CHAPTER 8

PRELIMINARY DESIGN

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8.1 OVERHEAD TRANSMISSION FACILITIES

8.1.1 Outline of 230kV Overhead Transmission Line

OHL_Route3 is double circuit overhead transmission line which branches at the midpoint of NPP and WPP and goes to GS5. The location of the transmission line is flat area with an altitude of 10 to 20 m. The ground is good in general. The route of the transmission line is restricted around GS5, because of the residence. The outline of 230kV transmission line is shown in Table 8.1-1. The location map of 230kV overhead transmission line after selection is shown in Fig. 8.1-1. A rough route sectional view is shown in Fig. 8.1-2 and the steel tower which is due to branch is shown in Fig. 8.1-3.

Table 8.1-1 Outline of 230kV Overhead Transmission Line

Route	OHL_Route3
Nominal Voltage	230kV
Circuits	2cct
Location	From : Midpoint of NPP and WPP To : GS5
Total Length	10.2km
Supporting structure	Steel tower or Special steel tower : 31
Conductor	TACSR*1 610mm^2 × 2 or equivalent
Ground Wire	OPGW*2 90mm^2 or equivalent
Ground Wire	AC*3 100mm^2 or equivalent

*1 TACSR : Thermal-resistant Aluminum alloy Conductor Steel Reinforced
*2 OPGW : Optical Fiber Ground Wire
*3 AC : Aluminum Clad Steel

Source: JICA Study Team

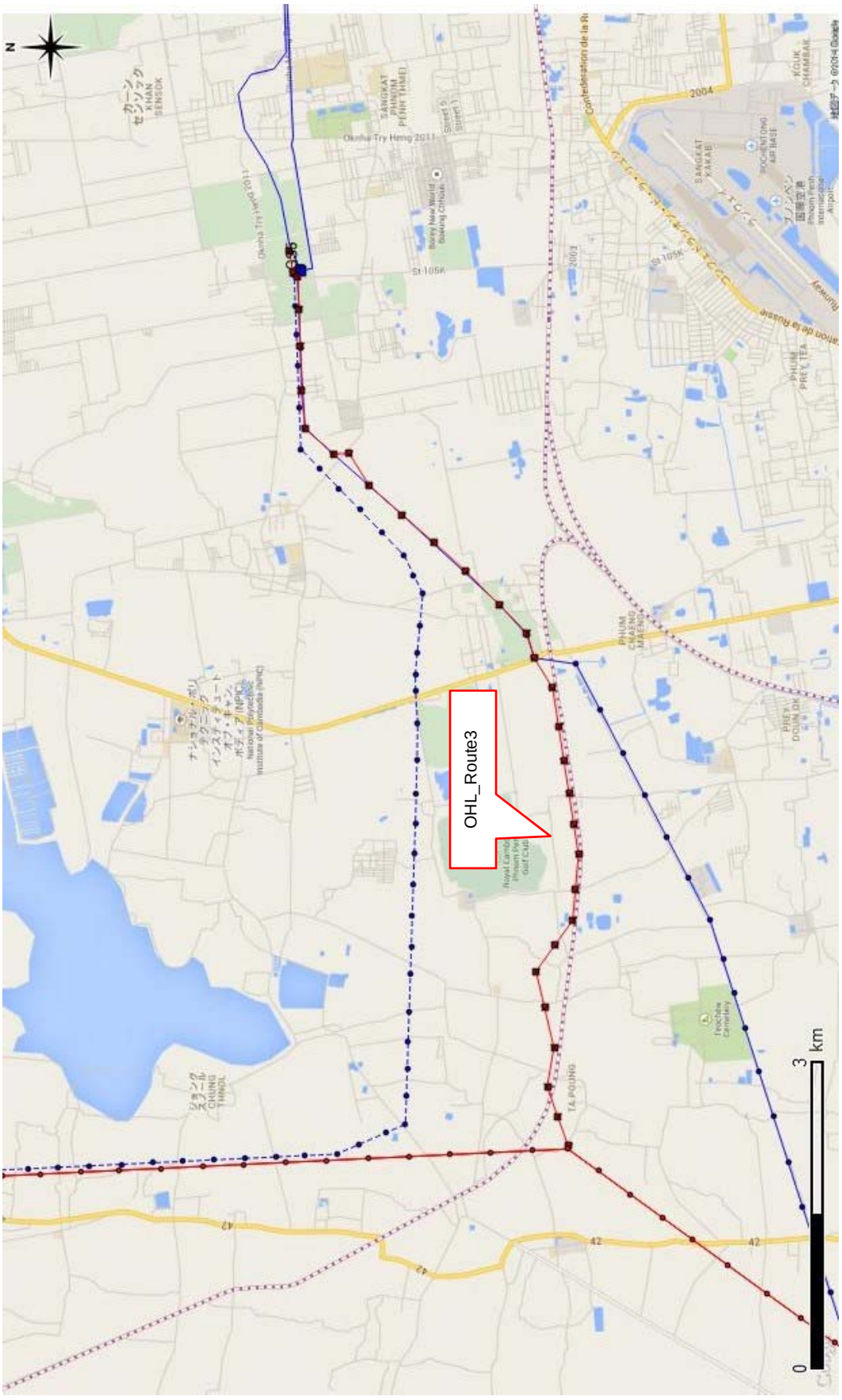
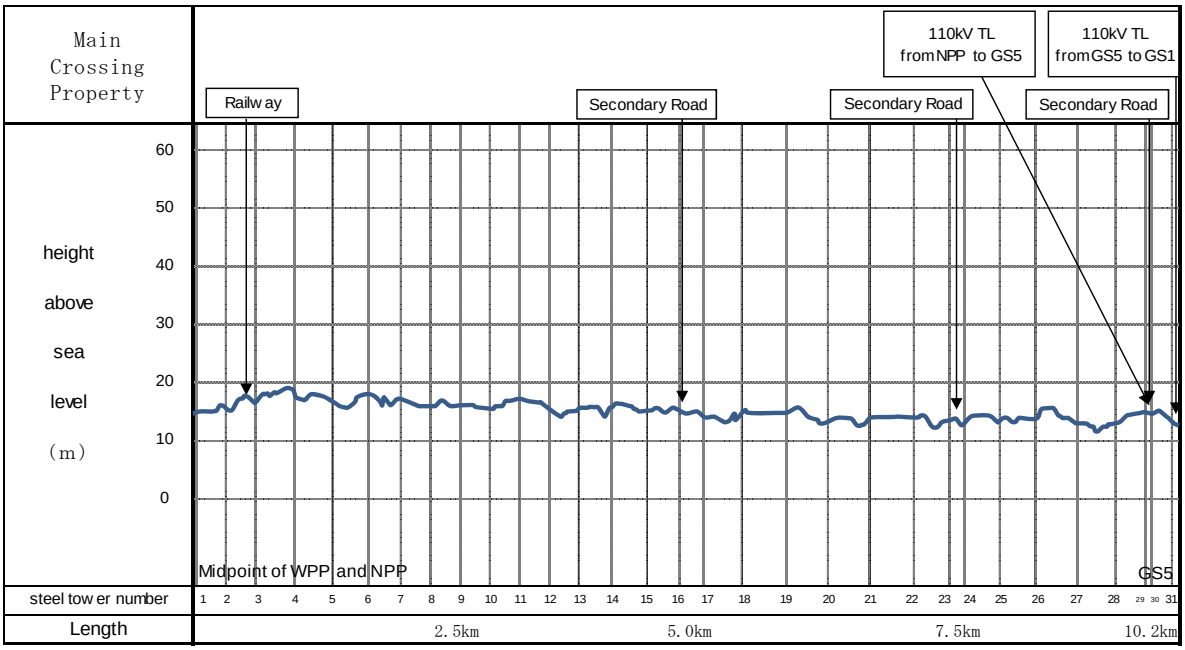


Fig. 8.1-1 Location Map of 230kV Overhead Transmission Line



Source: JICA Study Team

Fig. 8.1-2 Rough Route Sectional View of 230kV Overhead Transmission Line

Fig. 8.1-3 230kV Steel Tower in the Midpoint of NPP and WPP

8.1.2 Transmission Capacity of 230kV Overhead Transmission Line

OHL_Route3 branches from the 230kV transmission line between NPP and WPP. The transmission capacity of the 230kV overhead transmission line from the midpoint of NPP and WPP to GS5 shall be more than 861 MVA/cct which is equivalent of the 230kV transmission line between NPP and WPP. In consideration of the future substation's construction around the midpoint of NPP and WPP, TACSR 610mm^2 × 2 whose capacity is more than 1,300 MVA/cct shall be used. Conductor (transmission capacity) and Ground Wire which will be used by EDC's 230kV transmission lines are shown in Table 8.1-2.

Table 8.1-2 Conductor (Transmission Capacity) and Ground Wire used by EDC

Type		230kV (Capacity)
Conductor	TACSR	610mm^2 × 2 (1,359MVA/cct)
	ACSR*1	632mm^2 × 2 (861MVA/cct)
		400mm^2 × 2 (604MVA/cct)
		632mm^2 (430MVA/cct)
		400mm^2 (302MVA/cct)
Ground Wire	AC	90 mm^2, 100 mm^2
	GSW*2	90 mm^2
	OPGW	90 mm^2, 100 mm^2

*1 ACSR : Aluminum Conductor Steel Reinforced
*2 GSW : Galvanized Stranded Steel Wire Source: JICA Study Team

8.1.3 Preliminary Design of 230kV Overhead Transmission Line

Preliminary design of transmission line for this Study is carried out via the following steps 1 to 6. The preliminary design is carried out from the data which came to hand at the GREPTS (General Requirement of Electric Power Technical Standards), SREPTS (Specific Requirements of Electric Power Technical Standards), and a spot.

Step 1 Setup of climatic conditions
Step 2 Selection of conductor and ground wire
Step 3 Setup of Ground Clearance
Step 4 Setup of wiring conditions
Step 5 Setup of insulator set, supporting structure, and the foundation
Step 6 Separate setting of a special part

(1) Setup of climatic conditions

The main factors affecting the design of transmission line are climatic conditions. In consideration of SREPTS and the basic design of 230kV and 115kV overhead transmission line carried out by the Cambodia, basic climatic conditions are shown in Table 8.1-3. In consideration of not-paved roads and actual dust conditions, the pollution level shall be little considered.

Table 8.1-3 Basic Climatic Conditions

Items	Range	Value
Temperature	Maximum	40°C
	Minimum	15°C
	Average	28°C
Altitude above sea level		Not exceed 1,000m
Isokeraunic Level (IKL)		38-132 thunderstorm days/year
Climate		Tropical
Annual Rainfall	Average	1,290mm
Maximum Wind Velocity		32.0m/s
Maximum Humidity		100%
Pollution Level		Salt contamination is little considered. Tropical condition shall be considered.

Source: JICA Study Team

(2) Selection of conductors and ground wire

Conductor whose capacity is more than 1,300MVA/cct shall be used. Ground wires which are used at 230kV transmission line between NPP and WPP shall be used. Technical characteristics of conductor are shown in Table 8.1-4. And technical characteristics of ground wires are shown in Table 8.1-5. In consideration of IKL, two ground wires shall be attached.

Table 8.1-4 Technical Characteristics of Conductor

Type of Conductor	TACSR/AC 610 mm^2
Component of stranded wires	Al 54/3.80, AC 7/3.80
Total area of Conductor	691.8 mm^2
Total Diameter	34.20 mm
Weight	2,198 kg/km
Ultimate Tensile strength	180,000 N
Modulus of elasticity	71.8 kN/mm^2
Coefficient of linear expansion	20.6×10^{-6}/°C
Maximum working tension	Less than 72,000N
DC resistance at 20°C	0.0458 ohm/km

Source: JICA Study Team

Table 8.1-5 Technical Characteristics of Ground Wires (230kV)

Type	AC 100 mm^2	OPGW 90mm^2
Component of stranded wires	AC 7/4.3	AC 8/3.7, OP unit:1/6.0
Total area of wires	101.6 mm^2	106.4 mm^2
Total Diameter	12.9 mm	13.4 mm
Weight	643.7 kg/km	613.0 kg/km
Ultimate Tensile strength	112,400 N	98,300 N
Modulus of elasticity	149,100 N/mm^2	149,000 N/mm^2
Coefficient of linear expansion	12.9×10^{-6}/°C	12.9×10^{-6}/°C
Maximum working tension	Less than 40,460 N	Less than 35,380 N
DC resistance at 20°C	0.745 ohm/km	0.889 ohm/km
Number of optical fiber	—	24

Source: JICA Study Team

(3) Setup of ground clearance

The height of steel tower is determined by setup of clearance conditions. The minimum height from the ground is set by GREPTS and SRPETS. With this Study, in consideration of going through the flat ground near Phnom Penh and a large number of crossing roads, ground clearance is considered as the minimum height of conductor above ground of roads which secures 14.2m. Minimum height of conductor above ground (230kV) is shown in Table 8.1-6.

Table 8.1-6 Minimum Height of Conductor above Ground (230kV)

Definition area	clearances
Among bare conductors and supporting structures, arms, guy wires and so on	No less than 1.45m
Urban areas	7.7m
Areas where third persons hardly approach	6.7m
Roads and railways	14.2m
River and seas	Adding 4.2m
Other facilities	4.2m
Trees	3.2m

Source: JICA Study Team

(4) Setup of wire conditions

(a) Maximum working tension of conductor

The maximum working tension of the conductor is decided taking into account of the following two factors.

- The maximum tension (>Maximum working tension) of the conductor must not exceed 40 percent of the ultimate Strength Tensile of the conductor.

- EDS (Every Day Stress) (Tension at 28°C with no wind) is less than 25 percent of the ultimate strength tensile of the conductor.

(b) Maximum working tension of ground wire

The maximum working tension of the ground wire is generally set up like "the sag of the ground wire under EDS condition is below 80% of the conductor's sag at the standard span length (350m)". The result by which requirements were satisfied is shown in Table 8.1-7.

Table 8.1-7 Maximum Working Tension and EDS (Max Span Length = 500m)

Type	UTS	Maximum Working Tension	EDS
TACSR/AC 610mm^2	180,000N	49,030N (MWT / UTS =27%)	33,620N (EDS/UTS=19%)
AC 100mm^2	112,400N	19,620N (MWT / UTS =18%)	13,930N (EDS/UTS=13%)
OPGW 90mm^2	98,300N	19,620N (MWT / UTS =20%)	14,320N (EDS/UTS=15%)

* The part where span length is especially short and branch part inquire separately. Source: JICA Study Team

(c) Sag of conductor

Because the transmission line progress place of this study does not almost have a vertical interval and is subject to the influence of steel tower's height by span length, it sets the maximum span length to 500 m. The outline calculation result of sag by span length is shown in Table 8.1-8.

Table 8.1-8 Sag of Conductor (at 150°C with no wind)

Span length	Sag
200 m	6.77 m
250 m	8.80 m
300 m	11.3 m
350 m	14.2 m
400 m	17.5 m
450 m	21.1 m
500 m	25.1 m

Source: JICA Study Team

(5) Setup of insulator set, supporting structure, and the foundation

(a) Insulator set

The ball socket type or clevis type suspension insulator (standard disc type porcelain insulator) which shall comply with IEC (International Electrotechnical Commission) 60120 and 60305 or equivalent is used for an insulator set. The specifications of an insulator are shown in Table 8.1-9. An insulator is shown in Fig. 8.1-4. The insulator number may be 17 pieces equivalent to the 230kV transmission line which passes from WPP to NPP.

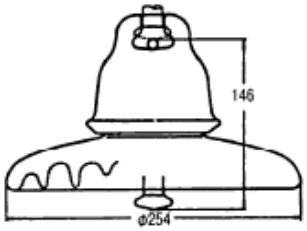


Fig. 8.1-4 SU165BN

Source: NGK Catalogue

Table 8.1-9 Insulator Size

Type	Height	Diameter	R.U.S.	Remarks
SU165BN × 2	146mm	254mm	330kN	Tension (NGK)
U160BP × 2	146mm	320mm	320kN	Tension (Chinese)
SU165BN	146mm	254mm	165kN	suspension (NGK)
U160BP	146mm	320mm	160kN	suspension (Chinese)
SU120CN	146mm	254mm	120kN	suspension (NGK)
U120BP	146mm	254mm	120kN	suspension (Chinese)

Source: JICA Study Team

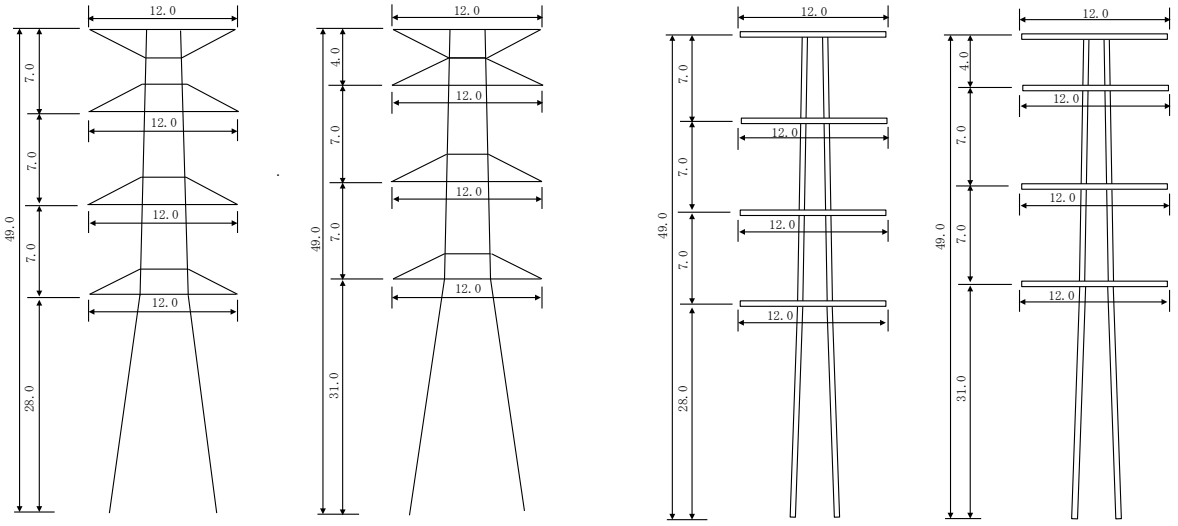
(b) Supporting structure

Supporting structure uses a steel tower or a special steel tower. Special steel tower shall be used along the railway. Fundamental steel tower types are four models (A ~ D) shown in Table 8.1-10. The part which crosses a 115kV transmission line designs individually. The example of the construction drawing of a steel tower is shown in Fig. 8.1-5

Table 8.1-10 Fundamental Steel Tower Type

Tower Type	Insulator String	Horizontal Angle of Line
A	Suspension	0° ~ 3°
B	Tension	0° ~ 30°
C	Tension with supporting	0° ~ 60°
D	Tension with supporting	Dead end tower

Source: JICA Study Team



Source: JICA Study Team

Fig. 8.1-5 Steel Tower's Example
(Left side : steel tower, Right side : Special steel tower)

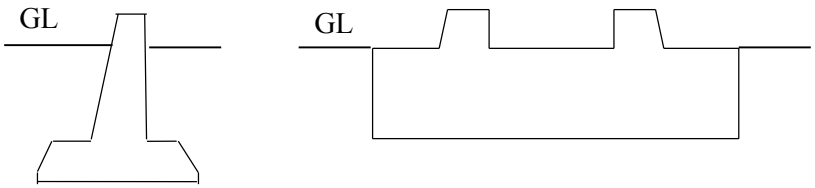
(c) Foundation

The result of having boring, it is assumed that supporters come out more shallowly. Therefore generally adopts Pad & Chimney foundation shown in Table 8.1-11. As the result of an additional geological survey, the possibility of the use of Mat foundation use is examined. The example of foundation type is shown in Fig. 8.1-6.

Table 8.1-11 Foundation Type and Application

Foundation Type	Application
Pad & Chimney	- N value : More than 10 - Flat area with good soil condition
Mat	- N value : Less than 10 - Flat area with soft soil condition, and in which differential displacement might occur at Pad & Chimney

Source: JICA Study Team



Source: JICA Study Team

Fig. 8.1-6 Foundation's Example
(Left :Pad & Chimney, Right :Mat)

(6) Separate setting of a special part

(a) The crossing part of 115kV transmission line

For the restrictions of this ground, it crosses 115kV transmission line 2 times. The height of steel tower is needed over 60m at least, because the height of the 115kV existing steel tower is 28 ~ 40m and it is a flat ground. Therefore, checking about the installation of the red and white steel tower and the aviation sign etc. is required.

(b) The part along the railway

The railway is not used now. But at the part along the railway, it considers so that there may be no cave-in of a railway in considering of the possibility of prospective use.

(c) Road crossing part

At the road crossing part, the height of the conductor at least needs 14.2m. But it makes higher, because of the existing distribution line and the existing structure.

8.1.4 230kV Estimated Cost of Construction

The estimated cost of construction shown in Table 8.1-12 was calculated based on the construction track record of the past in Cambodia and the estimate of Japanese companies. Because there were many uncertainties, a steel tower, the foundation, and a reserve fund included the maximum which may be assumed.

Table 8.1-12 Estimated Cost of Construction of 230kV Transmission Line

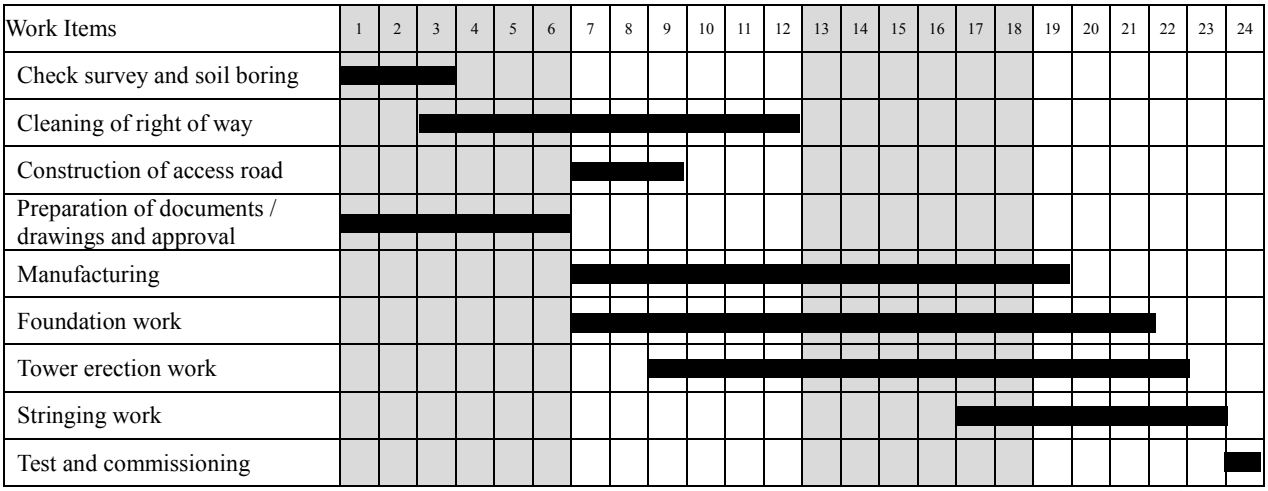
Category	No.	Items	From Midpoint of NPP and WPP to GS5; 230kV, 10.2km					
			Unit	Quantity	Unit Rate (1000US$)	Amount (1000US$)	FC (1000US$)	LC (1000US$)
Equipment Fee	1	Steel tower	sets	17	60.725	1,032.317	1,032.317	
	2	Special steel tower	sets	14	784.264	10,979.698	10,979.698	
	3	Conductor	km	122.4	10.600	1,297.440	1,297.440	
	4	Ground Wire	km	10.2	1.486	15.157	15.157	
	5	Optical Ground Wire	km	10.2	4.255	43.403	43.403	
	6	Junction BOX for OPGW	sets	7	0.234	1.640	1.640	
	7	Insulators	LS	1	231.000	231.000	231.000	
	8	Strings & Fittings	LS	1	160.776	160.776	160.776	
	9	Spare Parts & Others	LS	1	1,376.143	1,376.143	1,376.143	
		subtotal				*15,137.574*	*15,137.574*	*0.000*
Works Cost	10	Preparation of documents/drawings	LS	1	263.047	263.047		263.047
	11	Foundation Work	sets	17	56.521	960.859		960.859
	12	Foundation Work(special)	sets	14	118.694	1,661.720		1,661.720
	13	Tower Erection	sets	17	4.416	75.072		75.072
	14	Tower Erection(special)	sets	14	43.277	605.875		605.875
	15	Stringing & Sagging	km	10.2	6.938	70.770		70.770
	16	OPGW work	LS	1	6.308	6.308		6.308
	17	Temporary facilities	LS	1	80.685	80.685		80.685
	18	Others	LS	1	558.650	558.650		558.650
		subtotal				*4,282.986*	*0.000*	*4,282.986*
		Total				**19,420.560**	**15,137.574**	**4,282.986**

Source: JICA Study Team

8.1.5 230kV Rough Construction Process

The rough construction process shown in Table 8.1-13 was based on the track record neighboring countries and in the past. If land acquisition is completed, a process can be shortened by putting in many construction groups.

Table 8.1-13 Rough Construction Process of 230kV Transmission Line



Source: JICA Study Team

8.1.6 Outline of 115kV Overhead Transmission Lines

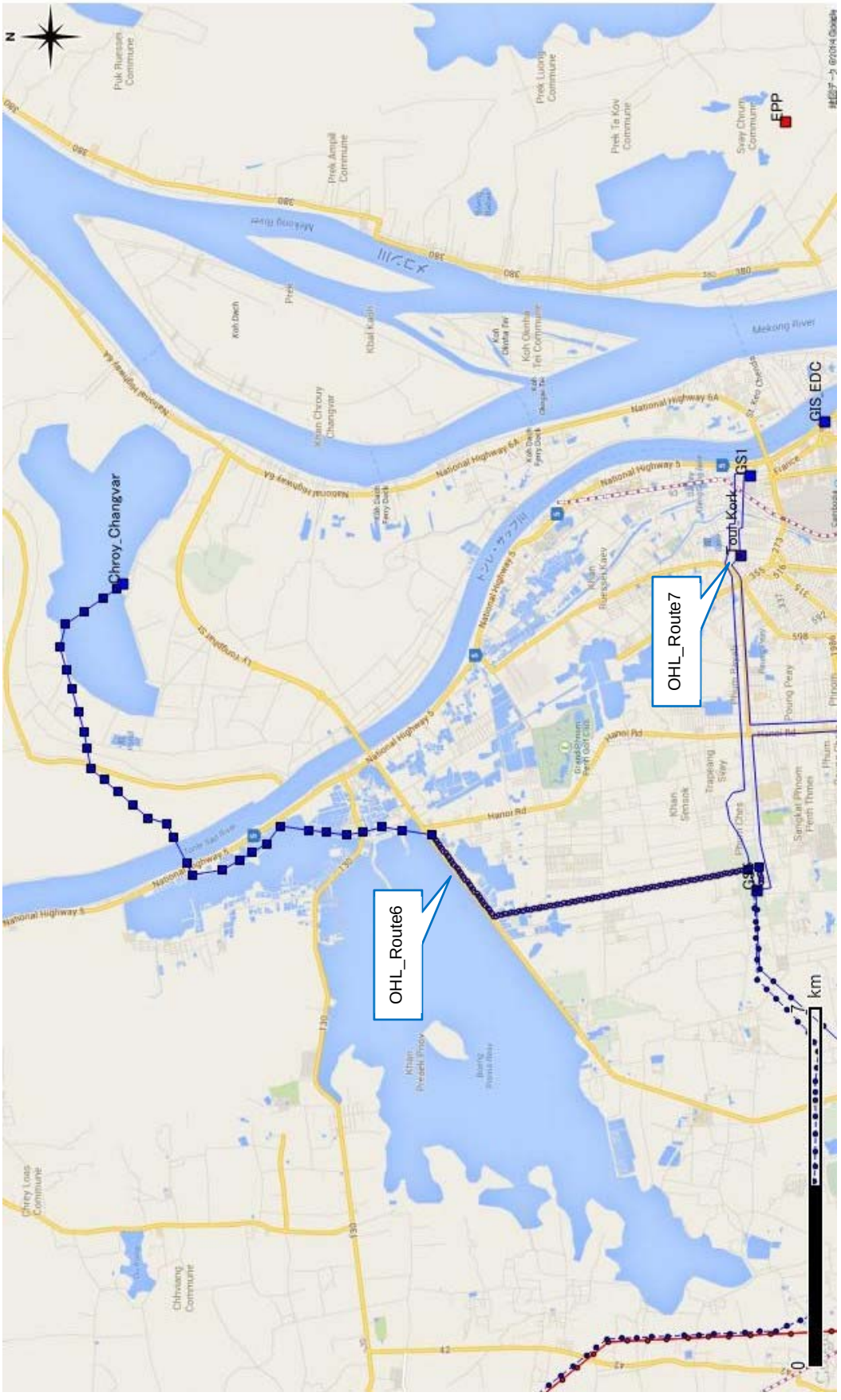
There are two 115kV overhead transmission lines in this Study. One is OHL_Route6 which connects from GS5 to Chroy Changvar S/S. Another is OHL_Route7 which branches at the midpoint of GS5 and GS1 and goes to Toul Kork S/S. The outline of 115kV overhead transmission lines is shown in Table 8.1-14. The location map of 115kV overhead transmission lines is shown in Fig. 8.1-7 and Fig. 8.1-8. A rough OHL_Route6 sectional view is shown in Fig. 8.1-9.

Table 8.1-14 Outline of 115kV Overhead Transmission Lines

Route	OHL_Route6	OHL_Route7
Nominal Voltage	115kV	115kV
Circuits	2cct	2cct
Location	From GS5 To Chroy Changvar	From Midpoint of GS5 and GS1 To Toul Kork
Total Length	20.2km	0.1km
Supporting structure	Concrete pole .....136 Steel pipe pole.....9 Steel tower .....33 (included 4cct steel tower: 4)	Steel pipe pole..... 1
Conductor	ACSR 632mm^2 or ACSR 250mm^2 equivalent	AAC* 250mm^2 × 2
Ground-Wire	OPGW 70mm^2 or equivalent AC 90mm^2 or equivalent	OPGW 70mm^2 × 2

*AAC : All Aluminum Conductor

Source: JICA Study Team



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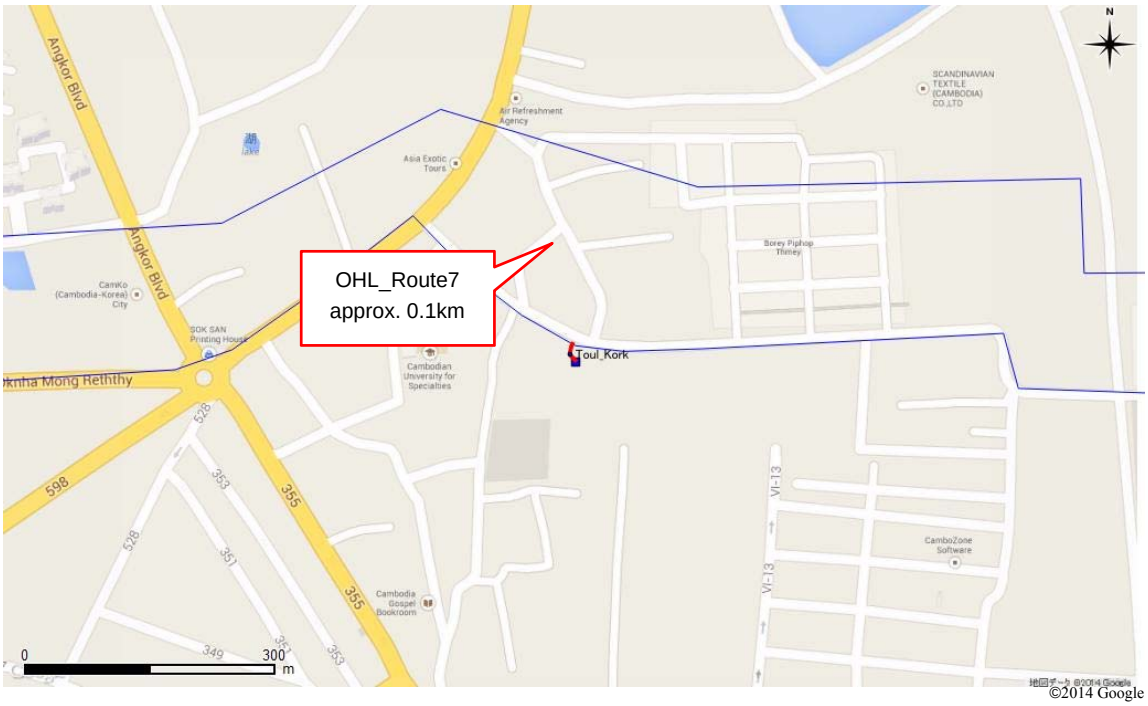
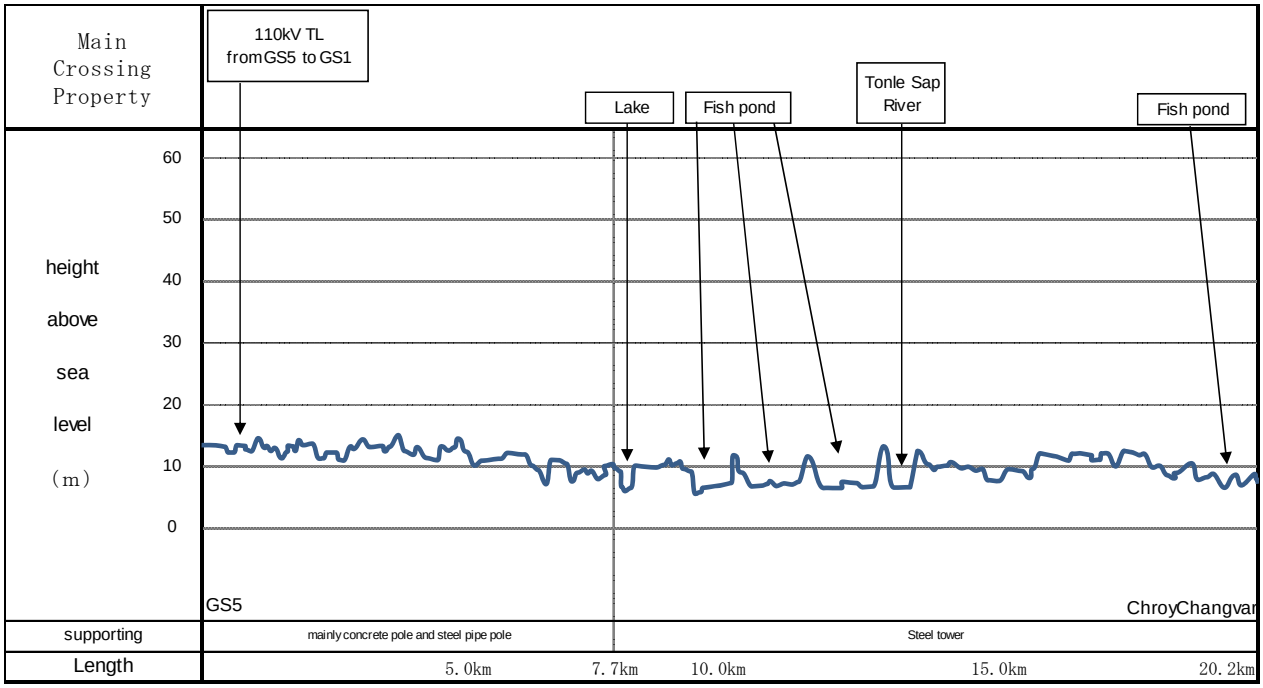
Source: JICA Study Team

Fig. 8.1-7 Location Map of 115kV Overhead Transmission Lines



Source: JICA Study Team

Fig. 8.1-8 Location Map of 115kV_OHL_Route7



Source: JICA Study Team

Fig. 8.1-9 Rough Route Sectional View of 115kV_OHL_Route6

8.1.7 Transmission Capacity of 115kV Overhead Transmission Line

The future demand of Chroy Changvar assumes 234 MW (246MVA) of maximum power demand in 2030 from Table 3.2-8 "Peak Demand of Each Grid Substation in Phnom Penh System". Therefore, OHL-Route6 shall have the transmission capacity of 75% of two circuits larger than this maximum power demand, and it shall use ACSR 632mm^2 which has an adoption track record in Cambodia. OHL_Route7 branches at the midpoint of GS5 and GS1. Therefore AAC 250mm^2 × 2 which is used at 115kV transmission line between GS5 and GS1 shall be used. Conductor (Transmission Capacity) and Ground Wire which are used by EDC are shown in Table 8.1-15.

Table 8.1-15 Conductor (Transmission Capacity) and Ground Wire used by EDC

Type		115kV (Capacity)
Conductor	ACSR	632mm^2 (215MVA/cct) 150mm^2 (85MVA/cct)
	AAC	250mm^2 × 2 (238MVA/cct)
Ground Wire	AC	90mm^2
	GSW	50mm^2, 70mm^2
	OPGW	70mm^2

8.1.8 Preliminary Design of 115kV Transmission Line

Preliminary design of 115kV transmission lines for this Study is carried out a procedure equivalent to 220kV.

(1) Setup of climatic conditions

The climatic conditions are the same as that of 230kV transmission line.

(2) Selection of conductors and ground wire

The conductor which has a track record by the 115kV transmission line is selected. Technical characteristics of conductor are shown in Table 8.1-16. And Technical characteristics of ground wire are shown in Table 8.1-17. In consideration of IKL, two ground wires shall be attached in the steel tower section.

Table 8.1-16 Technical Characteristics of Conductors (115kV)

Type of Conductor	ACSR 632mm^2	AAC 250 mm^2
Component of stranded wires	Al 45/4.20, St 7/2.80	19/4.22
Total area of Aluminum wires	666.55 mm^2	265.7 mm^2
Approximate Overall Diameter	33.60 mm	21.10 mm
Weight	2,060 kg/km	731 kg/km
Ultimate Tensile strength	148,700 N	40,400 N
Modulus of elasticity	71.1 kN/mm^2	56.0 kN/mm^2
Coefficient of linear expansion	20.85 × 10^{-6}/°C	23 × 10^{-6}/°C
Maximum working tension	Less than 53,500 N	Less than 14,540 N
DC resistance at 20°C	0.04633 ohm/km	0.1083 ohm/km

Source: JICA Study Team

Table 8.1-17 Technical Characteristics of Ground-wires (115kV)

Type	OPGW 70 mm^2	AC 90 mm^2
Component of stranded wires	St 8/3.2, Al 1/5.0	AC 7/4.115
Total area of steel wires	64.34 mm^2	93.05 mm^2
Overall Diameter	11.4 mm	12.35 mm
Weight	454 kg/km	619 kg/km
Ultimate Tensile strength	78,000 N	101,000 N
Modulus of elasticity	149 kN/mm^2	149 kN/mm^2
Coefficient of linear expansion	12.9×10^{-6}/°C	12.9×10^{-6}/°C
Maximum working tension	Less than 28,080 N	Less than 36,360 N
DC resistance at 20°C	0.774 ohm/km	0.9197 ohm/km
Number of optical fiber	24	—

Source: JICA Study Team

(3) Setup of ground clearance

The minimum height from the ground is set by GREPTS and SREPTS. Minimum height of conductor above ground (115kV) is shown in Table 8.1-18.

Table 8.1-18 Minimum Height of Conductor above Ground (115kV)

Definition area	clearances
Among bare conductors and supporting structures, arms, guy wires and so on	No less than 0.70m
Urban areas	7.0m
Areas where third persons hardly approach	6.0m
Roads and railways	13.5m
River and seas	Adding 3.5m
Other facilities	3.5m
Trees	2.5m

Source: JICA Study Team

(4) Setup of wire conditions

(a) Maximum working tension of conductor

The maximum working tension of the conductor is decided taking into account of the following two factors.

- The maximum tension (>Maximum working tension) of the conductor must not exceed 40 percent of the ultimate Strength Tensile of the conductor.
- EDS (Tension at 28°C with no wind) is less than 25 percent of the ultimate strength tensile of the conductor.

(b) Maximum working tension of ground wire

The maximum working tension of the ground wire is generally set up like “the sag of the ground wire under EDS condition is below 80% of the conductor’s sag at the standard span length (450m)”. The result by which requirements were satisfied is shown in Table 8.1-19.

Table 8.1-19 Maximum Working Tension and EDS (Max Span Length = 600m)

Type	UTS	Maximum Working Tension	EDS
ACSR 632mm^2	148,700N	47,070N (MWT / UTS =32%)	31,780N (EDS/UTS=22%)
AC 90mm^2	101,000N	19,620N (MWT / UTS =20%)	14,120N (EDS/UTS=14%)
OPGW 70mm^2	78,000N	19,620N (MWT / UTS =26%)	15,000N (EDS/UTS=20%)

* The part where span length is especially short and branch part inquire separately. Source: JICA Study Team

(c) Sag of conductor

Because the transmission line progress place of this study does not almost have a vertical interval and is subject to the influence of steel tower quantity by span length, it sets the maximum span length to 600m. The outline calculation result of sag by span length is shown in Table 8.1-20.

Table 8.1-20 Sag of Conductor (at 90°C with no wind)

Span length	Sag
200 m	5.34 m
250 m	7.09 m
300 m	9.49 m
350 m	12.3 m
400 m	15.4 m
450 m	18.9 m
500 m	22.9 m
550 m	27.2 m
600 m	32.0 m

Source: JICA Study Team

(5) Setup of insulator set, supporting structure, and the foundation

(a) Insulator set

The ball socket type or clevis type suspension insulator (standard disc type porcelain insulator) which shall comply with IEC 60120 and 60305 or equivalent is used for an insulator set. The specifications of an insulator are shown in Table 8.1-21. The insulator number may be 9 pieces equivalent to general 115kV transmission line.

Table 8.1-21 Insulator Size

Type	Height	Diameter	R.U.S.	Remarks
SU165BN	146mm	254mm	165kN	Tension (NGK)
U160BP	146mm	320mm	160kN	Tension (Chinese)
SU120CN	146mm	254mm	120kN	suspension (NGK)
U120BP	146mm	254mm	120kN	suspension (Chinese)

Source: JICA Study Team

(b) Supporting structure

Supporting structure uses a steel tower, a concrete pole, and a steel pipe pole. A concrete pole is adopted only as a suspension type. A steel pipe pole is used for the tension type connected with a concrete pole and a steel tower. A river crossing point is separately considered as an individual design.

(c) Foundation

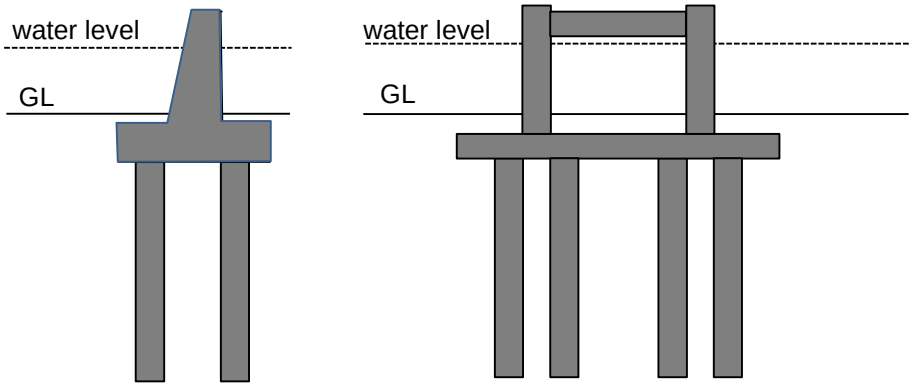
As the result of the boring, it is assumed that supporters are deep. Therefore, generally it adopts Pile foundation or Rahmen foundation shown in Table 8.1-22. As the result of an

additional geological survey, the use of other foundation is also considered. The structure of Pile foundation and Rahmen foundation is shown in Fig. 8.1-10.

Table 8.1-22 Foundation Type and Application

Foundation Type	Application
Pad & Chimney	- N value : More than 10 - Flat area with good soil condition
Mat	- N value : Less than 10 - Flat area with soft soil condition, and in which differential displacement might occur at Pad & Chimney
Pile	- N value : Less than 10 - Flat area with soft soil condition, and in which it is difficult to withstand compression stress at Pad & Chimney and Mat
Rahmen	- N value : Less than 10 - Flat area with soft soil condition, and high water level

Source: JICA Study Team



(Source: JICA Study Team)

Fig. 8.1-10 Foundation's Example
(Left : Pile, Right : Rahmen)

(6) Separate setting of a special part

(a) Crossing point in Tonle Sap River

At the crossing point in Tonle Sap River, the steel tower is the type of 4cct design with 230kV transmission line. The upside transmission lines are 230kV, and the lower transmission lines are 115kV. If crossing of a ship is taken into consideration, the height of the steel tower at least needs 90m. At the same time, the examination about the installation of the red and shite steel tower and the aviation sign etc. is required.

(b) Crossing point of 115kV transmission line

The transmission line needs to cross the 115kV transmission line from GS5 to GS1 near GS5. The steel tower adopts on the both ends of the crossing point.

8.1.9 115kV Estimated Cost of Construction

The estimated cost of construction shown in Table 8.1-23 and Table 8.1-24 was calculated based on the construction track record of the past in Cambodia. At the result of drilling, supporting structure and the foundation etc. included the maximum which may be assumed.

Table 8.1-23 Estimated Cost of Construction of 115kV_OHL_Route6

Category	No	Items	From GS5 to Chroy Changvar ; 115kV, ,20.2km					
			Unit	Quantity	Unit Rate (1000US$)	Amount (1000US$)	FC (1000US$)	LC (1000US$)
Equipment Fee	1	Steel tower	sets	33	46.958	1,549.627	1,549.627	
	2	concrete pole	sets	136	2.044	277.948	277.948	
	3	steel pole	sets	9	23.190	208.710	208.710	
	4	Conductor	km	121.2	7.913	959.056	959.056	
	5	Ground Wire	km	12.52	1.486	18.605	18.605	
	6	Optical Ground Wire	km	20.2	3.546	71.629	71.629	
	7	Junction BOX for OPGW	sets	14	0.234	3.280	3.280	
	8	Insulators	LS	1	318.654	318.654	318.654	
	9	Strings & Fittings	LS	1	221.783	221.783	221.783	
	10	Spare Parts & Others	LS	1	725.858	725.858	725.858	
		subtotal				*4,355.151*	*4,355.151*	*0.000*
WorksCost	11	Preparation of documents/drawings	LS	1	333.723	333.723		333.723
	12	Foundation Work(steel tower)	sets	33	109.953	3,628.449		3,628.449
	13	Foundation Work(concrete pole)	sets	136	1.997	271.555		271.555
	14	Foundation Work(steel pole)	sets	9	9.984	89.853		89.853
	15	Tower Erection(steel tower)	sets	33	2.934	96.834		96.834
	16	Tower Erection(concrete pole)	sets	136	0.478	65.008		65.008
	17	Tower Erection(steel pole)	sets	9	2.390	21.510		21.510
	18	Stringing & Sagging	km	20.2	5.046	101.929		101.929
	19	OPGW work	LS	1	7.569	7.569		7.569
	20	Temporary facilities & clearing	LS	1	329.859	329.859		329.859
	21	Others	LS	1	494.629	494.629		494.629
		subtotal				*5,440.917*	*0.000*	*5,440.917*
		Total				**9,796.068**	**4,355.151**	**5,440.917**

Source: JICA Study Team

Table 8.1-24 Estimated Cost of Construction of 115kV_OHL_Route7

Category	No	Items	From Midpoint of GS1 and GS5 to Toul Kork; 115kV, 0.1km					
			Unit	Quantity	Unit Rate (1000US$)	Amount (1000US$)	FC (1000US$)	LC (1000US$)
Equipment Fee	1	steel pole	sets	1	23.190	23.190	23.190	
	2	Conductor	km	1.2	2.873	3.448	3.448	
	3	Optical Ground Wire(+4.0km)	km	4.1	3.546	14.539	14.539	
	4	Junction BOX for OPGW	sets	2	0.234	0.469	0.469	
	5	Insulators	LS	1	4.536	4.536	4.536	
	6	Strings & Fittings	LS	1	3.157	3.157	3.157	
	7	Spare Parts & Others	LS	1	9.868	9.868	9.868	
		subtotal				*59.206*	*59.206*	*0.000*
WorksCost	8	Preparation of documents/drawings	LS	1	33.372	33.372		33.372
	9	*Foundation Work(steel pole)*	*sets*	*1*	*9.984*	*151.784*		*151.784*
	10	Tower Erection(steel pole)	sets	1	2.390	2.390		2.390
	11	Stringing & Sagging	km	4.1	2.250	9.225		9.225
	12	OPGW work	LS	1	2.250	2.250		2.250
	13	Others	LS	1	19.902	19.902		19.902
		subtotal				*218.923*	*0.000*	*218.923*
		Total				**278.129**	**59.206**	**218.923**

Source: JICA Study Team

8.1.10 115kV Rough Construction Process

The rough construction process shown in Table 8.1-25 is required for 12 months as a construction period in the dry season. If land acquisition is completed, a process can be shortened by putting in many construction groups.

Table 8.1-25 Rough Construction Process of 115kV Transmission Line

Work Items	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Check survey and soil boring																								
Cleaning of right of way																								
Construction of access road																								
Preparation of documents / drawings and approval																								
Manufacturing																								
Foundation work																								
Tower erection work																								
Stringing work																								
Test and commissioning																								

Source: JICA Study Team

8.2 UNDERGROUND TRANSMISSION FACILITIES

8.2.1 Outline of Underground Transmission Line Route

The 230kV/115kV underground transmission lines are shown in Table 8.2-1 and the route maps are shown in the following pages. And detailed cable route is shown in Appendix-4. UG_Route 5 was decided to be excluded from the scope of the Project following the discussion between JICA and EDC.

Table 8.2-1 Route Profile of 230kV/115kV Underground Transmission Lines

Route Name	Starting Point	Ending Point	Voltage Level	No. of Circuit	Route Length
UG_Route5	NCC*	GS3	115 kV	2	0.4 km
UG_Route4	GS5	NCC	230 kV	1	9.28 km

: UG_Route 5 was decided to be excluded from the scope of the Project following the discussion between JICA and EDC.

* NCC : National Control Center

Source: JICA Study Team

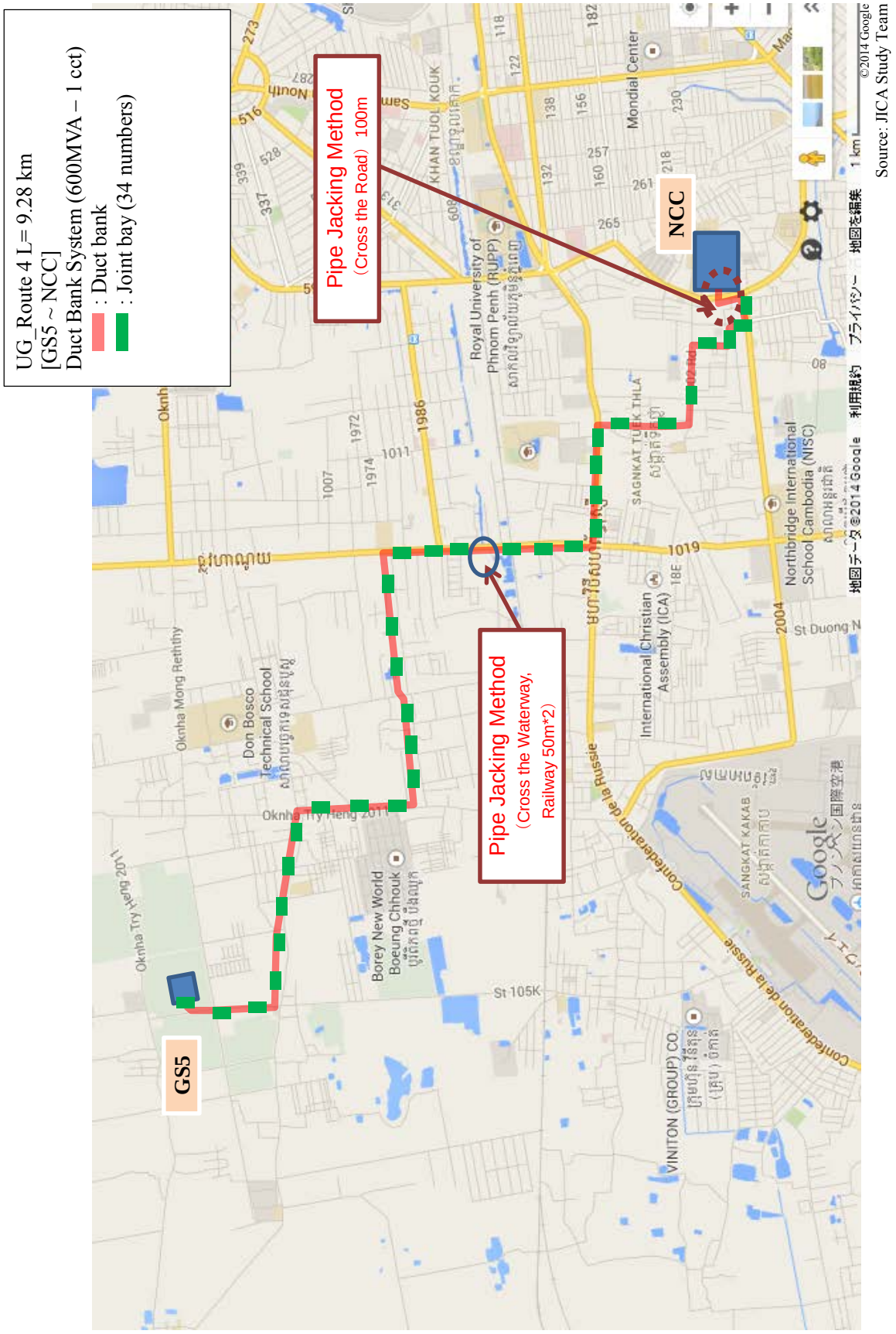


Fig. 8.2-1 Location Map of Tentative Route (UG_Route 4)

Fig. 8.2-2 Location Map of Tentative Route (UG_Route 5)

8.2.2 Transmission Capacity of Underground Transmission Line

The transmission capacity of the 230kV underground transmission line (1 circuit) from GS5 to NCC shall be 600MVA and the transmission capacity of the 115kV underground transmission line (2 circuits) from NCC to GS3 shall be 200MVA.

8.2.3 Type of 230kV/115kV Underground Cable and Installation Method

The duct bank system is to be applied as standard installation method of underground cable.

If the direct burial installation method is to be applied, open cut trenching will remain open for about one month, thus, there is a possibility of hindrances occurring to the life of the neighborhood and traffic disturbances, especially in the congested areas, narrow roads, heavy traffic roads, etc. To protect the above inconveniences, the duct bank system shall be applied to eliminate open cut places.

Moreover, in order to cope with the issue described in Section 4.2 (2) "Field survey of underground transmission line project of Phase 1", the points shown below adopt the pipe jacking method.

- From the technical viewpoint, the duct bank system construction method is very difficult. (Such as waterway crossing and railway crossing)
- Crossing of a wide road

(1) Burial Depth, Soil Temperature and Soil Thermal Resistivity

For the calculation of the current carrying capacity of the underground transmission line (cable), it is recommended that the maximum conductor temperature shall be 90°C as a mandatory condition to keep the XLPE (Cross-Linked Polyethylene) insulation in sound condition from the thermal deterioration/impact during its design life of 30 years.

In particular, if the burial depth is deeper, then the cables may be safer from the outside mechanical damages, but current carrying capacity of cables will be reduced according to the burial depth. In Cambodia, the burial depth of underground equipment such as the distribution cables and communication cables have been specified at 1.2m. Based on the above facts, the JICA Study Team decided that the burial depth should be a minimum of 1.2m from the surface of the ground.

On the other hand, the soil temperature and soil thermal resistivity were specified as 30°C and 1.2 K.m/W according to the same specified value of surrounding countries such as Thailand and Vietnam.

The above-mentioned parameter is the same as that of the Phase 1 Project (Preparatory Survey for Phnom Penh City Transmission and Distribution System Expansion Project in Cambodia).

(2) Cable Type and Installation Configuration

The current carrying capacities with related conductor sizes of 230kV/115kV underground cables shall be shown in Fig. 8.2-3 and Fig. 8.2-4 calculated on the conditions of Table 8.2-2.

Table 8.2-2 Calculated Conditions of Underground Cable Capacity

Burial depth (Top of ducts)	1.2 m
Distance between each cables	250 mm
Soil thermal resistivity	1.2 K.m/W
Soil temperature	30°C

Source: JICA Study Team

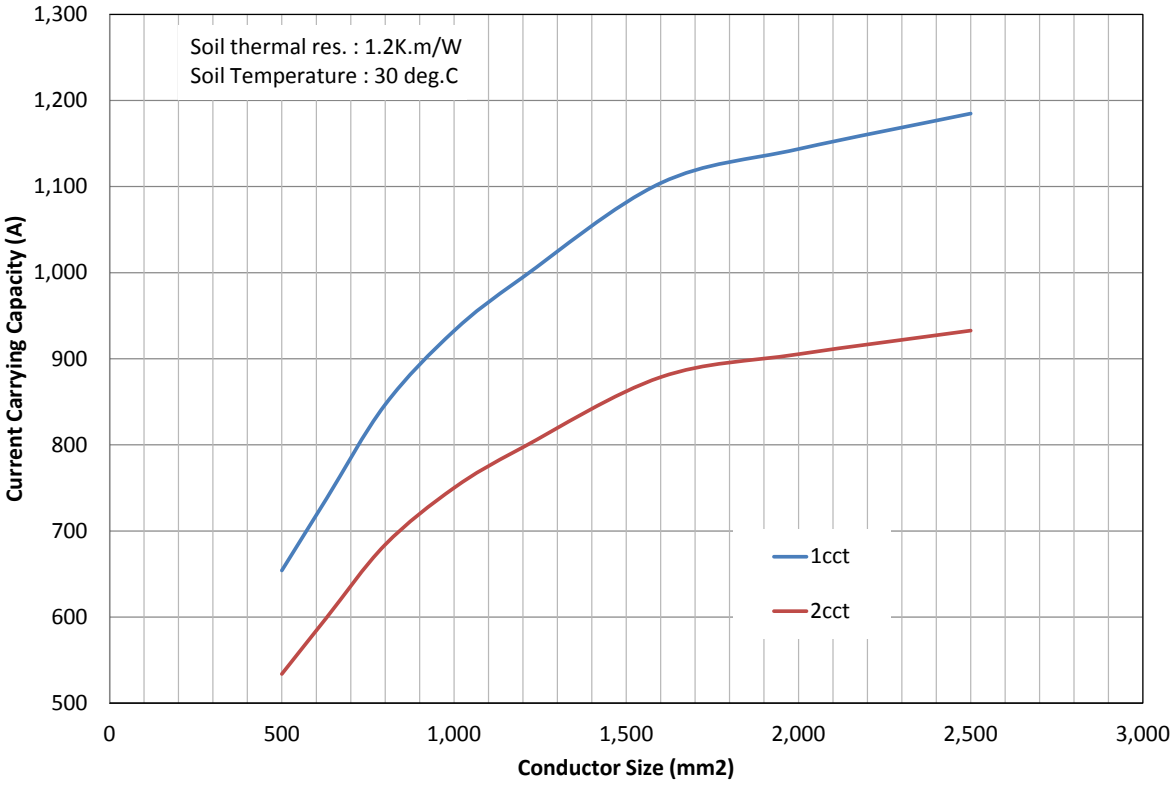


Fig. 8.2-3 Current Carrying Capacities of 230kV Underground Cables

Source: JICA Study Team

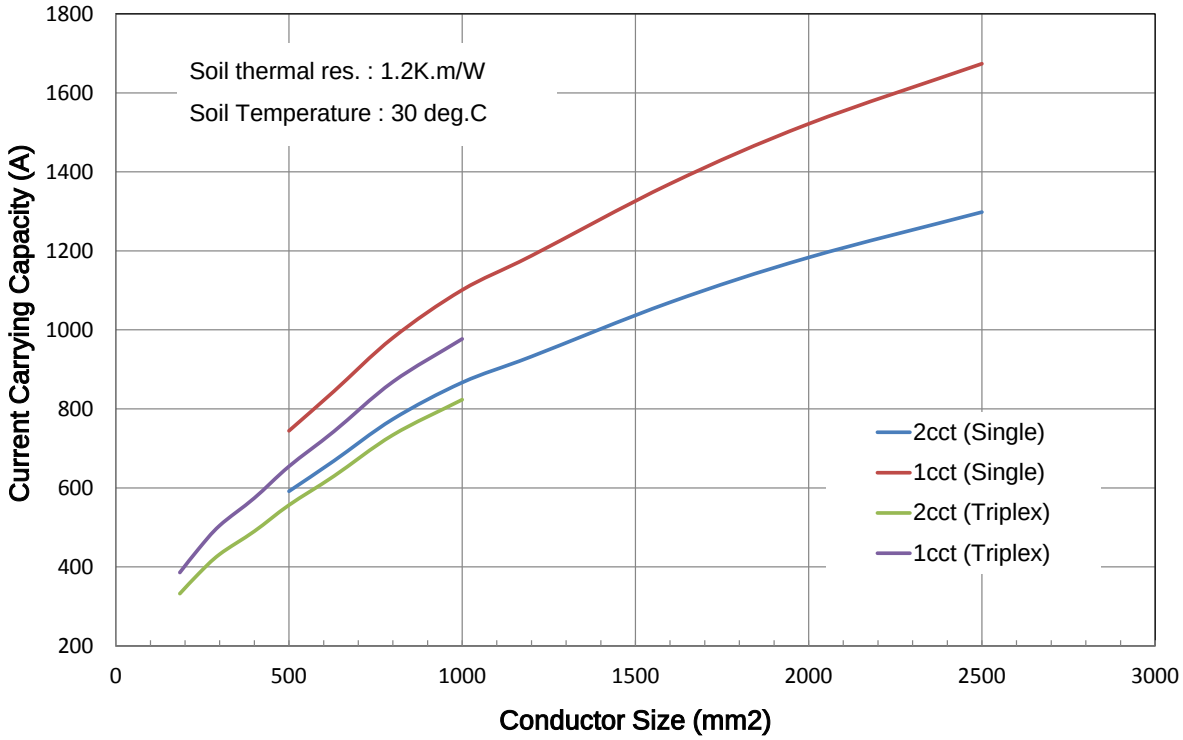


Fig. 8.2-4 Current Carrying Capacities of 115kV Underground Cables

Source: JICA Study Team

The required power current of the 600MVA transmission capacity at 230kV voltage is 1,506A. This power current is too large for the 230kV voltage level.

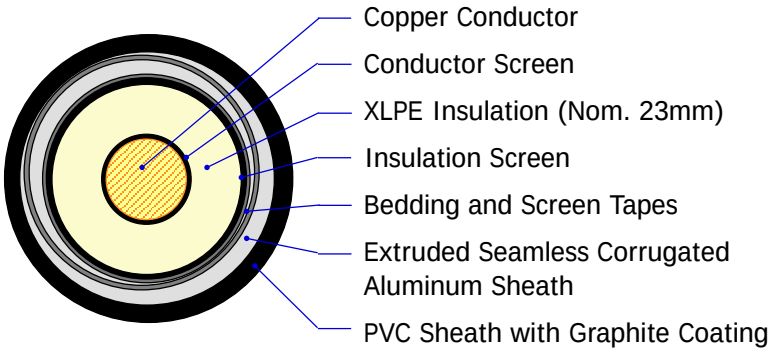
As shown in Fig. 8.2-3, the power current carrying capacity of the maximum conductor size of 2,500 mm^2 is 1,185A which is unable to pass the required capacity of 1,506A at a 600MVA transmission capacity.

Based on the above study, it is necessary to have two (2) cables per phase to carry the 600MVA transmission capacity. In other words, a total of six cables are necessary for the one circuit.

From the above calculation results shown in Fig. 8.2-3, dual cables with 1,200 mm^2 copper conductor are capable to pass the required capacity for a 600MVA transmission capacity at 230kV voltage.

The required power current of the 200MVA transmission capacity at 115kV voltage (2 cct) is 670A (133.3MVA/ cct). As shown in Fig. 8.2-4, both single and triplex cables with 1,000 mm^2 copper conductor are capable to pass the required capacity for a 200MVA (2cct) transmission capacity at 115kV voltage. From the result of study in the Phase 1 Project, the application of triplex cables is preferable due to cheaper civil construction costs.

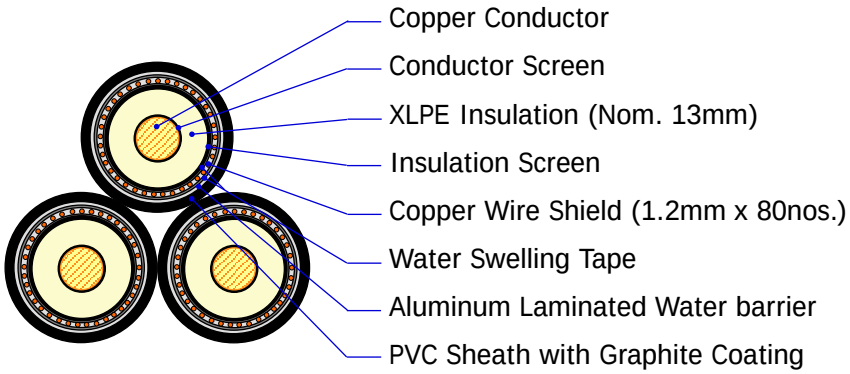
Typical cable construction of 230kV 1,200 mm^2 1-core type XLPE cable and 115kV 1,000 mm^2 triplex type XLPE cable are shown in Fig. 8.2-5 and Fig. 8.2-6.



	1,200 mm²
Overall diameter	Approx. 127 mm
Weight	Approx. 23 kg/m
Drum length	Max. 600 m

Fig. 8.2-5 Typical Cable Construction of 230kV 1,200mm² 1-core Type XLPE Cable

Source: JICA Study Team



	1,000 mm²
Core diameter	Approx. 88 mm
Overall diameter	Approx. 191 mm
Weight	Approx. 45 kg/m
Drum length	Max. 400 m

Fig. 8.2-6 Typical Cable Construction of 115kV 1,000 mm² Triplex Type XLPE Cable

Source: JICA Study Team

8.2.4 Study of Construction Method of Underground Transmission Facilities

The study of the construction method of underground transmission lines shall be done considering the following factors.

- ✓ Conditions of the road, such as the width, nos. of lanes, intersection, interruption, congestion, etc.
- ✓ Underground equipment, such as the manhole of a drainage system, water air valve, etc.
- ✓ Surrounding conditions, such as land estates, buildings, etc.

(1) Construction Method

Considering existing man made trees and manholes onto the sideway, and underground distribution cables beneath the sideway, underground cables will be installed under the roadway especially inside the space alongside the sideway. But Pipe Jacking Method is applied in the following locations.

- From the technical viewpoint, the duct bank system construction method is very difficult. (Such as waterway crossing and railway crossing)

- Crossing of a wide road with heavy traffic volume.

Comparison Sheet by construction method between 1-core / pipe and 3-core / pipe at 230kV is shows in Table 8.2-3.

From the comparison sheet shown in Table 8.2-3, the application of 1-core cable installed into one pipe method is preferable due to cheaper construction costs and shorter construction time in the 230kV underground transmission line. If externally caused injury and an accident occur, replacement of all the three cables will be needed. The viewpoint of this maintenance is also taken into consideration, 1-core / pipe is adopted.

Standard Cross-sectional Drawing (Duct Bank Method) is shown in Fig. 8.2-7.

Pipe Jacking Method applied to the following four locations;

✓ 230kV underground transmission line.
Waterway crossing 1 location (Refer to Fig. 8.2-1)
Railway crossing 1 location (Refer to Fig. 8.2-1)
Crossing of a wide road with heavy traffic volume in front of NCC
1 location (Refer to Fig. 8.2-1)

✓ 115kV underground transmission line.
Crossing of a wide road with heavy traffic volume in front of NCC
1 location (Refer to Fig. 8.2-2)

At the location of a straight road with clear view, and no traffic signal at nearby crossing road, the pipe jacking method is not necessary to apply. In this case, Duct Bank Method is acceptable even the cable crossing the intersection.

In this case, location is conducted by each lane to reduce the traffic jam.

Stand facility for pipe jacking method are required. Required size for construction base of pipe jacking method are shown in Fig. 8.2-8 and Fig. 8.2-9. And Standard Cross-sectional Drawing of Pipe Jacking Method is shown in Fig. 8.2-10.

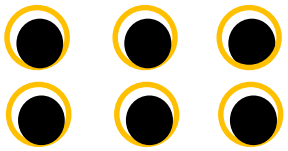
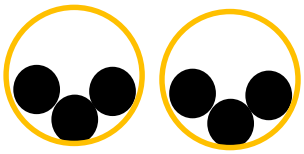
One of the points of concern for Pipe Jacking Method is the dielectric breakdown of cable.

Usually, air mortar is generally filled up in a Hume pipe with Pipe Jacking Method. However, by generation of heat from a cable, if air mortar dries, transfer of the heat to circumference soil will worsen. As a result, cable temperature is further raised, and in the worst case, the dielectric breakdown of cable may occur.

For this reason, the structure transmits the heat which a cable emits to surrounding soil, and emission cooling of the heat is promptly required.

As this countermeasure, TC Grout (Thermal Conduction Grout) is applied as a filling material between Hume pipe and pipe of cable. TC Grout drawing is shown in Fig. 8.2-11 as reference. And G value of each material is shown in Table 8.2-4.

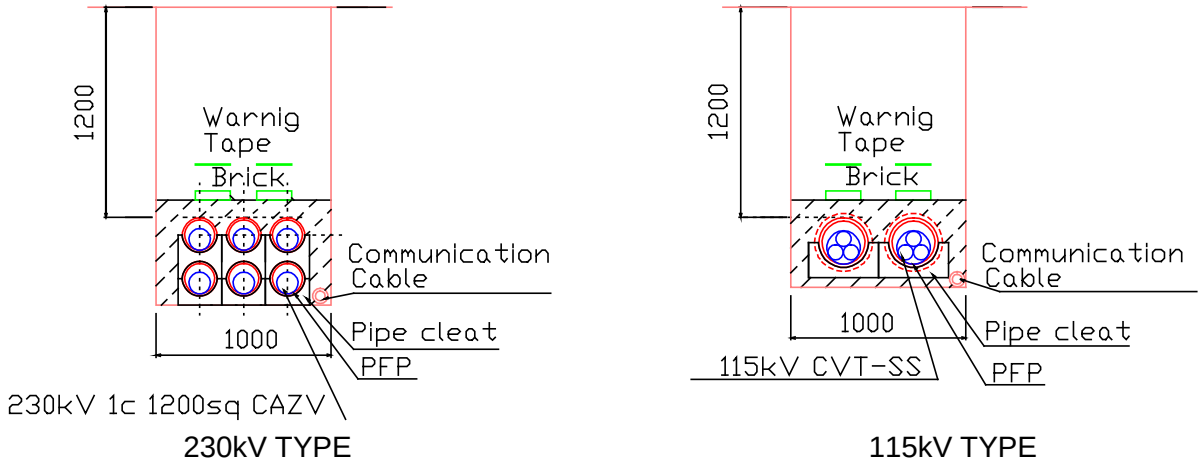
Table 8.2-3 Comparison Sheet by Construction Method between 1-core / Pipe and 3-core / Pipe (230kV)

Construction method	1-core /1 pipe	3-core / 1 pipe
Cross sectional view (conceptual)		
Inside diameter of pipe	ϕ 175 × 6 pipes	ϕ 300 × 2 pipes
Maximum span of installation cable	Approximately 300 m	Approximately 200 m
Material of pipe	Standard (116 USD/m × 9 km × 6 sets = 6.3 million USD)	Cheap (260 USD/m × 9 km × 2 sets = 4.7 million USD
Trench excavation, back filling and installation of pipes	Standard (361 USD/m × 9 km = 3.2 million USD)	Somewhat cheap (318 USD/m × 9 km = 2.9 million USD
Material of cable	Standard (353 USD/unit × 9km × 6 sets =19.1 million USD)	Same[1] (353 USD/unit × 9km × 6 sets =19.1 million USD)
Installation of cable	Standard (39 USD/unit × 9km × 6 sets =2.1 million USD)	Somewhat expensive (78 USD/unit × 9km × 2 sets =4.2 million USD)
Material of cable connection	Standard (14,124 USD/unit × 204 units =2.9 million USD)	Expensive (14,124 USD/unit × 270 units =3.8 million USD)
Construction cost of Joint Bay	Standard (64,200 USD/unit × 34 units =2.2 million USD)	Expensive (64,200 USD/unit × 45 units =2.9 million USD)
Total Cost	Standard (35.8 million USD)	Expensive (37.6 million USD)
Construction Period	Standard (14 months)	About 1.5 times (21 months)
Evaluation	Recommended	-

Length of underground transmission line: 9 km

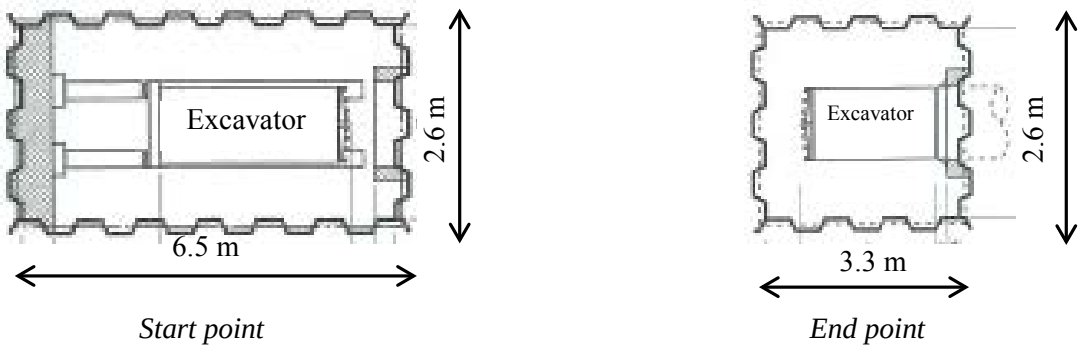
Source: JICA Study Team

1 Although this comparison was performed in the same cable size, since there is no distance between cable (Phase) according to the conditions, in the case of 3-core / pipe, increase of required cable diameter may occur.



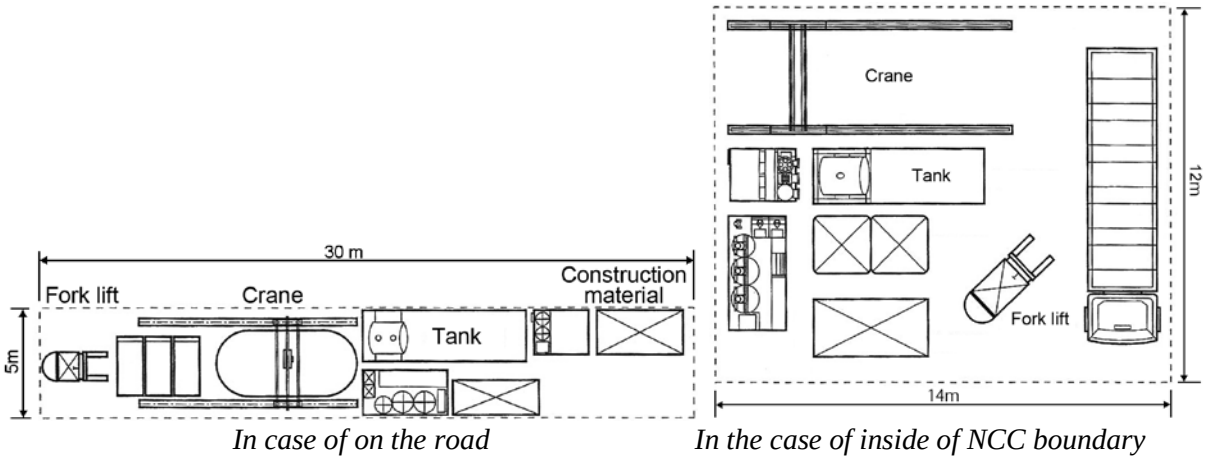
Source: JICA Study Team

Fig. 8.2-7 Standard Cross-sectional Drawing (Duct Bank Method)



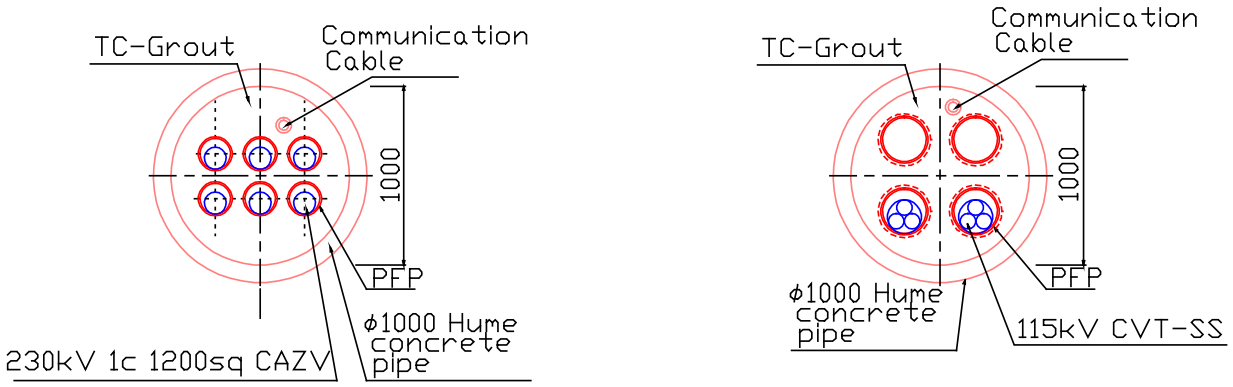
Source: JICA Study Team

Fig. 8.2-8 Required Scape for Stand of Pipe Jacking Method



Source: JICA Study Team

Fig. 8.2-9 Required Size for Construction Base of Pipe Jacking Method (Start point)



Source: JICA Study Team

Fig. 8.2-10 Standard Cross-sectional Drawing (Pipe Jacking Method)

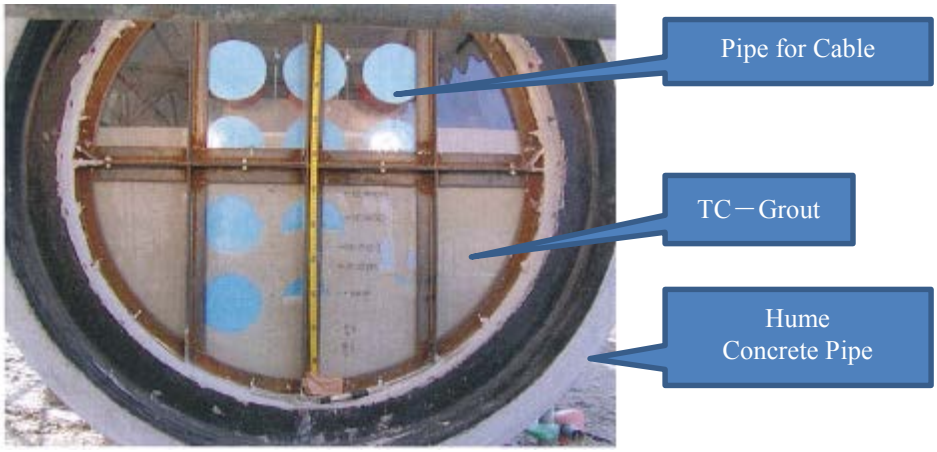


Fig. 8.2-11 Thermal Conduction Grout

Source: JICA Study Team

Table 8.2-4 G value of Each Material (k.cm/w)

Name of material	G value
Concrete	Approx. 100
Soil	Approx. 50 ~ 100
TC Grout	**Approx. 70 ~ 170**
Water	Approx. 170
Air mortar	Approx. 500 ~ 1,000
Air	Approx. 4,000

Source: JICA Study Team

(2) Study of Joint Bay

JICA Study Team studied the Joint Bay which was necessary for power cable connections. The structure figure of the Joint Bay are shown in Fig. 8.2-12.

✓ Structure of the Joint Bay
Temporary inside dimensions of Joint Bay for cable connection works are shown in Table 8.2-5. For economical and ruggedness structure, reinforced concrete structure shall be applied.

✓ Construction method of Joint Bay
It will take approximately several months from the laying of the power cable to the connection.
By adopting a temporary steel cover plate, common vehicles are able to pass through except during construction period of 230kV transmission line.

Table 8.2-5 Temporary Inside Dimension of Joint Bay

	Length	Width	Depth
230kV 1,200sq-1C × 6	10.5m	2m	1.6m
115kV 1,000sq-CVT × 2	8.1m	2m	1.6m

Source: JICA Study Team

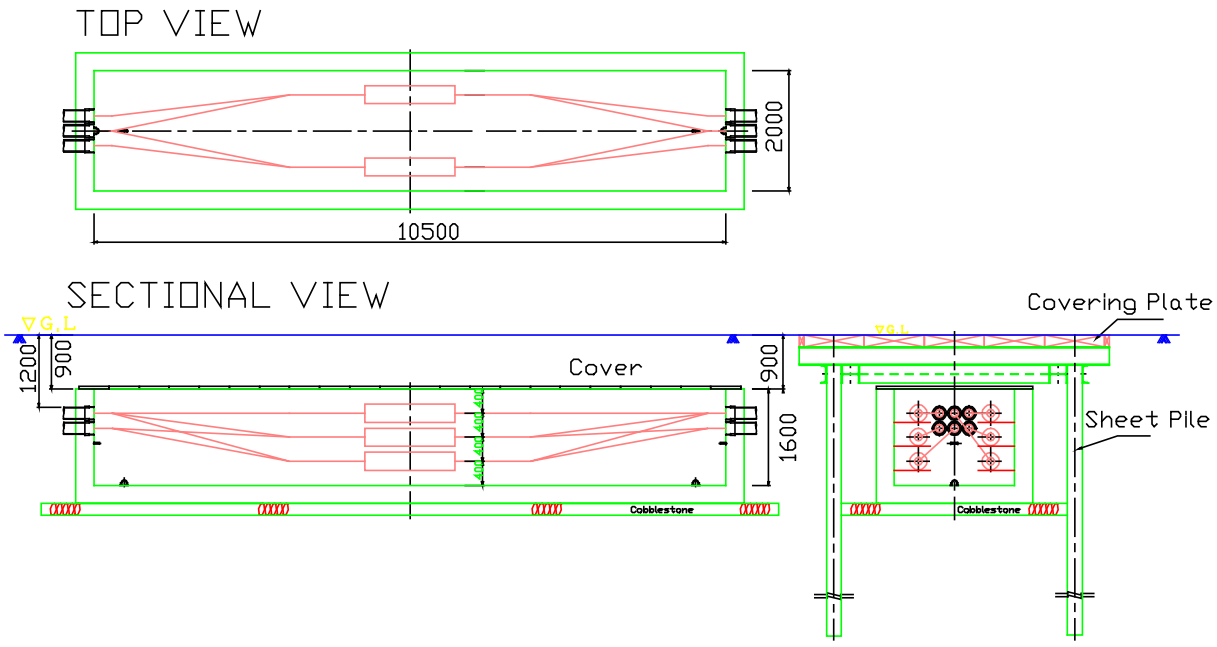


Fig. 8.2-12 Temporary Structure Figure of 230kV Joint Bay

Source: JICA Study Team

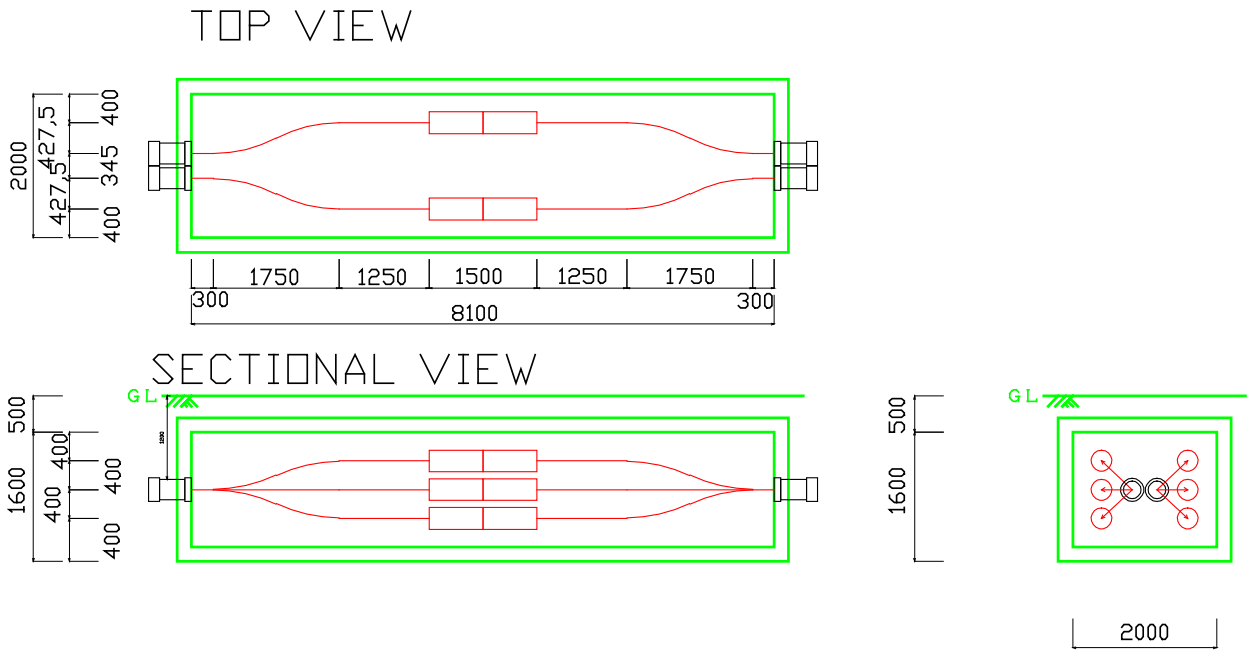


Fig. 8.2-13 Temporary Structure Figure of 115kV Joint Bay

Source: JICA Study Team

8.2.5 Budgetary Cost Estimate

Table 8.2-6 shows Budgetary Cost estimate of underground transmission facilities for the Project.

Table 8.2-6 Budgetary Cost Estimate for Underground Transmission Facilities

1. Route4 (From GS5 to NCC)

	NO.	Items	From GS5 to NCC; 230kV 600MVA(1cct), 9,280m					
			Unit	Quantity	Unit Rate (1000 US$)	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
Equipment Fee	1	230kV CV x 3 x2: 1,200sqmm 9,650m + 3% 9,280m+300m[GS5]+70m[NCC]=9,650m	m	59,637	0.353	21,051.861	21,051.861	
	2	Joint	set	204	14.124	2,881.296	2,881.296	
	3	Sealing End (Outdoor Type)	set	6	18.832	112.992	112.992	
	4	Sealing End (GIS Type)	set	6	16.478	98.868	98.868	
	5	Link Box	set	72	5.000	360.000	360.000	
	6	Communication cable 9,650m + 5% (24 core single mode fiber opticunderground cable)	km	10.14	14.020	142.163	142.163	
		subtotal				*24,647.180*	*24,647.180*	*0.000*
Works Cost	1	Trench Excavation, Backfilling [9,280m-100m-150m]	m	8,980	0.351	3,151.980		3,151.980
	2	Supply of PFP Pipes for Power cables	m	55,680	0.116	6,458.880	6,458.880	
	3	Supply of Pipe for Communication cable	m	9,650	0.006	57.900	57.900	
	4	Instalation of PFP Pipes	m	65,330	0.010	653.300		653.300
	5	Cable Pulling/Laying	m	57,900	0.039	2,258.100		2,258.100
	6	Joint Bay Construction	set	34	64.200	2,182.800		2,182.800
	7	Jointing, terminating, Earthing	set	288	23.219	6,687.072		6,687.072
	8	Instalation of Communication Cable	m	9,650	0.0390	376.350		376.350
	9	Construction by Pipe Jacking Method, Fixed Portion (for segment undercrossing waterway & railway)	L.S.	2	107.000	214.000	214.000	
	9a	Construction by Pipe Jacking Method, Variable Portion (for segment undercrossing waterway & railway)	m	100	4.864	486.400	486.400	
	10	Construction by Pipe Jacking Method, Fixed Portion (for segment undercrossing road)	L.S.	1	107.000	107.000	107.000	
	10a	Construction by Pipe Jacking Method, Variable Portion (for segment undercrossing road)	m	200	4.864	972.800	972.800	
		sub-total				*23,606.582*	*8,296.980*	*15,309.602*
Total						**48,253.762**	**32,944.160**	**15,309.602**

2. Route5 (From NCC to GS3)

	NO.	Items	From NCC to GS3; 115kV 200MVA, 400m (D)					
			Unit	Quantity	Unit Rate (1000 US$)	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
Equipment Fee	1	115kV CVT * 1,000sqmm 560m +3% : (2cct) [400+90m[GS3]+70m[NCC]=560m	m	824	0.803	661.672	661.672	
	2	Joint	set	12	5.000	60.000	60.000	
	3	Sealing End (Outdoor Type)	set	6	5.000	30.000	30.000	
	4	Sealing End (GIS Type)	set	6	8.000	48.000	48.000	
	5	Link Box	set	8	5.000	40.000	40.000	
	7	Communication cable 400m + 5% (24 core single mode fiber opticunderground cable)	km	0.59	14.020	8.272	8.272	
		subtotal				*847.944*	*847.944*	*0.000*
Works Cost	1	Trench Excavation, Backfilling [400m+90m[GS3]-100m]	m	390	0.351	136.890		136.890
	2	Supply of PFP Pipes	m	780	0.200	156.000	156.000	
	3	Supply of Pipe for Communication cable	m	390	0.010	3.900	3.900	
	4	Instalation of PFP Pipes	m	1,170	0.010	11.700		11.700
	5	Cable Pulling/Laying	m	1,120	0.039	43.680		43.680
	6	Joint Bay Construction	set	1	58.850	58.850		58.850
	7	Jointing, terminating, Earthing	set	32	7.500	240.000		240.000
	8	Construction by Pipe Jacking Method, Fixed Portion (for segment undercrossing road)	L.S.	1	42.800	42.800	42.800	
		Construction by Pipe Jacking Method, Variable Portion (for segment undercrossing road)	m	100	4.864	486.400	486.400	
	9	Instalation of Communication Cable	m	560	0.039	21.840		21.840
		sub-total				*1,202.060*	*689.100*	*512.960*
Total						**2,050.004**	**1,537.044**	**512.960**

3. Route NCC (From Olympic S/S to GS3)

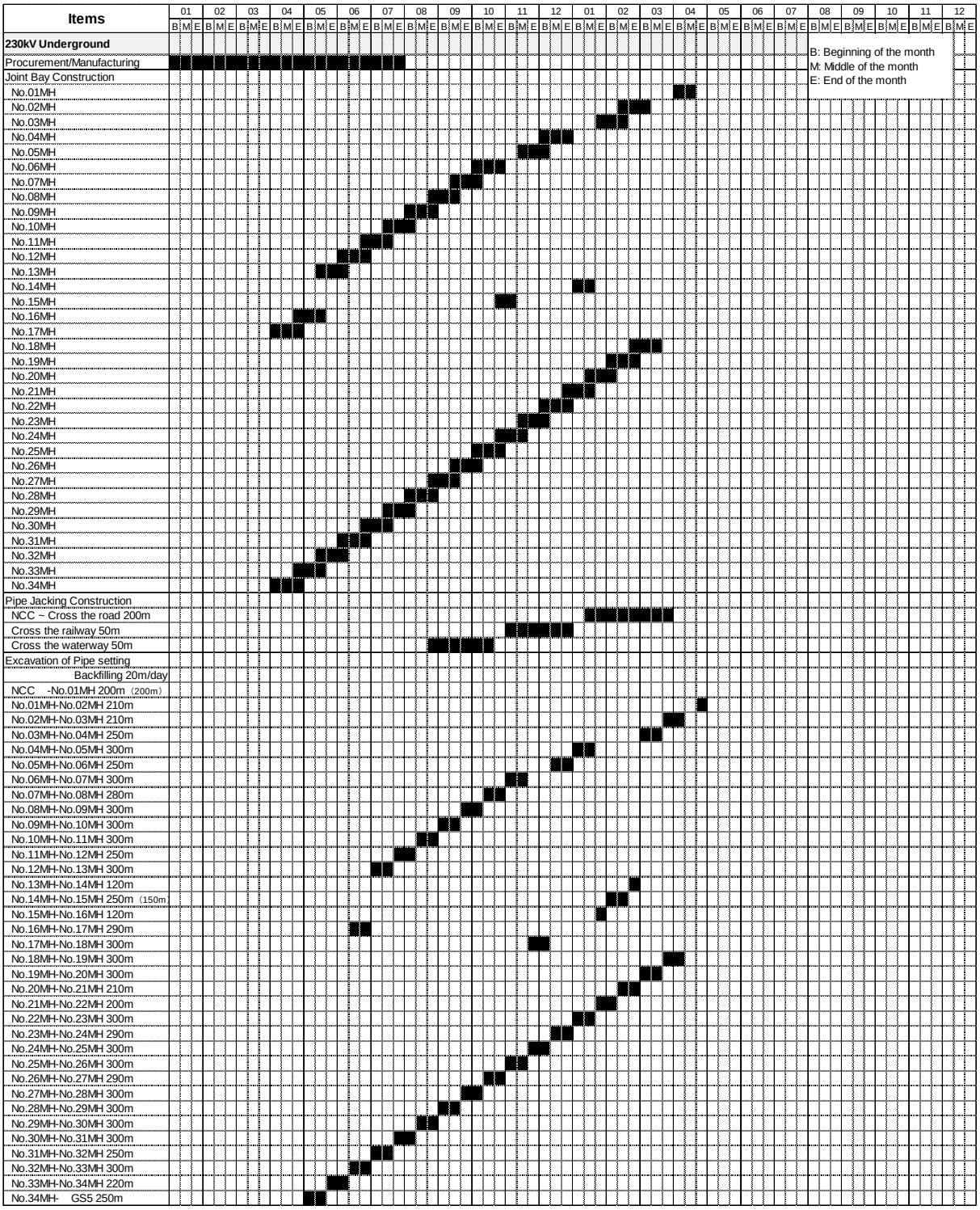
	NO.	Items	From Olympic S/S to GS3; 115kV 300MVA, (D)					
			Unit	Quantity	Unit Rate (1000 US$)	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
Works	1	Joint Work of 115kV cables at NCC SS	L.S.	1	494.850	494.850	196.000	298.850
		sub-total				*494.850*	*196.000*	*298.850*

Source: JICA Stud Team

8.2.6 Construction Schedule

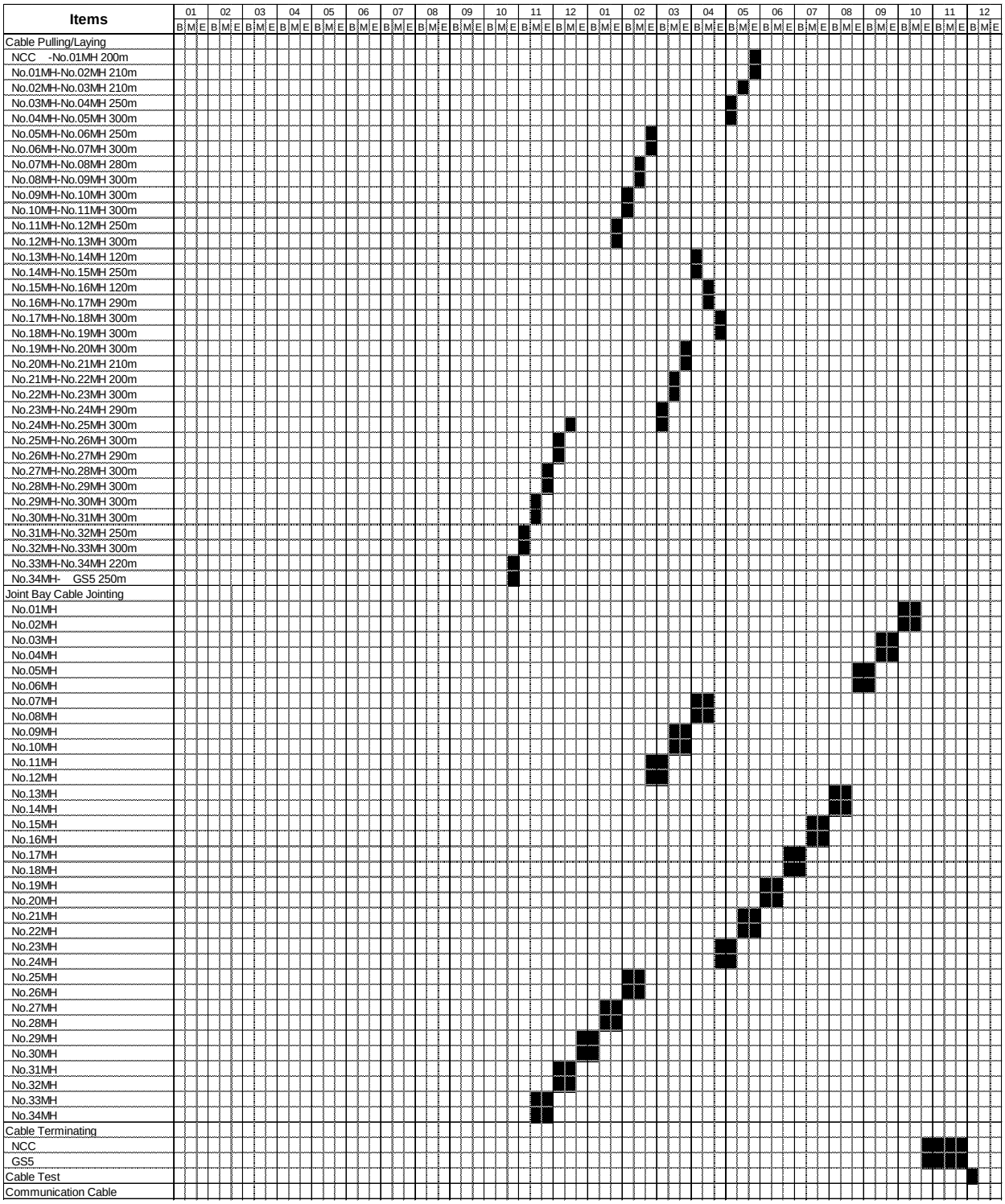
Construction schedule is shown in Table 8.2-7 and Table 8.2-8. Because two or more construction work teams are introduced, shorter implementation schedule will be expected.

Table 8.2-7 Construction Schedule for Underground Transmission Facilities 1



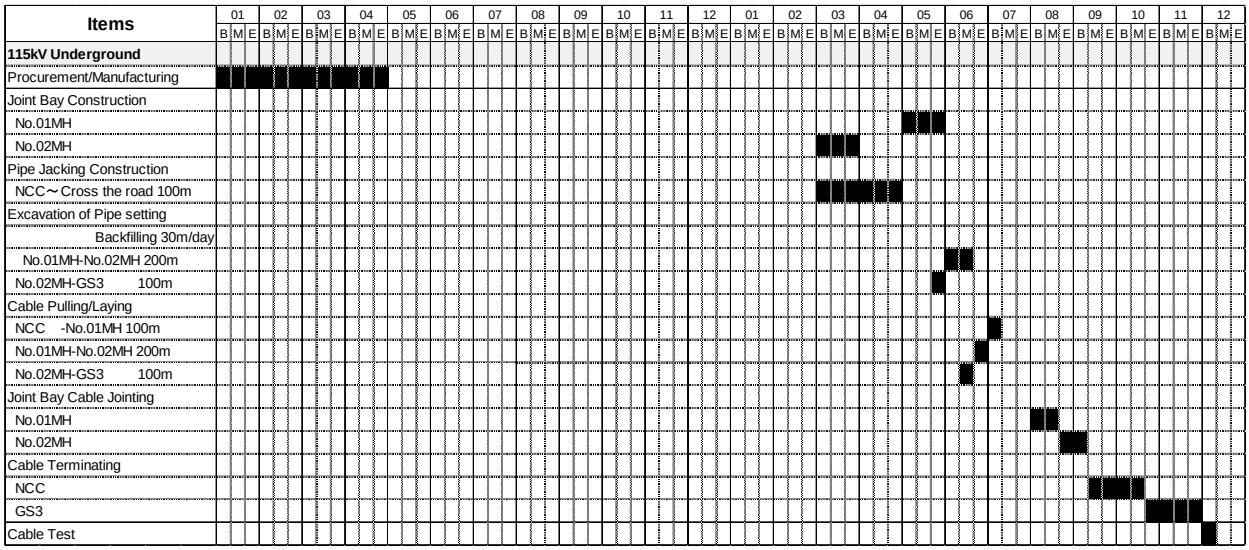
Source: JICA Study Team

Table 8.2-8 Construction Schedule for Underground Transmission Facilities 2



Source: JICA Study Team

Table 8.2-9 Construction Schedule for Underground Transmission Facilities 3



Source: JICA Study Team

8.3 SUBSTATION EQUIPMENT

8.3.1 New Substation (NCC, Toul Kork, Chroy Changvar)

(1) Design concept

(a) Substation type

One of the fundamental decisions to be made at the planning stage is the selection of the type of substation to be applied.

The general characteristics of a GIS (Gas Insulated Switchgear) substation make it particularly suitable for applications in urban areas, in environmentally sensitive areas, and in areas with high levels of atmospheric pollution. GIS substation is advantageous and new construction of the substation on site within a limited, even in the construction replacement substation of the application of the AIS (Air Insulated Switchgear).

Table 8.3-1 Comparison of AIS and GIS

	GIS	AIS
Installation area	small	large
Cost	high	low
Recovery time of equipment failure	long	short
Anti-fouling performance	high	low
Consideration of the surrounding environment	easy	difficult

Source: JICA Study Team

In this project, NCC and Toul Kork Substation construction sites that EDC has been secured are located in urban area of Phnom Penh City and the site size is too small to apply AIS. Therefore, JICA Study Team determined to apply the indoor type GIS substation to these two substations.

On the other hand, as for Chroy Changvar substation, assuming that the site area is sufficient, the application of AIS substation which has an advantage of cost was considered.

(b) Capacity of the substations

The final capacity of the new distribution substation shall be 150MVA, which is determined in consideration of the future demand and capacity of the other Phnom Penh City substation.

The final capacity of the new interconnection substation shall be 600MVA, which is determined in consideration of the future demand and effective utilization of transmission facilities capacity.

In addition, the initial capacity is 50% of the final plan capacity for both of distribution substation and interconnection substation.

(c) Capacity and number of transformers

Since the sites of NCC and Toul Kork are constrained, the capacity and number of transformer in NCC and Toul Kork should be as follows.

NCC: 230kV/115kV Transformer 300MVA ×1
(To secure a space for one future expansion)
115kV/22kV Transformer 75MVA ×1
(To secure a space for one future expansion)

Toul Kork: 115kV/22kV Transformer 75MVA ×1
(To secure a space for one future expansion)

Since the site has to keep a margin in order to take into account a scheduled extension to 230kV AIS substation, the capacity and number of transformer in Chroy Changvar is as follows.

Chroy Changvar: 115kV/22kV Transformer 75MVA × 1
(To secure a space for one or two future expansion)

(d) Protection rely system

The protection relay of the new substation should be to match that of the existing substation equipment from the viewpoint of maintenance and operations as much as possible. The main protection relays should be as shown in the following:

- 230kV & 115kV Bus protection relay: differential relay
- 230kV & 115kV Line protection relay: differential relay
- 230kV & 115kV Transformer protection relay: differential relay
- 22kV distribution line relay: over current relay, earth fault relay

(e) Reactive power supply capability

A phase modifying equipment to be installed in this project is shunt capacitor of 150MVar. Placement of phase modifying equipment in the new substation is as follows.

NCC: 115kV Shunt Capacitor 30MVar ×1
(The installed in substation building rooftop)

Chroy Changvar: 115kV Shunt Capacitor 30MVar ×1
(To ensure a space for three future expansion)

(2) Basic specifications of the main equipment

(a) Main transformer

Table 8.3-2 Basic Specification of Main Transformer (NCC)

		Basic specification
230kV/115kV Transformer	Type	YN Auto d1
	Rated voltage	230 kV／115 kV
	Rated capacity (Primary/secondary)	300MVA

Source: JICA Study Team

(b) Distribution transformer

Table 8.3-3 Basic Specification of Distribution Transformer

		Basic specification
115kV/22kV Transformer	Type	YNd11+zn
	Rated voltage	115 kV／22 kV
	Rated capacity (Primary/secondary)	75MVA

Source: JICA Study Team

(c) 230kV switchgear (NCC)

Table 8.3-4 Basic Specification of 230kV Switchgear

	Basic specification
Rated voltage	230 kV
Bus bar configuration	Single bus-bar type (Double bus in the future)
Insulation type	GIS
Rated current	2,000A
Rated short-time withstand current	40kA

Source: JICA Study Team

(d) 115kV switchgear

Table 8.3-5 Basic Specification of 115kV Switchgear

		Basic specification
NCC, Chroy Changvar	Rated voltage	115kV
	Bus bar configuration	Single bus bar type (double bus in the future *1)
	Insulation type	GIS (NCC) / AIS (Chroy Changvar)
	Rated current	1250A, 2,000A (Secondary MTr)
	Rated short-time withstand current	31.5kA
Toul Kork	Rated voltage	115 kV
	Bus bar configuration	Single bus bar type
	Insulation type	GIS
	Rated current	1,250A
	Rated short-time withstand current	31.5kA

Source: JICA Study Team

(e) 22kV switchgear

Table 8.3-6 Basic Specification of 22kV Switchgear

	Basic specification
Rated voltage	24 kV
Bus bar configuration	Single bus bar type
Housing	Metal-clad, indoor, switchgear
Rated current	2,500A or 3,150A (Bus-bar, Tr(75MVA)), 2,000A or 2,500A (Tr, Bus-tie), 300A or 630A (line)
Rated short-time withstand current	31.5kA

Source: JICA Study Team

(f) 115kV shunt capacitor

Table 8.3-7 Basic Specification of 115kV Shunt Capacitor

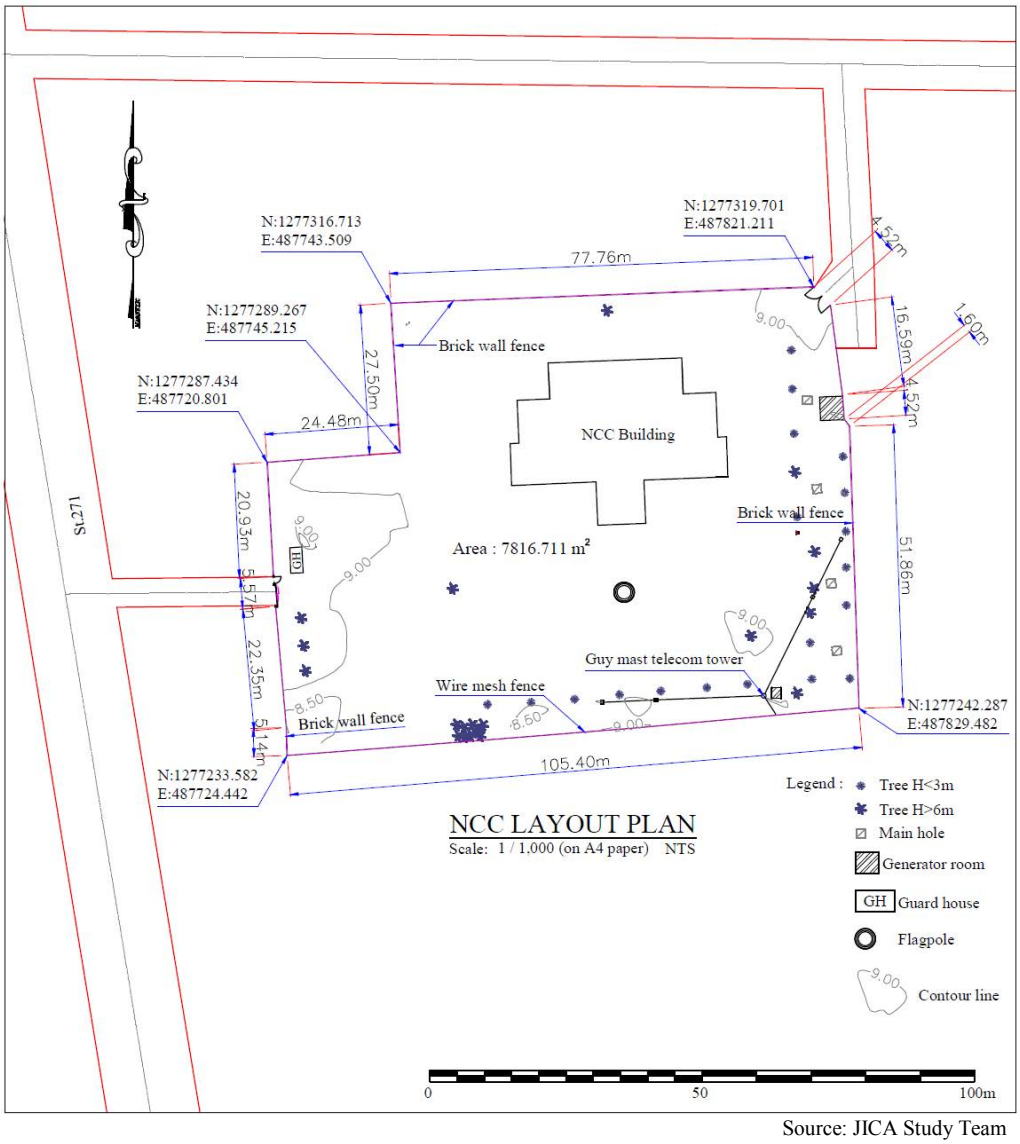
	Basic specification
Type	Can Type
Rated voltage	115 kV
Rated capacity	30MVar

Source: JICA Study Team

(3) New GIS substation at NCC

(a) Location

According to the result of the field survey, the location is a south part of the NCC. Fig. 8.3-1 shows a survey map of candidate site, whose size is approximately 30m × 105 m.



Source: JICA Study Team

Fig. 8.3-1 GIS Substation Site at NCC

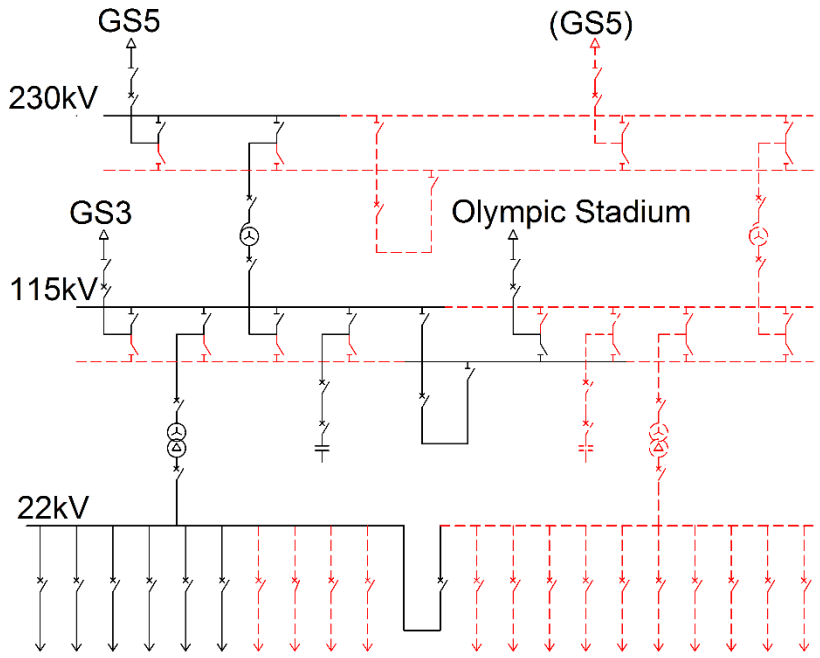
(b) Equipment & layout

Table 8.3-8 Substation Equipment (NCC)

	Number of equipment
230kV GIS bus	Single bus (Double bus in the future)
230kV line	1 lines (2 lines in the future)
230kV/115kV Transformer (300MVA)	1 banks (2 banks in the future)
115kV GIS bus	Single bus (Double bus in the future)
115kV line	2 lines (4 lines in the future)
115kV/22kV Transformer (75MVA)	1 bank (2 banks in the future)
115kV Shunt capacitor	1 unit (1 unit in the future)
22kV line	6 lines (20 lines in the future)

Source: JICA Study Team

In addition, Fig. 8.3-2 shows the single line diagram of the substation.



Source: JICA Study Team

Fig. 8.3-2 Single Line Diagram of Substation at NCC

For placement on site within a limited area, while ensuring access or passage for the instrument of future expansion of the space required for installation and maintenance work, the equipment arrangement design aims to be compact.

Equipment except the distribution transformer is disposed in the substation building.

Inside the building, interconnection transformer is located on the Ground floor, 230kV GIS is located on the 1st floor, 22kV SWG and 115kV GIS are located on the 2nd floor, and control room and others are located in the 3rd floor. And shunt capacitor is placed on the rooftop. In addition, since the carrying path of NCC site is narrow, it is proven that carrying

the three-phase one body tank by Schnabel trailer, which is a land transport of normal 230kV normal three-phase transformer, is difficult. As for surrounding NCC, extension of the carrying path is impossible for the urban area. In order to solve this transport problem, specific three-phase structure should be adopted. In general, specific three-phase structure transformer is divided into three tanks for each phase, transported by a low bed trailer and assembled on-site. Installation area of the transformer to be increased slightly compared to the normal three-phase one, but can be sufficiently placed in NCC site. On the other hand, since there is a possibility that the reinforcing road and traffic control is not required by low-floor trailer transportation, the cost benefit of transport is large.

1) Main gate carrying path

2) Rear gate carrying path

Fig. 8.3-3 NCC Carrying Path

Appendix-5-1-1 shows the equipment layout image of the substation at NCC site.
Appendix-5-1-2 and 5-1-3 shows the layout image in the NCC substation building.

(c) Construction costs

In this section, the construction costs for the substation are estimated based on the equipment described in (b) above.

1) Construction costs of substation equipment

Estimated conditions are described as follows.

- All equipment would be procured from abroad, and the price would be estimated in US dollars for the CIF (Cost, Insurance and Freight) price (FC: Foreign Currency).
- Costs for the procurement of spare parts and tools would be estimated at 5% of the total equipment costs (FC).
- The transportation fee would be estimated at 5% of the total equipment costs (LC: Local Currency).
- The building costs would be estimated in foreign currency (USD) portion (FC: 30%) and the local currency (USD conversion) portion (LC: 70%).
- The costs of the general civil and erection works would be estimated at 15% of the total equipment costs in foreign currency (USD) portion (FC: 70%) and local currency (USD conversion) portion (LC: 30%).
- The cost for such work items done by a contractor as equipment design, documentation etc. would be estimated as the miscellaneous cost. It would be estimated at 5% of the total costs (FC and LC) for equipment, building and general civil and erection work.

Table 8.3-9 Construction Cost (NCC)

category	NO.	Items	NCC					
			Unit	Quantity	Unit Rate (1000 US$)	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
Equipment Fee	**1**	**Switchgear**						
	1.1	230kV Gas Insulated Switchgear (2000A,40kA)	set	2	1240	2480	2480	0
	1.2	115kV Gas Insulated Switchgear (2000A,31.5kA)	set	6	475	2850	2850	0
	1.3	123kV GS (1200A, Multiple times operatable)	set	1	36	36	36	1
	1.4	22kV Switchgear (Indoor type, including control & protection)	set	8	25	200	200	0
	2	**Transformer**						
	2.1	230kV/115kV Transformer 300MVA	set	1	5900	5900	5900	0
	2.2	115kV/22kV Transformer 75MVA	set	1	1955	1955	1955	0
	2.3	22kV/400V Auxiliary Transformer	set	2	16	32	32	0
	2.4	Neutral Earthing Transformer & Resistor	set	1	6	6	6	0
	3	**Shunt Capacitor**						
	3.1	115kV SC 30MVA	set	1	855	855	855	0
	4	**Protection, Metering and Control**	set					
	4.1	Substation Automation System	set	1	298	298	298	0
	4.2	Control Panel for230kV Bays	set	1	55	55	55	0
	4.3	Control Panel for 115kV Bays	set	1	60	60	60	0
	4.4	Protection for 230kV line	set	1	77	77	77	0
	4.5	Protection for 230kV transformer	set	1	61	61	61	0
	4.6	230kV busbar protection relay panel	set	1	58	58	58	0
	4.7	230kV breaker-fail protection relay	set	1	13	13	13	0
	4.8	Protection for 115kV line	set	2	54	108	108	0
	4.9	Protection for 115kV transformer	set	1	45	45	45	0
	4.10	Protection for 115kV Bus coupler	set	1	54	54	54	0
	4.11	115kV busbar protection relay panel	set	1	58	58	58	0
	4,12	115kV breaker-fail protection relay	set	1	13	13	13	0
	4.13	115kV SC protection relay	set	1	45	45	45	0
	4.14	Energy Metering Panel & Recorder	set	1	310	310	310	0
	5	**Switch Board (LVAC,DC)**						
	5.1	A.C.(400V) distribution boards		1	18	18	18	0
	5.2	D.C.(110V) distribution boards		1	225	225	225	0
	6	**Communication and SCADA**						
	6.1	Control system including Fiber Optic equipment	Lot	1	161	161	161	0
	6.2	SCADA system						
	7	**AC/DC System**						
	7.1	110V DC system	Lot	1	194	194	194	0
	7.2	48V DC system	Lot	1	66	66	66	0
	7.3	Inverter system	Lot	1	30	30	30	0
	8	**Power & Control Cable**				0		
	8.1	230kV cable and termination	Lot	1	261	261	261	0
	8.2	115kV cable and termination	Lot	2	142	284	284	0
	8.3	22kV cable and termination	Lot	1	156	156	156	0
	8.4	LVAC & Control cable	Lot	1	150	150	150	0
	8.5	Earthing and lightning systems	Lot	1	39	39	39	
		Sub total (1+2+3+4+5+6+7+8)				*17153*	*17153*	*0*
	9	**Spare parts (5% of sub-total above)**	set	1	663	858	858	0
		subtotal				*18011*	*18011*	*0*
Building Cost	10	Preliminary works	Lot	1	494	494	148	346
	11	Reinfoeced Concrete	Lot	1	3216	3216	965	2251
	12	Steel Structure	Lot	1	168	168	50	118
	13	Architectural works	Lot	1	1574	1574	472	1102
	14	Electric equipment,Fire-fighting etc.	Lot	1	736	736	221	515
	15	Earthing and Lighting protection	Lot	1	758	758	227	531
		sub-total				*6946*	*2083*	*4863*
Works Cost	16	Transportation Fee (5% of Equipment Fee)	set	1		901	0	901
	17	Civil and Erection(15% of Equipment Fee)	set	1		2702	1891	811
		sub-total				*3603*	*1891*	*1712*
Design, etc.	18	Design, Documentation, etc. (5% of Equipment, Civil and erection)	set	1		1036	881	155
		sub-total				*1036*	*881*	*155*
NCC Total						**29,596**	**22,866**	**6,730**

Source: JICA Study Team

(d) Construction schedule

The construction schedule of the substation is shown below.

Table 8.3-10 Construction Schedule (NCC)

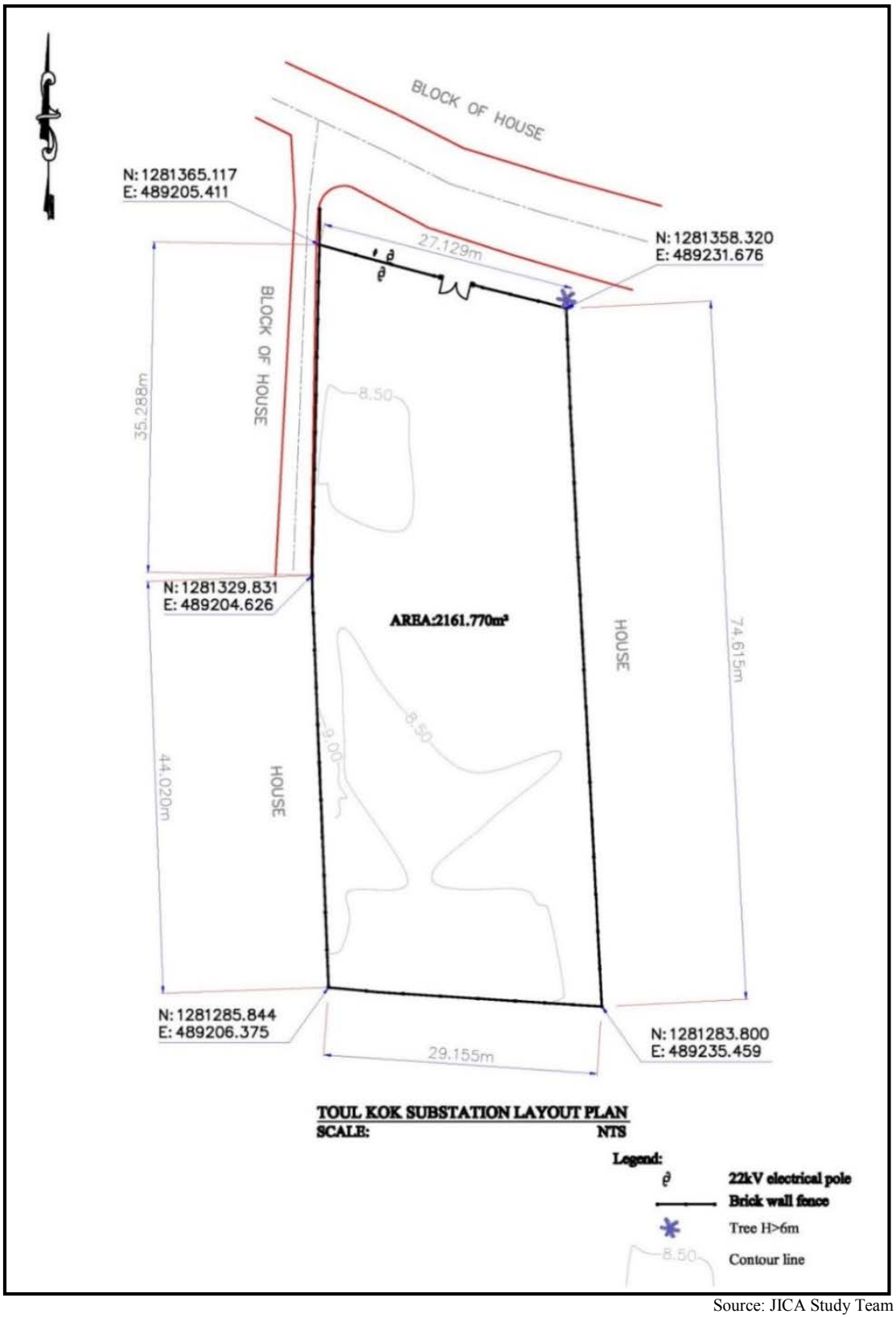
Year	First year												Second year												Third year					
Order	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Detail Designing																														
Building construction work																														
Manufacturing & Transportation																														
Installation work																				(Foundations)										
GIS(230kV,115kV)																														
Main Transformer																														
Distribution Transformer																														
115kV Shunt Capacitor																														
22kV Switchgear																														
Control system, Relay																														
Testing & Commissioning																														
Energizing																														▲

Source: JICA Study Team

(4) New GIS substation at the Toul Kork site

(a) Location

According to the result of the field survey, the location is facing the main road in the region and the route of the transmission line between GS5 and GS1. Fig. 8.3-4 shows a survey map of candidate site whose size is approximately 25m ×75 m.



Source: JICA Study Team

Fig. 8.3-4 Survey Map of Toul Kork Substation

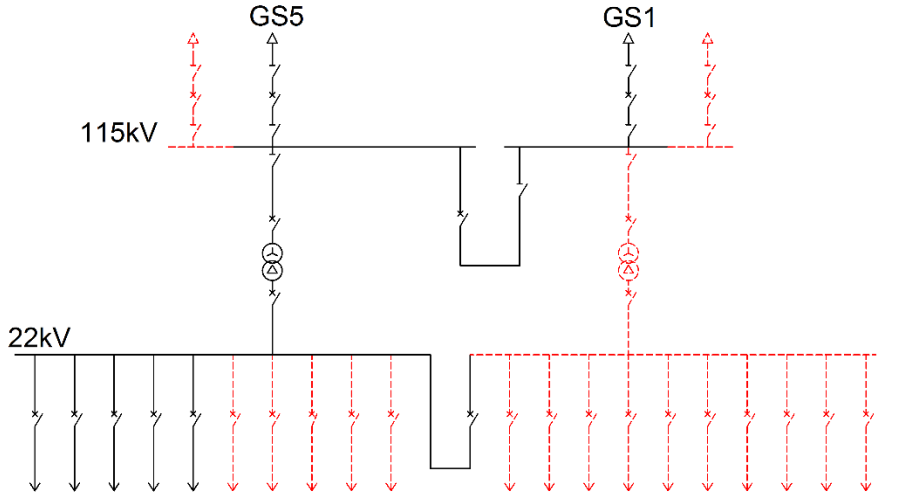
(b) Equipment & layout

Table 8.3-11 Substation Equipment (Toul Kork)

	Number of equipment
115kV GIS bus	Single bus
115kV line	2 lines (4 lines in the future)
115kV/22kV Transformer 50MVA	1 bank (2 banks in the future)
22kV line	5 lines (20 lines in the future)

Source: JICA Study Team

In addition, Fig. 8.3-5 shows the single line diagram of the Toul Kork substation.



Source: JICA Study Team

Fig. 8.3-5 Single Line Diagram of Substation at Toul Kork

For placement on site within a limited area, while ensuring access or passage for the instrument of future expansion of the space required for installation and maintenance work, the equipment arrangement design aimed to be compact.

Equipment except the distribution transformer and steel-tower is disposed in the substation building.
Inside the building, 115kV GIS are located on the Ground floor, 22kV switchgear is located on the 1st floor, and control room and others are located on the 2nd floor.

For the reduction of the steel tower site area, single lead-in steel tower is adopted. At the steel tower arm-on, the substation lead-in power cable is connected with the overhead transmission line.

Appendix-5-2-1 shows the equipment layout image of the substation at Toul Kork site.
Appendix-5-2-2 shows the layout image of the Toul Kork substation building.

(c) Construction costs

In this section, the construction costs for the substation is estimated based on the equipment described in (b) above.

1) Construction costs of substation equipment

Estimated conditions are described as follows.

- All equipment would be procured from abroad, and the price would be estimated in US dollars for the CIF price (FC).
- Costs for the procurement of spare parts and tools would be estimated at 5% of the total equipment costs (FC).
- The transportation fee would be estimated at 5% of the total equipment costs (LC).
- The building costs would be estimated in foreign currency (USD) portion (FC: 30%) and the local currency (USD conversion) portion (LC: 70%).
- The costs of the general civil and erection works would be estimated at 20% of the total equipment costs in foreign currency (USD) portion (FC: 70%) and local currency (USD conversion) portion (LC: 30%).
- The cost for such work items done by a contractor as equipment design, documentation etc. would be estimated as the miscellaneous cost. It would be estimated at 5% of the total costs (FC and LC) for equipment, building and general civil and erection work.

Table 8.3-12 Construction Cost (Toul Kork)

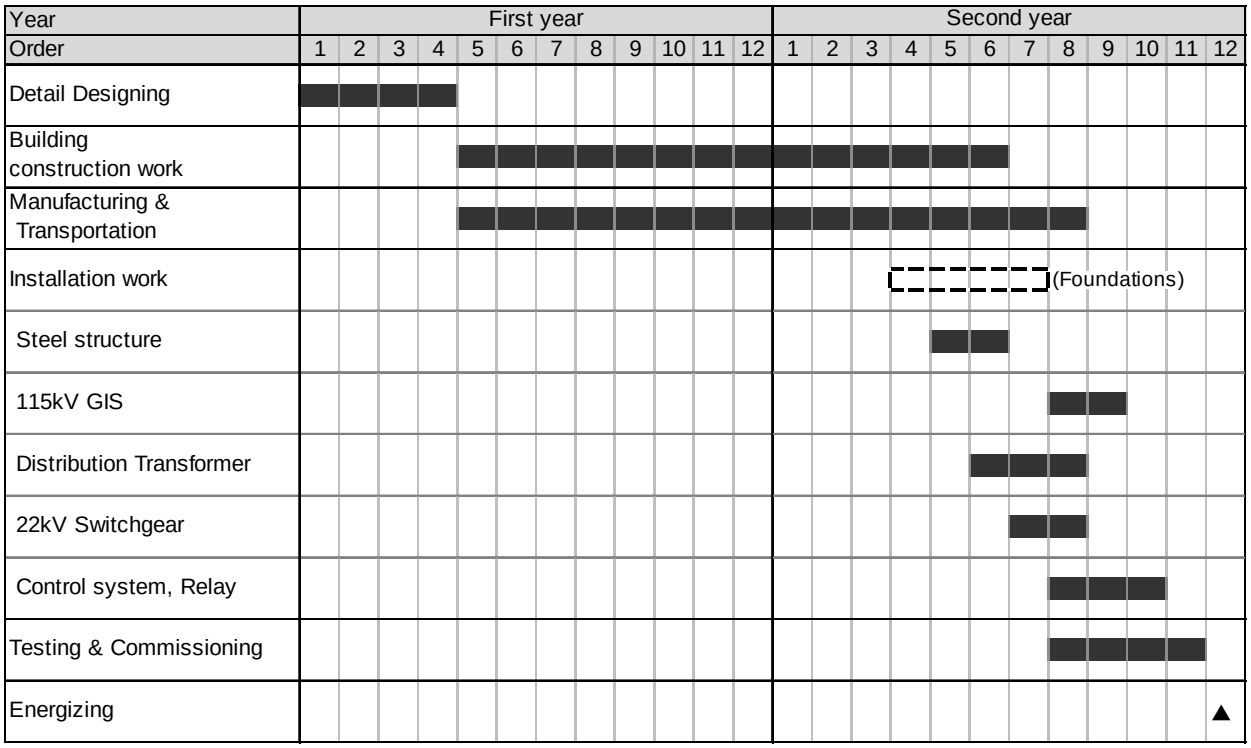
category	NO.	Items	Toulkork					
			Unit	Quantity	Unit Rate (1000 US$)	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
Equipment Fee	**1**	**Switchgear**						
	1.1	115kV Gas Insulated Switchgear (2000A,31.5kA)	set	4	338	1352	1352	0
	1.2	22kV Switchgear (Indoor type, including control & protection)	set	7	25	175	175	0
	2	**Transformer**						
	2.1	115kV/22kV Transformer 75MVA	set	1	1955	1955	1955	0
	2.2	22kV/400V Auxiliary Transformer	set	2	11	22	22	0
	2.3	Neutral Earthing Transformer & Resistor	set	1	6	6	6	0
	3	**Protection, Metering and Control**	set					
	3.1	Substation Automation System	set	1	298	298	298	0
	3.2	Control Panel for 115kV Bays	set	1	51	51	51	
	3.3	Protection for 115kV line	set	2	54	108	108	0
	3.4	Protection for 115kV transformer	set	1	45	45	45	0
	3.5	Protection for 115kV Bus coupler	set	1	54	54	54	0
	3.6	115kV busbar protection relay panel	set	1	58	58	58	
	3.7	115kV breaker-fail protection relay	set	1	13	13	13	
	3.8	Energy Metering Panel & Recorder	set	1	298	298	298	
	4	**Switch Board (LVAC,DC)**						
	4.1	Service Switchboard	Lot	1	243	243	243	0
	5	**Communication and SCADA**						
	5.1	Control system including Fiber Optic equipment	Lot	1	161	161	161	0
	6	**AC/DC System**						
	6.1	110V DC system	Lot	1	194	194	194	0
	6.2	48V DC system	Lot	1	66	66	66	0
	6.3	Inverter system	Lot	1	24	24	24	0
	7	**Power & Control Cable**				0		
	7.1	115kV cable and termination	Lot	2	156	312	312	0
	7.2	22kV cable and termination	Lot	1	68	68	68	0
	7.3	LVAC & Control cable	Lot	1	101	101	101	0
	8	**Miscellaneous Equipment**						
	8.1	Conductor and Fittings	set	1	23	23	23	
	8.2	Insulators and Fittings	set	1	5	5	5	
	8.3	Gantry steel structures & supports	set	1	60	60	60	
	8.4	Low voltage and control cables	set	1	124	124	124	
	8.5	Earthing and lightning systems	set	1	31	31	31	
		Sub total (1+2+3+4+5+6+7+8)				*5847*	*5847*	*0*
	9	**Spare parts(5% of sub-total above)**	set	1		292	292	0
		subtotal				*6139*	*6139*	*0*
Building Cost	10	Preliminary works	Lot	1	127	127	38	89
	11	Reinfoeced Concrete	Lot	1	828	828	248	580
	12	Steel Structure	Lot	1	43	43	13	30
	13	Architectural works	Lot	1	405	405	122	283
	14	Electric equipment,Fire-fighting etc.	Lot	1	368	368	110	258
	15	Earthing and Lighting protection	Lot	1	379	379	114	265
		sub-total				*2150*	*645*	*1505*
Works Cost	16	Transportation Fee (5% of Equipment Fee)	set	1		307	0	307
	17	Civil and Erection(20% of Equipment Fee)	set	1		1228	860	368
		sub-total				*1535*	*860*	*675*
Design, etc.	18	Design, Documentation, etc. (5% of Equipment, Civil and erection)	set	1		368	313	55
		sub-total				*368*	*313*	*55*
Toulkork Total						**10,192**	**7,957**	**2,235**

Source: JICA Study Team

(d) Construction schedule

The construction schedule of the substation is shown below.

Table 8.3-13 Construction Schedule (Toul Kork)

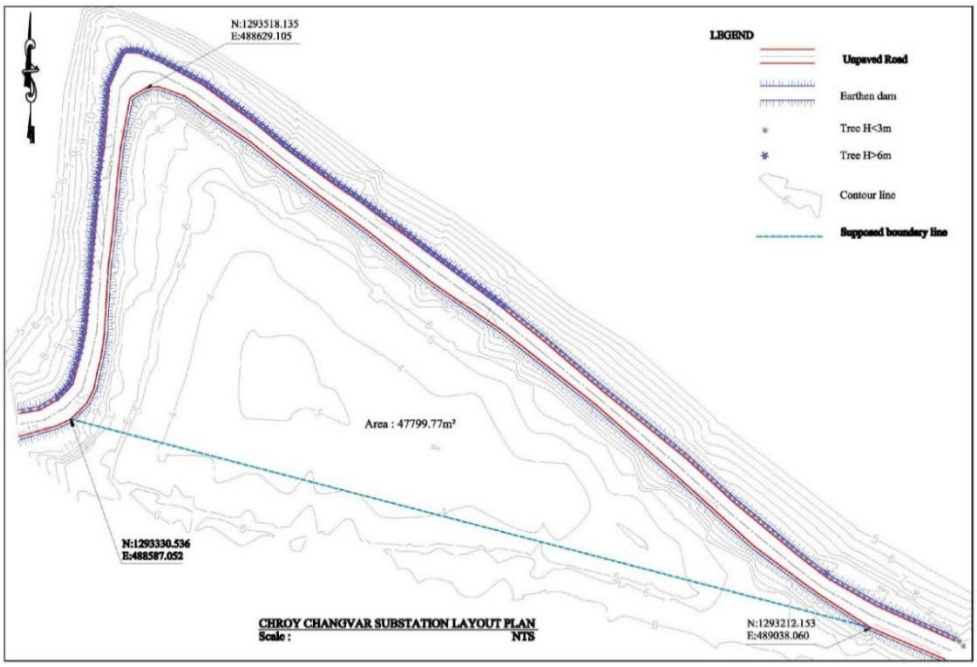


Source: JICA Study Team

(5) New AIS substation at site of Chroy Changvar

(a) Location

For the site selection of Chroy Changvar substation, EDC is negotiating with the company that is doing large-scale development of Chroy Changvar district. Substation site will be selected near the lowland where is facing the pond on the north side of the large-scale development area.



Source: JICA Study Team

Fig. 8.3-6 Candidate Area of Chroy Changvar Substation

In addition, EDC has a plan for 230kV step-up at Chroy Changvar substation in the future. Therefore, conditions for site selection are as follows.

- 115kV transmission line route can be secured.
- To ensure the site area required for AIS substation
- The access from the 230kV system is easy.
- To ensure the site area in consideration of 230kV step-up

Since vast vacant land (low wetland) was available around the predetermined Chroy Changvar substation site, JICA Study Team studied as follows on the assumption that these requirements are satisfied.

EDC is planning to ensure the land satisfy to all of these requirements.
(Example of the required land size is approximately 180m × 180m.)

Fig. 8.3-7 Circumstances of Chroy Changvar Substation Candidate Area

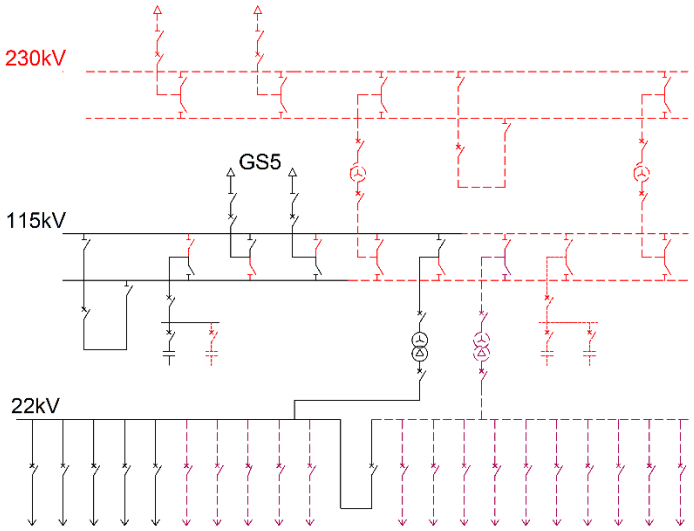
(b) Equipment & layout

Table 8.3-14 Substation Equipment (Chroy Changvar)

	Number of equipment
230kV bus	0 Bus (Double bus in the future)
230kV line	0 lines (4 lines in the future)
230kV/115kV Transformer (300MVA)	0 banks (2 banks in the future)
115kV bus	Single bus (Double bus in the future)
115kV line	2 lines (6 lines in the future)
115kV/22kV Transformer (75MVA)	1 bank (2 or 3 banks in the future)
115kV Shunt capacitor	1 unit (4 units in the future)
22kV line	4 lines (20 lines in the future)

Source: JICA Study Team

In addition, Fig. 8.3-8 shows the single line diagram of the Chroy Changvar substation.



Source: JICA Study Team

Fig. 8.3-8 Single Line Diagram of Substation at Chroy Changvar

The equipment layout was designed to be compact satisfying the following conditions.

- Ensuring the space for the installation work
- Ensuring the space for the future expansion (230kV step-up and 115kV Transmission line expansion)
- Ensuring the access and passage
- Ensuring the space required for the maintenance

Appendix-5-3 shows the equipment layout image of the substation at Chroy Changvar site.

(c) Construction costs

In this section, the construction costs for the substation is estimated based on the equipment described in (b) above.

1) Construction costs of substation equipment

Estimated conditions are described as follows.

- All equipment would be procured from abroad, and the price would be estimated in US dollars for the CIF price (FC).
- Costs for the procurement of spare parts and tools would be estimated at 5% of the total equipment costs (FC).
- The transportation fee would be estimated at 5% of the total equipment costs (LC).
- The building costs would be estimated in foreign currency (USD) portion (FC: 30%) and the local currency (USD conversion) portion (LC: 70%).
- The costs of the general civil and erection works would be estimated at 35% of the total equipment costs in foreign currency (USD) portion (FC: 70%) and local currency (USD conversion) portion (LC: 30%).
- The cost for such work items done by a contractor as equipment design, documentation etc. would be estimated as the miscellaneous cost. It would be estimated at 5% of the total costs (FC and LC) for equipment, building and general civil and erection work.

Table 8.3-15 Construction Cost (Chroy Changvar)

category	NO.	Items	ChroyChangvar					
			Unit	Quantity	Unit Rate (1000 US$)	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
Equipment Fee	**1**	**Switchgear**						
	1.1	123kV Circuit breaker(2000A,31.5kA)	set	5	45	225	225	0
	1.2	123kV Circuit break Disconnector+earthing switch with supporting structure (2000A,31.5kA)	set	2	14	28	28	0
	1.3	123kV Circuit break Disconnector with supporting structure (2000A,31.5kA)	set	6	12	72	72	0
	1.4	123kV GS (1200A, Multiple times operatable)	set	1	36	36	36	0
	1.5	115kV Current Transformer(3phase / 1set)	set	6	30	180	180	0
	1.6	115kV Capacitor type voltage transformers (1phase / 1set)	set	8	10	80	80	0
	1.7	Surge Arrester (96kV, 10kA, discharge class 3)	set	3	5	15	15	0
	1.8	22kV Switchgear (Indoor type, including control & protection)	set	6	25	150	150	0
	2	**Transformer**						
	2.1	115kV/22kV Transformer 75MVA	set	1	1955	1955	1955	0
	2.2	22kV/400V Auxiliary Transformer	set	2	11	22	22	0
	2.3	Neutral Earthing Transformer & Resistor	set	1	6	6	6	0
	3	**Shunt Capacitor**						
	3.1	115kV SC 30MVA	set	1	855	855	855	0
	4	**Protection, Metering and Control**	set					
	4.1	Substation Automation System	set	1	288	288	288	0
	4.2	Control Panel for 115kV Bays	set	1	51	51	51	0
	4.3	Protection for 115kV line	set	2	54	108	108	0
	4.4	Protection for 115kV transformer	set	1	45	45	45	0
	4.5	Protection for 115kV Bus coupler	set	1	54	54	54	0
	4.6	115kV busbar protection relay panel	set	1	58	58	58	
	4.7	115kV breaker-fail protection relay	set	1	13	13	13	
	4.8	115kV SC protection relay	set	1	45	45	45	0
	4.9	Energy Metering Panel & Recorder	set	1	298	298	298	0
	5	**Miscellaneous Equipment**						
	5.1	Conductor and Fittings	lot	1	320	320	320	0
	5.2	Insulators and Fittings	lot	1	320	320	320	0
	5.3	Gantry steel structures & supports	lot	1	480	480	480	0
	5.4	Earthing and Lighting system	lot	1	150	150	150	0
	6	**Switch Board (LVAC,DC)**				0		
	6.1	Service Switchboard	Lot	1	243	243	243	0
	7	**Communication and SCADA**				0		
	7.1	Control system including Fiber Optic equipment	Lot	1	161	161	161	0
	8	**AC/DC System**						
	8.1	110V DC system	Lot	1	194	194	194	0
	8.2	48V DC system	Lot	1	66	66	66	0
	8.3	Inverter system	Lot	1	24	24	24	0
	9	**Power & Control Cable**						
	9.1	22kV cable and termination	Lot	1	68	68	68	0
	9.2	LVAC & Control cable	Lot	1	101	101	101	0
		Sub total (1+2+3+4+5+6+7+8)				*6711*	*6711*	*0*
	10	**Spare parts (5% of sub-total above)**	set	1		336	336	0
		subtotal				*7047*	*7047*	*0*
Building Cost	11	Preliminary works	Lot	1	42	42	13	29
	12	Reinfoeced Concrete	Lot	1	343	343	103	240
	13	Steel Structure	Lot	1	18	18	5	13
	14	Architectural works	Lot	1	168	168	50	118
	15	Electric equipment,Fire-fighting etc.	Lot	1	368	368	110	258
	16	Earthing and Lighting protection	Lot	1	379	379	114	265
		sub-total				*1318*	*395*	*923*
Works Cost	17	Transportation Fee (5% of Equipment Fee)	set	1		352	0	352
	18	Civil and Erection(35% of Equipment Fee)	set	1		2466	1726	740
		sub-total				*2818*	*1726*	*1092*
Design, etc.	19	Design, Documentation, etc. (5% of Equipment, Civil and erection)	set	1		476	405	71
		sub-total				*476*	*405*	*71*
Chroy Changvar Total						**11,659**	**9,573**	**2,086**

Source: JICA Study Team

(d) Construction schedule

The construction schedule of the substation is shown below.

Table 8.3-16 Construction Schedule (Chroy Changvar)

Year	First year												Second year											
Order	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Detail Designing																								
Building construction work																								
Manufacturing & Transportation																								
Installation work																								
Steel structure																								
115kV Switchgear																								
Distribution Transformer																								
115kV Shunt Capacitor																								
22kV Switchgear																								
Control system, Relay																								
Testing & Commissioning																								
Energizing																								

(Foundations)

Source: JICA Study Team

8.3.2 Modification of GS3 and GS5

(1) GS3

(a) Present conditions and expandability

GS3 was originally designed in consideration of the future expansion of a maximum six (6) 115kV transmission line feeder bays in total. Since the two bays out of the six bays are currently being used for transmission line feeders going to GS1 and to CEP IPP power plant. Additionally in Phase 1, one bay is planning to be used for transmission line feeder going to Olympic Stadium GIS substation.

The remaining three (3) feeder bays are currently not in use although some feeder bays are now equipped with an unused switchgear which can be removed.

1) 115kV Switchgear installation position

2) 115kV Shunt capacitor installation position

Fig. 8.3-9 Vacant Space for Expansion in GS3

(b) Outline of the modifications

In GS3, switching equipment that is installed to connect the Olympic Stadium substation in phase 1 is modified for connection to the NCC substation. In addition, a shunt capacitor (30MVar) 1 unit is installed as a phase modifying equipment.

In addition to the above additional installation of equipment, the following items will be necessarily installed or modified under this Project.

1) 115kV Shunt capacitor control, switching and protection (GS3)
2) Modification of existing Substation Control System
3) SCADA and telecommunication equipment for the transmission line system change

(c) Outline of technical data of equipment

Table 8.3-17 Basic Specification of 115kV Switchgear and Shunt Capacitor

		Basic specification
115kV Switch gear	Rated voltage	115 kV
	Bus bar configuration	Single Bus-bar Type
	GIS or AIS	AIS
	Rated current	1,250A: Shunt capacitor
	Rated short-time withstand current	31.5kA
115kV Shunt capacitor	Type	Can Type
	Rated voltage	115 kV
	Rated capacity	30MVar

Source: JICA Study Team

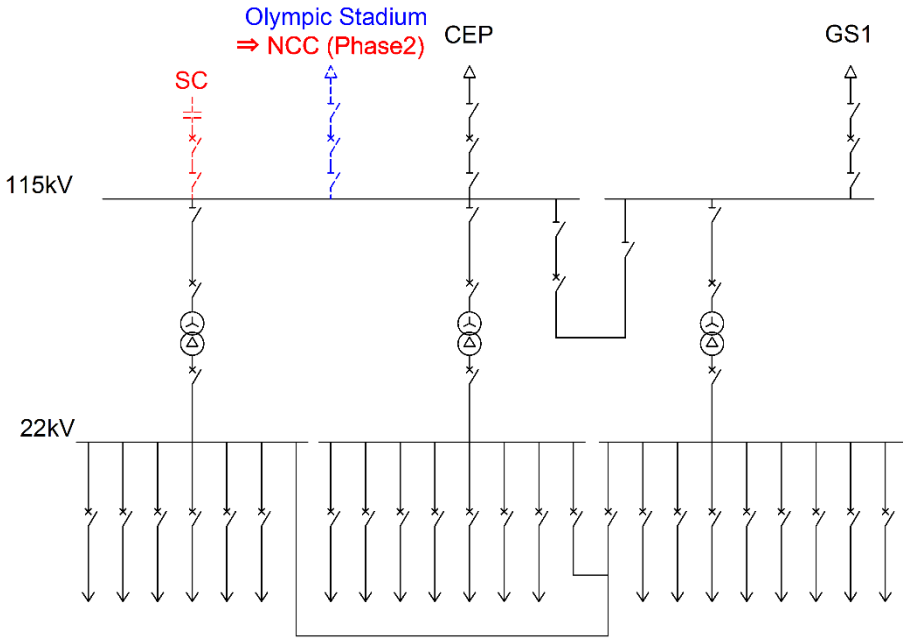
(d) Expanding equipment & layout

Table 8.3-18 Expanding Equipment

	Number of expanding equipment
115kV Shunt capacitor	1 unit

Source: JICA Study Team

In addition, Fig. 8.3-10 shows the single line diagram of the substation.



Source: JICA Study Team

Fig. 8.3-10 Single Line Diagram of GS3

Appendix-5-4 shows the equipment layout image of GS3.

(e) Project cost estimation for modification

The project cost for the above modification of GS3 is estimated below. Estimated conditions are described as follows.

- All equipment would be procured from abroad, and the price would be estimated in US dollars for the CIF price (FC).
- Costs for the procurement of spare parts and tools would be estimated at 5% of the total equipment costs (FC).
- Cost for such as control cables, etc. would be estimated at 5% of the total equipment costs (FC).
- The transportation fee would be estimated at 5% of the total equipment costs (LC).
- The costs of the general civil and erection works would be estimated at 15% of the total equipment costs in foreign currency (USD) portion (FC: 30%) and local currency (USD conversion) portion (LC: 70%).
- The cost for such work items done by a contractor as equipment design, documentation etc. would be estimated as the miscellaneous cost. It would be estimated at 5% of the total costs (FC and LC) for equipment, building and general civil and erection work.

Table 8.3-19 Construction Cost (GS3)

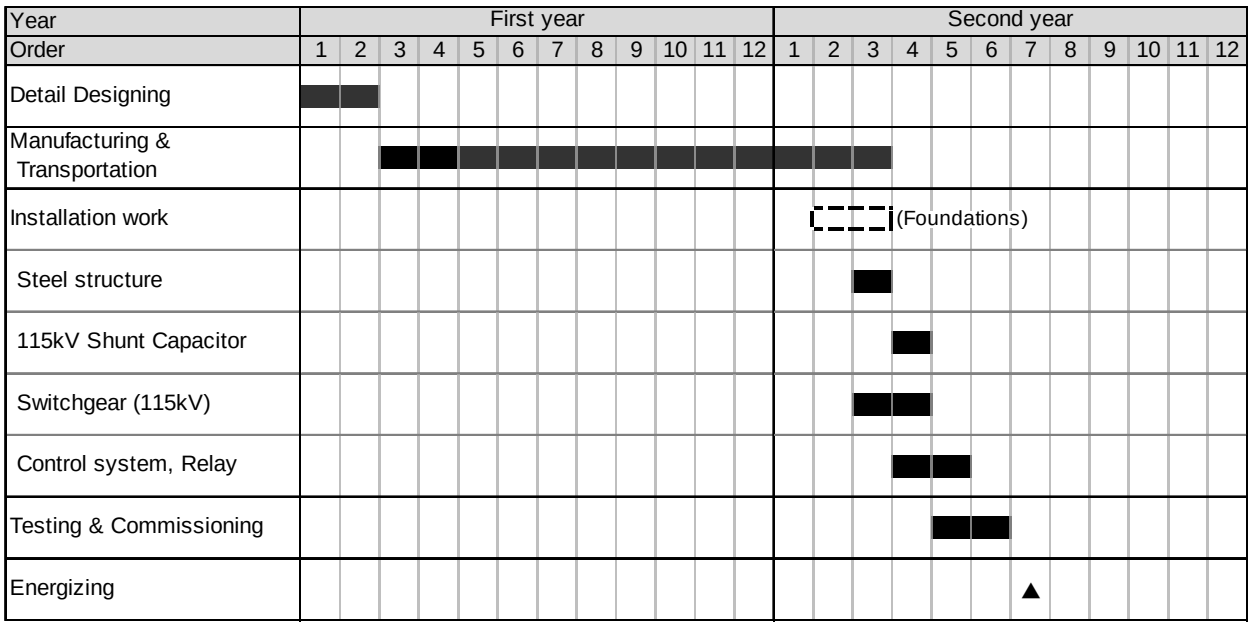
category	NO.	Items	GS3					
			Unit	Quantity	Unit Rate (1000 US$)	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
Equipment Fee	**1**	**Switchgear**						
	1.1	123kV Circuit breaker(1200A,31.5kA)	set	1	45	45	45	0
	1.2	123kV Circuit break Disconnector with supporting structure (2000A,31.5kA)	set	1	12	12	12	0
	1.3	115kV Current Transformer(3phase / 1set)	set	1	30	30	30	0
	2	**Shunt Capacitor**						
	2.1	115kV SC 30MVA	set	1	855	855	855	0
	3	**Protection, Metering and Control**	set					0
	3.1	Modification Substation Automation System	set	2	100	200	200	0
	3.2	Control Panel for 115kV Bays	set	1	20	20	20	0
	3.3	115kV SC protection relay	set	1	45	45	45	0
	3.4	Energy Metering Panel & Recorder	set	1	54	54	54	0
	4	**Miscellaneous Equipment**						
	4.1	Conductor and Fittings	lot	1	50	50	50	0
	4.2	Insulators and Fittings	lot	1	50	50	50	0
	4.3	Gantry steel structures & supports	lot	1	150	150	150	0
	4.4	Earthing and Lighting system	lot	1	30	30	30	0
	5	**Communication and SCADA**						
	5.1	Control system including Fiber Optic equipment	Lot	1	79	79	79	0
	6	**Power & Control Cable**						
	6.1	115kV cable and termination	Lot	1	156	156	156	0
	6.2	Control cable	Lot	1	22	22	22	0
		Sub total(1+2+3+4+5+6)				*1798*	*1798*	*0*
	6	**Spare parts(5% of sub-total above)**	set			90	90	0
		subtotal				*1888*	*1888*	*0*
Works Cost	7	Transportation Fee (5% of Equipment Fee)	set			94	0	94
	8	Civil and Erection(15% of Equipment Fee)	set			283	198	85
		sub-total				*377*	*198*	*179*
Design, etc.	9	Design, Documentation, etc.	set			109	93	16
		(5% of equipment, civiul and erection)						
		sub-total				*109*	*93*	*16*
GS3 Total						**2374**	**2179**	**195**

Source: JICA Study Team

(f) Implementation Schedule

The implementation schedule for the modification of GS3 is presented below.

Table 8.3-20 Construction Schedule (GS3)

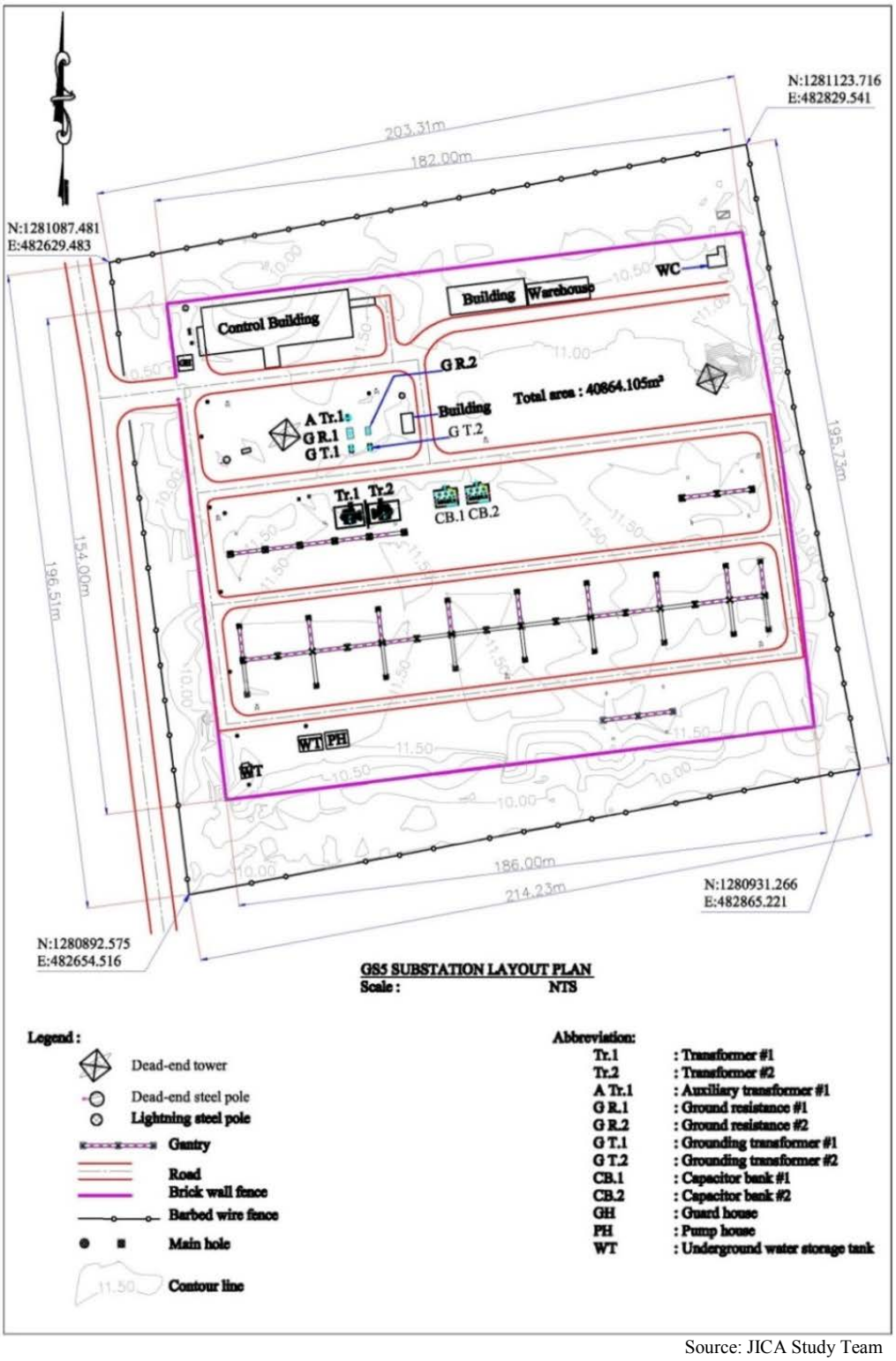


Source: JICA Study Team

(2) GS5

(a) Present conditions and expandability

Because GS5 has a structure in which distribution transformers is installed in the 115kV switchyard, 230kV bay does not exist.
Despite 6 of the 15 bays of 115kV is free, there are only 5 times of a square which can be arranged in a side-by-side of 230kV AIS bus bay in unused space on the north side of these 6 free bays.
On the other hand, according to the acquisition of a vacant land on the east side, the expandability would be secured. In that case, 230kV AIS bus bay is about 8 times of a space which can be arranged side-by-side.



Source: JICA Study Team

Fig. 8.3-11 Survey Map of GS5

(b) Outline of the modifications

i) 230kV/115kV main transformer : 2 units

In order to 115kV system enhancement, two main transformers (300MVA × 2) will be installed.

ii) 230kV switchgear: 6 bays

Total 6 bays
The followings will be additionally installed.
In order to be connected to the SPP and NPP, 230kV overhead transmission feeder bay × 2.
In order to be connected to the NCC, 230kV underground transmission cable bay ×1.
230kV Bus-tie bay ×1.
230kV/115kV main transformer primary bay ×2.

iii) 115kV shunt capacitor: 2 units

In order to 115kV reactive power supply, two shunt capacitors (30MVA × 2) will be installed.

iv) 115kV switchgear: 6 bays

Total 6 bays
The following will be additionally installed.
In order to be connected to the Chroy Changvar, 115kV overhead transmission feeder bay × 2.
115kV Bus-tie bay ×1.
115kV phase modifying equipment bay ×1.
230kV/115kV main transformer secondary bay ×2.

In addition, since EDC decided that EDC will purchase a vacant land, it was possible to perform the modification using AIS facilities that were expected to benefit in all costs, maintenance and operation than GIS one.

1) GS5 115kV bus north side

2) Vacant land east of GS5

Fig. 8.3-12 230kV AIS Equipment Expansion Candidate Area of GS5

In addition to the above additional installation of switchgear, the following items will be necessarily installed or modified under this Project.

1) 230kV bus, transmission line feeder and transformer control and protection

2) 115kV bus, transmission line, transformer and shunt capacitor control and protection
3) Modification of existing Substation Control System
4) SCADA and telecommunication equipment for the new transmission line system

(c) Outline of technical data of equipment

i) 230kV/115kV main transformer

Table 8.3-21 Basic Specification of 230kV/115kV Main Transformer

	Basic specification
Type	YN Auto d1
Rated voltage	230 kV / 115 kV
Rated capacity (Primary/secondary)	300MVA

Source: JICA Study Team

ii) 230kV Switchgear

Table 8.3-22 Basic Specification of 230kV Switchgear

	Basic specification
Rated voltage	230kV
Bus bar configuration	Double bus-bar Type
GIS or AIS	AIS
Rated current	2,000A
Rated short-time withstand current	40kA

Source: JICA Study Team

iii) 115kV Shunt capacitor

Table 8.3-23 Basic Specification of 115kV Switchgear

	Basic specification
Type	Can Type
Rated voltage	115 kV
Rated capacity	30MVar

Source: JICA Study Team

iv) 115kV Switchgear

Table 8.3-24 Basic Specification of 115kV Switchgear

	Basic specification
Rated voltage	115kV
Bus bar configuration	Double bus-bar Type
Insulation type	AIS
Rated current	1,250A: Transmission line / 2,000A: MTr secondly
Rated short-time withstand current	31.5kA

Source: JICA Study Team

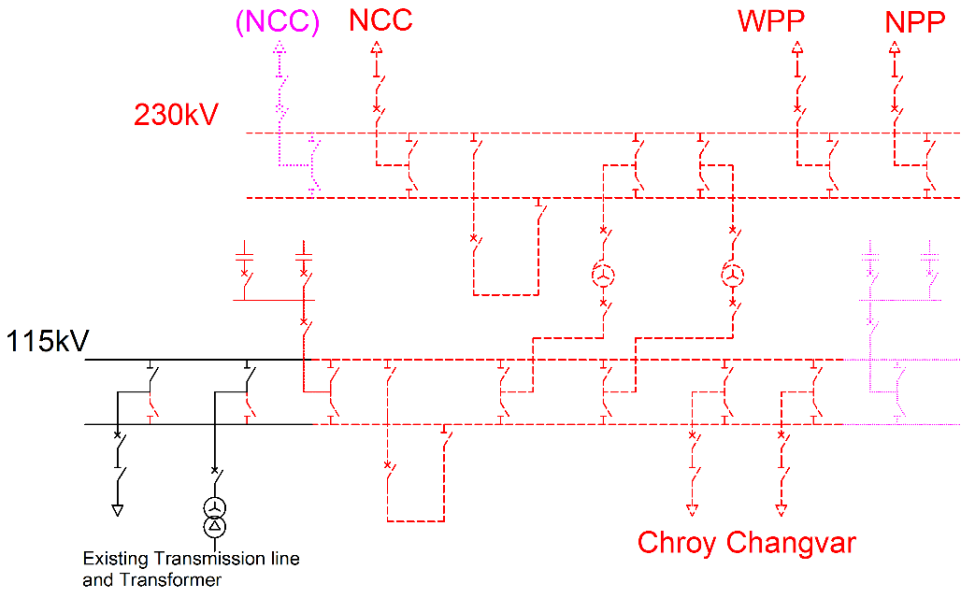
(d) Expanding equipment & layout

Table 8.3-25 Expanding Equipment (GS5)

	Number of equipment
230kV AIS bus	Double bus
230kV line	3 lines (2 Transmission line, 1 power-cable)
230kV/115kV Transformer (300MVA)	2 Banks
115kV Shunt capacitor	2 units (4 units in the future)
115kV AIS bus	Expansion to Double bus (Existing Single bus)
115kV line	2 lines

Source: JICA Study Team

In addition, Fig. 8.3-13 shows the single line diagram of the substation.



Source: JICA Study Team

Fig. 8.3-13 Single Line Diagram of GS5

From the point of view of project cost reduction, EDC would like to install 230kV AIS extension by land acquisition than installing 230kV GIS to the existing vacant lot. Therefore, site extension is adopted.

Appendix-5-5 shows the equipment layout image of the substation at GS5.

(e) Project cost estimation for modification

The project cost for the above modification of GS5 is estimated below. Estimated conditions are described as follows.

- All equipment would be procured from abroad, and the price would be estimated in US dollars for the CIF price (FC).

- Costs for the procurement of spare parts and tools would be estimated at 5% of the total equipment costs (FC).
- Cost for such as control cables, etc. would be estimated at 5% of the total equipment costs (FC).
- The transportation fee would be estimated at 5% of the total equipment costs (LC).
- The costs of the general civil and erection works would be estimated at 15% of the total equipment costs in foreign currency (USD) portion (FC: 30%) and local currency (USD conversion) portion (LC: 70%).
- The cost for such work items done by a contractor as equipment design, documentation etc. would be estimated as the miscellaneous cost. It would be estimated at 5% of the total costs (FC and LC) for equipment, building and general civil and erection work.

Table 8.3-26 Construction Cost (GS5)

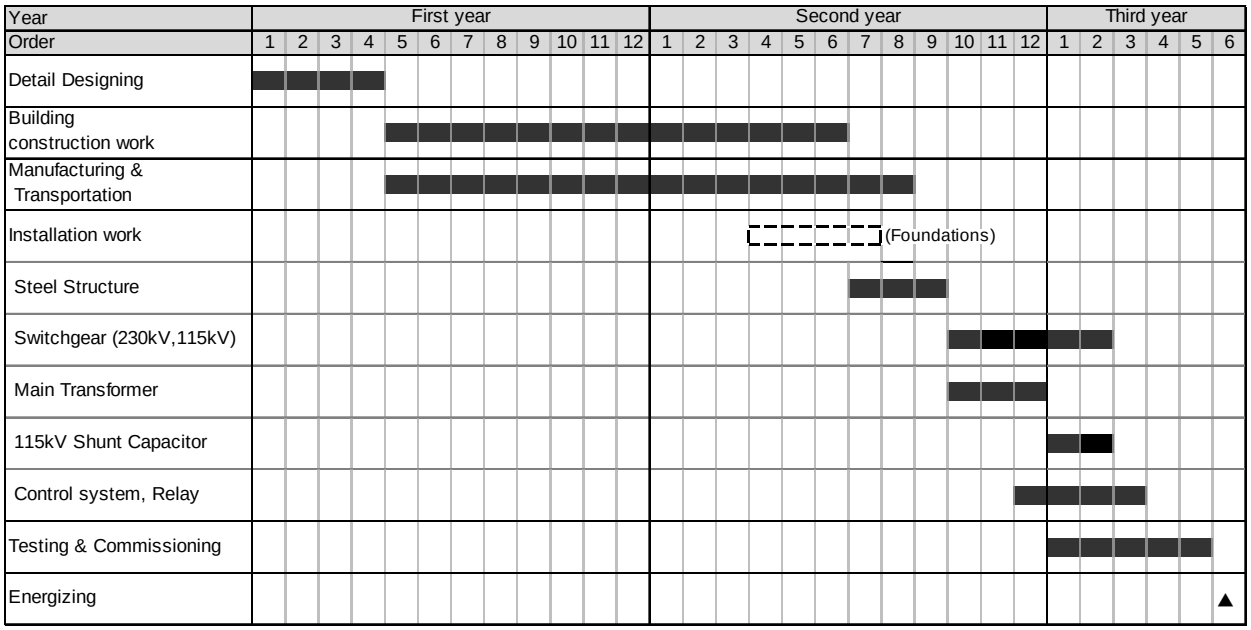
category	NO.	Items	GS5					
			Unit	Quantity	Unit Rate (1000 US$)	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
Equipment Fee	**1**	**Switchgear**						
	1.1	245kV Circuit breaker(2000A,40kA)	set	6	140	840	840	0
	1.2	245kV Circuit break Disconnector+earthing switch with supporting structure (2000A,40kA)	set	3	41	123	123	0
	1.3	245kV Circuit break Disconnector with supporting structure (2000A,40kA)	set	12	29	348	348	0
	1.4	245kV Current Transformer (3phase / 1set)	set	6	46	276	276	0
	1.5	245kV Capacitor type voltage transformers (1phase / 1set)	set	9	15	135	135	0
	1.6	Surge Arrester (192kV, 10kA, discharge class 3)	set	5	10	50	50	0
	1.7	123kV Circuit breaker(2000A,31.5kA)	set	6	45	270	270	0
	1.8	123kV GS (1200A, Multiple times operatable)	set	2	36	72	72	0
	1.9	123kV Circuit break Disconnector+earthing switch with supporting structure (2000A,31.5kA)	set	2	12	24	24	0
	1.10	123kV Circuit break Disconnector with supporting structure (2000A,31.5kA)	set	19	14	266	266	0
	1.11	115kV Current Transformer(3phase / 1set)	set	8	30	240	240	0
	1.12	115kV Capacitor type voltage transformers (1phase / 1set)	set	5	10	50	50	0
	1.13	Surge Arrester (96kV, 10kA, discharge class 3)	set	4	5	20	20	0
	1.14	22kV Switchgear (Indoor type, including control & protection)	set	2	25	50	50	0
	2	**Transformer**						0
	2.1	230kV/115kV Transformer 300MVA	set	2	5600	11200	11200	0
	2.2	22kV/400V Auxiliary Transformer	set	2	11	22	22	0
	3	**Shunt Capacitor**						
	3.1	115kV SC 30MVA	set	2	855	1710	1710	0
	4	**Protection, Metering and Control**	set					
	4.1	Substation Automation System	set	1	298	298	298	0
	4.2	Control Panel for230kV Bays	set	1	106	106	106	0
	4.3	Control Panel for 115kV Bays	set	1	40	40	40	0
	4.4	Protection for 230kV line	set	3	77	231	231	0
	4.5	Protection for 230kV transformer	set	2	61	122	122	0
	4.6	Protection for 230kV Bus coupler	set	1	61	61	61	0
	4.7	230kV busbar protection relay panel	set	1	58	58	58	
	4.8	230kV breaker-fail protection relay	set	1	13	13	13	
	4.9	Protection for 115kV line	set	2	54	108	108	0
	4.10	Protection for 115kV Bus coupler	set	1	54	54	54	0
	4.11	115kV busbar protection relay panel	set	1	58	58	58	
	4.12	115kV breaker-fail protection relay	set	1	13	13	13	
	4.13	115kV SC protection relay	set	2	45	90	90	0
	4.14	Energy Metering Panel & Recorder	set	1	298	298	298	0
	5	**Miscellaneous Equipment**						
	5.1	230kV Conductor and Fittings	lot	7	50	350	350	0
	5.2	115kV Conductor and Fittings	lot	18.5	24	444	444	0
	5.3	230kV Insulators and Fittings	lot	7	6	42	42	0
	5.4	115kV Insulators and Fittings	lot	18.5	6	111	111	0
	5.5	230kV Gantry steel structures & supports	lot	14	59	826	826	0
	5.6	115kV Gantry steel structures & supports	lot	18.5	20	370	370	0
	5.7	Earthing and Lighting system	lot	1	171	171	171	0
	6	**Switch Board (LVAC,DC)**						
	6.1	Service Switchboard	Lot	1	243	243	243	0
	7	**Communication and SCADA**						
	7.1	Control system including Fiber Optic equipment	Lot	1	179	179	179	0
	8	**AC/DC System**	Lot					
	8.1	110V DC system	Lot	1	194	194	194	0
	8.2	48V DC system	Lot	1	66	66	66	0
	8.3	Inverter system	Lot	1	30	30	30	0
	9	Power & Control Cable						
	9.1	22kV cable and termination	Lot	1	68	68	68	0
	9.2	LVAC & Control cable	Lot	1	273	273	273	0
		Sub total (1+2+3+4+5+6+7)				*20613*	*20613*	*0*
	10	**Spare parts (5% of sub-total above)**	set	1		1031	1031	0
		subtotal				*21644*	*21644*	*0*
Building Cost	11	Preliminary works	Lot	1	42	42	13	29
	12	Reinfoeced Concrete	Lot	1	268	268	80	188
	13	Steel Structure	Lot	1	14	14	4	10
	14	Architectural works	Lot	1	132	132	40	92
	15	Electric equipment,Fire-fighting etc.	Lot	1	368	368	110	258
	16	Earthing and Lighting protection	Lot	1	379	379	114	265
		sub-total				*1203*	*361*	*842*
Works Cost	17	Transportation Fee (5% of Equipment Fee)	set	1		1082	0	1082
	18	Civil and Erection(15% of Equipment Fee)	set	1		3247	2273	974
		sub-total				*4329*	*2273*	*2056*
Design, etc.	19	Design, Documentation, etc. (5% of Equipment, Civil and erection)	set	1		1245	1058	187
		sub-total				*1245*	*1058*	*187*
GS5 Substation Total						**28421**	**25336**	**3085**

Source: JICA Study Team

(f) Implementation Schedule

The implementation schedule for the modification of GS5 is presented below.

Table 8.3-27 Construction Schedule (GS5)



Source: JICA Study Team

8.4 DISTRIBUTION FACILITY

8.4.1 Outline of Distribution Facility

Distribution facility is connected between a distribution substation and a customer, such as house, building, and factory, and it consists of a pole, conductor, and transformer and so on.

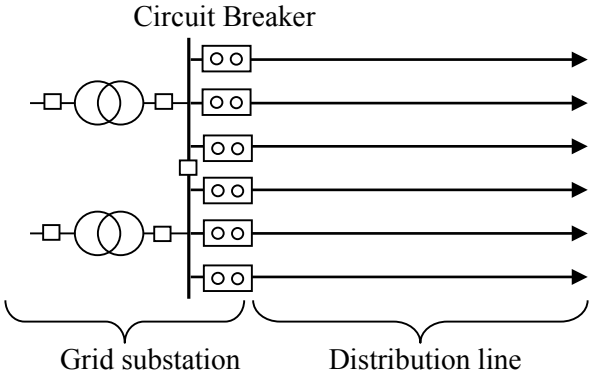
In Phnom Penh, a certain supply capacity is secured in present situation because distribution facilities are already constructed. On the other hand, power demand is expected to grow significantly in the future because the large-scale development projects are planned in many places.

Under such a situation, it is important to utilize existing distribution lines effectively and to expand new distribution lines in order to respond the power demand in the future.

Fig. 8.4-1 State of Phnom Penh City

(1) Configuration of distribution line

There are 6 (six) grid substations in around Phnom Penh City and electric power is supplied by distribution lines from each grid substation. Distribution line circuit breaker is installed in each line, and the amount of power supply is about 10MW in case that the capacity of circuit breaker is 300A.



Source: JICA Study Team

Fig. 8.4-2 Example of Connection

(2) Voltage level

Voltage level of distribution line can be roughly divided into low voltage and medium voltage mainly, and voltage in Phnom Penh City is shown in Table 8.4-1.

Table 8.4-1 Voltage Level of Distribution Line

Classification	Voltage
Medium voltage	22kV
Low voltage	400V, 230V

Source: JICA Study Team

(3) Power distribution system

Power distribution system is mainly divided into overhead line and underground line. Overhead line is common system in Cambodia, but the underground line has been adopted in the center of Phnom Penh City. In

case of the new distribution line, it is necessary to select the power distribution system based on the current state.

Fig. 8.4-3 Overhead Line

Fig. 8.4-4 Underground Line (under construction)

8.4.2 Standards of Power Distribution Facility and Construction

(1) Standards of power distribution facility

Design Standards of EDC based on the power technical standard and power technical standard detailed regulation are as follows.

(a) Concrete Pole

The standard of pole is shown in Table 8.4-2. Length of pole is 7.5~14m, and strength is 2~10kN. Embedment of more than 1/6 of the length of a pole is required at the construction work, in addition, reinforcement by foundation block is required depending on the angle of distribution line and soil coefficient.

Method of reinforcement by foundation block is shown in Fig. 8.4-6.

Fig. 8.4-5 Example of Concrete Pole

Table 8.4-2 Standard of Concrete Pole

Concrete pole table			
Length	**Strength**	**Installation depth**	**Foundation block**
7.5 m	2 kN	1.25 m	
9 m	2 kN	1.50 m	0.60 x 0.40 m
9 m	5 kN	1.50 m	0.70 x 0.45 m
9 m	8 kN	1.50 m	0.85 x 0.70 m
12 m	3 kN	2.00 m	0.60 x 0.40 m
12 m	6 kN	2.00 m	0.75 x 0.50 m
12 m	9 kN	2.00 m	0.90 x 0.75 m
14 m	4 kN	2.35 m	0.70 x 0.45 m
14 m	6.5 kN	2.35 m	0.80 x 0.50 m
14 m	10 kN	2.35 m	1.00 x 0.75 m

Source: Design standard distribution networks, EDC

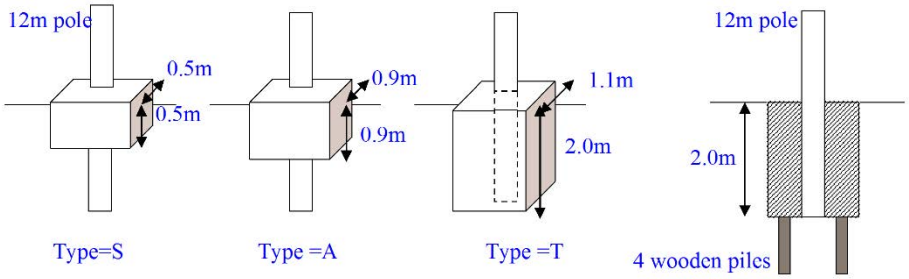


Fig. 8.4-6 Method of Reinforcement

Source: Design standard distribution networks, EDC

(b) 22kV distribution line

Conductors and cables conformed by IEC or ICEA (Insulated Cable Engineers Association) are adopted at 22kV distribution lines.

In general, bare conductors are adopted for overhead line, and cables are adopted for underground line.

In case of overhead line, insulated conductors or cables are adopted in order to ensure the clearance between distribution line and other structure.

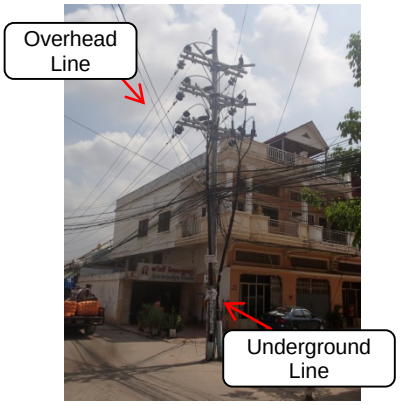


Fig. 8.4-7 Example of 22kV Distribution Line

i) 22kV overhead bare conductor

Table 8.4-3 22kV Overhead Bare Conductor

MV overhead line conductors				
	Bare conductors			
Type	240 mm^2 AAC	150 mm^2 AAC		70 mm^2 AAC
EDC nomenclature				
Photograph				
Implementation range	MV overhead network			
Standards	IEC 61089			

Source: Design standard distribution networks, EDC

ii) 22kV overhead insulated conductor

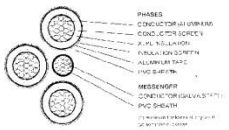
Table 8.4-4 22kV Overhead Insulated Conductor

MV overhead line conductors					
	Partial insulated conductor				
Type	240 mm^2		150 mm^2		70 mm^2
EDC nomenclature					
Photograph					
Implementation range	MV overhead network				
Standards	ICEA S-66-524				

Source: Design standard distribution networks, EDC

iii) 22kV overhead cable

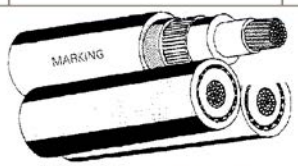
Table 8.4-5 22kV Overhead Cable

MV overhead line conductors				
	Aerial Bundled Cable			
Type	240 mm^2	150 mm^2	70 mm^2	
EDC nomenclature				
Photograph				
Implementation range	MV overhead network			
Standards	IEC 60502			

Source: Design standard distribution networks, EDC

iv) 22kV underground cable

Table 8.4-6 22kV Underground Cable

MV underground cables			
	MV twisted underground cable		
Type	3 x 240 mm^2 Alu	3 x 150 mm^2 Alu	3 x 70 mm^2 Alu
EDC nomenclature EDC	0840 1178	0840 1014	
Photograph			
Implementation range	MV underground network		
Standards	IEC 60502		

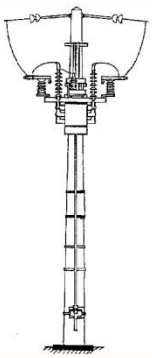
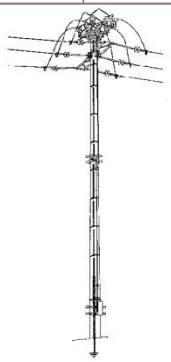
Source: Design standard distribution networks, EDC

(c) Line switch

There are some kinds of distribution line switch. LBS (Load Break Switch) and DS (Disconnecting Switch) are pole mounted type, and switchgear is indoor type.

i) Pole mounted type

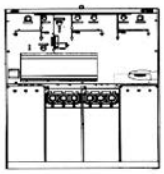
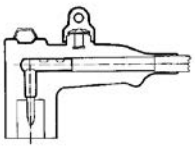
Table 8.4-7 Pole Mounted Type Switch

Overhead MV switches				
Type	630 A	400 A	200 A	
EDC nomenclature				
Photograph				
Implementation range	On the main feeder.		spur line.	
Standards	IEC 60420		IEC 60420	

Source: Design standard distribution networks, EDC

ii) Indoor type

Table 8.4-8 Indoor Type Switch and Cable Terminal

Ring main units and 630 A plug-in connector			
	RMU 2S + T	RMU 2S + 2T	MV plug-in connector
EDC nomenclature			a) 630 A = b) 200 A =
Photograph			
Implementation range	Load break switches ensuring incoming / outgoing feeder sectioning and transformer protection	Load break switch ensuring incoming / outgoing feeders sectioning and protection for two transformers	Plug-in connector for MV single core cables on ring main units
Standards	IEC 60298, 60265, 60129, 60694, 60420, 60056		IEC

Source: Design standard distribution networks, EDC

Fig. 8.4-8 Pole Mounted Type Switch

Fig. 8.4-9 Indoor Type Switch

(2) Standard of construction

(a) Clearance

i) Minimum height of the overhead line

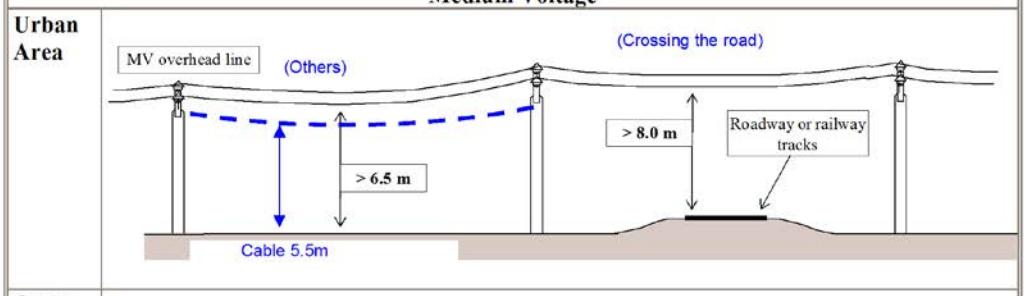
Minimum height of overhead line is different depending on voltage, conductor type, construction area, and crossing a road or not.

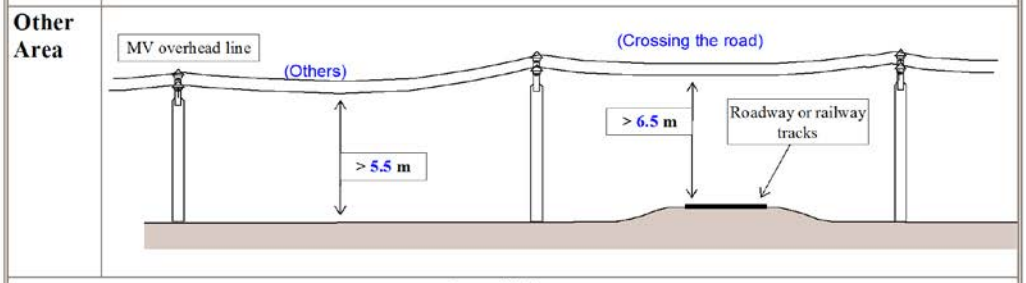
For example, to construct a 22kV overhead insulated conductor in Phnom Penh, it is necessary to ensure a height of 8.0m or more at a road crossing point, at other point, it is necessary to ensure a height of 6.5m or more.

Table 8.4-9 Minimum Height of the Overhead Line

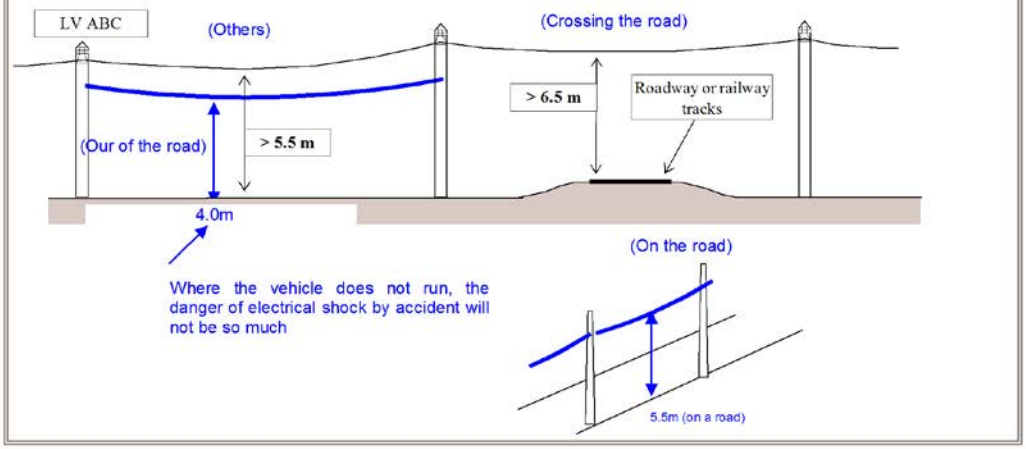
The minimum height of the Overhead line				
	LV Overhead line	**MV Overhead line**		
		Urban Area		**Other Area**
		Cable	**Others**	
Crossing a road	6.5m	8.0m	8.0m	6.5m
Others	5.5m(*)	5.5m	6.5m	5.5m
(*)The minimum height of the low voltage conductor is mitigated up to 4.0m on the place out of the road.				

Medium Voltage





Low Voltage



Source: Design standard distribution networks, EDC

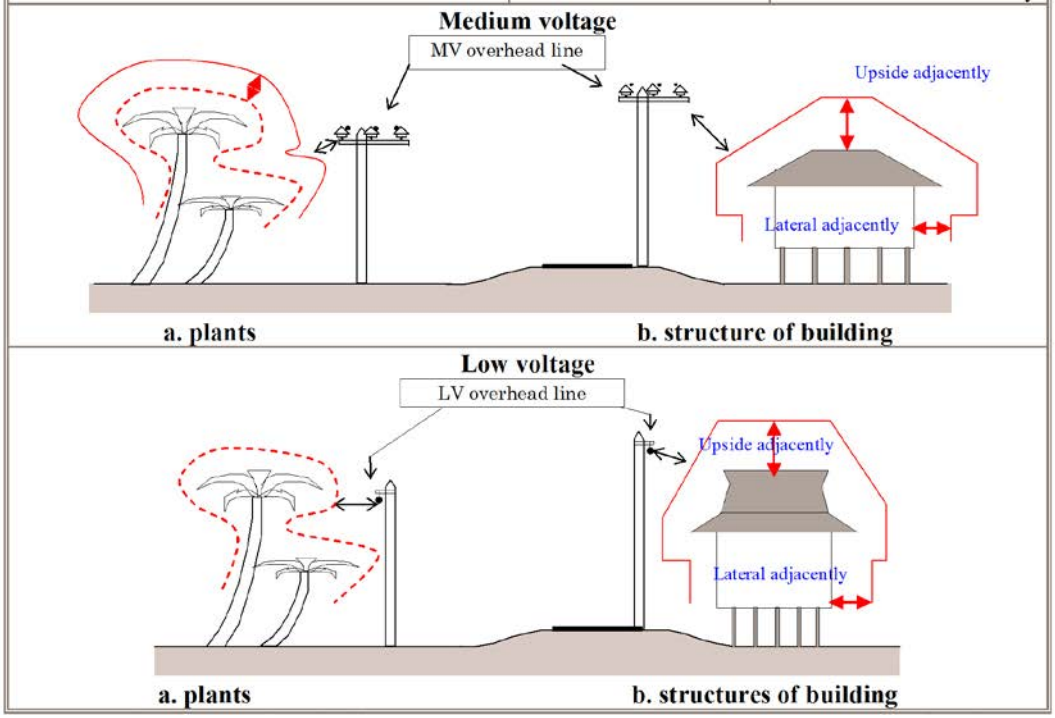
ii) Clearance between overhead line and others

It is necessary to ensure a clearance between overhead line and a plant or a structure such as house and building.

For example, it is necessary to ensure a clearance more than 1.5m away from the side of a large building to construct 22kV overhead insulated conductor around a building.

Table 8.4-10 Clearance between Overhead Line and Others

Clearance between overhead line and others					
				LV	MV
Structures of building	Upside adjacency	With the possibility for persons to climb on	Bare conductor		3.0m
			Insulated conductor	2.0m	2.5m
			Cable	1.0m	1.2m
		Others	Bare conductor	-	3.0m
			Insulated conductor	1.2m	1.5m
			Cable	0.4m	0.5m
	Lateral and downside adjacency		Bare conductor	-	3.0m
			Insulated conductor	1.2m	1.5m
			Cable	0.4m	0.5m
Plants			Bare conductor	-	2.0m
			Insulated conductor	Shall not contact directly	
			Cable	Shall not contact directly	



Source: Design standard distribution networks, EDC

iii) Adjacency and crossing of 22kV overhead line

It is necessary to ensure a clearance between 22kV and other lines.

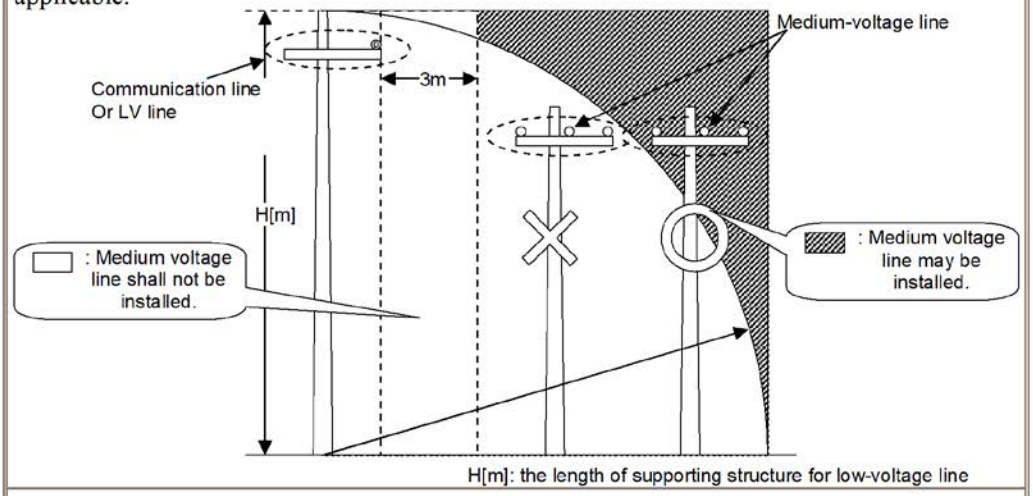
For example, in case of 22kV insulated conductor or cable, it is necessary to ensure a clearance more than 0.5m between each line.

Table 8.4-11 Adjacency and Crossing of 22kV Overhead Line

Adjacency and Crossing of MV

Other objects		Direction of adjacency or crossing	Clearance		
			Insulated Conductor	Cable	Others
Medium voltage line	Insulated Conductor	Lateral adjacency	0.5m or more	0.5m or more	2.0m or more
	Cable	Lateral adjacency	0.5m or more	0.5m or more	2.0m or more
	Others	Lateral adjacency	2.0m or more	2.0m or more	2.0m or more
Low voltage line		Downside adjacency	1.0m or more	0.5m or more	2.0m or more
		Upside adjacency and crossing	(*1)	0.5 or more	(*1)
Communication line		Downside adjacency	1.0m or more	0.5m or more	2.0m or more
		Upside adjacency and crossing	(*2)	0.5 or more	(*2)

(*1)(*2) If the MV line keeps the horizontal clearance of 3.0m or more with LV line or communication line, LV line or Communication line does not come in contact with the MV line when the supporting structure of the LV line or Communication line collapsed, this not be applicable.



Source: Design standard distribution networks, EDC

(b) Underground line

i) Standard construction and depth of burial

Direct burial system is standard for underground line.

Depth of burial is 1.2m or more at the point receiving pressure from vehicles and other objects, and 0.6m or more at other point.

However, it is necessary to use pipes in case that an underground line crosses a major road, or in case a depth shown in Table 8.4-12 cannot be obtained.

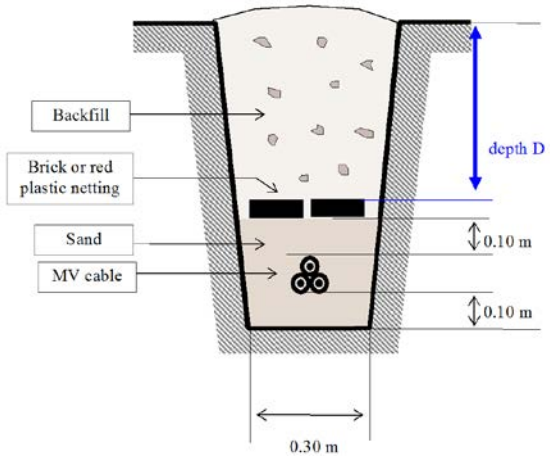


Fig. 8.4-10 Standard Construction

Source: Design standard distribution networks, EDC

Table 8.4-12 Depth in Case of Direct Burial System

Depth in case of direct burial system	
Installation position	**Depth**
At a place where there is a danger of receiving pressure from vehicles or other objects	D = 1.2 m or more
Other place	D = 0.6 m or more

Source: Design standard distribution networks, EDC

ii) Clearance between underground line and other electrical lines

It is necessary to ensure 0.15m or more between low voltage line and low voltage line. And it is necessary to ensure 0.3m or more between medium voltage line and other lines.

Table 8.4-13 Clearance between Underground Line and Other Electrical Lines

Clearance between plural underground lines		
New line	Other electrical lines	
	Low-voltage	Medium-voltage
Low-voltage	0.15m	0.3m
Medium-voltage	0.3m	0.3m

Source: Design standard distribution networks, EDC

iii) Clearance between underground line and other buried object

In the case of 22kV underground line, it is necessary to ensure 0.6m or more from the communication line, 1.0m or more from the gas pipe, 0.3m or more from water supply

and sewerage.

Table 8.4-14 Clearance between Underground Line and Other Lines

Clearance between plural underground lines				
New line	Other electrical lines			
	Communication line	Gas	Water	Sewerage
Low-voltage	(* 0.1)0.3m	Shall not contact directly		
Medium-voltage	(* 0.1)0.6m	1.0m	0.3m	0.3m

(*) Approval of the owner of the communication line shall be required

(Source: Design standard distribution networks, EDC)

8.4.3 Basic Concept of Expansion of Distribution Line

(1) Measures associated with the new substation

At present, it is in situation that buildings are under construction in many places in Phnom Penh City, it should be prioritized to utilize the existing distribution lines, such as loads divides, in order to respond to the increase in electricity demand due to the development of those relatively small.

On the other hand, power demand is expected to increase 10% on average per year after year 2014 due to the large-scale development plans. Power demand is expected to increase rapidly at candidate sites of new substation (① NCC, ② Toul Kork area, ③ Chroy Changvar area), because large-scale development plans are concentrated in these areas.

Therefore, it is necessary to extend the distribution equipment with tuned to these development plans.

Scale	Countermeasure	Timing of implementation
Small	Utilizing the existing distribution lines (for example, loads divides)	Correspondence of each time
Large	Planned expansion of distribution line	With tuned to the development plan

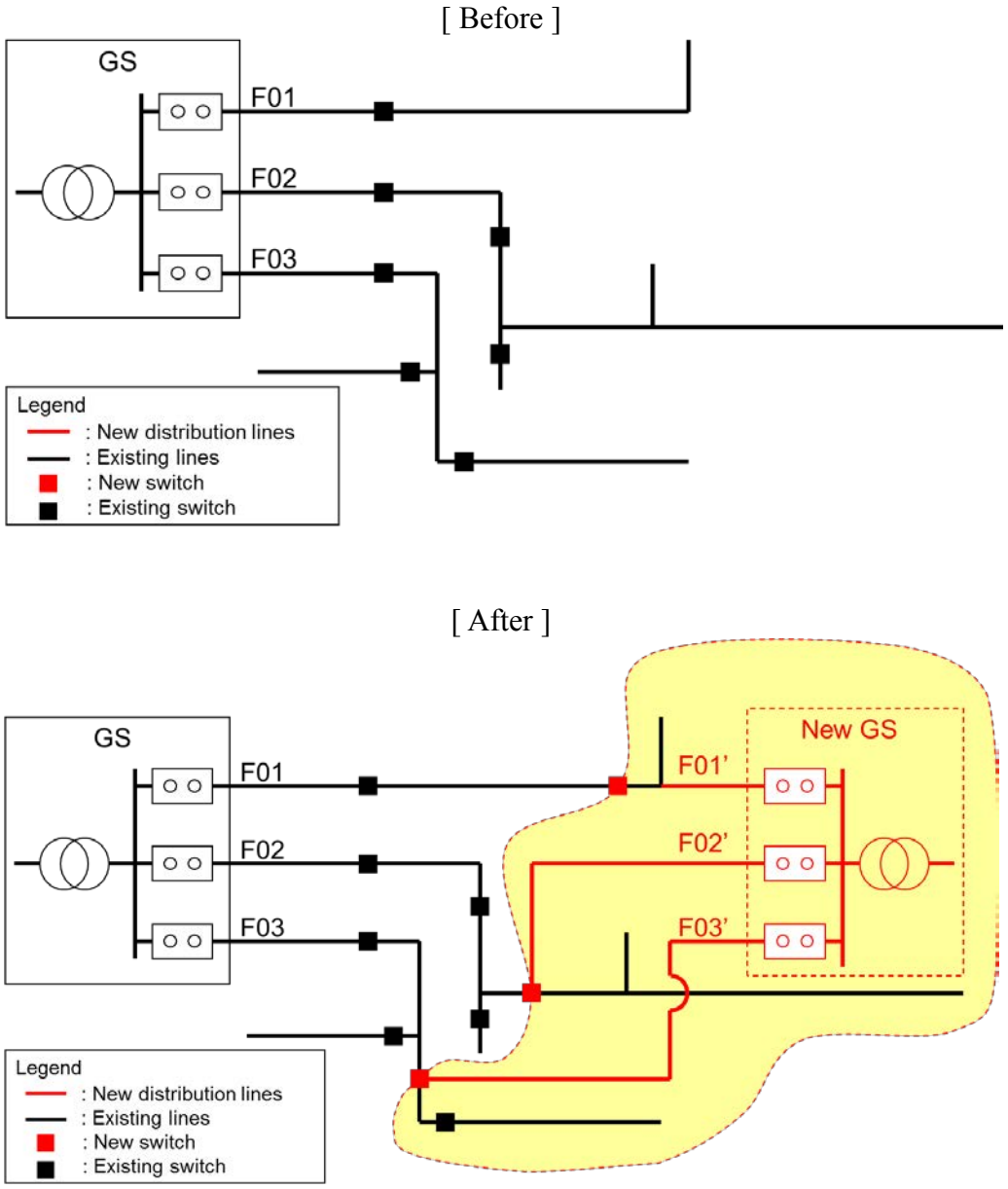
However, JICA Study Team could not confirm the situation that a large-scale development plan is progressing specifically at the field survey.

Therefore, in this Study, the priority is to divide loads, and to improve the power supply capacity and supply reliability with tuned to the new grid substation.

(2) Method of loads divides

The method of loads divides is shown in Fig. 8.4-11 based on concept of Section 8.4.4 (1).

In that way, electric power supplied by the existing grid substation will be reduced and reserve margin will be increased and power interchange form the other feeder is possible, so the supply reliability will be improved.



(Source: JICA Study Team)

Fig. 8.4-11 Image of Method of Loads Divides with tuned to the New Substation

(3) Measures associated with the new transmission line

As the results of the first field survey, there is a possibility that the new transmission line will be the same route as the existing distribution line. In this case, countermeasure work will be required in order to ensure the clearance between new transmission line and existing distribution line. For example, it is necessary to change conductors to cables and make the supporting point lower as shown in Fig. 8.4-13.

In addition, in case that sufficient clearance between cable and existing structures will not be ensured, it is necessary to consider underground cable or route changes by reconstructing pole.

Therefore, it is necessary to perform optimum measures depending on the surrounding circumstances, after determining the route of the transmission line to be established, it is necessary to examine measures again.

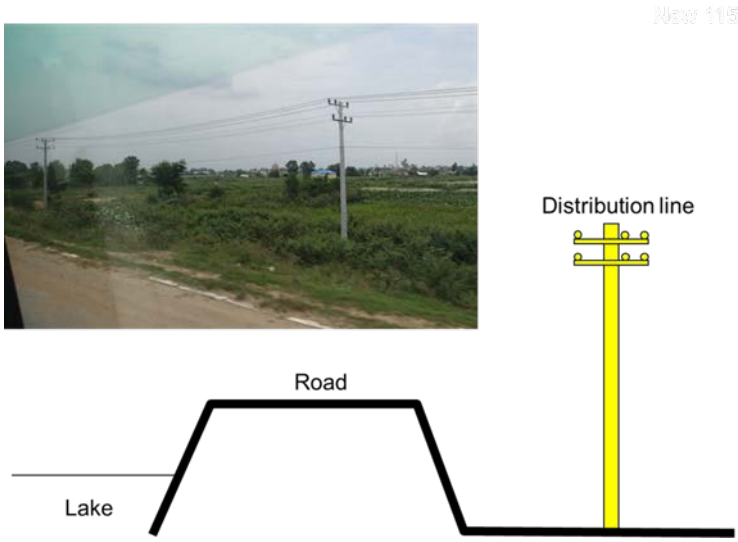
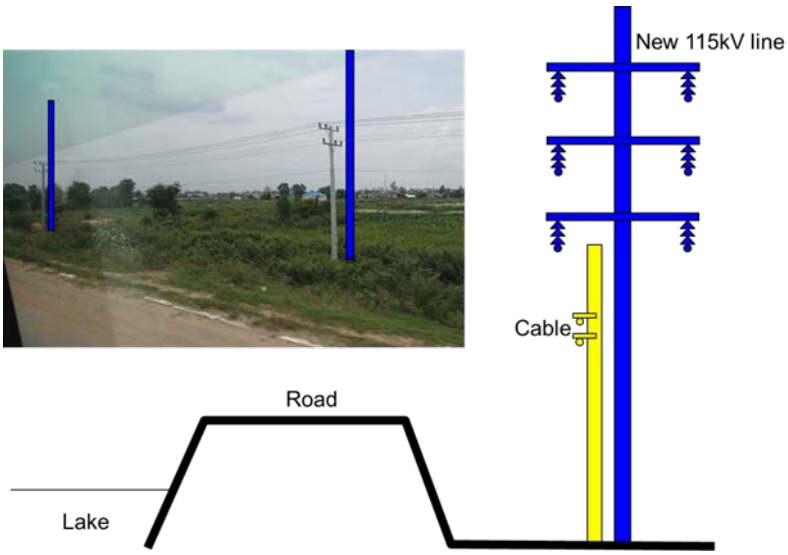


Fig. 8.4-12 Current Situation



Source: JICA Study Team

Fig. 8.4-13 Example of Countermeasure Work

8.4.4 Method of Examination of New Distribution Line Route

JICA Study Team investigated the route of new distribution line in the following steps, based on Design Standard Distribution Networks of EDC and information get through the field survey.

- Step 1 : Study of candidates for connection points of existing distribution line
- Step 2 : Study of distribution system (Overhead/Underground)
- Step 3 : Study of new distribution line route from new GS to candidates of connection points

However, JICA Study Team has examined what can be expected possibly carried out under certain assumptions in this preliminary design. Eventually, it is necessary to design in details after getting the approval of the use of land, and checking the status of existing buried objects such as water supply etc.

(1) Study of candidates for connection points of existing distribution line (Step1)

JICA Study Team has selected connection points that can be expected to divide loads or improve supply reliability. And JICA Study Team has taken into consideration to make effective use of existing facility when selecting the connection point.

(2) Study of distribution system (Overhead/Underground) (Step2)

JICA Study Team investigated the distribution system based on the design criteria of EDC and the status of existing distribution line at new substation candidate sites around.

(3) Study of new distribution line route from new GS to candidate of connection points (Step3)

JICA Study Team investigated the new distribution line route between from new GS to candidate of connection points selected by step 1. And JICA Study Team has also taken notice of following basic points to consider.

[Basic points to consider]

- To construct in public land such as public road
- To shorten the route length for economy
- To construct along the wide road and avoid the place where many people and cars are concentrated such as market, in consideration of construction work and maintenance work.

8.4.5 Preliminary Design

(1) NCC

JICA Study Team designed to expand six new distribution lines, and connection point is indoor switchgear. In addition, JICA Study Team selected underground distribution system based on existing line.

One line will be laid in land of NCC to improve the supply reliability for NCC. Other five lines will be in land of the road, in this case, permission by municipality having jurisdiction over the road is necessary.

Table 8.4-15 Candidate Connection Point (NCC GS)

	Candidate connection point*	Distribution system (OH/UG)	Approximately route length[km]	Remarks
①	S259	UG	0.1	Backup for supply to NCC
②	S356	UG	2.0	
③	S155	UG	2.0	
④	S388	UG	2.2	
⑤	S283	UG	3.0	
⑥	S160	UG	3.8	

*S: Substation (Source: JICA Study Team)

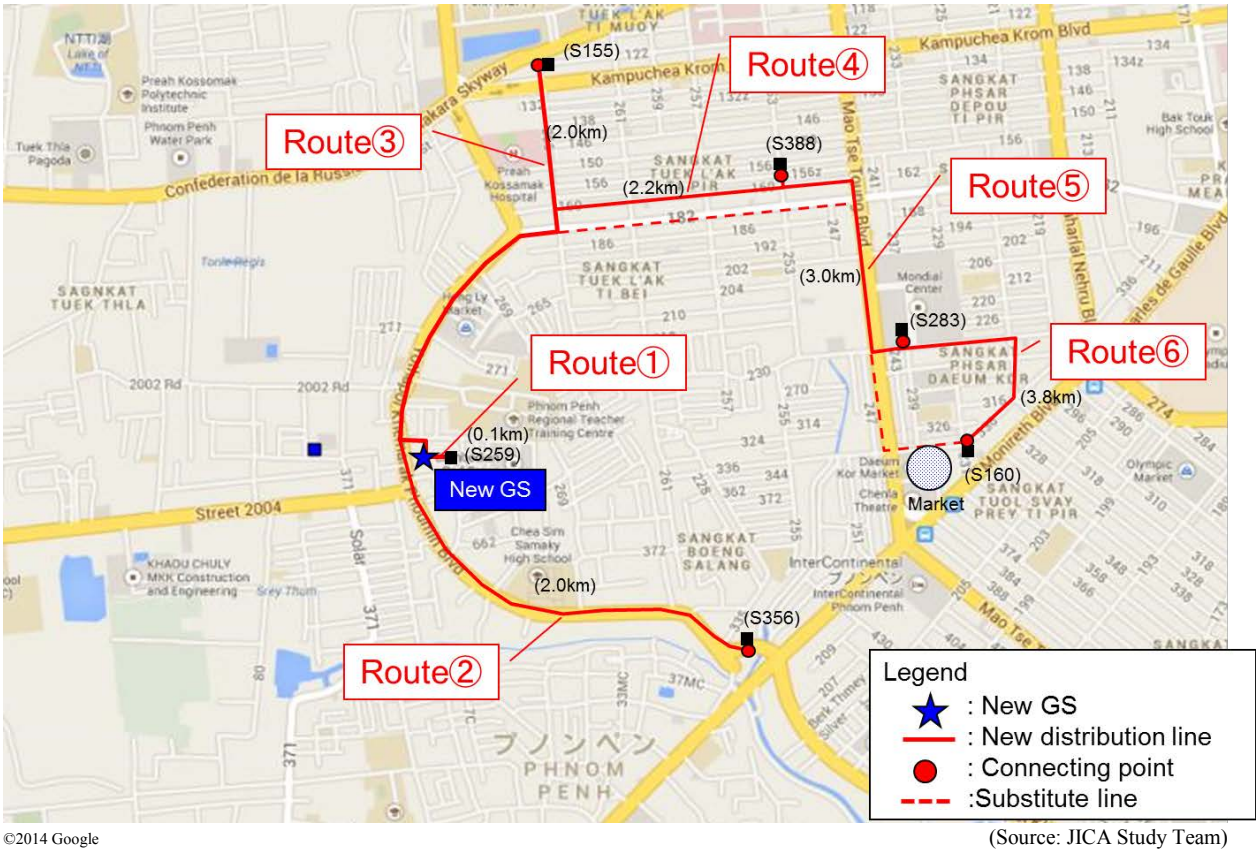


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Fig. 8.4-14 Route of Distribution Line (NCC GS)

(2) Toul Kork

JICA Study Team designed to expand five new distribution lines, and connection point is overhead line or indoor switchgear. In addition, JICA Study Team selected underground distribution system based on existing line. In case of connecting to overhead line, distribution system will be changed from underground system to overhead system at near the site of connection point, after that it will be connected to overhead line.

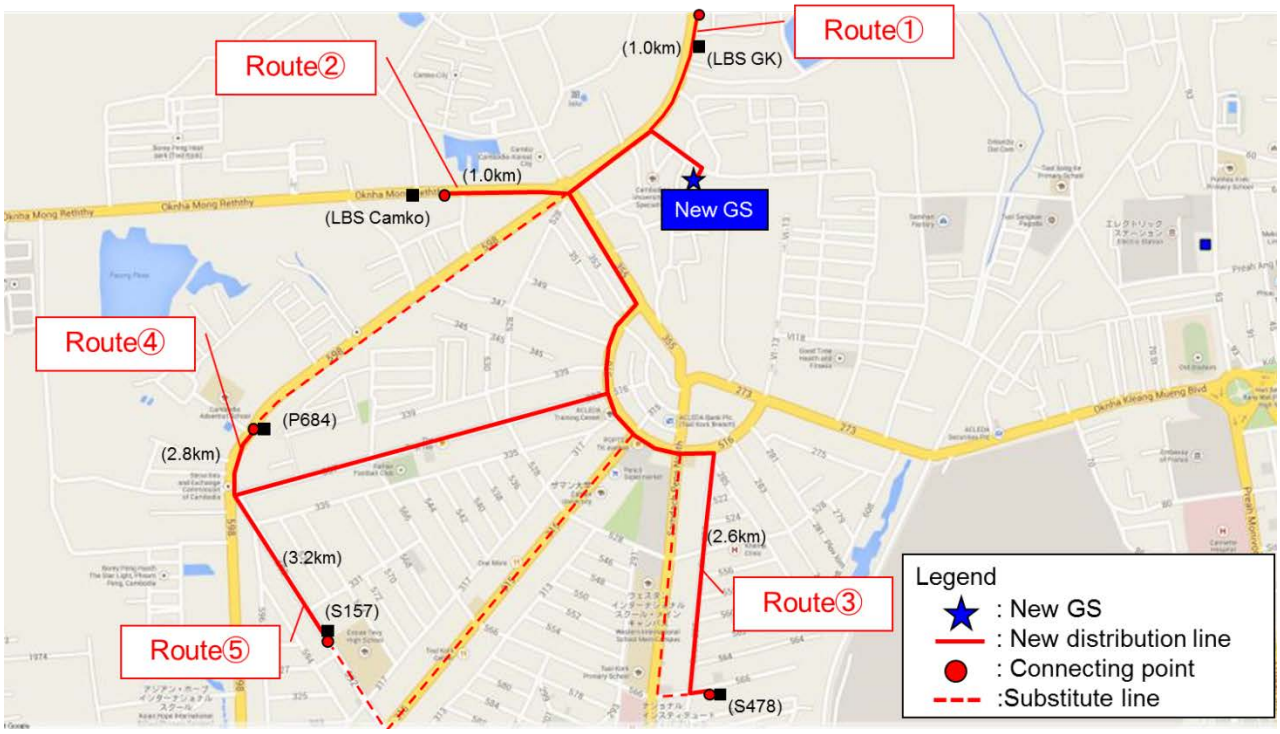
All five lines will be laid in land of the road, and permission by municipality having jurisdiction over the road is necessary.

Table 8.4-16 Candidate Connection Point (Toul Kork GS)

	Candidate connection point*	Distribution system (OH/UG)	Approximately route length[km]	Remarks
①	Around LBS_GK	UG+OH	1.0	
②	Around LBS_Camko	UG+OH	1.0	
③	S478	UG	2.6	
④	Around P684	UG+OH	2.8	
⑤	S157	UG	3.2	

*S: Substation

Source: JICA Study Team



Source: JICA Study Team

Fig. 8.4-15 Route of Distribution Line (Toul Kork GS)

(3) Chroy Changvar

JICA Study Team designed to expand five new distribution lines, and connection point is overhead line or indoor switchgear. Basically, distribution line is overhead system, but a part of them is underground system based on existing line.

Almost lines will be laid in land of the road, and the permission by municipality having jurisdiction over the road is necessary. However, around site of candidate new GS is all private land and there is no public land such as road, therefore the permission by owner of private land for construction of distribution line is necessary too.

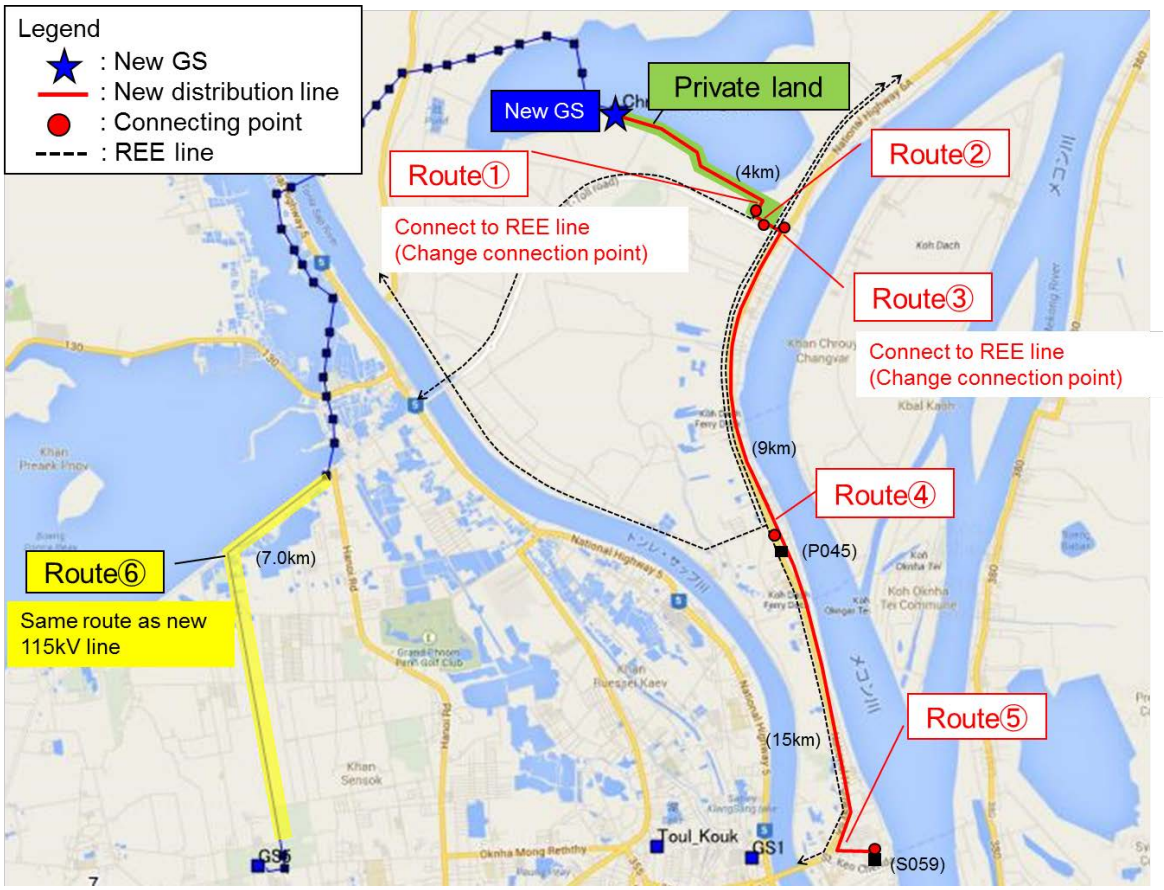
Chroy Changvar is the area where REE (Rural Electricity Enterprise) given a license by EAC (Electricity Authority of Cambodia) can supply and retail electricity, therefore distribution lines which owner is not EDC are installed. These distribution lines are supplied from GS1 and GS6 now, therefore supply should be changed from existing GS to new GS. Furthermore, connection point between EDC grid and REE line should be changed by discuss with REE.

In addition, modification work of existing distribution line will be necessary because a part of new 115kV transmission lines will be installed at same route as distribution line.

Table 8.4-17 Candidate Connection Point (Chroy Changvar GS)

	Candidate connection point*	Distribution system (OH/UG)	Approximately route length [km]	Remarks
①	Around the intersection between national road 6A and Toll road	OH	4.0	Construct in private land and public road. Connect to REE line. (Change connection point)
②	Around the intersection between national road 6A and Toll road	OH	4.0	Construct in private land and public road.
③	Around the intersection between national road 6A and Toll road	OH	4.0	Construct in private land and public road. Connect to REE line. (Change connection point)
④	Around P045	OH	9.0	Construct in private land and public road.
⑤	S059	OH+UG	15.0	Construct in private land and public road.
⑥	—	OH	7.0	Same route as new 115kV line.

*S: Substation, P:Pole mounted transformer Source: JICA Study Team



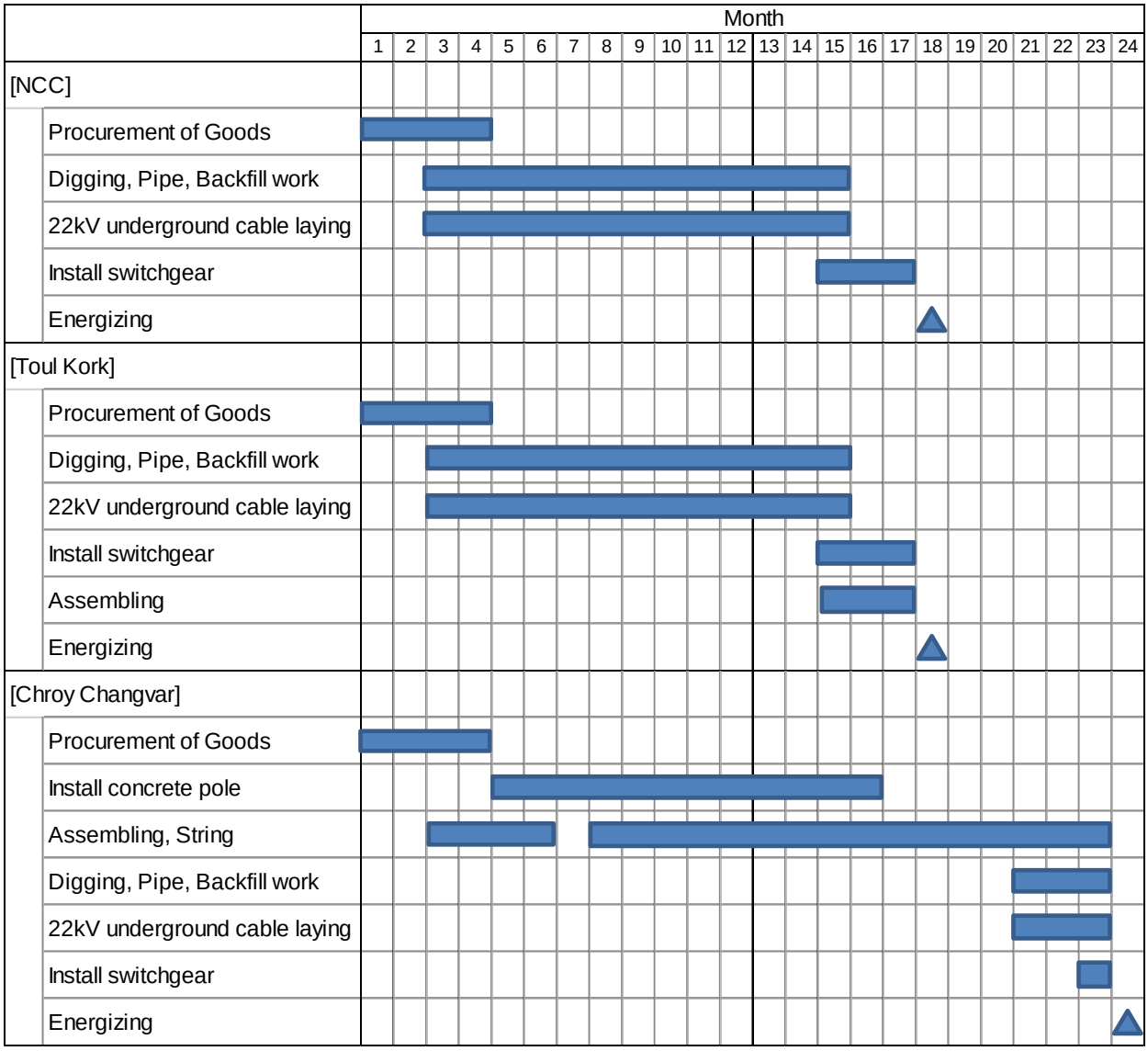
(Source: JICA Study Team)

Fig. 8.4-16 Route of Distribution Line (Chroy Changvar GS)

8.4.6 Construction Schedule

Construction schedule is shown in Table 8.4-18.

Table 8.4-18 Construction Schedule



Source: JICA Study Team

8.4.7 Cost Estimation

(1) Estimation conditions

JICA Study Team estimated the construction cost based on following conditions.

(a) Overhead line

- Between new GS to first concrete pole is adopted underground cable, and the length is 100m uniformed.
- Interval of concrete poles is 50m uniformed.
- Total length of conductor or cable is 1.05 times as route length.
- Pole mounted type switch will be installed at first concrete pole and connection point with existing distribution line respectively.

(b) Underground line

- Total cable length is 1.05 times as route length.
- Interval of junction point of cable is 250m uniformed.
- Cable pipe will be installed according to the design criteria of EDC. Total pipe length is 0.15 times as route length with reference to past construction work.
- New indoor type switchgear will be installed at connection point.

(2) Cost estimation

JICA Study Team estimated the construction cost as follows. And breakdown cost for each GS is shown in Table 8.4-19 to Table 8.4-17.

GS name	Cost estimation		
	FC (1000US$)	LC (1000US$)	Total
NCC	0.000	1,814.467	1,814.467
Toul Kork	0.000	1,390.358	1,390.358
Chroy Changvar	0.000	1,659.738	1,659.738
Total	**0.000**	**4,864.563**	**4,864.563**

Table 8.4-19 Breakdown Cost (NCC GS)

Category	Items	Unit	Quantity	Unit Rate	Amount	FC	LC
				(1000 US$)	(1000 US$)	(1000 US$)	(1000 US$)
Equipment Fee	Underground cable Al- 3×240mm^2	m	13,755	0.029	398.895	0.000	398.895
	Junction box for undergrounding	pcs	47	0.606	28.482	0.000	28.482
	PVC Pipe f125*4000, Thickness≧6mm	pcs	493	0.033	16.269	0.000	16.269
	Switchgear	set	6	30.250	181.500	0.000	181.500
	Accessaries for underground line (temination, joint sleeve, earthing, etc.) (5% of equipment)	lot	1	31.257	31.257	0.000	31.257
	Concrete pole	pcs	0	0.440	0.000	0.000	0.000
	Cross arm (for support conductor)	set	0	0.066	0.000	0.000	0.000
	Insulator	pcs	0	0.033	0.000	0.000	0.000
	Bare conducter AAC 1×240mm^2	m	0	0.005	0.000	0.000	0.000
	Overhead cable ABC 3×240mm^2	m	0	0.033	0.000	0.000	0.000
	Junction box for overhead	pcs	0	0.517	0.000	0.000	0.000
	Lightning arrester	pcs	0	0.060	0.000	0.000	0.000
	LBS, 630A	pcs	0	4.003	0.000	0.000	0.000
	Metering system	set	0	7.934	0.000	0.000	0.000
	Accessaries for overhead line (guy, earthing, support cable, insulator, LBS etc.) (5% of equipment)	lot	1	0.000	0.000	0.000	0.000
	Sub Total				**656.403**	**0.000**	**656.403**
	Excavation and back filling	m	13,100	0.077	1,008.700	0.000	1,008.700
	Install underground cable (Including install PVC pipe)	m	13,755	0.010	137.550	0.000	137.550
	Install junction box for undergrounding	set	47	0.132	6.204	0.000	6.204
	Install switchgear (Including remove existing switch gear)	set	6	0.935	5.610	0.000	5.610
	Install concrete pole	pcs	0	0.077	0.000	0.000	0.000
	Install corss arm	set	0	0.003	0.000	0.000	0.000
	Install insulator	pcs	0	0.003	0.000	0.000	0.000
	Install conductor	m	0	0.001	0.000	0.000	0.000
	Install overhead cable	m	0	0.003	0.000	0.000	0.000
	Install junction box for overhead	pcs	0	0.002	0.000	0.000	0.000
	Install lightning arrester (Including grounding devise)	pcs	0	0.106	0.000	0.000	0.000
	Install LBS (Including grounding system)	pcs	0	0.724	0.000	0.000	0.000
	Install metering system (Including remove existing metering system)	set	0	1.935	0.000	0.000	0.000
	Remove conductor	m	0	0.001	0.000	0.000	0.000
	Sub Total				**1,158.064**	**0.000**	**1,158.064**
Total					**1,814.467**	**0.000**	**1,814.467**

Source: JICA Study Team

Table 8.4-20 Breakdown Cost (Toul Kork GS)

Category	Items	Unit	Quantity	Unit Rate	Amount	FC	LC
				(1000 US$)	(1000 US$)	(1000 US$)	(1000 US$)
Equipment Fee	Underground cable Al- 3×240mm^2	m	11,130	0.029	322.770	0.000	322.770
	Junction box for undergrounding	pcs	37	0.606	22.422	0.000	22.422
	PVC Pipe f125*4000, Thickness≧6mm	pcs	399	0.033	13.167	0.000	13.167
	Switchgear	set	2	30.250	60.500	0.000	60.500
	Accessaries for underground line (temination, joint sleeve, earthing, etc.) (5% of equipment)	lot	1	20.943	20.943	0.000	20.943
	Concrete pole	pcs	0	0.440	0.000	0.000	0.000
	Cross arm (for support conductor)	set	0	0.066	0.000	0.000	0.000
	Insulator	pcs	0	0.033	0.000	0.000	0.000
	Bare conducter AAC 1×240mm^2	m	0	0.005	0.000	0.000	0.000
	Overhead cable ABC 3×240mm^2	m	0	0.033	0.000	0.000	0.000
	Junction box for overhead	pcs	0	0.517	0.000	0.000	0.000
	Lightning arrester	pcs	9	0.060	0.540	0.000	0.540
	LBS, 630A	pcs	3	4.003	12.009	0.000	12.009
	Metering system	set	0	7.934	0.000	0.000	0.000
	Accessaries for overhead line (guy, earthing, support cable, insulator, LBS etc.) (5% of equipment)	lot	1	0.627	0.627	0.000	0.627
	Sub Total				**452.978**	**0.000**	**452.978**
	Excavation and back filling	m	10,600	0.077	816.200	0.000	816.200
	Install underground cable (Including install PVC pipe)	m	11,130	0.010	111.300	0.000	111.300
	Install junction box for undergrounding	set	37	0.132	4.884	0.000	4.884
	Install switchgear (Including remove existing switch gear)	set	2	0.935	1.870	0.000	1.870
	Install concrete pole	pcs	0	0.077	0.000	0.000	0.000
	Install corss arm	set	0	0.003	0.000	0.000	0.000
	Install insulator	pcs	0	0.003	0.000	0.000	0.000
	Install conductor	m	0	0.001	0.000	0.000	0.000
	Install overhead cable	m	0	0.003	0.000	0.000	0.000
	Install junction box for overhead	pcs	0	0.002	0.000	0.000	0.000
	Install lightning arrester (Including grounding devise)	pcs	9	0.106	0.954	0.000	0.954
	Install LBS (Including grounding system)	pcs	3	0.724	2.172	0.000	2.172
	Install metering system (Including remove existing metering system)	set	0	1.935	0.000	0.000	0.000
	Remove conductor	m	0	0.001	0.000	0.000	0.000
	Sub Total				**937.380**	**0.000**	**937.380**
Total					**1,390.358**	**0.000**	**1,390.358**

Source: JICA Study Team

Table 8.4-21 Breakdown Cost (Chroy Changvar GS)

Category	Items	Unit	Quantity	Unit Rate	Amount	FC	LC
				(1000 US$)	(1000 US$)	(1000 US$)	(1000 US$)
Equipment Fee	Underground cable Al- 3×240mm^2	m	630	0.029	18.270	0.000	18.270
	Junction box for undergrounding	pcs	0	0.606	0.000	0.000	0.000
	PVC Pipe f125*4000, Thickness≧6mm	pcs	24	0.033	0.792	0.000	0.792
	Switchgear	set	1	30.250	30.250	0.000	30.250
	Accessaries for underground line (temination, joint sleeve, earthing, etc.) (5% of equipment)	lot	1	2.466	2.466	0.000	2.466
	Concrete pole	pcs	460	0.440	202.400	0.000	202.400
	Cross arm (for support conductor)	set	720	0.066	47.520	0.000	47.520
	Insulator	pcs	2,160	0.033	71.280	0.000	71.280
	Bare conducter AAC 1×240mm^2	m	113,400	0.005	567.000	0.000	567.000
	Overhead cable ABC 3×240mm^2	m	9,450	0.033	311.850	0.000	311.850
	Junction box for overhead	pcs	36	0.517	18.612	0.000	18.612
	Lightning arrester	pcs	30	0.060	1.800	0.000	1.800
	LBS, 630A	pcs	10	4.003	40.030	0.000	40.030
	Metering system	set	2	7.934	15.868	0.000	15.868
	Accessaries for overhead line (guy, earthing, support cable, insulator, LBS etc.) (5% of equipment)	lot	1	63.818	63.818	0.000	63.818
	Sub Total				**1,391.956**	**0.000**	**1,391.956**
	Excavation and back filling	m	600	0.077	46.200	0.000	46.200
	Install underground cable (Including install PVC pipe)	m	630	0.010	6.300	0.000	6.300
	Install junction box for undergrounding	set	0	0.132	0.000	0.000	0.000
	Install switchgear (Including remove existing switch gear)	set	1	0.935	0.935	0.000	0.935
	Install concrete pole	pcs	460	0.077	35.420	0.000	35.420
	Install corss arm	set	720	0.003	2.160	0.000	2.160
	Install insulator	pcs	2,160	0.003	6.480	0.000	6.480
	Install conductor	m	113,400	0.001	113.400	0.000	113.400
	Install overhead cable	m	9,450	0.003	28.350	0.000	28.350
	Install junction box for overhead	pcs	36	0.002	0.072	0.000	0.072
	Install lightning arrester (Including grounding devise)	pcs	30	0.106	3.180	0.000	3.180
	Install LBS (Including grounding system)	pcs	10	0.724	7.240	0.000	7.240
	Install metering system (Including remove existing metering system)	set	2	1.935	3.870	0.000	3.870
	Remove conductor	m	28,350	0.001	14.175	0.000	14.175
	Sub Total				**267.782**	**0.000**	**267.782**
Total					**1,659.738**	**0.000**	**1,659.738**

Source: JICA Study Team

CHAPTER 9

PROJECT PLAN

CHAPTER 9 PROJECT PLAN

9.1 CONSTRUCTION SCHEDULE

This Chapter discusses construction schedule for the Project.

9.1.1 Overall Implementation Schedule for the Project

The implementation schedule is shown in Fig. 9.1-1 and Fig. 9.1-2.

The Project will be completed in 59 months from the L/A (Loan Agreement) to the commissioning in case the STANDARD BIDING DOCUMENTS UNDER JAPANESE ODA LOANS PROCUREMENT of Plant Design, Supply and Installation (PLANT) for substation works and those of works (WORKS) for other facilities such as overhead transmission facility, underground transmission facility and distribution facility were applied (refer to Fig. 9.1-1).

In case the STANDARD BIDDING DOCUMENTS UNDER JAPANESE ODA LOANS PROCUREMENT of Plant Design, Supply and Installation (PLANT) for all the project facilities were applied, the Project will be completed in 57 months (refer to Fig. 9.1-2).

PLANT was adapted for substation works, WORKS was adapted for other facilities to this project following the discussion between JICA and EDC.

	[Item]	[Month]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
		Season															Rainy Season												Rainy Season												Rainy Season												Rainy Season											
1	**Loan Agreement (1)**		1																																																												
2	**IEIA Approval (5)**						5																																																									
3	**Land Acquisition [*1] (6)**							6																																																								
4	**Selection of Consultant (8)**				8																																																											
5	**Detailed design (15)**											15																																																				
5-1	Preparation of Design Report																																																														
5-2	Site survey and Soil investigation (2.5)											2.5																																																				
5-3	Detailed design for Package1 (4)												4																																																				
5-4	Preparation of Design Report (2)																	2																																														
5-5	Detailed design for Package2 (12)												12																																																			
5-6	Preparation of Design Report (2)																									2																																						
6A	**Tender Assistance for S/S [Package 1] (10)**																			10																																													
6A-1	Preparation of Tender Documents (1.5)																			1.5																																													
6A-2	JICA's concurrence (0.5)																				0.5																																												
6A-3	Tender Period (3)																					3																																											
6A-4	Tender Evaluation 1 (Qualificationl) (0.5)																								0.5																																						
6A-5	Tender Evaluation 2 (Technical) (1)																									1																																					
6A-6	JICA's concurrence (0.5)																										0.5																																			
6A-7	Tender Evaluation 3 (Cost) (1)																										1																																		
6A-8	JICA's concurrence (0.5)																										0.5																																	
6A-9	Contract Negotiation (1)																										1																																
6A-10	JICA's concurrence (0.5)																										0.5																															
6B	**Tender Assistance for OHL,UG and D/L [Package 2] (10)**																										10																															
7A	**Construction Period [Package 1] (30)**																												30																														
	Construction/Extension of Substation Facilities (S/S)																																																											
7A-1	230kV/115kV/ 22kV NCC GIS S/S																												30																														
	115kV/22kV Toul Kork GIS S/S																												24																														
	115kV/22kV Chroy Changvar AIS S/S (Especially To be required access road for																												24																														
	Extension of GS3 (115kV AIS)																												19																														
	Extension of GS5 (230kV/115kV AIS)																												30																														
7B	**Construction Period [Package 2] (25)**																																																											
	Construction of Overhead Transmission Line Facilities (OHL)																																																											
7B-1	230kV OHL from NPP/WPP to NCC																																																											
	115kV OHL from GS5 to Chroy Changvar																																																											
	Construction of Underground Transmission Line Facilities (UG)																																																										
7B-2	230kV UG from GS5 to NCC																																																										
	115kV UG from NCC to GS3																																																										
	Construction of Distribution Facility (D/L)																																																										
7B-3	Around NCC S/S																																																										
	Around Toul Kork S/S																																																										
	Around Chroy Changvar S/S																																																										
7B-4	Commissioning																																																										

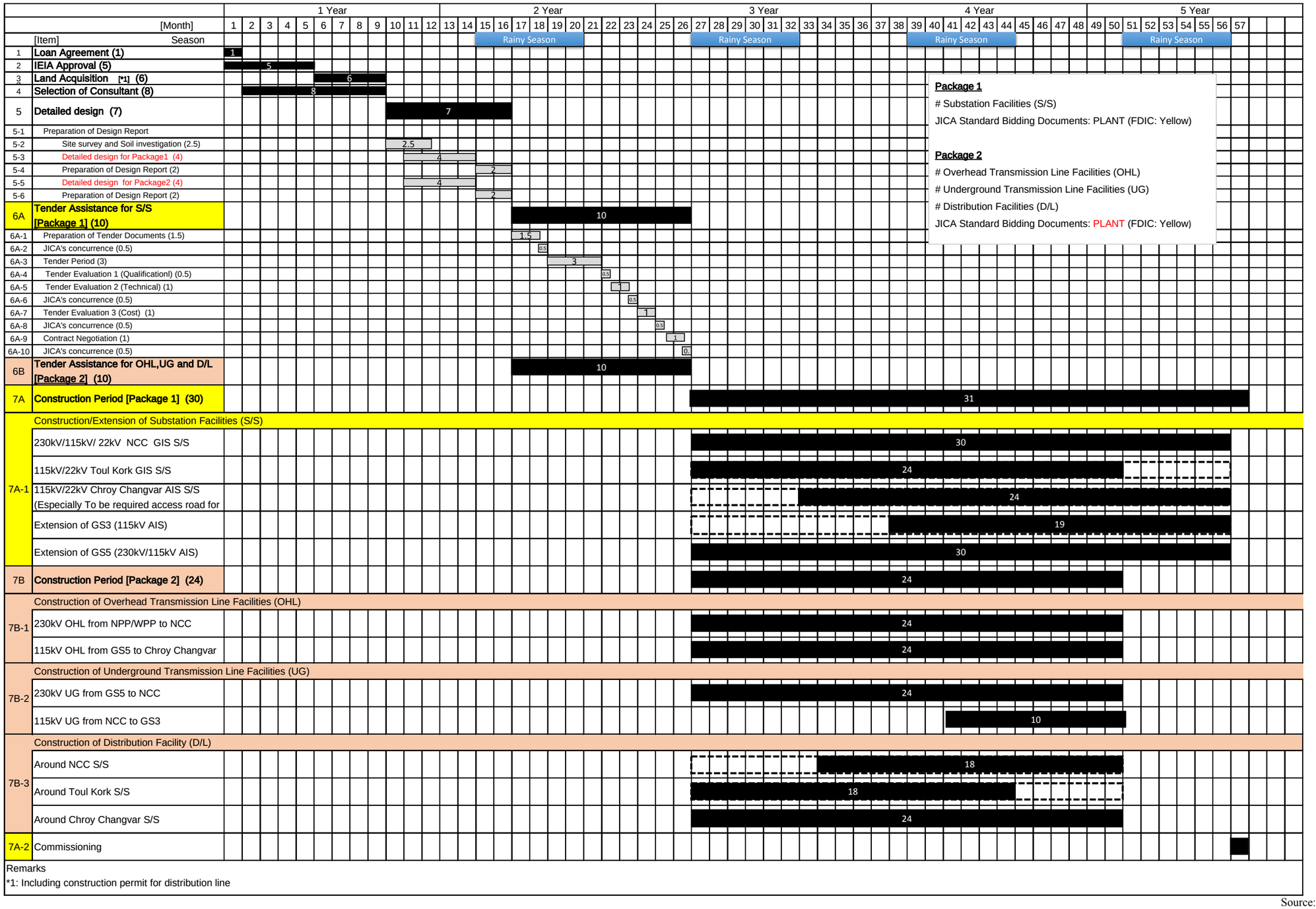
Package 1
Substation Facilities (S/S)
JICA Standard Bidding Documents: PLANT (FDIC: Yellow)

Package 2
Overhead Transmission Line Facilities (OHL)
Underground Transmission Line Facilities (UG)
Distribution Facilities (D/L)
JICA Standard Bidding Documents: WORKS (FDIC: Red)

Remarks
*1: Including construction permit for distribution line

Source: JICA Study Team

Fig. 9.1-1 Implementation Schedule for the Project (Plan 1: Substation: PLANT, Other: WORKS)



Source: JICA Study Team

Fig. 9.1-2 Implementation Schedule for the Project (Plan 2: ALL Facilities: PLANT)

9.2 PROJECT COST ESTIMATION

The result of the project cost estimation is reported here.
The exchange rates among US$ (US dollar), JPY (Japanese Yen) and KHR (Cambodian Riel) are as follows;

US$ 1 = JPY 108.1
US$ 1 = KHR 4058
KHR 1 = JPY 0.0266

9.2.1 Construction and Expansion of Substations

(1) Equipment and Installation Work Cost

Substation-related works included in the Project are; new construction of NCC (National Control Center), Toul Kork, and Chroy Changvar Substations, and expansion of GS3 and GS5 substations. The cost estimation result for these works is discussed in the section 8.3 of the previous chapter.

(2) Civil Work Cost

Works for the construction of Chroy Changvar substation and expansion of GS5 will involve civil works of certain volume. The costs for the civil works were estimated as shown in the tables below.

Table 9.2-1 Cost Estimate of Civil Works for Construction of Chroy Changvar Substation

Items	Chroy Changvar					
	Unit	Q'ty	Unit Rate (1000US$)	Amount (1000US$)	FC (1000US$)	LC (1000US$)
Road Expansion [9m × 3m × 1000m]	cum	27000	0.006	162	0	162
Land Reclamation [180m × 180m × 6m]	cum	194400	0.006	1,166	0	1166
Land Leveling [180m × 180m]	sqm	32400	0.100	3,240	0	3240
			Total	**4,568**		**4,568**

Source: JICA Study Team

Table 9.2-2 Cost Estimate of Civil Works for Expansion of GS5 Substation

No. Items	GS5					
	Unit	Q'ty	Unit Rate (1000US$)	Amount (1000US$)	FC (1000US$)	LC (1000US$)
GS5 Land Leveling [210m x 210m]	sqm	44100	0.125	5,513	0	5,513

Source: JICA Study Team

(3) Summary of Cost Estimate for Construction and Expansion of Substations

The cost estimate for construction of three new substations and expansion of two existing substation are summarized in the table below.

Table 9.2-3 Summary of Cost Estimation of Construction and Expansion of Substations

	Description	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
Construction of New Substations	1. NCC Substation			
	1.1 Equipment Cost	18,011	18,011	0
	1.2 Installation Work Cost, including architectural and design works	11,585	4,855	6,730
	sub total	29,596	22,866	6,730
	2. Toul Kork Substation			
	2.1 Equipment Cost	6,139	6,139	0
	2.2 Installation Work Cost, including architectural and design works	4,053	1,818	2,235
	sub total	10,192	7,957	2,235
	3. Chroy Changvar Substation			
	3.1 Equipment Cost	7,047	7,047	0
	3.2 Installation Work Cost, including architectural and design works	4,612	2,526	2,086
	3.3 Land Preparation Cost	4,568	0	4,568
	sub total	16,227	9,573	6,654
	Total New Substations	56,015	40,396	15,619
Extension of Existing Substations	1. GS3 Substation Extension			
	1.1 Equipment Cost	1,888	1,888	0
	1.2 Installation Work Cost, including design works	486	291	195
	sub total	2,374	2,179	195
	2. GS5 Substation Extension			
	2.1 Equipment Cost	21,644	21,644	0
	2.2 Installation Work Cost, including architectural and design works	6,777	3,692	3,085
	2.3 Land Preparation Cost	5,513	0	5,513
	sub total	33,934	25,336	8,598
	Total Extension	36,308	27,515	8,793
Total Construction Cost for Substations		**92,323**	**67,911**	**24,412**

Source: JICA Study Team

9.2.2 Construction of Overhead Transmission Lines

(1) Equipment and Installation Work Cost

Overhead transmission line-related works included in the Project are; 230kV (10.2 km), 115kV (20.2km + 0.1km). The cost estimation result for these works is discussed in the section 8.1 of the previous chapter.

(2) Summary of Cost Estimate for Construction of Overhead Transmission Lines

The cost estimate for construction of overhead transmission lines are summarized in the table below.

Table 9.2-4 Summary of Cost Estimation of Construction of Overhead Transmission Lines

Description	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
1. 230kV, Midpoint NPP-WPP to GS5			
1.1 Equipment Cost	15,138	15,138	0
1.2 Installation Work Cost	4,283	0	4,283
Subtotal	19,421	15,138	4,283
2. 115kV, GS5 to Chroy Changvar (Route 6)			
2.1 Equipment Cost	4,355	4,355	0
2.2 Installation Work Cost	5,441	0	5,441
subtotal	9,796	4,355	5,441
3. 115kV, Midpoint GS1-GS5 to Toul Kork (Route 7)			
3.1 Equipment Cost	59	59	0
3.2 Installation Work Cost	63	0	63
subtotal	*122*	*59*	*63*
Total Construction Cost for Transmission Lines	29,339	19,552	9,787

Source: JICA Study Team

9.2.3 Construction of Underground Transmission Lines

(1) Equipment and Installation Work Cost

Underground transmission line-related works included in the Project is; 230kV Route 4 (9.28km). Also, the Project includes the works necessary for the connection of 115kV line at new transformers in the NCC sub-station. The 115kV line between Olympic sub-station and GS3 sub-station via NCC is scheduled to be constructed in Phase 1 project. The cost estimation result for these works is discussed in the section 8.2 of the previous chapter.

(2) Summary of Cost Estimation of Construction of Underground Transmission Lines

The estimated costs for the construction of 230kV and 115kV underground transmission lines are summarized in the table below.

Table 9.2-5 Summary of Cost Estimation of Construction of Underground Transmission Lines

Description	Amount (1000 US$)	FC (1000 US$)	LC (1000 US$)
1. 230kV Underground Transmission Line Route 4 (GS5 to NCC)			
1.1 Equipment Cost	24,647	24,647	0
1.2 Installation Work Cost	23,607	8,297	15,310
sub total	48,254	32,944	15,310
2. Joint Work of 155kV line between Olympic S/S and GS3			
Joint Work	495	196	299
sub total	495	196	299
Total	**48,749**	**33,140**	**15,608**

Source: JICA Study Team

9.2.4 Construction of Distribution Lines

(1) Equipment and Installation Work Cost

Distribution line-related works included in the Project are; NCC substation area, Toul Kork substation area and Chroy Changvar area. The cost estimation result for these works is discussed in the section 8.4 of the previous chapter.

(2) Summary of Cost Estimation of Construction of Distribution Lines

The cost estimate for construction of distribution lines are summarized in the table below.

Table 9.2-6 Summary of Cost Estimation of Construction of Distribution Lines

Description	Amount (1000US$)	FC (1000US$)	LC (1000US$)
1. NCC Area			
1.1 Equipment Cost	656	0	656
1.2 Installation Work Cost	1,158	0	1,158
sub total	*1,814*	*0*	*1,814*
2. Toul Kork Area			
2.1 Equipment Cost	453	0	453
2.2 Installation Work Cost	937	0	937
sub total	*1,390*	*0*	*1,390*
3. Chroy Changvar Area			
3.1 Equipment Cost	1,392	0	1,392
3.2 Installation Work Cost	268	0	268
sub total	*1,660*	*0*	*1,660*
Total Distribution Line	**4,865**	**0**	**4,865**

Source: JICA Study Team

9.2.5 Other Cost

(1) Environmental Monitoring

The cost of the environmental monitoring works to be carried out according to the plan discussed in Section 7.1.9.2 was estimated. The result is shown in the table below.

Table 9.2-7 Summary of Cost Estimation of Environmental Monitoring Works

Item		Price (US$)	Quantity	Unit	Total (US$)	Remarks
Cost Estimate for EMP Implementation						
Consultation & Workshop		3,000	1	set	3,000	-
Provision of Public Health Information		2,500	1	set	2,500	-
Cost Estimate for Monitoring						
Weekly Checking by DCC	Payroll including Transport Fee	120	152	days	18,240	- Monitoring requires 2 days/time for covering project area - Monitoring requires 1 month before the construction and 1 month after construction in addition to 33 months of construction period - 152weeks * 1day
Quarter Checking by EDC	Payroll including Transport Fee	120	24	days	2,880	- 36months/3months * 2days
Monthly Checking by DCC	Payroll including Transport Fee	120	70	days	8,400	- Monitoring requires 2 days/time for covering project area - Monitoring requires 1 month before the construction and 1 month after construction in addition to 33 months of construction period - 35months * 2days
Monthly Checking by EDC	Payroll including Transport Fee	120	70	days	8,400	ditto
Checking of Public Health and Workers Safety	Payroll including Transport Fee	120	2	days	240	- Checking requires 2 times during construction period
Contingency 10%					4,366	-
Grand Total					**48,026**	**-**

Source: JICA Study Team

(2) Land Acquisition and Compensation

Land acquisition costs including the purchase of assets on the lands for Chroy Changvar substation, GS5 substation, and transmission towers, compensation for land use restriction under ROW of transmission lines, management cost for land acquisition and compensation, and contingency thereof, were estimated and discussed in Section 7.2.8.2. These costs are included in the total project cost.

Also, there will be land lease costs to be incurred for the access road to Chroy Changvar Substation and overhead transmission lines;

Chroy Changvar Substation: area [12m × 1,000m] × unit price [US$100] = US$ 1,200,000
Overhead Transmission Lines area [3m × 1,000m] × unit price [US$ 75] = US$ 225,000

These costs are also incorporated in the total project cost.

(3) EDC's Administration

EDC will incur cost for project administration. EDC has a standard estimation factor, which is "3% of construction cost". Using this factor, the administration cost was estimated.

(4) Consulting Service Fee

Consulting service fee was estimated on the basis of the draft TOR to be discussed in Section 4 of this chapter.

Billing rates applied in the estimation were as follows;

International Consultant	JPY 2,895,000 per month
National Consultant	KHR 12,500,000 per month

(5) Other Costs

Allowance for price escalation (Price Contingency)

Price contingency was estimated as; 2% p.a. for foreign currency portion of the construction cost, and 4.4% p.a. for local currency portion.

Physical Contingency

Physical contingency was estimated as 5% of the construction cost added with price contingency.

Tax

VAT (Value Added Tax) was estimated by applying 10% to the local portion of the construction cost including price and physical contingencies, consulting service cost and land acquisition cost. Import tax was estimated by applying 15% to the foreign portion of the construction cost including price and physical contingencies.

IDC (Interest During Construction)

IDC was estimated with the interest rate of 0.01% p.a.

9.2.6 Total Project Cost

Total Project Cost is shown in the table below, with classification of foreign/local currencies. In the table, items except "I. Construction Cost" are the results of currency conversions from JPY for foreign currency portion, and from KHR for local currency portion, to US dollar. Therefore, they include small errors in conversion and rounding. Also, the items V through XI include adjustment for price escalation and do not equal the amounts mentioned above in this section.

Table 9.2-8 Total Project Cost

	Total (US$1,000)	FC (US$1,000)	LC (US$1,000)
I. CONSTRUCTION COST	**175,276**	**120,603**	**54,673**
1. Package One (Substations)	92,323	67,911	24,412
1.1 Construction of New Substations	56,015	40,396	15,619
1.2 Extension of Existing Substations	36,308	27,515	8,793
2. Package Two (Transmission and Distribution)	82,953	52,692	30,261
2.1 Overhead Transmission Lines	29,339	19,552	9,787
2.2 Underground Transmission Lines	48,749	33,140	15,609
2.3 Distribution Lines	4,865	0	4,865
II. PRICE ESCALATION	**22,455**	**10,906**	**11,549**
III. PHYSICAL CONTINGENCY	**9,886**	**6,575**	**3,311**
IV. INTEREST DURING CONSTRUCTION	**83**	**83**	**0**
V. CONSULTING SERVICES	**17,704**	**15,256**	**2,448**
VI. LAND ACQUISITION / COMPENSATION	**15,986**	**0**	**15,986**
VII. ENVIRONMENTAL MONITORING	**54**	**0**	**54**
VIII. ADMINISTRATION	**7,248**	**0**	**7,248**
IX. TAX (VAT and Import Tax)	**49,497**	**0**	**49,497**
TOTAL PROJECT COST	**298,190**	**153,423**	**144,766**

Source: JICA Study Team

9.3 STUDY OF PROCUREMENT

9.3.1 Package

In consideration of the scale of this Project, this Project is divided into two packages, i.e., Package 1 (Substation Facilities) and the Package 2 (Overhead transmission facilities, Underground transmission facilities and Distribution facilities), and each contractor is selected by international competitive bidding.

9.3.2 Standard Bidding Document

In this project, two kind of standard bidding documents[1] which are prepared by JICA, are available. One is STANDARD BIDDING DOCUMENTS UNDER JAPANESE ODA LOANS PROCUREMENT OF WORKS (**WORKS**), and the other is STANDARD BIDDING DOCUMENTS UNDER JAPANESE ODA LOANS PROCUREMENT OF PLANT DESIGN, SUPPLY AND INSTALLATION (**PLANT**). Comparison between Red Book and Yellow Book is shown in Table 9.3-2. And Comparison in the Project schedule and Total cost by Standard Bidding Document is shown in Table 9.3-2. PLANT was adapted for substation works, WORKS was adapted for other facilities to this project following the discussion between JICA and EDC.

Table 9.3-1 Comparison between Red Book and Yellow Book (FIDIC*)

		Red Book 1999	Yellow Book 1999
Target facilities		Required for civil works.	Required for all Plant Design, Supply and Installation.
Similar Standard Bidding Document		PLANT	WORKS
	Name of Standard Bidding Document	Conditions of Contract for **Construction** For Building and Engineering Works Designed by the Employer	Conditions of Contract for **Plant and Design Build** For Electrical and Mechanical Plant, and For Building and Engineering Works, Designed by the Contractor
	Design	Owner (EDC) ✓ Owner shall designs almost facilities.	The Contractor ✓ The Contractor shall conduct a designs procurement and installation. ✓ The contractor needs to satisfy the outline and specification which were specified in the contract document.
	The engineer	The engineer manages the contract, supervise the construction and proves payment.	
	Contract price and Payment	Based on the bill of quantities of actual construction. ✓ The contract price is based on the quantity for every item, and calculated by applying a unit price. ✓ When an addition occurs, the right for the contractor to receive an additional price is defined.	Total package amount (lamp sum) contract ✓ Payment is single lump sum credit, when the milestone was attained. ✓ When an addition occurs, the right for the contractor to receive an additional price is defined.

*FIDIC : International Federation of Consulting Engineers Source: JICA Study Team

1 http://www.jica.go.jp/english/our_work/types_of_assistance/oda_loans/oda_op_info/guide/tender/

Table 9.3-2 Comparison in Project Schedule and Total Cost by Standard Bidding Document

		Plan 1	Plan 2
Package / Standard Bidding Document	Package 1	Substation Facilities : PLANT	Substation Facilities : PLANT
	Package 2	Overhead transmission facilities, Underground transmission facilities and Distribution facilities : WORKS	Overhead transmission facilities, Underground transmission facilities and Distribution facilities : PLANT
Implementation Schedule		59 months	57 months
Total Cost		Cost of Consultant becomes high for a number of million USD.	Standard
Design		Substation: The Contractor	Substation: The Contractor
		Others: Owner	Others: the Contractor
Remarks		By applying a WORKS Standard Bidding Document, a design risk may be able to be corresponded before the Contractor's bid, and a project delay risk may be small compared with a PLANT Standard Bidding Document.	

9.4 TERMS OF REFERENCE (TOR)

9.4.1 Work Contents of Implementation Agency, Consultant and Contractor

The following works will be implemented by the implementation agency (EDC), the Consultants and the Contractors.

(1) Implementation Agency of Cambodia (EDC)

EDC shall allot the following roles during project implementation.

1) Organizing a new Project Management Unit for the Project,
2) Coordination among the related ministries for smooth implementation of the Project,
3) Acquisition of land for substation facilities and overhead transition facilities,
4) Prior securing of the environmental certificate for the Project from the MOE (Ministry of Environment),
5) All necessary certificates to start the construction for the Project
6) Appointment of the Project consultants, and cooperation with /assistance to them,
7) Close communication with institution(s) of the Project fund on bidding, contracts, procurement, project progress, and other information,
8) Proper actions for necessary procedures on facility import for the Project,
9) Issue of payment certificates for consultants and contractors,
10) Claim management of contractors, local people, and others,
11) Prosecution of the commissioning test of the Project,
12) Education and training of employees for operation and maintenance for overhead transmission facilities, underground transmission facilities and AIS (Air Insulated Switchgear) / GIS (Gas Insulated Switchgear) substations facilities,
13) Proper and operations and maintenance of the facilities after commissioned, and
14) Securing budget and staffs to execute the above matters.

(2) Project Consultants

The Consultants shall allot the following particulars.

1) Detailed design related to preparation of bid documents for the Project including a field survey and line route investigation,
2) Preparation of the design report for the Project and submission to EDC,
3) Preparation of the bidding documents for the Project and submission to EDC,
4) Evaluation of proposals forwarded by bidders and assistance to EDC evaluation committee in selecting prospective bidders for the contracts,
5) Assistance to EDC in contract negotiations with prospective bidders and in conclusion of the contracts,
6) Examination on manufacturing/working drawings and various communications from the contractors for approval,

7) Inspections and tests for equipment and materials to be carried out at the contractors' factories prior to shipment,
8) Project management and supervision of the contractors' field works,
9) Preparation of the completion report for the Project and submission to EDC,
10) Inspection on facilities immediately prior to expiration of the guarantee period for facilities and
11) Transfer of knowledge to EDC staff in charge of the Project.

(3) Contractors

The Project will be executed in full-turn-key contracts. The Contractors shall allot the following works.

1) Implementation design to complete the Project based on site survey and route survey,
2) Manufacturing/procurement and tests of the equipment and materials,
3) All civil/building works, installation of equipment and materials and the factory test
4) Verification of proper functions of all the facilities completed,
5) Commissioning of the facilities to EDC,
6) Transfer of knowledge to EDC through their working period for construction, maintenance and operation of the project facilities.

9.4.1 Staffing Plan of the Project

The following staff from EDC and the Consultants will proceed the Project.

(1) Implementation Agency of Cambodia (EDC)

1) Project Manager in the EDC's project office is to be assigned throughout the whole project period. (He will also be a counterpart of the consultants.)

2) Staffs of the EDC's related environment division for monitoring environmental measures taken by the contractors are to be timely dispatched to the sites. Persons from the related province and/or district may also monitor the situation.

3) Overhead transmission line and Underground transmission line inspectors including persons from EDC: at least one civil work inspector throughout the Contractors' civil works, at least one inspector for cable installation. Those inspectors should be responsible not only for the supervision of the Contractors' work but also for communication and negotiation with authorities on the matters over which EDC has responsibility.

4) The Contractor may simultaneously execute the works of two substations. EDC's inspectors will be lined up with one person for civil/building works and one person for electrical works per each substation. On-the-job training participants for the O&M (Operation and Maintenance) of each substation under the Project are separate from the inspectors.

5) The Contractor will construct distribution lines and communication lines. EDC's inspectors will be lined up with one person for these installation works.

6) In addition to the aforementioned inspection team and trainees, a procurement committee, project implementation unit, management committee, and bid evaluation committee will be organized as a standard rule of EDC for project implementation and perform each duty for the Project. As demanded, EDC sections concerning the customs of imported goods, payment procedures, and communications with other authorities will execute their duties for the Project.

(2) Consultants

- **Detailed Design and Preparation of Bidding Documents**

  The Consultants will execute the detailed design, cost estimate and detailed implementation plan for the Project through discussions with EDC and in accordance with results of the field survey and investigation. Design report prepared by the consultants will cover whole results of the design. After approval of the report by the funding institutions or in parallel with report preparation, the consultants will produce bidding documents for the Project.

- **Public Bid and Contract**

  The Consultants will carry out assistance to EDC during public announcements of the bid, bid opening, bid evaluation, contract negotiation and preparation of the contract documents.

- **Procurement Management**

  The consultants will manage all works for examinations on the contractors' drawings and designs, and inspection/tests of equipment/materials at the contractors' factory.

- **Supervision of Contractors' Field Works**

  Through the whole period of the Contractors' field works, the consultants will supervise all the field works. The Consultants will have responsibility for education of EDC's operators and maintenance people for the facilities after completion of the Project.

- **Commissioning Test and Inspection for Defect Liability Period**

  After completion of the construction of all facilities, the consultants will supervise the contractors' commissioning tests of individual facilities for the overhead transmission facilities, the underground transmission lines, substations facilities and distribution facilities and also for the system's operation test combining both the transmission facilities and the substation. Furthermore, the Consultants will check and approve the project completion report of the completed facilities to be submitted by the contractors, and assist EDC with their procedures for issuing the taking-over certificates to the contractors. Immediately before the expiration of the defect liability period of the Project facilities, the consultants in conjunction with EDC will inspect all the project-related facilities to issue the final certificates to the contractors.

9.4.2 TOR for Consulting Services in Detailed Design / Construction Supervision Stage

Outline of TOR for the consulting services are shown below.

[Scope of the Project]

The Project consists of:

1) Construction of about the following 230kV/115 kV overhead transmission lines
   - About 10km of 230kV NPP/WPP - GS5

- About 20km of 115kV GS5 - Chroy Changvar
- About 0.1km of 115kV GS1/GS5 - Toul Kork

2) Construction of the following 230kV/115 kV underground transmission lines
- About 9km of 230kV GS5 - NCC
- About 0.4km of 115kV NCC - GS3

3) Construction of 230/115/22kV GIS/AIS substations, and rehabilitation of exiting GS3 and GS5
- 230/115/22 GIS substation at NCC : New
- 115/22 GIS substation at Toul Kork : New
- 115/22 AIS substation at Chroy Changvar New
- Rehabilitation of exiting GS 3
- Rehabilitation of exiting GS 5

4) Construction of distribution lines
- Around NCC
- Around Toul Kork
- Chroy Changvar

[Scope of Consulting Services]

The Scope of the Consulting Services is to;

Detail Design and Tendering

a) Collect all engineering data required for designing the Project facilities,

b) Prepare detailed designs for overhead transmission line facilities, transmission line facilities, substations, distribution facilities taking into account, the design practices used by EDC and current international standards,

c) Prepare bidding documents for all equipment and services required to implement the project to be suitable for international competitive bidding procedures, and

d) Assist EDC to invite and evaluate award contracts.

Coordination

Assist EDC to maintain the proper coordination and communication between EDC and JICA.

Supervision during Implementation Stage

a) Review and approve the contractor's documents and drawings and witness tests on equipment, if necessary,

b) Review contractor's manufacturing and delivery schedule of equipment and materials,

c) Supervise the construction of project facilities and help the Contractors conform to the specifications,

d) Assist EDC to institute cost control, project accounts, and quality assurance mechanisms, and check and approve the contractor's bills, and

e) Review and compile as-built drawings, and review the operation and maintenance manuals made by the Contractor for accuracy and adequacy.

Commissioning and Tests

a) Check and approve Contractor's procedure of commissioning and acceptance tests,

b) Witness commissioning and acceptance tests, and assist EDC in association with EDC's engineers to take over the completed facilities, and

c) Submit a detailed test report to EDC.

Submission of Report

a) Submit Monthly Progress Reports to EDC,

b) Assist EDC in preparing Quarterly Progress Reports to JICA, and

c) Submit a Project Completion Report providing details of project implementation, problems encountered, solution adopted, and detailing and explaining any variation in project costs and implementation from the original estimates.

Capacity Building for O&M of Underground Transmission Line and GIS Substation

a) Confirm the current status of EDC's power system facilities and O&M,

b) Assist EDC to establish the work contents of the underground transmission line and GIS substation,

c) Assist EDC to establish the organization and management of these facilities,

d) Assist EDC to establish O&M criteria/manuals, and

f) Give O&M training for these facilities

In addition to the above tasks, the Consultant should adhere to the Guidelines published by JICA in carrying out the Consulting Services.

9.5 JAPANESE TECHNOLOGY TO BE APPLIED

9.5.1 115kV XLPE (Cross-Linked Polyethylene) Cable

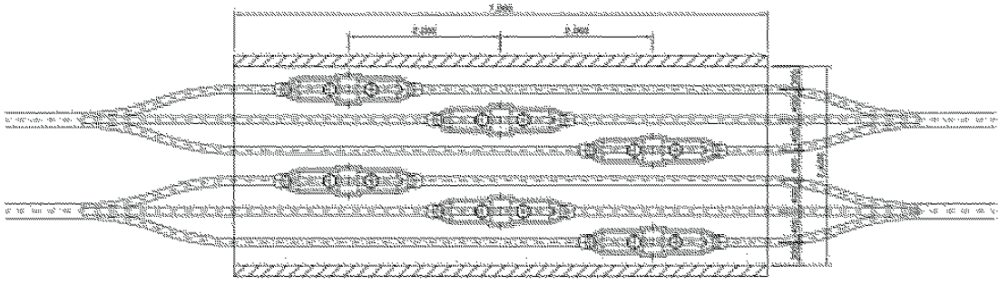
The comparison between both types of cables is shown in Table 9.5-1.

Table 9.5-1 Comparison between Single Cable and Triplex Cable (115kV)

	Single cable	Triplex cable
Transmission system	To achieve the same level of transmission losses of triplex cable, the following techniques shall be applied: *Phase transposition of each cable, *Application of cross bonding system for earthing.	Simple transmission system scheme
Dimension of joint bay	It is necessary to absorb cable expansion behavior by using an off-set system at a joint bay. Due to the above treatment, Dimension of cable joint bay will be increased by about 30% of that of the triplex cable.	To reduce joint bay dimensions due to the self-absorption characteristics of cable expansion.
Unit length	Standard.	Although cable weight will be heavy, it is capable of supplying the same length of single cable.
Cable unit price	Standard.	Same as 3 × Single cables

Source: JICA Study Team

To select the triplex cables, it is capable to make the simple transmission system scheme, shorten the construction time due to the decrease of cable numbers, compact the joint bay dimensions due to the self-absorption characteristics of the cable expansion and expected to reduce the total cable project costs (Refer to Appendix-7).



Source: JICA Study Team

Fig. 9.5-1 Typical Joint Arrangement

In terms of the application of triplex cables, 66kV triplex cables were developed and put into service more than 40 years and 154kV triplex cables were developed and put into service in 2005 in Japan. On the other hand, In Cambodia, 22kV 3 × 240 mm^2 triplex cables with 33kms in total were applied and introduced in Phnom Penh under the Japan Grant Project in 2002.

Based on the above background, it is suitable to apply the triplex cables for this project.

9.5.2 Special Three-Phase Transformer

According to the study in Section 8.3.1, about 230kV/115kV main transformer to the NCC new substation, carrying the three-phase one body tank by Schnabel trailer is a land transport means of normal 230kV normal three-phase transformer has proven difficult. In order to solve this transport problem, special three-phase structure shall be adopted. Special three-phase structure transformer is transported by dividing the tank for each phase, and assembled on-site to be transported at a low bed trailer in general.

Comparison with the normal three-phase type and special three-phase type and ordinary three single-phase is shown in the following. Evaluation in applying to the NCC is shown in parentheses. ○ and none described: application Yes, △: conditional apply Allowed, ×: Not applicable.

Table 9.5-2 Comparison of the Transformer Constitution

	normal three-phase	specific three-phase	three single-phase units
Maximum transport weight	100%	35 ~ 45%	40～50%
Maximum transport volume	100%	16%	16%
Land transportation means	Schnabel trailer (×)	Low-floor trailer (○)	Low-floor trailer (○)
Installation area	100% (○)	125% (○)	170% (×)
Installation work period	100%	120%	170%
Installation work space	100%	100 ~ 120%	160%
Internal open work of site assembly	Not required (○)	Required (△)	Not required (○)
Adopted possibility	×	○	×

Installation area of the transformer to increase slightly compared to the normal three-phase, but can be placed in NCC site sufficiently. On the other hand, since there is a possibility that the reinforcing road and traffic control may be not required by the use of low-floor trailer, the cost benefits of transport is large. On the other hand, Special three-phase is accompanied by internal open to site assembly time, but this is a work of great impact, such as moisture absorption of insulation paper or the like, the quality of the transformer, this is work that requires particular attention to the quality control. Therefore, adopting the special three-phase transformer which is applied site assemble quality control standards, is important. (The decomposition transport transformer can be adopted as well, if site assemble quality control standards are applied.)

Further, since the installation area is increased, three single-phase units cannot be applied to the NCC with limited land area.

CHAPTER 10

PROJECT IMPLEMENTATION AND O/M ORGANIZATION

CHAPTER 10 PROJECT IMPLEMENTATION AND OPERATION AND MAINTENANCE ORGANIZATION

10.1 EDC's Financial Status

Table 10.1-1 shows the balance sheets for 2009 to 2012 from the EDC's annual reports. The table is added with the liquidity ratios and own equity ratios calculated by the study team. The liquidity ratio shows the continuous improvement during the period, and exceeded 150% in 2012. This means that EDC owns current asset enough to cover short-term debts, which is an index of financial healthiness of EDC. Throughout the period, the own equity ratio was kept at around 40%, showing the company's effort to keep the balance between the debt and the equity under expansive conditions.

Table 10.1-1 EDC's Balance Sheet

(Unit: Cambodian Riel 1,000)

	2009	2010	2011	2012
ASSETS	**1,377,817,340**	**1,854,458,690**	**2,265,827,452**	**2,967,276,566**
Non-current assets	791,072,614	1,261,333,433	1,428,131,911	1,847,187,790
Property, plant and equipment	790,960,747	1,066,646,944	1,226,183,735	1,652,736,044
Intangible assets	111,867	401,132	292,514	195,993
Other non-current assets		194,285,357	201,655,662	194,255,753
Current assets	586,744,726	593,125,257	837,695,541	1,120,088,776
Cash and cash equivalents	153,350,951	289,457,512	408,817,458	578,738,523
Trade and other receivables	150,873,266	186,275,785	287,024,944	373,215,974
Inventories	79,074,471	117,391,960	141,853,139	168,134,279
Other receivables	203,446,038			
EQUITY				
Assigned capital	614,393,127	662,390,444	680,173,081	680,185,054
Retained earnings		159,775,668	309,565,644	512,017,298
Accumulated losses	-23,343,787			
LIABILITIES				
Non-current liabilities	391,288,665	528,834,132	677,283,540	1,061,124,393
Borrowings	330,724,570	458,220,206	591,915,355	958,626,156
Customer deposits	59,898,913	68,164,789	78,258,708	89,724,146
Provision for retirement benefit	665,182	864,135	1,356,918	1,961,385
Deferred tax liability-net	-	1,585,002	5,752,559	10,812,706
Current liabilities	395,479,335	503,458,446	598,805,187	713,949,821
Borrowings	94,906,670	200,234,757	169,485,555	145,177,973
Finance Lease Liability	42,701,150	13,651		
Trade and other payables	234,557,571	272,301,325	408,479,660	536,924,009
Income tax	23,313,944	30,908,713	20,839,972	31,847,839
TOTAL EQUITY AND LIABILITIES	**1,377,817,340**	**1,854,458,690**	**2,265,827,452**	**2,967,276,566**
Liquidity Ratio	97%	118%	140%	157%
Own Equity Ratio	43%	44%	44%	40%

Source: EDC Annual Report, modified by Study Team for consistency

Table 10.1-2 is the profit and loss statement for the same period. EDC's revenue has been increasing along with the expanding electricity sales. The profit has been expanding accordingly. After 2009, both the revenue and profit almost doubled. On the side of expenditures, the cost of purchase of power is prominent. The prices of power purchase from surrounding countries can be

a risk factor to EDC's finance. Interview to EDC revealed that there was no particular risk hedge measure taken for currency exchange rate fluctuation, but it set the upper limit on price of power purchases from IPPs (Independent Power Producer(s)). Also, the increase of salaries is significant, which reflects almost 10 % annual increase of man powers in recent years and its management policy "to provide its employee with competitive remuneration and benefits to ensure good living conditions ".

Table 10.1-2 Profit and Loss Statement

(Unit: Cambodian Riel 1,000)

	2009	2010	2011	2012
Revenue				
Electricity sales	1,215,763,623	1,577,667,850	1,808,509,354	2,253,164,604
Connection service fees	10,574,579	12,866,750	15,691,822	17,665,928
Other income	4,989,068	8,498,287	18,025,953	11,649,917
Operating expenses				
Purchased power	-875,453,346	-1,144,613,037	-1,348,820,232	-1,681,832,803
Fuel costs	-61,018,894	-32,782,648	-60,830,107	-69,308,114
Import duty	-10,596,794	-31,262,376	-35,821,899	-40,305,082
Salaries and other benefits	-29,764,019	-47,764,116	-65,436,166	-84,249,349
Other operating expenses	-34,410,007	-44,093,732	-48,368,994	-56,247,420
Depreciation(&Amortization)	-36,663,509	-40,111,790	-49,683,369	-58,872,605
Amortization			-108,618	-96,521
Foreign Exchange Loss net		-7,284,996		
Operating profit	183,420,701	251,120,192	233,157,744	291,568,555
Net finance costs	-19,768,955	-23,385,520	-40,710,828	-33,847,806
Profit before income tax	163,651,746	227,734,672	192,446,916	257,720,749
Income tax expense	-34,315,556	-44,615,217	-42,656,940	-55,269,095
Net profit for the year/total	129,336,190	183,119,455	149,789,976	202,451,654

Source: EDC Annual Report, modified by Study Team for consistency

Finally, the cash flow for the same period is shown in Table 10.1-3. In 2012, Cambodian Riel 140 billion was invested in physical assets, out of net inflow of Cambodian Riel 300 billion. This investment activity still left Cambodian Riel 170 billion in the year. Considering the further increase of electricity demand and resulting sales, EDC will likely be able to continue its investment activity no less than in 2012 for coming years. For 2012, the increase of borrowing was expansive, so was the repayment. However, as pointed out with the Balance Sheet, the equity and debt have been in balance, showing the EDC's effort to keep the financial position to be able to invest, supported by expansive demand for electricity.

Table 10.1-3 EDC's Cash Flow

(Unit: Cambodian Riel 1,000)

	2009	2010	2011	2012
Cash flow from operating activities				
Profit before income tax	130,229,827	227,734,672	192,446,916	257,720,749
Adjustments for:				
Depreciation and amortization		40,111,790	49,791,987	58,969,126
Revenue from transfer of assets from customers			-9,010,141	-
Loss on disposal of property, plant and equipment		2,544,085	598,173	1,596,196
Foreign expense		-12,941,938	-2,065,749	-7,865,808
Interest expense		23,385,520	37,707,767	34,482,370
Addition/reversal of allowance for bad and doubtful debts			-4,292,253	2,756,808
Allowance for retirement benefits		198,953	492,783	604,467
Allowance for inventory obsolescence		1,412,521	3,994,905	510,572
Reversal of Impairment Loss on Trade Receivables		-894,261		
Changes in:				
Trade and other receivables		-22,923,945	-31,620,486	-45,899,808
Inventories		-44,973,693	-67,392,929	-80,909,003
Other non-current assets		-9,904,251	-7,370,305	7,399,909
Trade and other payables		37,743,754	51,011,287	136,209,876
Customer deposits		8,265,876	10,093,919	11,465,438
Net cash generated from operations		249,759,083	224,385,874	377,040,892
Interest paid		-5,421,736	-14,509,745	-42,247,897
Income tax paid	-14,507,858	-35,435,446	-48,558,124	-31,814,007
Interest received	238,251	1,304,092		
Net cash generated from operating activities	115,960,220	210,205,993	161,318,005	302,978,988
Cash flows from Investing activities				
Purchases of property, plant and equipment	-15,435,505	-92,213,377	-68,884,618	-140,145,212
Proceeds from sale of property, plant and equipment	357,908	4,765,678	7,057,087	2,371,434
Decrease in Other Assets		7,480,619		
Purchases of Intangible Assets	-20,950	-357,010		
Net cash used in investing activities	-15,098,547	-80,324,090	-61,827,531	-137,773,778
Cash flow from financing activities				
Proceeds from borrowings	6,872,146	6,235,352	22,909,596	74,269,593
Payments on borrowings	-181,088		-3,040,124	-69,565,711
Government grants			-	11,973
Payments on finance lease		-10,694		
Net cash generated from financing activities	6,929,309	6,224,658	19,869,472	4,715,855
Net increase in cash and cash equivalents	107,552,731	136,106,561	119,359,946	169,921,065
Cash and cash equivalents at beginning of the year	45,798,220	153,350,951	289,457,512	408,817,458
Cash and cash equivalents at end of the year	153,350,951	289,457,512	408,817,458	578,738,523

Source: EDC Annual Report, modified by Study Team for consistency

10.2 EDC's Project Organization and O&M Organization

10.2.1 Current Project Organization and O&M Organization

(1) Head office

At present, EDC and the IPPs generate power, and the EDC transmits and distributes power exclusively to the Phnom Penh metropolitan area. The following is an organizational chart of EDC.

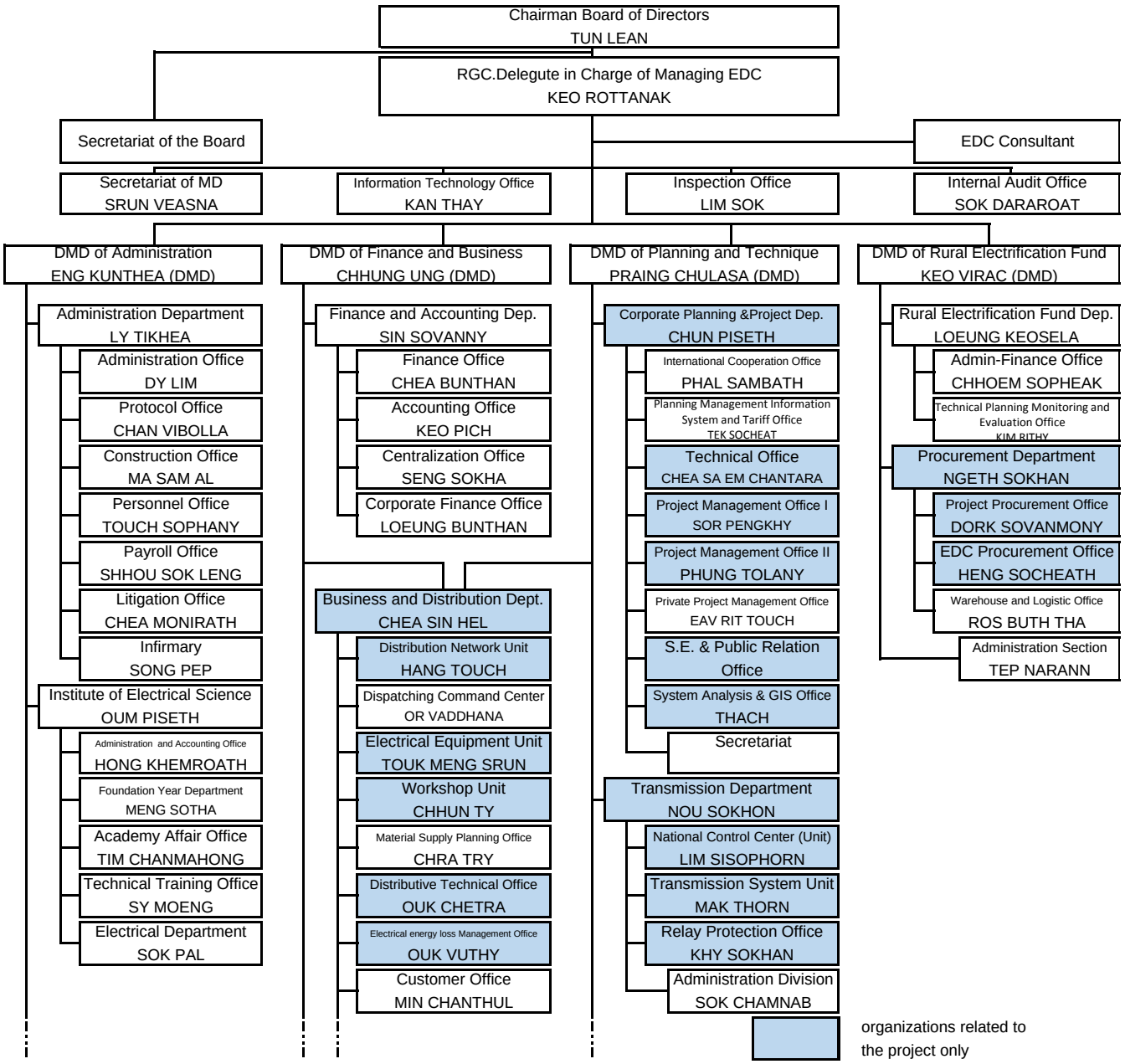


Fig. 10.2-1 Organizational Chart of EDC (organizations related to the project only)

(2) Project Organization

The PMO (Project Management Office)-I or II under the Corporate Planning & Project Department manages the projects funded by international organizations.

(3) O&M Organization

The O&M of the existing substation (GS1, GS2, GS3, GS4) are carried out by the substation head + operator (each 3 operators of 4 groups), and a total of 13 staff (excluding the security guard).

The SCADA (Supervisory Control and Data Acquisition) system has already been introduced into all substations, and NCC (National Control Center) has the equipment that can acquire operational data and information on the substation directly from NCC. However, the signal is not transferred by the difference of the protocol of the SCADA system between NCC and the substations. Because the counter test has not been executed even if the data and information can be taken into the NCC SCADA system, these are inaccurate and untrustworthy. Therefore, the NCC SCADA system does not function.

About this protocol problem, the Chinese consultant employed by EDC conducted the investigation and already prepared the countermeasure.

10.2.2 Proposal for the Project and O&M Organizations

(1) Project implementation

Given that EDC promotes a lot of Projects, EDC will decide which organization executes this Project immediately before this Project starts. However, it is assumed that PMO will be in charge for this Project.

JICA Study Team believes that the PMOs have enough capacity to implement the project with the technical advice of a consultant, since they have been doing the same kind of work. It is necessary to consider that there is no engineer who is well versed in 230kV/115kV underground cable at EDC because this equipment is the first time to set up in Cambodia except Phase 1 project which is under selection of the Consultant. Concretely, EDC establishes a system to acquire a sufficient amount of technical knowhow by participating in the construction of the Project and the engineer who can become the person in charge of O&M of the 230kV/115kV underground cable in the future is arranged in the PMO of this Project.

Moreover, to achieve good technical skills, overseas training in Japan is recommended at the construction stage. In Japan, there is many experience about maintenance of 230kV/115kV underground cable. Therefore if EDC engineers take training by Power Company in Japan, improvement in technical skill is expectable. This training will be conducted by the Consultant at construction stage.

(2) O&M

It is expected that the Transmission Dept. and Business and Distribution Dept. of EDC will be responsible for the O&M of the new facilities after construction is completed. The Transmission Department was separated from the former Transmission and Distribution Department in 2007. They have enough experience in the maintenance of the distribution system, but, limited experience in transmission system maintenance work.

Given that 230kV/115kV underground cable is basically laid underground, daily checks and

patrols are unnecessary, and a special organization for O&M is unnecessary. However, it is important to grasp the buried position and depth accurately from the perspective of checking the relation between the other underground structures and to take proper action in the event of some abnormality. It is necessary to acquire information on the construction dug up near the location laid underground at an early stage so that the underground cable may evade the risk of being affected by other construction work, and to urge the execution of countermeasures for those who execute construction.

Same as the Phase 1, it is advisable that 13 staff should be assigned arranged at the newly established substation for O&M as well as the existing substations. The O&M of substation are planned by the substation head + operator (each 3 operators of 4 groups).

Moreover, Technology Transfer including capacity building at site is recommended at the construction stage. This training will be conducted by the Consultant at construction stage.

CHAPTER 11

EVALUATION OF PROJECT

CHAPTER 11 EVALUATION OF PROJECT

11.1 Quantitative Evaluation

11.1.1 Benefit of Project

The effects to be realized by this Project were already discussed in Chapter 3; to alleviate insufficiency of distribution transformer capacity in the Phnom Penh system, to improve the stability of the whole Phnom Penh power system, and to reduce system losses, etc., among which the alleviation of the insufficiency of distribution transformer capacity has the most notable quantitative effect. This effect was chosen to be the subject of the evaluation of the benefit brought about by the Project.

The electricity demand in the Phnom Penh system has been, and will be increasing at a very high rate. Before the expected completion of this Project in 2020, there will be the increase of the capacity of distribution transformers scheduled to be in place including those of Phase 1 Project. Even after the completion of this Project, the demand will soon exceed the augmented capacity.

Under such a circumstance, the estimation of the effect on the increase of energy sales made possible by this Project required a modeling of the working of transformers in three substations to be constructed by the Project. This model is explained by the illustration shown in Fig. 11.1-1, where MW_0: transformer capacity without the Project, MW_1: transformer capacity with the Project, and abc: daily duration curve.

Transformers installed by the Project will work, just after the completion of the Project, for three hours at around each of two daily demand peaks. The energy distributed through the transformers is shown in the shaded area in the figure. The demand will be increasing: the installed transformers will work for twelve hours sometime later, and will eventually reach full capacity operation. This process is assumed to unfold during the period between 2020 and 2030, and thereafter, transformers are assumed to be working constantly at full capacity.

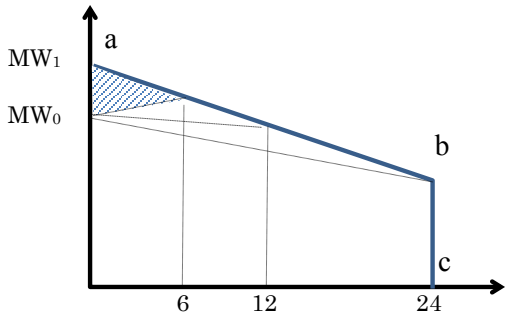


Fig. 11.1-1 Model of Energy Sales Increase

Source: JICA Study Team

On the basis of this assumption, the effect of the Project was calculated for the period between 2020 to 2030, which is shown in the table below, where; a. power demand, b. energy demand, c. additional energy to be distributed through three transformers installed by the Project, and d. additional energy to be delivered to customers (additional energy sold). Between c and d, distribution loss 3% was considered.

Table 11.1-1 Additional Energy Sold by the Project

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
a. Power Demand (MW)	954	1,061	1,169	1,277	1,387	1,496	1,652	1,809	1,967	2,126	2,285
b. Energy Demand (GWh)	5,767	6,414	7,065	7,721	8,381	9,045	9,988	10,936	11,890	12,849	13,813
c. Additional energy distributed through three new transformers (GWh)	222	277	333	388	443	665	887	1,109	1,330	1,552	1,774
d. Additional energy sold (GWh)	215	269	323	376	430	645	860	1,075	1,291	1,506	1,721

Source: JICA Study Team

11.1.2 Financial and Economic Evaluation

(1) Financial Evaluation

In financial evaluation, the benefit is defined by the increase of sales for additional energy delivered to customers by the Project, and the cost consists of expenses incurred for the implementation and operation of the Project, and expenses for the purchase of additional energy with which additional sales will be possible. The financial viability of the Project is evaluated in terms of FIRR (Financial Internal Rate of Return). The conditions of the evaluation are as follows;

Project Period	30 years (consisting of 5-year construction and 25-year operation periods),
Project Cost	total project cost mentioned in Section 9.2 above,
Finance	JICA loan: 100% of JICA-loan eligible portion, US$ 225.3 million, own fund: the remaining portion, US$ 72.7 million,
Loan condition	interest rate 0.01 % p.a., maturity period 30 years (grace period 10 and repayment 20 years),
Income	energy sales, sold for KHR 782 per kWh (obtained by the electricity sales divided by energy sold, figures from EDC Annual Report, energy sold is subject to 3% distribution loss),
Cost	energy purchase cost, for US¢ 10.5 per kWh (energy purchased allows for 7% transmission loss), annual O&M (Operation and Maintenance) cost of equipment installed: 3% of project cost less taxes (subject to inflation) depreciation straight line method, 20 years,
Inflation	4.4% p.a.
tax	corporate income tax 20%.

Where necessary, the exchange rates between currencies as shown in Chapter 9 were applied.

Unit cost of energy purchase, US¢ 10.5 per kWh, was assumed in the following manner;

As of 2014, the prices of energy from IPP (Independent Power Producer)-hydro and IPP-thermal (coal) are US¢ 8.0 and US¢ 11.0 per kWh, respectively. The price of IPP-thermal is likely to rise due to the price hike of imported coal. Annual rise of IPP thermal price was assumed to be 3%,

on the basis of coal price change forecast by IEA[1].

EDC has set the upper limit of IPP thermal energy purchase price at US¢ 13.0 per kWh. If we apply 3% p.a. rise on 2014 IPP-thermal energy price US¢ 11.0, it will exceed US¢ 13.0 in 2020, when the project is expected to start operation. Therefore, IPP-thermal energy purchase price for the project is assumed at US¢ 13.0 per kWh.

According to the Power Development Master Plan that EDC is currently preparing, EDC will be securing energy mostly from IPP-hydro and IPP-thermal in 2020 and onward, and their proportions will be approximately 50:50. The unit cost of energy purchase was thus derived from the average of IPP-hydro price and IPP-thermal price for 2020, US¢ 10.5 per kWh.

To meet the fast growing demand, EDC will have to largely depend on ongoing and under-planning IPP projects for securing energy in coming years. However, in the long run, more risk-prone hydro development may fall behind schedule, which pushes up the proportion of IPP-thermal in the energy procurement. Sensitivity analysis discussed later deals with this risk, assuming that the proportion of IPP-thermal increases from 50 % in 2020 to 80% in 2030 and stays thereafter. The (weighted) average cost of energy purchase would be US¢ 12.0 per kWh in 2030.

Cash flow was calculated for the conditions mentioned above, and FIRR defined by the return on the own fund (Equity IRR) and by the return on the whole investment cost (Project IRR) were obtained.

Equity IRR, which shows the financial return on the own fund spent by the project proponent, was calculated at 25.0 %. According to the interview to EDC, the electric utility is able to secure fund from its main bank at an interest rate of 7% p.a. Taking this as the cost of capital, Equity IRR 25.0% is well above the cost of capital. Therefore, the Project is judged to be financially viable.

Meanwhile, the Project IRR, which is the return on the Project as a whole without identifying financing sources, for the same conditions otherwise, was 12.9%. This means that if the interest rate of the loan secured for part of the initial investment cost of the project was lower than 12.9 %, the return on its own fund (that is Equity IRR) will always be above 12.9 %. This is also a strong indication that the Project will be financially sound.

A series of sensitivity tests was conducted for the cash flow analysis discussed above. The following adverse conditions were considered in the tests,

a) overrun of project cost +10%
b) downward deviation of energy sales -10%
c) price hike of imported energy proportion of IPP-thermal gradually rises from 50% in 2020 to 80% in 2030
d) simultaneous occurrence of the above three conditions

The results are shown in the table below. In either setting, Equity IRR exceeds the deemed cost of capital, 7%, suggesting the financial robustness of the Project. NPV (Net Present Value) of the Project, obtained with an SDR (Social Discount Rate) 12.0%, base year 2014, for each condition is also shown in the table.

[1] World Energy Outlook 2013, International Energy Agency

Table 11.1-2 Sensitivity Test of FIRR

	Equity IRR	Project IRR	NPV (US$ million)
Original conditions	25.0 %	12.9 %	131.3
a) overrun of project cost +10%	23.3 %	11.9 %	119.9
b) downward deviation of expected sales -10%	23.2 %	11.8 %	106.8
c) increase of energy purchase cost (thermal proportion rises to 80%)	22.5 %	10.9 %	89.5
d) simultaneous occurrence of a, b, c	18.8 %	8.8 %	57.4

Source: JICA Study Team

(2) Economic Analysis

In economic analysis, economic viability of a project is evaluated through comparison of economic cost and economic benefit of the project.

To obtain economic cost of the Project, the following adjustments were made to the financial cost used in the financial analysis;

value added tax (VAT)	:	not included in the economic cost as it is a transfer within the Cambodian economy,
foreign currency portion of project cost	:	the estimated cost was deemed to be "border price basis" and used as they were, except that the import tax was deducted,
local currency portion of project cost	:	to be converted to "shadow price basis" by multiplying the Standard Conversion Factor (SCF) 0.9,
land acquisition cost and compensation	:	these costs were deemed to represent the opportunity costs of relevant assets, and used as they were,
O&M cost, management cost of EDC	:	the estimated costs were used as they were.

On the other hand, the economic benefit of the Project was estimated by an alternative method, in the following manner.

This Project will involve transmission lines, substations and distribution lines, and the only plausible alternative to the Project was diesel-powered privately owned generating equipment. The Project is then deemed to realize the benefit by replacing the energy generated with less efficient private diesel units.

The cost of such diesel generation was studied somewhere else: one of such examples of recent years is an ADB's study[2] where the unit cost was estimated at US$0.47/kWh for non-household users. However, this study was for the rural areas of Cambodia, and may possibly lead to too high an estimate. Meanwhile, the final report of the Phase 1 project preceding this Project used US$0.20/kWh in the economic analysis as a cost of the alternative, having made reference to the contract tariff in the PPSEZ (Special Economic Zone in Phnom Penh), US$0.193/kWh. A private electricity service for PPSEZ has a certain size, and probably includes provision of distribution

2 Proposed Loan and Administration of Loan Kingdom of Cambodia: Medium-Voltage Sub-Transmission Expansion Sector Project, Report and Recommendation of the President to the Board of Directors, Project Number: 42361, November 2012, Asian Development Bank

network. These characteristics of PPSEZ are good attributes to be deemed as an alternative to this Project. The latest annual report of EAC[3] shows the licensed tariff of Colben Energy PPSEZ Limited which operates in PPSEZ, to be US$0.2016/kWh for the year 2013. This tariff was used as a cost of alternative energy to the Project, therefore, the unit benefit of the Project, in the economic analysis.

The economic cost and benefit were calculated in the method discussed above, and compared to obtain the EIRR (Economic Internal Rate of Return).

As a result, EIRR was obtained at 17.5 %. The SDR, against which EIRR is compared, should be 12%, considering the present economic development status of Cambodia. The obtained EIRR 17.5% is well above SDR 12%. Therefore, the Project is expected to be economically viable.

The sensitivity test was conducted for the EIRRs. The same adverse conditions as in the financial analysis were considered. The results are shown in the table below. Under either condition, the EIRR was shown to exceed 12%. In summary, the Project is considered to remain economically efficient, and expected to contribute the economy of the country under various unfavorable conditions.

Table 11.1-3 Sensitivity Test of EIRR

	EIRR
Original conditions	17.5 %
a) overrun of project cost +10%	15.6 %
b) downward deviation of expected sales -10%	16.2 %
c) increase of energy purchase cost (thermal proportion rises to 80%)	15.5 %
d) simultaneous occurrence of a, b, c	12.5 %

Source: JICA Study Team

3 The Annual Report on Power Sector of the Kingdom of Cambodia 2014 Edition, Electricity Authority of Cambodia

Table 11.1-4 Cash Flow of the Project (Original Condition)

	unit	-4 2015	-3 2016	-2 2017	-1 2018	0 2019	1 2020	2 2021	3 2022	4 2023	5 2024	6 2025	7 2026	8 2027	9 2028	10 2029	11 2030	12 2031	13 2032	14 2033	15 2034	16 2035	17 2036	18 2037	19 2038	20 2039	21 2040	22 2041	23 2042	24 2043	25 2044
INCOME SCHEDULE																															
Energy Sold	GWh						215.1	268.9	322.6	376.4	430.2	645.3	860.3	1,075.4	1,290.5	1,505.6	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7	1,720.7
Applied Rate	US$/kWh						0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193	0.193
Operating Revenue																															
Revenue from Power Sales	US$million						41.4	51.8	62.2	72.5	82.9	124.3	165.8	207.2	248.7	290.1	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6
Deduct Sales Tax (VAT)	US$million						0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Operating Revenue	US$million						41.4	51.8	62.2	72.5	82.9	124.3	165.8	207.2	248.7	290.1	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6
Operating Expenses																															
Energy Purchased	GWh						239.0	298.7	358.5	418.2	478.0	717.0	955.9	1,194.9	1,433.9	1,672.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9	1,911.9
Energy Price	US$/kWh						0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105	0.105
Energy Purchase cost	US$million						25.1	31.4	37.6	43.9	50.2	75.3	100.4	125.5	150.6	175.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7	200.7
Maitenance cost	US$million						8.9	9.3	9.7	10.2	10.6	11.1	11.6	12.1	12.6	13.2	13.7	14.4	15.0	15.6	16.3	17.0	17.8	18.6	19.4	20.3	21.1	22.1	23.0	24.1	25.1
Depreciation	US$million						13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	0.0	0.0	0.0	0.0	0.0
Total Operating Expenses	US$million						47.0	53.7	60.4	67.1	73.8	99.4	125.0	150.6	176.2	201.8	227.5	228.1	228.7	229.4	230.1	230.8	231.6	232.3	233.2	234.0	221.9	222.8	223.8	224.8	225.9
Earnings before Interest and Tax (EBIT)	US$million						-5.6	-1.9	1.8	5.4	9.1	25.0	40.8	56.7	72.5	88.3	104.1	103.5	102.8	102.2	101.5	100.8	100.0	99.2	98.4	97.6	109.7	108.8	107.8	106.8	105.7
Non-Operating Expenses																															
Interest payment	US$million						0.000	0.000	0.000	0.000	0.000	0.023	0.021	0.020	0.019	0.018	0.017	0.016	0.015	0.014	0.012	0.011	0.010	0.009	0.008	0.007	0.006	0.005	0.003	0.002	0.001
Earnings before Tax	US$million						-5.6	-1.9	1.8	5.4	9.1	24.9	40.8	56.7	72.5	88.3	104.1	103.5	102.8	102.2	101.5	100.8	100.0	99.2	98.4	97.6	109.7	108.8	107.8	106.8	105.7
Sales Additional Tax																															
additional tax (none)																															
Taxable Income	US$million						-5.6	-1.9	1.8	5.4	9.1	24.9	40.8	56.7	72.5	88.3	104.1	103.5	102.8	102.2	101.5	100.8	100.0	99.2	98.4	97.6	109.7	108.8	107.8	106.8	105.7
Income Tax	US$million						0.0	0.0	0.4	1.1	1.8	5.0	8.2	11.3	14.5	17.7	20.8	20.7	20.6	20.4	20.3	20.2	20.0	19.8	19.7	19.5	21.9	21.8	21.6	21.4	21.1
Net INCOME	US$million						-5.6	-1.9	1.4	4.3	7.3	20.0	32.6	45.3	58.0	70.6	83.2	82.8	82.3	81.7	81.2	80.6	80.0	79.4	78.7	78.0	87.8	87.0	86.2	85.4	84.6
CASH FLOW																															
Operating Cash Flow	US$million																														
Operating Income	US$million						41.4	51.8	62.2	72.5	82.9	124.3	165.8	207.2	248.7	290.1	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6	331.6
Operating Expenses	US$million						-47.0	-53.7	-60.4	-67.1	-73.8	-99.4	-125.0	-150.6	-176.2	-201.8	-227.5	-228.1	-228.7	-229.4	-230.1	-230.8	-231.6	-232.3	-233.2	-234.0	-221.9	-222.8	-223.8	-224.8	-225.9
Taxes and duties	US$million						0.0	0.0	-0.4	-1.1	-1.8	-5.0	-8.2	-11.3	-14.5	-17.7	-20.8	-20.7	-20.6	-20.4	-20.3	-20.2	-20.0	-19.8	-19.7	-19.5	-21.9	-21.8	-21.6	-21.4	-21.1
Financing Activities																															
Interest payment	US$million						0.000	0.000	0.000	0.000	0.000	-0.023	-0.021	-0.020	-0.019	-0.018	-0.017	-0.016	-0.015	-0.014	-0.012	-0.011	-0.010	-0.009	-0.008	-0.007	-0.006	-0.005	-0.003	-0.002	-0.001
Principal repayment	US$million						0.0	0.0	0.0	0.0	0.0	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3	-11.3
Investment Activities																															
Own Capital Contribution	US$million	-9.47	-10.49	-9.01	-20.44	-18.55	-3.46	-1.28	0.00																						
Cash flow	FIRR=25.0%	-9.47	-10.49	-9.01	-20.44	-18.55	3.96	9.83	14.44	17.36	20.28	21.70	34.40	47.07	59.73	72.37	85.00	84.51	84.01	83.48	82.93	82.36	81.76	81.13	80.48	79.80	76.48	75.74	74.96	74.15	73.31
Cash Balance		-9.5	-20.0	-29.0	-49.4	-68.0	-64.0	-54.2	-39.7	-22.4	-2.1	19.6	54.0	101.1	160.8	233.2	318.2	402.7	486.7	570.2	653.1	735.5	817.2	898.4	978.8	1,058.6	1,135.1	1,210.9	1,285.8	1,360.0	1,433.3
DSCR	min=2.92											2.922	4.047	5.170	6.292	7.413	8.532	8.490	8.446	8.400	8.352	8.302	8.249	8.194	8.137	8.077	7.784	7.719	7.651	7.579	7.505
	AVG=7.36																														
Project IRR after Tax	FIRR=12.9%	-11.68	-14.94	-44.93	-105.67	-95.83	-10.62	4.29	14.44	17.36	20.28	32.99	45.69	58.36	71.02	83.66	96.28	95.80	95.29	94.76	94.21	93.64	93.04	92.41	91.76	91.07	87.76	87.01	86.23	85.42	84.58
cumulative		-11.68	-26.62	-71.55	-177.22	-273.05	-283.68	-279.38	-264.95	-247.58	-227.31	-194.31	-148.63	-90.27	-19.25	64.41	160.69	256.49	351.78	446.54	540.75	634.39	727.43	819.84	911.59	1,002.66	1,090.42	1,177.43	1,263.67	1,349.09	1,433.66
Discounted Cash Flow and NPV=	131.30	-8.46	-8.36	-6.42	-12.99	-10.53	2.00	4.45	5.83	6.26	6.53	6.24	8.83	10.79	12.22	13.22	13.86	12.31	10.92	9.69	8.60	7.62	6.76	5.99	5.30	4.69	4.02	3.55	3.14	2.77	2.45
at SDR=	12.0%																														

Source: JICA Study Team

Table 11.1-5 Comparison of Economic Cost and Benefit (Original Condition)

	Economic Benefit			Economic Cost					Balance		
year	Energy Provided [GWh]	Alternative Tariff [US$/kWh]	Alternative Energy Cost [US$ mil]	Capital Cost [US$ mil]	Energy Purchased [GWh]	Purchased Energy Price [US$/kWh]	Purchased Energy Cost [US$ mil]	OM Cost [US$ mil]	Benefit	Cost	**Net Benefit**
2015				-10.359						-10.4	-10.36
2016				-13.023						-13.0	-13.02
2017				-36.054						-36.1	-36.05
2018				-84.907						-84.9	-84.91
2019				-77.011						-77.0	-77.01
2020	215.1	0.202	43.4	-14.498	239.0	0.105	-25.1	-9.83	43.4	-49.4	-6.06
2021	268.9	0.202	54.2	-5.487	298.7	0.105	-31.4	-10.26	54.2	-47.1	7.08
2022	322.6	0.202	65.0		358.5	0.105	-37.6	-10.72	65.0	-48.4	16.69
2023	376.4	0.202	75.9		418.2	0.105	-43.9	-11.19	75.9	-55.1	20.78
2024	430.2	0.202	86.7		478.0	0.105	-50.2	-11.68	86.7	-61.9	24.86
2025	645.3	0.202	130.1		717.0	0.105	-75.3	-12.19	130.1	-87.5	42.61
2026	860.3	0.202	173.4		955.9	0.105	-100.4	-12.73	173.4	-113.1	60.34
2027	1,075.4	0.202	216.8		1,194.9	0.105	-125.5	-13.29	216.8	-138.8	78.05
2028	1,290.5	0.202	260.2		1,433.9	0.105	-150.6	-13.87	260.2	-164.4	95.73
2029	1,505.6	0.202	303.5		1,672.9	0.105	-175.7	-14.48	303.5	-190.1	113.39
2030	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-15.12	346.9	-215.9	131.02
2031	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-15.79	346.9	-216.5	130.36
2032	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-16.48	346.9	-217.2	129.66
2033	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-17.21	346.9	-218.0	128.94
2034	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-17.96	346.9	-218.7	128.18
2035	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-18.75	346.9	-219.5	127.39
2036	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-19.58	346.9	-220.3	126.56
2037	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-20.44	346.9	-221.2	125.70
2038	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-21.34	346.9	-222.1	124.80
2039	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-22.28	346.9	-223.0	123.86
2040	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-23.26	346.9	-224.0	122.88
2041	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-24.28	346.9	-225.0	121.86
2042	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-25.35	346.9	-226.1	120.79
2043	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-26.47	346.9	-227.2	119.68
2044	1,720.7	0.202	346.9		1,911.9	0.105	-200.7	-27.63	346.9	-228.4	118.51
										EIRR=	17.5%

Source: JICA Study Team

11.1.3 Estimation of Impact on CO_2 Emission

One of the benefits of the Project is a reduction of system losses. The energy equivalent to the reduction of system losses is the avoided production of energy realized by the Project. Therefore, CO_2 that was to be emitted in relation to the production of the energy is the reduction of CO_2 emission due to the Project.

In order to compare a system loss when the Project is carried out with a system loss when the Project is not carried out, the result shown in Fig. 3.3-11 was first assumed to be a state when the Project is carried out. On the other hand, as the case where the Project is not carried out, it assumed that new distributing substations do not exist, and analysis was carried out where the load of the substations is allocated to existing distributing substations (overload is ignored). When annual energy losses are calculated from the result, they become the following values and the difference is 16,180MWh.

without Project	annual energy loss	= 149,979 MWh
with Project	the same	= 133,799 MWh

There is an example of the study on CO_2 emission factor for EDC's power grid published[4] by a Japanese research institute IGES (Institute for Global Environmental Strategies). However, the study period for Phnom Penh grid was 2007-2009, after which the import of power has grown greatly. Further, the power demand for Phnom Penh grid for 2020 is forecast to be four times as large as in 2009.

The emission factor obtained in the aforementioned study cannot be used as it is. The study's result was modified to be used in the assessment here, as below.

a) The generated energy of power stations connected to Phnom Penh grid in 2008 was largest at 1,227GWh, and the emission factor for the year was 0.6951 t-CO_2/MWh (GES study report),

b) The demanded energy in 2020 was estimated to be 5,767GWh in this report,

c) The difference of energy in a) and b) above is assumed to be filled with imported power from Vietnam, whose CO2 emission is 0.429t-CO2/MWh (IEA report[5]),

d) using the energy in a) and b) above to weight-average the emission factors (0.6951 and 0) to obtain the emission factor for 2020.

CO_2 emission factor for 2020 = $0.6951 \times [1227/5767] + 0.429 \times [(5767-1227)/5767]$
$= 0.4856$ t-CO_2/MWh

Using this factor, the reduction of CO_2 emission by the Project was calculated to be 7,857 t-CO_2 per year, as shown in the table below.

4 Grid Emission Factor of the Phnom Penh Electricity Grid, 2011, Institute for Global Environmental Strategies

5 CO_2 Emissions from Fuel Combustion, International Energy Agency, 2013

Table 11.1-1 Reduction of CO_2 Emission by the Project (as of 2020)

Calculation Result Sheet : New or Existing			
	Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)		
Reduction of GHG emission by the Project (t-CO_2/y)			$ER_y = BE_y - PE_y$ (t-CO_2/y)
1. Baseline Emission $BE_y = BL_y \times EF_{BL,y}$			
BE_y	Baseline Emission : Emission of GHG without improvement of efficiency by the Project	72,830	t-CO_2/y
BL_y	Energy Loss before the Project	149,979	MWh/y
$EF_{BL,y}$	CO2 Emission factor of power grid in question	0.486	t-CO_2/MWh
2.Project Emission $PE_y = PL_y \times EF_{BL,y}$			
PE_y	Project Emission : Emission of GHG with improvement of efficiency by the Project	64,973	t-CO_2/y
PL_y	Energy Loss after the Project	133,799	MWh/y
$EF_{BL,y}$	CO2 Emission factor of power grid in question	0.486	t-CO_2/MWh
3. Reduction of emission due to the Project $ER_y = BE_y - PE_y$ (t-CO_2/y)			
ER_y	Reduction of emission due to the Project	7,857	t-CO_2/y
BE_y	Baseline Emission : Emission of GHG without improvement of efficiency by the Project	72,830	t-CO_2/y
PE_y	Project Emission : Emission of GHG with improvement of efficiency by the Project	64,973	t-CO_2/y

11.2 Proposal of Operation and Effect Indicators

11.2.1 Proposal of Operation and Effect Indicators

As operation and effect indicators for performing an ex-post valuation, three indicators shown in Table 11.2-1 are proposed.

Table 11.2-1 Operation and Effect Indicators to Propose

Indicator	Function	Purpose	
		As Operation Indicator	As Effect Indicator
a) Facility availability factor [%]	Maximum load[MW]/ (Rated capacity of the facility [MVA] * power factor)	To evaluate whether the distributing substation is operated proper	To evaluate whether the facility availability factor has been improved by the proper value after the Project
b) Outage times [times/year]	Annual outage times in the Project area occurred by fault at installed connection transformer and continuation of outage more than one minute	To evaluate whether reliability is kept proper	To evaluate whether reliability has been improved by the proper value after the Project
c) Electricity supply [MWh]	Annual electric energy transmitted from the target transformer	To check that the distributing substation is utilized efficiently.	To evaluate the increased energy

Source: JICA Study Team

Besides, it can be targeted at connection and distribution transformers and transmission lines regarding the facility availability factor and the electricity supply. However, since the power flow of the facility of those other than distributing transformers depends on the operation conditions of the system at the evaluation time greatly. For example, the power flow changes with operation status (opening-and-closing status) of 115kV transmission lines. Therefore, they are unsuitable as indicators and the facility availability factor and the electricity supply of only a distributing transformer are proposed as indicators here.

11.2.2 Targeted Values of Operation and Effect Indicators

The targeted values are set up aiming at the two-year back (2022) of the project completion.

The targeted values of operation and effect indicators are shown in Table 11.2-2. Besides, the facility availability factor was calculated by making the demand estimate value in 2022 of each substation into a maximum load value.

Table 11.2-2 Targeted Values of Operation and Effect Indicators

Indicator	Facility	Standard value	Targeted value	Remarks
a) Facility availability factor [%]	NCC* S/S (115/22kV)	—	98%	- Power factor 95% - The demand forecast value in 2022 of JICA Study Team is used for the maximum load. (69.5 at NCC, 70.3 at Toul Kork and 119.7 at Chroy Changvar) - Assumed that 75MVA transformer at Chroy Changvar S/S will be extended by 2022.
	Toul Kork S/S (115/22kV)	—	99%	
	Chroy Changvar S/S (115/22kV)	—	84%	
b) Outage times [times/year]	GS5 (230/115kV)	—	0	—
	NCC S/S (230/115kV)	—	0	—
c) Electricity supply [MWh]	NCC S/S (115/22kV)	—	89,104	Targeted value is distributed proportionally with the demand forecast value in 2022, after computing 3 substation sum total value by the method described in Section 11.1.
	Toul Kork S/S (115/22kV)	—	90,119	
	Chroy Changvar S/S (115/22kV)	—	153,383	

* NCC : National Control Center

Source: JICA Study Team

APPENDICES

APPENDIX-1

PHOTOGRAPHS OF UNDERGROUND TRANSMISSION LINE

Appendix-1 Photographs of Underground Transmission Line

UG_Route4 (April 24, 2014)

Point 1 (UG_Route4: GS5 >NCC)

Point 2 (UG_Route4: GS5 >NCC)

Point 3 (UG_Route4: GS5 >NCC)
Waterway

Point 4 (UG_Route4: GS5 >NCC)
Railway

Point 5 (UG_Route4: GS5 >NCC)

UG_Route4 (GS5 - NCC)
230kV Cable

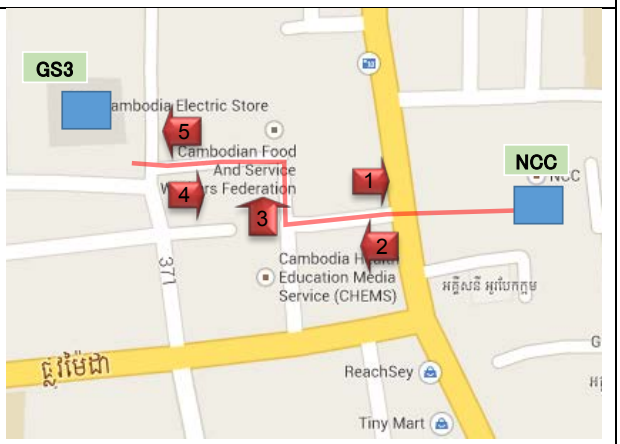
Point 1 (UG_Route5: NCC > GS3)

Point 2 (UG_Route5: NCC > GS3)

Point 3 (UG_Route5: NCC > GS3)

Point 4 (UG_Route5: NCC > GS3)

Point 5 (UG_Route5: NCC > GS3)



UG_Route5 (NCC - GS3)
115kV Cable

APPENDIX-2

GEOLOGICAL INSPECTION

FINAL REPORT FOR DRILLING AND SPT TEST

I. INTRODUCTION

The objective of soil investigation is to obtain soil parameters for foundation design of substation and transmission line infrastructure. Soil investigation works included drilling, SPT test, soil sampling, site testing and laboratory testing. The works are carried out at NCC, Tuol Kork SS, Chroy Changvar SS; GS5 SS and along the transmission line route as shown in table below.

Table 1: Borehole location name

No.	Borehole No.	Site	Coordination	
			Easting	Northing
1	S1	NCC Substation (O Bek Ka Orm)	487759	1277252
2	S2	NCC Substation (O Bek Ka Orm)	487801	1277255
3	S3	Tuol Kork Substation	489221	1281345
4	S4	Tuol Kork Substation	489221	1281305
5	S5	GS5 Substation	482764	1281059
6	S6	GS5 Substation	482780	1281019
7	S7	GS5 Substation	482743	1281016
8	S8	Chroy Changvar Substation	488653	1293456
9	S9	Chroy Changvar Substation	488633	1293386
10	T1	Transmission line 230kV Mid point WPP/NPP to GS5 SS	478878	1278792
11	T2	Transmission line 230kV Mid point WPP/NPP to GS5 SS	474097	1278396
12	T3	Transmission line 115kV GS5 to Chroy Changvar SS	482136	1286158
13	T4	Transmission line 115kV GS5 to Chroy Changvar SS	483190	1292173
14	T5	Transmission line 115kV GS5 to Chroy Changvar SS	485450	1294126

II. METHODOLOGY OF TEST

The Standard Penetration Test (SPT) is a soil boring test; Rotary Auger Method is used to take in all boreholes drilling with SPT split-spoon sampler. The Standard Penetration Test were made borehole at every 1.50 meter intervals till the end of the proposed depth.

II.1. DESCRIPTION OF TEST

This method describes the standard penetration test using the split-spoon sampler to obtain the resistance of soil to penetration (N-value), using a 63.5 kg hammer falling 0.76 m; and to obtain representative samples for identification and laboratory tests.

The method is applicable to all soil types. It is most often used in granular materials but also in other materials when simple in-place bearing strengths are required. It is also used when samples cannot easily be recovered by other means.

II.2. APPARATUS AND MATERIAL

Drilling equipment - any drilling equipment is acceptable that provides a reasonably clean hole, which is at least 5 mm larger than the sampler or sampling rods, and less than 170 mm diameter.

Sampling rods - steel A-rod is used to connect the sampler to the drive weight assembly. A-rod should be used unless otherwise directed.

Split-spoon sampler - consists of 3 main parts; head, split-barrel and shoe, as shown in Figure 3. A core catcher should be installed to prevent loss of sample. Shoes which have been damaged should be replaced or repaired.

Drive-weight assembly - consisting of a 63.5 kg weight (hammer), a driving head (anvil) and a guide permitting free fall of 0.76 m and an over lift capability of at least 100 mm.

Cathead operating at approximately 100 rpm, equipped with suitable rope and overhead sheave for lifting drive-weight.

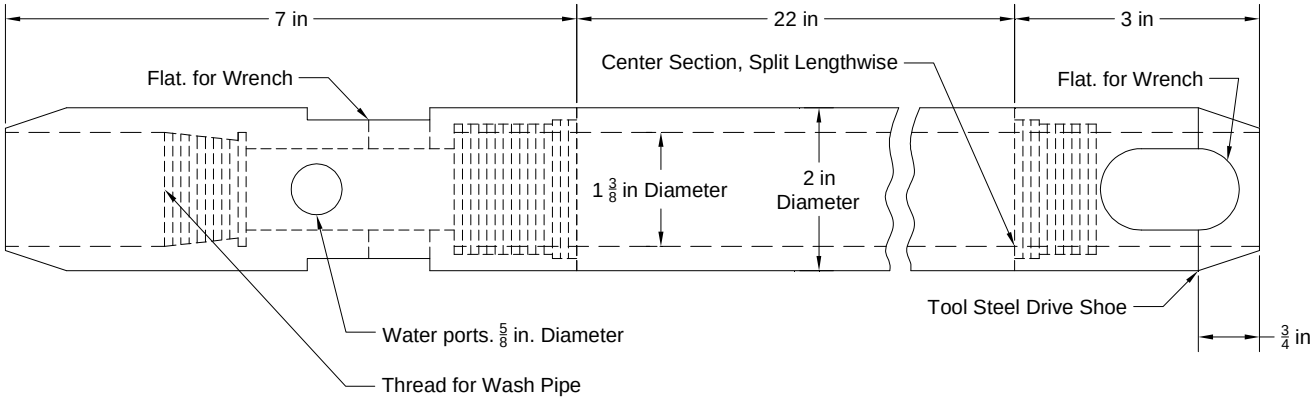


Figure 1 – Split-spoon sampler for the standard penetration test

II.3. PROCEDURE

a. Test Hole

Drill the hole to the desired sampling depth and clean out all disturbed material. If a wet drill is used, flush out all cuttings.

b. Assembling Equipment

Attach the split-spoon sampler to the A-rod and lower into the hole until it is sitting on the undisturbed material. Attach the drive weight assembly. Lift the 63.5 kg hammer approximately 0.76 m and allow it to fall on the anvil delivering one seating blow. Mark the drill rod in 3 successive 0.15 m increments to observe penetration. Mark the drive weight assembly to indicate a 0.76 m hammer lift.

c. Penetration Testing

Raise and drop the hammer 0.76 m successively by means of the rope and cathead, using no more than 2 1/4 wraps around the cathead. The hammer should be operated between 40 and 60 blows per minute and should drop freely. Continue the driving until either 0.45 m has been penetrated or 100 blows has been applied.

Record the number of blows for each .15 m of the penetration. The first 0.15 m increment is the "seating" drive. The sum of the blows for second and third increment of 0.15 m penetration is

termed "penetration resistance or "N-value". If the blow count exceeds 100 in total, terminate the test and record the number of blows for the last 0.30 m of penetration as the N-value. If less than 0.30 m is penetrated in 100 blows, record the depth penetrated and the blow count. If the sampler advances below the bottom of the hole under its own weight, note this condition on the log.

d. Handling Sample

Bring the sampler to the surface and open it. Remove any obvious contamination from the ends or sides and drain excess water. Carefully scrape or slice along one side to expose fresh material and any stratification. Record the length, composition, color, stratification and condition of sample. Remove sample and wrap it or seal in a plastic bag to retain moisture. If the sample can be removed relatively intact, wrap it in several layers of plastic to strengthen it and seal ends with tape. Mark the sample "top" and "bottom" if applicable and label it with an identification number.

e. Mobilization of Drilling Machine

For drilling machine, we use PAT DRILL 201 and YBM-2 (as shown in picture below) which is really light weight machine. YBM-2 was used at some location that is easy to mobilize in. For some others location we used PAT DRILL 201 that is installed on the steel tube scaffolding and operated by modified motor to drill, hang up and drops 63.5Kg of SPT hammer.

Figure 2 – PAT DRILL 201

Figure 3 – YBM-2

This type of machine is easy to mobilize part by part into the difficult condition of site location such as in the rice field which has no access road and on the water that is suitable for bridge construction project. The area damaged of drilling work is about 5m x 5m and it would be tested around 10m far away from the tower location so we can adjust the testing location to where the damage of rice field is much reduced.

In figure below is described about the drop weight arrangement part which can be separated piece by piece and bring to the testing location.

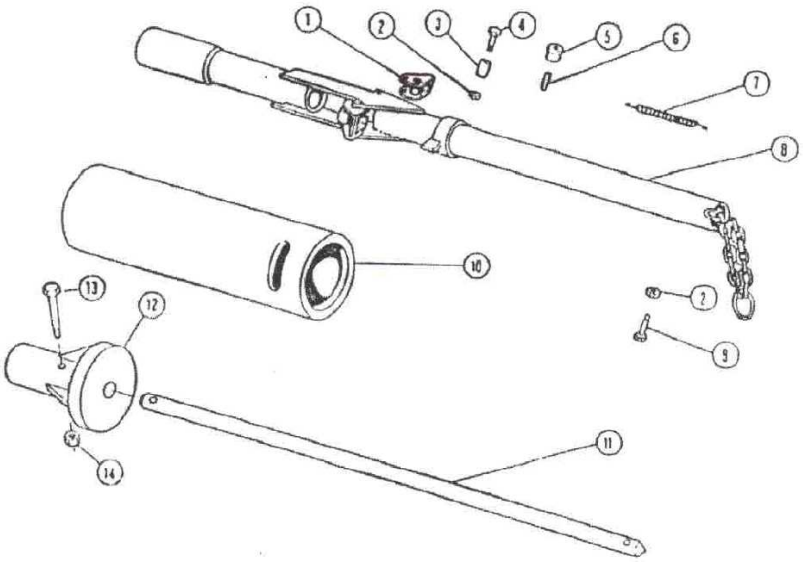


Figure 4 – Drop weight arrangement

1. Latching finger
2. Nut
3. Nylon bush
4. Hex head bolt
5. Roller
6. Pin
7. Spring
8. Lifting tube
9. Hex head bolt
10. Barrel
11. Anvil assembly
12. Gulde
13. Hex head bolt
14. Nyloc nut

II.4. FIELD WORK

a. Boring with Sampling and SPT

Rotary Auger Method carried out with 90mm of normal diameter by drilling machine model PAT Drill 201. Disturbed sample will be taken in all strata and undisturbed sample will be taken in all boreholes drilling with the SPT Split – spoon sampler. The standard penetration test (SPT) will make borehole at every 1m intervals till the end of the proposed depth.

All Sample and Undisturbed Samples have been kept in the PVC pipe and plastic bag to maintain in to be in good condition and were put it in the core box, for analyzing in laboratory.

b. Taking Undisturbed Sample

All sample and undisturbed sample will be kept in PVC pipe and plastic bag to maintain in a good condition and put it in the core box, for analyzing in laboratory.

10 samples will be taken as undisturbed soil sample and 8 by borehole drilling. The diameter of undisturbed sample by 35mm and the depth that has to take from 1.45m to 15.45m depth to compare the natural ground level.

II.5. LABORATORY TESTING PROGRAM AND EQUIPMENT

a. Soil Laboratory Testing Program

The Laboratory Testing program included:

1. Soil Classification
2. Natural water contents determination
3. Density and dry density determination
4. Atterberg limit tests of selected cohesive or sandy soil
5. Sieves distribution test
6. Unconfined compression test

The laboratory testing was supervised By Mr. KETCHANSAVUTH Geology engineer and director of Soil Laboratory, and Operator of testing as follow:

- Mrs. BO CHAN THOL (assistant engineer)
- Mrs. CHOU SAREM (assistant engineer)

The tests were carried out at the soils laboratory facility. The testing procedure used in general accordance with ASTM Standard and AASHTO Standard.

The following were carried out:

1- Soil Classification (AASHTO)
2- Natural Moisture Content (AASHTO T-265)
3- Plastic Limit (AASHTO T-90)
4- Liquid Limit (AASHTO T-89)
5- Grain Size (AASHTO T-1557)
6- Bulk and dry density with moisture content of undisturbed sample (AASHTO T-204-90)
7- Unconfined compression test with moisture content (ASTM D2166-85)

b. Soil Laboratory Equipment

- SIEVE & AGGREGATE SHAKERS EL 80-0350
- CASAGRAMDE devices for liquid limit determination
- PROCTOR and CBR probes EL 24-9160 Series CBR-Test 50
- OVEN EL22-0110
- BALANCES (EL 22-5701 x EL 22-7090)

III. RESULT

III.1. BORING LOG

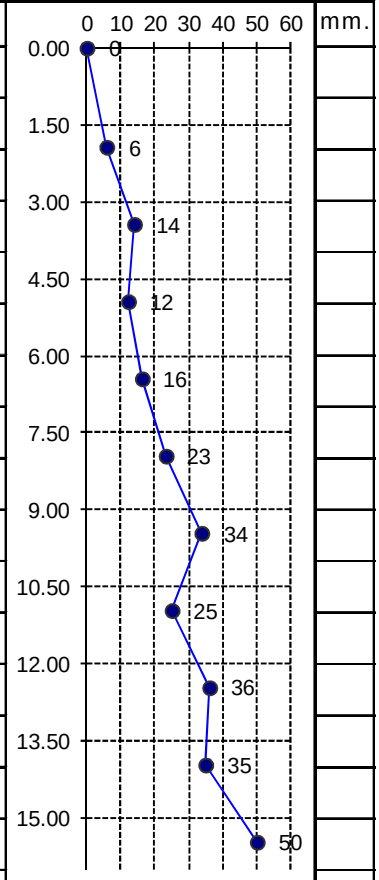
a. NCC Substation

PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **S1**	
SITE: NCC Substation (O Bek Ka Orm)											Date Started: 27/6/2014	
E:487759 , N:1277252 , BH Elevation: 0.00						EQUIPMENT: YBM - 2					Date Finished: 27/6/2014	
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test					Recovery ratio
							N_0	N_1	N_2	N-value (Blows / 300mm)		
m	No			m.		m.	Blow s / 150mm			0 10 20 30 40 50 60		mm.
1			Soil Filling (0.00m - 1.50m)	1.50						0.00 0		
2						1.50-1.95	1	3	3	1.50 6		
3			Firm to Stiff Red CLAY (1.50m - 5.00m)	3.50						3.00		
4						3.00-3.45	3	4	8	12		
5						4.50-4.95	5	9	15	4.50 24		
6			Very Stiff Grey Sandy CLAY (5.00m - 9.50m)	4.30						6.00		
7						6.00-6.45	3	6	10	16		
8						7.50-7.95	4	7	14	7.50 21		
9										9.00		
10			Hard to Very Very Hard Yellow Clayey SAND (9.50m - 15.00m)	6.50		9.00-9.45	5	9	15	24		
11						10.50-10.95	6	11	12	10.50 23		
12										12.00		
13						12.00-12.45	15/15	15/10	50	50		
14						13.50-13.95	35/15	15/5	50/20	13.50 50		
15										15.00		
						15.00-15.45				16.50		
LEGEND:				Water Strike: No						> 50 blows / 30 cm		
UD - Undisturbed Sample				Water Level: No								

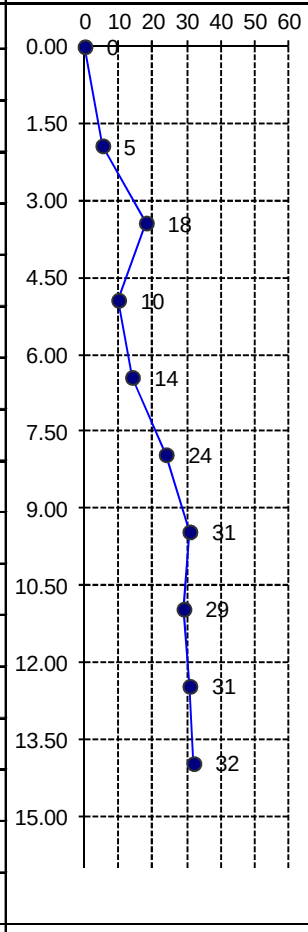
PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **S2**
SITE: NCC Substation (O Bek Ka Orm)											Date Started: 28/6/2014
E:487801 , N:1277255 , BH Elevation: 0.00					EQUIPMENT: YBM - 2						Date Finished: 28/6/2014
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test			N-value (Blows / 300mm)	Recovery ratio
							N_0	N_1	N_2		
m	No			m.		m.	Blow s / 150mm			0 10 20 30 40 50 60	mm.
1			Soil Filling (0.00m - 1.60m)	1.60						0.00 0	
2			Firm to Stiff Red Grey CLAY (1.60m - 5.00m)	3.40		1.50-1.95	1	1	4	1.50 5	
3											
4						3.00-3.45	2	4	7	3.00 11	
5						4.50-4.95	4	6	9	4.50 15	
6			Very Stiff to Hard Grey Sandy CLAY (5.00m - 8.50m)	3.50							
7						6.00-6.45	4	6	10	6.00 16	
8						7.50-7.95	4	10	20	7.50 30	
9											
10			Hard to Very Hard CLAY (8.50m - 15.00m)	7.50		9.00-9.45	6	10	14	9.00 24	
11						10.50-10.95	8	12	19	10.50 30	
12											
13						12.00-12.45	10	15	15	12.00 30	
14						13.50-13.95	25	> 50	> 50	13.50 50	
15											
						15.00-15.45				15.00	
										16.50	
LEGEND:				Water Strike: No						> 50 blows / 30 cm	
UD - Undisturbed Sample				Water Level: No							

b. Tuol Kork Substation

PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **S3**	
SITE: Tuol Kork Substation											Date Started: 31-May-14	
E:489221 , N:1281345 , BH Elevation: 0.00						EQUIPMENT: YBM - 2					Date Finished: 1-Jun-14	
	Samples	Sample Type	DESCRIPTION OF STRATA	Depth & Thick	Legend	Depth testing	SPT Test					Recovery ratio
							N_0	N_1	N_2	N-value (Blows / 300mm)		
m	No			m.		m.	Blows / 150mm					mm.
1			Firm Brown CLAY (0.00m - 3.00m)	3.00								
2						1.50-1.95	2	3	3			
3												
4			Stiff Red Sandy CLAY (3.00m - 4.50m)	1.50		3.00-3.45	3	6	8			
5						4.50-4.95	2	5	7			
6			Red Meduim Dense SAND (4.50m - 14.50m)	10.00								
7						6.00-6.45	5	6	10			
8						7.50-7.95	6	11	12			
9												
10						9.00-9.45	6	12	21			
11						10.50-10.95	6	9	16			
12												
13						12.00-12.45	10	16	20			
14						13.50-13.95	10	16	15			
15			Hard Grey Clayey SAND (14.50m - 16.00m)	1.50								
16						15.00-15.45	15	21	29			
17						16.50-16.95						
LEGEND:				Water Strike: No						> 50 blows / 30 cm		
UD - Undisturbed Sample				Water Level: No								



PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **S4**
SITE: Tuol Kork Substation											Date Started: 30/5/2014
E:489221 , N:1281305 , BH Elevation: 0.00					EQUIPMENT: YBM - 2						Date Finished: 31/5/2014
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test			N-value (Blows / 300mm)	Recovery ratio
							N_0	N_1	N_2		
m	No			m.		m.	Blow s / 150mm				mm.
1			Firm Sandy CLAY (0.00m - 1.50m)	1.50							
2						1.50-1.95	1	2	3		
3			Firm to Stiff Grey Organic CLAY	1.00							
4			(1.50m - 2.50m)			3.00-3.45	4	8	10		
5			Stiff Red Grey Sandy CLAY	2.00		4.50-4.95	2	4	6		
6											
7			(2.50m - 4.50m)			6.00-6.45	3	6	8		
8						7.50-7.95	6	11	18		
9											
10			Meduim Dense Grey SAND	9.50		9.00-9.45	7	12	19		
11			(4.50m - 14.00m)			10.50-10.95	6	13	16		
12											
13						12.00-12.45	11	14	17		
14						13.50-13.95	7	14	18		
15											
16						15.00-15.45					
17						16.50-16.95					
LEGEND:				Water Strike: No						32 blows / 30 cm	
UD - Undisturbed Sample				Water Level: No							



c. GS5 Substation

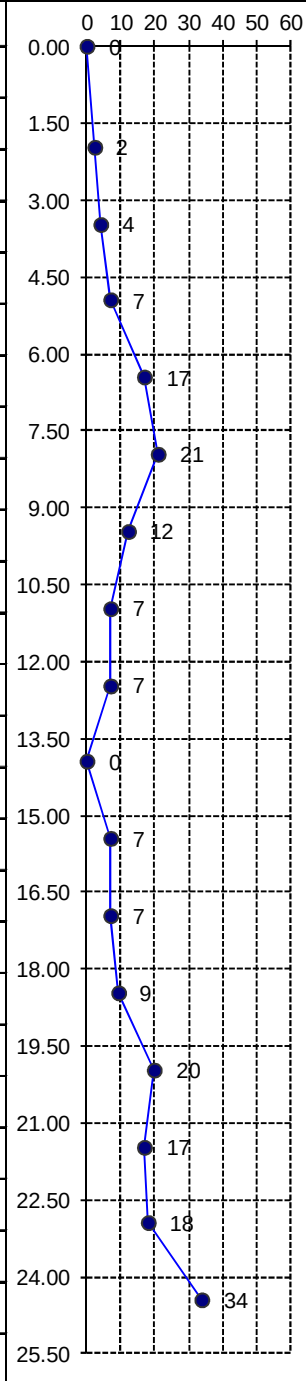
PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **S5**	
SITE: GS5 Substation											Date Started: 19/6/2014	
E:482764 , N:1281059 , BH Elevation: 0.00					EQUIPMENT: YBM - 2						Date Finished: 19/6/2014	
	Samples	Sample Type	DESCRIPTION OF STRATA	Depth & Thick	Legend	Depth testing	SPT Test					Recovery ratio
							N_0	N_1	N_2	N-value (Blows / 300mm)		
m	No			m.		m.	Blows / 150mm			0 10 20 30 40 50 60		mm.
1			Soft Red CLAY	2.30						0.00		
2			(0.00m - 2.30m)			1.50-1.95	0	1	1	1.50		
3												
4			Very Hard Grey Sandy CLAY	7.80		3.00-3.45	6	11	14	3.00		
5						4.50-4.95	5	13	21	4.50		
6			(2.30m - 9.50m)							6.00		
7						6.00-6.45	10	18	22			
8						7.50-7.95	13	23	27	7.50		
9										9.00		
10						9.00-9.45	18	23	21			
11			Dense Grey SAND	3.00		10.50-10.95	31/15	19/8	50/23	10.50		
12			(9.50m - 12.50m)									
13						12.00-12.45	7	15	24	12.00		
14						13.50-13.95				13.50		
15												
16						15.00-15.45				15.00		
17						16.50-16.95						
LEGEND:				Water Strike: No						39 blows / 30 cm		
UD - Undisturbed Sample				Water Level: No								

PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **S6**
SITE: GS5 Substation											Date Started: 17/6/2014
E:482780 , N:1281019 , BH Elevation: 0.00					EQUIPMENT: YBM - 2						Date Finished: 17/6/2014
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test			N-value (Blows / 300mm)	Recovery ratio
							N_0	N_1	N_2		
m	No			m.		m.	Blow s / 150mm			0 10 20 30 40 50 60	mm.
1			Firm to Stiff Yellow CLAY with Gravel (0.00m - 4.50m)	4.50						0.00 0	
2						1.50-1.95	4	2	2	1.50 4	
3											
4						3.00-3.45	3	4	6	3.00 10	
5						4.50-4.95	2	4	7	4.50 11	
6			Medium Dense Grey SAND with Gravel (4.50m - 12.30m)	7.80							
7						6.00-6.45	5	11	12	6.00 23	
8						7.50-7.95	11	15	2	7.50 38	
9											
10						9.00-9.45	10	20	22	9.00 41	
11						10.50-10.95	10	12	18	10.50 30	
12											
13			Hard Grey Sandy CLAY (12.30m - 14.00m)	1.70		12.00-12.45	12	11	35	12.00 46	
14						13.50-13.95	10	15	18	13.50 33	
15											
16						15.00-15.45				15.00	
17						16.50-16.95					
LEGEND:				Water Strike: No						33 blows / 30 cm	
UD - Undisturbed Sample				Water Level: No							

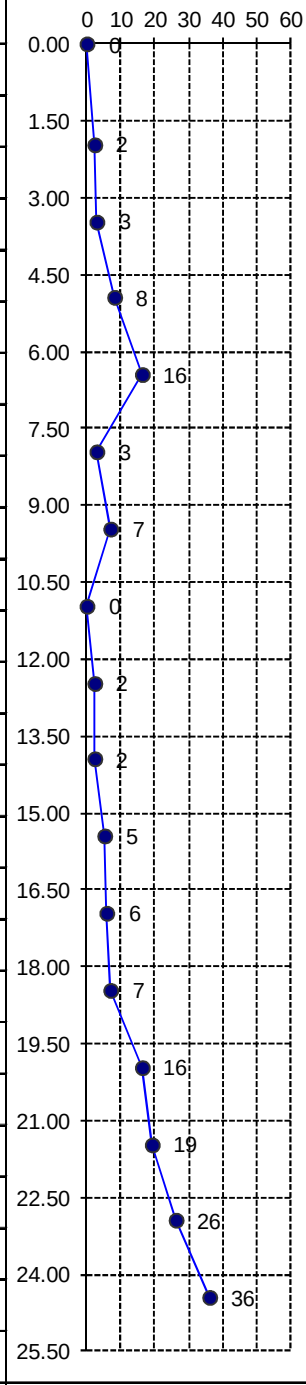
PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **S7**
SITE: GS5 Substation											Date Started: 18/6/2014
E:482743 , N:1281016 , BH Elevation: 0.00					EQUIPMENT: YBM - 2						Date Finished: 18/6/2014
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test				Recovery ratio
							N_0	N_1	N_2	N-value (Blows / 300mm)	
m	No			m.		m.	Blow s / 150mm			0 10 20 30 40 50 60	mm.
1			Soil Filling (0.00m - 1.50m)	1.50						0.00 0	
2						1.50-1.95	5	5	1	1.50 6	
3			Firm to Stiff Grey SAND (1.50m - 3.00m)	1.50							
4			Firm Red Grey Sandy CLAY	2.60		3.00-3.45	2	5	9	3.00 14	
5			(3.00m - 5.60m)			4.50-4.95	3	5	4	4.50 9	
6											
7						6.00-6.45	10	14	19	6.00 33	
8						7.50-7.95	17	26	24/5	7.50 50	
9			Dense Red Grey Sand	6.70							
10			(5.60m - 12.30m)			9.00-9.45	16	15	16	9.00 31	
11						10.50-10.95	15	24	26/2	10.50 50	
12											
13			Dense Grey SAND with Gravel	0.20		12.00-12.45	6	13	25	12.00 38	
14			(12.30m - 12.50m)			13.50-13.95				13.50	
15											
16						15.00-15.45				15.00	
17						16.50-16.95					
LEGEND:				Water Strike: No						38 blows / 30 cm	
UD - Undisturbed Sample				Water Level: No							

d. Chroy Changvar Substation

PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **S8**	
SITE: Chroy Changvar Substation											Date Started: 1/7/2014	
E:488653 , N:1293456 , BH Elevation: 0.00						EQUIPMENT: PAT Drill 201					Date Finished: 2/7/2015	
	Samples	Sample Type	DESCRIPTION OF STRATA	Depth & Thick	Legend	Depth testing	SPT Test					Recovery ratio
							N_0	N_1	N_2	N-value (Blows / 300mm)		
m	No			m.		m.	Blows / 150mm					mm.
1												
2						1.50-1.95	1	1	1			
3			Soft to Very Stiff Yellow CLAY									
4						3.00-3.45	0	2	2			
5			(0.00m - 9.00m)	9.00		4.50-4.95	2	3	4			
6												
7						6.00-6.45	4	8	9			
8						7.50-7.95	6	9	12			
9												
10						9.00-9.45	4	5	7			
11						10.50-10.95	2	2	5			
12												
13						12.00-12.45	1	2	5			
14			Very Soft to Firm Grey CLAY			13.50-13.95	0	0	0			
15												
16			(9.00m - 19.50m)	10.50		15.00-15.45	0	3	4			
17						16.50-16.95	3	4	3			
18												
19						18.00-18.45	3	4	5			
20						19.50-19.95	5	9	11			
21			Very Stiff Brown CLAY									
22			(19.50m - 22.00m)	2.50		21.00-21.45	7	8	10			
23			Medium Dense Grey SAND			22.50-22.95	5	9	9			
24												
25			(22.00m - 24.45m)	2.45		24.00-24.45	7	14	20			
26												
LEGEND:				Water Strike: No						34 blows / 30 cm		
UD - Undisturbed Sample				Water Level: No								



PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **S9**
SITE: Chroy Changvar Substation											Date Started: 02/07/2014
E:488633 , N:1293386 , BH Elevation: 0.00					EQUIPMENT: PAT Drill 201						Date Finished: 02/07/2015
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test			N-value (Blows / 300mm)	Recovery ratio
							N_0	N_1	N_2		
m	No			m.		m.	Blow s / 150mm				mm.
1			Very Soft Red CLAY								
2			(0.00m - 3.00m)			1.50-1.95	1	1	1		
3											
4				7.50		3.00-3.45	1	1	2		
5						4.50-4.95	1	4	4		
6			Soft to Firm Grey CLAY								
7			(3.00m - 7.50m)			6.00-6.45	3	6	10		
8						7.50-7.95	0	0	3		
9											
10						9.00-9.45	1	3	4		
11						10.50-10.95	0	0	0		
12											
13			Very Soft to Hard Sandy CLAY			12.00-12.45	0	1	1		
14			(7.50m - 22.00m)	10.50		13.50-13.95	0	1	1		
15											
16						15.00-15.45	1	2	3		
17						16.50-16.95	1	2	4		
18											
19						18.00-18.45	2	3	4		
20						19.50-19.95	4	7	9		
21											
22						21.00-21.45	3	12	17		
23			Medium Dense Grey SAND			22.50-22.95	4	10	16		
24				2.50							
25			(22.00m - 24.45m)			24.00-24.45	7	15	21		
26											

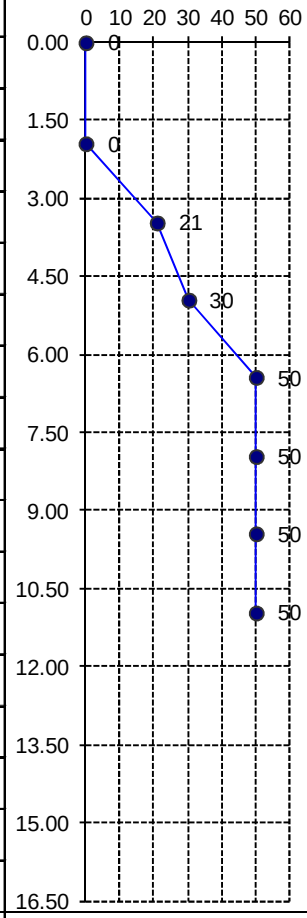


LEGEND:	Water Strike: No	36 blows / 30 cm
UD - Undisturbed Sample	Water Level: No	

e. Transmission line 230kV Mid point WPP/NPP to GS5 Substation

PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **T1**	
SITE: Transmission Line 230Kv Mid Point WPP/NPP to GS5 SS											Date Started: 26/6/2014	
E:478878 , N:1278792 , BH Elevation: 0.00						EQUIPMENT: PAT Drill 201					Date Finished: 26/6/2014	
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test			N-value (Blows / 300mm)		Recovery ratio
							N_0	N_1	N_2			
m	No			m.		m.	Blow s / 150mm			0 10 20 30 40 50 60		mm.
1			Fine SAND (0.00m - 1.50m)	1.50						0.00		
2						1.50-1.95	30		> 50	1.50	50	
3			Very Dense Clayey SAND	4.50								
4						3.00-3.45	25/6		> 50	3.00	50	
5			(1.50m - 6.00m)			4.50-4.95	25/5		> 50	4.50	50	
6										6.00	32	
7			Hard Yellow CLAY (6.00m - 7.60m)	1.60		6.00-6.45	10	15	17			
8						7.50-7.95	15/15	35/5	> 50	7.50	50	
9			Very Hard Sandy CLAY	3.40								
10			(7.60m - 11.00m)			9.00-9.45	20/5		> 50	9.00	50	
11						10.50-10.95	15/7		> 50	10.50	50	
12												
13						12.00-12.45				12.00		
LEGEND:				Water Strike: No						> 50 blows / 30 cm		
UD - Undisturbed Sample				Water Level: No								

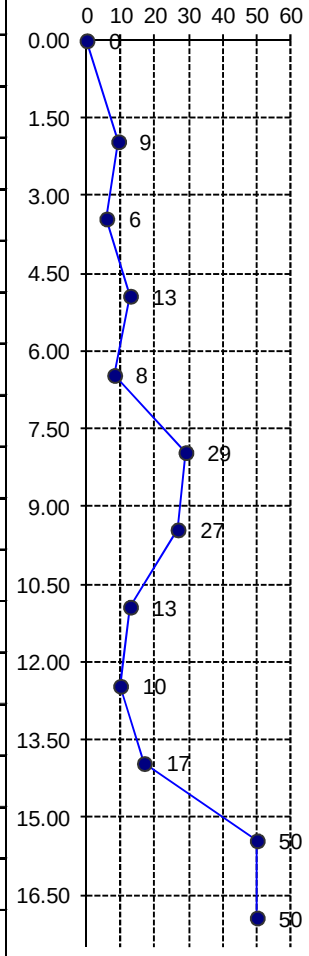
PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **T2**	
SITE: Transmission Line 230Kv Mid Point WPP/NPP to GS5 SS											Date Started: 24/6/2014	
E:474097 , N:1278396, BH Elevation: 0.00						EQUIPMENT: PAT Drill 201					Date Finished: 24/6/2014	
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test			N-value (Blows / 300mm)		Recovery ratio
							N_0	N_1	N_2			
m	No			m.		m.	Blow s / 150mm					mm.
1			Soft Grey Sandy CLAY (0.00m - 3.00m)	3.00								
2						1.50-1.95						
3												
4			Very Soft to Very Hard Yellow Sandy CLAY with Gravel (3.00m - 11.00m)	8.00		3.00-3.45	5	9	14			
5						4.50-4.95	5	12	19			
6												
7						6.00-6.45	9	19/15	31/10			
8						7.50-7.95	11	30/15	20/10			
9												
10						9.00-9.45	15	30/15	20/9			
11						10.50-10.95	25/15	25/11	> 50			
12												
13						12.00-12.45						
14						13.50-13.95						
15												
16						15.00-15.45						
LEGEND:				Water Strike: No						> 50 blows / 30 cm		
UD - Undisturbed Sample				Water Level: No								



f. Transmission line 115kV GS5 to Chroy Changvar Substation

PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **T3**	
SITE: Transmission Line 115 Kv GS5 to Chroy Chongvar SS											Date Started: 21/6/2014	
E:482136 , N:1286158 , BH Elevation: 0.00						EQUIPMENT: PAT Drill 201					Date Finished: 21/6/2014	
	Samples	Sample Type	DESCRIPTION OF STRATA	Depth & Thick	Legend	Depth testing	SPT Test			N-value (Blows / 300mm)		Recovery ratio
							N_0	N_1	N_2			
m	No			m.		m.	Blows / 150mm			0 10 20 30 40 50 60		mm.
1			Very Stiff to Hard Brown CLAY (0.00m - 9.00m)	9.00						0.00 6		
2						1.50-1.95	5	6	6	1.50 12		
3												
4						3.00-3.45	5	7	9	3.00 16		
5						4.50-4.95	8	14	20	4.50 34		
6												
7						6.00-6.45	7	16	20	6.00 36		
8						7.50-7.95	4	5	7	7.50 12		
9												
10			Meduim Dense to Very Dense SAND (9.00m - 16.00m)	7.00		9.00-9.45	4	7	6	9.00 13		
11						10.50-10.95	6	6	7	10.50 13		
12												
13						12.00-12.45	15	19	25	12.00 44		
14						13.50-13.95	7	15	27	13.50 42		
15												
16						15.00-15.45	11	23	27	15.00 50		
17						16.50-16.95						
LEGEND:				Water Strike: No						> 50 blows / 30 cm		
UD - Undisturbed Sample				Water Level: No								

PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **T4**
SITE: Transmission Line 115 Kv GS5 to Chroy Chongvar SS											Date Started: 29/6/2014
E:483190 , N:1292173 , BH Elevation: 0.00					EQUIPMENT: PAT Drill 201						Date Finished: 29/6/2014
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test			N-value (Blows / 300mm)	Recovery ratio
							N_0	N_1	N_2		
m	No			m.		m.	Blow s / 150mm				mm.
1			Firm to Very Stiff Grey CLAY (0.00m - 13.70m)	13.70							
2						1.50-1.95	3	4	5		
3											
4						3.00-3.45	3	2	4		
5						4.50-4.95	3	5	9		
6											
7						6.00-6.45	1	3	5		
8						7.50-7.95	5	12	17		
9											
10						9.00-9.45	5	12	15		
11						10.50-10.95	4	6	7		
12											
13						12.00-12.45	1	6	4		
14			Very Dense Grey SAND with Gravel (13.70m - 17.00m)	3.30		13.50-13.95	1	7	10		
15											
16						15.00-15.45	15	22	28		
						16.50-16.95	22/15	28/5			



LEGEND:	Water Strike: No	> 50 blows / 30 cm
UD - Undisturbed Sample	Water Level: No	

PROJECT NAME: Preparatory Suvey for PP Transmission and Distribution System Expansion Project in Cambodia Phapse 2											Borehole No. **T5**
SITE: Transmission Line 115 Kv GS5 to Chroy Chongvar SS											Date Started: 05/07/2014
E:485450 , N:1294126 , BH Elevation: 0.00					EQUIPMENT: PAT Drill 201						Date Finished: 06/07/2015
	Samples	Sample Type	DESCRIPTION OF STRATA	Dept h & Thick	Legend	Depth testing	SPT Test			N-value (Blows / 300mm)	Recovery ratio
							N_0	N_1	N_2		
m	No			m.		m.	Blow s / 150mm			0 10 20 30 40 50 60	mm.
1										0.00 0	
2			Stiff Brown CLAY	3.50		1.50-1.95	4	6	8	1.50 14	
3			(0.00m - 3.50m)								
4						3.00-3.45	1	3	4	3.00 7	
5						4.50-4.95	1	3	4	4.50 7	
6			Very Soft Dark Grey Silty CLAY								
7			(3.50m - 10.80m)	7.30		6.00-6.45	1	1	3	6.00 4	
8						7.50-7.95	0	0	1	7.50 1	
9											
10						9.00-9.45	0	0	1	9.00 1	
11			Loose Dark Grey Clayey SAND			10.50-10.95	0	0	6	10.50 6	
12			(10.80m - 12.00m)	1.20							
13						12.00-12.45	6	15/11	10/30	12.00 45	
14			Medium Dense to Dense Grey SAND			13.50-13.95	4	10	15	13.50 25	
15			(12.00m - 17.00m)	5.00							
16						15.00-15.45	5	11	15	15.00 26	
17						16.50-16.95	15	18	22	16.50 40	
18										18.00	
LEGEND:				Water Strike: No						40 blows / 30 cm	
UD - Undisturbed Sample				Water Level: No							

III.2. LABORATORY TEST

a. Sieving analysis

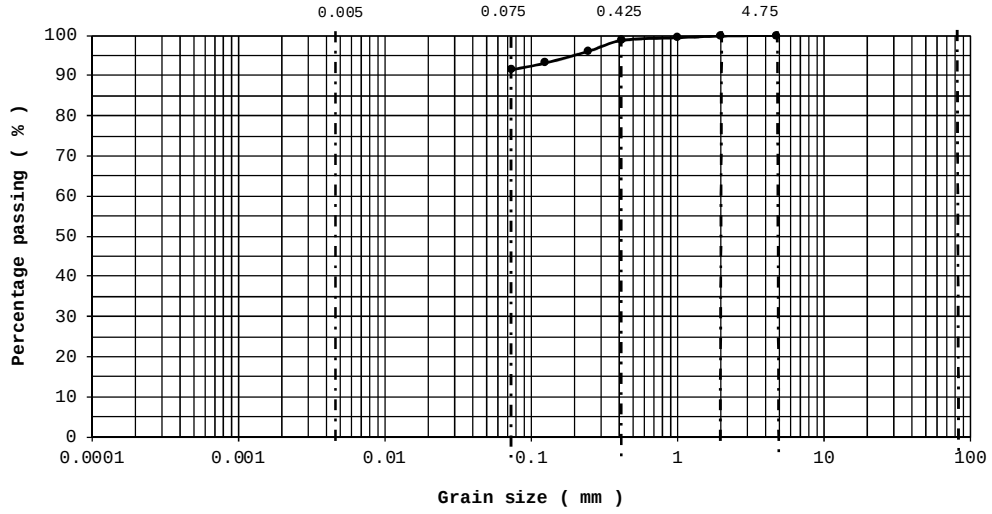
- **NCC Substation**

SIEVING ANALYSIS

Borehole: S-1 Testing Date : 20-Jul-14
Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	19.83 %
Grain size(mm)	% passing
0.075	91.44
0.125	93.08
0.250	96.08
0.425	98.78
1	99.41
2	99.82
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	91 %
Sand :	9 %
Gravel :	0 %

Sample Description :

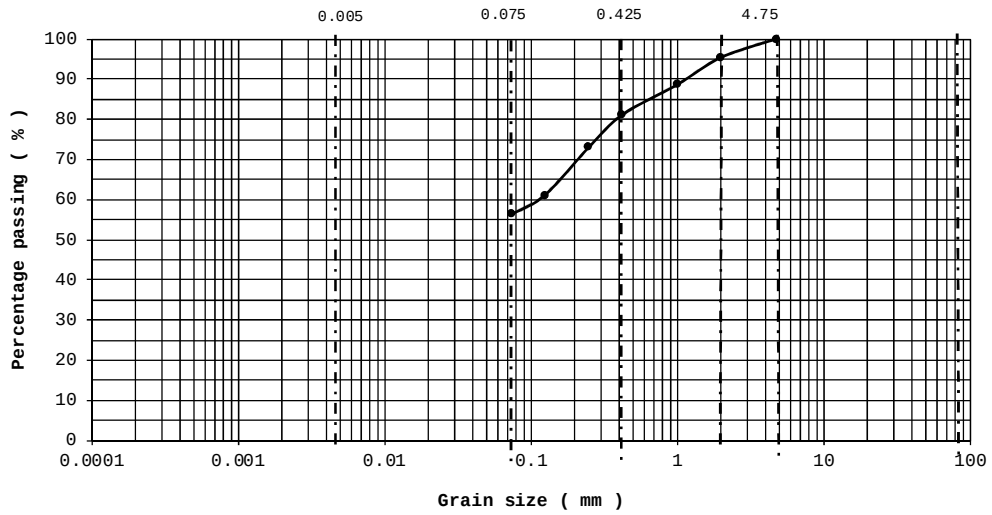
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: S-1 Testing Date : 20-Jul-14
Depth : 7.50- 7.95m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	13.05 %
Grain size(mm)	% passing
0.075	56.38
0.125	61.08
0.250	73.04
0.425	81.18
1	88.59
2	95.40
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	56 %
Sand :	44 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

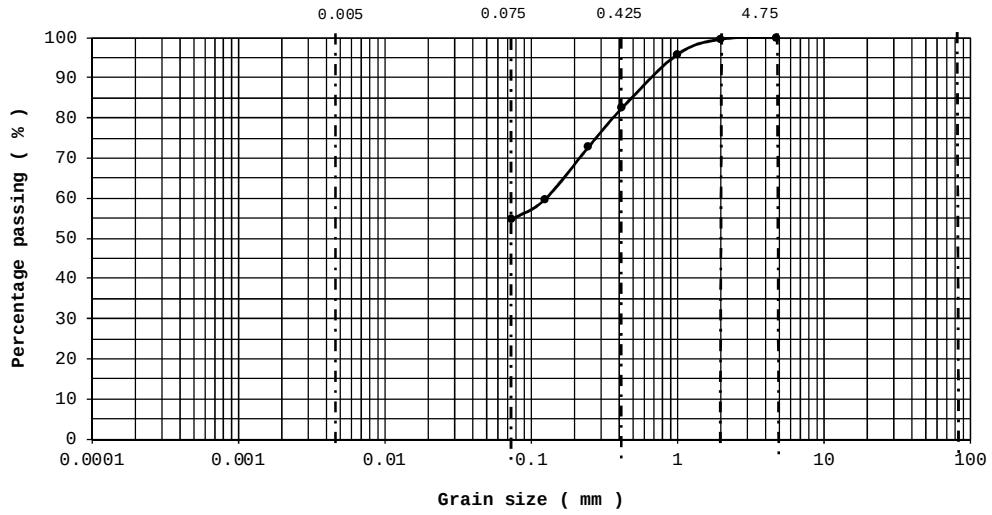
Borehole: S-1 Testing Date : 20-Jul-14

Depth : 12.00- 12.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	21.88 %
Grain size(mm)	% passing
0.075	54.73
0.125	59.63
0.250	72.83
0.425	82.59
1	95.71
2	99.60
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	55 %
Sand :	45 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

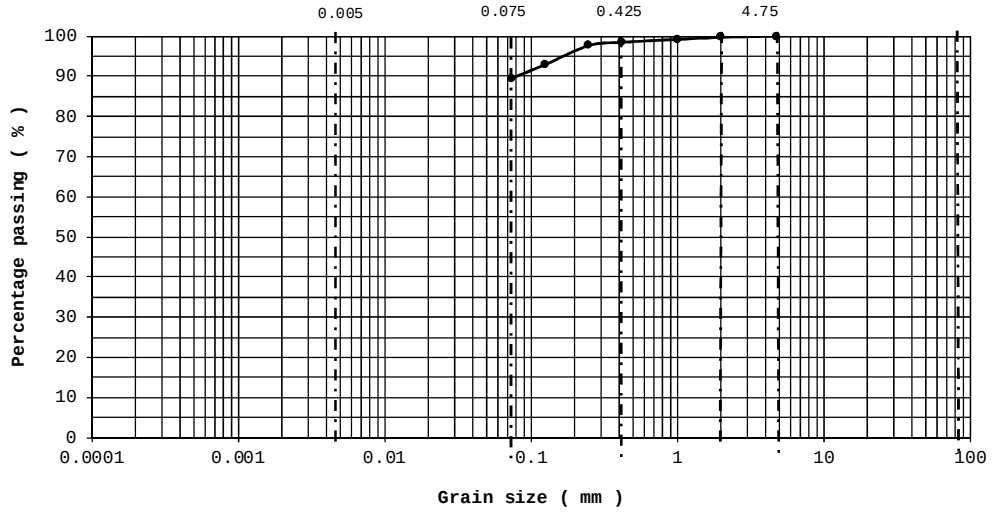
Borehole: S-2 Testing Date : 20-Jul-14

Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	19.58 %
Grain size(mm)	% passing
0.075	89.56
0.125	92.86
0.250	97.63
0.425	98.46
1	99.16
2	99.70
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	90 %
Sand :	10 %
Gravel :	0 %

Sample Description :

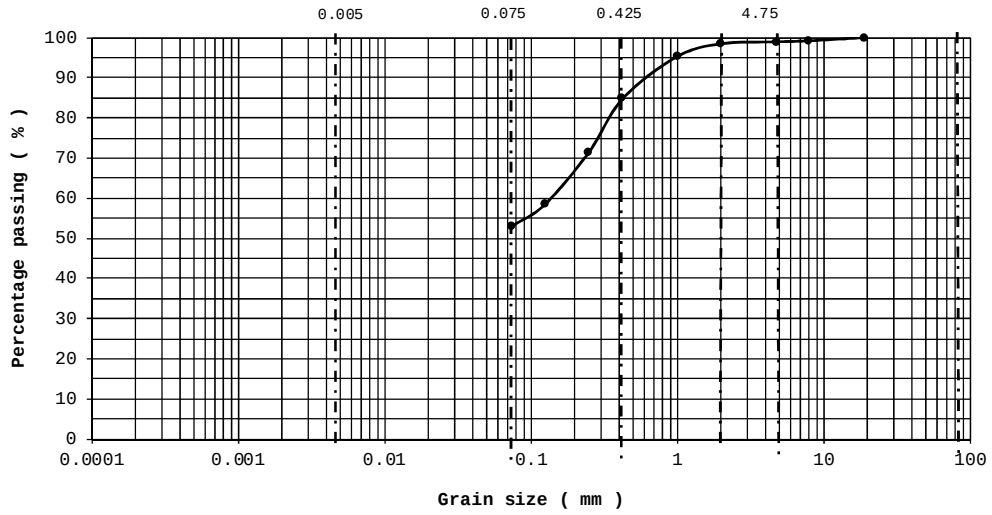
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: S-2 Testing Date : 20-Jul-14
Depth : 7.50- 7.95m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	13.49 %
Grain size(mm)	% passing
0.075	53.05
0.125	58.38
0.250	71.41
0.425	84.77
1	95.23
2	98.45
4.75	98.93
8	99.19
19	100.00
31.5	
63	

Silt+Clay :	53 %
Sand :	46 %
Gravel :	1 %

Sample Description :

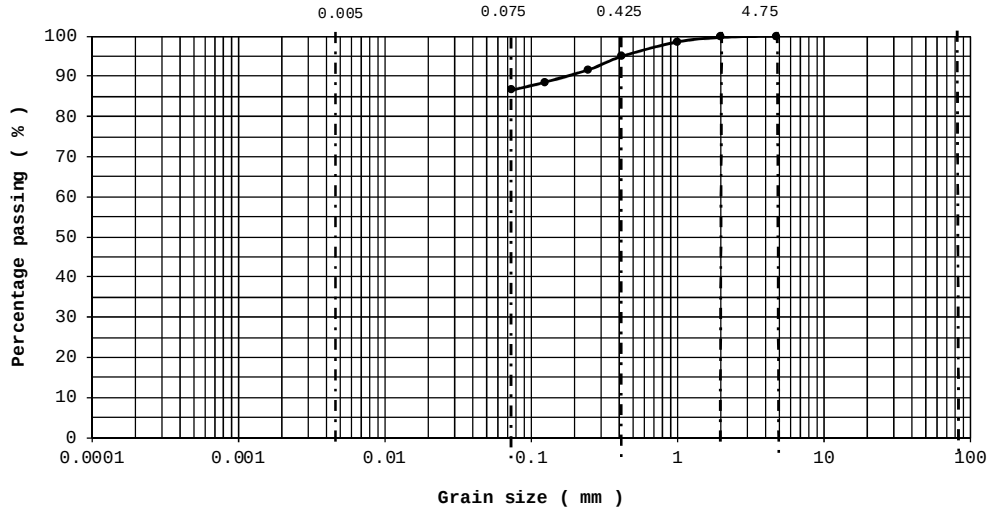
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: S-2 Testing Date : 20-Jul-14
Depth : 10.50- 10.95m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	23.45 %
Grain size(mm)	% passing
0.075	86.54
0.125	88.51
0.250	91.66
0.425	95.01
1	98.54
2	99.66
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	87 %
Sand :	13 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

- **Tuol Kork Substation**

SIEVING ANALYSIS

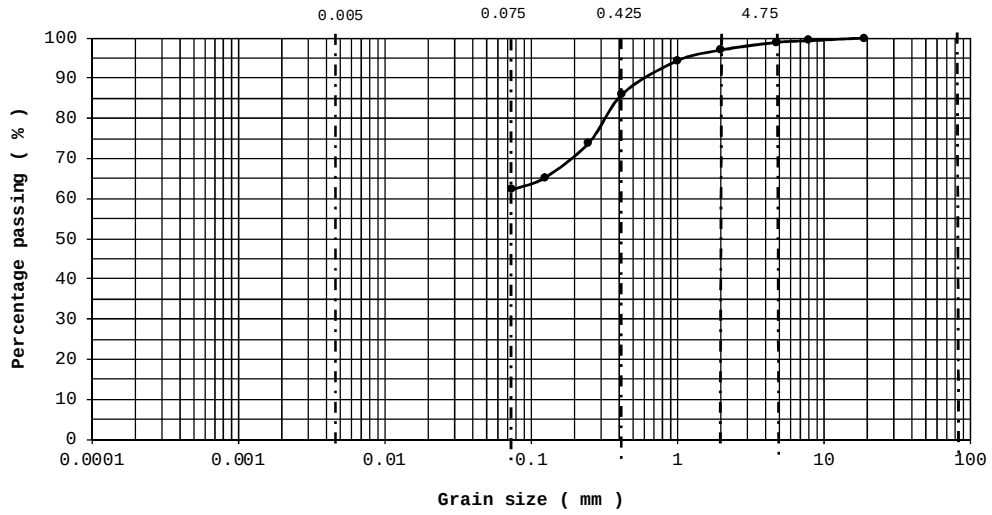
Borehole: **S3** Testing Date : 3-Jun-14

Depth : 3.00- 3.45m Sample No.: SPT-2

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	14.26 %
Grain size(mm)	% passing
0.075	62.22
0.125	65.17
0.250	73.89
0.425	86.07
1	94.27
2	96.99
4.75	98.88
8	99.31
19	100.00
31.5	
63	

Silt+Clay :	62 %
Sand :	37 %
Gravel :	1 %

Sample Description :

CLAY	SILT	SAND: Fine / Medium / Coarse	GRAVEL	Cobble

SIEVING ANALYSIS

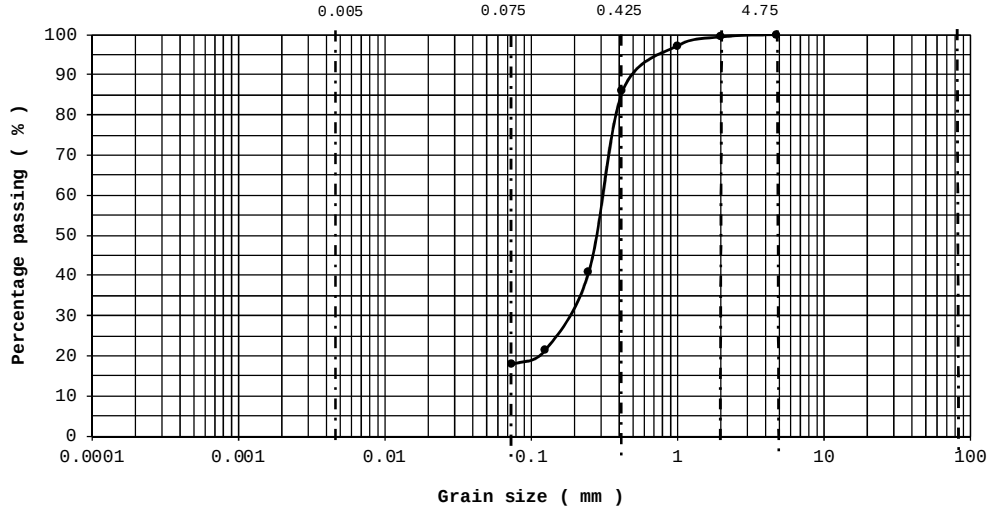
Borehole: **S3** Testing Date : 3-Jun-14

Depth : 6.00- 6.45m Sample No.: SPT-4

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	18.75 %
Grain size(mm)	% passing
0.075	17.80
0.125	21.25
0.250	40.89
0.425	85.89
1	97.15
2	99.43
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	18 %
Sand :	82 %
Gravel :	0 %

Sample Description :

CLAY	SILT	SAND: Fine / Medium / Coarse	GRAVEL	Cobble

SIEVING ANALYSIS

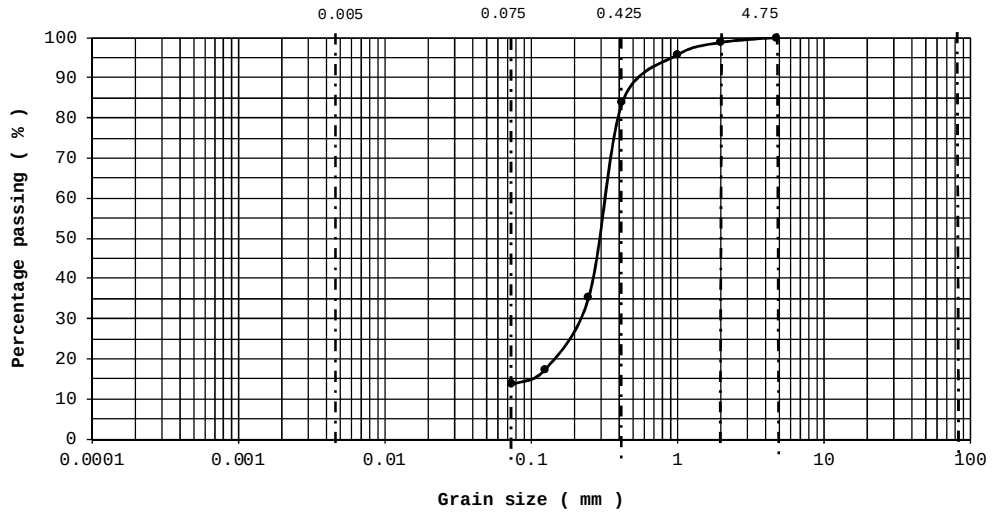
Borehole: **S3** Testing Date : 3-Jun-14

Depth : 9.00- 9.45m Sample No.: SPT-6

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	18.84 %
Grain size(mm)	% passing
0.075	13.58
0.125	17.19
0.250	35.39
0.425	84.00
1	95.64
2	98.78
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	14 %
Sand :	86 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

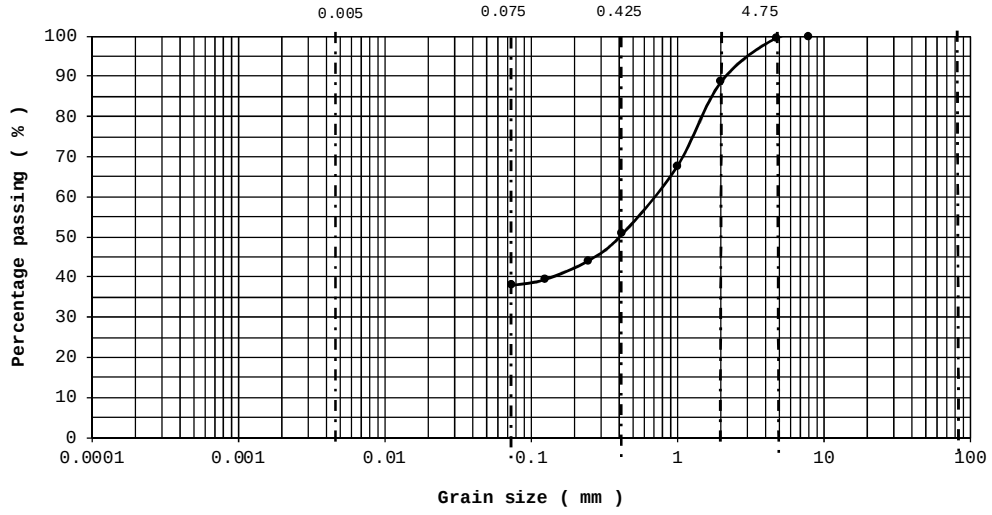
Borehole: **S3** Testing Date : 3-Jun-14

Depth : 15.00- 15.45m Sample No.: SPT-10

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	14.08 %
Grain size(mm)	% passing
0.075	37.90
0.125	39.34
0.250	44.10
0.425	50.73
1	67.47
2	88.60
4.75	99.49
8	100.00
19	
31.5	
63	

Silt+Clay :	38 %
Sand :	62 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

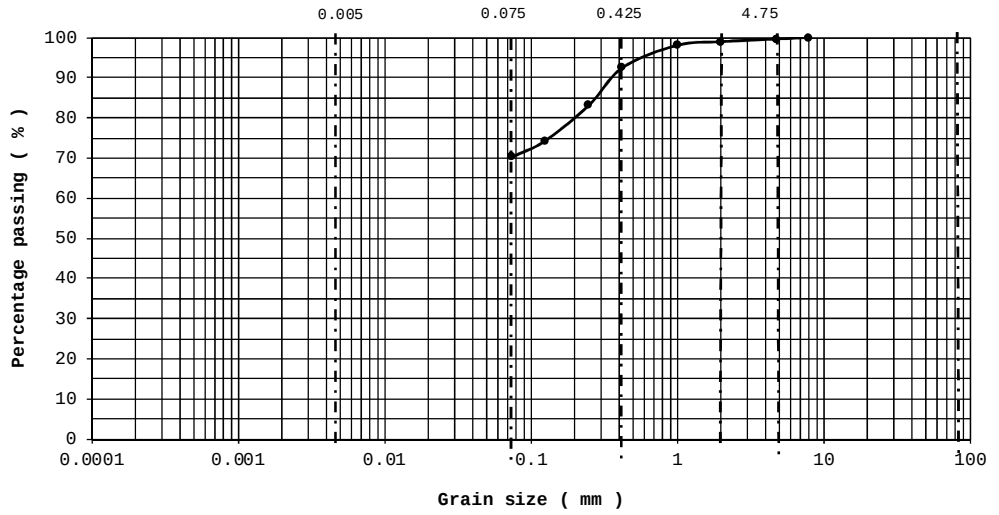
Borehole: **S4** Testing Date : 3-Jun-14

Depth : 1.50- 1.95m Sample No.: SPT-1

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	26.46 %
Grain size(mm)	% passing
0.075	70.23
0.125	74.20
0.250	83.11
0.425	92.50
1	98.04
2	98.96
4.75	99.64
8	100.00
19	
31.5	
63	

Silt+Clay :	70 %
Sand :	29 %
Gravel :	1 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

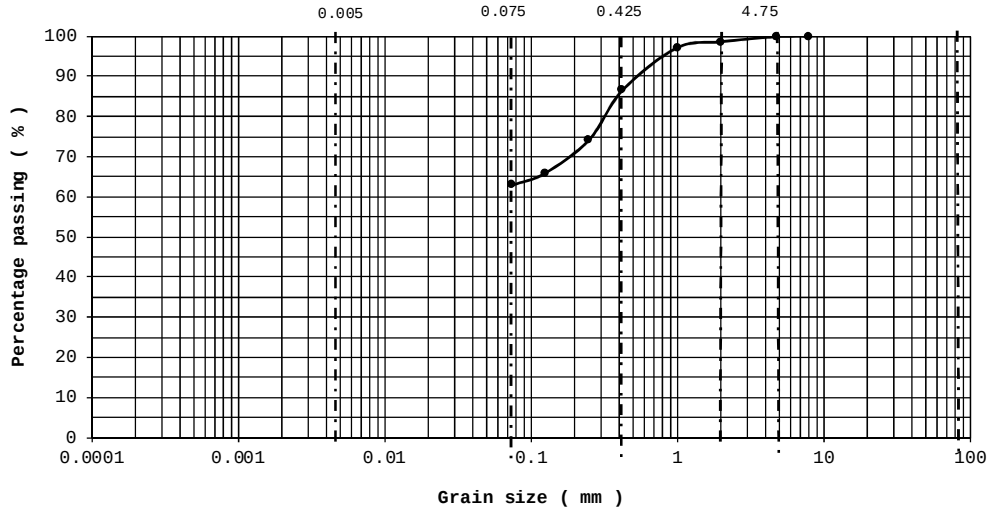
Borehole: **S4** Testing Date : 3-Jun-14

Depth : 3.00- 3.45m Sample No.: SPT-2

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	16.06 %
Grain size(mm)	% passing
0.075	62.87
0.125	65.79
0.250	74.08
0.425	86.55
1	97.08
2	98.59
4.75	99.86
8	100.00
19	
31.5	
63	

Silt+Clay :	63 %
Sand :	37 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

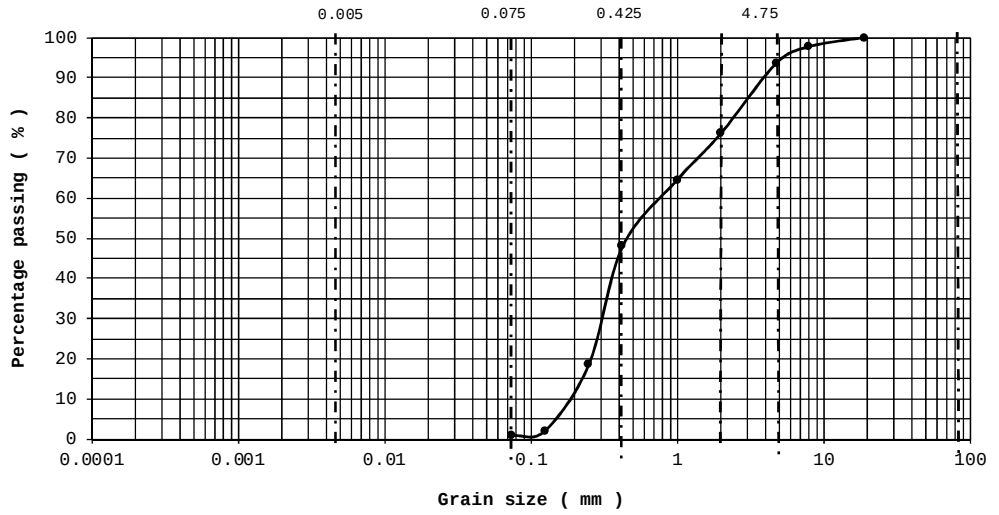
Borehole: **S4** Testing Date : 3-Jun-14

Depth : 4.50-4.95m Sample No.: SPT-3

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	17.45 %
Grain size(mm)	% passing
0.075	0.81
0.125	1.96
0.250	18.54
0.425	47.94
1	64.48
2	76.15
4.75	93.53
8	97.74
19	100.00
31.5	
63	

Silt+Clay :	1 %
Sand :	93 %
Gravel :	6 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

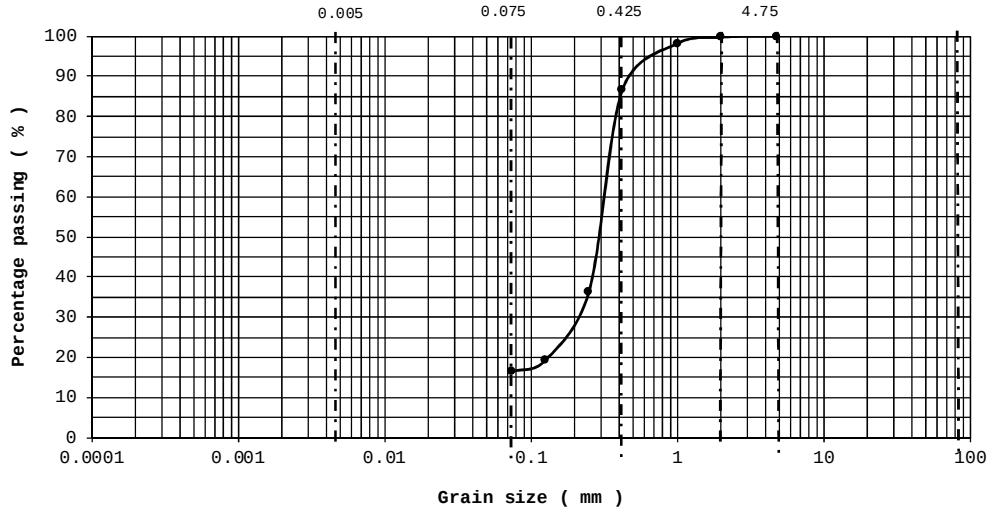
Borehole: **S4** Testing Date : 3-Jun-14

Depth : 9.00- 9.45m Sample No.: SPT-6

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	17.80 %
Grain size(mm)	% passing
0.075	16.45
0.125	19.12
0.250	36.21
0.425	86.76
1	98.12
2	99.71
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	16 %
Sand :	84 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

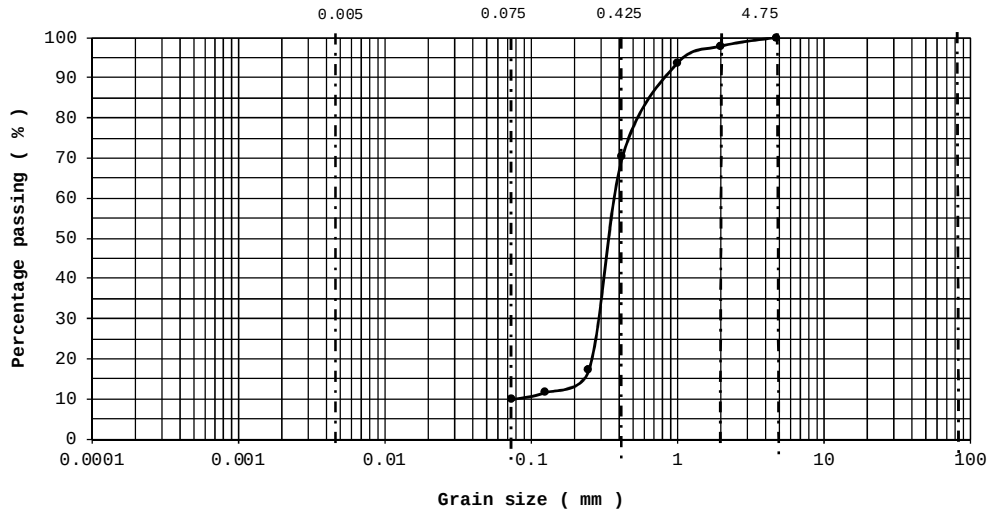
Borehole: **S4** Testing Date : 3-Jun-14

Depth : 12.00- 12.45m Sample No.: SPT-8

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	17.12 %
Grain size(mm)	% passing
0.075	9.78
0.125	11.53
0.250	17.10
0.425	70.38
1	93.52
2	97.86
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	10 %
Sand :	90 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

- **GS5 Substation**

SIEVING ANALYSIS

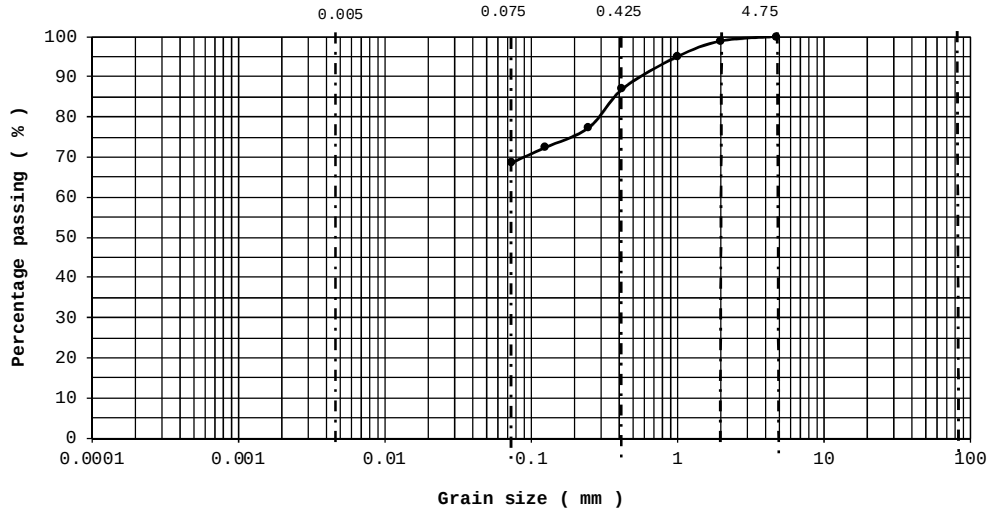
Borehole: S5 Testing Date : 20-Jul-14

Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	13.79 %
Grain size(mm)	% passing
0.075	68.64
0.125	72.30
0.250	77.34
0.425	86.95
1	94.96
2	98.90
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	69 %
Sand :	31 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

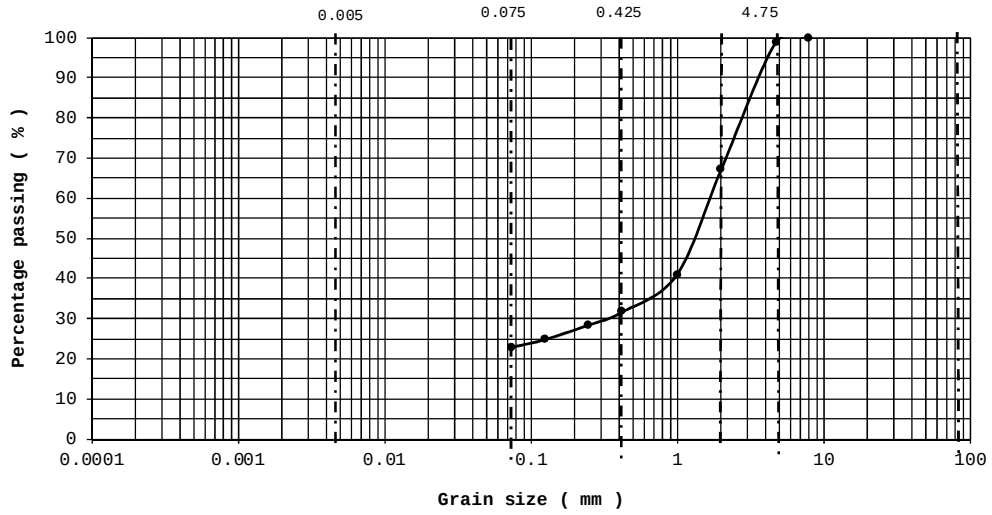
Borehole: S5 Testing Date : 20-Jul-14

Depth : 7.50- 7.95m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	10.64 %
Grain size(mm)	% passing
0.075	22.83
0.125	24.74
0.250	28.36
0.425	31.63
1	40.92
2	67.04
4.75	98.86
8	100.00
19	
31.5	
63	

Silt+Clay :	23 %
Sand :	76 %
Gravel :	1 %

Sample Description :

CLAY	SILT	SAND (Fine / Medium / Coarse)	GRAVEL	Cobble

SIEVING ANALYSIS

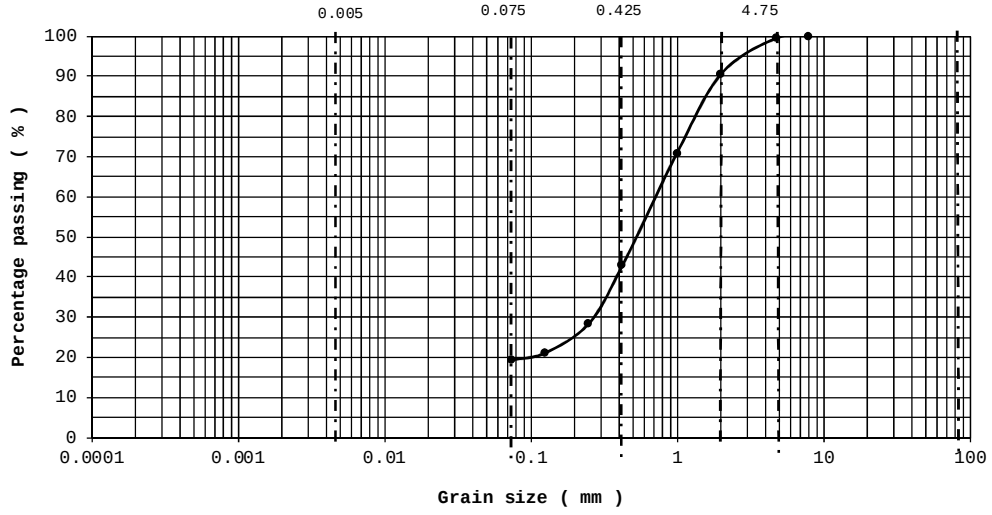
Borehole: S5 Testing Date : 20-Jul-14

Depth : 12.00- 12.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	13.43 %
Grain size(mm)	% passing
0.075	19.33
0.125	21.03
0.250	28.40
0.425	42.95
1	70.83
2	90.57
4.75	99.45
8	100.00
19	
31.5	
63	

Silt+Clay :	19 %
Sand :	80 %
Gravel :	1 %

Sample Description :

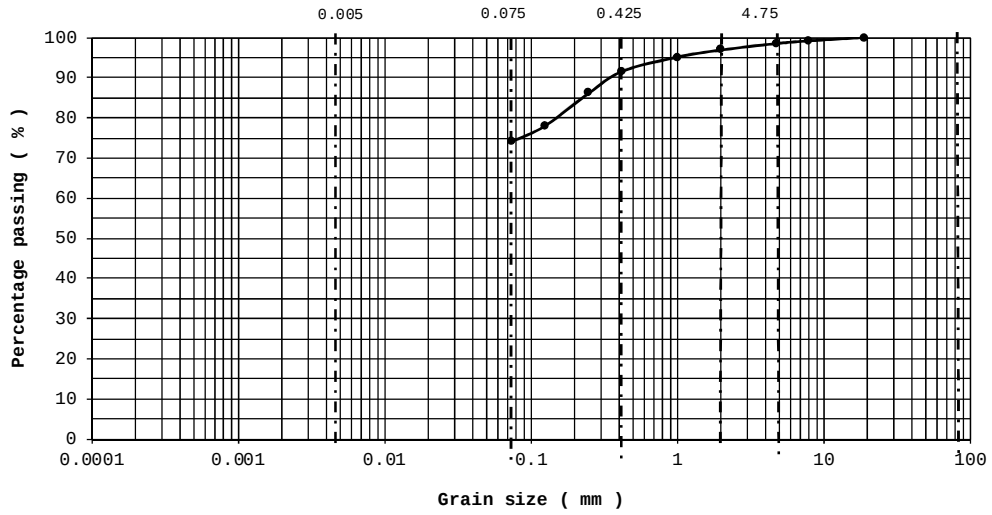
CLAY	SILT	SAND (Fine / Medium / Coarse)	GRAVEL	Cobble

SIEVING ANALYSIS

Borehole: S6 Testing Date : 20-Jul-14
Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	19.17 %
Grain size(mm)	% passing
0.075	74.14
0.125	77.94
0.250	86.16
0.425	91.60
1	95.11
2	96.88
4.75	98.49
8	99.17
19	100.00
31.5	
63	

Silt+Clay :	74 %
Sand :	24 %
Gravel :	2 %

Sample Description :

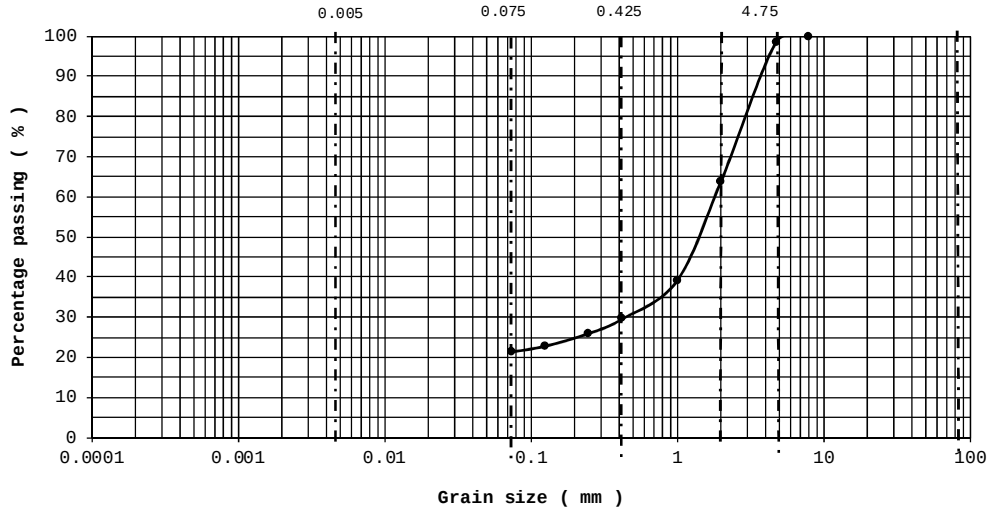
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: S6 Testing Date : 20-Jul-14
Depth : 7.50- 7.95m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	12.71 %
Grain size(mm)	% passing
0.075	21.32
0.125	22.72
0.250	25.93
0.425	29.56
1	39.01
2	63.81
4.75	98.45
8	100.00
19	
31.5	
63	

Silt+Clay :	21 %
Sand :	77 %
Gravel :	2 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

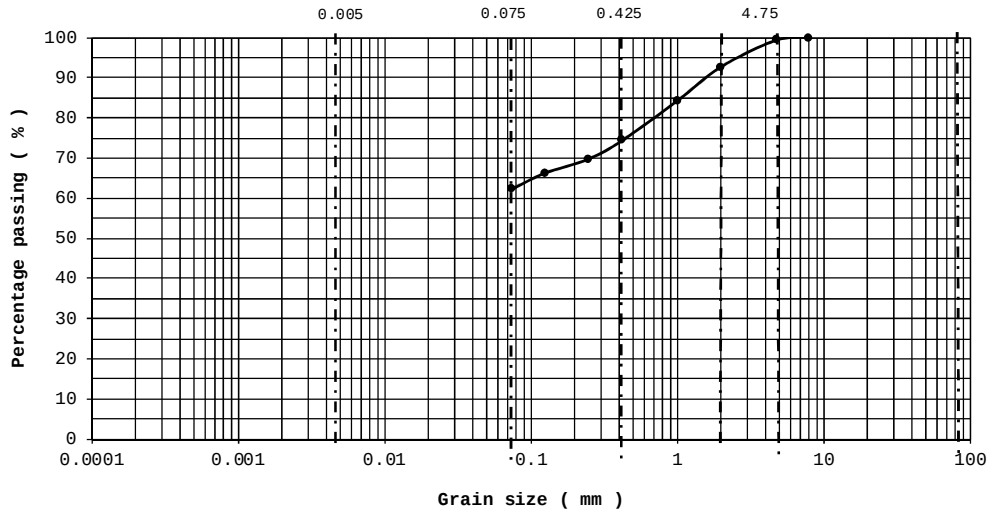
Borehole: S6 Testing Date : 20-Jul-14

Depth : 12.00- 12.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	17.19 %
Grain size(mm)	% passing
0.075	62.28
0.125	66.18
0.250	69.75
0.425	74.42
1	84.17
2	92.69
4.75	99.31
8	100.00
19	
31.5	
63	

Silt+Clay :	62 %
Sand :	37 %
Gravel :	1 %

Sample Description :

CLAY	SILT	SAND: Fine / Medium / Coarse	GRAVEL	Cobble

SIEVING ANALYSIS

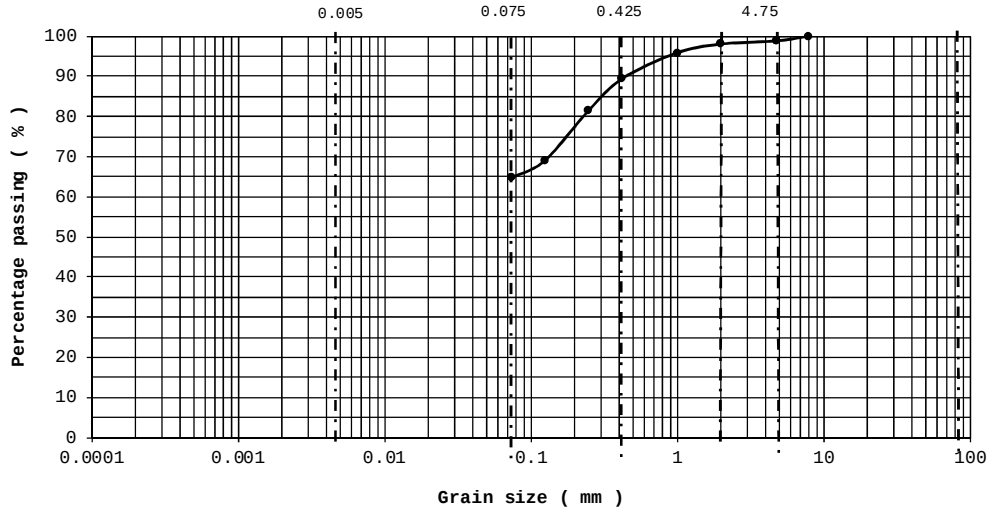
Borehole: S7 Testing Date : 20-Jul-14

Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	21.83 %
Grain size(mm)	% passing
0.075	64.77
0.125	69.00
0.250	81.53
0.425	89.46
1	95.82
2	98.02
4.75	98.81
8	100.00
19	
31.5	
63	

Silt+Clay :	65 %
Sand :	34 %
Gravel :	1 %

Sample Description :

CLAY	SILT	SAND: Fine / Medium / Coarse	GRAVEL	Cobble

SIEVING ANALYSIS

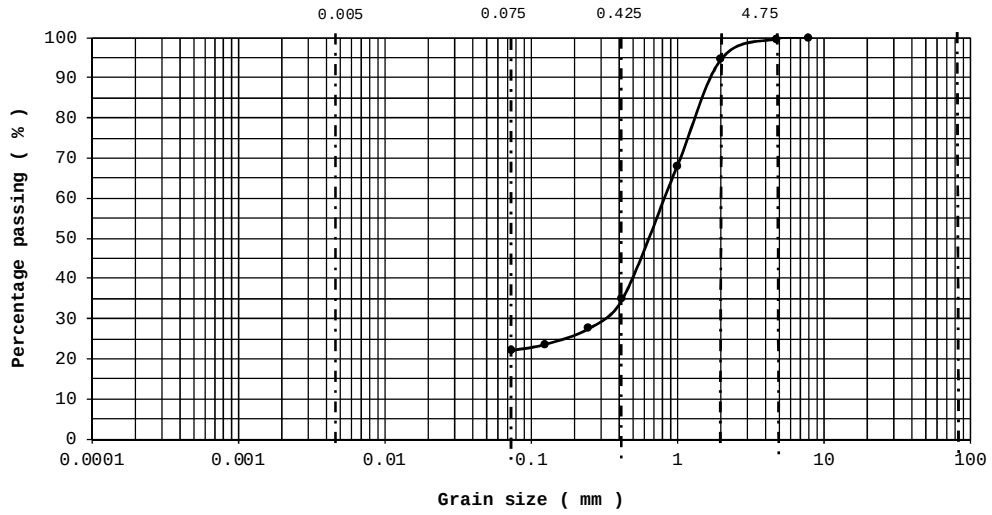
Borehole: S7 Testing Date : 20-Jul-14

Depth : 6.00- 6.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	12.92 %
Grain size(mm)	% passing
0.075	22.05
0.125	23.50
0.250	27.49
0.425	34.88
1	67.83
2	94.58
4.75	99.65
8	100.00
19	
31.5	
63	

Silt+Clay :	22 %
Sand :	78 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

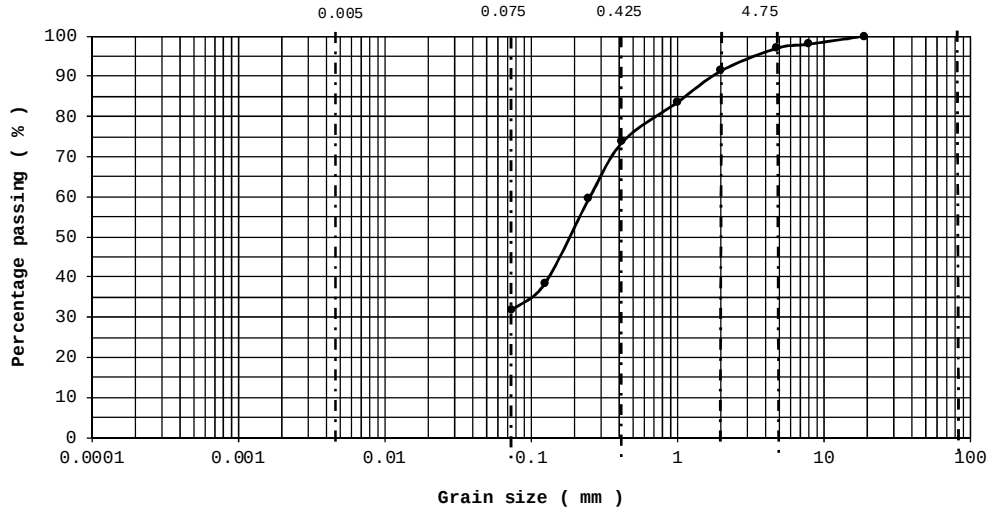
Borehole: S7 Testing Date : 20-Jul-14

Depth : 12.00- 12.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	10.79 %
Grain size(mm)	% passing
0.075	31.80
0.125	38.32
0.250	59.45
0.425	73.62
1	83.43
2	91.32
4.75	96.92
8	97.99
19	100.00
31.5	
63	

Silt+Clay :	32 %
Sand :	65 %
Gravel :	3 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

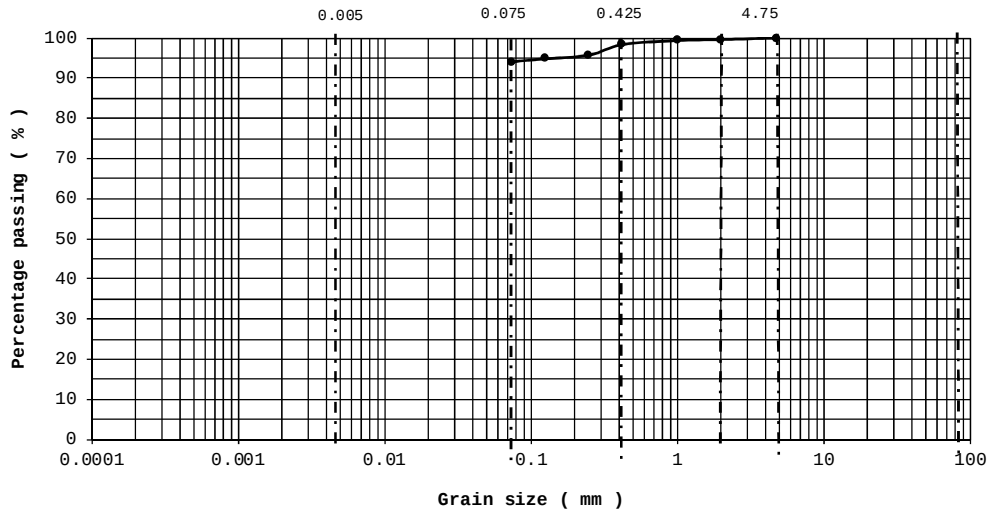
- **Chroy Changvar Substation**

SIEVING ANALYSIS

Borehole: S8 Testing Date : 20-Jul-14
Depth : 6.00- 6.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	19.25 %
Grain size(mm)	% passing
0.075	94.08
0.125	94.80
0.250	95.71
0.425	98.36
1	99.36
2	99.61
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	94 %
Sand :	6 %
Gravel :	0 %

Sample Description :

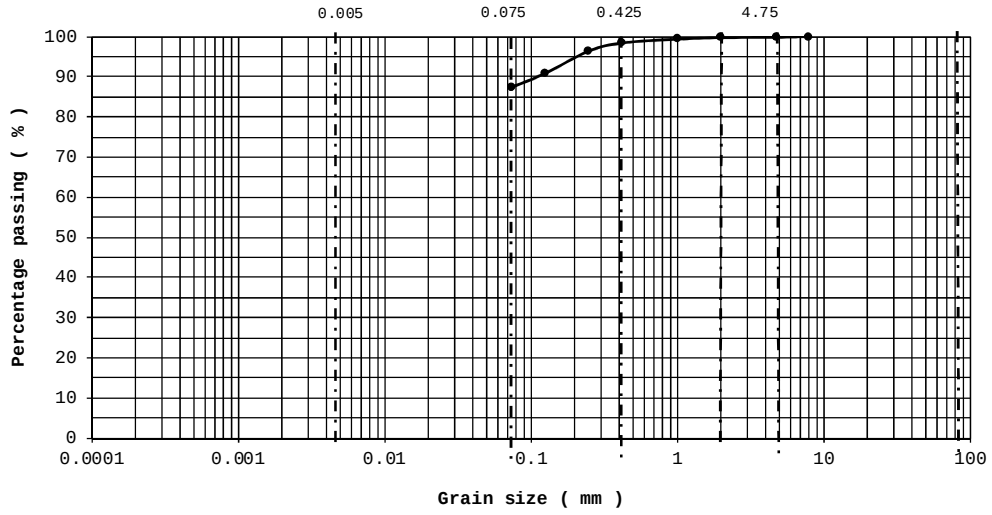
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: S8 Testing Date : 20-Jul-14
Depth : 19.50- 19.95m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	21.53 %
Grain size(mm)	% passing
0.075	87.45
0.125	90.77
0.250	96.40
0.425	98.41
1	99.33
2	99.72
4.75	99.81
8	100.00
19	
31.5	
63	

Silt+Clay :	87 %
Sand :	12 %
Gravel :	1 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

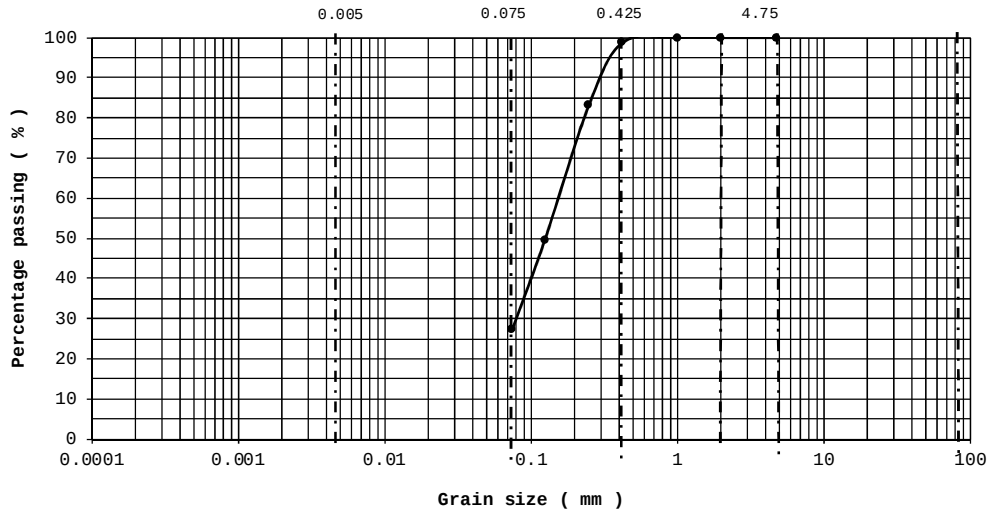
Borehole: S8 Testing Date : 20-Jul-14

Depth : 24.00-24.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	18.68 %
Grain size(mm)	% passing
0.075	27.27
0.125	49.58
0.250	83.11
0.425	98.75
1	100.00
2	100.00
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	27 %
Sand :	73 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

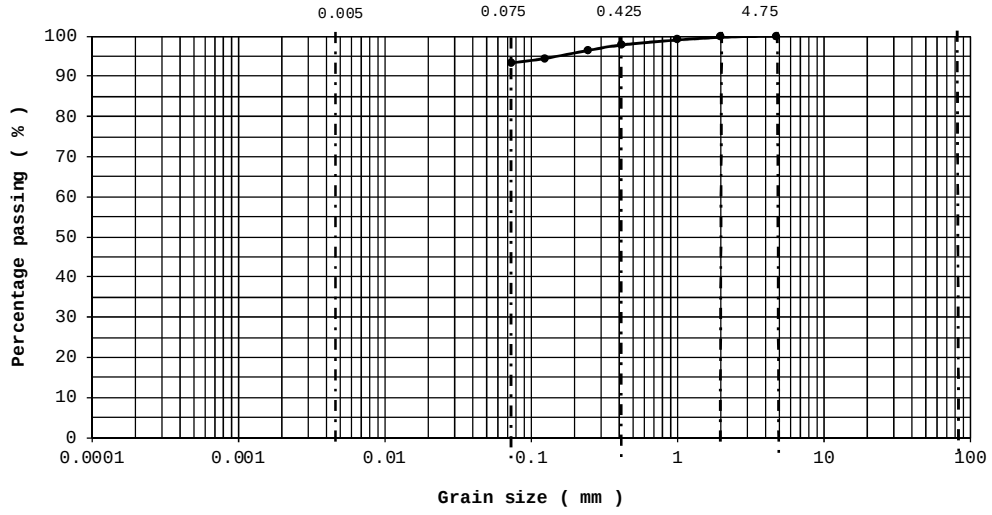
Borehole: S9 Testing Date : 20-Jul-14

Depth : 6.00- 6.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	22.92 %
Grain size(mm)	% passing
0.075	93.33
0.125	94.44
0.250	96.47
0.425	97.83
1	99.02
2	99.70
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	93 %
Sand :	7 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

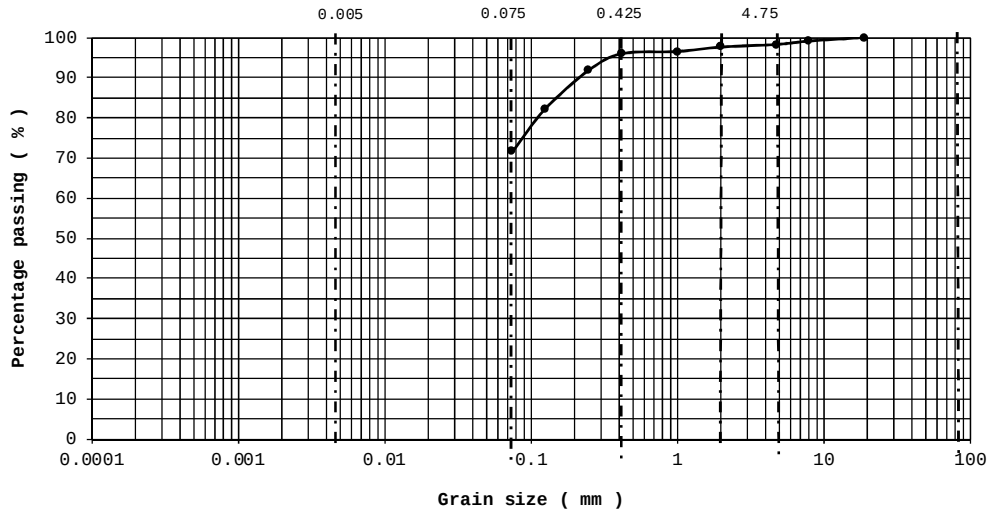
Borehole: S9 Testing Date : 20-Jul-14

Depth : 19.50-19.95m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	20.69 %
Grain size(mm)	% passing
0.075	71.54
0.125	82.11
0.250	91.87
0.425	95.99
1	96.51
2	97.63
4.75	98.26
8	99.13
19	100.00
31.5	
63	

Silt+Clay :	72 %
Sand :	27 %
Gravel :	1 %

Sample Description :

CLAY	SILT	SAND: Fine / Medium / Coarse	GRAVEL	Cobble

SIEVING ANALYSIS

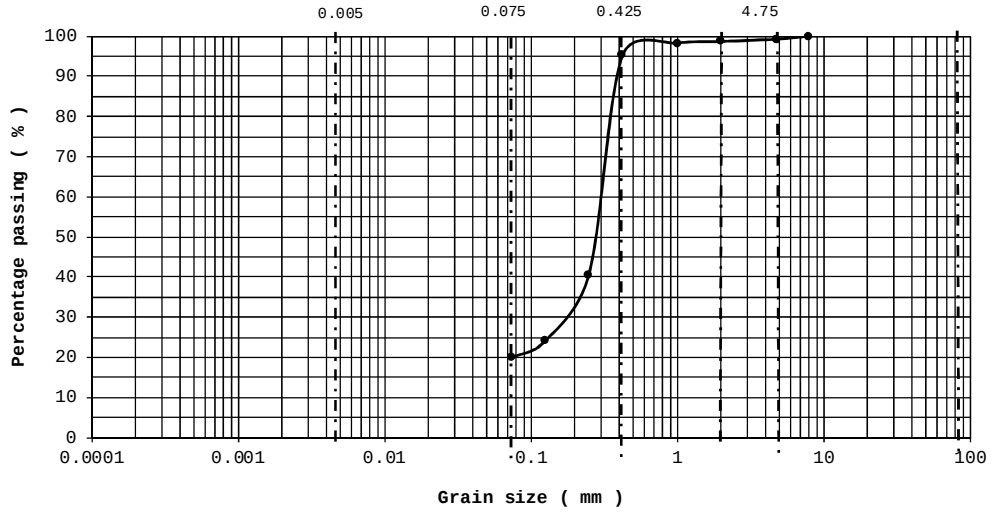
Borehole: S9 Testing Date : 20-Jul-14

Depth : 24.00- 24.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	18.50 %
Grain size(mm)	% passing
0.075	19.96
0.125	23.98
0.250	40.58
0.425	95.22
1	98.24
2	98.68
4.75	99.22
8	100.00
19	
31.5	
63	

Silt+Clay :	20 %
Sand :	79 %
Gravel :	1 %

Sample Description :

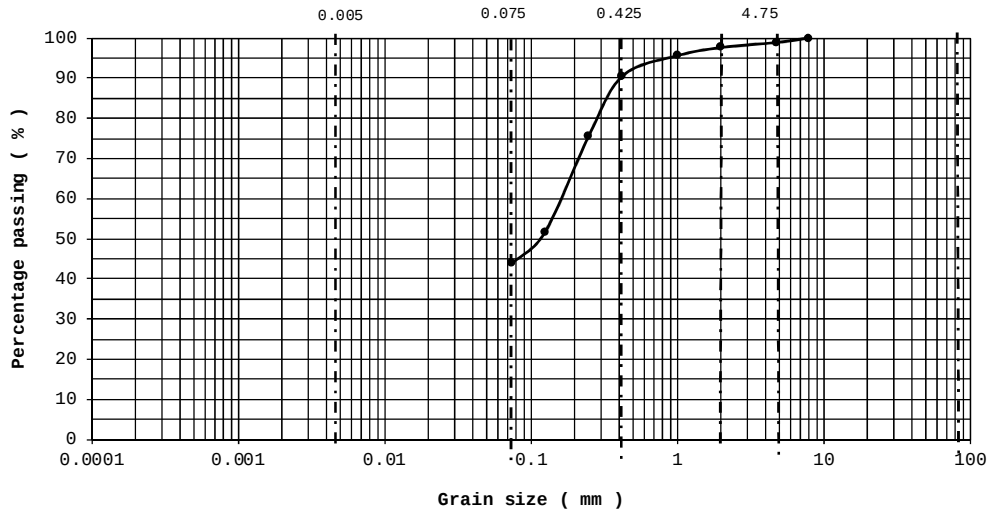
CLAY	SILT	SAND: Fine / Medium / Coarse	GRAVEL	Cobble

- Transmission line 230kV Mid point WPP/NPP to GS5 Substation

SIEVING ANALYSIS

Borehole: T1 Testing Date : 20-Jul-14
Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem



Moist. Content 13.20 %

Grain size(mm)	% passing
0.075	43.89
0.125	51.54
0.250	75.65
0.425	90.53
1	95.56
2	97.61
4.75	98.87
8	100.00
19	
31.5	
63	

Silt+Clay :	44 %
Sand :	55 %
Gravel :	1 %

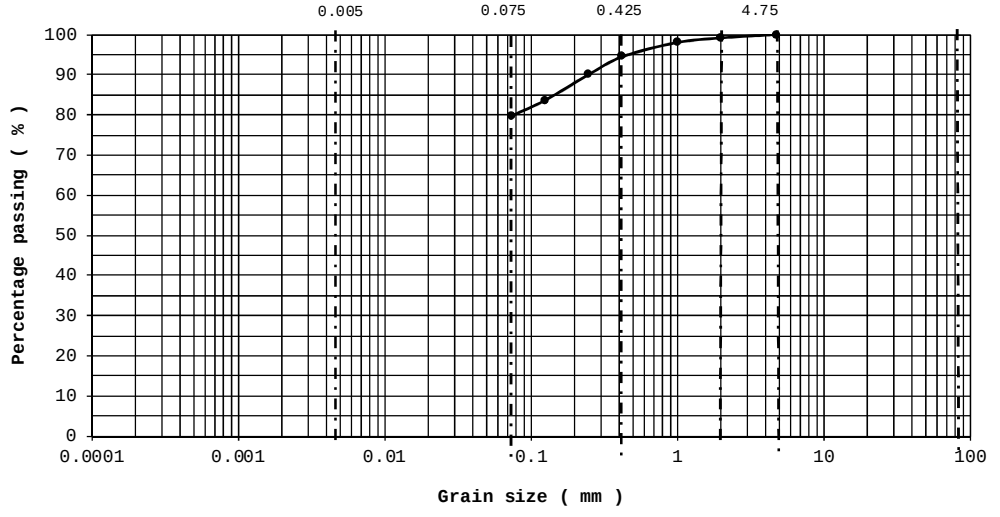
Sample Description :

CLAY	SILT	SAND: Fine / Medium / Coarse	GRAVEL	Cobble

SIEVING ANALYSIS

Borehole: T1 Testing Date : 20-Jul-14
Depth : 6.00- 6.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem



Moist. Content 15.35 %

Grain size(mm)	% passing
0.075	79.82
0.125	83.59
0.250	90.04
0.425	94.50
1	98.00
2	99.16
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	80 %
Sand :	20 %
Gravel :	0 %

Sample Description :

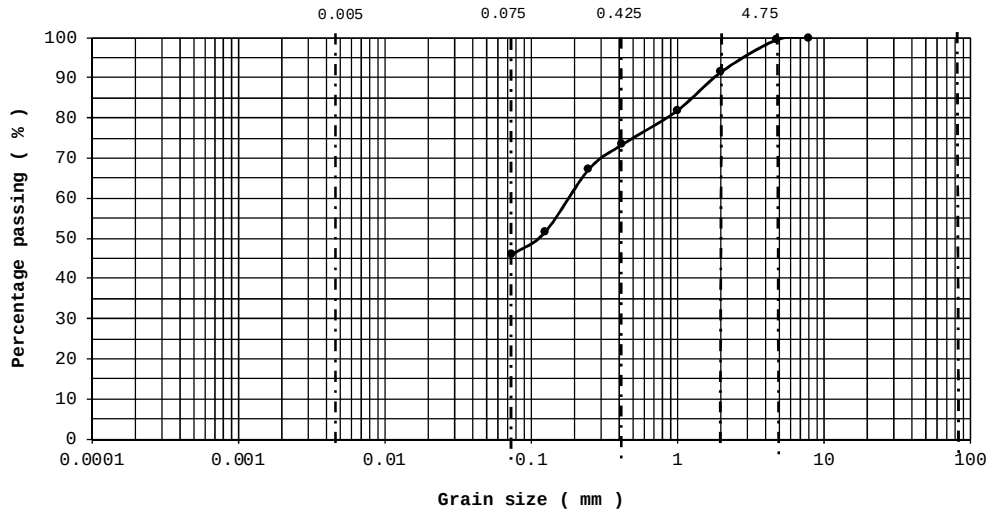
CLAY	SILT	SAND: Fine / Medium / Coarse	GRAVEL	Cobble

SIEVING ANALYSIS

Borehole: T1 Testing Date : 20-Jul-14
Depth : 10.50- 10.95m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	17.40 %
Grain size(mm)	% passing
0.075	45.99
0.125	51.44
0.250	67.15
0.425	73.37
1	81.72
2	91.39
4.75	99.37
8	100.00
19	
31.5	
63	

Silt+Clay :	46 %
Sand :	53 %
Gravel :	1 %

Sample Description :

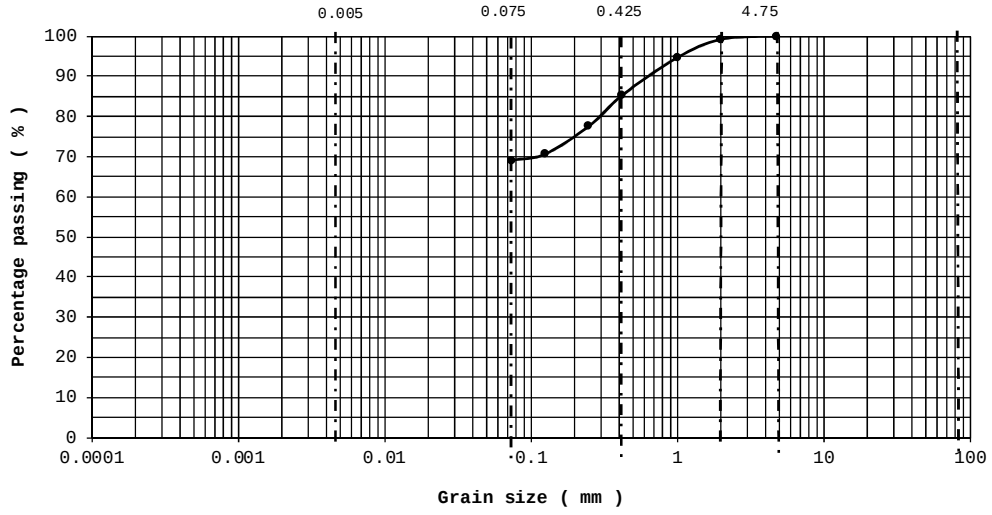
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: T2 Testing Date : 20-Jul-14
Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	10.97 %
Grain size(mm)	% passing
0.075	69.08
0.125	70.58
0.250	77.55
0.425	85.33
1	94.59
2	99.20
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	69 %
Sand :	31 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

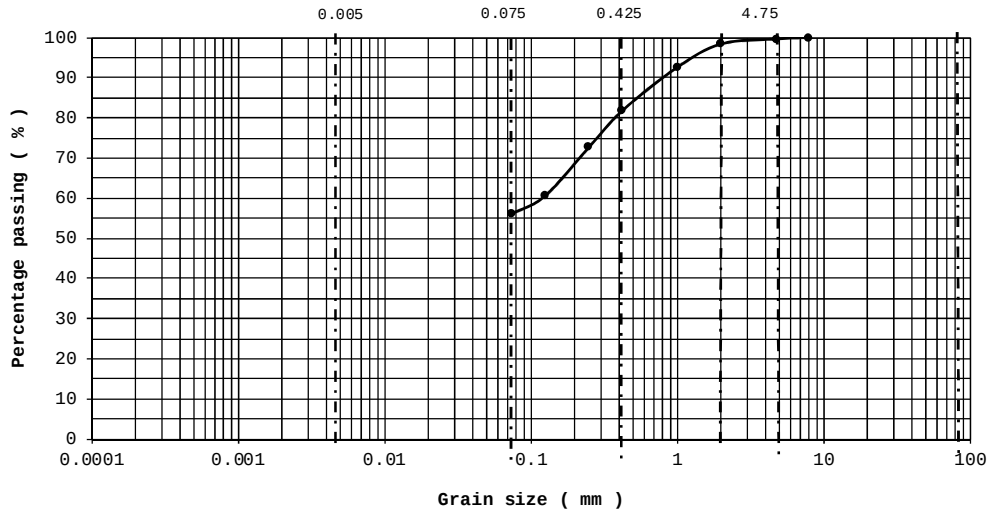
Borehole: T2 Testing Date : 20-Jul-14

Depth : 4.50-4.95m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	14.58 %
Grain size(mm)	% passing
0.075	56.14
0.125	60.49
0.250	72.64
0.425	81.83
1	92.52
2	98.39
4.75	99.64
8	100.00
19	
31.5	
63	

Silt+Clay :	56 %
Sand :	43 %
Gravel :	1 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

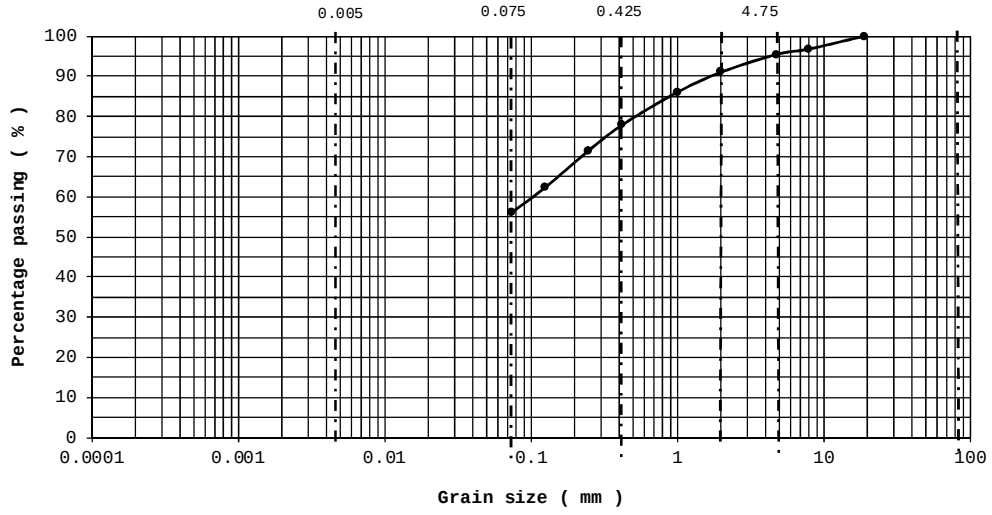
Borehole: T2 Testing Date : 20-Jul-14

Depth : 6.00- 6.45m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	16.48 %
Grain size(mm)	% passing
0.075	56.17
0.125	62.21
0.250	71.52
0.425	77.93
1	85.96
2	90.99
4.75	95.40
8	96.78
19	100.00
31.5	
63	

Silt+Clay :	56 %
Sand :	39 %
Gravel :	5 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

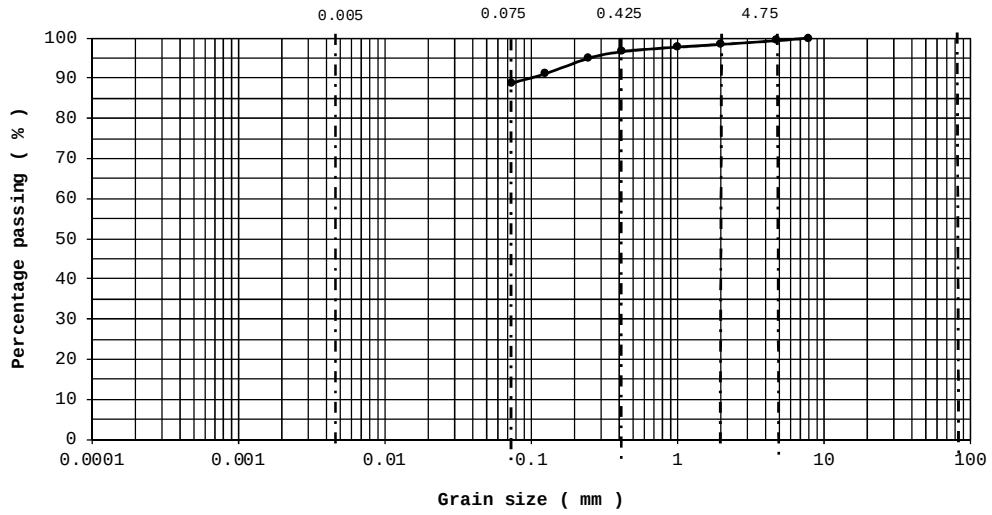
- **Transmission line 115kV GS5 to Chroy Changvar Substation**

SIEVING ANALYSIS

Borehole: T3 Testing Date : 20-Jul-14
Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	14.89 %
Grain size(mm)	% passing
0.075	88.79
0.125	91.04
0.250	94.95
0.425	96.60
1	97.73
2	98.39
4.75	99.31
8	100.00
19	
31.5	
63	

Silt+Clay :	89 %
Sand :	11 %
Gravel :	0 %

Sample Description :

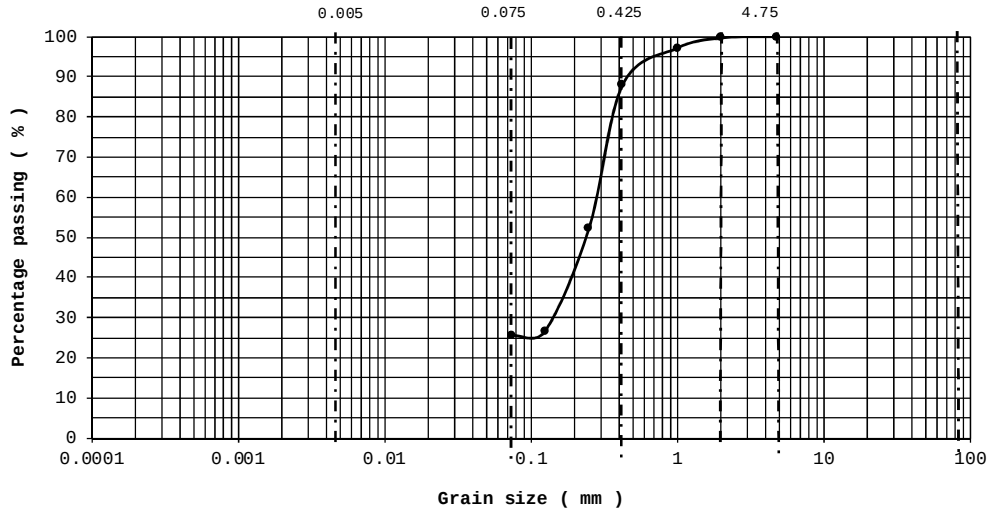
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: T3 Testing Date : 20-Jul-14
Depth : 9.00- 9.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	19.31 %
Grain size(mm)	% passing
0.075	25.52
0.125	26.53
0.250	52.09
0.425	87.96
1	97.09
2	99.67
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	26 %
Sand :	74 %
Gravel :	0 %

Sample Description :

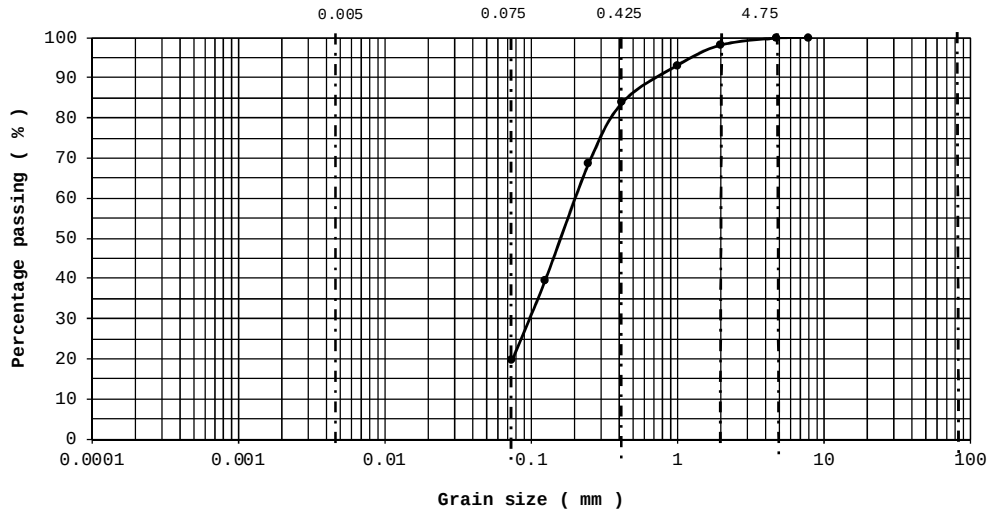
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: T3 Testing Date : 20-Jul-14
Depth : 12.00- 12.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	15.63 %
Grain size(mm)	% passing
0.075	19.64
0.125	39.26
0.250	68.71
0.425	83.84
1	93.02
2	98.12
4.75	99.84
8	100.00
19	
31.5	
63	

Silt+Clay :	20 %
Sand :	80 %
Gravel :	0 %

Sample Description :

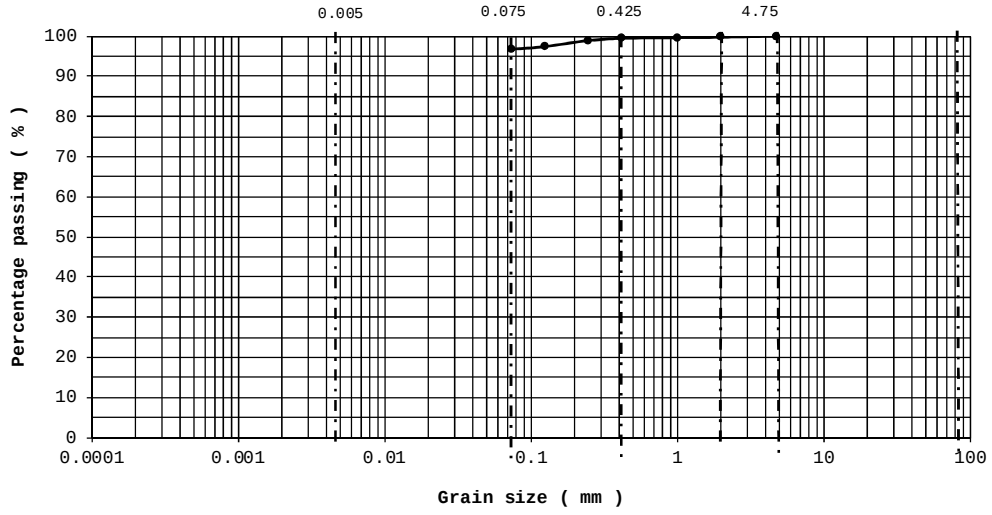
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: T4 Testing Date : 20-Jul-14
Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	21.44 %
Grain size(mm)	% passing
0.075	96.73
0.125	97.38
0.250	98.90
0.425	99.45
1	99.61
2	99.72
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	97 %
Sand :	3 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

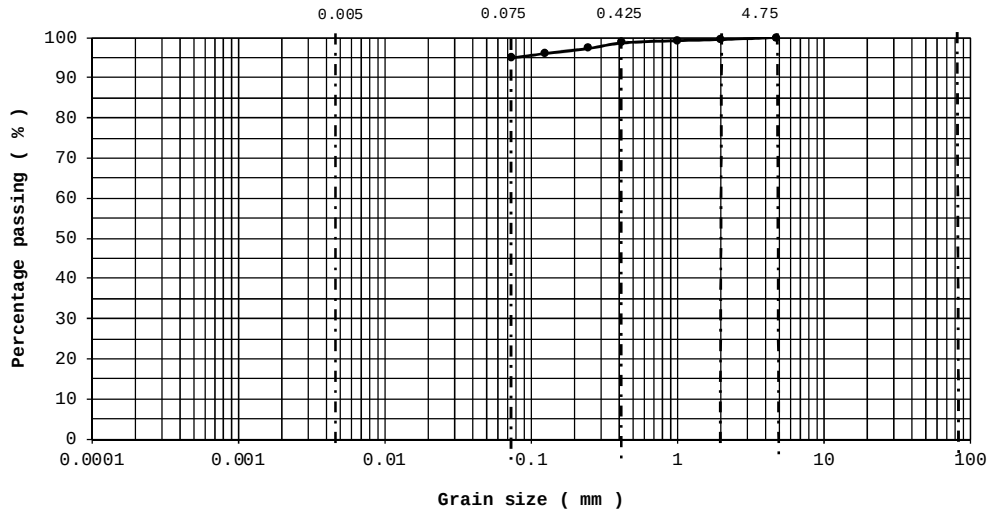
Borehole: T4 Testing Date : 20-Jul-14

Depth : 7.50- 7.95m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	21.95 %
Grain size(mm)	% passing
0.075	94.95
0.125	96.00
0.250	97.29
0.425	98.66
1	99.22
2	99.49
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	95 %
Sand :	5 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

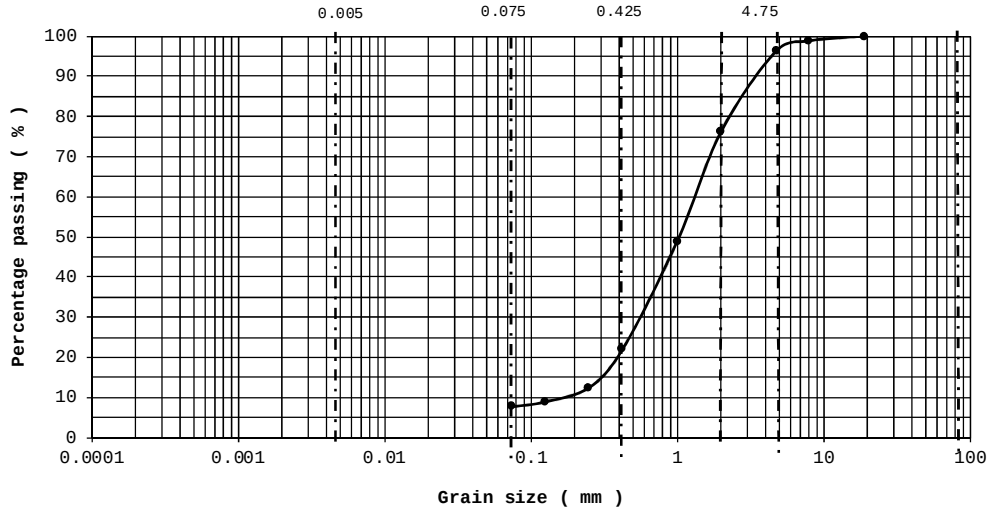
Borehole: T4 Testing Date : 20-Jul-14

Depth : 16.50- 16.95m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	13.20 %
Grain size(mm)	% passing
0.075	7.67
0.125	8.85
0.250	12.38
0.425	21.98
1	48.78
2	76.18
4.75	96.23
8	98.83
19	100.00
31.5	
63	

Silt+Clay :	8 %
Sand :	89 %
Gravel :	3 %

Sample Description :

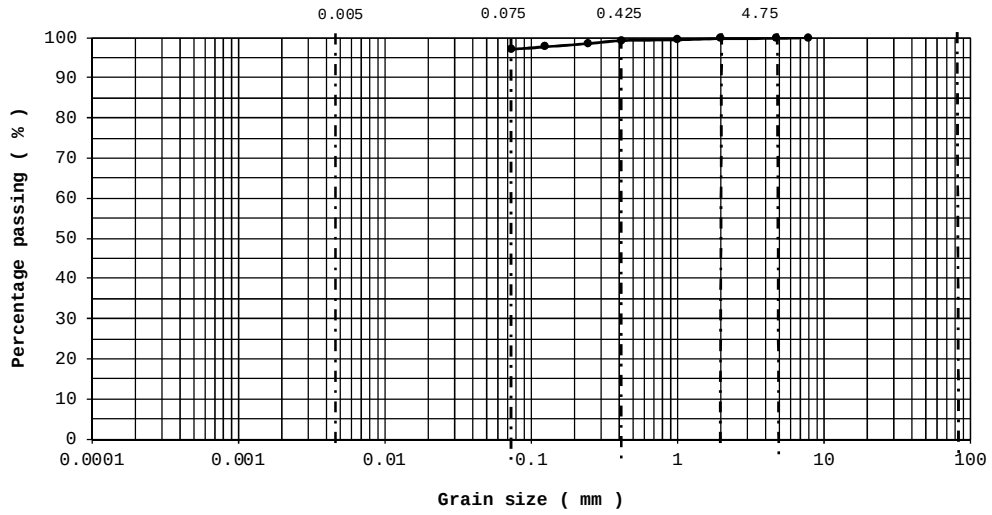
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: T5 Testing Date : 20-Jul-14
Depth : 3.00- 3.45m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	24.84 %
Grain size(mm)	% passing
0.075	97.06
0.125	97.67
0.250	98.50
0.425	99.25
1	99.42
2	99.72
4.75	99.79
8	100.00
19	
31.5	
63	

Silt+Clay :	97 %
Sand :	3 %
Gravel :	0 %

Sample Description :

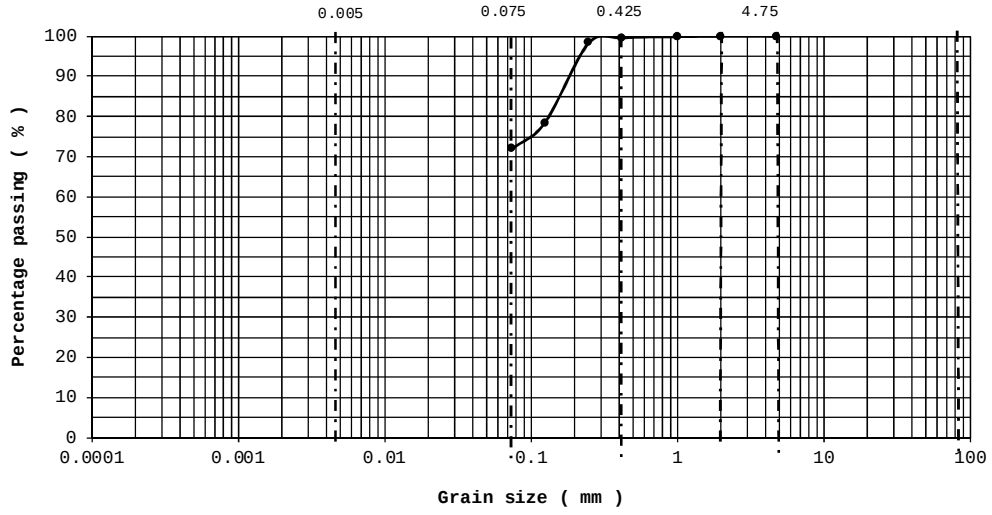
CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

Borehole: T5 Testing Date : 20-Jul-14
Depth : 7.50- 7.95m Sample No.:

Checked by : Ket Chansavuth
Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	32.76 %
Grain size(mm)	% passing
0.075	71.96
0.125	78.37
0.250	98.32
0.425	99.55
1	99.85
2	100.00
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	72 %
Sand :	28 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

SIEVING ANALYSIS

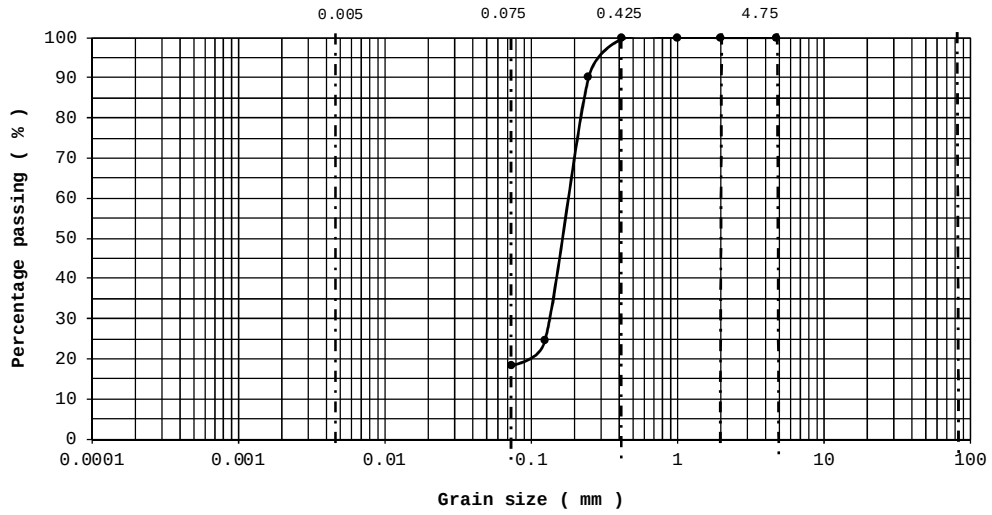
Borehole: T5 Testing Date : 20-Jul-14

Depth : 16.50- 16.95m Sample No.:

Checked by : Ket Chansavuth

Tested by : Chou Sarem

PARTICLE SIZE DISTRIBUTION CURVE



Moist. Content	27.97 %
Grain size(mm)	% passing
0.075	18.11
0.125	24.37
0.250	90.23
0.425	99.68
1	100.00
2	100.00
4.75	100.00
8	
19	
31.5	
63	

Silt+Clay :	18 %
Sand :	82 %
Gravel :	0 %

Sample Description :

CLAY	SILT	Fine	Medium	Coarse	GRAVEL	Cobble
		SAND				

b. Unconfined compression test

- NCC Substation

Borehole : **S1**

Sample No:	Depth: 3.00- 3.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.2	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_0 , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**1.961**	
Proving ring capacity	680.27kg	Moisture Cont., %	**19.83**	
		Dry Density , g/cm^3	**1.636**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	σ = P (1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5435**	6	0.263	**26.13**
1	**1.0870**	14	0.613	**60.64**
1.5	**1.6304**	21	0.920	**90.46**
2	**2.1739**	28	1.226	**119.95**
2.5	**2.7174**	33	1.445	**140.58**
3	**3.2609**	38	1.664	**160.98**
3.5	**3.8043**	40	1.752	**168.50**
4	**4.3478**	40	1.752	**167.55**
4.5	**4.8913**	36	1.576	**149.93**
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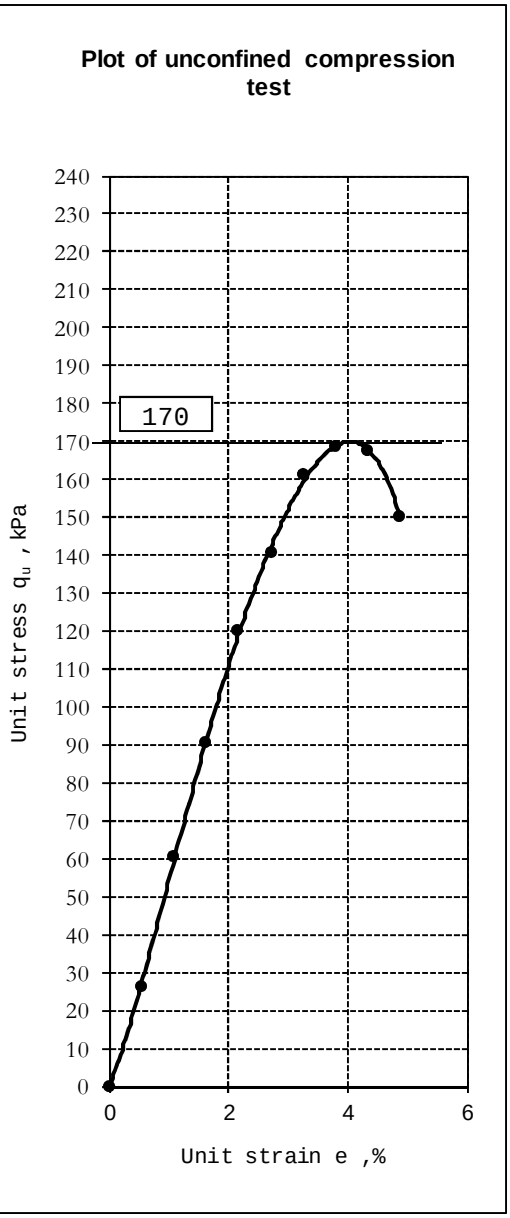

Unconfined Compressive Strength q_U = **170** kPa

Cohesion = q_u / 2 = **85** kPa

Borehole : **S1**

Sample No:	Depth: 7.50- 7.95m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_0 , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.174**	
Proving ring capacity	680.27kg	Moisture Cont., %	**13.05**	
		Dry Density , g/cm^3	**1.923**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5556**	10	0.438	**43.55**
1	**1.1111**	18	0.788	**77.95**
1.5	**1.6667**	24	1.051	**103.35**
2	**2.2222**	30	1.314	**128.45**
2.5	**2.7778**	36	1.576	**153.27**
3	**3.3333**	42	1.839	**177.79**
3.5	**3.8889**	42	1.839	**176.77**
4	**4.4444**	39	1.708	**163.19**
4.5	**5.0000**	37	1.620	**153.92**
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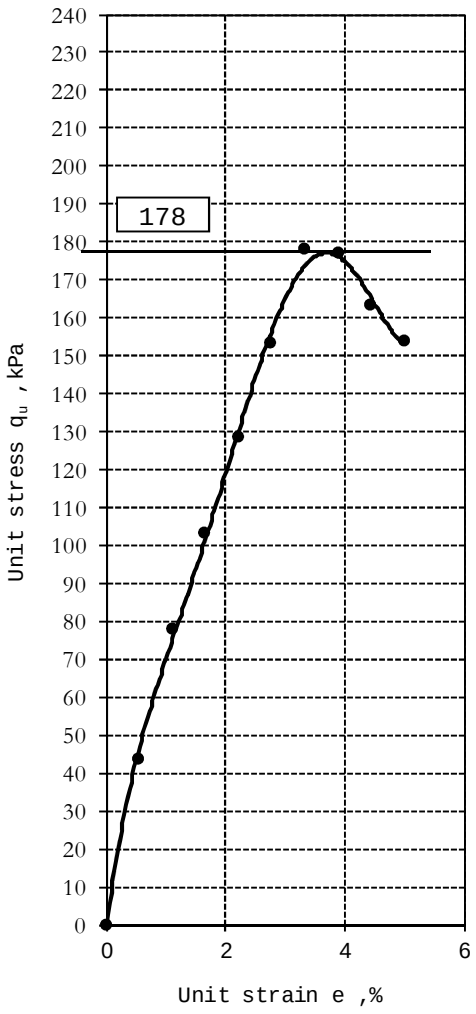
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **178** kPa

Cohesion = q_u / 2 = **89** kPa

Borehole : **S2**

Sample No:	Depth:6.00- 6.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	8.8	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_o , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**1.965**	
Proving ring capacity	680.27kg	Moisture Cont., %	**19.58**	
		Dry Density , g/cm^3	**1.643**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5682**	6	0.263	**26.12**
1	**1.1364**	13	0.569	**56.28**
1.5	**1.7045**	18	0.788	**77.48**
2	**2.2727**	22	0.963	**94.15**
2.5	**2.8409**	26	1.139	**110.62**
3	**3.4091**	30	1.314	**126.89**
3.5	**3.9773**	34	1.489	**142.97**
4	**4.5455**	36	1.576	**150.48**
4.5	**5.1136**	36	1.576	**149.58**
5	**5.6818**	32	1.401	**132.17**
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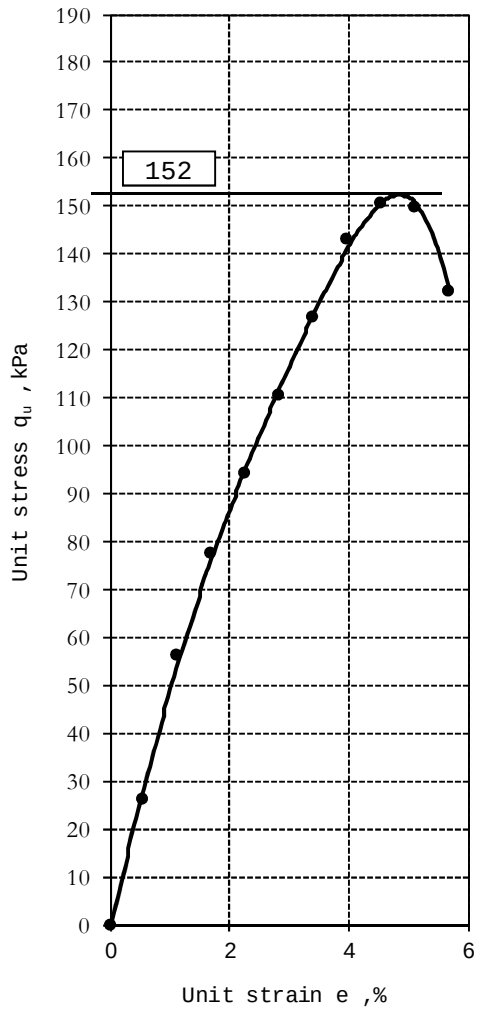
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **152** kPa

Cohesion = q_u / 2 = **76** kPa

Borehole : **S2**

Sample No:	Depth: 10.50- 10.95m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.1	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_o , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.012**	
Proving ring capacity	680.27kg	Moisture Cont., %	**23.45**	
		Dry Density , g/cm^3	**1.630**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5495**	10	0.438	**43.55**
1	**1.0989**	20	0.876	**86.62**
1.5	**1.6484**	30	1.314	**129.21**
2	**2.1978**	36	1.576	**154.18**
2.5	**2.7473**	42	1.839	**178.87**
3	**3.2967**	48	2.102	**203.26**
3.5	**3.8462**	50	2.190	**210.53**
4	**4.3956**	50	2.190	**209.33**
4.5	**4.9451**	47	2.058	**195.64**
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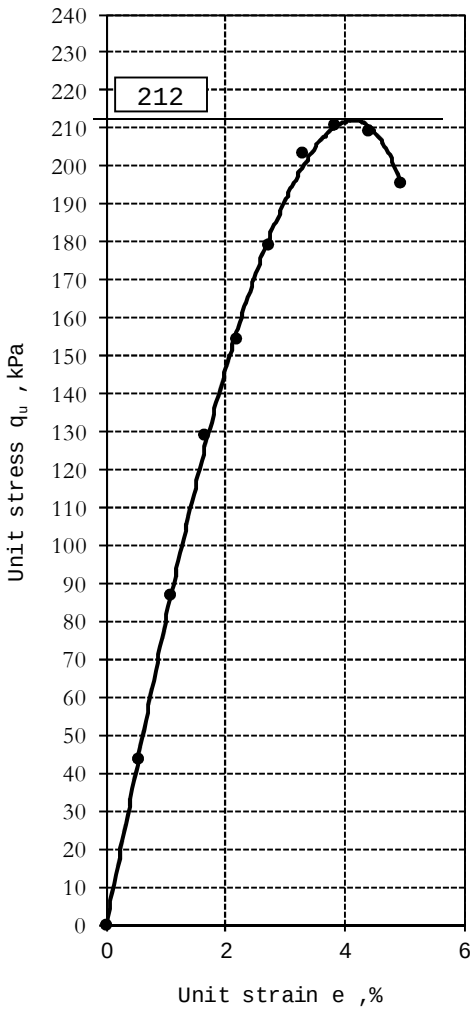
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **212** kPa

Cohesion = q_u / 2 = **106** kPa

- **Tuol Kork Substation**

Borehole : **S3**

Sample No: SPT-2	Depth: 3.00- 3.45m	Tested date :4/06/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.2	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_0 , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.148**	
Proving ring capacity	680.27kg	Moisture Cont., %	**14.26**	
		Dry Density , g/cm^3	**1.880**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	σ = P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5435**	4	0.175	**17.42**
1	**1.0870**	8	0.350	**34.65**
1.5	**1.6304**	11	0.482	**47.38**
2	**2.1739**	15	0.657	**64.26**
2.5	**2.7174**	18	0.788	**76.68**
3	**3.2609**	21	0.920	**88.96**
3.5	**3.8043**	23	1.007	**96.89**
4	**4.3478**	26	1.139	**108.90**
4.5	**4.8913**	28	1.226	**116.62**
5	**5.4348**	30	1.314	**124.23**
5.5	**5.9783**	30	1.314	**123.52**
6	**6.5217**	27	1.182	**110.52**
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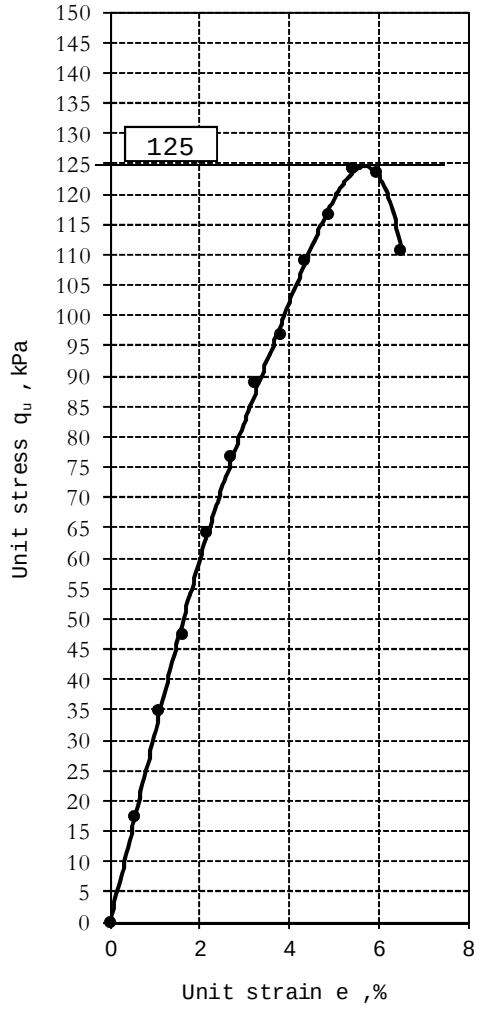
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **125** kPa

Cohesion = q_u / 2 = **62.5** kPa

Borehole : **S4**

Sample No: SPT-1	Depth: 1.50- 1.95m	Tested date :4/06/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	8.9	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_o , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**1.923**	
Proving ring capacity	680.27kg	Moisture Cont., %	**26.46**	
		Dry Density , g/cm^3	**1.521**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5618**	4	0.175	**17.42**
1	**1.1236**	6	0.263	**25.98**
1.5	**1.6854**	8	0.350	**34.44**
2	**2.2472**	10	0.438	**42.81**
2.5	**2.8090**	12	0.525	**51.07**
3	**3.3708**	14	0.613	**59.24**
3.5	**3.9326**	14	0.613	**58.90**
4	**4.4944**	12	0.525	**50.19**
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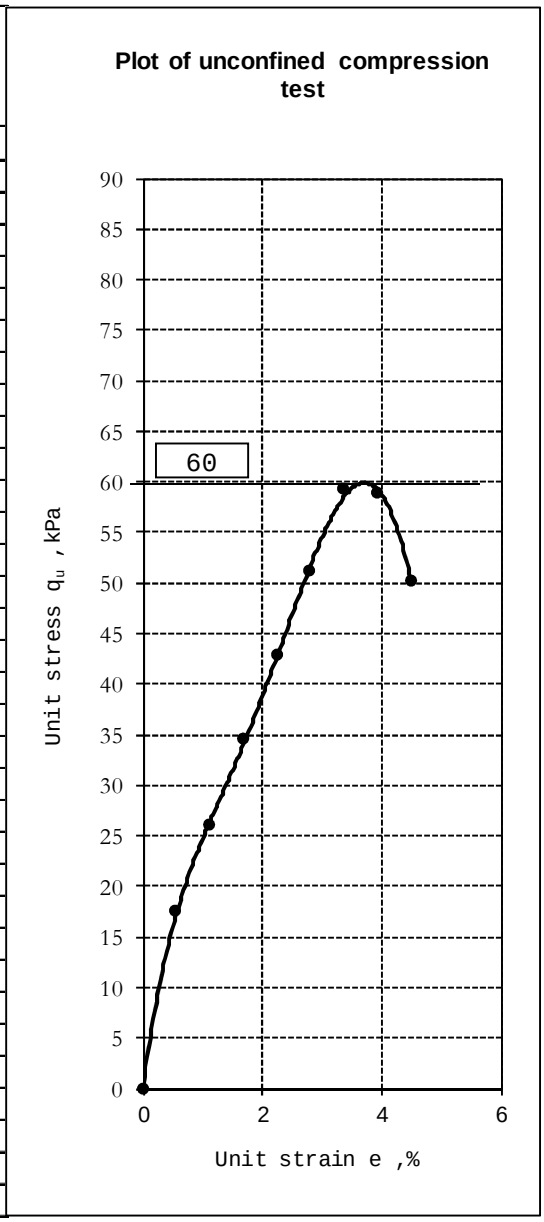

Unconfined Compressive Strength q_U = **60** kPa

Cohesion = q_u / 2 = **30** kPa

Borehole : **S4**

Sample No: SPT-1	Depth: 3.00- 3.45m	Tested date :4/06/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.6	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_o , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.173**	
Proving ring capacity	680.27kg	Moisture Cont., %	**16.06**	
		Dry Density , g/cm^3	**1.872**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	σ = P (1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5208**	10	0.438	**43.56**
1	**1.0417**	20	0.876	**86.67**
1.5	**1.5625**	26	1.139	**112.08**
2	**2.0833**	30	1.314	**128.63**
2.5	**2.6042**	36	1.576	**153.54**
3	**3.1250**	40	1.752	**169.69**
3.5	**3.6458**	45	1.971	**189.87**
4	**4.1667**	45	1.971	**188.85**
4.5	**4.6875**	43	1.883	**179.47**
5	**5.2083**	42	1.839	**174.34**
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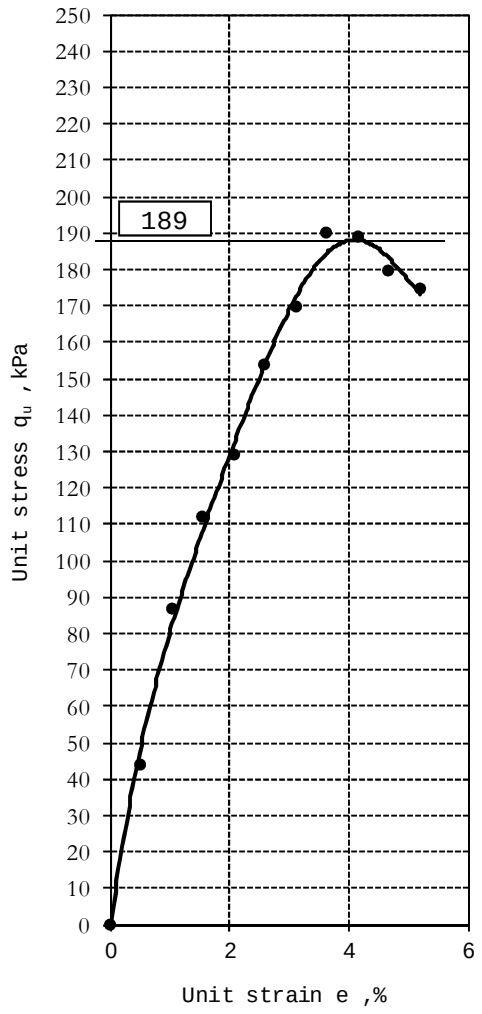
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **189** kPa

Cohesion = q_u / 2 = **94.5** kPa

- **GS5 Substation**

Borehole : **S5**

Sample No:	Depth:3.00- 3.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.1	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_0 , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.046**	
Proving ring capacity	680.27kg	Moisture Cont., %	**13.79**	
		Dry Density , g/cm^3	**1.798**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	σ = P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5495**	10	0.438	**43.55**
1	**1.0989**	20	0.876	**86.62**
1.5	**1.6484**	30	1.314	**129.21**
2	**2.1978**	40	1.752	**171.31**
2.5	**2.7473**	44	1.927	**187.38**
3	**3.2967**	47	2.058	**199.03**
3.5	**3.8462**	47	2.058	**197.90**
4	**4.3956**	45	1.971	**188.40**
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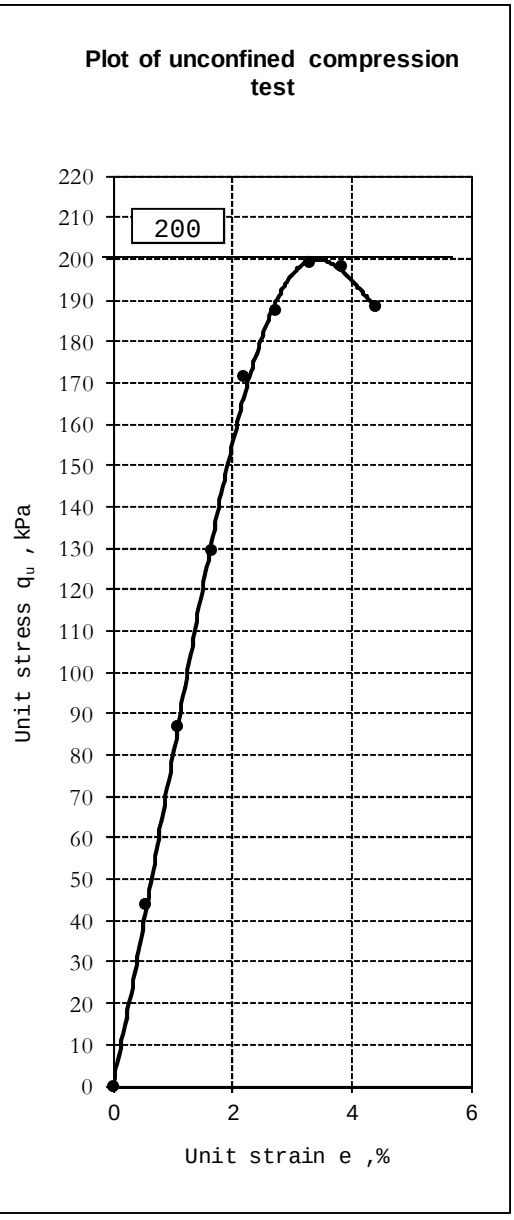

Unconfined Compressive Strength q_U = **200** kPa

Cohesion = q_u / 2 = **100** kPa

Borehole : **S5**

Sample No:	Depth:3.00- 3.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	8.6	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_o , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.220**	
Proving ring capacity	680.27kg	Moisture Cont., %	**13.43**	
		Dry Density , g/cm^3	**1.957**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5814**	9	0.394	**39.18**
1	**1.1628**	18	0.788	**77.91**
1.5	**1.7442**	25	1.095	**107.57**
2	**2.3256**	35	1.533	**149.70**
2.5	**2.9070**	35	1.533	**148.81**
3	**3.4884**	33	1.445	**139.47**
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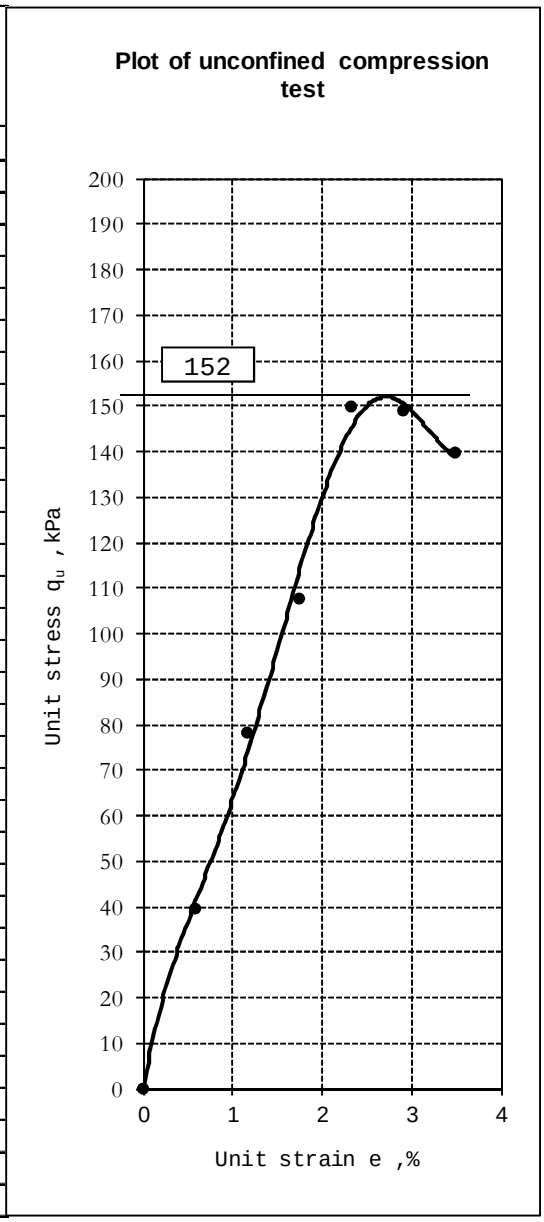

Unconfined Compressive Strength q_U = **152** kPa

Cohesion = q_u / 2 = **76** kPa

Borehole : **S6**

Sample No:	Depth:3.00- 3.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	8.6	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_o , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.047**	
Proving ring capacity	680.27kg	Moisture Cont., %	**19.17**	
		Dry Density , g/cm^3	**1.718**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5814**	6	0.263	**26.12**
1	**1.1628**	10	0.438	**43.28**
1.5	**1.7442**	16	0.701	**68.84**
2	**2.3256**	22	0.963	**94.10**
2.5	**2.9070**	26	1.139	**110.55**
3	**3.4884**	30	1.314	**126.79**
3.5	**4.0698**	34	1.489	**142.83**
4	**4.6512**	34	1.489	**141.96**
4.5	**5.2326**	32	1.401	**132.80**
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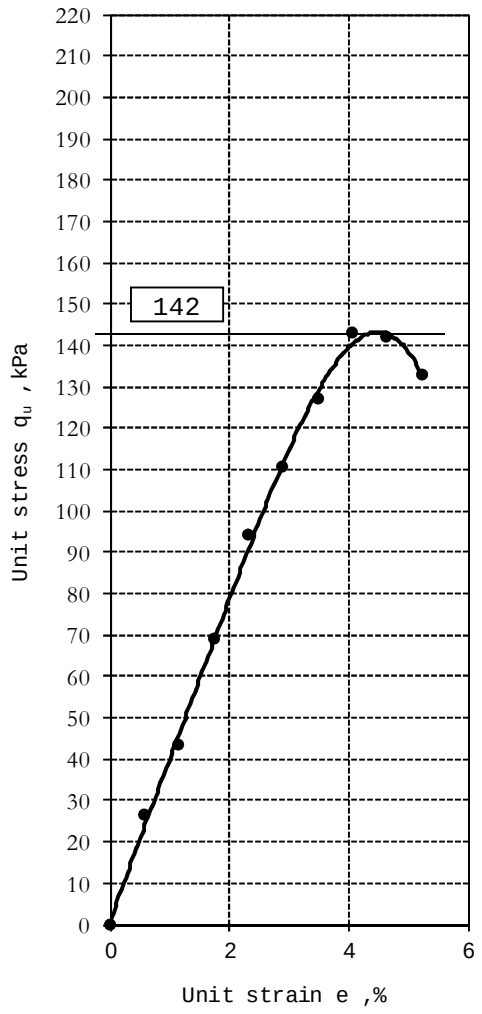
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **142** kPa

Cohesion = q_u / 2 = **71** kPa

Borehole : **S7**

Sample No:	Depth:3.00- 3.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.3	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.60	
Plasticity Index I_P (%)		Area A_o , cm^2	10.174	
Specific gravity G_s		Bulk Density , g/cm^3	**1.997**	
Proving ring capacity	680.27kg	Moisture Cont., %	**19.14**	
		Dry Density , g/cm^3	**1.677**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	σ = P (1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5376**	6	0.248	**24.70**
1	**1.0753**	11	0.455	**45.04**
1.5	**1.6129**	13	0.538	**52.94**
2	**2.1505**	15	0.621	**60.75**
2.5	**2.6882**	17	0.704	**68.47**
3	**3.2258**	19	0.786	**76.11**
3.5	**3.7634**	21	0.869	**83.65**
4	**4.3011**	22	0.911	**87.14**
4.5	**4.8387**	22	0.911	**86.65**
5	**5.3763**	20	0.828	**78.33**
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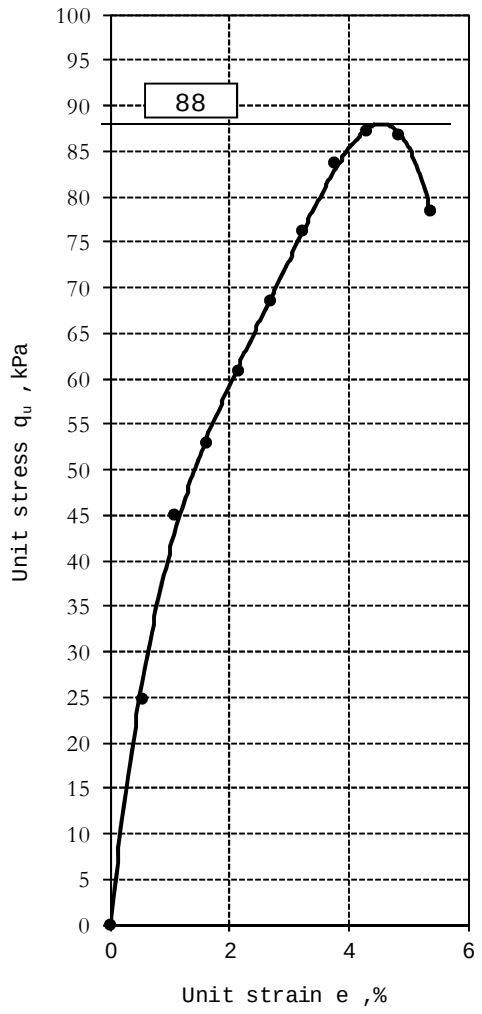
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **88** kPa

Cohesion = q_u / 2 = **44** kPa

Borehole : **S7**

Sample No:	Depth:6.00- 6.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.4	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.60	
Plasticity Index I_P (%)		Area A_o , cm^2	10.174	
Specific gravity G_s		Bulk Density , g/cm^3	**2.016**	
Proving ring capacity	680.27kg	Moisture Cont., %	**14.03**	
		Dry Density , g/cm^3	**1.768**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5319**	6	0.248	**24.70**
1	**1.0638**	10	0.414	**40.95**
1.5	**1.5957**	14	0.579	**57.02**
2	**2.1277**	18	0.745	**72.92**
2.5	**2.6596**	22	0.911	**88.64**
3	**3.1915**	26	1.076	**104.18**
3.5	**3.7234**	30	1.242	**119.55**
4	**4.2553**	30	1.242	**118.89**
4.5	**4.7872**	27	1.118	**106.41**
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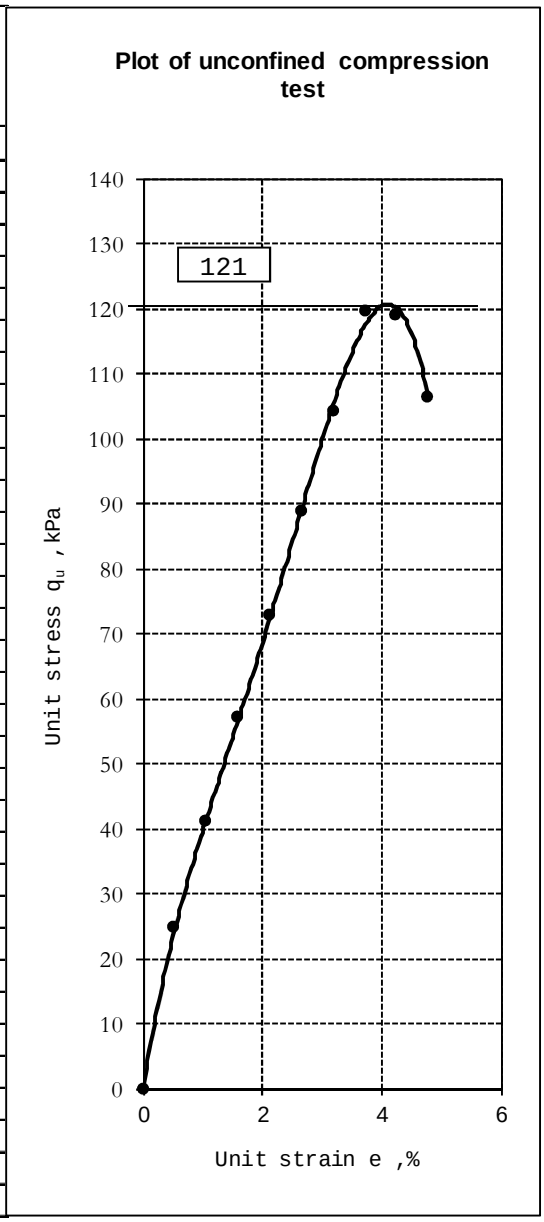

Unconfined Compressive Strength q_U = **121** kPa

Cohesion = q_u / 2 = **60.5** kPa

- **Chroy Changvar Substation**

Borehole : **S8**

Sample No:	Depth:6.00- 6.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_0 , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**1.923**	
Proving ring capacity	680.27kg	Moisture Cont., %	**19.25**	
		Dry Density , g/cm^3	**1.612**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	σ = P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5556**	6	0.263	**26.13**
1	**1.1111**	15	0.657	**64.96**
1.5	**1.6667**	25	1.095	**107.65**
2	**2.2222**	35	1.533	**149.86**
2.5	**2.7778**	45	1.971	**191.58**
3	**3.3333**	53	2.321	**224.35**
3.5	**3.8889**	56	2.452	**235.69**
4	**4.4444**	56	2.452	**234.33**
4.5	**5.0000**	54	2.365	**224.65**
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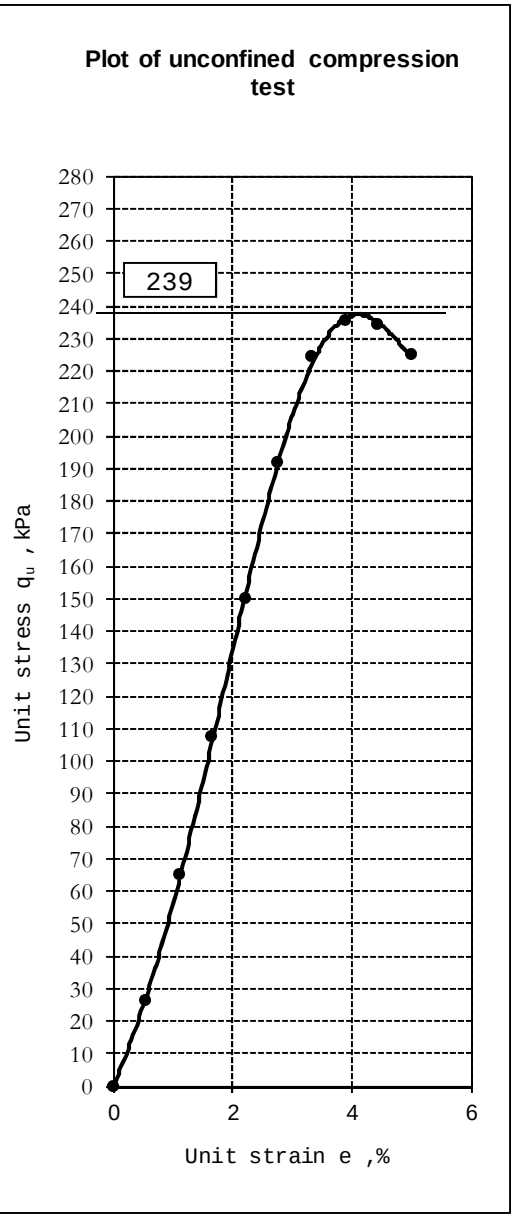

Unconfined Compressive Strength q_U = **239** kPa

Cohesion = q_u / 2 = **119.5** kPa

Borehole : **S8**

Sample No:	Depth:19.5- 19.55m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.70	
Plasticity Index I_P (%)		Area A_0 , cm^2	10.747	
Specific gravity G_s		Bulk Density , g/cm^3	**1.981**	
Proving ring capacity	680.27kg	Moisture Cont., %	**14.70**	
		Dry Density , g/cm^3	**1.727**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5556**	9	0.353	**35.07**
1	**1.1111**	20	0.784	**77.50**
1.5	**1.6667**	30	1.176	**115.59**
2	**2.2222**	40	1.567	**153.25**
2.5	**2.7778**	50	1.959	**190.48**
3	**3.3333**	50	1.959	**189.39**
3.5	**3.8889**	47	1.842	**177.00**
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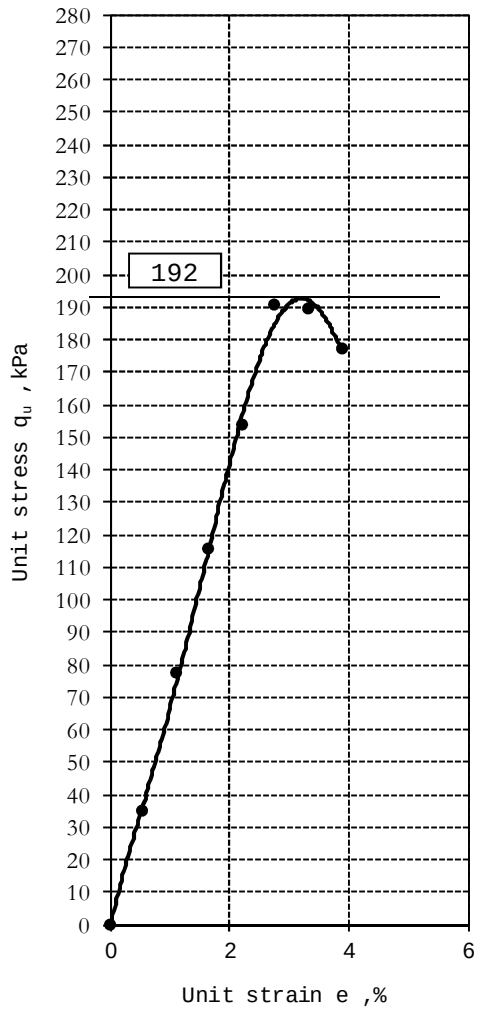
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **192** kPa

Cohesion = q_u / 2 = **96** kPa

Borehole : **S9**

Sample No:	Depth:6.00- 6.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	8.5	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_o , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**1.953**	
Proving ring capacity	680.27kg	Moisture Cont., %	**22.92**	
		Dry Density , g/cm^3	**1.589**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5882**	6	0.263	**26.12**
1	**1.1765**	12	0.525	**51.93**
1.5	**1.7647**	16	0.701	**68.83**
2	**2.3529**	20	0.876	**85.52**
2.5	**2.9412**	24	1.051	**102.01**
3	**3.5294**	28	1.226	**118.29**
3.5	**4.1176**	30	1.314	**125.96**
4	**4.7059**	30	1.314	**125.19**
4.5	**5.2941**	27	1.182	**111.97**
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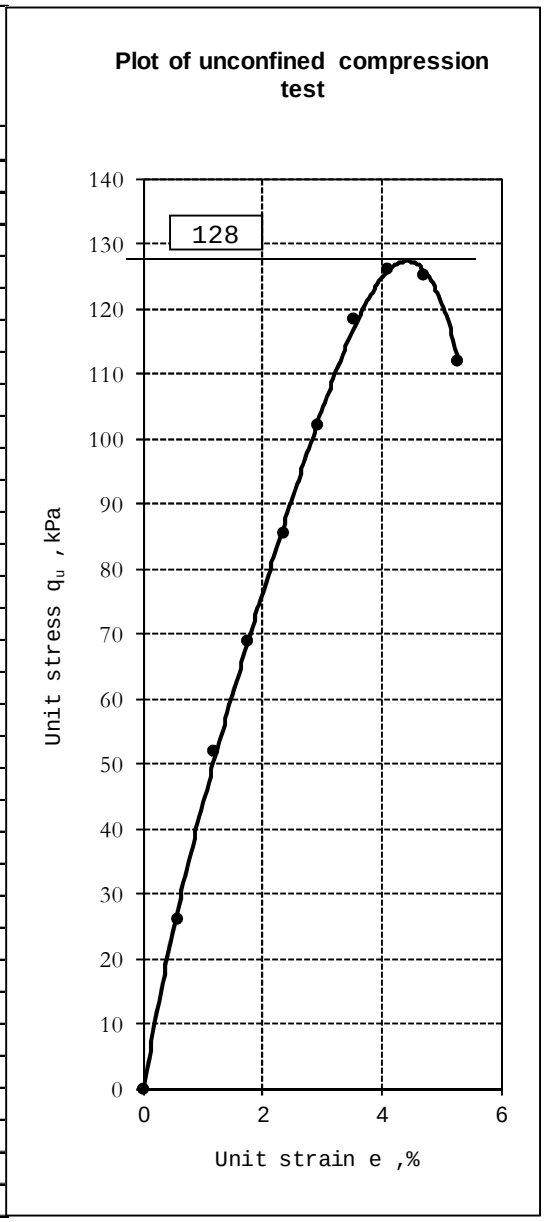

Unconfined Compressive Strength q_U = **128** kPa

Cohesion = q_u / 2 = **64** kPa

Borehole : **S9**

Sample No:	Depth: 19.50- 19.95m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_o , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.140**	
Proving ring capacity	680.27kg	Moisture Cont., %	**20.69**	
		Dry Density , g/cm^3	**1.773**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5556**	6	0.263	**26.13**
1	**1.1111**	10	0.438	**43.30**
1.5	**1.6667**	14	0.613	**60.28**
2	**2.2222**	18	0.788	**77.07**
2.5	**2.7778**	22	0.963	**93.66**
3	**3.3333**	26	1.139	**110.06**
3.5	**3.8889**	30	1.314	**126.26**
4	**4.4444**	30	1.314	**125.53**
4.5	**5.0000**	27	1.182	**112.32**
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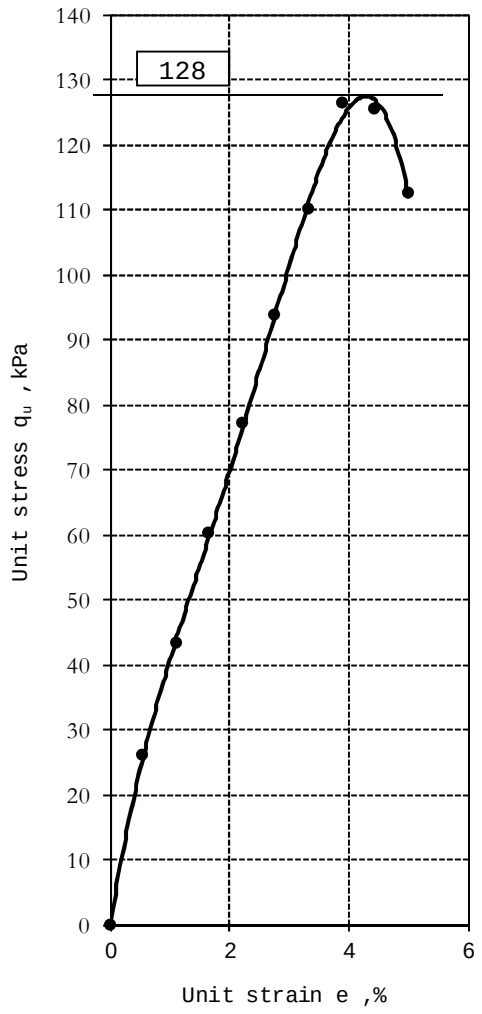
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **128** kPa

Cohesion = q_u / 2 = **64** kPa

- **Transmission line 230kV Mid point WPP/NPP to GS5 Substation**

Borehole : **T1**

Sample No:	Depth: 6.00- 6.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.1	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_0 , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.022**	
Proving ring capacity	680.27kg	Moisture Cont., %	**15.35**	
		Dry Density , g/cm^3	**1.752**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5495**	10	0.438	**43.55**
1	**1.0989**	20	0.876	**86.62**
1.5	**1.6484**	30	1.314	**129.21**
2	**2.1978**	40	1.752	**171.31**
2.5	**2.7473**	50	2.190	**212.94**
3	**3.2967**	60	2.627	**254.08**
3.5	**3.8462**	70	3.065	**294.74**
4	**4.3956**	80	3.503	**334.92**
4.5	**4.9451**	90	3.941	**374.62**
5	**5.4945**	100	4.379	**413.84**
5.5	**6.0440**	100	4.379	**411.44**
6	**6.5934**	97	4.248	**396.76**
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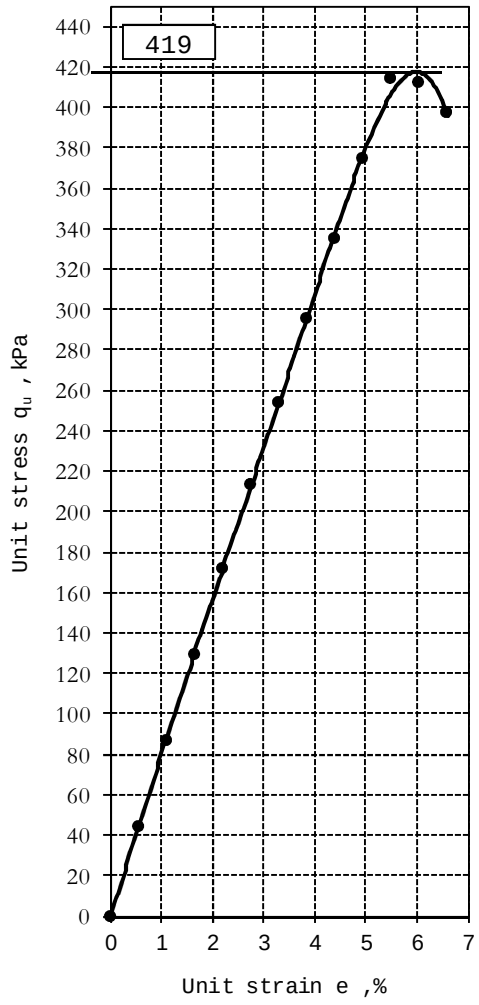
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **419** kPa

Cohesion = q_u / 2 = **209.5** kPa

Borehole : **T2**

Sample No:	Depth: 4.50- 4.95m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.1	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.60	
Plasticity Index I_P (%)		Area A_0 , cm^2	10.174	
Specific gravity G_s		Bulk Density , g/cm^3	**2.175**	
Proving ring capacity	680.27kg	Moisture Cont., %	**14.58**	
		Dry Density , g/cm^3	**1.899**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5495**	10	0.414	**41.16**
1	**1.0989**	20	0.828	**81.87**
1.5	**1.6484**	30	1.242	**122.13**
2	**2.1978**	40	1.656	**161.93**
2.5	**2.7473**	50	2.070	**201.27**
3	**3.2967**	60	2.483	**240.16**
3.5	**3.8462**	70	2.897	**278.60**
4	**4.3956**	80	3.311	**316.58**
4.5	**4.9451**	90	3.725	**354.10**
5	**5.4945**	95	3.932	**371.61**
5.5	**6.0440**	95	3.932	**369.45**
6	**6.5934**	91	3.767	**351.83**
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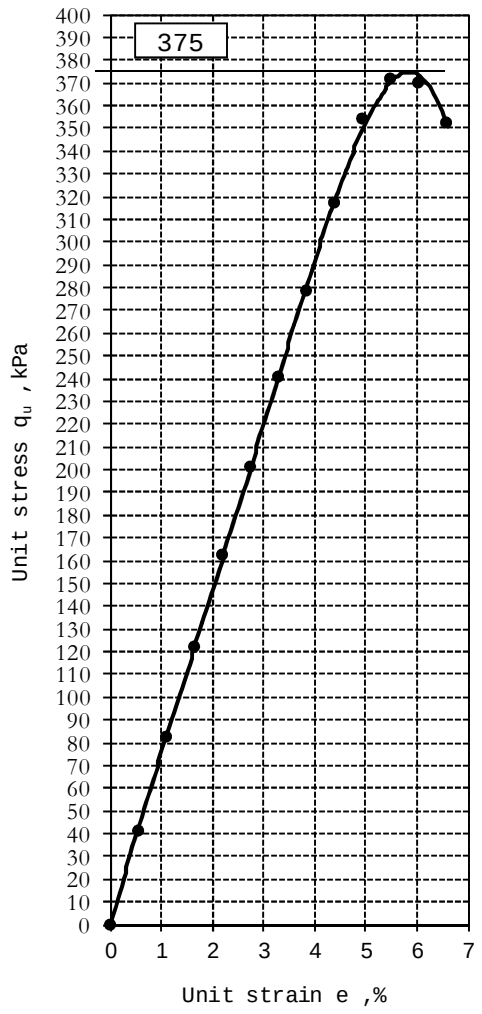
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **375** kPa

Cohesion = q_u / 2 = **187.5** kPa

Borehole : **T2**

Sample No:	Depth: 6.00- 6.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	8.6	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_o , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**2.058**	
Proving ring capacity	680.27kg	Moisture Cont., %	**16.48**	
		Dry Density , g/cm^3	**1.767**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5814**	10	0.438	**43.54**
1	**1.1628**	15	0.657	**64.92**
1.5	**1.7442**	25	1.095	**107.57**
2	**2.3256**	35	1.533	**149.70**
2.5	**2.9070**	45	1.971	**191.33**
3	**3.4884**	51	2.233	**215.54**
3.5	**4.0698**	51	2.233	**214.24**
4	**4.6512**	49	2.146	**204.59**
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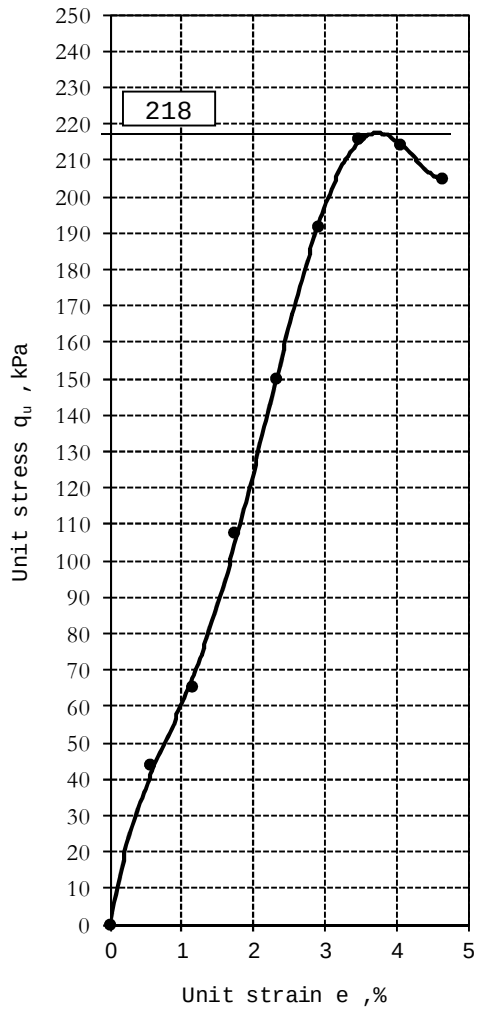
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **218** kPa

Cohesion = q_u / 2 = **109** kPa

- **Transmission line 115kV GS5 to Chroy Changvar Substation**

Borehole : **T3**

Sample No:	Depth: 3.00- 3.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.50	
Plasticity Index I_P (%)		Area A_0 , cm^2	9.616	
Specific gravity G_s		Bulk Density , g/cm^3	**1.905**	
Proving ring capacity	680.27kg	Moisture Cont., %	**14.89**	
		Dry Density , g/cm^3	**1.658**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	σ = P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5556**	10	0.438	**43.55**
1	**1.1111**	20	0.876	**86.61**
1.5	**1.6667**	30	1.314	**129.18**
2	**2.2222**	40	1.752	**171.27**
2.5	**2.7778**	47	2.058	**200.10**
3	**3.3333**	51	2.233	**215.89**
3.5	**3.8889**	51	2.233	**214.65**
4	**4.4444**	47	2.058	**196.67**
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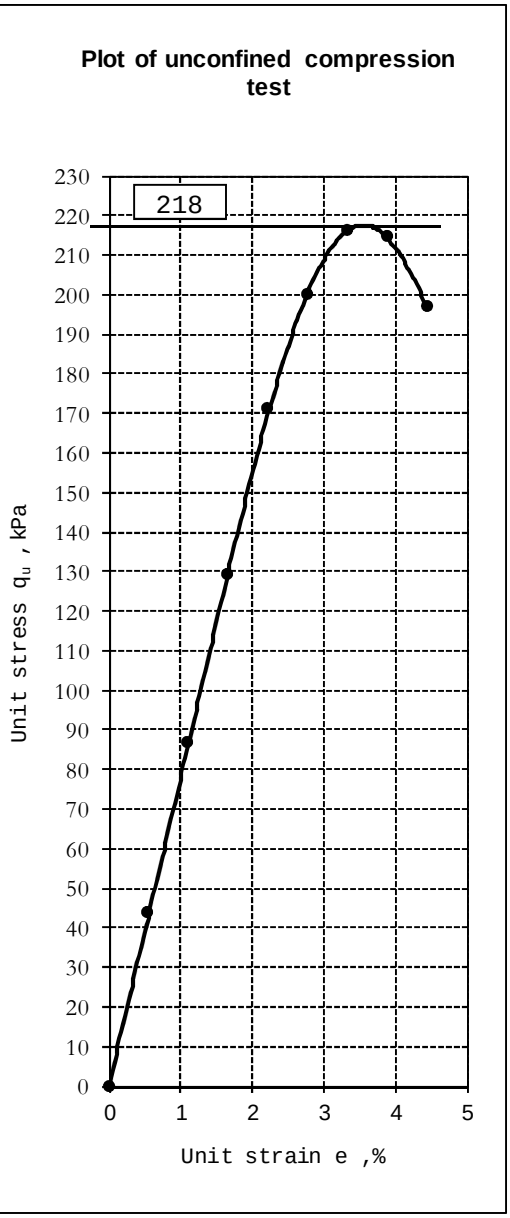

Unconfined Compressive Strength q_U = **218** kPa

Cohesion = q_u / 2 = **109** kPa

Borehole : **T4**

Sample No:	Depth: 3.00- 3.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	8.5	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.60	
Plasticity Index I_P (%)		Area A_o , cm^2	10.174	
Specific gravity G_s		Bulk Density , g/cm^3	**1.681**	
Proving ring capacity	680.27kg	Moisture Cont., %	**27.05**	
		Dry Density , g/cm^3	**1.323**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5882**	4	0.166	**16.46**
1	**1.1765**	8	0.331	**32.72**
1.5	**1.7647**	13	0.538	**52.86**
2	**2.3529**	16	0.662	**64.67**
2.5	**2.9412**	20	0.828	**80.35**
3	**3.5294**	20	0.828	**79.86**
3.5	**4.1176**	17	0.704	**67.47**
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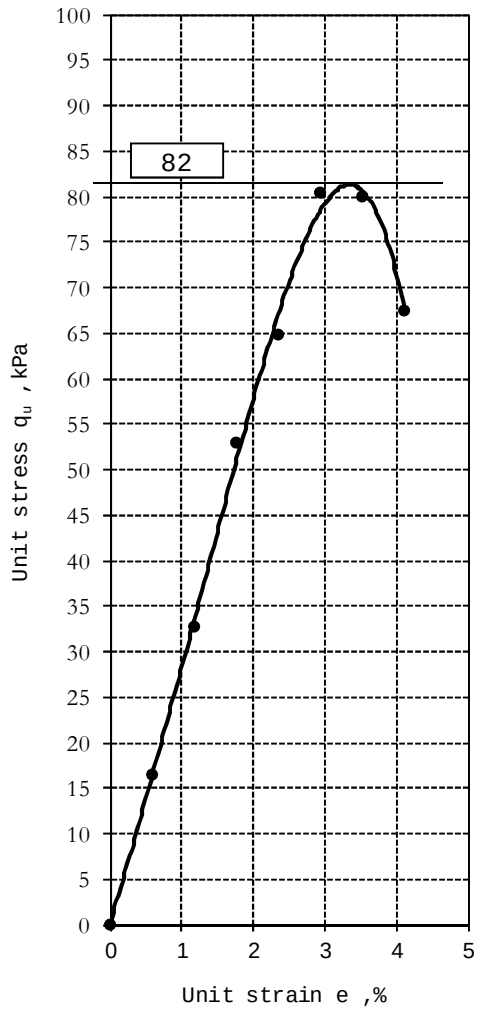
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **82** kPa

Cohesion = q_u / 2 = **41** kPa

Borehole : **T4**

Sample No:	Depth: 17.50- 17.95m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	8.7	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.60	
Plasticity Index I_P (%)		Area A_0 , cm^2	10.174	
Specific gravity G_s		Bulk Density , g/cm^3	**1.866**	
Proving ring capacity	680.27kg	Moisture Cont., %	**25.82**	
		Dry Density , g/cm^3	**1.483**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	$\sigma =$ P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5747**	6	0.248	**24.69**
1	**1.1494**	15	0.621	**61.37**
1.5	**1.7241**	22	0.911	**89.49**
2	**2.2989**	26	1.076	**105.14**
2.5	**2.8736**	30	1.242	**120.61**
3	**3.4483**	36	1.490	**143.87**
3.5	**4.0230**	40	1.656	**158.91**
4	**4.5977**	44	1.821	**173.75**
4.5	**5.1724**	48	1.987	**188.40**
5	**5.7471**	48	1.987	**187.26**
5.5	**6.3218**	45	1.863	**174.49**
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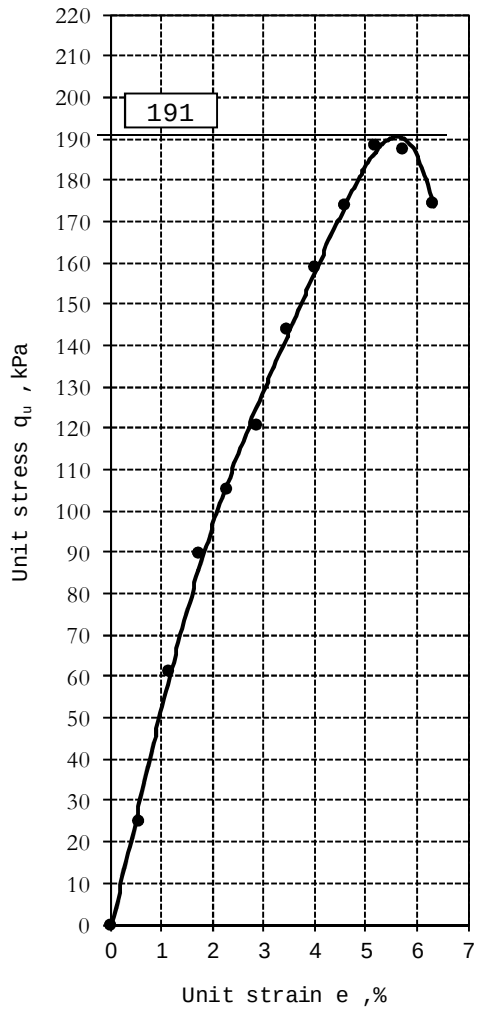
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **191** kPa

Cohesion = q_u / 2 = **95.5** kPa

Borehole : **T5**

Sample No:	Depth: 3.00- 3.45m	Tested date :20/07/2014
Tested by: Mr.Sum Bunkong	Checked by:Mr. Ket Chansavuth	

Liquid Limit W_L (%)		Height L_0 , cm	9.5	Sketch of failure
Plastic Limit W_P (%)		Diameter , cm	3.40	
Plasticity Index I_P (%)		Area A_o , cm^2	9.075	
Specific gravity G_s		Bulk Density , g/cm^3	**1.985**	
Proving ring capacity	680.27kg	Moisture Cont., %	**24.84**	
		Dry Density , g/cm^3	**1.590**	

Sample deformation (mm)	ε , % $\Delta L/L_0 *100$	Proving ring 1/100mm	Total load on sample kgf/cm^2	σ = P(1-ε/100) kN/m^2
0	**0**	0	0	**0**
0.5	**0.5263**	4	0.186	**18.46**
1	**1.0526**	7	0.325	**32.14**
1.5	**1.5789**	9	0.418	**41.10**
2	**2.1053**	11	0.510	**49.97**
2.5	**2.6316**	13	0.603	**58.74**
3	**3.1579**	13	0.603	**58.42**
3.5	**3.6842**	10	0.464	**44.69**
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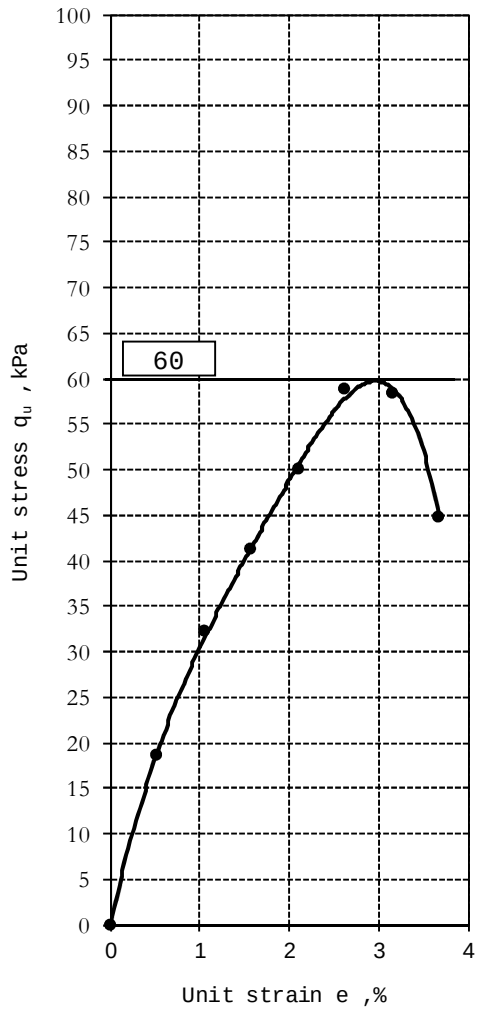
Plot of unconfined compression test



Unconfined Compressive Strength q_U = **60** kPa

Cohesion = q_u / 2 = **30** kPa

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

Sheet No.
Date: 24-Jul-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. S1 Elevation: m
PROJECT : CHROY CHANGVAR SUBSTATION
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 µ m (%)		q_u (kPa)	Cohesion (kPa)	ϕ (°)	C (kPa)	
	3.00- 3.45	19.83	1.961	1.636		36.3	18.3	18.1	8.6	0	9	91	98.78	CL	170	85			
	7.50- 7.95	13.05	2.174	1.923		32.4	17.2	15.3	-26.9	0	44	56	81.18	CL	178	89			
	12.00- 12.45	21.88				32.2	12.3	19.9	48.2	0	45	55	82.59	CL					

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Table No.S1

Date :24/07/2014

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

Sheet No.
Date: 24-Jul-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. S2 Elevation: m
PROJECT : CHROY CHANGVAR SUBSTATION
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	φ (°)	C (kPa)	
	3.00- 3.45	19.58	1.965	1.643		44.6	12.7	31.8	21.5	0	10	90	98.46	CL	152	76			
	7.50- 7.95	13.49				32.7	14.2	18.5	-3.9	1	46	53	84.77	CL					
	10.50- 10.95	23.45	2.012	1.630		32.9	17.9	15.0	36.9	0	13	87	95.01	CL	212	106			

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Table No.S2

Date :.....24...../..07...../2014.....

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

Sheet No.
Date: 06-Jun-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. **S3** Elevation: m
PROJECT :
LOCATION: **Tuol Kork**

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	φ (°)	C (kPa)	
SPT-2	3.00- 3.45	14.26	2.148	1.880		37.6	17.6	20.1	-16.4	1	37	62	86.07	CL	125	62.5			
SPT-4	6.00- 6.45	18.75								0	82	18	85.89	SM					
SPT-6	9.00- 9.45	18.84								0	86	14	84.00	SM					
SPT-10	15.00- 15.45	14.08				23.8	14.2	9.6	-1.4	0	62	38	50.73	SC					

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Table No.S3

Date :..06...../..06...../..2014.....

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

Sheet No.
Date: 06-Jun-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. **S4** Elevation: m
PROJECT :
LOCATION: **Tuol Kork**

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 µ m (%)		q_u (kPa)	Cohesion (kPa)	ϕ (°)	C (kPa)	
SPT-1	1.50- 1.95	26.46	1.923	1.521		45.0	17.6	27.4	32.3	1	29	70	92.50	CL	60	30			
SPT-2	3.00- 3.45	16.06	2.173	1.872		39.0	18.2	20.8	-10.3	0	37	63	86.55	CL	189	94.5			
SPT-3	4.50- 4.95	17.45								6	93	1	47.94	SM					
SPT-6	9.00- 9.45	17.80								0	84	16	86.76	SM					
SPT-8	12.00- 12.45	17.12								0	90	10	70.38	SM					

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Table No.S4

Date: 06 / 06 / 2014

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

Sheet No.
Date: 24-Jul-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No: **S5** Elevation: m
PROJECT : **GS 5 SUBSTATION**
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	ϕ (°)	C (kPa)	
	3.00- 3.45	13.79	2.046	1.798		54.2	15.4	38.8	4.1	0	31	69	86.95	CH	200	100			
	7.50- 7.95	10.64				19.0	18.5	0.5	-1679	1	76	23	31.63	SM					
	12.00- 12.45	13.43	2.220	1.957		26.2	18.5	7.7	-66.5	1	80	19	42.95	SM	152	76			

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Table No.GS5

Date :.....24...../.....07...../.....2014.....

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

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Date: 24-Jul-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. **S6** Elevation: m
PROJECT : **GS 5 SUBSTATION**
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	φ (°)	C (kPa)	
	3.00- 3.45	19.17	2.047	1.718		45.3	16.5	28.9	9.4	2	24	74	91.60	CL	142	71			
	7.50- 7.95	12.71				30.4	13.0	17.4	-1.6	2	77	21	29.56	SC					
	12.00- 12.45	17.19				33.5	17.3	16.1	-0.9	1	37	62	74.42	CL					

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Table No.GS6

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Engineering Department
Soil Quality Analysis Office

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SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. S7 Elevation: m
PROJECT : GS 5 SUBSTATION
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 µ m (%)		q_u (kPa)	Cohesion (kPa)	ϕ (°)	C (kPa)	
	3.00- 3.45	19.14	1.997	1.676		53.8	16.9	36.9	6.2	1	34	65	89.46	CH	88	44			
	6.00- 6.45	14.03	2.016	1.768		23.8	11.5	12.3	20.7	0	78	22	34.88	SC	121	60.5			
	12.00-12.45	10.79				23.3	13.0	10.4	-21.0	3	65	32	73.62	SC					

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SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. S8 Elevation: m
PROJECT : CHROY CHANGVAR SUBSTATION
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	φ (°)	C (kPa)	
	6.00- 6.45	19.25	1.923	1.613		40.2	20.1	20.1	-4.1	0	6	94	98.36	CL	239	119.5			
	19.50- 19.95	14.70	1.981	1.727		41.0	18.1	22.9	-14.8	1	12	87	98.41	CL	192	96			
	24.00- 24.45	18.68				21.0	12.7	8.3	71.9	0	73	27	98.75	SC					

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Soil Quality Analysis Office

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SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. S9 Elevation: m
PROJECT : CHROY CHANGVAR SUBSTATION
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	φ(°)	C (kPa)	
	6.00- 6.45	22.92	1.953	1.589		55.4	15.5	40.0	18.6	0	7	93	97.83	CH	128	64			
	19.50- 19.95	20.69	2.140	1.773		31.2	16.2	15.0	30.1	1	27	72	95.99	CL	128	64			
	24.00- 24.45	18.50								1	79	20	95.22	SM					

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Date :.....24...../.....07...../.....2014.....

Ministry of Water Resources and Meteorology
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Sheet No.
Date: 24-Jul-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. T1 Elevation: m
PROJECT : Transmission Line 230KV mid point WPP/NPP
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	ϕ (°)	C (kPa)	
	3.00- 3.45	13.20				29.4	14.9	14.6	-11.3	1	55	44	90.53	SC					
	6.00- 6.45	15.35	2.022	1.753		29.7	14.0	15.7	8.7	0	20	80	94.50	CL	419	209.5			
	10.50- 10.95	17.40				27.0	19.9	7.1	-34.9	1	53	46	73.37	SC					

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Table No.T1

Date :....24...../...07...../2014.....

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

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SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. T2 Elevation: m
PROJECT : Transmission Line 230KV mid point WPP/NPP
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	φ (°)	C (kPa)	
	3.00- 3.45	10.97				53.6	18.0	35.6	-19.9	0	31	69	85.33	CH					
	4.50- 4.95	14.58	2.175	1.898		37.7	18.1	19.6	-18.0	1	43	56	81.83	CL	375	187.5			
	6.00- 6.45	16.48	2.058	1.767		38.2	16.0	22.2	2.3	5	39	56	77.93	CL	218	109			

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Date :..24../..07../..2014....

Table No.T2

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

Sheet No.
Date: 24-Jul-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. T3 Elevation: m

PROJECT : Transmission Line 230KV mid point WPP/NPP

LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay (%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	φ (°)	C (kPa)	
	3.00- 3.45	14.89	1.905	1.658		37.5	14.1	23.4	3.4	0	11	89	96.60	CL	218	109			
	9.00- 9.45	19.31				21.4	13.7	7.7	72.9	0	74	26	87.96	SC					
	12.00- 12.45	15.63								0	80	20	83.84	SM					

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KET CHANSAVUTH

Table No.T3

Date :.....24...../...07...../2014.....

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

Sheet No.
Date: 24-Jul-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. T4 Elevation: m
PROJECT : Transmission Line 230KV mid point WPP/NPP
LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	φ (°)	C (kPa)	
	3.00- 3.45	27.05	1.681	1.323		42.1	14.9	27.2	44.6	0	3	97	99.45	CL	82	41			
	7.50- 7.95	21.95				46.4	17.4	28.9	15.7	0	5	95	98.66	CL					
	16.50- 16.95	13.20								3	89	8	21.98	SM					
	17.50- 17.95	25.82	1.866	1.483											191	95.5			

SIGNATURE
Director Laboratory

KET CHANSAVUTH

Table No.T4

Date :....24..../..07..../2014.....

Ministry of Water Resources and Meteorology
Engineering Department
Soil Quality Analysis Office

Sheet No.
Date: 24-Jul-14

SUMMARY OF LABORATORY TEST RESULTS

BOREHOLE No. **T5** Elevation: m

PROJECT : Transmission Line 230KV mid point WPP/NPP

LOCATION:

Sample No.	Depth (m)	W (%)	Densities		G_s	Atterberg Limits				Grain size distribution				Soil Class	Uncof.Compr.		Direct Shear		Es (kPa)
			ρ_w (T/m^3)	ρ_d (T/m^3)		LL (%)	PL (%)	PI (%)	I_L (%)	Gravel (%)	Sand (%)	Silt+Clay(%)	<425 μ m (%)		q_u (kPa)	Cohesion (kPa)	φ (°)	C (kPa)	
	3.00- 3.45	24.84	1.985	1.590		42.7	18.9	23.8	24.9	0	3	97	99.25	CL	60	30			
	7.50- 7.95	32.76				30.9	15.2	15.7	112.0	0	28	72	99.55	CL					
	16.50- 16.95	27.97				19.2	16.1	3.1	385.7	0	82	18	99.68	CL-ML					

Table No.T5

SIGNATURE
Director Laboratory

KET CHANSAVUTH

Date :.....24...../.....07...../2014.....

IV. CONCLUSION

The calculation results here are just a calculation base on the data obtained from limited soil test study. To obtain more precise and more reliable data and results, further full-scale investigation and study shall be conducted prior to the construction time.

Further detail foundation size and embedded depth will be design according to loads of tower, substation building or high voltage electrical equipment and underground water level.

Every soil test locations are not too bad for construction except borehole S8 and S9 at Chroy Changvar Substation which is the needed to consider about the design depth of pile plus the height of soil backfill.

V. BOREHOLE LOCATION LAYOUT

Figure 5 – NCC Substation

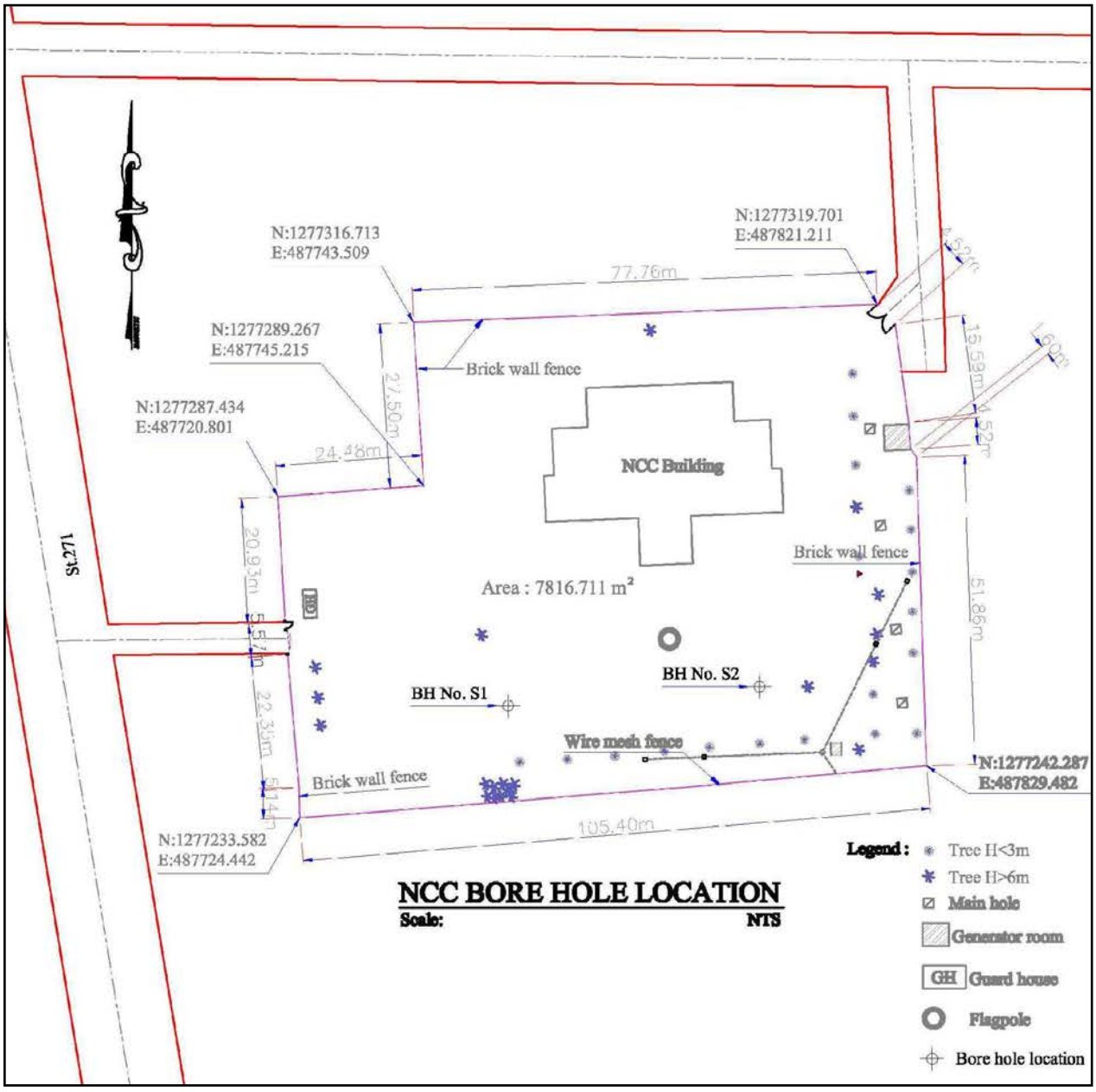


Figure 6 – Tuol Kork Substation

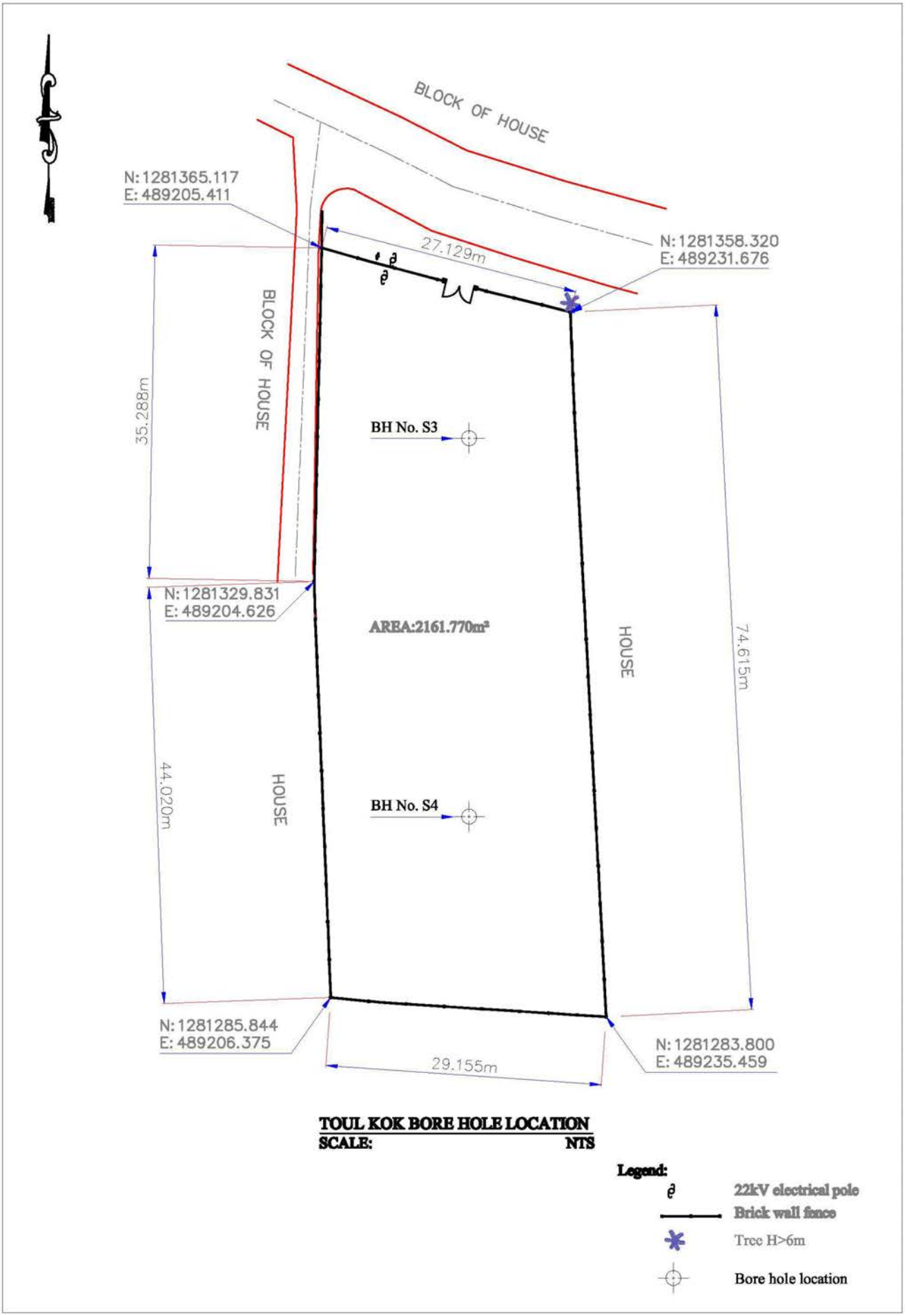


Figure 7 – GS5 Substation

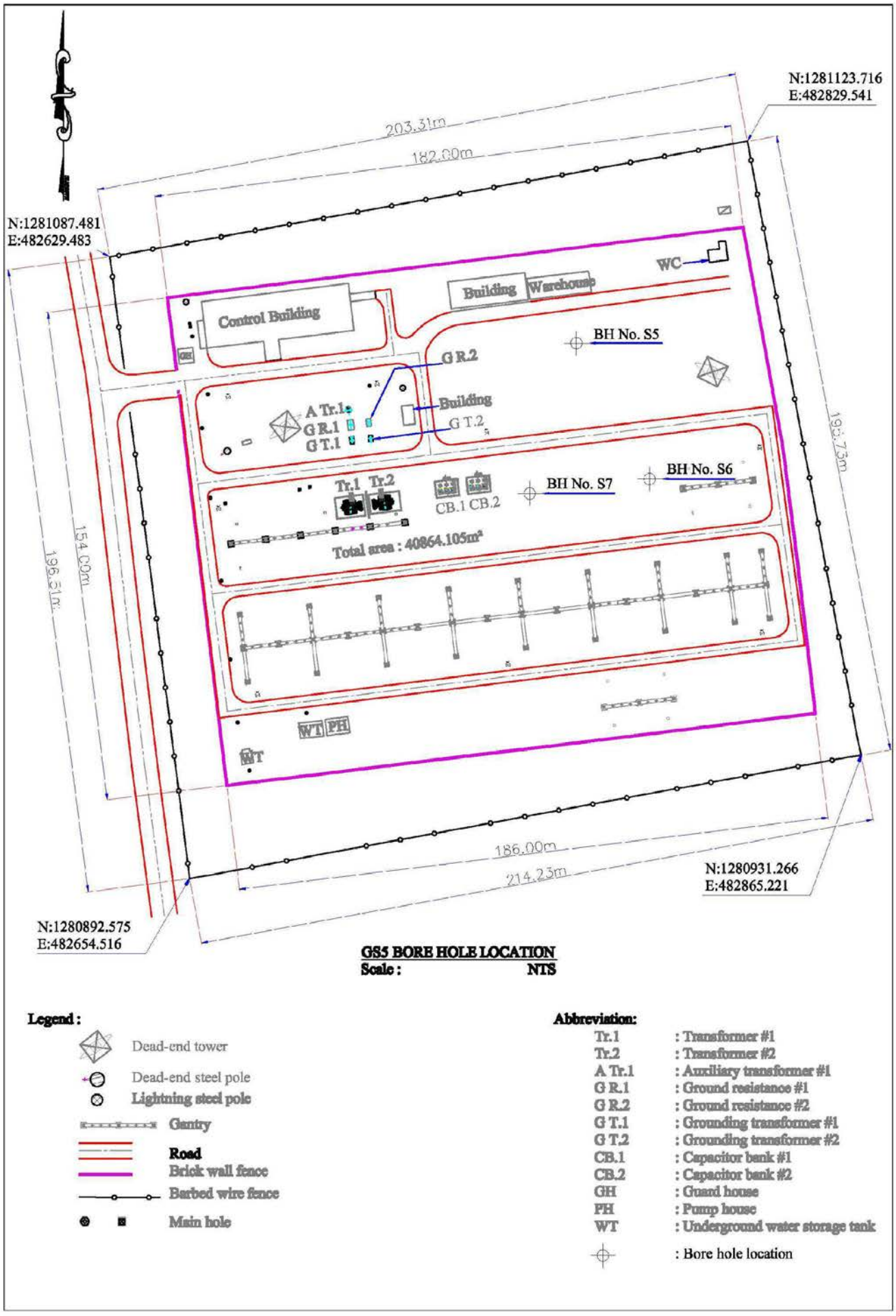


Figure 8 – Chroy Changvar Substation

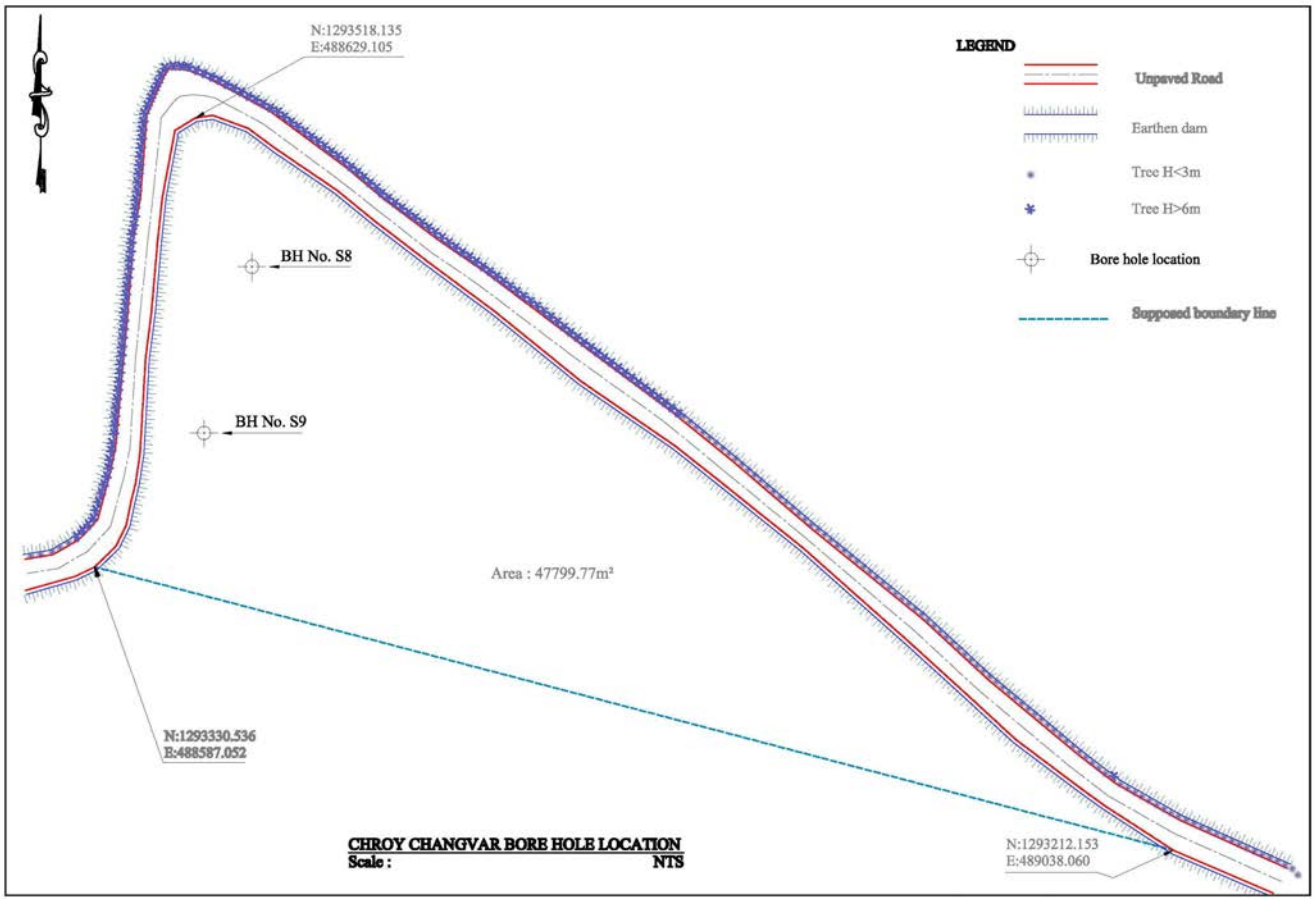


Figure 9 – Transmission line 230kV Mid point WPP/NPP to GS5 Substation

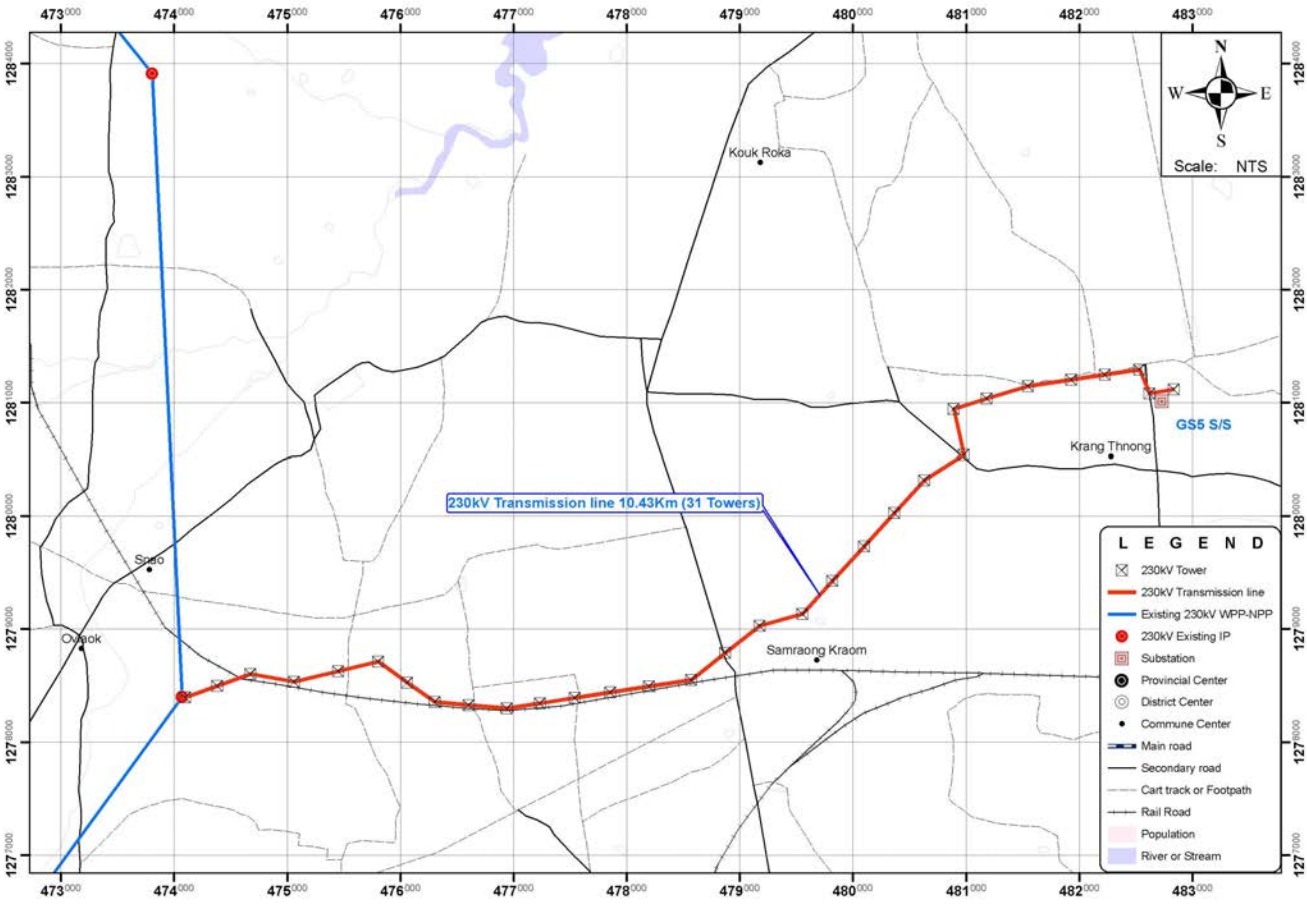
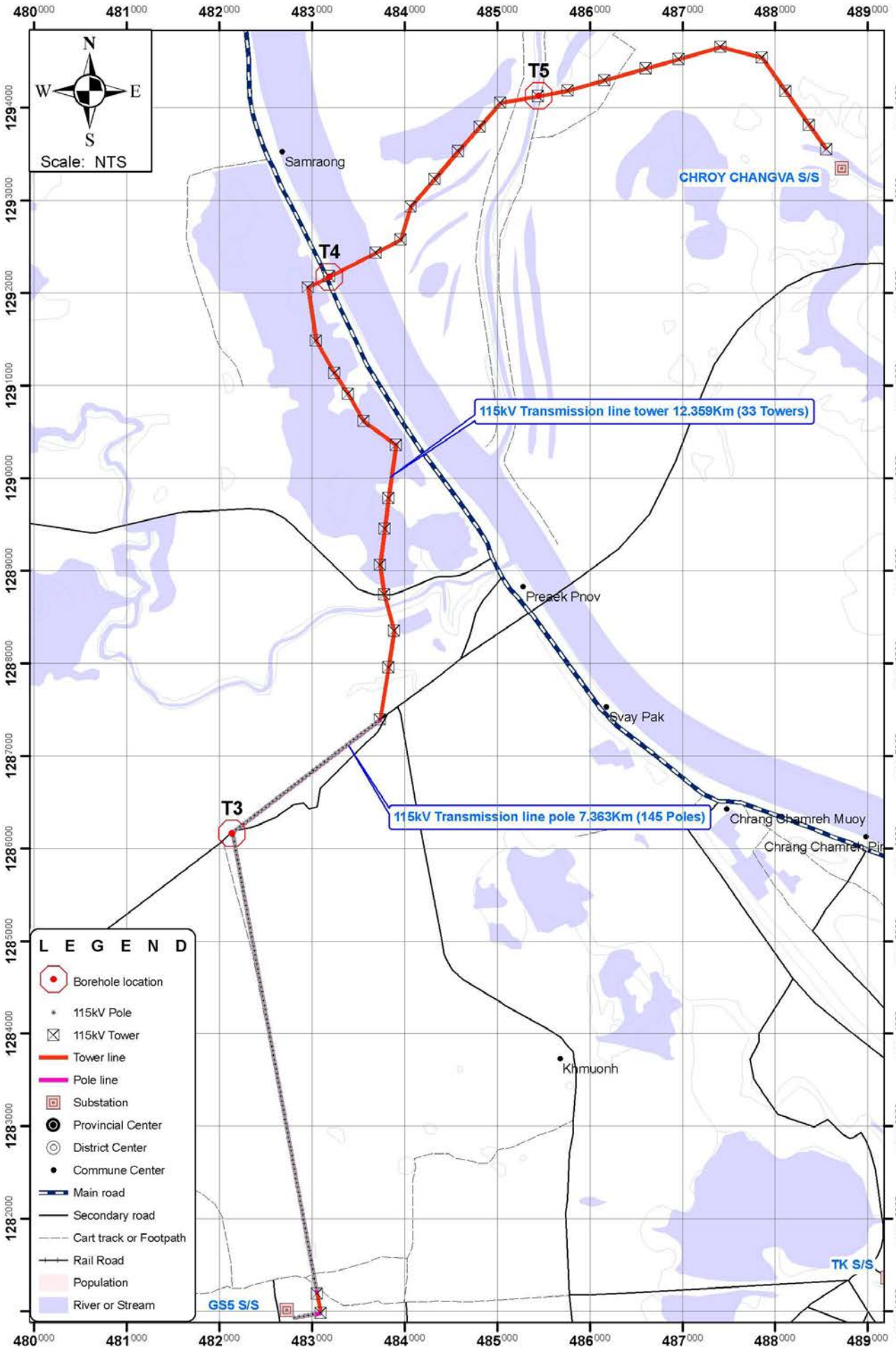


Figure 10 – Transmission line 115kV GS5 to Chroy Changvar Substation



VI. PICTURE OF ACTIVITIES

Field test

BH: S1 (GS5 SS)

BH: S1 (GS5 SS)

BH: S3 (Tuol Kork SS)

BH: S4 (Tuol Kork SS)

BH: S5 (GS5 SS)

BH: S6 (GS5 SS)

BH: S7 (GS5 SS)

BH: S8 (Chroy Changvar SS)

BH: S9 (Chroy Changvar SS)

BH: T1

BH: T2

BH: T3

BH: T4

BH: T5

Laboratory test

APPENDIX-3

MINUTES OF MEETING

Appendix-3 Minutes of Meetings

==========

1. Minutes of First Stakeholder Meeting

Date:	Tuesday, April 29th, 2014		
Time:	9:00AM-11:15AM		
Location:	Conference Room of EDC, Building A		
Purpose:	1. Public Disclosure for Stakeholders; 2. Collection of Stakeholders on the Project and Envisaged Environmental Impact		
Attendees: **(28 persons)**	JICA Survey Team	6 persons	See attached list
	Representative of JICA Cambodia	1 person	
	Phnom Penh City Hall	1 person	
	EIA office, Ministry of Environment (MOE)	2 persons	
	Department of Land Management Urban Planning, Construction and Cadastral	1 person	
	Department of Land Management, Urban Planning and Construction, Phnom Penh	1 persons	
	Ang Snuol District, Kandal province	1 person	
	Por Senchey Khan[1]	1 person	
	Saen Sok Khan	1 person	
	Tuol Kouk Khan	1 person	
	EDC	12 persons	
Outcome:			
Dr. **Chulasa PRAING** (9:10AM-9:35AM)	The meeting was chaired by Dr. Chulasa Praing, Deputy Managing Director, EDC. Summary of his opening remarks of Dr. Praing Chulasa is as follows: "Today, I am very pleased to meeting all of you. I much appreciate and welcome for your participation today. Before starting the presentation for the first stakeholder meeting for Phase - 2 of the subject Project, I would like to share you some information related to the Phase – 1 Project. For Phase-1 of the Project, the study itself has already been completed. The two consulting firms, namely Tokyo Electric and NIPPON KOEI conducted the study of Phase - 1. There were two main line routes for the underground of High Voltage Transmission Line of 115 kV. (1) From substation (GS3) in O Bek Kaom to substation at Olympic stadium with 300 MVA of the transformer capacity. It continued from the substation at Olympic stadium to another substation in Hun Sen Garden (next to Koh Pich island) with about 150 MVA of the transformer capacity. (2) Another line started from Grid Substation #1 in Toul Sangkae (at the North of Phnom Penh) to the new substation at EDC headquarters. This line also linked to the substation at Hun Sen Garden (next to Koh Pich island). Anyway, for the line from substation at Hun Sen Garden to GS2 at Khbal Khnal was not included in the Phase 1 project. Our Prime Minister, Samdech Hun Sen, provided land in Hun Sen Garden for the substation construction and office. We will have team in this office for intervention whenever it faces problem, because here there are building of national assembly, foreign affairs and international cooperation, Royal Palace, etc., so we need another office here. For location in Olympic Stadium, Ministry of Education, Youth and Sports has already agreed to provide the land to EDC for substation construction. It is the first time that we will have substations constructed in the building in Phnom Penh like Olympic Stadium, Hun Sen Garden with high capacity, Really, the cost of land in these locations is very high; however for substation in suburban areas, we can construct		

[1] Khan is Khmer word used for district in City (Khan=District).

	our substation as usual in the open land due to its cost of land. For Phase-1 project, it is preparing for bid for implementation next year. Anyway, this Phase-2 project is going to extend from Phase 1. High-voltage transmission line of 230 kV will be installed to reach Phnom Penh City in this phase. As present condition, High-voltage transmission line of 230 kV is just located at around Phnom Penh. We will distribute to the central part of Phnom Penh through overhead transmission line of 115 kV. Thus, Phnom Penh City will get electricity around 500 or 600 MW after the completion of Phase-2 project. The requirement of electricity for Phnom Penh is very high; it is about 70% in total demand in the country. So, this meeting is the first stakeholder meeting for Phase-2 project. We would like to suggest all of the participants from the affected areas by the project in Phnom Penh City and Kandal province *(Phnom Penh: Toul Kork Khan, Sen Sok Khan, Pour Senchey Khan, Rousey Keo Khan and Ang Snoul district in Kandal province)* to facilitate and cooperate with our study team in order to resolve any problems because it is the project of Royal Government in which the loan comes from the Government of Japan including the Consultant from Japan too. Therefore, we have to cooperate in order to get good results. After general introduction of the Project and its purpose, Dr. Chulasa Praing, he declared to open the meeting then let JICA survey team to give the presentation."
Mr. Say Bora Representative of JICA-Cambodia (9:35-9:40)	Mr. Bora gave some words on behalf of JICA as Mr. Watanabe could not attend in the meeting. "We hope that all of the stakeholders will participate well with this Project; then the Consultant should do with the good solution for any affection. Thanks to you all."
Mr. Yukao Tanaka, Team Leader (9:40-10:00)	Mr. Tanaka provided statement on behalf of the JICA Survey Team. "Good morning. First of all, I would like to say hello to all participants. My name is Yukao Tanaka, Team Leader for this Preparatory Survey for Phase 2. Surely, this Project is very important for Phnom Penh City as Dr. Praing Chulasa mentioned in his opening remarks. The Project will contribute to meet the future power demand. Anyway, this Project is similar to the Phase 1 Project of which the tudy was completed earlier. After completion of Phase 1 study, JICA decided to continue for Phase 2 Study. NEWJEC and The Chugoku Electric were selected by JICA to conduct the Preparatory Survey for Phase 2 Project. Thus, we will try our best to complete the study satisfactory to Cambodian side including environmental issues. So, this meeting is very essential and important for carrying out the study. Finally, in this opportunity we express heartfelt gratitude to your kind cooperation and understanding on the project in advance.
Mr. Sour Sethy and Mr. Mao Visal (10:00-10:30)	Based on the Presentation Paper as attached to this Minutes, presentation in Khmer language was done.
	Discussion Session
Mr. Khiev Sam Oeun, Vice Governor of Sen Sok Khan (10:35-10:45)	As previous time, we had already faced with some problems on the affected land by large poles of transmission line. Thus, please tell us the way or method of solution for the affected people. Does the project pay to the affected people based on the present market price of land or assets? They (developer) have negotiated with the affected people for the cost of land based on the present value. However, it was not the same price when EDC paid the compensation. **<u>Suggestion</u>**: - Please show me the affected locations in Sen Sok Khan. - Please provide us the clear route of that line. We will be easy to inform to the people. **<u>Responded by</u>**: EDC (Dr. **Chulasa PRAING)** - For this matter, we had the independent team to investigate and study about the cost of land in 2010. However, they started to compensate in 2012, while the cost

	of land was increasing by month. The most of the problems resulted from long time delay for compensation thus the price changed from the time of study. Thus, we know about this problem. - So, we suggested this Project (Phase-2) should proceed faster to avoid happening of this kind of matter again. - We will try to reduce impacts and the problems as much as possible.
Mr. Ou Sophorn, EIA Department, MoE	We are happy with EDC to proceed this Project. But, related to EIA's works I would like to share some information as follows: - At the moment, we have the new procedure to make faster in the department of EIA. - Project owner should submit the TOR for the EIA study to EIA Department (MoE) before starting the study. - International Consultant should do operate with local consultants which is listed by MoE to study and prepare report of IEIA or EIA. - As this Project is categorized as B, it should prepare the IEIA. Thus please add and follow the guideline of Environmental Impact Assessment, Prakas No. 376. We also have the new internal procedure as follows: - There is no more inter-ministry meeting for EIA or IEIA report. - MoE established a unit to check quality of the EIA/IEIA report. - EIA department will visit the project site in order to decide and evaluate the submitted report. **Question raised by EDC, Mr. Mao Visal** - Will the project of Royal Government also need to submit the report of EIA/IEE to obtain approval from CDC? - What is the format of TOR? Does MoE have the format? If there is, we will follow that one. **Answered by Mr. Ou Sophorn, EIA Department, MoE** - No need to submit EIA/IEE to CDC because it is the project of the government. The report will be approved only by MoE for this EDC project. Only private sector will continue to submit it to the CDC.
Mr. Pen Say, vice governor of Ang Snoul District, Kandal Province	**Question:** - How many of communes will be affected by this Project? - How the Project will compensate to the affected people? **Answered by EDC, Dr. Praing Chulasa** - We will have a team to study about that soon. - Now, the Project is ongoing, thus the location has not yet been clear. We will inform you after the study.
Mr. Chea Lyse, City Hall	We did not know about the location of the project sites, thus, we do not have idea. **Suggested by EDC, Dr. Praing Chulasa** - Local authority should cooperate with our study team in order to complete the study successfully. - Again I would like to ask your cooperation with our team.
Mr. Em Vannarith, presentation from Toul Kork Khan	I have no idea about this matter when EDC and JICA did not show us the clear location of the project in Toul Kork Khan. However, please provide us the information about this after EDC and JICA finished this study. Please tell us about the compensation method for the affected people.
Dr. Chulasa Praing (11:15 AM)	Finally, I suggested all of the participants from all institutions and Khans/Districts to please kindly cooperate with our survey team for the purpose of development in our City. I would like to express our thanks and close the meeting.

Participant List

No.	Name	Position	Organization
1	Tomokazu Kimura	Manager	JICA Survey Team
2	Dr. Praing Chulasa	Deputy Managing Director	EDC
3	Mao Visal	Manager, Social, Environmental, and Public Relation Office	EDC
4	Heav Chanvisal	Deputy Manager, Social, Environmental, and Public Relation Office	EDC
5	Kgin Kanida	Deputy Chief, Plannning, Management Information System, and Tariff Office	EDC
6	Miki Haga	Coodinator	JICA Survey Team
7	Muon Vathana	Staff, Transmission Department	EDC
8	Pen Say	Deputy Chief	Angsnoul District
9	Chet Chanprasour	Deputy Chief, Project Procurement Office	EDC
10	Dy Sanith	Deputy Chief, Urban Plannning	Ministry of Urban Planning and Construction
11	Oishi Yoshiko	Environmental Engineer	JICA Survey Team
12	Shunsuke Matusmoto	Transmissionline Engineer	JICA Survey Team
13	Junya Shinohara	Sub Team Leader / Demand Forecast, Chugoku Electric Power Co., Inc	JICA Survey Team
14	Yukao Tanaka	Team Leader / System Planning	JICA Survey Team
15	Say Bora	Officer	JICA Cambodia office
16	Sok Pounlork	Vice Chief, Legistrative Disputed and International Cooperation Office	MOE
17	Ou Sophorn	Chief of Project Review Office	MOE
18	Em Vannarith		Toul Kork Distrct
19	Bin Sopheakda	Vice Chief, Envieonmental Management Division	EDC
20	Sour You	Environmental Assistant	Chean Engineering
21	Sambath Chariya	Chief, Public Relation Division	EDC
22	Sorn Phearun	Deputy Chief, Project Study Division	EDC
23	Chhon Virys	Staff, Project Procurement Office	EDC
24	Dork Sovanmony	Chief, Procurement Office	EDC
25	Teav Someourn	Deputy Chief	Sen Sok District
26	Chea Lysae	Staff, Urban Planning Phnom Pehn	Ministry of Urban Planning and Construction
27	Ang Men	Staff	Pur Senchery District
28	Mao Kolmardi	Deputy Director, Department of Urban Management	Phnom Pehn City Hall
29	Nget Sokhan	Director, Procurement Department	EDC
30	Sour Sethyethy	Facilitator / Environmental Spacialist	Chean Engineering
31	Chun Piseth	Director of Planning & Project	EDC

2. Minutes of Second Stakeholder Meeting

Date:	Wednesday, September 10th, 2014		
Time:	3:00 PM - 5:35 PM		
Location:	Conference Room of EDC, Building A		
Purpose:	1. Public Disclosure for Stakeholders about project outline and Draft results of Environmental and Social Consideration; 2. Collection of Stakeholders' opinions on the Project and Expected Environmental Impacts and Mitigation.		
Attendees: **(29 persons)**	JICA Survey Team	4 persons	See attached list
	Phnom Penh City Hall	1 person	
	EIA office, Ministry of Environment (MOE)	1 person	
	Department of Land Management Urban Planning, Construction and Cadastral	1 person	
	Department of Public Works, Phnom Penh	2 persons	
	Ang Snuol District, Kandal province	1 person	
	Russei Keo Khan[2]	2 person	
	Sen Sok Khan	1 person	
	Tuol Kork Khan	1 person	
	EDC	7 persons	
Outcome:			
Dr.Chulasa PRAING (3:00PM-3:09PM)	The meeting was chaired by Dr. **Chulasa Praing**, Deputy Managing Director of EDC. Today, I am very pleasure to meeting you all. I much appreciate and welcome for your participation today. I would like to inform that this is the Phase 2 of the project. Phase 1 was for inside Phnom Penh, by JICA as well, 115kV underground networks starting from Ou Baek Kaom Grid Substation (GS3) - Olympic Stadium Substation (new) – Samdech Hun Sen's Park Substation (new) – EDC Headquarter (new substation) – Tuol Sangkae Grid Substation (GS1). This is the first 115kV underground networks ever be built together with another EDC's funded project (also 115kV underground networks) connecting from Kbal Thnal Grid Substation (GS2) to Samdech Hun Sen's Park Substation. This is to enhance the security and reliability of power supply for Phnom Penh. For this phase 2, the purpose is to tap power from 230kV transmission line from NPP (GS6) to supply Phnom Penh. JICA's study Phase 2 concludes that it is necessary to import huge capacity power to supply Phnom Penh area through GS5. Our transmission capacity into Phnom Penh area is nearly 1000MW. With these new transmission lines in collaborated with current transmission system will secure power supply for Phnom Penh area until year 2030, meaning over 10 years guaranteed. After general introduction of project and its purpose, Dr. Chulasa Praing, he declared to open the meeting then let JICA survey team to give the presentation about the essential of the project, open discussion about how resettlement and mitigation measures to implement to speed up the project.		
Mr. Yukao Tanaka & Translation (3:09PM-3:11PM)	Good Afternoon, My name is Yukao Tanaka. The outline was already explained by Dr. Chulasa. Firstly, we appreciate very much for your kind cooperation in our study and we hope this project will evolve smoothly of course from the support of all relevant stakeholders. We will explain the project in detail including environmental evaluation; of course, you are sharing your valuable time on this project. Thank you.		
Mr. Sour Sethy and Mr. Mao Visal (3:11PM-4:00PM)	Made the presentation		

[2] Khan is Khmer word used for district in City (Khan=District).

	Discussion Session
Mr. Duong Samkeat, Deputy Director of EIA Dpt, MoE (4:01PM-4:20PM)	Thank you for the presentation. First of all, I would like to support this project; however, I have a series of questions and/or suggestions as follows. **Suggestion**: (1) Concerning slide no. 9, Organization Chart of the Preparatory Survey for the Project, I saw the project study is by two parties, one side is a governmental institution i.e. EDC, and another side is the JICA Study Team incorporated with Consultants (two international Consultants, Newjec & Chugoku EPCO). I just would like to remind, as I expect my colleague might informed you all in the first meeting, that every project study it is oblige to cooperate with local consultant, which are listed by MoE. This is to conform to new Ministerial Prakas No. 215 issued on May 19, 2014. This requirement is to facilitate EDC when JICA Team leaves. (2) Regarding Slide No. 15, Procedure of Environmental and Social Consideration (1), my question is: Is that JICA's idea that this project requires only IEE level? Also, you show guideline of JICA, why not show guideline of MoE as well? (3) In slide No. 17, Procedure of Environmental and Social Consideration (3), after "PO submits IEIA to MoE", there are two phases for the review and comment prior to get approval by MoE. Phase 1 is "Review and comments by Dept. of EIA, MoE" and Phase 2 (which is missing in the flowchart) is **"Review and comments by ministerial level of MoE"**. (4) In slide No. 19; Please consider to include "**Traffic impact/disturbance**". (5) Concerning Slide No. 20, I saw you used mostly **secondary data**. Do you have primary data? Please consider about **primary data**. (6) Regarding Slide No. 28, you mentioned in the Mitigation measures to be EDC responsible in case of **"fishery catching greatly reduce"**. Are there any kind of this happens in the project area actually? If no, please consider to remove the item. **Responded to Question (6) by**: EDC (Mr. Chun Piseth and Dr. Chulasa**)** - This is maybe general guideline of JICA to consider all possible impacts to include in the study. Based on above question, JICA should reply and indicate the location of impact. If in reality, there is no impact on fishery production, we will consider removing this item from the document. - Some areas showing in the map indicating water bodies that may concern you about fishery catching activities over there, but, for your info, in the very near future these areas will be all backfilled, as they are located in the **developing areas**.
Mr. Duong Samkeat, Deputy Director, MoE (4:30PM-4:35PM)	My last questions, (7) Refer to slide no. 31, It's Environment Monitoring Plan. Please consider **budget** for the implementation as it will be under EDC's responsibilities in the future. (8) The same slide, please consider removing some items which are actually not exist in the project such as water pollution (pH, TSS, DO, COD), Ecosystem and Livelihood. **Answered by Mr. Chun Piseth, EDC** - Normally this spending is included in the Project's budget. In particular, compensation of land for towers is under EDC responsibilities. - EDC and JICA will consider the suggestion to remove the items.
Officer from Department of Public works and Transport 4:45PM-4:55PM	**Suggestion:** - My primary concern is about road damage/shrinkage after first year of the construction. As I saw many previous projects, during first year the repaired road is ok, but after that it became damage that may sometime cause accidents. I would like to request more responsibilities from the project owner about this matter. - Another thing, please consult with department of public works and transport to get proper information about the road expansion plan for correctly spotting the towers or underground cable crossings. **Answered by EDC, Mr. Chun Piseth** - Thank you very much for the suggestions and feedbacks.

JICA Expert, Dr. Pascal Seng and EDC translation 5:15PM-5:25PM	I just would like to confirm of the converting a portion of existing 115kV transmission line to 230kV line by this project. We don't have to secure the compensation of ROW for that portion. So our first question is, we got the information that when this 115kV line was laid 10 years ago, the compensation was done. We don't know how width, 15m or 30m? We don't know yet. So in this project we will not compensate the ROW for this line portion. Is that all right? I think we will obtain the detail information about the compensation here 10 years ago from somebody in EDC. Second question, here is railway with some right-of-way. New idea is to build a segment of 230kV line just along ROW of the railway so that we don't have to get new ROW for this 230kV line. Is there anybody from Ministry of Public Works? How wide is the railway's right-of-way? And are we able to build a transmission line just on along this ROW of the railway? **Answered by EDC Personnel** - Compensation for 115kV line from Kirirom 10 years ago is only for tower location, ROW compensation is not sure but EDC has all the documents. **Answered by Officer from Ministry of Public Works** - In a sub-decree, Right-of-Way for railway is 30m from centerline. In a Prakas, it preserves Right-of-Way to be used for public facilities the last outer 2 meter (i.e. between 28^{th} – 30^{th} meters). Therefore it is to cooperate with the ministry of public works.
JICA Expert, Dr. Pascal Seng translation 5:25PM-5:27PM	Question to MoE: How long does it take to review and approve the document after submission? (a) TOR (b) Report **Answered by Mr. Duong Samkeat, MoE** - About one or two weeks for TOR review and approve. - 30 working days for final report review and approve.
Mr. Chun Piseth, EDC (5:35PM)	Finally, I suggested all of participants from all institutions and Khans/districts, please kindly cooperate with our study team in order to execute this project smoothly. I would like to thank and close the meeting.

Participant List

No.	Name	Position	Organization
1	Dr. Praing Chulasa	Deputy Management Director	EDC
2	Mao Visal	Manager of Social Environment	EDC
3	Chun Piseth	Director of Planning & Project	EDC
4	Chen Sophanna	Deputy Head of Social Environment	EDC
5	Duong Samkeat	Deputy Director	MoE
6	Dy Sanith	Deputy Director of Department of Land Management Urban Planning, Construction and Cadastral	ML.C
7	Ouk Sophea	Officer	Sensok Khan, Phnom Penh
8	Dy Lack	Officer	Toul Kork Khan, Phnom Penh
9	Kheng Chireakmony	Officer	Dept. of Public Works
10	Eng Kim Bora	Officer	Dept. of Public Works
11	Sor Phara	Officer	Phnom Penh City Hall Representative
12	Neak Bo	Deputy Director of Administration	Russei Keo Khan, Phnom Penh
13	Yukao Tanaka	Team Leader	JICA Study team
14	Shinohara Junya	Sub Team Leader	The Chugoku Electric Power Co., Inc
15	Kenichir Yagi	N/A	JICA Study team
16	Masaru Nishida	N/A	JICA Study team
17	Yoshiko Oishi	Environmental Engineer	JICA Study team
18	Dr. Seng T. Pascal	Managing Director	Cheang Engineering Consultants (CEC)
19	Sour Sothy	Coordinator	CEC
20	Sokh Channak	Officer	Ang Snuol District Hall, Kandal Province
21	Shunsuke Matsumoto	Transmission Line Engineer	The Chugoku Electric Power Co., Inc
22	Naoyuki Nemoto	N/A	JICA
23	Miki Haga	Assistant Coordinator	JICA Study team
24	Hiroki Kato	N/A	JICA
25	Yushi Tsukada	N/A	JICA
26	Misaki Kawaguchi	N/A	JICA
27	Bin Sopheada	Vice Chief of Environmental Management Division	EDC
28	Sorn Phearun	Deputy Chief of Project Study Division	EDC
29	Sambath Chariya	Chief of Public Relation Division	EDC

3. Minutes of First Public Consultation Meeting on 230kV OHL Area

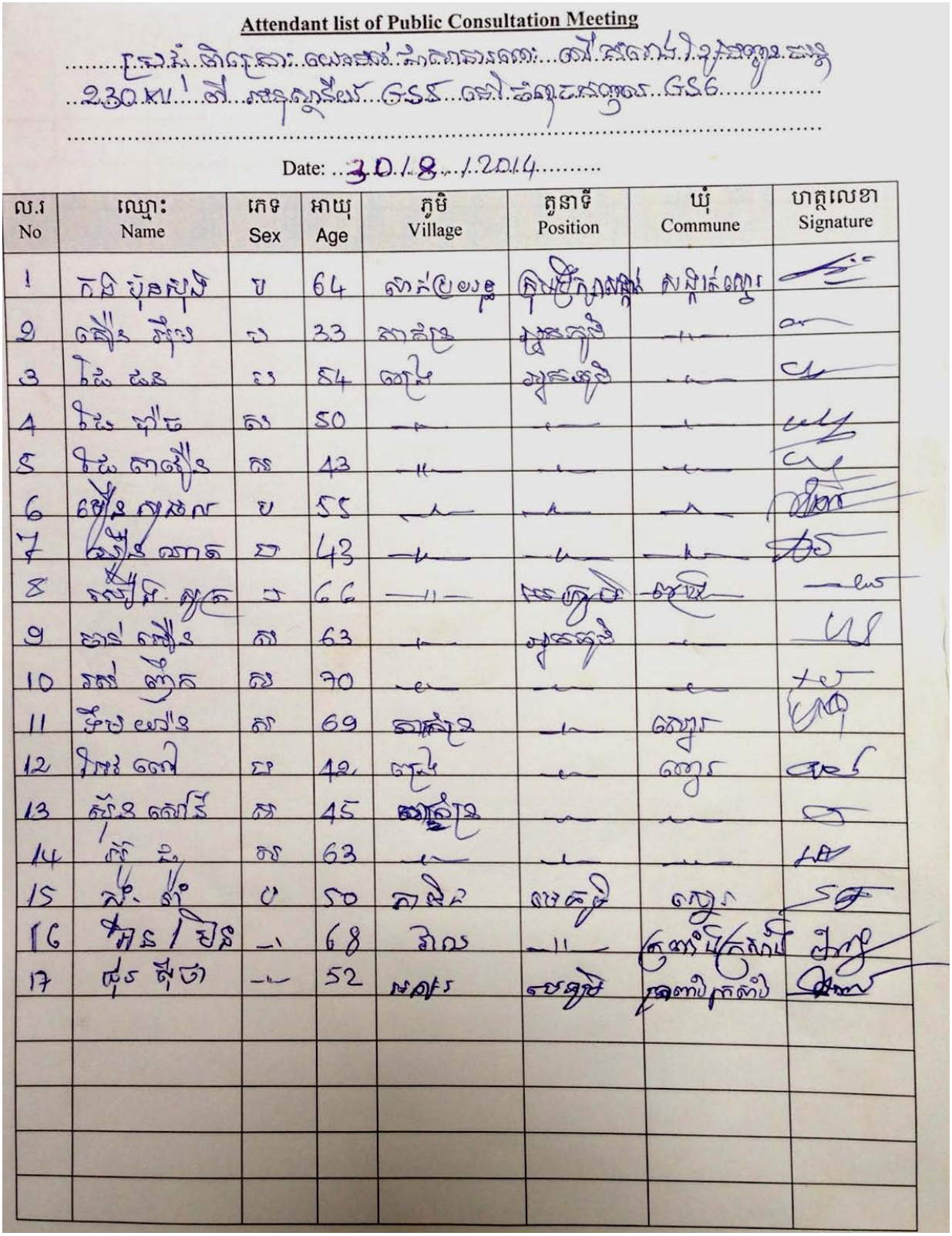
Date:	Saturday, August 30th, 2014
Time:	9:00AM-10:15AM
Location:	Pong Ro village, Snoar Sagkat, Por Sen Chey Khan
Participants:	17 persons; villages and village chiefs from affected villages
Purpose:	1. Public Disclosure for affected villagers; 2. Collection of opinions from affected villagers about the project and compensation policy

Statements and Inquiries Provided by Attendees:

No.1 Name: Mr. Kong Bunsong	Sex: Male Age: 64	Occupation: Representative of Sak Proyuth village and Commune council member in Snoar Sangkat, Por Sen Chey Khan
Statement or Inquiry: I suggested all participants raise their idea and suggestion in this meeting. On be haft of Snoar Sangkat, I support the project of government, but I suggest EDC and JICA Survey Team to minimize the impact on affected villages in this Sangkat. Our people need the safety and fair compensation.		
No.2 Name: Mr. Souen Soth	Sex: Male Age: 66	Occupation: Village chief of Pong Ro village, Snaor Sankat
Statement or Inquiry: There are two towers affected in my land. How to compensate these affected land?		
Response if any: At the tower location EDC will purchase at replacement cost. After acquisition all the lands will be transferred to the EDC property. The land located under the transmission line ROW will be compensated through different methods based on types of land use such rice field, commercial area, residential area etc. After detail design, EDC team and Provincial Resettlement Sub-Committee (PRSC) will discuss in detail with you about the price of affected land with acceptable price.		
No.3 Name: Mr. Moeurn Sophal	Sex: Male Age: 55	Occupation: Villager in Pong Ro village
Statement or Inquiry: Whenever transmission line goes across our village, the price of land in our village will decrease the price. So, we need the acceptable price of affected land.		
Response if any: This project is a government project, funded by JICA, Japan. You can negotiate with the compensation team. After detail design, EDC team and Provincial Resettlement Sub-Committee (PRSC) will discuss in detail with you about the price of affected land with acceptable price.		
No.4 Name: Phay Path	Sex: Female Age: 55	Occupation: Villager in Pong Ro village
Statement or Inquiry: If my land is affected by this project, you should buy all of my land. I need the price of land as in current market.		
Response if any: As the first question, at the tower location EDC will purchase at replacement cost. Under the transmission line ROW the land will be acquired through different methods based on types of land use such rice field, commercial area, residential area etc.		
No.5 Name: Sun Chanthy	Sex: Female Age: 45	Occupation: Villager of Ta En village, Snoar Sankat
Statement or Inquiry: The line across my land; you should pay me all of affected land. I need the price of land as in current market.		
Response if any: If the line across your land, EDC will compensate as I told you following the type of land. After compensate the land still belongs to you but the land cannot be used for residence.		
No.6 Name: Mr. Moeurn Nat	Sex: Male Age: 43	Occupation: Villager of Ta En village, Snoar Sankat
Statement or Inquiry: I need the acceptable compensation for affected land, but I also need the safety from this high-voltage transmission line. So, I suggest the designed team should install the security tools to protect our villagers from electric shock and lightening.		

Response if any: We will write your suggestion in report then submit to JICA Survey Team to know about what you worried about.		
No.7 Name: Chan Oeurn	Sex: Female Age: 63	Occupation: Villager of Ta En village, Snoar Sankat
Statement or Inquiry: This transmission line is close to my house, so I worry about my safety from electricity. So, I suggest the designed team should install the security tools to protect our villagers from electric shock and lightening. Moreover, if it is too close to my house, JICA Survey Team and EDC should resettle my house to safety location.		
Response if any: We will inform all your suggestions to EDC and JICA Team.		
No.8Name: Mr. Som Poum	Sex: Male Age: 50	Occupation: Villager of Ta En village, Snoar Sankat
Statement or Inquiry: I have two suggestion: (1). EDC and JICA Survey Team should consider my people to get safety from electricity, (2). All affected people should be compensate with price in market.		
Response if any: We will inform all your suggestions to EDC and JICA Team.		

Participant List



Attendant list of Public Consultation Meeting

Date: 30/8/2014

លរ No	ឈ្មោះ Name	ភេទ Sex	អាយុ Age	ភូមិ Village	តួនាទី Position	ឃុំ Commune	ហត្ថលេខា Signature
1			64				
2			33				
3			54				
4			50				
5			43				
6			55				
7			43				
8			66				
9			63				
10			70				
11			69				
12			42				
13			45				
14			63				
15			50				
16			68				
17			52				

4. Minutes of Second Public Consultation Meeting on 230kV OHL Area

Date:	Saturday, October 18th, 2014
Time:	9:30AM-11:00AM
Location:	Prey Muol village, Kraing Thnung Sagnat Sagkat, Sen Sok Khan
Participants:	21 persons; villages and village chiefs from affected villages
Purpose:	1. Public Disclosure for affected villagers; 2. Collection of opinions from affected villagers about the project and compensation policy

Statements and Inquiries Provided by Attendees:

No.1 Name: Mr. Kong Yat	Sex: Male Age: 49	Occupation: Villager in Pry Kla village
Statement or Inquiry: I am happy to know that you change the line route. I come from Prey Kla village. How you compensate the tower location on the existing location, new location and the ROW.		
Response if any: We are also happy to know that EDC decided to change the line route. At the tower location EDC will purchase at replacement cost. The foundation of each tower is around 10m x 10m = 100 m2. EDC will compensate 15m x 15m = 225 m2 for a new location and probably an additional 225 m2 – 100m2=125 m2 for the existing location. After acquisition all the lands will be transferred to the EDC property. The land located under the transmission line ROW will be acquired through different methods based on the types of land use such rice field, commercial area, residential area. After detail design, The compensation committee including EDC team and Provincial Resettlement Sub-Committee (PRSC) will discuss in detail with you about the procedure and price of affected land with acceptable price. Today, it is the public consultation, we come to provide you the information and collect the information from all of you.		
No.2 Name: Mrs. Chim Sokheng	Sex: Female Age: 55	Occupation: Samroang Krom village, Po SenChey,
Statement or Inquiry: I worry about my house affected by this transmission line ROW. How many meters from center line of transmission route will be affected by this ROW? How to compensate the house and the land on the ROW?		
Response if any: We need only 15 meters from centerline (30 meters in total) for the ROW. Please prepare your title of property showing that you are the land owner, the compensation committee will discuss in detail with you about the procedure and price of house and affected land.		
No.3 Name: Mr. Suong Suy	Sex: Male Age: 50	Occupation: Chief of Prey Moul village
Statement or Inquiry: Use the clearance of Railroad is a good idea. I support this option. How many towers will be installed in the private land? On be haft of people in my village, I suggest EDC and Government to pay the affected people with the current price of market for affected land.		
Response if any: 5 towers will be installed in the private land. Regarding the compensation policy a committee including EDC team and Provincial Resettlement Sub-Committee will discuss in detail with you about the procedure and price of affected land with acceptable price. Today, it is the public consultation, we come to provide you the information and collect the information from all of you.		
No.4 Name: Chhim Samrith	Sex: Female Age: 69	Occupation: Villager of Kork Rokar village, Prey Pnov Sankat
Statement or Inquiry: I am happy to know that you use the existing transmission line route. The old transmission line route passed in the middle of my land. When will you start the compensation negotiation?		
Response if any: The compensation committee including EDC team and Provincial Resettlement Sub-Committee will discuss in detail with you about the procedure and price after detail design. According to my experience the compensation negotiation will start may be in 2016.		
No.5 Name: Sim Soknae	Sex: Female Age: 24	Occupation: Villager in Prey Moul village
Statement or Inquiry: Do you compensate with the current price in the market our affected land? How long will be took from the end of negotiation to the payment?		
Response if any: The compensation cost depends on your negotiation between EDC and you. After your approval at the end of negotiation, you will receive the payment within one month. Any way you will have a Public Consultation Meeting with EDC and compensation team before negotiation. You can discuss in detail with them.		

Participant List

Attendant list of Public Consultation Meeting

[illegible] 230 kV [illegible] GS5 [illegible] GS6

Date: 18/10/2014

ល.រ No	ឈ្មោះ Name	ភូមិ Village	តួនាទី Position	ឃុំ Commune	ហត្ថលេខា Signature
1	[illegible]	[illegible]	[illegible]	[illegible]	[signature]
2	[illegible]	-//-	[illegible]	[illegible]	[signature]
3	[illegible]	[illegible]	[illegible]	[illegible]	[signature]
4	[illegible]	[illegible]		-//-	[signature]
5	[illegible]	[illegible]	[illegible]	[illegible]	[signature]
6	[illegible]	[illegible]		[illegible]	[signature]
7	[illegible]	[illegible]	[illegible]	[illegible]	[signature]
8	[illegible]	[illegible]	-//-	-//-	[signature]
9	[illegible]	[illegible]	-//-	-//-	[signature]
10	[illegible]	[illegible]	-//-	-//-	[signature]
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18	[illegible]	-//-	-//-	-//-	[signature]
19	[illegible]	[illegible]	[illegible]	-//-	[signature]
20	[illegible]	[illegible]	[illegible]	[illegible]	[signature]
21	[illegible]	[illegible]		[illegible]	[signature]

5. Minutes of Second Public Consultation Meeting on 115kV OHL Area

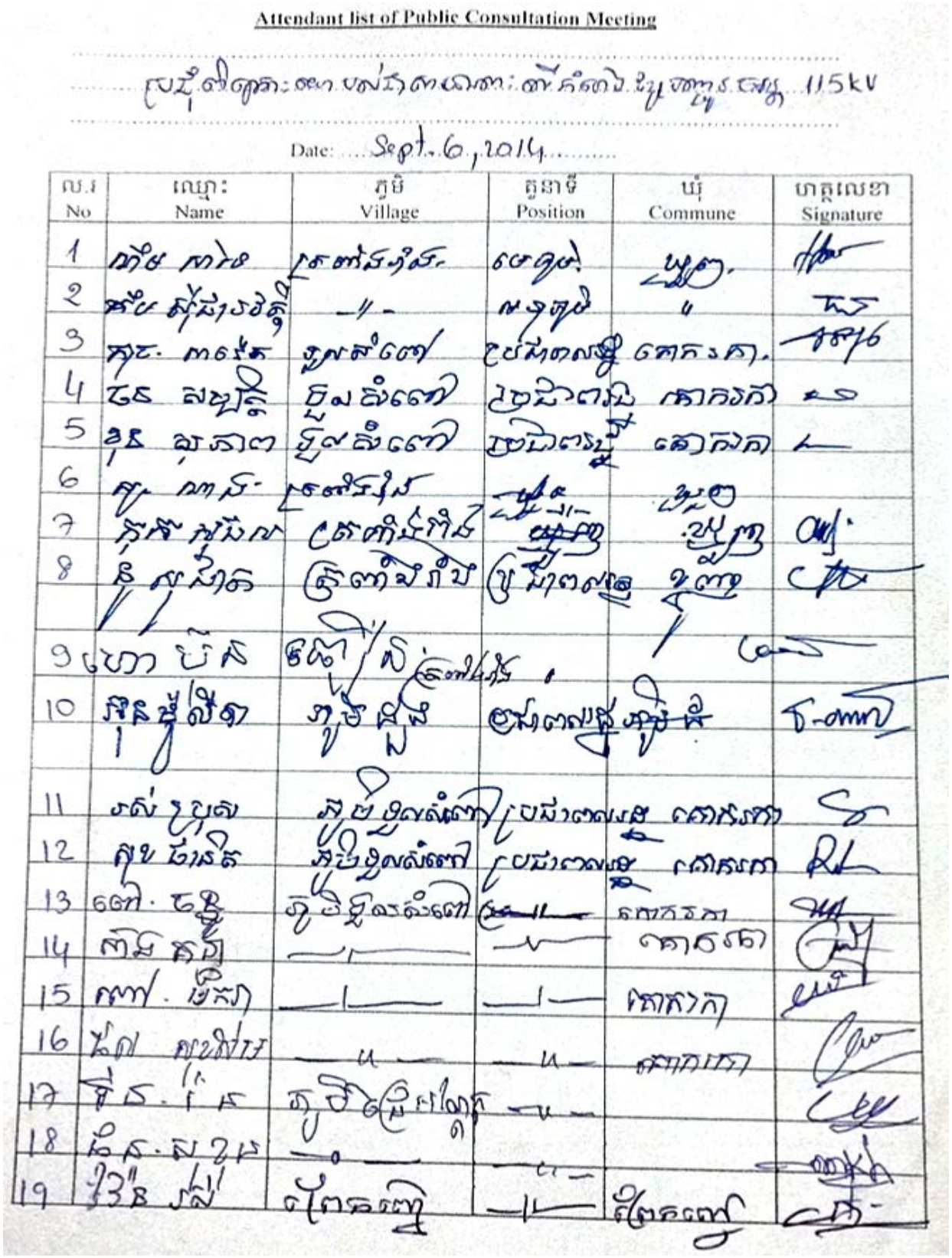
Date:	Saturday, August 6th, 2014
Time:	8:00AM-10:30AM
Location:	Doung primary school in Doung village, Preak Phnao, Sagnat Por Sen Sok Khan
Participants:	36 persons; villages and village chiefs from affected villages
Purpose:	1. Public Disclosure for affected villagers; 2. Collection of opinions from affected villagers about the project and compensation policy

Statements and Inquiries Provided by Attendees:

No.1 Name: Mr. Sim Ngim	Sex: Male Age: 50	Occupation: Villager in Preak Kroum village
Statement or Inquiry: I have a land in Chrey Andet village, but please tell me the size of this affection. Could I build any building under this wire line? Who will compensate my affected land?		
Response if any: The required land for steel tower is three types, 15x15, 20x20, and 25x25. But your land will be acquired by 15x15. At the tower location EDC will purchase at replacement cost. Under the transmission line ROW, the land will be acquired through different methods based on types of land use such rice field, commercial area, residential area etc. If the line across only your land, EDC will compensate as I told you following the type of land. After compensation the land still belongs to you but the land cannot be used for construct building. Also, the trees higher than 3 meters shall be cut.		
No.2 Name: Ngil Chhoum	Sex: Male Age: 55	Occupation: Samroung Tiev Village Chief
Statement or Inquiry: I think that my village will not be affected much by this project, because the new line will construct on the existing route. This project will use the concrete pole to install there. So, it is no problem. Moreover, this project will construct next to the embankment of canal, thus, I think that it will have no affection.		
Response if any: We note your observations. EDC and JICA team will take care about the technical problem of this pole according to the technical standard.		
No.3 Name: Poa Chanthou	Sex: Female Age: 40	Occupation: Village Chief, Samroung Toul village
Statement or Inquiry: My house will also be affected by pole and row; so, will this project give the good compensation for affection of my house and land? Moreover, many houses in my village also affected by row, thus, I suggest survey team to compensate these affection.		
Response if any: After finalizing the detailed engineering drawing by PIC, the compensation team including EDC and PSRC (representative of commune, district and province) will conduct demarcation at ground, the exact locations of towers, the ROW and the boundary. Land, structures, crops and trees located with the demarcated boundary will be properly recorded. Moreover, they will calculate the fee for move your house and other from the ROW. So, you and your villagers can negotiate with the compensation team.		
No.4 Name: Mr. Tin Rorn	Sex: Male Age: 45	Occupation: Villager in Chrey Andet village
Statement or Inquiry: My land and Aquaculture pond will affect by tower 25x25, it in the middle of my land. I will not able to do anything for my aquaculture. So, could study team move to the edge of my land? so that I can continue my career.		
Response if any: We will report this to design team.		
No.5 Name: Ven Ros	Sex: Male Age: 40	Occupation: Villager of Preak Pnov Sankat
Statement or Inquiry: My house is under the ROW, so, will project give the compensation of this affection or relocation of my house?		

Response if any: Sure, as I informed before, that after finalizing the detailed engineering drawing by PIC, the compensation team including EDC and PSRC will conduct demarcation at ground, the exact locations of towers, the ROW, the houses and the boundary of your land. Please prepare your title of property of your land or your house or others documents able to justify that you are the owner of them		
No.6 Name: Bun Thong	Sex: Male Age: 60	Occupation: Village chief of Doung village
Statement or Inquiry: We have no objection for the construction of this transmission line project. JICA is a serious organization, I hope that the affected properties and land will compensate with the current price in the market.		
Response if any: EDC will compensate your affected land with the acceptable price according to JICA and government guideline.		

Participant List



Attendant list of Public Consultation Meeting

ប្រជុំពិគ្រោះយោបល់សាធារណៈ ស្តីពីគំរោង ខ្សែបញ្ជូន 115kV

Date: Sept. 6, 2014

ល.រ No	ឈ្មោះ Name	ភូមិ Village	តួនាទី Position	ឃុំ Commune	ហត្ថលេខា Signature
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	ឈ្មោះ Name	ភូមិ Village	តួនាទី Position	ឃុំ Commune	ហត្ថលេខា Signature
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	ឈ្មោះ Name	ភូមិ Village	តួនាទី Position	ឃុំ Commune	ហត្ថលេខា Signature
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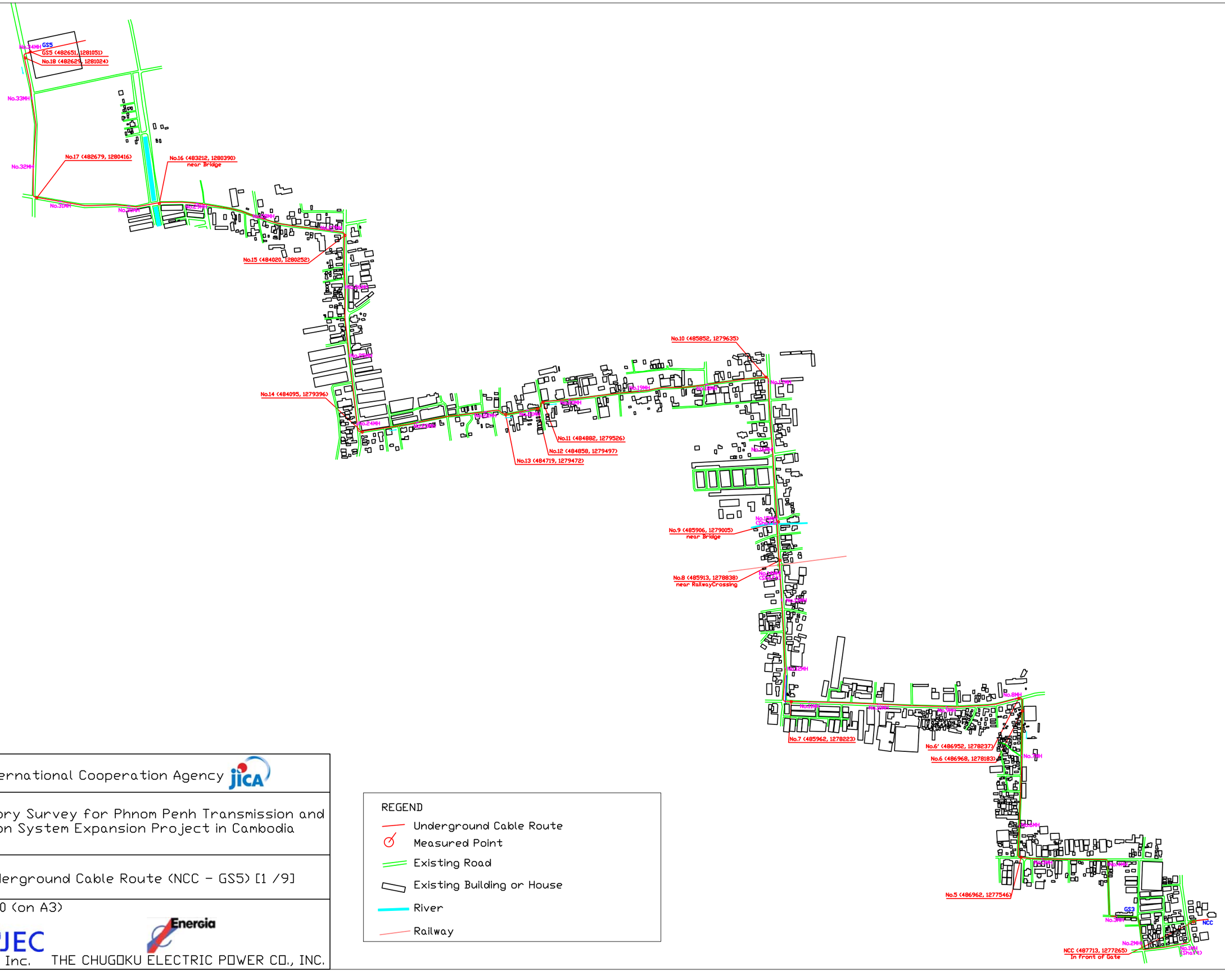
APPENDIX-4

UNDERGROUND TRANSMISSION LINE ROUTE MAP (GS5-NCC)

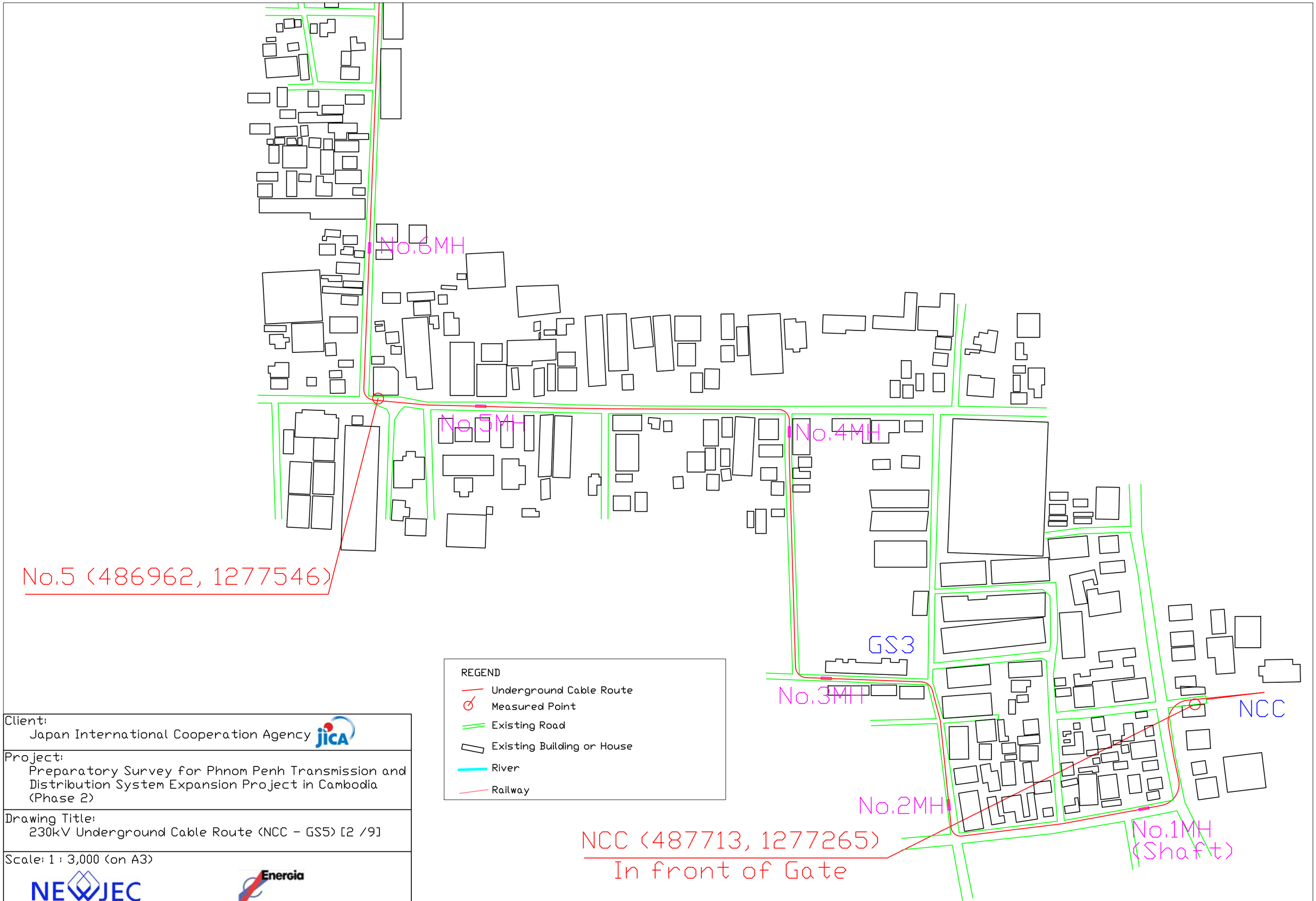


Client:	Japan International Cooperation Agency JICA
Project:	Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)
Drawing Title:	230kV Underground Cable Route (NCC – GS5) [1 /9]
Scale: 1 : 15,000 (on A3)	

NEWJEC Inc. THE CHUGOKU ELECTRIC POWER CO., INC.

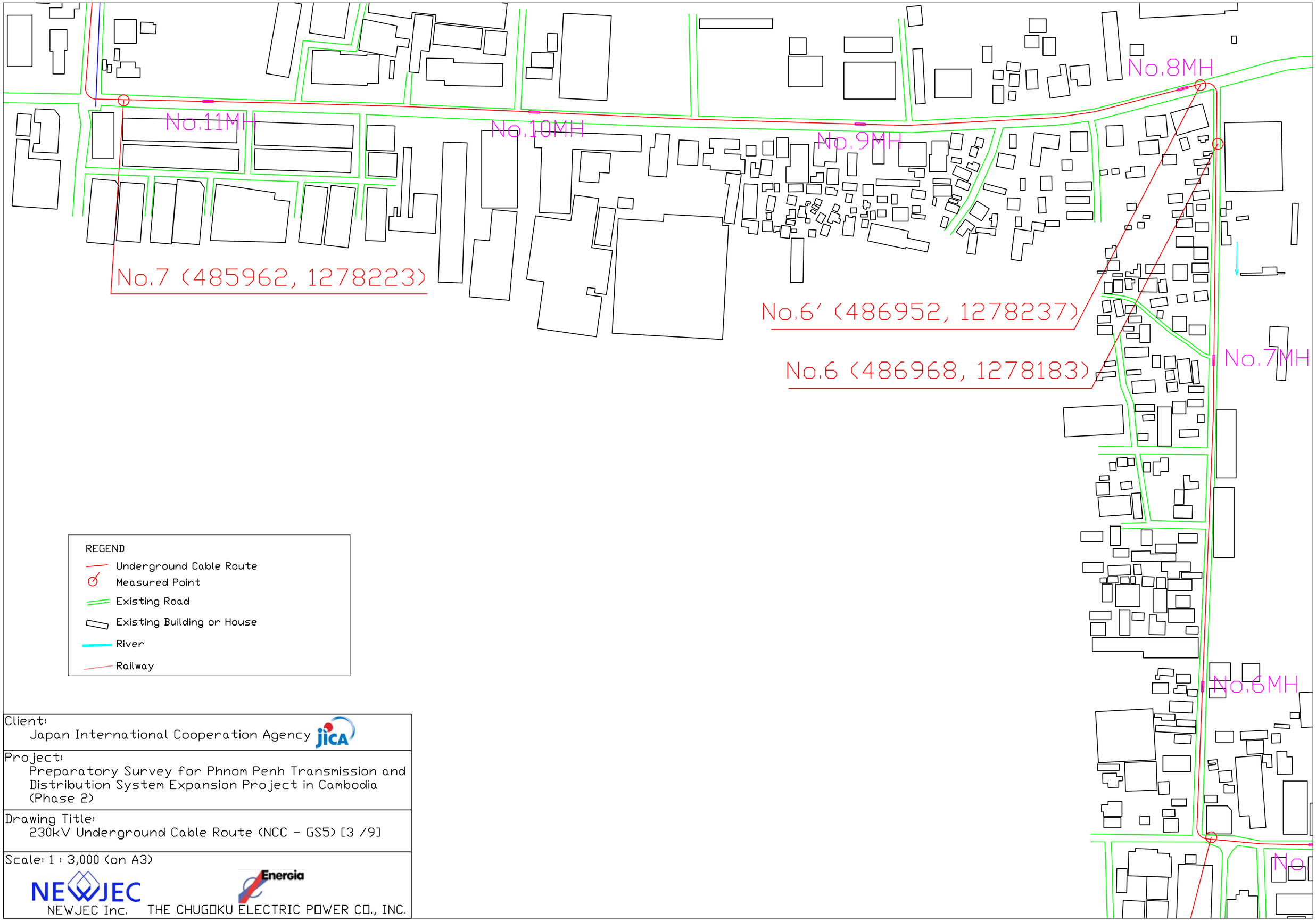
REGEND

- Underground Cable Route
- Measured Point
- Existing Road
- Existing Building or House
- River
- Railway



Client:	Japan International Cooperation Agency JICA
Project:	Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)
Drawing Title:	230kV Underground Cable Route (NCC – GS5) [2 /9]
Scale: 1 : 3,000 (on A3)	

NEWJEC Inc. THE CHUGOKU ELECTRIC POWER CO., INC.



Client:
Japan International Cooperation Agency JICA

Project:
Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)

Drawing Title:
230kV Underground Cable Route (NCC - GS5) [3 /9]

Scale: 1 : 3,000 (on A3)

NEWJEC Inc. THE CHUGOKU ELECTRIC POWER CO., INC.

No.16MH

No.15MH
(Shaft)

No.9 (485906, 1279005)
near Bridge

No.8 (485913, 1278838)
near RailwayCrossing

No.14MH
(Shaft)

No.13MH

No.12MH

No.11MH

REGEND

- Underground Cable Route
- Measured Point
- Existing Road
- Existing Building or House
- River
- Railway

Client:
Japan International Cooperation Agency JICA

Project:
Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)

Drawing Title:
230kV Underground Cable Route (NCC – GS5) [4 /9]

Scale: 1 : 3,000 (on A3)

NEWJEC Inc. THE CHUGOKU ELECTRIC POWER CO., INC.

No.19MH

No.18MH

No.17MH

No.20MH

21MH

No.11 (484882, 1279526)

No.12 (484858, 1279497)

3 (484719, 1279472)

No.16MH

No.15MH
(Shaft)

No.9 (485906, 1279005)
near Bridge

REGEND

- Underground Cable Route
- Measured Point
- Existing Road
- Existing Building or House
- River
- Railway

Client:
Japan International Cooperation Agency JICA

Project:
Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)

Drawing Title:
230kV Underground Cable Route (NCC - GS5) [5 /9]

Scale: 1 : 3,000 (on A3)

NEWJEC Inc. THE CHUGOKU ELECTRIC POWER CO., INC.

No.25MH

96)

No.24MH

No.23MH

No.22MH

No.21MH

No.20MH

No.11 (484882,

No.12 (484858, 12

No.13 (484719, 1279472)

REGEND

- Underground Cable Route
- Measured Point
- Existing Road
- Existing Building or House
- River
- Railway

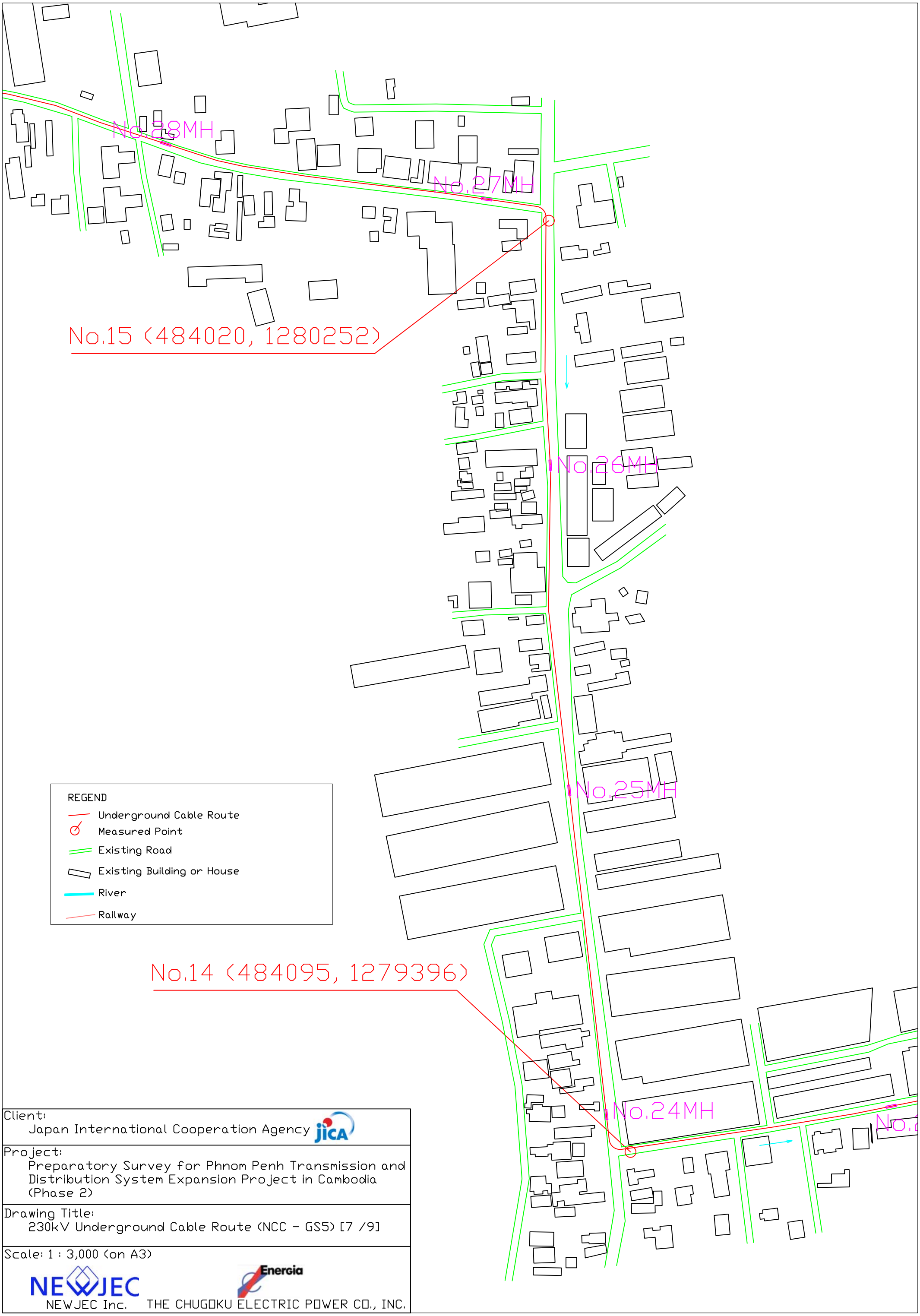
Client:
Japan International Cooperation Agency JICA

Project:
Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)

Drawing Title:
230kV Underground Cable Route (NCC – GS5) [6 /9]

Scale: 1 : 3,000 (on A3)

NEWJEC Inc. THE CHUGOKU ELECTRIC POWER CO., INC.



Client:
Japan International Cooperation Agency

Project:
Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)

Drawing Title:
230kV Underground Cable Route (NCC – GS5) [7 /9]

Scale: 1 : 3,000 (on A3)

NEWJEC Inc. THE CHUGOKU ELECTRIC POWER CO., INC.

32679, 1280416)

No.16 (483212, 1280390)
near Bridge

No.30MH

No.29MH

No.28MH

No.27MH

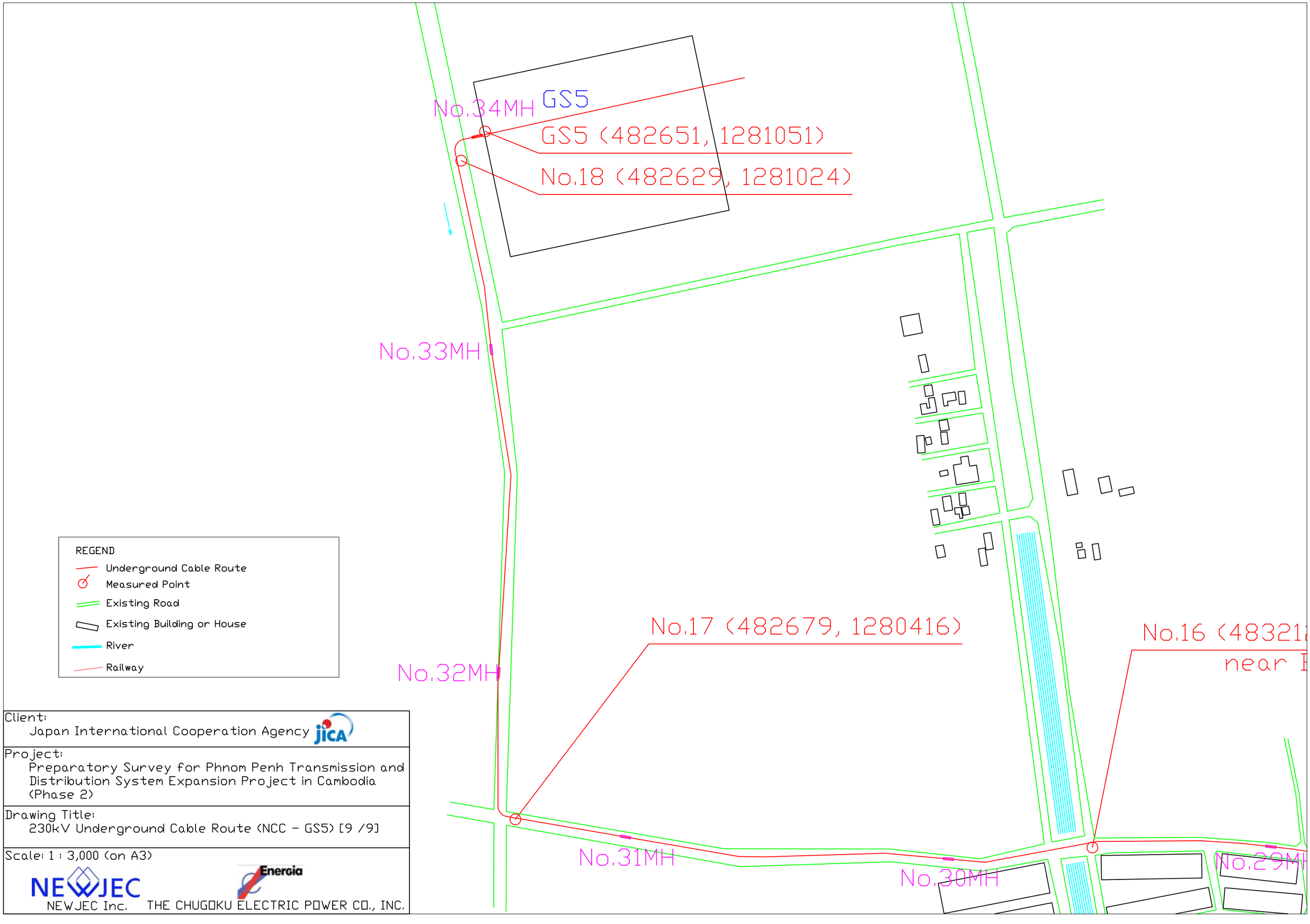
No.15 (484020, 1280252)

No.26MH

Client: Japan International Cooperation Agency JICA	
Project: Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)	
Drawing Title: 230kV Underground Cable Route (NCC – GS5) [8 /9]	
Scale: 1 : 3,000 (on A3)	
NEWJEC Inc.	THE CHUGOKU ELECTRIC POWER CO., INC.

REGEND

- Underground Cable Route
- Measured Point
- Existing Road
- Existing Building or House
- River
- Railway



REGEND

- Underground Cable Route
- Measured Point
- Existing Road
- Existing Building or House
- River
- Railway

Client:
Japan International Cooperation Agency

Project:
Preparatory Survey for Phnom Penh Transmission and Distribution System Expansion Project in Cambodia (Phase 2)

Drawing Title:
230kV Underground Cable Route (NCC – GS5) [9 /9]

Scale: 1 : 3,000 (on A3)

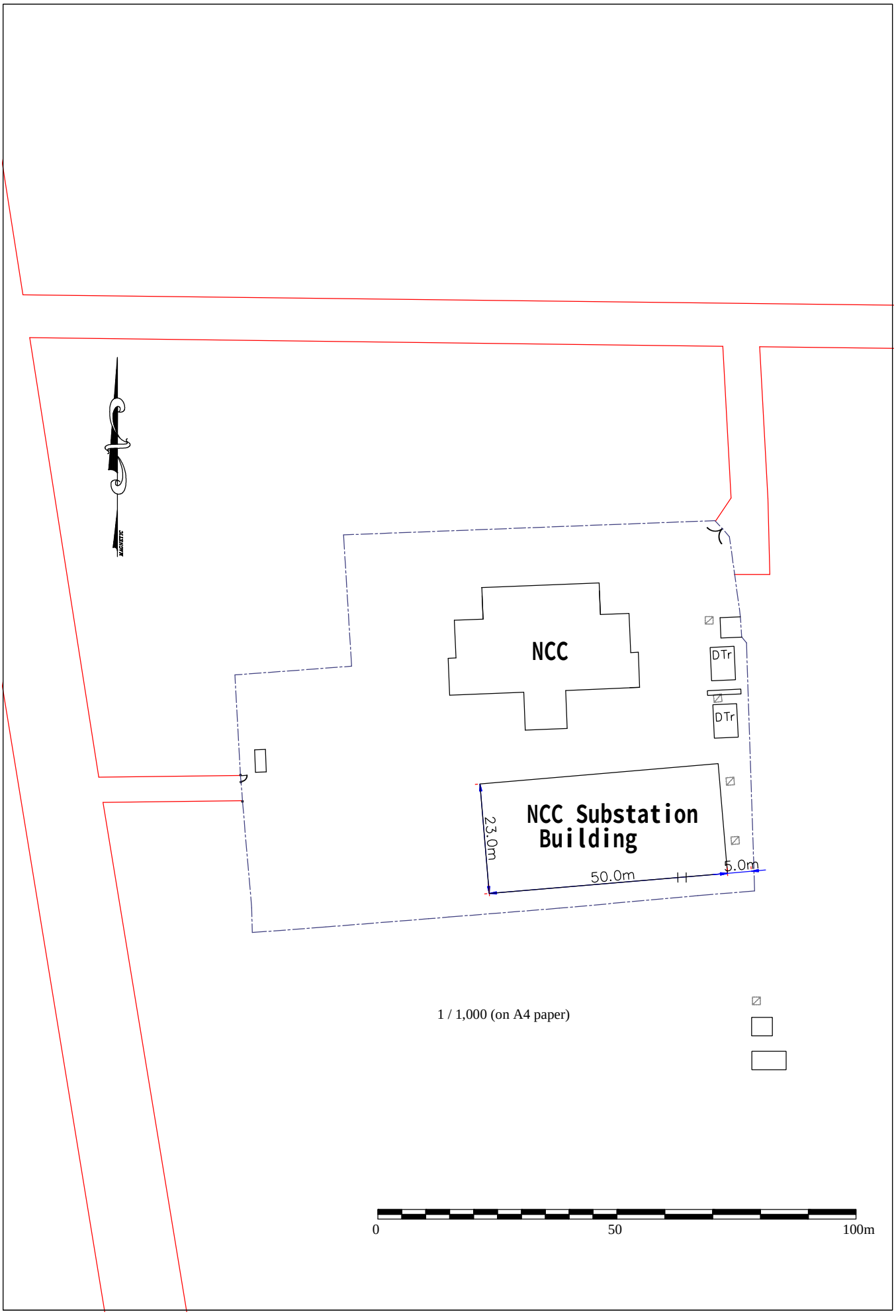
NEWJEC Inc. THE CHUGOKU ELECTRIC POWER CO., INC.

APPENDIX-5

LAYOUT OF SUBSTATION FACILITY

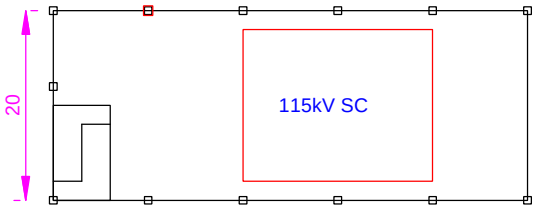
NCC Substation Layout Plan

Appendix 5-1-1



NCC Substation Building Floor Layout Plan

Rooftop



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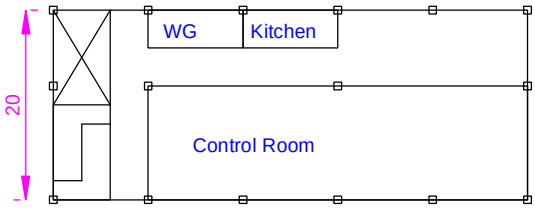
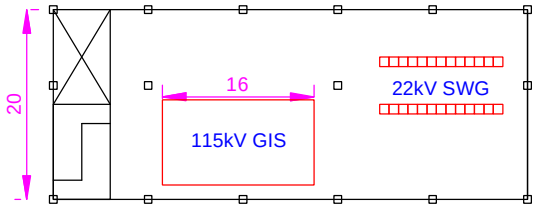
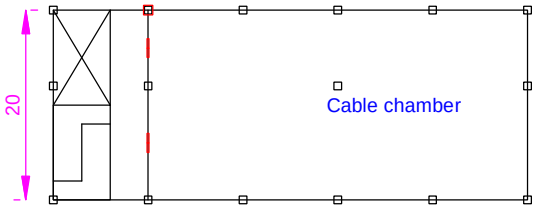


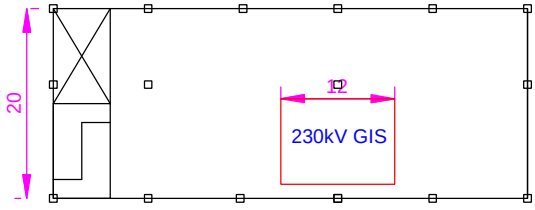
2nd



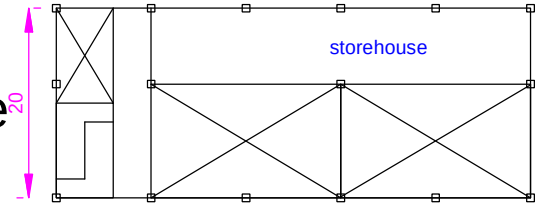
Cable



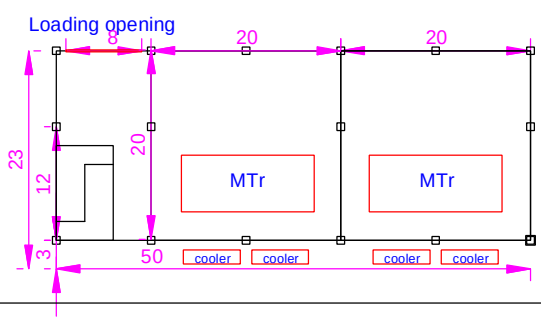
1st



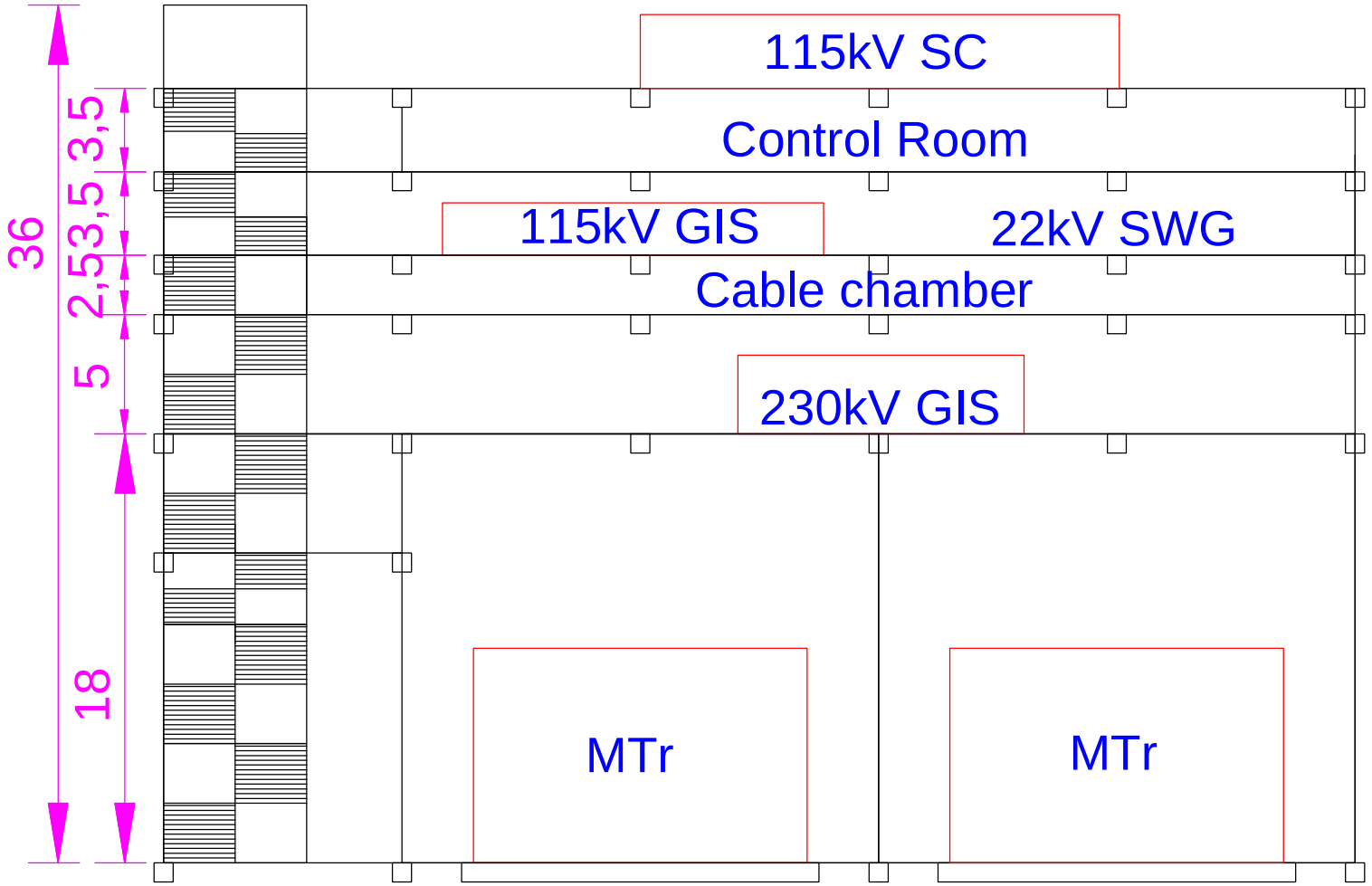
Mezzanine



Ground



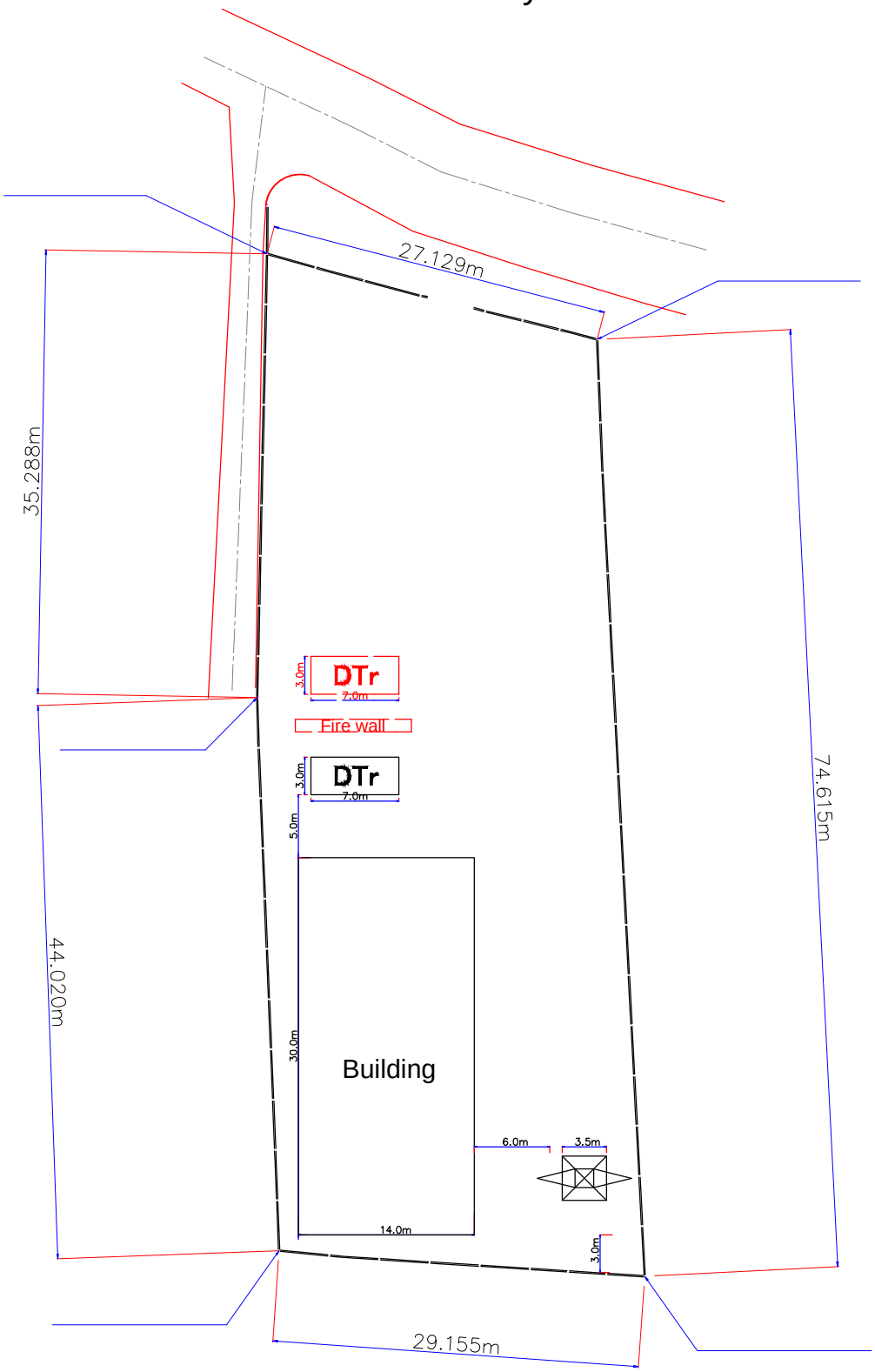
NCC Substation Building Floor Layout Plan (Sectional view)



Rooftop
3rd
2nd
Cable
1st
Mezzanine

Ground

Toul Kork Substation Layout Plan

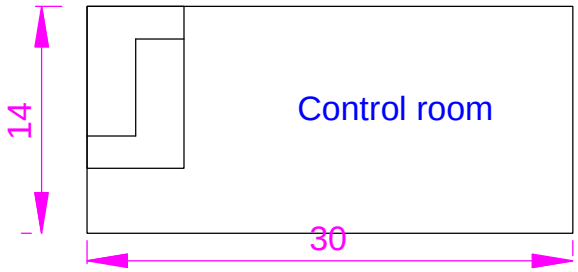


1 / 500 (on A4 paper)

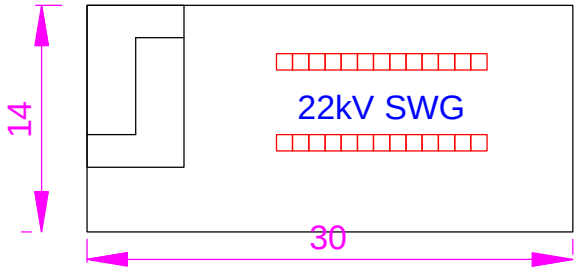
0 10 20 30 40 50m

Toul Kork Substation Building Floor Layout Plan

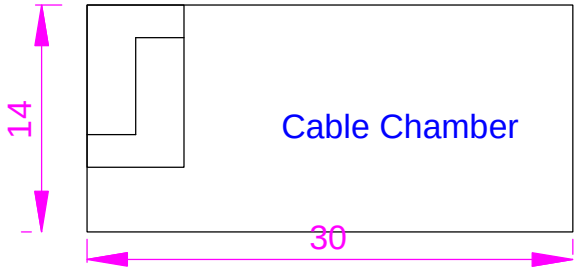
2nd



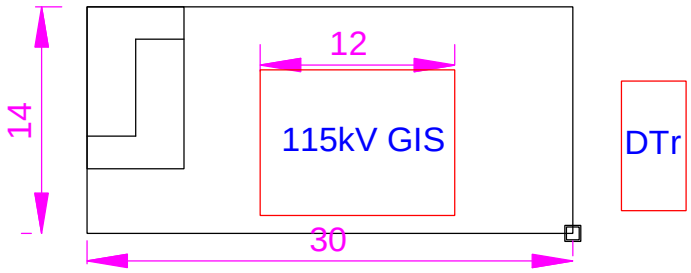
1st



Cable

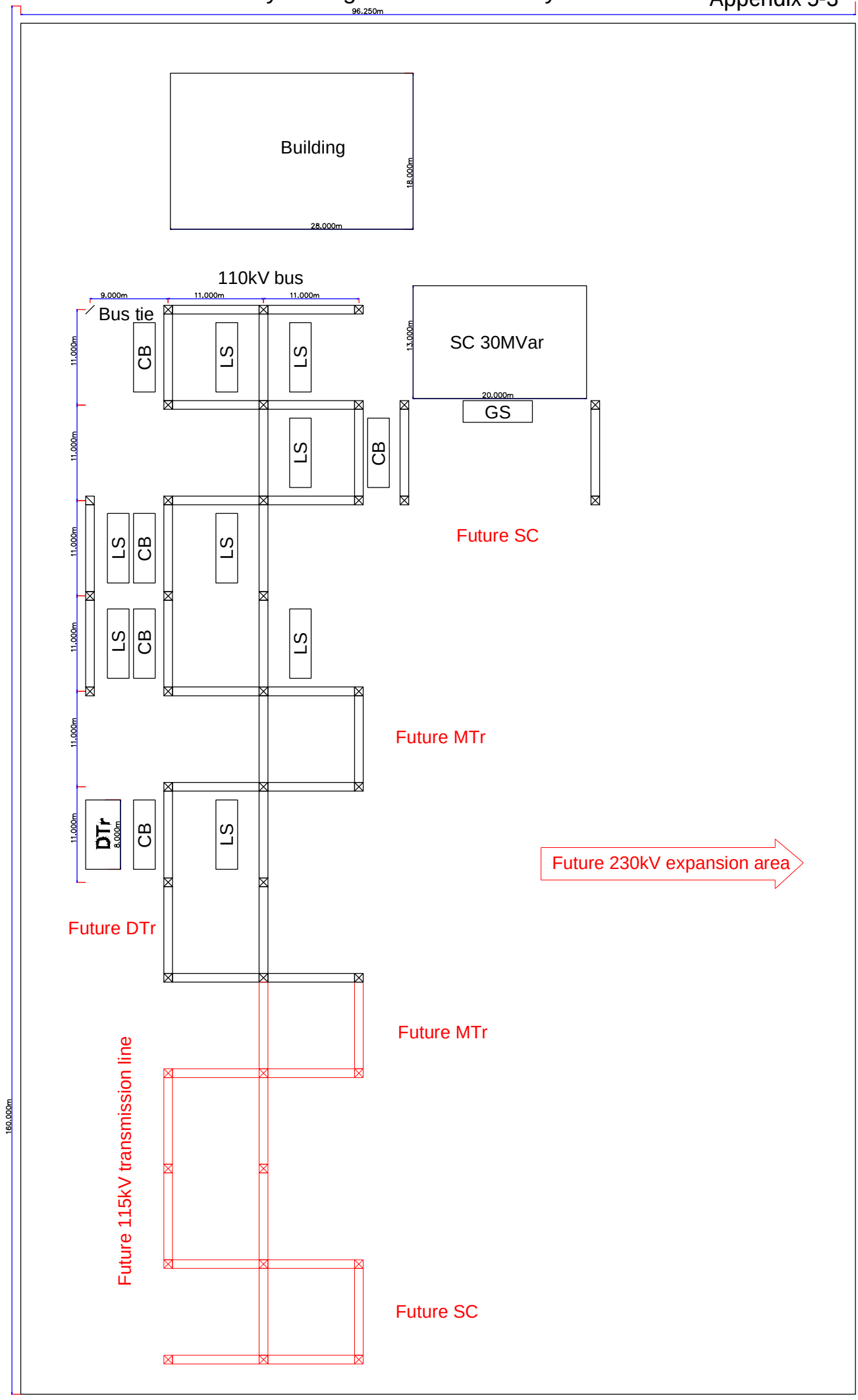


Ground

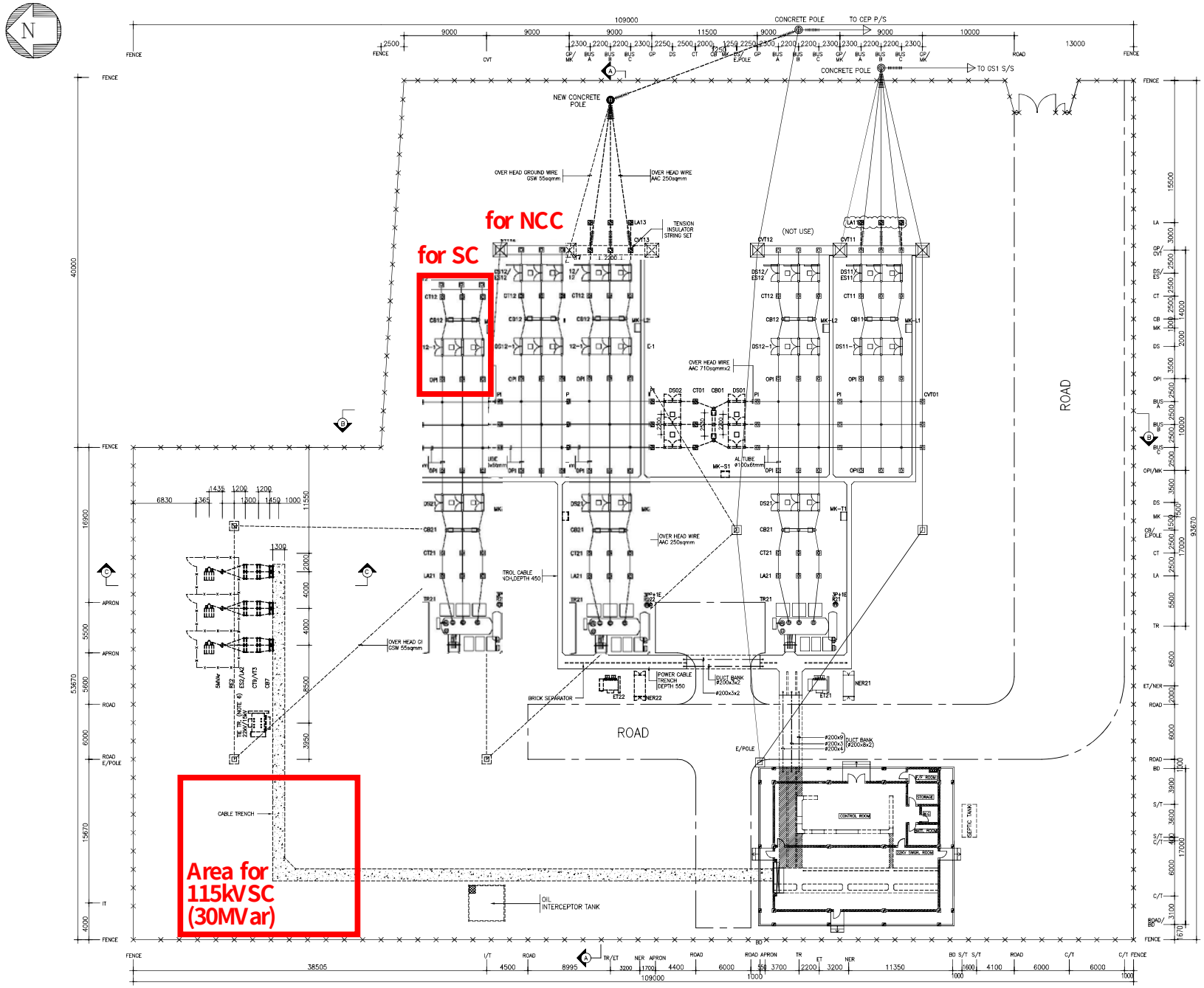


Chroy Changvar Substation Layout Plan

Appendix 5-3



GS3 Layout Plan



EQUIPMENT LIST

(NEW EQUIPMENTS WERE UNDERLINED AT FIRST COLUMME IN BELOW TABLE)

TAG. NO.	DESCRIPTION	REMARKS
CVT11,CVT12,CVT13, CVT01,CVT02	115/√3/0.11/√3/0.11KV T06VA CL0.5 3P/3P	
DS11/ES11,DS12/ES12,DS13/ES13	123KV 1250A 31.5KA	
DS11-1,DS12-1,DS13-1 DS21,DS22	123KV 1250A 31.5KA	
DS01,DS02	123KV 2000A 31.5KA	
CT11,CT12,CT13	123KV 1250A 15VA 1000-500/1/1/1/1A CLX 1000-500/1A CL0.5	
CT21,CT22	123KV 1250A 15VA 600-300/1A CLX 600-300/1A CL10P20 1000-500/1/1A CLX 600-300/1A CL0.5	
CT01	123KV 2000A 15VA 1000-500/1/1/1/1A CLX 2000-1000-500/1A CL0.5	
CB11,CB12,CB13 CB21,CB22,CB21	123KV 3150A 31.5KA	
DPI	123KV	
PI	123KV	
MK-L1,MK-L2,MK-L3 MK-S1,MK-T1,MK-T2	OUTDOOR, WEATHER-PROOF, SELF STANDING TYPE	
LA11,LA12,LA13,LA21,LA12,LA13	72KV 10KA W/SURGE COUNTER	
TR21	3PH 115/22KV 30/50MVA ONAN/ODAF,Ynd11yn0,%Z=10	
TR22	3PH 115/22KV 30/50MVA ONAN/ODAF,Ynd11,%Z=10	
ET11	1PH 15/√3/0.23KV 150KVA %Z=4	
ET12,ET22	3PH 22/0.4-0.23KV 250KVA Zyyn11,%Z=4	
ER11	230V 376.5A 0.665Ω 30sec	
NER12,NER22	22/√3KV 787A 30SEC, 50A CONTIN, 3.76 Ω	
R1,R2	POWER RECEPTACLE OUTDOOR, WEATHER PROOF 3P+1E 400V,100A	
CB7	CIRCUIT BREAKER – 36KV 2000A 31.5KA	
CT9	22KV 300-600/1A, 10P20 15VA 300-600/1A, CL 1.0 15VA	
VT3	22/√3-0.11/√3-0.11/√3 KV 50VA 0.5CL 3P/3P	
ES2	EARTHING SWITCH 24KV,630A,25kA/1s	
LA2	LIGHTNING ARRESTER 21KV,10KA	
RE2	REACTOR 24kV,0.2mH,200A,25kA/1s	
5MVar	CAPPACITOR BANK 22KV 5.0MVAr 50Hz	

NOTE:

1. EXISTING CABLE TRENCH
   NEW CABLE TRENCH
   EXISTING CABLE TUNNEL
2. SCOPE OF WORK
   EXISTING EQUIPMENT
3. ALL DIMENSIONS IN THIS DRAWING MEAN MILLIMETER.
4. ALL DIMENSIONS OF CABLE TRENCHES INDICATE IT OF INSIDE.
5. : ADDITIONAL SCOPE
6. EXISTING 22/15kV TIE-TRANSFORMER SHALL RELOCATED FROM TRANSFORMER BAY (TR22) TO NEW LOCATION

DOCUMENT STATUS:

Rev.	Date	Description	Author	Chkd.	Appd.
0	Jan 23, 2008	Issued for approval	MAIT	NGUY	NGUY

Project: RURAL ELECTRIFICATION AND TRANSMISSION PROJECT
IDA Credit No. 3840-KH
MODIFICATION OF 115KV GRID SUBSTATIONS IN PHNOM PENH

Customer: ELECTRICITE DU CAMBODGE

Consultant: NIPPON KOEI Co. Ltd in association with R&N Engineering Consultants

Contractor: CONSORTIUM AREVA T&D Ltd./ COMINASIA Pte.Ltd/ COMINKHMERE Co.Ltd.

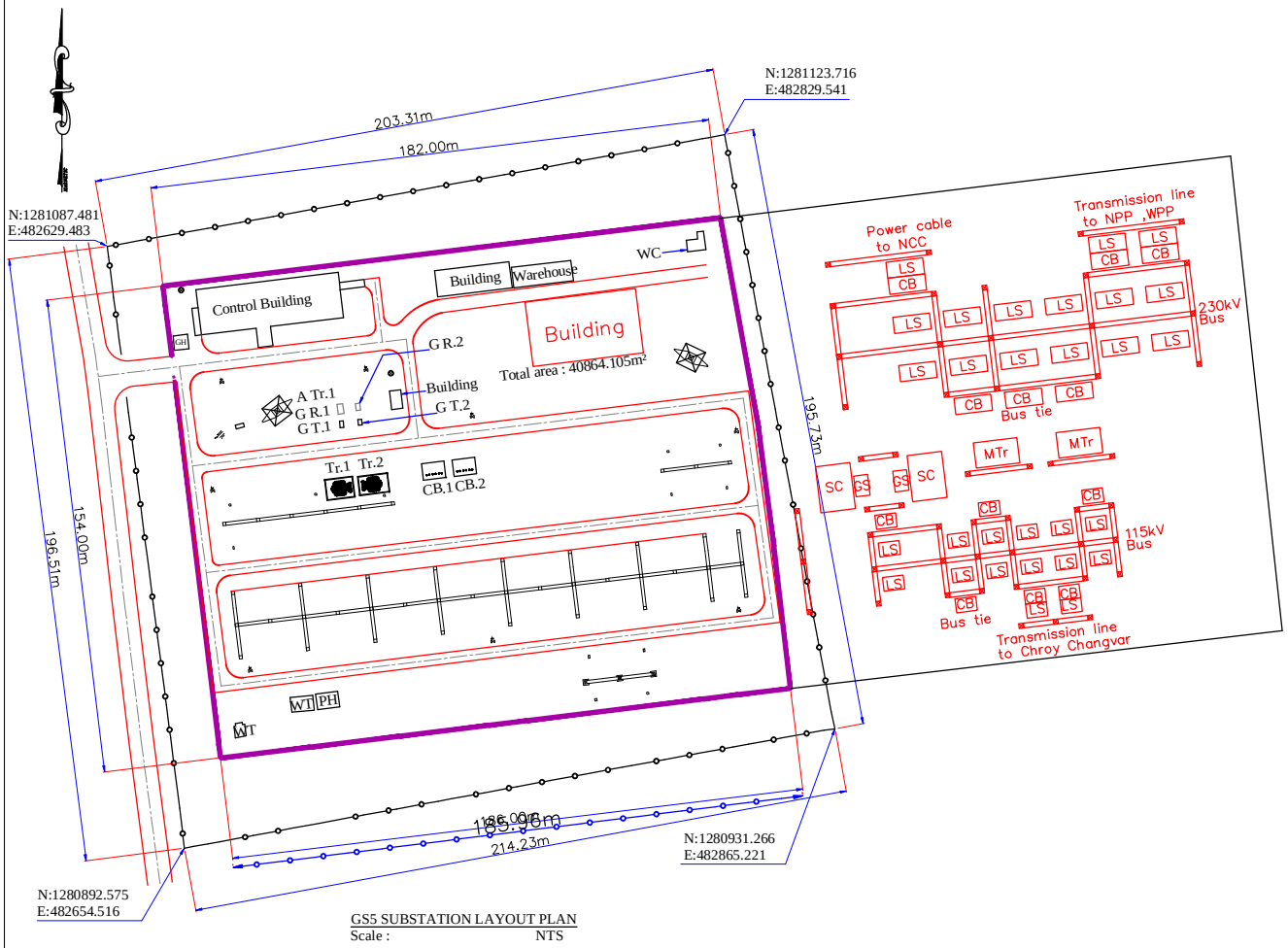
Document Title: GS3 - SWITCHYARD EQUIPMENT ARRANGEMENT

Project No.:				Format:				Total page:	
Designed by:	MAI NGOC TUAN			Checked & Approved by:	NGUYEN VAN NGOC				
Function	Name	Sign	Date	Function	Name	Sign	Date		
Approved	NGUN								
Checked	NGUN								
Author	MAIT								

Drawing No.: D1506-100-302 Date: Rev:

GS5 Layout Plan

Appendix 5-5



GS5 SUBSTATION LAYOUT PLAN
Scale : NTS

Legend :

- Dead-end tower
- Dead-end steel pole
- Lightning steel pole
- Gantry
- Road
- Brick wall fence
- Barbed wire fence
- Main hole
- Contour line

Abbreviation:

Tr.1	: Transformer #1
Tr.2	: Transformer #2
A Tr.1	: Auxiliary transformer #1
G R.1	: Ground resistance #1
G R.2	: Ground resistance #2
G T.1	: Grounding transformer #1
G T.2	: Grounding transformer #2
CB.1	: Capacitor bank #1
CB.2	: Capacitor bank #2
GH	: Guard house
PH	: Pump house
WT	: Underground water storage tank

APPENDIX-6

TRAFFIC COUNT VOLUME

Appendix 6 Traffic Count Volume

Point 1 : Toul Kork S/S

Point No. 1	Date: 04/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
6:00 - 6:10	54	17	2	0
6:10 - 6:20	81	12	0	0
6:20 - 6:30	159	16	3	0
6:30 - 6:40	329	24	3	0
6:40 - 6:50	380	29	3	0
6:50 - 7:00	342	32	5	0
7:00 - 7:10	417	38	7	0
7:10 - 7:20	285	29	4	0
7:20 - 7:30	192	19	2	0
7:30 - 7:40	199	37	7	0
7:40 - 7:50	218	35	7	0
7:50 - 8:00	250	24	9	0
8:00 - 8:10	178	28	7	0
8:10 - 8:20	189	24	8	0
8:20 - 8:30	181	25	7	0
8:30 - 8:40	135	35	3	0
8:40 - 8:50	144	14	7	0
8:50 - 9:00	141	26	4	0
9:00 - 9:10	168	21	13	0
9:10 - 9:20	200	21	4	0
9:20 - 9:30	131	29	5	0
9:30 - 9:40	113	23	4	0
9:40 - 9:50	144	20	12	0
9:50 - 10:00	159	27	14	0
10:00 - 10:10	136	27	8	0
10:10 - 10:20	172	29	10	0
10:20 - 10:30	150	22	16	0
10:30 - 10:40	216	24	9	0
10:40 - 10:50	167	30	9	0
10:50 - 11:00	163	24	4	0
11:00 - 11:10	193	24	6	0
11:10 - 11:20	191	26	8	0
11:20 - 11:30	157	28	8	1
11:30 - 11:40	215	39	13	0
11:40 - 11:50	196	22	11	0
11:50 - 12:00	189	40	10	0
12:00 - 12:10	183	30	6	0
12:10 - 12:20	150	20	8	0
12:20 - 12:30	174	25	6	0
12:30 - 12:40	148	28	7	1
12:40 - 12:50	163	23	6	0
12:50 - 13:00	155	13	4	0
13:00 - 13:10	145	22	7	0
13:10 - 13:20	143	20	7	0
13:20 - 13:30	148	15	8	0
13:30 - 13:40	103	33	13	0

Point No. 1	Date: 04/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
13:40 - 13:50	117	23	7	1
13:50 - 14:00	122	30	9	0
14:00 - 14:10	134	25	16	1
14:10 - 14:20	104	57	7	0
14:20 - 14:30	159	28	11	0
14:30 - 14:40	124	29	6	0
14:40 - 14:50	118	30	10	1
14:50 - 15:00	129	25	13	0
15:00 - 15:10	170	41	10	0
15:10 - 15:20	130	29	8	0
15:20 - 15:30	136	38	12	0
15:30 - 15:40	158	32	14	0
15:40 - 15:50	149	31	10	0
15:50 - 16:00	154	25	13	0
16:00 - 16:10	208	31	14	0
16:10 - 16:20	206	28	6	0
16:20 - 16:30	203	36	10	0
16:30 - 16:40	195	42	9	0
16:40 - 16:50	174	43	2	0
16:50 - 17:00.	187	44	6	0
17:00 - 17:10	238	34	5	1
17:10 - 17:20	313	38	10	0
17:20 - 17:30	227	35	11	1
17:30 - 17:40	198	52	7	0
17:40 - 17:50	145	27	8	0
17:50 - 18:00	90	36	1	1
18:00 - 18:10	152	38	8	0
18:10 - 18:20	175	41	6	0
18:20 - 18:30	151	29	1	0
18:30 - 18:40	254	27	3	0
18:40 - 18:50	153	25	2	0
18:50 - 19:00	176	26	3	0
19:00 - 19:10	146	30	3	0
19:10 - 19:20	172	22	2	0
19:20 - 19:30	124	20	3	0
19:30 - 19:40	145	19	1	0
19:40 - 19:50	107	11	0	0
19:50 - 20:00	87	19	1	1
20:00 - 20:10	139	27	1	0
20:10 - 20:20	79	8	2	0
20:20 - 20:30	67	13	4	0
20:30 - 20:40	123	15	1	0
20:40 - 20:50	84	15	3	3
20:50 - 21:00	37	14	2	0
21:00 - 21:10	38	16	1	0
21:10 - 21:20	31	10	0	0
21:20 - 21:30	30	5	1	0
21:30 - 21:40	29	12	0	0
21:40 - 21:50	16	10	1	0
21:50 - 22:00	18	4	0	0

Point No. 1	Date: 04/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
22:00 - 22:10	34	11	5	0
22:10 - 22:20	22	3	1	0
22:20 - 22:30	18	3	3	0
22:30 - 22:40	9	3	2	0
22:40 - 22:50	15	1	1	0
22:50 - 23:00	7	4	1	0
23:00 - 23:10	9	2	0	0
23:10 - 23:20	2	3	0	0
23:20 - 23:30	8	4	1	0
23:30 - 23:40	9	4	1	0
23:40 - 23:50	5	2	1	0
23:50 - 24:00	4	5	0	0
24:00 - 24:10	5	4	0	0
24:10 - 24:20	4	1	0	0
24:20 - 24:30	8	0	0	0
24:30 - 24:40	0	1	0	0
24:40 - 24:50	2	0	0	0
24:50 - 1:00	3	1	0	0
1:00 - 1:10	5	0	1	0
1:10 - 1:20	1	3	0	0
1:20 - 1:30	1	1	0	0
1:30 - 1:40	3	2	0	0
1:40 - 1:50	4	1	0	0
1:50 - 2:00	1	5	0	0
2:00 - 2:10	2	0	2	0
2:10 - 2:20	3	0	0	0
2:20 - 2:30	0	2	0	0
2:30 - 2:40	2	0	0	0
2:40 - 2:50	1	0	0	0
2:50 - 3:00	1	0	0	0
3:00 - 3:10	2	0	0	0
3:10 - 3:20	1	0	2	0
3:20 - 3:30	1	0	1	0
3:30 - 3:40	4	1	1	0
3:40 - 3:50	7	2	2	0
3:50 - 4:00	1	2	0	0
4:00 - 4:10	4	1	1	0
4:10 - 4:20	1	3	0	0
4:20 - 4:30	7	4	1	0
4:30 - 4:40	8	2	4	0
4:40 - 4:50	6	1	0	0
4:50 - 5:00	10	1	2	0
5:00 - 5:10	18	3	3	0
5:10 - 5:20	31	6	4	0
5:20 - 5:30	33	1	2	0
5:30 - 5:40	65	5	1	0
5:40 - 5:50	65	4	3	0
5:50 - 6:00	91	7	8	1

Point 2 : Chroy Changvar S/S

Point No. 2	Date: 05/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
6:00 - 6:10	44	34	8	2
6:10 - 6:20	54	52	8	0
6:20 - 6:30	55	48	8	0
6:30 - 6:40	62	57	11	0
6:40 - 6:50	77	73	16	0
6:50 - 7:00	90	68	12	0
7:00 - 7:10	87	66	13	0
7:10 - 7:20	86	64	8	0
7:20 - 7:30	70	58	9	2
7:30 - 7:40	71	59	10	0
7:40 - 7:50	77	59	14	0
7:50 - 8:00	79	60	10	0
8:00 - 8:10	74	62	9	0
8:10 - 8:20	79	56	6	0
8:20 - 8:30	87	57	9	1
8:30 - 8:40	87	67	9	0
8:40 - 8:50	92	71	11	0
8:50 - 9:00	96	76	11	0
9:00 - 9:10	105	103	12	2
9:10 - 9:20	36	43	5	0
9:20 - 9:30	90	104	16	1
9:30 - 9:40	82	111	18	2
9:40 - 9:50	86	107	22	2
9:50 - 10:00	83	97	15	1
10:00 - 10:10	86	142	13	1
10:10 - 10:20	48	59	9	0
10:20 - 10:30	50	94	13	0
10:30 - 10:40	119	158	31	0
10:40 - 10:50	54	91	18	0
10:50 - 11:00	79	54	21	0
11:00 - 11:10	63	73	6	0
11:10 - 11:20	68	79	11	0
11:20 - 11:30	52	60	22	0
11:30 - 11:40	63	73	13	1
11:40 - 11:50	50	72	10	0
11:50 - 12:00	36	50	6	1
12:00 - 12:10	30	40	3	0
12:10 - 12:20	37	32	5	0
12:20 - 12:30	27	30	8	0
12:30 - 12:40	34	29	6	0
12:40 - 12:50	40	36	8	0
12:50 - 13:00	48	42	12	1
13:00 - 13:10	53	44	12	0
13:10 - 13:20	48	37	10	0
13:20 - 13:30	54	46	11	1
13:30 - 13:40	59	53	11	0
13:40 - 13:50	67	67	15	0
13:50 - 14:00	70	87	17	0
14:00 - 14:10	59	95	11	1

Point No. 2	Date: 05/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
14:10 - 14:20	63	99	13	0
14:20 - 14:30	53	79	10	0
14:30 - 14:40	52	69	9	0
14:40 - 14:50	53	82	12	1
14:50 - 15:00	61	82	8	1
15:00 - 15:10	46	57	8	0
15:10 - 15:20	41	48	8	0
15:20 - 15:30	36	46	9	0
15:30 - 15:40	44	52	8	0
15:40 - 15:50	45	60	11	0
15:50 - 16:00	51	57	11	1
16:00 - 16:10	54	58	11	0
16:10 - 16:20	57	58	9	0
16:20 - 16:30	61	58	8	0
16:30 - 16:40	59	61	9	0
16:40 - 16:50	66	62	12	0
16:50 - 17:00.	73	63	11	0
17:00 - 17:10	71	60	9	0
17:10 - 17:20	76	61	8	0
17:20 - 17:30	84	60	7	0
17:30 - 17:40	86	66	10	0
17:40 - 17:50	93	75	9	0
17:50 - 18:00	91	75	7	0
18:00 - 18:10	80	66	7	0
18:10 - 18:20	72	65	7	0
18:20 - 18:30	66	59	5	0
18:30 - 18:40	59	58	4	0
18:40 - 18:50	57	58	4	0
18:50 - 19:00	50	52	3	0
19:00 - 19:10	51	48	3	0
19:10 - 19:20	45	44	1	0
19:20 - 19:30	44	44	3	0
19:30 - 19:40	37	38	2	0
19:40 - 19:50	32	36	2	0
19:50 - 20:00	25	32	1	0
20:00 - 20:10	21	27	0	0
20:10 - 20:20	19	22	1	0
20:20 - 20:30	19	20	3	0
20:30 - 20:40	16	18	2	0
20:40 - 20:50	14	16	1	0
20:50 - 21:00	12	16	2	0
21:00 - 21:10	9	17	4	0
21:10 - 21:20	10	20	3	0
21:20 - 21:30	7	19	4	0
21:30 - 21:40	8	17	3	0
21:40 - 21:50	10	13	2	0
21:50 - 22:00	6	13	2	0
22:00 - 22:10	4	9	2	0
22:10 - 22:20	4	11	4	0
22:20 - 22:30	6	6	3	0

Point No. 2	Date: 05/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
22:30 - 22:40	5	4	3	0
22:40 - 22:50	5	6	3	0
22:50 - 23:00	2	5	2	0
23:00 - 23:10	3	3	1	0
23:10 - 23:20	5	2	1	0
23:20 - 23:30	1	4	2	0
23:30 - 23:40	2	2	1	0
23:40 - 23:50	4	3	1	0
23:50 - 24:00	2	3	0	0
24:00 - 24:10	1	2	1	0
24:10 - 24:20	2	1	1	0
24:20 - 24:30	2	1	0	0
24:30 - 24:40	0	2	0	0
24:40 - 24:50	3	1	1	0
24:50 - 1:00	2	1	0	0
1:00 - 1:10	1	2	0	0
1:10 - 1:20	3	2	1	0
1:20 - 1:30	1	1	0	0
1:30 - 1:40	3	2	1	0
1:40 - 1:50	0	1	0	0
1:50 - 2:00	1	0	0	0
2:00 - 2:10	1	2	0	0
2:10 - 2:20	1	1	0	0
2:20 - 2:30	2	2	0	0
2:30 - 2:40	1	2	0	0
2:40 - 2:50	1	1	0	0
2:50 - 3:00	3	4	1	0
3:00 - 3:10	2	2	0	0
3:10 - 3:20	4	2	0	0
3:20 - 3:30	3	2	0	0
3:30 - 3:40	3	3	0	0
3:40 - 3:50	3	2	0	0
3:50 - 4:00	5	3	1	0
4:00 - 4:10	4	5	0	0
4:10 - 4:20	7	6	0	0
4:20 - 4:30	7	5	1	0
4:30 - 4:40	7	4	0	0
4:40 - 4:50	9	7	1	0
4:50 - 5:00	9	7	0	0
5:00 - 5:10	12	15	2	0
5:10 - 5:20	17	10	0	0
5:20 - 5:30	23	14	6	1
5:30 - 5:40	27	16	4	0
5:40 - 5:50	41	25	4	0
5:50 - 6:00	50	38	13	0

Point 3 : NCC S/S

Point No. 3	Date: 05/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
6:00 - 6:10	584	30	5	0
6:10 - 6:20	953	72	14	1
6:20 - 6:30	641	109	9	0
6:30 - 6:40	755	92	5	0
6:40 - 6:50	758	150	9	2
6:50 - 7:00	2180	109	14	1
7:00 - 7:10	2941	139	10	0
7:10 - 7:20	1545	127	22	0
7:20 - 7:30	1665	167	29	0
7:30 - 7:40	1357	147	13	0
7:40 - 7:50	1236	170	30	1
7:50 - 8:00	1249	194	20	0
8:00 - 8:10	1227	194	20	4
8:10 - 8:20	898	142	31	0
8:20 - 8:30	1041	169	24	0
8:30 - 8:40	850	186	32	0
8:40 - 8:50	863	239	36	0
8:50 - 9:00	800	165	27	0
9:00 - 9:10	785	159	33	0
9:10 - 9:20	809	143	34	0
9:20 - 9:30	795	132	38	0
9:30 - 9:40	788	154	37	1
9:40 - 9:50	734	164	40	0
9:50 - 10:00	825	135	37	0
10:00 - 10:10	811	143	40	2
10:10 - 10:20	786	148	49	0
10:20 - 10:30	834	142	29	0
10:30 - 10:40	892	123	39	1
10:40 - 10:50	859	155	28	1
10:50 - 11:00	972	151	30	0
11:00 - 11:10	1103	142	22	0
11:10 - 11:20	1045	181	16	1
11:20 - 11:30	936	144	31	2
11:30 - 11:40	873	154	28	1
11:40 - 11:50	951	162	25	4
11:50 - 12:00	735	134	25	0
12:00 - 12:10	821	159	21	0
12:10 - 12:20	843	145	31	1
12:20 - 12:30	685	136	20	0
12:30 - 12:40	816	127	28	0
12:40 - 12:50	821	143	31	0
12:50 - 13:00	920	119	46	0
13:00 - 13:10	946	100	29	0
13:10 - 13:20	894	131	32	1
13:20 - 13:30	922	140	30	2
13:30 - 13:40	886	158	43	2
13:40 - 13:50	834	127	31	0
13:50 - 14:00	937	148	36	0
14:00 - 14:10	471	71	23	0

Point No. 3	Date: 05/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
14:10 - 14:20	814	174	42	5
14:20 - 14:30	775	167	35	1
14:30 - 14:40	689	149	37	4
14:40 - 14:50	781	167	36	5
14:50 - 15:00	769	168	31	2
15:00 - 15:10	714	149	48	1
15:10 - 15:20	859	177	45	1
15:20 - 15:30	540	123	26	1
15:30 - 15:40	746	153	32	1
15:40 - 15:50	734	181	39	2
15:50 - 16:00	791	180	43	0
16:00 - 16:10	724	196	37	1
16:10 - 16:20	810	188	39	1
16:20 - 16:30	1027	190	41	0
16:30 - 16:40	990	179	26	3
16:40 - 16:50	1106	157	34	1
16:50 - 17:00.	1213	171	23	1
17:00 - 17:10	1488	151	26	0
17:10 - 17:20	1231	155	17	2
17:20 - 17:30	1537	134	21	2
17:30 - 17:40	1335	126	33	1
17:40 - 17:50	1168	161	15	1
17:50 - 18:00	1195	133	22	2
18:00 - 18:10	1237	188	20	2
18:10 - 18:20	1185	168	20	1
18:20 - 18:30	1203	164	22	1
18:30 - 18:40	1180	155	18	0
18:40 - 18:50	1126	133	16	0
18:50 - 19:00	1102	152	24	1
19:00 - 19:10	919	127	10	2
19:10 - 19:20	1051	165	27	2
19:20 - 19:30	866	151	11	3
19:30 - 19:40	946	132	16	3
19:40 - 19:50	687	105	11	1
19:50 - 20:00	743	116	20	3
20:00 - 20:10	741	131	15	1
20:10 - 20:20	893	109	14	4
20:20 - 20:30	889	110	6	1
20:30 - 20:40	855	116	22	3
20:40 - 20:50	716	111	16	3
20:50 - 21:00	556	109	13	3
21:00 - 21:10	413	79	17	0
21:10 - 21:20	430	109	15	0
21:20 - 21:30	371	100	10	6
21:30 - 21:40	343	94	17	4
21:40 - 21:50	300	81	8	4
21:50 - 22:00	279	56	3	3
22:00 - 22:10	325	55	5	0
22:10 - 22:20	360	50	10	0
22:20 - 22:30	244	43	10	1

Point No. 3	Date: 05/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
22:30 - 22:40	247	66	16	0
22:40 - 22:50	213	56	9	1
22:50 - 23:00	216	35	11	0
23:00 - 23:10	198	37	7	0
23:10 - 23:20	187	37	3	0
23:20 - 23:30	144	30	6	0
23:30 - 23:40	150	32	5	0
23:40 - 23:50	130	29	4	0
23:50 - 24:00	132	25	7	0
24:00 - 24:10	144	20	4	0
24:10 - 24:20	116	16	6	0
24:20 - 24:30	99	26	6	0
24:30 - 24:40	81	6	2	0
24:40 - 24:50	79	17	6	0
24:50 - 1:00	74	13	6	0
1:00 - 1:10	71	18	4	0
1:10 - 1:20	61	18	3	0
1:20 - 1:30	91	16	1	0
1:30 - 1:40	68	10	3	0
1:40 - 1:50	56	4	3	0
1:50 - 2:00	79	10	2	0
2:00 - 2:10	96	11	3	0
2:10 - 2:20	65	11	5	0
2:20 - 2:30	52	8	3	0
2:30 - 2:40	64	10	2	0
2:40 - 2:50	75	5	5	0
2:50 - 3:00	85	13	4	0
3:00 - 3:10	70	11	3	0
3:10 - 3:20	67	1	3	0
3:20 - 3:30	42	5	4	0
3:30 - 3:40	52	12	3	0
3:40 - 3:50	63	8	4	0
3:50 - 4:00	61	6	7	0
4:00 - 4:10	79	5	14	0
4:10 - 4:20	91	9	14	0
4:20 - 4:30	79	7	9	0
4:30 - 4:40	97	19	13	0
4:40 - 4:50	177	13	11	1
4:50 - 5:00	156	13	12	0
5:00 - 5:10	170	19	21	0
5:10 - 5:20	272	29	19	1
5:20 - 5:30	305	42	22	2
5:30 - 5:40	494	20	21	1
5:40 - 5:50	520	40	18	10
5:50 - 6:00	657	42	17	23

Point 4 : Road 2002

Point No. 4	Date: 04/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
6:00 - 6:10	127	21	4	0
6:10 - 6:20	155	21	3	0
6:20 - 6:30	407	28	4	0
6:30 - 6:40	220	29	3	0
6:40 - 6:50	422	38	2	0
6:50 - 7:00	360	36	4	0
7:00 - 7:10	334	30	6	0
7:10 - 7:20	350	47	11	0
7:20 - 7:30	259	43	8	0
7:30 - 7:40	278	67	7	0
7:40 - 7:50	270	46	12	0
7:50 - 8:00	358	50	8	0
8:00 - 8:10	220	50	15	0
8:10 - 8:20	141	69	6	0
8:20 - 8:30	164	49	14	0
8:30 - 8:40	187	40	12	0
8:40 - 8:50	191	43	10	0
8:50 - 9:00	211	34	10	0
9:00 - 9:10	163	28	15	0
9:10 - 9:20	190	35	11	0
9:20 - 9:30	139	37	11	0
9:30 - 9:40	137	22	17	0
9:40 - 9:50	122	23	13	0
9:50 - 10:00	121	17	12	0
10:00 - 10:10	144	19	11	0
10:10 - 10:20	182	26	15	0
10:20 - 10:30	154	24	5	0
10:30 - 10:40	212	28	35	0
10:40 - 10:50	231	26	10	0
10:50 - 11:00	284	43	12	0
11:00 - 11:10	257	48	15	1
11:10 - 11:20	283	49	10	0
11:20 - 11:30	253	53	12	0
11:30 - 11:40	246	44	10	0
11:40 - 11:50	215	53	14	1
11:50 - 12:00	170	54	8	0
12:00 - 12:10	171	37	13	0
12:10 - 12:20	169	32	8	0
12:20 - 12:30	188	33	17	1
12:30 - 12:40	200	30	12	0
12:40 - 12:50	268	28	12	0
12:50 - 13:00	241	41	8	0
13:00 - 13:10	200	32	11	0
13:10 - 13:20	203	34	9	0
13:20 - 13:30	212	35	9	0
13:30 - 13:40	172	42	8	0
13:40 - 13:50	176	36	11	0
13:50 - 14:00	153	33	13	0
14:00 - 14:10	155	31	11	0

Point No. 4	Date: 04/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
14:10 - 14:20	170	26	14	0
14:20 - 14:30	151	25	19	0
14:30 - 14:40	145	21	16	0
14:40 - 14:50	146	30	8	0
14:50 - 15:00	172	26	14	0
15:00 - 15:10	178	37	12	0
15:10 - 15:20	149	20	7	0
15:20 - 15:30	166	26	14	0
15:30 - 15:40	179	29	9	0
15:40 - 15:50	161	27	6	0
15:50 - 16:00	197	24	21	0
16:00 - 16:10	211	25	5	0
16:10 - 16:20	208	26	6	0
16:20 - 16:30	234	32	19	0
16:30 - 16:40	258	37	12	0
16:40 - 16:50	270	39	10	0
16:50 - 17:00.	330	42	12	0
17:00 - 17:10	375	36	12	1
17:10 - 17:20	436	35	7	0
17:20 - 17:30	436	38	9	0
17:30 - 17:40	438	32	6	0
17:40 - 17:50	481	41	9	0
17:50 - 18:00	431	39	4	1
18:00 - 18:10	387	34	14	0
18:10 - 18:20	337	28	4	0
18:20 - 18:30	347	36	10	0
18:30 - 18:40	342	31	6	0
18:40 - 18:50	436	55	5	0
18:50 - 19:00	291	32	4	0
19:00 - 19:10	326	33	6	0
19:10 - 19:20	268	25	7	0
19:20 - 19:30	255	16	7	0
19:30 - 19:40	248	29	1	0
19:40 - 19:50	251	26	4	0
19:50 - 20:00	199	21	3	0
20:00 - 20:10	211	34	10	0
20:10 - 20:20	193	38	4	0
20:20 - 20:30	194	33	4	0
20:30 - 20:40	190	26	3	0
20:40 - 20:50	158	20	0	0
20:50 - 21:00	98	25	2	0
21:00 - 21:10	88	31	1	0
21:10 - 21:20	67	18	0	0
21:20 - 21:30	88	13	1	0
21:30 - 21:40	56	46	2	0
21:40 - 21:50	61	18	3	0
21:50 - 22:00	70	12	0	0
22:00 - 22:10	45	13	1	1
22:10 - 22:20	51	10	1	0
22:20 - 22:30	49	10	0	0

Point No. 4	Date: 04/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
22:30 - 22:40	19	6	0	0
22:40 - 22:50	43	6	0	0
22:50 - 23:00	33	5	1	0
23:00 - 23:10	17	8	1	0
23:10 - 23:20	30	2	0	0
23:20 - 23:30	16	4	0	0
23:30 - 23:40	33	9	0	0
23:40 - 23:50	15	5	2	0
23:50 - 24:00	18	2	0	0
24:00 - 24:10	16	2	1	0
24:10 - 24:20	15	3	0	0
24:20 - 24:30	17	6	1	0
24:30 - 24:40	6	1	1	0
24:40 - 24:50	9	2	1	0
24:50 - 1:00	9	2	3	0
1:00 - 1:10	6	4	0	0
1:10 - 1:20	9	5	0	0
1:20 - 1:30	13	4	0	0
1:30 - 1:40	6	0	0	0
1:40 - 1:50	19	7	0	0
1:50 - 2:00	18	1	0	0
2:00 - 2:10	3	1	0	0
2:10 - 2:20	13	1	0	0
2:20 - 2:30	11	0	0	0
2:30 - 2:40	7	2	0	0
2:40 - 2:50	3	1	5	0
2:50 - 3:00	6	4	1	0
3:00 - 3:10	9	1	1	0
3:10 - 3:20	8	1	1	0
3:20 - 3:30	5	0	0	0
3:30 - 3:40	7	1	1	0
3:40 - 3:50	6	1	1	0
3:50 - 4:00	2	1	0	0
4:00 - 4:10	3	0	1	0
4:10 - 4:20	3	0	1	0
4:20 - 4:30	4	2	1	0
4:30 - 4:40	10	3	5	0
4:40 - 4:50	4	1	0	0
4:50 - 5:00	21	0	4	0
5:00 - 5:10	22	2	4	0
5:10 - 5:20	29	6	3	0
5:20 - 5:30	40	3	8	1
5:30 - 5:40	49	3	3	0
5:40 - 5:50	48	9	2	1
5:50 - 6:00	94	7	4	0

Point 5 : Russian Confederation Blvd.

Point No. 5	Date: 09/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
6:00 - 6:10	1123	188	7	2
6:10 - 6:20	1637	284	14	3
6:20 - 6:30	1746	264	17	6
6:30 - 6:40	3043	323	10	8
6:40 - 6:50	2670	383	17	5
6:50 - 7:00	3464	440	18	11
7:00 - 7:10	3368	503	20	14
7:10 - 7:20	2997	374	20	8
7:20 - 7:30	2894	362	16	1
7:30 - 7:40	2774	643	12	6
7:40 - 7:50	2669	529	17	3
7:50 - 8:00	2606	544	31	5
8:00 - 8:10	2609	603	23	4
8:10 - 8:20	2543	608	31	6
8:20 - 8:30	2105	575	31	9
8:30 - 8:40	1754	624	31	6
8:40 - 8:50	1547	538	27	7
8:50 - 9:00	2048	551	28	1
9:00 - 9:10	2039	629	23	3
9:10 - 9:20	1800	559	20	3
9:20 - 9:30	2016	552	32	1
9:30 - 9:40	2013	706	38	4
9:40 - 9:50	1354	752	37	7
9:50 - 10:00	1604	619	24	5
10:00 - 10:10	1451	490	32	5
10:10 - 10:20	1502	529	37	7
10:20 - 10:30	1505	620	31	2
10:30 - 10:40	1798	461	35	7
10:40 - 10:50	2450	553	30	5
10:50 - 11:00	2205	554	22	3
11:00 - 11:10	2238	493	20	3
11:10 - 11:20	1557	537	32	4
11:20 - 11:30	2109	524	27	2
11:30 - 11:40	977	594	26	6
11:40 - 11:50	1679	536	25	3
11:50 - 12:00	1925	525	21	4
12:00 - 12:10	1403	491	20	2
12:10 - 12:20	1640	461	19	3
12:20 - 12:30	1890	489	27	4
12:30 - 12:40	1582	542	35	4
12:40 - 12:50	1670	489	28	1
12:50 - 13:00	1693	553	24	9
13:00 - 13:10	1653	495	31	1
13:10 - 13:20	1751	475	29	1
13:20 - 13:30	1796	484	39	2
13:30 - 13:40	1636	528	33	4
13:40 - 13:50	1607	531	25	7
13:50 - 14:00	1634	681	38	8
14:00 - 14:10	1361	464	33	5

Point No. 5	Date: 09/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
14:10 - 14:20	1625	479	31	3
14:20 - 14:30	1497	475	24	2
14:30 - 14:40	1514	446	27	6
14:40 - 14:50	1395	377	15	2
14:50 - 15:00	1518	491	12	6
15:00 - 15:10	1439	548	25	2
15:10 - 15:20	1460	465	40	4
15:20 - 15:30	1674	483	41	5
15:30 - 15:40	1548	528	30	5
15:40 - 15:50	1510	513	28	1
15:50 - 16:00	2189	589	12	2
16:00 - 16:10	2278	472	25	4
16:10 - 16:20	2182	337	23	2
16:20 - 16:30	2195	363	30	5
16:30 - 16:40	2825	566	30	1
16:40 - 16:50	2015	549	27	5
16:50 - 17:00.	2846	525	28	4
17:00 - 17:10	3176	540	25	8
17:10 - 17:20	3312	413	11	3
17:20 - 17:30	3227	503	19	5
17:30 - 17:40	3105	564	36	4
17:40 - 17:50	3380	576	12	8
17:50 - 18:00	4158	623	6	5
18:00 - 18:10	3749	527	3	4
18:10 - 18:20	3448	545	18	6
18:20 - 18:30	3122	513	9	7
18:30 - 18:40	2117	571	6	3
18:40 - 18:50	2553	545	9	4
18:50 - 19:00	2401	533	10	3
19:00 - 19:10	2867	621	12	1
19:10 - 19:20	2430	496	8	5
19:20 - 19:30	2295	482	6	5
19:30 - 19:40	2561	425	11	6
19:40 - 19:50	2171	405	9	1
19:50 - 20:00	1949	428	10	3
20:00 - 20:10	1953	338	15	4
20:10 - 20:20	1941	368	13	0
20:20 - 20:30	1914	332	8	0
20:30 - 20:40	1739	372	8	3
20:40 - 20:50	1745	418	13	3
20:50 - 21:00	1742	454	3	3
21:00 - 21:10	1431	396	9	3
21:10 - 21:20	1256	398	9	1
21:20 - 21:30	1091	381	4	1
21:30 - 21:40	945	355	9	5
21:40 - 21:50	953	389	5	1
21:50 - 22:00	510	386	7	0
22:00 - 22:10	1085	529	5	1
22:10 - 22:20	1199	333	3	1
22:20 - 22:30	564	258	6	3

Point No. 5	Date: 09/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
22:30 - 22:40	1206	273	7	2
22:40 - 22:50	964	217	14	1
22:50 - 23:00	613	185	9	1
23:00 - 23:10	758	203	5	0
23:10 - 23:20	923	301	5	1
23:20 - 23:30	989	177	4	0
23:30 - 23:40	490	237	4	1
23:40 - 23:50	485	193	6	1
23:50 - 24:00	622	153	3	1
24:00 - 24:10	320	113	3	2
24:10 - 24:20	394	99	2	0
24:20 - 24:30	344	86	3	0
24:30 - 24:40	282	65	3	0
24:40 - 24:50	262	53	7	1
24:50 - 1:00	242	61	8	0
1:00 - 1:10	250	80	1	0
1:10 - 1:20	270	66	10	0
1:20 - 1:30	221	74	2	0
1:30 - 1:40	224	83	5	0
1:40 - 1:50	242	48	6	0
1:50 - 2:00	139	30	6	0
2:00 - 2:10	196	56	9	0
2:10 - 2:20	186	62	8	0
2:20 - 2:30	194	52	13	0
2:30 - 2:40	176	48	5	0
2:40 - 2:50	189	42	6	0
2:50 - 3:00	184	45	12	0
3:00 - 3:10	209	20	9	0
3:10 - 3:20	197	43	11	1
3:20 - 3:30	180	65	19	0
3:30 - 3:40	285	31	13	3
3:40 - 3:50	186	26	12	1
3:50 - 4:00	215	43	11	4
4:00 - 4:10	211	44	14	3
4:10 - 4:20	166	108	13	10
4:20 - 4:30	254	92	9	2
4:30 - 4:40	359	96	17	4
4:40 - 4:50	602	129	14	7
4:50 - 5:00	613	131	12	9
5:00 - 5:10	637	147	22	7
5:10 - 5:20	605	156	9	2
5:20 - 5:30	967	204	20	3
5:30 - 5:40	968	190	15	1
5:40 - 5:50	1013	278	11	5
5:50 - 6:00	1474	200	13	4

Point 6 : Hanoi Highway

Point No. 6	Date: 10/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
6:00 - 6:10	137	12	5	0
6:10 - 6:20	129	23	6	0
6:20 - 6:30	169	15	11	0
6:30 - 6:40	311	33	17	0
6:40 - 6:50	386	38	25	0
6:50 - 7:00	435	28	14	1
7:00 - 7:10	434	40	13	0
7:10 - 7:20	360	61	18	0
7:20 - 7:30	329	50	15	0
7:30 - 7:40	352	55	18	0
7:40 - 7:50	484	58	33	0
7:50 - 8:00	408	52	15	0
8:00 - 8:10	319	50	15	0
8:10 - 8:20	387	83	25	0
8:20 - 8:30	315	76	29	0
8:30 - 8:40	342	84	25	0
8:40 - 8:50	303	63	18	0
8:50 - 9:00	370	141	23	0
9:00 - 9:10	316	80	29	1
9:10 - 9:20	261	44	24	0
9:20 - 9:30	335	63	32	0
9:30 - 9:40	234	65	17	0
9:40 - 9:50	313	65	23	0
9:50 - 10:00	291	68	20	1
10:00 - 10:10	278	104	24	0
10:10 - 10:20	320	61	45	2
10:20 - 10:30	323	93	24	0
10:30 - 10:40	266	73	22	0
10:40 - 10:50	292	82	26	0
10:50 - 11:00	297	65	23	0
11:00 - 11:10	198	46	20	0
11:10 - 11:20	266	62	29	0
11:20 - 11:30	291	78	26	0
11:30 - 11:40	310	94	31	0
11:40 - 11:50	347	80	29	0
11:50 - 12:00	218	59	19	0
12:00 - 12:10	274	90	12	0
12:10 - 12:20	220	60	15	0
12:20 - 12:30	182	50	9	0
12:30 - 12:40	179	47	10	0
12:40 - 12:50	229	43	20	0
12:50 - 13:00	248	58	24	1
13:00 - 13:10	260	62	24	0
13:10 - 13:20	272	85	17	0
13:20 - 13:30	289	61	23	0
13:30 - 13:40	233	72	22	0
13:40 - 13:50	298	56	20	0
13:50 - 14:00	253	60	30	0
14:00 - 14:10	228	33	31	0

Point No. 6	Date: 10/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
14:10 - 14:20	319	39	35	0
14:20 - 14:30	260	60	14	0
14:30 - 14:40	311	74	25	0
14:40 - 14:50	350	89	26	1
14:50 - 15:00	277	46	15	1
15:00 - 15:10	339	70	30	0
15:10 - 15:20	324	58	20	0
15:20 - 15:30	310	42	24	0
15:30 - 15:40	367	65	14	1
15:40 - 15:50	365	77	27	0
15:50 - 16:00	426	64	28	0
16:00 - 16:10	448	63	22	0
16:10 - 16:20	391	82	32	0
16:20 - 16:30	409	69	21	0
16:30 - 16:40	439	92	14	0
16:40 - 16:50	423	70	18	0
16:50 - 17:00.	436	66	22	0
17:00 - 17:10	499	85	5	0
17:10 - 17:20	457	59	16	0
17:20 - 17:30	481	62	11	0
17:30 - 17:40	491	99	11	1
17:40 - 17:50	431	83	10	0
17:50 - 18:00	417	95	16	0
18:00 - 18:10	595	113	15	0
18:10 - 18:20	489	76	17	0
18:20 - 18:30	455	82	11	0
18:30 - 18:40	441	74	12	2
18:40 - 18:50	500	68	15	0
18:50 - 19:00	463	80	13	0
19:00 - 19:10	366	55	8	0
19:10 - 19:20	402	75	8	1
19:20 - 19:30	354	47	17	0
19:30 - 19:40	318	36	11	0
19:40 - 19:50	337	48	14	0
19:50 - 20:00	195	26	9	0
20:00 - 20:10	224	47	15	0
20:10 - 20:20	248	62	9	0
20:20 - 20:30	232	40	11	2
20:30 - 20:40	206	25	15	0
20:40 - 20:50	201	35	11	1
20:50 - 21:00	210	35	18	1
21:00 - 21:10	171	42	9	0
21:10 - 21:20	164	41	13	0
21:20 - 21:30	154	31	11	0
21:30 - 21:40	148	24	5	0
21:40 - 21:50	139	21	3	0
21:50 - 22:00	121	24	1	0
22:00 - 22:10	71	14	10	0
22:10 - 22:20	106	14	11	0
22:20 - 22:30	112	33	5	0

Point No. 6	Date: 10/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
22:30 - 22:40	124	23	9	0
22:40 - 22:50	73	17	10	0
22:50 - 23:00	61	24	5	1
23:00 - 23:10	121	40	16	0
23:10 - 23:20	75	20	8	0
23:20 - 23:30	67	16	3	1
23:30 - 23:40	50	4	2	0
23:40 - 23:50	49	5	3	0
23:50 - 24:00	72	9	4	0
24:00 - 24:10	26	9	1	0
24:10 - 24:20	28	10	4	0
24:20 - 24:30	20	6	2	0
24:30 - 24:40	19	6	2	0
24:40 - 24:50	34	9	3	0
24:50 - 1:00	39	7	3	0
1:00 - 1:10	12	7	2	0
1:10 - 1:20	20	7	5	0
1:20 - 1:30	41	3	1	0
1:30 - 1:40	20	3	3	0
1:40 - 1:50	42	3	3	0
1:50 - 2:00	46	7	2	0
2:00 - 2:10	18	2	1	0
2:10 - 2:20	24	1	6	0
2:20 - 2:30	10	4	2	0
2:30 - 2:40	8	15	6	1
2:40 - 2:50	29	3	4	0
2:50 - 3:00	31	4	3	0
3:00 - 3:10	18	1	2	0
3:10 - 3:20	24	2	6	0
3:20 - 3:30	16	3	0	0
3:30 - 3:40	6	2	1	0
3:40 - 3:50	28	5	4	0
3:50 - 4:00	28	12	5	0
4:00 - 4:10	22	13	9	0
4:10 - 4:20	32	7	12	0
4:20 - 4:30	24	1	2	0
4:30 - 4:40	21	4	4	0
4:40 - 4:50	46	5	3	0
4:50 - 5:00	38	5	5	0
5:00 - 5:10	53	10	13	0
5:10 - 5:20	73	13	7	0
5:20 - 5:30	87	15	16	3
5:30 - 5:40	137	18	20	3
5:40 - 5:50	212	12	13	0
5:50 - 6:00	196	16	12	0

Point 7 : GS5 S/S

Point No. 7	Date: 11/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
6:00 - 6:10	12	0	2	0
6:10 - 6:20	10	0	1	0
6:20 - 6:30	14	2	0	0
6:30 - 6:40	20	0	0	0
6:40 - 6:50	26	3	2	0
6:50 - 7:00	30	2	1	0
7:00 - 7:10	33	3	3	0
7:10 - 7:20	13	2	4	0
7:20 - 7:30	15	1	7	0
7:30 - 7:40	14	4	3	0
7:40 - 7:50	13	4	10	0
7:50 - 8:00	20	2	3	0
8:00 - 8:10	12	3	1	0
8:10 - 8:20	18	3	5	0
8:20 - 8:30	23	1	2	0
8:30 - 8:40	23	3	3	0
8:40 - 8:50	12	2	0	0
8:50 - 9:00	22	3	3	0
9:00 - 9:10	20	2	6	0
9:10 - 9:20	11	0	3	0
9:20 - 9:30	9	1	3	0
9:30 - 9:40	7	2	6	0
9:40 - 9:50	22	0	4	0
9:50 - 10:00	17	2	4	0
10:00 - 10:10	10	2	6	0
10:10 - 10:20	9	0	3	0
10:20 - 10:30	4	2	2	0
10:30 - 10:40	10	3	6	0
10:40 - 10:50	13	6	4	0
10:50 - 11:00	10	2	10	0
11:00 - 11:10	10	3	1	0
11:10 - 11:20	8	4	2	0
11:20 - 11:30	8	2	2	0
11:30 - 11:40	6	2	4	0
11:40 - 11:50	15	2	3	0
11:50 - 12:00	11	2	2	0
12:00 - 12:10	14	2	2	0
12:10 - 12:20	13	2	5	0
12:20 - 12:30	11	2	2	0
12:30 - 12:40	12	1	2	0
12:40 - 12:50	10	1	0	0
12:50 - 13:00	10	0	4	0
13:00 - 13:10	8	0	2	0
13:10 - 13:20	6	0	5	0
13:20 - 13:30	6	0	7	0
13:30 - 13:40	14	1	5	0
13:40 - 13:50	8	0	7	0
13:50 - 14:00	6	1	4	0
14:00 - 14:10	7	4	1	0

Point No. 7	Date: 11/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
14:10 - 14:20	2	0	5	0
14:20 - 14:30	13	0	7	0
14:30 - 14:40	11	5	8	0
14:40 - 14:50	11	2	6	0
14:50 - 15:00	9	3	6	0
15:00 - 15:10	6	2	1	0
15:10 - 15:20	11	1	7	0
15:20 - 15:30	13	2	1	0
15:30 - 15:40	12	0	1	0
15:40 - 15:50	10	1	2	0
15:50 - 16:00	9	3	5	0
16:00 - 16:10	9	1	5	0
16:10 - 16:20	13	3	4	0
16:20 - 16:30	11	0	6	0
16:30 - 16:40	16	1	2	0
16:40 - 16:50	13	1	5	0
16:50 - 17:00.	8	3	2	0
17:00 - 17:10	28	0	8	0
17:10 - 17:20	19	4	5	0
17:20 - 17:30	14	1	6	0
17:30 - 17:40	11	0	4	0
17:40 - 17:50	13	0	5	0
17:50 - 18:00	15	1	6	0
18:00 - 18:10	11	1	9	0
18:10 - 18:20	24	1	0	0
18:20 - 18:30	17	1	1	0
18:30 - 18:40	29	0	2	0
18:40 - 18:50	14	1	0	0
18:50 - 19:00	22	1	1	0
19:00 - 19:10	17	2	2	0
19:10 - 19:20	7	1	0	0
19:20 - 19:30	2	1	0	0
19:30 - 19:40	6	1	2	0
19:40 - 19:50	5	0	1	0
19:50 - 20:00	9	2	0	0
20:00 - 20:10	2	2	0	0
20:10 - 20:20	4	0	0	0
20:20 - 20:30	3	0	0	0
20:30 - 20:40	3	0	0	0
20:40 - 20:50	0	0	0	0
20:50 - 21:00	2	0	0	0
21:00 - 21:10	0	0	0	0
21:10 - 21:20	2	0	0	0
21:20 - 21:30	0	1	0	0
21:30 - 21:40	0	0	0	0
21:40 - 21:50	0	0	0	0
21:50 - 22:00	1	0	0	0
22:00 - 22:10	3	1	2	0
22:10 - 22:20	0	1	0	0
22:20 - 22:30	0	0	0	0

Point No. 7	Date: 11/06/2014			
Time	Type 1	Type 2	Type 3	Type 4
22:30 - 22:40	1	0	0	0
22:40 - 22:50	0	0	0	0
22:50 - 23:00	1	0	0	0
23:00 - 23:10	0	0	0	0
23:10 - 23:20	0	0	0	0
23:20 - 23:30	0	0	1	0
23:30 - 23:40	3	0	0	0
23:40 - 23:50	0	0	1	0
23:50 - 24:00	0	0	0	0
24:00 - 24:10	0	0	0	0
24:10 - 24:20	4	1	0	0
24:20 - 24:30	0	0	0	0
24:30 - 24:40	0	1	1	0
24:40 - 24:50	0	0	0	0
24:50 - 1:00	2	0	0	0
1:00 - 1:10	1	0	0	0
1:10 - 1:20	0	0	0	0
1:20 - 1:30	0	0	0	0
1:30 - 1:40	1	0	0	0
1:40 - 1:50	0	0	0	0
1:50 - 2:00	0	0	0	0
2:00 - 2:10	0	0	0	0
2:10 - 2:20	0	0	0	0
2:20 - 2:30	0	0	0	0
2:30 - 2:40	0	0	0	0
2:40 - 2:50	0	0	0	0
2:50 - 3:00	1	0	0	0
3:00 - 3:10	0	0	0	0
3:10 - 3:20	0	0	0	0
3:20 - 3:30	1	0	0	0
3:30 - 3:40	3	0	0	0
3:40 - 3:50	0	0	1	0
3:50 - 4:00	1	0	0	0
4:00 - 4:10	0	0	1	0
4:10 - 4:20	1	0	0	0
4:20 - 4:30	1	0	0	0
4:30 - 4:40	0	0	0	0
4:40 - 4:50	0	0	1	0
4:50 - 5:00	2	0	0	0
5:00 - 5:10	2	0	1	0
5:10 - 5:20	3	0	0	0
5:20 - 5:30	1	0	0	0
5:30 - 5:40	4	1	0	0
5:40 - 5:50	7	0	0	0
5:50 - 6:00	6	0	0	0

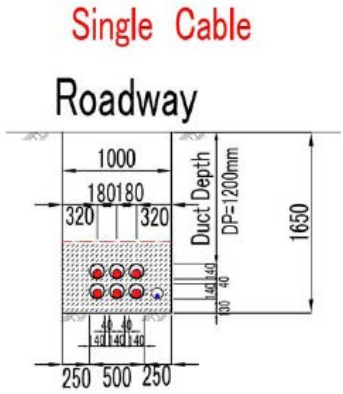
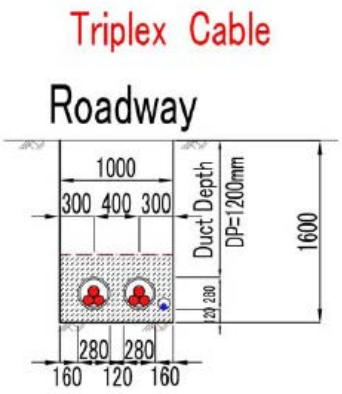
APPENDIX-7

COMPARISON SHEET BETWEEN SINGLE CORE CABLE AND 3-CORE CABLE

Appendix-7 Comparison Sheet between Single Core Cable and 3-Core Cable

Source: Final Report of Preparatory Survey for Phnom Penh Transmission Line and Distribution System Construction Project (November 2013)

Comparison Sheet between Single Core Cable and 3-Core Cable

	Single core cable	3-core cable
Installation configuration		
Cable size	1,000mm^2	1,000mm^2
Construction time	12 months	11 months
Cost of supply equipment	1,637US$/m	1,649US$/m
Cost of civil and erection	1,084US$/m	976US$/m
Total construction cost	2,721US$/m	2,625US$/m
Evaluation	△	◎

(In case of 3.6km cable route) Source: JICA Phase1 Survey Team

From the above comparison sheet, the application of 3-core cables is preferable due to cheaper construction costs and shorter construction time.

As for the application of the 3-core cables of over 100kV voltage grade all over the world, only 154kV triplex type (3- cable assembly type) XLPE cables were developed and put into service in Japan.

APPENDIX-8

ENVIRONMENTAL CHECKLIST, ENVIRONMENTAL MONITORING FORM AND ENVIRONMENTAL MONITORING COST

Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) N (c) N (d) N	(a) We are preparing IEIA at present. (b) ditto (c) This project is not required other environmental permit. (d) ditto
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) Y	(a) EDC explained contents of the project and the potential impacts to stakeholder's authorities and line ministries in the stakeholder meetings (SHM) on 29 April 2014 and 10 September. And public consultation meetings for local residents were organized on 10 August and 6 September. (b) The comments from stakeholders will be reflected to the project design.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) The routes of overhead transmission lines (OHL) of 230kV and 115kV were compared in order to minimize the impact on environment and social. At the result 230kV OHL was selected the route to avoid residential area as far as possible. And 115kV was selected the route to pass the most shallow area of the lake.
2 Pollution Control	(1) Water Quality	(a) Is there any possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? If the water quality degradation is anticipated, are adequate measures considered?	(a) N	(a) Works which cause water quality degradation in down stream water areas are not expected.
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) There is no protected area in and around the project area. But the OHL will pass near Basset Marsh, one of Important Bird and Biodiversity Areas (IBAs) which is categorised by Birdlife International. If the possibility that affected it will be expected, mitigation measures such as bird fly diverter will be put in.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Are adequate measures taken to prevent disruption of migration routes and habitat fragmentation of wildlife and livestock? (e) Is there any possibility that the project will cause the negative impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystem due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered? (f) In cases where the project site is located in undeveloped areas, is there any possibility that the new development will result in extensive loss of natural environments?	(a) N (b) N (c) Y (d) Y (e) Y (f) N	(a) Most of project areas are located in the urban developed area and farm lands. Part of project area is in the wetland, but this area is limited. (b) Protected habitats of endangered species are not included in the project area. (c) Adequate protection measures will be taken to reduce the impacts on the ecosystem if significant ecological impacts will be anticipated. (d) Adequate measures will be taken to if migration routes and habitat fragmentation of wildlife and livestock will be prevented and disrupted. (e) Partially overhead transmission line will pass through the lake. In order to minimize the impact on fishes, the temporary access road is planned not to cut off the lake to construct towers in the lake. (f) Most of project area have already been developed.
	(3) Topography and Geology	(a) Is there any soft ground on the route of power transmission and distribution lines that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed? (b) Is there any possibility that civil works, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides? (c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?	(a) N (b) N (c) N	(a) The possibility of slope failures or landslides is identified on the route of power transmission and distribution lines. (b) Works which cause slope failures or landslides are not expected. (c) Works which soil run off are not expected. If soil run off, adequate measures will be taken to prevent.

Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Are the compensations going to be paid prior to the resettlement? (e) Are the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) Y (b) Y (c) Y (d) Y (e) Y (f) Y (g) Y (h) Y (i) Y (j) Y	(a) - In 230kV TL, land acquisition for the towers is 0.225ha. 11 APs are found as these owners. The scale of land acquisition of every affected person is small. Since the 3 structures are found in the ROW, 15 APs total of 3 AHs may resettle. Land acquisition for the GS5 S/S is 4.41ha. The owner is a village comunity. Village comunity's land is vacant. - In 115kV TL, land acquisition for the towers and pokes is 0.808 ha. 21 APs are hound as these owners. The scale of land acquisition of every affected person is small. Since the 17 structures are found in the ROW of 230kV, 59 APs total of 13 AHs may resettle. Land acquisition for Chroy Changvar S/S is 3.24 ha. The owner is LYP (developer). (b) Compensation for land acquisition will be adequately explained to affected people at the consultation meeting. But the impact by land acquisition is not significant. (c) The adequate compensation costs will be planned based on the replacemet cost. (d) The compensation wil be paid prior to the resettlement. (e) The compensation policies will be included in the resettlement plan. (f) The resettlement plan will be prepared taking them into consideration . (g) Public consultation will be organized to obtain agreements on compensation with the affected people.
4 Social Environment	(2) Living and Livelihood	(a) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? (b) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary? (c) Is there any possibility that installation of structures, such as power line towers will cause a radio interference? If any significant radio interference is anticipated, are adequate measures considered? (d) Are the compensations for transmission wires given in accordance with the domestic law?	(a) Y (b) Y (c) N (d) Y	(a) - The fishery may be impacted by construction of the towers in the lake. But it is expected not to be significant. - The temporary and small impact on the surrounding traffic situation, is anticipated. However, the impact is limited. The construction schedule and time period will be considered and shared with the neighborhood. The traffic order or facilitator will be provided at crossing points of busy road in period of the project construction. (b) Health education such as HIV/AIDS will be provided to the project workers by EDC and contractor. Firstly, EDC and contractor will aid training about diseases including HIV/AIDS to project staff etc. to avoid the spread of disease to between people. (c) The radio interference is not expected by the project. But if any significant radio interference is anticipated, adequate measures such as construction of the comunity antenna will be implemented. (d) The compensations for ROW of transmission line are implemented according to land law, EDC regulation, and General Requirements of Electri Power Technical Standards of Kingdom of Cambodia, Ministry of Industry, Mine and Energy, 2004, amended 2007.
	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) Not applicable since there is any local archeological, historical, cultural, and religious heritage affected by project.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) Y	(a) The towers and overhead transmission lines cause change of landscape in rural area. But the impact is limited.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources respected?	(a) N (b) N	(a) (b) There are not ethnic minorities and indigenous peoples in and around the project area.

Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a) The EDC and constructor will implement the project in compliance with the Labor Law stipulated by RGC. (b) The contractor will follow all safety working standards by providing safety tool and equipment such as boot, gloves, eye-glasses, and helmet. And they will conduct periodical patrol of working conditions. (c) The safety education and training for labors about sanitation, security and rules/discipline and daily activity will be are implemented by EDC and DCC. And the safety management plan will be prepared and observed by DCC. (d) As mentioned above, not only security guards but also all construction labors will be trained by education program for social consideration. In addition, periodical patrol of workers will be implemented to avoid local conflict.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) Y (b) Y (c) Y	(a) Following measures are proposed to reduce impacts by the construction (i) Noise; to use noise-reducing machineries, (ii) Dust and emission; to use low-emission vehicle and equipment, dust prevention such as covering of solid or sprinkling of water (iii) Turbid water; proper and quick treatment of suspended solids or soil, (iv) Waste; minimalize of the waste and proper treatment. (b) As mentioned above, in order to minimize the impact on fishes, the temporary access road is planned not ot cut off the lake to construct towers in the lake. (c) The following measures are proposed to reduce any negative impacts: (i) to disseminate information on the limitation period of construction works to commune council and other, (ii) to publicize the construction schedule to the neighborhood etc. (iii) to provide a traffic order ot facilitator at crossing points of busy road in period of the project construction.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) N	(a) About noise, water quality, birds, fish, fishery, and appropriate compensation, monitoring program are implemented. In addition, checking at the construction site is proposed for the potential impact. (b) Noise monitoring by observation and instrumental measurement in the field monthly are proposed. (c) Monitoring is proposed to be carried out by Design and Construct Contractor, supervised by Project Implementation Consultant under the responsibility of EDC. (d) At present, the format and the frequency of the report are not provided from regulatory authorities.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Road checklist should also be checked (e.g., projects including installation of electric transmission lines and/or electric distribution facilities).	(a) N	(a) Temporary access road will be constructed, but its distance is short.
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed, (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) There is no possibility to impact on the transboundary or global environment.

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

Monitoring Form: Monitoring of Noise and Vibration

a) Type of work: _____

b) Monitoring Frequency: □ 1st / □ 2nd / □ 3 rd

c) Monitoring Period: From Date Month Year

To Date Month Year

		Item		Unit	Date1 DD/MM /YY	Date2 DD/MM /YY	Date3 DD/MM /YY	Remark (Date)
		Day Time (6:00-18:00) Noise - Residential Area :60 dB(A) - Commercial Area: 70dB(A)						
No.1	(Detail of Location)	Noise-1	L_{eq}	dB(A)				
		Noise-2	L_{min}	dB(A)				
		Noise-3	L_{max}	dB(A)				
No.2	(Detail of Location)	Noise-1	L_{eq}	dB(A)				
		Noise-2	L_{min}	dB(A)				
		Noise-3	L_{max}	dB(A)				
No.3	(Detail of Location)	Noise-1	L_{eq}	dB(A)				
		Noise-2	L_{min}	dB(A)				
		Noise-3	L_{max}	dB(A)				
No.4	(Detail of Location)	Noise-1	L_{eq}	dB(A)				
		Noise-2	L_{min}	dB(A)				
		Noise-3	L_{max}	dB(A)				
No.5	(Detail of Location)	Noise-1	L_{eq}	dB(A)				
		Noise-2	L_{min}	dB(A)				
		Noise-3	L_{max}	dB(A)				

Monitoring Form: Monitoring of Waste Management

a) Detail of location: _____

b) Type of work: _____

c) Monitoring Period: From Date Month Year

To Date Month Year

No.	Type of waste	Volume (Unit)	Detail	Treatment Measure	Remark
1	Construction soil	(ton)			
2	Concrete	(ton)			
3	……				
4					
5					

Monitoring Form : Compensation

a) Detail of location: _____

b) Type of work: _____

c) Monitoring Period: From Date Month Year

To Date Month Year

Resettlement Activities	Planned Total	Unit	Progress in Quantity			Progress in %		Expected Date of Compensation	Responsible Organization
			During the Quarter	Till the last Quarter	Up to the Quarter	Till the last Quarter	Up to the Quarter		
Preparation of RAP									EDC
Employment of Census Survey		Man-month							
Implementation of Census Survey									
Approval of RAP									
Finalization of PAPs List		No. of PAPs							
Progress of Compensation Payment		No. of HHs							
Lot 1		No. of HHs							
Lot 2		No. of HHs							
Lot 3		No. of HHs							
Lot 4		No. of HHs							
Progress of Land Acquisition (All Lots)		ha							
Lot 1		ha							
Lot 2		ha							
Lot 3		ha							
Lot 4		ha							
Progress of Asset Replacement (All Lots)		No. of HHs							
Lot 1		No. of HHs							
Lot 2		No. of HHs							
Lot 3		No. of HHs							
Lot 4		No. of HHs							

Monitoring Form: Visual Checking at the Construction Site

a) Detail of location: _____

b) Type of work: _____

c) Monitoring Period: From Date Month Year

To Date Month Year

Item	DD/MM /YY	Result	DD/MM /YY	Result	DD/MM /YY	Result	DD/MM /YY	Result
1) Air pollution (dust, noise) at the water body near the construction site								
2) Water pollution (turbidity, soil sediment) at the water body near the construction site								
2) Public Health and work safety								
3) Traffic near the construction site								
4) Others, if any								

Environmental Monitoring Cost

Item		Price (US$)	Q'ty		Total (US$)	Remarks
Cost Estimate for EMP Implemetation						
Consultation & Workshop		3,000	1	set	3,000	-
Provision of Public Health Insformation		2,500	1	set	2,500	-
Cost Estimate for Monitoring						
Weekly Checking by DCC	Payroll including Transport Fee	120	152	days	18,240	- Monitoring requires 2 days/time for covering project area - Monitoring requires 1 month before the construction and 1 month after construction in addition to 33 months of construction period - 152weeks * 1day
Quarter Checking by EDC	Payroll including Transport Fee	120	24	days	2,880	- 36months/3months * 2days
Monthly Checking by DCC	Payroll including Transport Fee	120	70	days	8,400	- Monitoring requires 2 days/time for covering project area - Monitoring requires 1 month before the construction and 1 month after construction in addition to 33 months of construction period - 35months * 2days
Monthly Checking by EDC	Payroll including Transport Fee	120	70	days	8,400	ditto
Checking of Public Health and Workers Safety	Payroll including Transport Fee	120	2	days	240	- Checking requires 2 times during construction period
Contingency 10%					4,366	-
Grand Total					**48,026**	