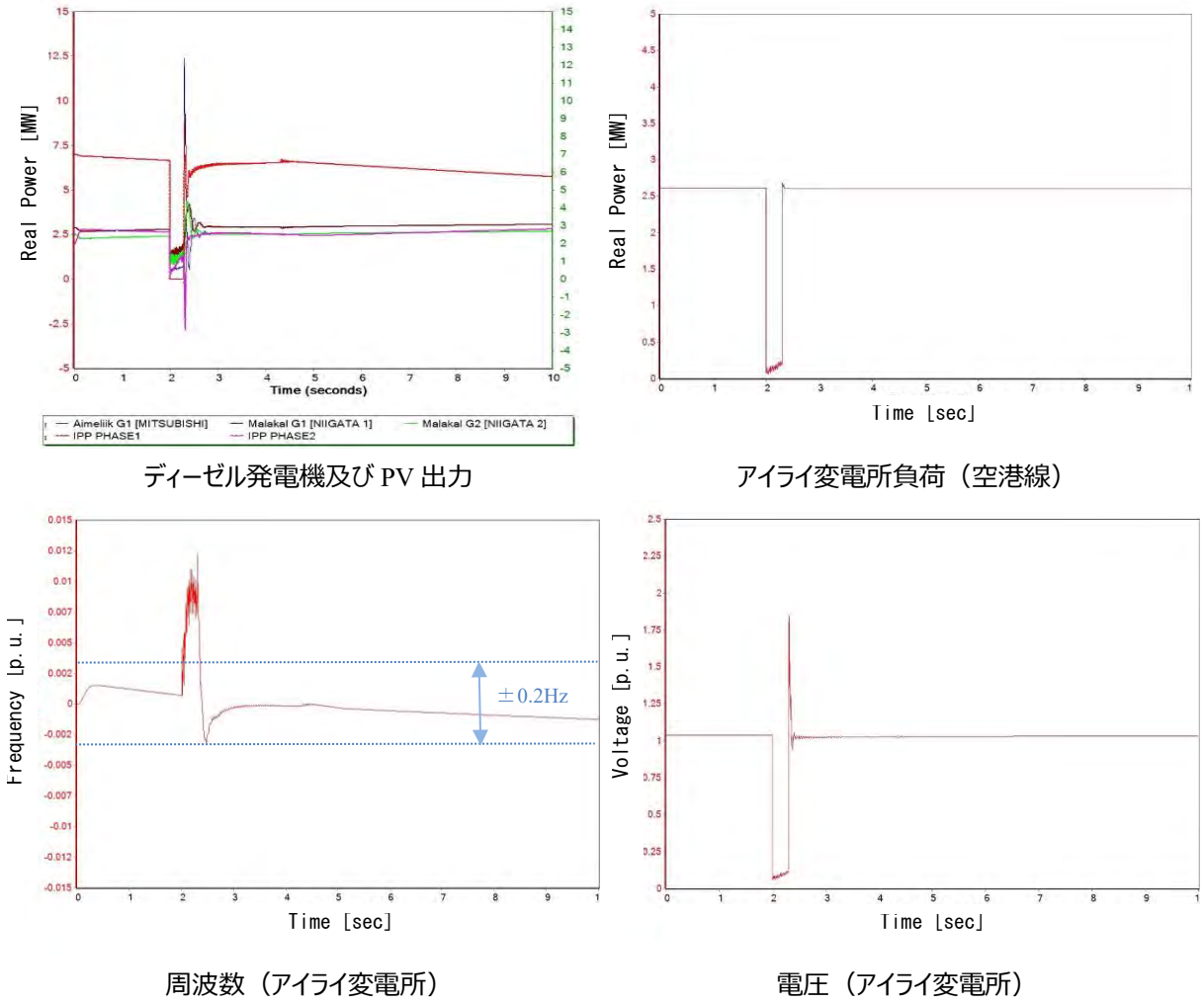
上記送電線事故により Phase-1－開閉所線からの送電が不可能となるが、本プロジェクトにて新設されるコクサイ変電所－コロール変電所（IPP-Phase2）線により、再閉路後、安定的に電力を供給することが確認できる。また、再閉路後も Phase-1 および Phase-2 の PV 出力変動に応じて各ディーゼル発電出力が追従するため、周波数が適正範囲内（基準値±0.2Hz）で維持できていることが確認できる。



送電線負荷（Phase-1－開閉所線）



送電線負荷（コクサイ変電所－Phase-2 線）



ディーゼル発電機及び PV 出力　　アイライ変電所負荷（空港線）

周波数（アイライ変電所）　　電圧（アイライ変電所）

出典：調査団作成

図 2.9　過渡安定度解析結果（2027 年）

4） 2034 年系統

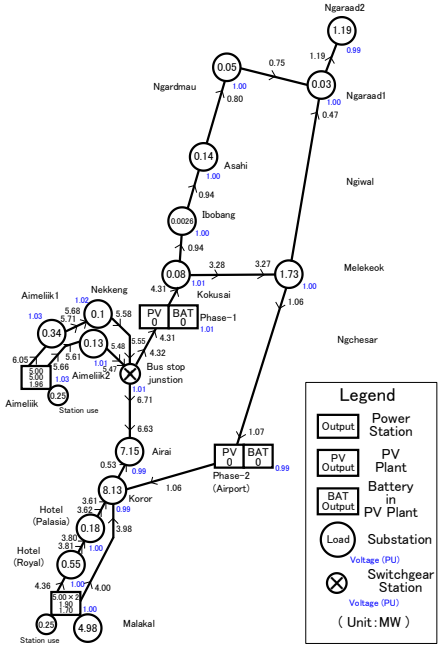
① 対象系統

2034 年にエサール（Ngchesar）変電所が完成しコクサイ変電所－Phase-2 線に連系される。また、エサール変電所とガラルド 1 変電所間が 34.5kV 線により接続され大ループが完成する。負荷に供給する発電力は以下の通り仮定し系統的に厳しい条件を設定した。

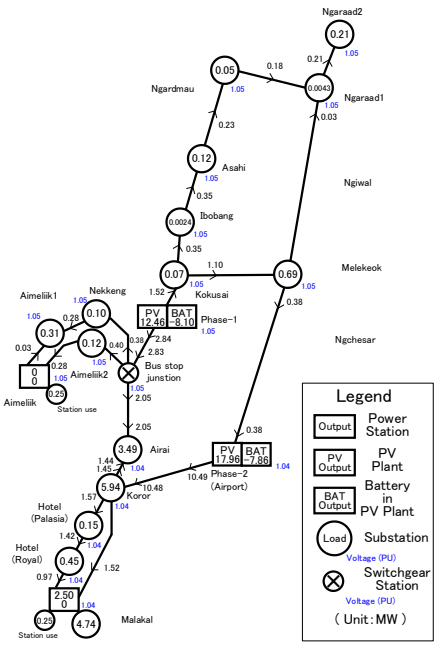
- 最大需要時（再エネ出力ゼロ）：需要ピークは 19 時～20 時頃であり日没後のため PV は発電しておらず、また PV 地点に設置された蓄電池は短周期補償用電池（PV 脱落時補償）であり出力は基本的にゼロであるため、負荷全量に対してはディーゼル発電機のみが供給している。需要は High ケースの 24.2MW とした。ディーゼル発電機の運転台数は 7 台であり、各発電所の運転台数は PPUC の運用方針を踏まえアイメリーク発電所 3 台、マラカル発電所 4 台とした。
- オフピーク需要時（再エネ最大出力）時：昼間時間帯のため、Phase-1 の PV は最大出力で発電しているものとし、需要は Low ケースの 16.2MW とした。また、ディーゼル発電機の運転台数はマラカル発電所 1 台（最小負荷率 50%）とした。

② 潮流解析

図 2.10 に潮流解析結果を示す。最大潮流は、最大需要時で開閉所―アイライ変電所線の 6.71MW、再エネ出力最大時は Phase-2－コロール変電所線の 10.49MW であり、送電容量 21.5MW に十分に小であり過負荷の恐れはない。電圧面では最大需要時 99～103%、再エネ出力最大時は 104～105%の範囲にあり適正値（基準値 100±5%）を維持している。



2034 年 最大需要時（再エネ出力ゼロ）

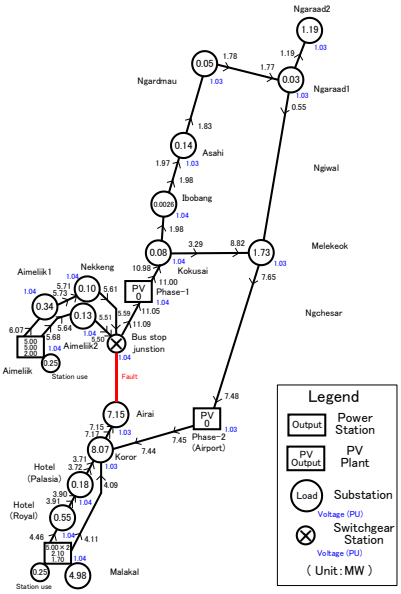


2034 年 オフピーク需要時（再エネ最大出力）

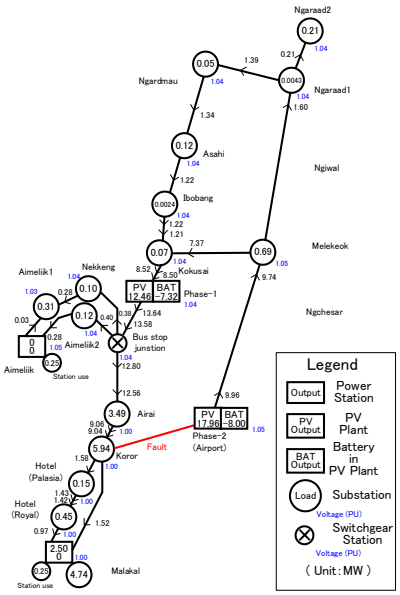
出典：調査団作成

図 2.10 潮流解析結果（2034 年）

また、図 2.11 に最大潮流送電線にて事故が発生し同送電線が開放された場合の潮流解析解析結果を示す。同図より、最大潮流は、最大需要時（開閉所―アイライ線にて送電線事故）では Phase-1－開閉所線の 11.09MW、再エネ出力最大時（Phase-2―コロール線にて送電線事故）においても同線の 13.64MW であり送電容量 21.50 MW に十分に小であるため、過負荷の恐れはない。また、電圧面では最大需要時 103～104%、再エネ出力最大時は 100～105%の範囲にあり適正値（基準電圧±5%）を維持している。



2034 年 最大需要時（再エネ出力ゼロ）



2034 年 オフピーク需要時（再エネ最大出力）

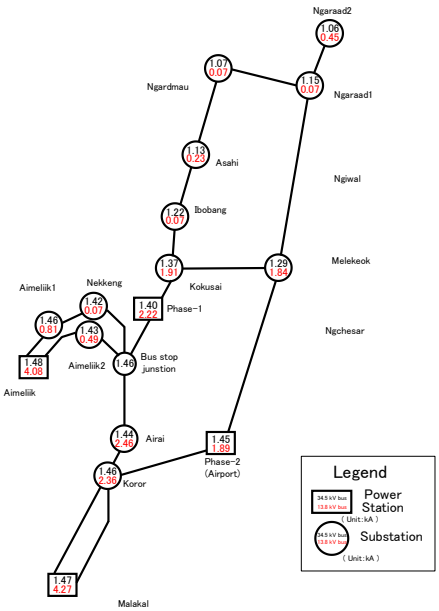
出典：調査団作成

図 2.11 潮流解析結果（2034 年、送電線事故時）

③ 事故電流

図 2.14 に事故電流解析結果を示す。なお、解析にあたっては、様々な系統運用における最大値を算出するためアイメリーク発電所並びにマラカル発電所の既設ディーゼル発電機 7 台が運転しているものとして仮定した。

解析結果としては､3 相短絡電流の最大値は 34.5 kV 系統ではアイメリーク発電所の 1.48 kA、13.8 kV 系統ではマラカル発電所の 4.27 kA であり遮断器定格の 12.5 kA に対して十分に小であり全く問題ないことが確認できた。



出典：調査団作成

図 2.12 事故電流解析結果（2034 年）

(5) 結論

系統解析結果を下記に示す。

表 3-1-1-3.1 潮流解析結果

系統解析	2021 年 （調査時点）	2024 年	2027 年 （評価年次）	2034 年
潮流解析 （健全時：最大需要時およびオフピーク）	○ 潮流・電圧 問題なし	○ 潮流・電圧 問題なし	○ 潮流・電圧 問題なし	○ 潮流・電圧 問題なし
潮流解析 （事故時：最大需要時およびオフピーク）	-	-	○ 潮流・電圧 問題なし	○ 潮流・電圧 問題なし
事故電流解析 （短絡電流計算）	○ 遮断器定格 12.5 kA 以下	-	-	○ 遮断器定格 12.5 kA 以下
潮流解析（プロジェクトなし） （健全時：最大需要時）	-	-	× 潮流・電圧 問題あり （アイライ変電所 の過負荷等）	-
安定度解析（定態安定度・過渡安定度）	-	-	○ 安定度上問題なし （系統慣性は十分 に考慮すること）	-

現状系統ならびに 2034 年に至る中間断面系統を含め、潮流解析面ならびに事故電流面の問題はない。また、安定度面においても、これまで 1 回線送電線のため両発電所の連系が喪失していたが、2024 年に完成する本プロジェクトの新設 34.5kV 送電線（コロール変電所－コクサイ変電所線およびマラカル発電所－コロール変電所線）により変電所への供給送電線の 2 ルート化が実現するため、系統事故時においても両発電所の安定運転が可能となる。

以上より、将来計画（2024 年～2034 年）及び事故防止策（N-1 事故）を考慮した各設備仕様の妥当性を確認することできた。故に、本プロジェクトで供与する送変電設備により、コロール島とバベルダオブ島における電力供給の信頼性・安定性の向上並びに再生可能エネルギー導入の促進を図ることができると考える。なお、Phase-1 や Phase-2 などの大規模再エネ出力時においては、系統における慣性を十分に考慮の上、ディーゼル発電機の台数を決定する必要がある。