ANNEX 8-1 Basic Design Report for Reconstruction of Quay Wall Structures

1 INTRODUCTION

1.1 Background

The existing quay area at Galle Fishery Harbor area consists of a jetty (90m long and 15m wide), a western quay area (90m+35m long) and an eastern quay area (approximately 120m long). The jetty and the western quays are the main quay areas in the Harbor and are the busy fishery area with facilities such as an auction hall, offices, ice plants, cold storages and so on. The eastern quay, which has been seriously damaged by the tsunami, almost in its entirety, was mainly used for small to medium-size fishery boats due to its water depth (designed at - 1.5m MSL).

The Ceylon Fishery Harbors Corporation (CFHC) under the Ministry of Fisheries & Aquatic Resources has decided to restore this quay area together with its buildings and facilities as a part of construction works financed by the Japanese non-project grant. A design and build method has been employed for these construction works which include a quay wall, slipway and various buildings and facilities of the Galle fishery harbor.

1.2 Natural Conditions

(1) Meteorological Conditions

1) Topography

Sri Lanka is located between the latitude of 5.55 and 9.50 degrees N and between the longitude of 79.42 and 81.52 degrees E, whose national land is topographically divided into the following four (4) Regions:

i) Central Highlands, ranging in elevation from 1,000 to 2,500 m;
ii) Northern Lowlands, having gentle sloping area;
iii) Southwest area, having steep sloping area; and
iv) Southeast area, having steep sloping area.

The northern part from the center of the island is almost plains, while the southern part is mountainous and surrounded by coastal plains. The highest point of in Sri Lanka is Mt. Pidurutalagala, 2,525 m above sea level, in Nuwara Eliya District. The country has a maximum length of about 430 km and a maximum width of about 220 km, and an area of about 65,000 km^2.

Sri Lanka consists of 9 provinces: Western, Central, Southern, North-Western, Sabaragamuwa, Northern Eastern, Uva and North-Central, and 25 districts. Project site for the project (Galle) is located in Southern province.
Galle city is located in Galle district, about 120 km south of Colombo, on the south - west coast of Sri Lanka. Galle fishery harbor is adjacent with Galle commercial port in Galle bay.

2) Climate

The climate of Sri Lanka is generally divided into three types in based on topographic condition. The northern and the south-east areas are generally classified by “Dry-Zone”, other hand the central highlands and the south-west areas belong to “Wet-Zone” with heavy rainfall. Area between the two areas (“Dry Zone” in the northern and south-east area, and “Wet Zone” in the central highlands and south-west area) is called as “Medium-Dry Zone”.

3) Rainfall

The climate of Sri Lanka has been significantly affected by two monsoons (South-West Monsoon and Northeast Monsoon) through the year, therefore the general climate can be divided into the four (4) distinct periods as follow.

i) South-West Monsoon (Yala) (May to September)

There is monsoon blowing in from the south-east, Indian Ocean. During the period, 1,000 to 3,500 mm rainfall in the south-west part and 3,000 to 3,500 mm rainfall in the central highlands part occur respectively.

ii) North-East Monsoon (Maha) (December to February)

There is monsoon blowing in from the north-east, Indian Ocean. During the period, 500 to 2,500 mm rainfall in the east part of the island occurs.

iii) Inter-monsoon (March to April)

Heavy rainfalls in the south-west part due to wet air flow from the south-west, Indian Ocean.

iii) Inter-monsoon (October to November)

Heavy rainfalls occur in whole part of the country due to tropical cyclone in Indian Ocean.
Usually, more than 30 % of annual rainfall occurs during the south-west monsoon, another remaining 70 % is caused by the north-west monsoon.
For rainfall data of the project site, monthly rainfall data of Galle is available as shown in below table.

Monthly Rainfall in Galle (unit: mm)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep	Oct.	Nov.	Dec.	Annual
Rainfall	85	71	111	207	290	188	163	186	256	323	321	177	2,378

Source: Meteorological Department, "Study on Urgent Development of the Port of Galle as a Regional Port, Oct. 2000"

4) Temperature

Monthly maximum and minimum temperature in Galle is summarized below.

Monthly Temperature in Galle (unit: °C)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep	Oct.	Nov.	Dec.	Mean
Max.	29.0	29.9	30.6	30.6	29.8	29.0	28.6	28.4	28.5	28.7	29.0	29.1	29.3
Min.	22.8	23.0	23.9	24.8	25.5	25.2	24.8	24.7	24.7	24.1	23.5	23.1	24.2
Mean	25.9	26.5	27.3	27.7	27.7	27.1	26.7	26.6	26.6	26.4	26.3	26.1	26.8

Source: Meteorological Department, "Study on Urgent Development of the Port of Galle as a Regional Port, Oct. 2000"

5) Humidity

The average humidity in the Galle area is around 80 % during daytime and 88 % during nighttime throughout the year. Daytime humidity increases in the months of July - August up to 85 % and relatively low humidity of the order 70 % occur in January - February.

Monthly Humidity in Galle (unit: Mean %)

Month	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep	Oct.	Nov.	Dec.	Mean
Day	78.2	72..8	73.6	78.2	81.6	88.3	84.2	85.8	82.8	81.7	79.2	79.0	80.0
Night	88.6	86.0	87.0	88.2	88.8	87.4	90.2	89.4	88.0	89.2	89.4	91.3	88.6

Source: Meteorological Department, "Study on Urgent Development of the Port of Galle as a Regional Port, Oct. 2000"

6) Wind

The wind pattern in Sri Lanka is mainly associated with the monsoons. During the south-west monsoon, western and southern parts of the island are normally subject to high winds. In the Galle area, wind speed occasionally reaches 15 - 20 knots (7.7 m/sec - 10.3 m/sec) during the south west monsoon. From the analysis of wind data collected a 3-year period at the Galle from 1986 to 1988, it has been found that wind speeds at the Galle exceeded 20 knots (= 10.3 m/sec) at a frequency of 0.1 % and 10 knots (= 7.7 m/sec) at a frequency of 10.5 %.

Wind direction in Galle is mostly confined to south-west sector. Wile during the north-east monsoon, wind and direction are not as regular as during south-west. However, the predominant wind directions during this season are found as north and east-north-east.

7) Cyclone

Southern area in Sri Lanka is not attacked by cyclones so much. Recently Batticaloa Cyclone damaged to Eastern area in Sri Lanka in 1978, the maximum wind speed is recorded 100 knots.

8) Earthquake

There has been no big earthquake in Sri Lanka, and is no standard for facilities against earthquake.

(2) Oceanographic Conditions

1) Tide

Tide levels at project harbor and neighboring ports are summarized in below.

Tide Level at Project Harbor and Neighboring Port (unit: EL, m)

Level / Location	Colombo port	Galle port	Tangalle port	Hambantota port	Kirinda port
HWL	+0.72	+0.61	+0.53	+0.47	+0.33
MSL	+0.38	+0.34	+0.28	+0.25	+0.17
LWL	+0.20	+0.10	+0.10	+0.10	+0.10
D.L.	+0.00	+0.00	+0.00	+0.00	+0.00

Source: Meteorological Department, "The Project for Implementation of Fishery Harbor Facilities and Fisheries Training Center at Tangalle, 2000

2) Wave

50 years occurrence rate of deepwater wave at Galle bay has been calculated as bellow by wave observation record at 12 km from Galle port.

50 years Occurrence Rate of Deepwater Wave

Main Direction	Significant wave $H_{1/3}$	Highest wave H_{max}	Period
WSW	6.2 m	10.7 m	12.3 sec

Source: Meteorological Department, "Study on Urgent Development of the Port of Galle as a Regional Port, Oct. 2000"

3) Onshore and Offshore Boring

Results of borings are shown in Annex 8-2.

2 Design Criteria and Conditions

2.1 Required Facilities

The scope of the quay structures consist of:

- - 3.5m Quay;
- Slipway (60 m);
- Retaining wall structure;
- Ancillary facilities;
- Pavement behind the quay structures; and
- Design of Winch and Associated Facilities/Equipment.

2.2 Functions

(1) -3.5m Quay

The quay will be 95 m long and the water depth near the quay is at least -3.5 m MSL. The quay will be associated with a 6.0 m wide apron. The height of the quay face will be +1.45m MSL, designed to discharge surface water directly into the sea. The quay will mainly be used as preparation & resting berths, and designed to accommodate fishing boats up to 60ft class. Steel sheet piles will be used for the quay rehabilitation considering the site conditions such as subsoil profile.

(2) Slipway

The slipway will be constructed for fishing boat repairs and maintenance and includes a cradle & winch system, rail track, etc. The proposed slipway is 7.0m in width and has 2.5m clearance at each side, with slope ratio of 1:10, ranging from +2.50 to -3.5m MSL, The surface of the slipway will be paved with pre-cast concrete blocks and in-situ concrete construction. The slipway has designed for cradle-mounted boats up to 60ft.

(3) Retaining Wall Structure

Along the slipway, retaining walls will be put up. A part of west-side retaining wall that will be connected to the quay wall, with its length approximately 20m from the quay face, will have a similar structure to the quay wall, regarded as part of the quay wall. The remaining parts of the retaining wall has been designed with a gravity type structure.

(4) Ancillary Facilities

Ancillary facilities for the quay such as fenders, bollards and mooring rings are to be constructed. All such facilities will have enough capacities to endure the intended operation of the quay in accordance with the requirements.

(5) Pavement behind the Quay and Slipway

In order to enable smooth and effective operations of the fishery port activities, the surrounding areas of the quay and slipway will have proper paving or surfacing. The pavement behind the slipway will be asphalt concrete paving and/or concrete paving. Behind the Quay apron, an area of at least 4m in width, are land-leveled finished with a gravel surfacing.

(6) Winch, Winch House and Cradle System

A winch house with a $16m^2$ (4.0x4.0m) area will be constructed in the slipway area to shelter a winch and its related facilities/equipment. The winch house will be constructed with a RC Beam & Column and concrete block wall as indicated in relevant drawings. A winch and cradle system will be required for the operation of the slipway.

2.3 Design Criteria and Conditions

(1) Usage Conditions

The quay structure has been designed in accordance with the following usage requirements:

- Fishing boats ranging from 20 ft to 60 ft;
- Maximum boat sizes are considered; and
- LOA=20.0m, Breadth=5.0m, Full Load draft= 2.5m (unloaded; 2.0m).

(2) Design Loads

1) Dead Loads

- Concrete (plain): 24.0 kN/m^2
  (reinforced/ pre-stressed): 25.0 kN/m^3
- Steel material: 77.0 kN/m^3
- Rocks/ stones (dry): 8.0 kN/m^3
  (saturated): 20.0 kN/m^3
- Seawater: 10.1 kN/m^3

2) Live Load / Surcharge Load

- Uniform Live Load: for the quay wall: 10 kN/m^2
- for retaining walls: 20 kN/m^2

3) Vehicle Load: 50-ton truck crane for retaining walls design

4) Horizontal Loads

Horizontal loads such as bollard pulls, fender reactions, earth pressures, seismic forces, etc. have been precisely calculated based on the facilities requirements, usage conditions and natural conditions.

(3) Corrosion Rate

The following corrosion rates of steel sheet piles have been applied:

1) HWL ~ -0.5 m:	0.1 ~ 0.3 mm/year
	(Design Corrosion Rate: 0.2 mm/year)
2) -0.5m ~ Sea bed:	0.1 ~ 0.2 mm/year
	(Design Corrosion Rate 0.1 mm/year)
3) Below seabed:	0.03 mm/year

3 Quay Wall

3.1 Alternative Plan

For the reconstruction of the quay wall at Galle fishery harbor, steel sheet pile type and gravity type has been compared. Although the existing quay wall is gabion type, this alternative was been considered because it has been less durable. Typical cross sections of steel sheet pile type and gravity type are shown in the following figure. After comparing cost and construction terms, steel sheet pile has been recommended.

3.2 Calculation Result of Steel Sheet Pile

As a result of calculation of steel sheet pile type and stability, type and the minimum penetration depth have been determined to be SP-IV and -13.5 m (MSL). Summary of calculation result is shown in the following tables and figures. The calculation has been carried out by computer software “Cantilever Sheet Piled Quay Wall and Stability Analysis on Port Facility Design Series by ARATANI”.

Safety factor of bearing capacity has been calculated at 2.096 when the penetration depth is at -13.5m. The calculation has been carried out with Bishop Method.

Center of slip circle: (X, Y) = (1 , 15), Radius: R = 31 m
Where; X axis and Y axis has been assumed at New Face line =0 and MSL ±0m=0

Table 1 Summary of Calculation Result of Cantilever Sheet Piled Quay Wall

		Normal Condition		Seismic Condition		
		Before Corrosion	**After Corrosion**	**Before Corrosion**	**After Corrosion**	
Stress	Under water	---	143.2	---	133.5	N/mm^2
	Under seabed	94.2	116.1	88.9	109.5	N/mm^2
Displacement on Top		8.142	10.151	7.795	9.669	cm
Penetration depth (Calculation Result)		-13.094	-12.717	-13.156	-12.779	m

Note: corrosion term has been assumed at 50 years.

3.3 Pavement behind the Quay Structures

Apron Type behind quay wall and retaining wall for slipway has been assumed at concrete paving and asphalt paving. The design load is summarized below.

(1) Live Load / Surcharge Load

- Uniform live load for quay wall: 10 kN/m^2
- Uniform live load for retaining walls: 20 kN/m^2

(2) Vehicle Load: 50 ton truck crane for retaining walls

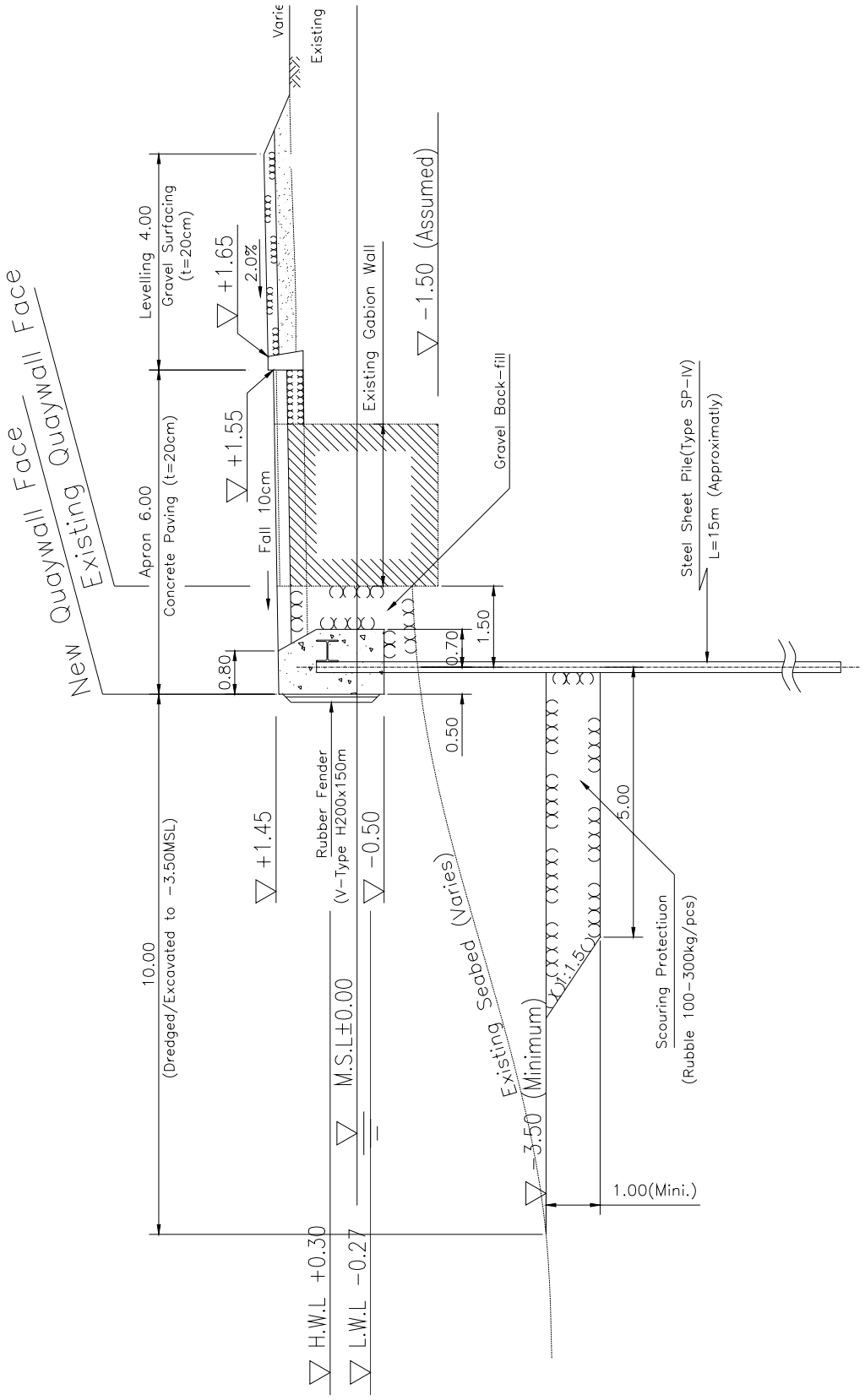


Figure 1 Typical cross section of quay wall (steel sheet pile type)

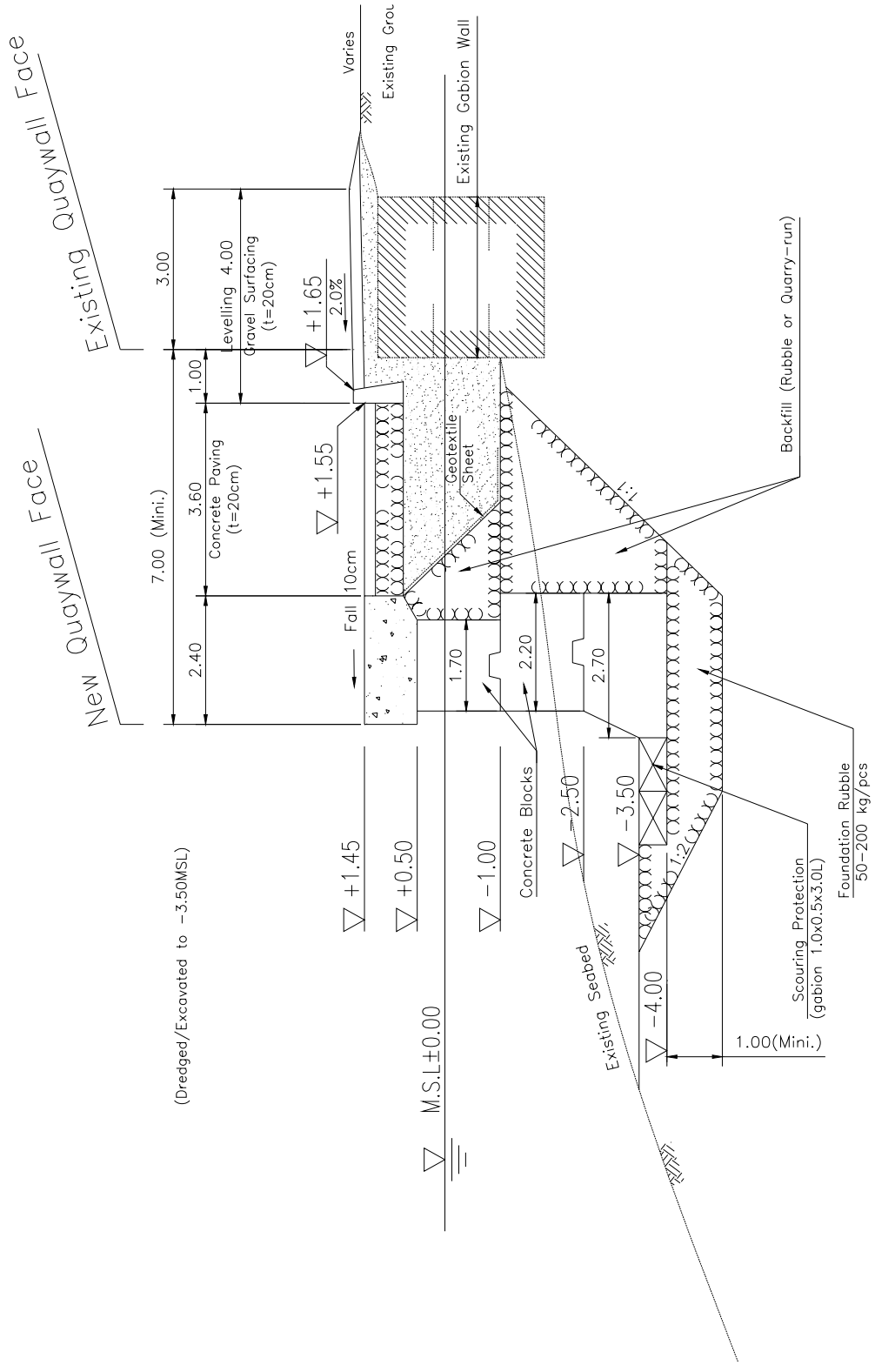


Figure 2 Typical cross section of quay wall (gravity type)

4 Slipway

4.1 Basic Dimension

The following dimensions have been determined in consideration of objective boat (LOA = max. 20.0m, Breadth = max. 5.0m).

- Slope of Slipway 1:10
- Width of pavement 6 m
- Width between retaining wall 12 m
- Thickness of concrete pavement 30 cm
- Thickness of Foundation rubble 70 cm (min.)

Pavement of slipway has been assumed pre-cast concrete.

4.2 Retaining Wall Structure

(1) Wall Type

For retaining wall, gravity type (pre-cast concrete and In-situ concrete) has been determined. The typical cross section is shown in the below figure. Concerning the retaining wall at front left side of slipway, gabion type as shown in figure below has been assumed. Only a temporarily structure will be constructed by the project, because future plan has not been decided in this area. Safety factors of wall stability are shown in the following table.

Table 2 Safety factors of retaining wall stability

		Ordinal	Condition
Sliding	Section ±0.0 m	1.57	>1.2
	Section -1.0 m	1.49	>1.2
	Section -1.5 m	1.64	>1.2
Overturning	Section ±0.0 m	2.62	>1.2
	Section -1.0 m	2.30	>1.2
	Section -1.5 m	1.97	>1.2
Bearing Capacity of Foundation under Concrete Wall	Section -1.5 m	2.47	>1.0
Bearing Capacity of Sand Ground under Foundation Mound	Section -2.0 m	1.15	>1.0

Safety factor of bearing capacity has been calculated at 1.879 when the slip way level is assumed -1.5m.
Center of slip circle: (X, Y) = (-1 , 2), Radius: R = 5 m
Where;
X axis and Y axis has been assumed at Retaining Wall Face line =0 and MSL ±0m = 0.

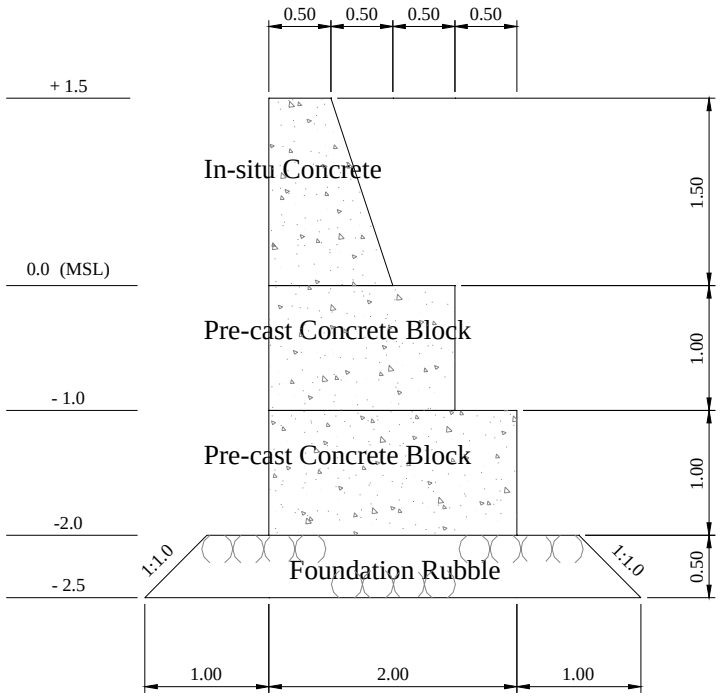


Figure 3 Typical cross section of retaining wall (pre-cast concrete type)

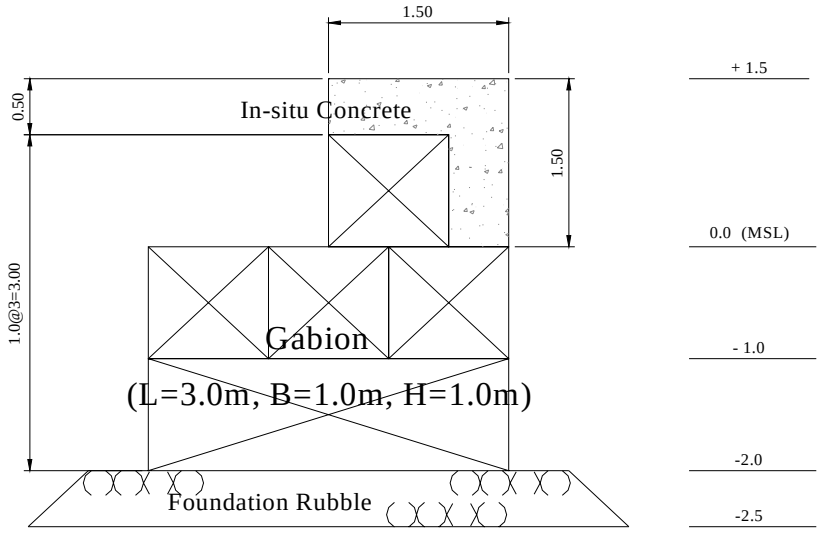


Figure 4 Typical cross section of retaining wall (Gabion type)

4.3 Mooring system

The following mooring equipment will be provided on the quay:

- 50 kN bollard with maximum interval at 10.0m; and
- Mooring rings installed at 5.0m intervals, except where bollard will be installed.

4.4 Fender System

Rubber fender will be satisfy the following requirements:

Shape: V-Type
Height: 200 mm
Length: 1,500 mm
Energy Absorption (Minimum): 20kN-m
Reaction Force (Maximum): 35kN

4.5 Winch

The winch system will be capable to safely handle the fishing boat (60 ft class) mounted on the cradle with the intended slipway slope (1:10). The hauling up capacity of the winch will not be less than 10.0 ton. All the steel materials will be stainless steel or appropriate corrosion protection coated steels.

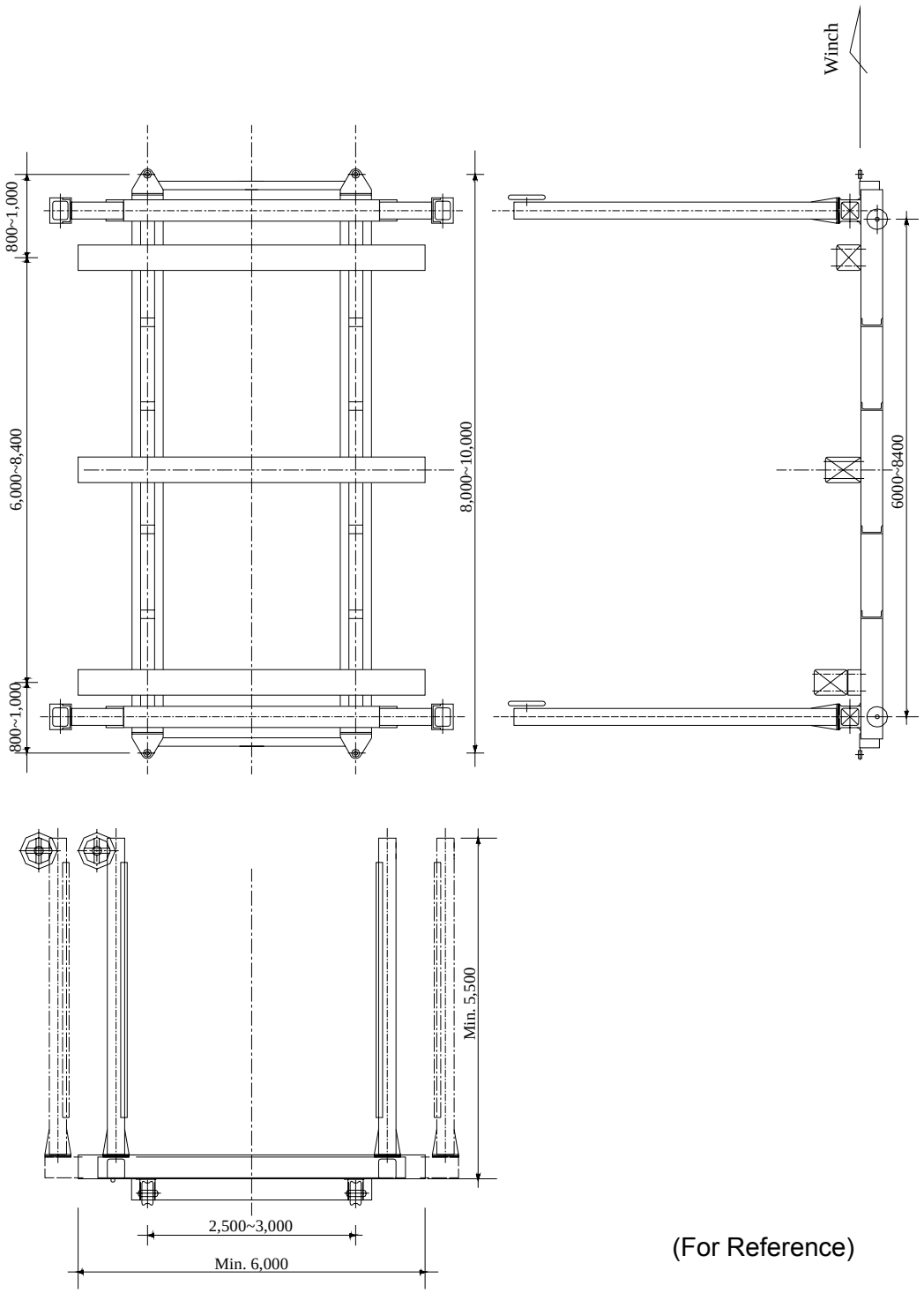
The minimum composition of the winch system will be shown below:

- Winch: Minimum hauling capacity and speed; 10.0 ton and 10 m/min. respectively;
- Wire rope guide roller: 1 set;
- Rail stoppers: 2 pcs;
- Mooring rings: 2 pcs;
- Wind up Limit Switch: 1 set;
- Rail: 64m approx; and
- Chain cables & shackles: 1 set.

4.6 Cradle

Cradle will be same with the type used for slipway at Tangalle Fishery Harbor or other construction approved by the CFHC Engineer.

The Contractor will study and design an appropriate cradle, and submit to the Engineer for his approval prior to the construction. When the Contractor intends to adopt a similar construction with the Tangalle slipway, the dimensions of the cradle will be as indicated in the figure below (It is not regarded as the design requirement). All the steel materials will be anti-corrosion type or with an appropriate corrosion protection. Contractor will decide dimensions of the cradle and it should not cause any modification of the planned slipway design.



(For Reference)

Figure 5 Out View of Cradle similar to Tangalle Fisher Harbor

ANNEX 8-2 Onshore and Offshore Boring for Galle Fishery Harbor

1 Survey Area

The location of three boring is shown in the Table 3 and Figure 3.

Table 3 Coordinate of Borehole

	Borehole No.	Location		Elevation (m MSL) (Sea bed)
		N	E	
Onshore Boring	BH-G01	93,475.003	139,838.620	+ 1.54
	BH-G02	93,373.251	139,775.260	+ 1.72
	BH-G03	93,274.364	139,757.240	+ 1.57
Offshore Boring	BH-G04	93,272.224	139,873.758	- 1.80
	BH-G05	93,282.048	139,842.747	- 2.05
	BH-G06	93,298.605	139,785.210	- 3.05

2 Results of the survey

Geological profile is shown in Figure 4 and 5. The summary of tests is shown in the Table 4 to 9. These results indicate that:

Onshore Boring Result (BH-G01, 02 and 03)

1) The groundwater level was encountered at the depth of 1.35 m, 1.80 m and 1.35 m from the existing ground level at boreholes BH-G01, BH-G02 and BH-G03 respectively.
2) A medium dense slightly silty to silty sand layer was encountered up to about 7 m. (N-value = 10 to 25)
3) The above was followed by a very loose silty sand layer up to the depths of about 10 m which was underlain by medium dense silty sand up to 12~14m. (N-value = 0 to 5)
4) Then a very soft sand clay was found up to 12~14 m where as a organic clay layer was encountered at BH-G02 from 13.5 ~ 15.5 m depth range. (N-value = 15 to 30)
5) A slightly silty sand layer was found next up to the depths of 17 m at BH-G01 and BH-G02 respectively while BH-G03 has a stiff sand clay layer from 12.7 m to 18 m. (N-value = 0 to 10)

6) This is followed by the completely weathered rock up to 26 m depth at BH-G01, 28 m at BH-G02 and 21.5 m at BH-G03. (N-value = 15 to 30)
7) Then the weathered rock was found until terminated of boreholes BH-G01, BH-G02 and BH-G03 at the depths of 29 m, 31 m and 27.5 m respectively.

Offshore Boring Result (BH-G04, 05 and 06)

1) The seawater column at the boreholes BH-G04, BH-G05 and BH-G06 are 4.00m, 1.70m was 3.0m respectively and the depths were measured by assuming existing jetty level as zero.
2) The first layer at the seabed was a boulder with sand up to the depth of 7.00m at BH-G04, 4.50m at BH-G05 and 5.50 m at BH-G06 from the existing jetty level.
3) Then loose to medium dense clayey sand was found up to 9.75m depth at BH-G04, 7.00m at BH-G05 and 12.00m at BH-G06.
4) The above was followed by soft to very soft sandy clay layer up to the depth of 15.50m at BH-G04, 12.00m at BH-G05 and 15.00m at BH-G06 while firm sandy clay layer was from 12.00m to 14.00 m at BH-G05 and medium dense clayey sand layer was from 15.50Mm to 17.30m at BH-G04.
5) The completely weathered rock was then penetrated up to the depth of 29.00m, 16.00m and 20.75m at BH-G04, BH-G05 and BH-G06 respectively.
6) The above was followed by moderately weathered rock at BH-G04 from 29.00m to 29.75m while slightly weathered rock was found until termination of the boreholes BH-G04, BH-G05 and BH-G06 at the depths of 31.00m, 18.00m and 22.75m respectively.

Table 4 Summary of Laboratory Tests of BH-G01

BH No		Depth	N mess	O.B. Press	C_N	n_1	n_2	n_3	n_4	N_{55}	N_{55} Avg	Es/kPa	Ks/MN/m^3
1	Layer-01	1.00	**24**	17	2.37	1.42	0.75	1.00	1.00	60.59			
		2.00	**24**	24	2.00	1.42	0.75	1.00	1.00	50.99			
		3.00	**13**	31	1.76	1.42	0.75	1.00	1.00	24.30			
		4.00	**24**	38	1.59	1.42	0.75	1.00	1.00	40.52			
		5.00	**22**	45	1.46	1.42	0.85	1.00	1.00	38.69			
		6.00	**12**	52	1.36	1.42	0.85	1.00	1.00	19.63	39.12	13535.9	135.359
	Layer-02	7.00	**2**	59	1.27	1.42	0.95	1.00	1.00	3.43			
		8.00	**2**	66	1.20	1.42	0.95	1.00	1.00	3.25			
		9.00	**2**	73	1.15	1.42	0.95	1.00	1.00	3.09	3.25	2776.46	27.765
	Layer -03	10.00	**15**	80	1.09	1.42	0.95	1.00	1.00	22.11			
		11.00	**28**	87	1.05	1.42	1.00	1.00	1.00	41.66	31.89	11365.6	113.656
	Layer -04	12.00	**0**	94	1.01	1.42	1.00	1.00	1.00	0.00			
		13.00										2000	10.667
	Layer-05	14.00	**11**	110	0.93	1.42	1.00	1.00	1.00	14.56			
		15.00	**15**	118	0.90	1.42	1.00	1.00	1.00	19.16			
		16.00	**12**	126	0.87	1.42	1.00	1.00	1.00	14.84	16.18	6655.49	66.555
	Layer-06	17.00	**16**	134	0.85	1.42	1.00	1.00	1.00	19.18			
		18.00	**13**	144	0.82	1.42	1.00	1.00	1.00	15.03			
		19.00	**11**	154	0.79	1.42	1.00	1.00	1.00	12.30			
		20.00	**19**	164	0.76	1.42	1.00	1.00	1.00	20.59			
		21.00	**19**	544	0.42	1.42	1.00	1.00	1.00	11.31			
		22.00	**21**	184	0.72	1.42	1.00	1.00	1.00	21.48			
		23.00	**20**	194	0.70	1.42	1.00	1.00	1.00	19.93			
		24.00	**50**	204	0.69	1.42	1.00	1.00	1.00	48.58			
		25.00	**25**	214	0.67	1.42	1.00	1.00	1.00	23.72	21.35	18173.6	181.736

Table 5 Summary of Laboratory Tests of BH-G02

BH No		Depth	N mess	O.B. Press	C_N	n_1	n_2	n_3	n_4	N_{55}	N_{55} Avg	Es/kPa	Ks/MN/m^3
2	Layer-01	1.00	**12**	17	2.37	1.42	0.75	1.00	1.00	30.29			
		2.00	**26**	24	2.00	1.42	0.75	1.00	1.00	55.24			
		3.00	**8**	31	1.76	1.42	0.75	1.00	1.00	14.96			
		4.00	**21**	38	1.59	1.42	0.75	1.00	1.00	35.46			
		5.00	**6**	45	1.46	1.42	0.85	1.00	1.00	10.55			
		6.00	**11**	52	1.36	1.42	0.85	1.00	1.00	17.99			
		7.00	**9**	59	1.27	1.42	0.95	1.00	1.00	15.45	25.71	9511.67	95.117
	Layer -02	8.00	**3**	66	1.20	1.42	0.95	1.00	1.00	4.87			
		9.00	**3**	73	1.15	1.42	0.95	1.00	1.00	4.63	4.75	3224.66	32.247
	Layer-03	10.00	**20**	80	1.09	1.42	0.95	1.00	1.00	29.48			
		11.00	**42**	87	1.05	1.42	1.00	1.00	1.00	62.49			
		12.00	**26**	94	1.01	1.42	1.00	1.00	1.00	37.22			
		13.00	**24**	101	0.97	1.42	1.00	1.00	1.00	33.14	40.58	13974.7	139.747
	Layer -04	14.00											
		15.00	**7**	117	0.90	1.42	1.00	1.00	1.00	8.98	8.98	2000	10.667
	Layer -05	16.00	**16**	125	0.88	1.42	1.00	1.00	1.00	19.86			
		17.00	**10**	133	0.85	1.42	1.00	1.00	1.00	12.03	15.95	6584.12	65.841
	Layer-06	18.00	**20**	143	0.82	1.42	1.00	1.00	1.00	23.21			
		19.00	**18**	153	0.79	1.42	1.00	1.00	1.00	20.20			
		20.00	**14**	163	0.77	1.42	1.00	1.00	1.00	15.22			
		21.00	**14**	173	0.74	1.42	1.00	1.00	1.00	14.77			
		22.00	**19**	183	0.72	1.42	1.00	1.00	1.00	19.49			
		23.00	**14**	193	0.70	1.42	1.00	1.00	1.00	13.99			
		24.00	**21**	203	0.69	1.42	1.00	1.00	1.00	20.45			
		25.00	**14**	213	0.67	1.42	1.00	1.00	1.00	13.31			
		26.00	**17**	223	0.66	1.42	1.00	1.00	1.00	15.80			
		27.00	**20**	233	0.64	1.42	1.00	1.00	1.00	18.18			
		28.00	**-**								17.46	16231.1	162.311

Table 6 Summary of Laboratory Tests of BH-G03

BH No		Depth	N mess	O.B. Press	C_N	n_1	n_2	n_3	n_4	N_{55}	N_{55} Avg	Es/kPa	Ks/MN/m^3
3	Layer-01	1.00	**24**	17	2.37	1.42	0.75	1.00	1.00	60.59			
		2.00	**24**	24	2.00	1.42	0.75	1.00	1.00	50.99			
		3.00	**10**	31	1.76	1.42	0.75	1.00	1.00	18.69			
		4.00	**22**	38	1.59	1.42	0.75	1.00	1.00	37.15			
		5.00	**14**	45	1.46	1.42	0.85	1.00	1.00	24.62			
		6.00	**13**	52	1.36	1.42	0.85	1.00	1.00	21.27	35.55	12465.1	124.651
	Layer -02	7.00	**5**	59	1.27	1.42	0.95	1.00	1.00	8.58			
		8.00	**2**	66	1.20	1.42	0.95	1.00	1.00	3.25			
		9.00	**3**	73	1.15	1.42	0.95	1.00	1.00	4.63	5.49	3445.7	34.457
	Layer -03	10.00	**0**	81	1.09	1.42	0.95	1.00	1.00	0.00			
		11.00	**0**	89	1.04	1.42	1.00	1.00	1.00	0.00			
		12.00	**5**	97	0.99	1.42	1.00	1.00	1.00	7.05	7.05	2000	10.667
	Layer-04	13.00	**14**	105	0.95	1.42	1.00	1.00	1.00	18.96			
		14.00	**9**	113	0.92	1.42	1.00	1.00	1.00	11.75			
		15.00	**6**	121	0.89	1.42	1.00	1.00	1.00	7.57			
		16.00	**45**	129	0.86	1.42	1.00	1.00	1.00	54.98			
		17.00	**18**	137	0.84	1.42	1.00	1.00	1.00	21.34	22.92	8676.42	86.764
	Layer-05	18.00	**15**	147	0.81	1.42	1.00	1.00	1.00	17.17			
		19.00	**20**	157	0.78	1.42	1.00	1.00	1.00	22.15			
		20.00	**33**	167	0.76	1.42	1.00	1.00	1.00	35.44			
		21.00	**28**	177	0.74	1.42	1.00	1.00	1.00	29.21	24.92	19960	199.600

Table 7 Summary of Laboratory Tests of BH-G04

BH No		Depth	N mess	O.B. Press	C_N	n_1	n_2	n_3	n_4	N_{55}	N_{55} Avg	Es/kPa	Ks/MN/m^3
4	Layer-01	7.00	**18**	48	1.4124	1.42	0.95	1.00	1.00	34.25			
		8.00	**17**	55	1.3195	1.42	0.95	1.00	1.00	30.22			
		9.00	**10**	62	1.2428	1.42	0.95	1.00	1.00	16.74	27.07	13463.28	134.633
	Layer-02	10.00	**1**	70	1.1696	1.42	0.95	1.00	1.00	1.58			
		11.00	**3**	78	1.1080	1.42	1.00	1.00	1.00	4.71			
		12.00	**4**	86	1.0552	1.42	1.00	1.00	1.00	5.99			
		13.00	**0**	94	1.0093	1.42	1.00	1.00	1.00	0.00			
		14.00	**3**	102	0.9689	1.42	1.00	1.00	1.00	4.12			
		15.00	**4**	110	0.9330	1.42	1.00	1.00	1.00	5.29	3.62	2884.552	15.384
	Layer-03	16.00	**14**	119	0.8971	1.42	1.00	1.00	1.00	17.81			
		17.00	**22**	128	0.8649	1.42	1.00	1.00	1.00	26.99	22.40	18699.2	186.992
	Layer-04	18.00	**50**										
		25.00		198	0.6954	1.42	1.00	1.00	1.00	49.31	49.31	32156.5	321.565

Table 8 Summary of Laboratory Tests of BH-G05

BH No		Depth	N mess	O.B. Press	C_N	n_1	n_2	n_3	n_4	N_{55}	N_{55} Avg	Es/kPa	Ks/MN/m^3
5	Layer-01	5.00	**3**	29.5	1.8017	1.42	0.85	1.00	1.00	6.52			
		6.00	**5**	36.5	1.6197	1.42	0.85	1.00	1.00	9.76	8.14	7404.513	74.045
	Layer-02	7.00	**2**	44.5	1.4669	1.42	0.95	1.00	1.00	3.95			
		8.00	**2**	52.5	1.3506	1.42	0.95	1.00	1.00	3.64			
		9.00	**3**	60.5	1.2581	1.42	0.95	1.00	1.00	5.09			
		10.00	**0**	68.5	1.1824	1.42	0.95	1.00	1.00	0.00			
		11.00	**2**	76.5	1.1188	1.42	1.00	1.00	1.00	3.17	3.17	2751.015	14.672
	Layer-03	12.00	**8**	84.5	1.0645	1.42	1.00	1.00	1.00	12.08			
		13.00	**8**	92.5	1.0175	1.42	1.00	1.00	1.00	11.54			
		14.00	**10**	100.5	0.9761	1.42	1.00	1.00	1.00	13.84	12.49	5546.473	29.581
	Layer-04	15.00	**42**	110.5	0.9309	1.42	1.00	1.00	1.00	55.45	55.45	18434.64	184.346

Table 9 Summary of Laboratory Tests of BH-G06

BH No		Depth	N mess	O.B. Press	C_N	n_1	n_2	n_3	n_4	N_{55}	N_{55} Avg	Es/kPa	Ks/MN/m^3
6	Layer-01	6.00	**9**	37.25	1.6034	1.42	0.85	1.00	1.00	17.39			
		7.00	**3**	44.25	1.4711	1.42	0.95	1.00	1.00	5.95			
		8.00	**1**	51.25	1.3669	1.42	0.95	1.00	1.00	1.84			
		9.00	**2**	58.25	1.2822	1.42	0.95	1.00	1.00	3.45			
		10.00	**10**	65.25	1.2114	1.42	0.95	1.00	1.00	16.32			
		11.00	**13**	72.25	1.1513	1.42	1.00	1.00	1.00	21.23	11.03	8329.795	83.298
	Layer-02	12.00	**3**	80.25	1.0924	1.42	1.00	1.00	1.00	4.65			
		13.00	**2**	88.25	1.0417	1.42	1.00	1.00	1.00	2.95			
		14.00	**13**	96.25	0.9975	1.42	1.00	1.00	1.00	18.39	8.66	4399.15	23.462
	Layer-03	15.00	**32**	106.3	0.9494	1.42	1.00	1.00	1.00	43.08			
		16.00	**24**	116.3	0.9076	1.42	1.00	1.00	1.00	30.89			
		17.00	**27**	126.3	0.8709	1.42	1.00	1.00	1.00	33.35			
		18.00	**28**	136.3	0.8383	1.42	1.00	1.00	1.00	33.29			
		19.00	**26**	146.3	0.8092	1.42	1.00	1.00	1.00	29.84	34.09	24544.96	245.450

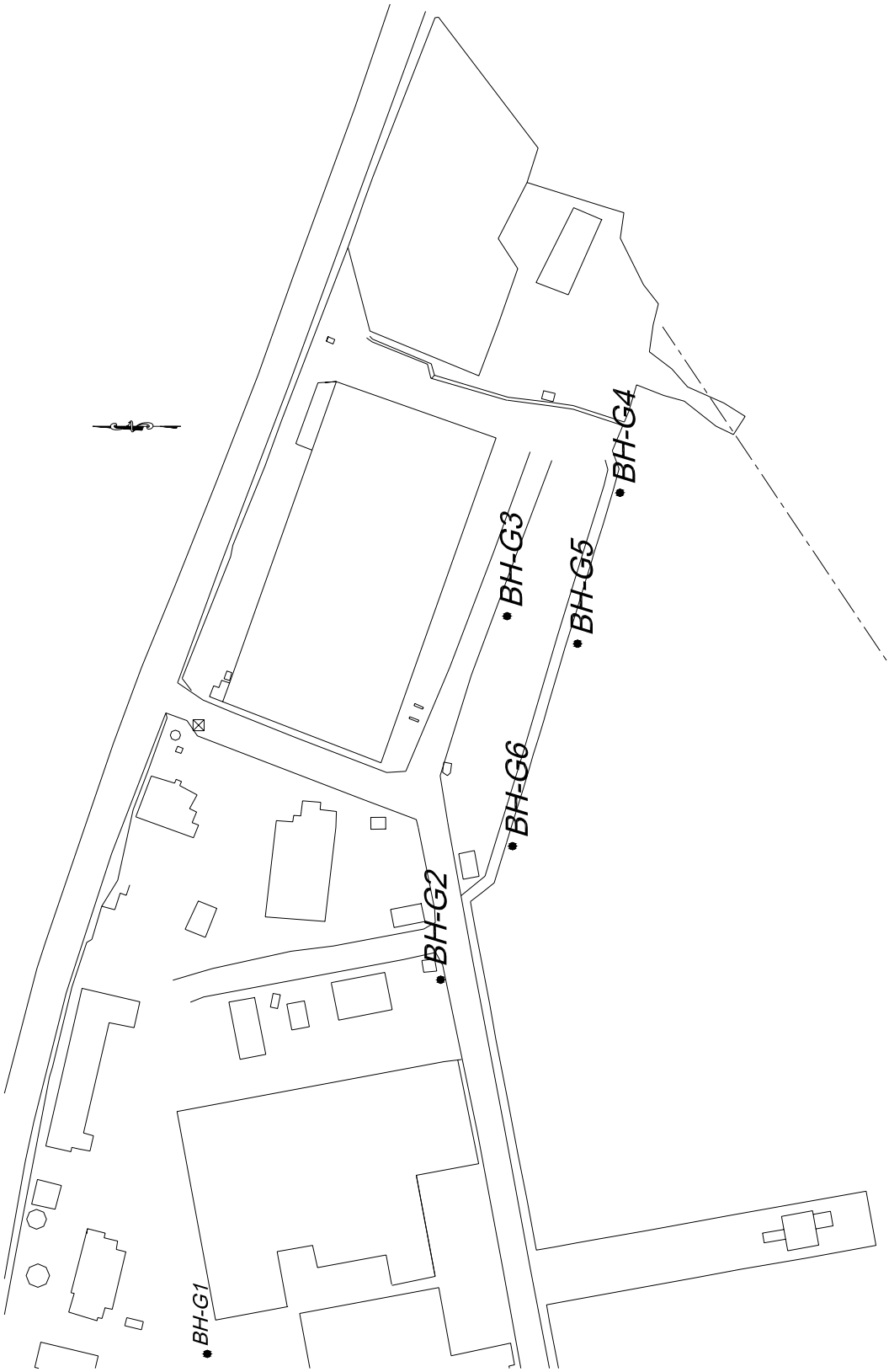


Figure 6 Location of 6 onshore and offshore boreholes

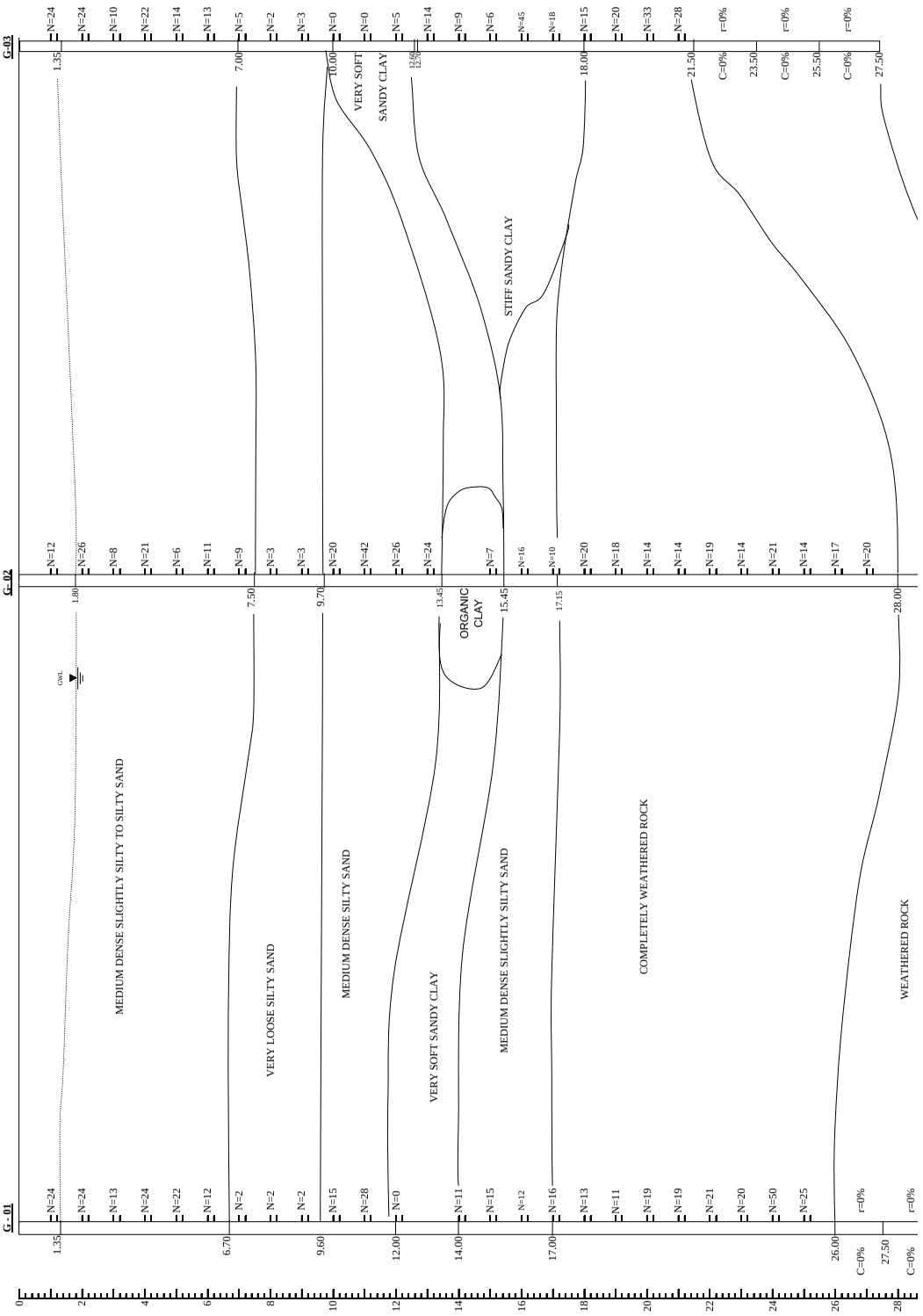


Figure 7 Geological Profile of onshore borehole

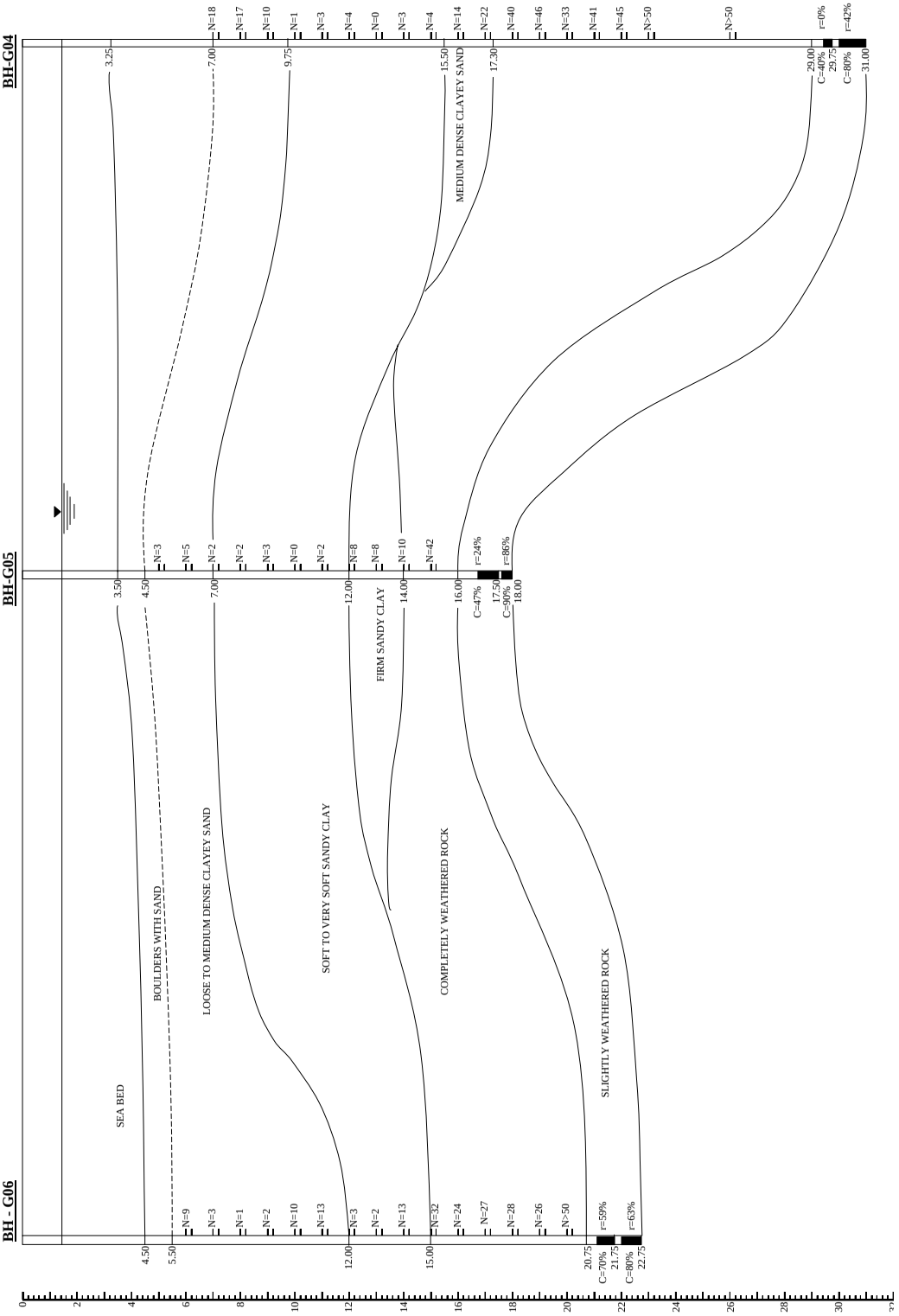


Figure 8 Geological Profile of onshore borehole

ANNEX 10-1 Data Collection

No.	Category	Data and Information Collected for the Study	Obtained from	Remarks
1	MAP	Sri Lanka MAP (S=1/250,000)	Survey Department	paper
2	MAP	1:10,000 (Contour Map) around Matara Division	Survey Department	(CAD data)
3	MAP	1:10,000 (Land Use Map) around Matara Division	Survey Department	(CAD data)
4	MAP	1:5,000 (Contour Map) Central of Matara Town	Survey Department	(CAD data)
5	MAP	1:5,000 (Land Use Ma) Central of Matara Town	Survey Department	(CAD data)
6	MAP	Sub-division Boundary Map in Matara Divison	Division Secretary Matara	paper
7	GIS	GIS data around Matara division	UDA GIS center	(GIS data)
8	GIS	ICONOS around Matara division	UDA GIS center	(GIS data)
9	Hazard Map	Flood Hazard Map (Colombo)	CFC	(GIS data)
10	Hazard Map	Safety Places & Buildings in Flood or Tsunami	Municipal Counsil MATARA	paper
11	Hazard Map	Tsunami Affected Area	UDA GIS center	jpg
12	Hazard Map	Landslide Hazard Map	NBRO	Paper
13	Hazard Map	Landslide (4 books)	NBRO	Book
14	Hazard Map	Guideline of Landslide Hazard Map	NBRO	Book
26	Hazard Map	Guidance of preparation of flood hazard map	MOLIT, JAPAN (2005.6.29)	Paper
27	Hazard Map	Guidance and examples of preparation of flood hazard map	FRICS, JAPAN (2002.9)	Book
28	Hazard Map	No.3569, Papers prepared by PWRI, “ A manual of formulation of urban river improvement in the developing countries “	Public Works Research Institute (1998/10)	Paper
29	Hazard Map	“THE URGENT REHABILITATION AND RECONSTRUCTION PLAN (URRP) FOR BANDA ACEH CITY, TENDER DOCUMENT FOR PEOPLE BEHAVIOR SURVEY.”	JICA URRP STUDY TEAM	Word Doc.
30	Hazard Map	“Hazard Map - preparation and usage”	Japan Association of Surveyors	Book
31	Hazard Map	“Manual of Tsunami, High tide hazard map”	Coastal Development Institute of Technology, Japan	Book
32	Disaster Management	“Disaster Reduction and Technology”	The Institution of Professional Engineer, Japan	Book

No.	Category	Data and Information Collected for the Study	Obtained from	Remarks
33	Disaster Management		UNDP	Book
34	Disaster Managemant	PARLIAMENT OF THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA, SRI LANKA DISASTER MANAGEMENT ACT, No.13 OF 2005		Book
35	Disaster Management	Implementation of Landslide Mitigation Works Operation Professional Combine Report	Ratnapura District, Department of Geology & Department of Civil Engineering Consultancy Bureau	Book
36	Disaster Management	Guidelines for Construction in Areas Prone to Cyclones and Highwinds	Sri Lanka Urban-Hazard Disaster Mitigation Project(SLUMDMP), Ministry of Housing and Plantation Infrastructure	Book
37	Disaster Management	Guidelines for Construction in Landslide Prone Areas	Sri Lanka Urban-Hazard Disaster Mitigation Project(SLUMDMP), Ministry of Housing and Plantation Infrastructure	Book
38	Disaster Management	Guidelines for Construction in Flood Prone Areas	Sri Lanka Urban-Hazard Disaster Mitigation Project(SLUMDMP), Ministry of Housing and Plantation Infrastructure	Book
39	Disaster Management	Joint Technical Emergency Operation Experiences on Landslide Disaster Mitigation, Sri Lanka	A A Virajh Dias & Nihal Rupasingh	Book
40	Disaster Management	LANDSLIDES '98	National Building Research Organization Publications (1994-1998)	Book
41	Disaster Management	Report of McRAP (MATARA City RENEWAL ACTION PROGRAMME)	Government of Sri Lanka(2005.6)	copy
42	Disaster Management	Interim Report (DRAFT)	JICA STUDY TEAM (2005.10)	copy
43	Disaster Management	Workshop on Lessons Learned in the Recent Disaster Events and Approaches for Long-term Disaster Risk Management in Sri Lanka	Asian Disaster Preparedness Center, Nov. 2003	Book
44	Flood Control/ Water Resource	Flood and Dams in the Monsoon Asia Forecasting of Flood Discharges", Eng.(Miss) P.P.G.Dias	Deputy Director, Plan Implementation Branch, Irrigation Department, Bauddhaloka Mawatha, Sri Lanka	Paper
45	Flood Control/ Water Resource	"FIELD INVESTIGATION OF THE FLOOD DISASTER IN SOUTH-WEST AREA OF SRI LANKA OCURRED IN MAY 2003", No. 49, Reports	Committee on Hydroscience and Hydraulic Engineering (2005.2)	Paper

No.	Category	Data and Information Collected for the Study	Obtained from	Remarks
46	Flood Control/ Water Resource	Report of Study for Flood Control in Kalu Ganga in Sri Lanka	Infrastructure Development Institute, Japan (2004.3)	Paper
47	Flood Control/ Water Resource	Concept Paper: Flood Protection for Nilwala Ganga Basin	Ministry of Irrigation and Water Management, (2003.7)	Paper
48	Flood Control/ Water Resource	Water for People and Nature Arumugam Commemoration Volume, Sri Lanka Water Heritage History of Water Conservation Volume 2	Ministry of Irrigation and Water Management	Book
49	Flood Control/ Water Resource	Feasibility Report on Multi-Purpose Development of the Nilwala Ganga, Gin Ganga,and Kalu Ganga Volume1 - Text and Tables	Engineering Consultants Inc., Sep.1968	Book
50	Flood Control/ Water Resource	Feasibility Report on Multi-Purpose Development of the Nilwala Ganga, Gin Ganga,and Kalu Ganga Volume2 - Figures	Engineering Consultants Inc., Sep.1968	Book
51	Flood Control/ Water Resource	Power Point Materials (Ratanpura District Floods and Landslides, May 2003)	Ratanpura District	PPT
52	Flood Control/ Water Resource	Kalu Ganga Multi-Purpose Project Pre-Feasibility Study Vol.2 Flood Protection	Project SRL/86/006, Financed by UNDP, Executed by World Bank, Mar. 1989	Book
53	Flood Control/ Water Resource	Kalu Ganga Multi-Purpose Project Pre-Feasibility Study Supporting Report A Hydrology	Project SRL/86/006, Financed by UNDP, Executed by World Bank, Mar. 1989	Book
54	Flood Control/ Water Resource	Western River Basins Sector Project TA3030 - SRI, Working Document D, Kalu Ganga Basin Detailed Basin Assessment	Danish Hydraulic Institute, Jun.1999	Book
55	Flood Control/ Water Resource	Floods in Sriranka - May 2003	Laith Chandrapala, Center for Climate Studies, Department of Meteorology, Colombo 7	Paper
56	Flood Control/ Water Resource	Water Heritage of Sri Lanka	D.L.O. Mendis	Book

ANNEX 10-2 Questionnaire for Tsunami/Flood Inundation Survey

RECOVERY, REHABILITATION AND DEVELOPMENT PROJECT
FOR TSUNAMI AFFECTED AREA OF SOUTHERN REGION
IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

QUESTIONNAIRE FOR THE LOCAL PEOPLE
ON FLOOD DAMAGE SURVEY (DRAFT)

Sample No.	F -
Date	*Month Day Year* / /
Time	*Begin End #Min* / /
Name of Respondent **/ Sex** **/ Marital Status** **/ Age** **/Address**	 a. Male b. Female a. Single b. Married c. Widow/widower
Name of Interviewer	

INSTRUCTION

a. Encircle the letter in the Answer Sheet opposite the number correspondent to the number on the Questionnaire or fill up the blank according to the instruction.
b. On descriptive questions, please write down briefly and clearly your opinions/suggestions on the prescribed lined.
c. Answer all questions to the best of your knowledge. Please don't leave any numbers blank.

SECTION I : INUNDATION CONDITION

Q1 Did you experience a flood in Matara area on March, 2003?

a. Yes b. No

Q2 What were the inundation conditions in the flood?

Q2-1 Location:

a. Distance from Nilwara River : _____m far from River
b. Distance from tributary : _____m far from tributary
c. Coordination : x:_____ y: _____
d. Structure : _____
e. Detail Location : _____

(for example, …. m far from road/ village halls)

Q2-2 Inundation Condition:

a. Inundation depth : above _____
: _____cm maximum
b. Inundation period : _____days (hours)
c. Inundation area :_____
d. Inundation speed: 1) very fast (within a few minutes)
2) fast (within one hour)
3) slow (within a few hours)
4) very slow
e. Current direction From _____
To _____
f. Current velocity : _____cm/sec
g. Others :_____

Q3 Flood/ inundation damages in the flood

a. Date:_____
b. House totally destroyed Yes, No,
c. Hose partially destroyed (specify:_____),
d. Flooded above the floor level (highest height above floor:_____cm),
e. Flooded below the floor level (highest height above ground _____cm),
f. Movable assets destroyed (specify:_____),
g. Crops totally lost (specify:_____),

h. Crops partially lost (specify:_____),
i. Livestock totally lost (specify:_____)

j. Livestock partially lost (specify:_____)
k. Family members died (number:_____)
l. Family members injured (number:_____)
m. Infrastructures damaged
- road (location:_____)
- embankment (location:_____)
- others (specify :_____)
n. Others (specify :_____)

SECTION II FLOOD FORECASTING AND WARNING

Q4 Did you ever receive forecasting and warning on impending occurrences such as floods and typhoon from your public officers?

a. Yes (How?): _____

b. No (Reasons): _____

a-1 If "Yes", was the warning made adequately and timely?

_____

SECTION III EVACUATION

Q5 History and background of the dwelling in present place

Q5-1 How long have you been living here?

_____years

Q5-2 Do you think that living in this area is dangerous due to flood?

a. I do not think I am living in a dangerous place.
b. I feel some danger but do not take it seriously.
c. I feel that I am living in a very dangerous place.

Q6 Do you know the flood-prone areas and official evacuation areas in the municipality?

a. Yes (Where?):_____
b. No (Why) :_____
_____

Q7 Did you evacuate during flooding?

a. Yes b. No

If your answer is "Yes", please answer the following questions.

Q8-1 Where did you evacuate "at first"?

a Detail Location (structure) : _____
_____

(for example, …. m far from road/ village halls)

b Distance from your house : _____m
c Distance from Nilwara River : _____m
d Distance from tributary : _____m
e Coordination : x:_____ y: _____

Q8-2 How long have you stayed at the destination after the evacuation?

_____ hours or _____days

Q8-3 How did you moved to destination?

a. on foot b. bicycle c. motor car

Q8-4 Did you remember the route to destination?

a. Yes b. No

Q8-5 Was there any accident on the way to the destination or did you hard about the accident?

a. yes, there was some accidents
b. yes, I heard about accident
c. no, there was not accident

Q9-1 Where did you evacuate "at final"?

a Detail Location (structure) : _____
_____

(for example, …. m far from road/ village halls)

b Distance from your house : _____m

c Distance from Nilwara River : _____m
d Distance from tributary : _____m
e Coordination : x:_____ y: _____

Q9-2 How many hour did you stay destination? _____ days

Q9-3 How did you moved to destination?

a. on foot b. bicycle c. motor car

Q9-4 Did you remember the route to destination?

a. Yes b. No

Q9-5 Was there any accident on the way to the destination or did you hard about the accident?

a. yes, there was some accidents
b. yes, I heard about accident
c. no, there was not accident

SECTION IV FLOOD HAZARD MAP

Q10 Did you ever known about "Hazard Map"?

a. Yes b. No

Q11 What kind of information will be necessary in "Hazard Map"

a. Evacuation center
b. Evacuation route
c. Hazard area on evacuation route
d. Criteria of evacuation
e. Medical care facility
f. Others (specify_____)

Q12 How to use "Hazard Map" in the future?

_____
_____
_____

Thank You Very Much.

RECOVERY, REHABILITATION AND DEVELOPMENT PROJECT
FOR TSUNAMI AFFECTED AREA OF SOUTHERN REGION
IN THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

QUESTIONNAIRE FOR THE LOCAL PEOPLE
ON TSUNAMI DAMAGE SURVEY (DRAFT)

Sample No.	T -
Date	*Month Day Year* / /
Time	*Begin End #Min* / /
Name of Respondent **/ Sex** **/ Marital Status** **/ Age** **/Address**	 a. Male b. Female a. Single b. Married c. Widow/widower
Name of Interviewer	

INSTRUCTION

a. Encircle the letter in the Answer Sheet opposite the number correspondent to the number on the Questionnaire or fill up the blank according to the instruction
b. On descriptive questions, please write down briefly and clearly your opinions/suggestions on the prescribed lined.
c. Answer all questions to the best of your knowledge. Please don't leave any numbers blank.

SECTION I : INUNDATION CONDITION

Q1 Did you experience a tsuami in Matara area on December, 2004?

a. Yes b. No

Q2 What were the inundation conditions in the tsunami?

Q2-1 Location:

a. Distance from coastline : _____m far from coastline
b. Coordination : x:_____ y: _____
c. Structure : _____
d. Detail Location : _____

(for example, …. m far from road/ village halls)

Q2-2 Inundation Condition:

a. Inundation depth : above _____
: _____cm maximum
b. Inundation period : _____minutes
c. Inundation area :_____
d. Inundation speed: 1) very fast (within a few seconds)
2) fast (within a minute)
3) slow (within a few minutes)
4) very slow
e. Current direction From _____
To _____
f. Current velocity : _____cm/sec
g. Others :_____

Q3 Tsunami/ inundation damages in the flood

a. Date:_____
b. House totally destroyed Yes, No,
c. Hose partially destroyed (specify:_____),
d. Inundated above the floor level(highest height above floor:_____cm),
e. Inundated below the floor level (highest height above ground cm),
f. Movable assets destroyed (specify:_____),
g. Crops totally lost (specify:_____),
h. Crops partially lost (specify:_____),
i. Livestock totally lost (specify:_____)

j. Livestock partially lost (specify:_____)
k. Family members died (number:_____)
l. Family members injured (number:_____)
m. Infrastructures damaged
- road (location:_____)
- embankment (location:_____)
- others (specify :_____)
n. Others (specify :_____)

SECTION II TSUNAMI FORECASTING AND WARNING

Q4 Did you ever receive forecasting and warning on impending occurrences such as tsunami from your public officers?

a. Yes (How?): _____

b. No (Reasons): _____

a-1 If "Yes", was the warning made adequately and timely?

_____

SECTION III EVACUATION

Q5 History and background of the dwelling in present place

Q5-1 How long have you been living here?

_____years

Q5-2 Do you think that living in this area is dangerous due to tsunami?

a. I do not think I am living in a dangerous place.
b. I feel some danger but do not take it seriously.
c. I feel that I am living in a very dangerous place.

Q6 Do you know the tsunami affected areas and official evacuation areas in the municipality?

a. Yes (Where?):_____
b. No (Why) :_____
_____

Q7 Did you evacuate during tsunami?

a. Yes b. No

If your answer is "Yes", please answer the following questions.

Q8-1 Where did you evacuate "at first"?

a Detail Location (structure) : _____
_____

(for example, …. m far from road/ village halls)

b Distance from your house : _____m
c. Distance from coastline : _____m
d Coordination : x:_____ y: _____

Q8-2 How long have you stayed at the destination after the evacuation?
_____ _____ hours or _____days

Q8-3 How did you moved to destination?

a. on foot b. bicycle c. motor car

Q8-4 Did you remember the route to destination?

a. Yes b. No

Q8-5 Was there any accident on the way to the destination or did you hard about the accident?

a. yes, there was some accidents
b. yes, I heard about accident
c. no, there was not accident

Q9-1 Where did you evacuate "at final"?

a Detail Location (structure) : _____
_____

(for example, …. m far from road/ village halls)

b Distance from your house : _____m
c. Distance from coastline : _____m
d Coordination : x:_____ y: _____

Q9-2 How long have you stayed at the destination after the evacuation? _____ Hours(days)

Q9-3 How did you moved to destination?

a. on foot b. bicycle c. motor car

Q9-4 Did you remember the route to destination?

a. Yes b. No

Q9-5 Was there any accident on the way to the destination or did you hard about the accident?

a. yes, there was some accidents
b. yes, I heard about accident
c. no, there was not accident

SECTION IV FLOOD HAZARD MAP

Q10 Did you ever known about "Hazard Map"?

a. Yes b. No

Q11 What kind of information will be necessary in "Hazard Map"

g. Evacuation center
h. Evacuation route
i. Hazard area on evacuation route
j. Criteria of evacuation
k. Medical care facility
l. Others (specify_____)

Q12 How to use "Hazard Map" in the future?

_____
_____
_____

Thank You Very Much.

ANNEX 10-3 Tsunami Simulation Model

Table Parameter of Fault Model (Tohoku University)

	Fault plate Upper edge depth	slipping volume	direction	angle of inclination	slipping inclination	Length	width	Base point		Crashing time
	HH(km)	D(m)	TH(°)	DL(°)	RD(°)	L(km)	W(km)	Y0	X0	
1.Tohoku Univ.										
Fault-1	7	11	329	15	110	330	150	2.50	95.75	0
Fault-2	7	11	340	15	110	570	150	5.00	94.00	0
Fault-3	7	11	5	15	110	300	150	10.00	92.00	0

Table Parameter of Fault Model (Kyoto Univ.)

	Fault plate Upper edge depth	slipping volume	direction	angle of inclination	slipping inclination	Length	width	Base point		Crashing time
	HH(km)	D(m)	TH(°)	DL(°)	RD(°)	L(km)	W(km)	Y0	X0	
2.Kyoto Univ.										
	17.387	13.9	330	8	90	560	150	2.50	95.25	0

Table) Parameter of Fault Model (Koshimura Tohoku Univ.)

	Fault plate Upper edge depth	slipping volume	direction	angle of inclination	slipping inclination	Length	width	Base point		Crashing time
	HH(km)	D(m)	TH(°)	DL(°)	RD(°)	L(km)	W(km)	Y0	X0	
3.Koshimura et all（Tohoku Univ.）										
South Segment	10	11	329	15	90	500	150	2.50	94.80	0
North Segment	10	11	358	15	90	400	150	6.50	92.00	0

Table Parameter of Fault Model (JAMSTEC)

	Fault plate Upper edge depth	slipping volume	direction	angle of inclination	slipping inclination	Length	width	Base point		Crashing time
	HH(km)	D(m)	TH(°)	DL(°)	RD(°)	L(km)	W(km)	Y0	X0	
4.JAMSTEC								Propagation Velocity Vr=0.7km/s		
E14	10	0.6	25	10	130	100	150	13.51	92.01	1857
E13	10	27.8	15	10	120	100	150	12.51	91.78	1714
E12	10	26.3	10	10	115	100	150	11.56	91.63	1571
E11	10	6.7	10	10	115	100	150	10.66	91.48	1429
E10	10	12.6	0	10	106	100	150	9.60	91.51	1286
E9	10	2.1	350	10	99	100	150	8.60	91.64	1143
E8	10	12.1	335	10	86	100	150	7.64	92.08	1000
E7	10	10	330	10	90	100	150	6.78	92.53	857
E6	10	24	350	10	100	100	150	6.12	92.63	714
E5	10	11	345	10	102	100	150	5.18	92.88	571
E4	10	29.7	340	10	105	100	150	4.15	93.16	429
E3	10	15.5	330	10	104	100	150	3.33	93.64	286
E2	10	0.6	310	10	91	100	150	2.57	94.50	143
E1	10	17.1	290	10	71	100	150	2.13	95.54	0

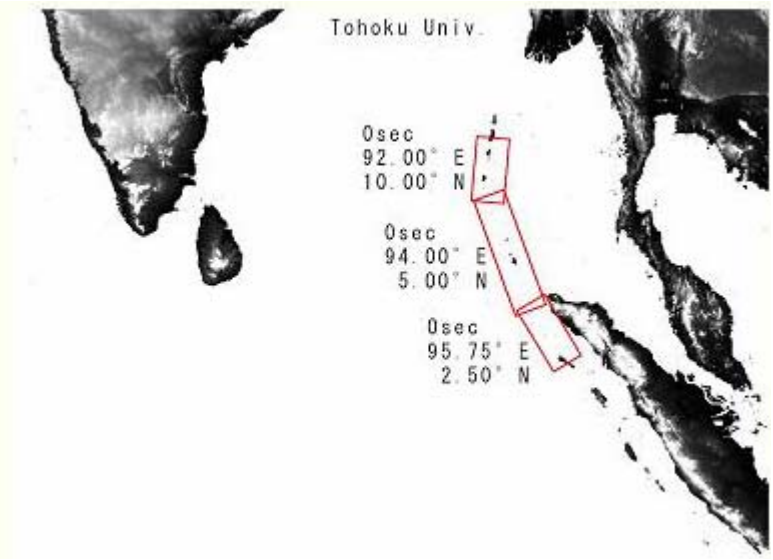
Table Parameter of Fault Model (AIST)

	Fault plate Upper edge depth	slipping volume	direction	angle of inclination	slipping inclination	Length	width	Base point		Crashing time
	HH(km)	D(m)	TH(°)	DL(°)	RD(°)	L(km)	W(km)	Y0	X0	
5.AIST								Propagation Velocity Vr=1.0km/s		
1	3	0.0	315	10	95	100	100	1.75	95.60	0
2	20	4.3	315	10	95	100	100	2.38	96.23	100
3	3	24.6	315	10	95	100	100	2.40	94.90	200
4	20	0.0	315	10	95	100	100	3.00	95.60	300
5	3	24.6	325	10	100	100	100	3.20	94.10	400
6	20	12.3	325	10	100	100	100	3.71	94.83	500
7	3	12.8	330	10	105	100	100	4.00	93.50	600
8	20	1.8	330	10	105	100	100	4.44	94.27	700
9	3	1.9	340	10	105	100	100	4.90	93.00	800
10	20	4.5	340	10	105	100	100	5.30	93.80	900
11	3	6.0	342	10	100	100	100	5.82	92.68	1000
12	20	3.2	342	10	100	100	100	6.15	93.50	1100
13	3	6.5	340	10	95	100	100	6.72	92.38	1200
14	20	0.0	340	10	95	100	100	7.02	93.22	1300
15	3	7.1	337	10	85	100	100	7.64	92.08	1400
16	20	3.5	337	10	85	100	100	8.00	92.90	1500
17	3	3.2	350	10	99	100	100	8.60	91.64	1600
18	3	2.7	0	10	106	100	100	9.60	91.51	1700
19	3	0.0	10	10	115	100	100	10.66	91.48	1800
20	3	0.0	10	10	115	100	100	11.56	91.63	1900
21	3	0.0	15	10	120	100	100	12.51	91.78	2000
22	3	1.0	25	10	130	100	100	13.51	92.01	2100

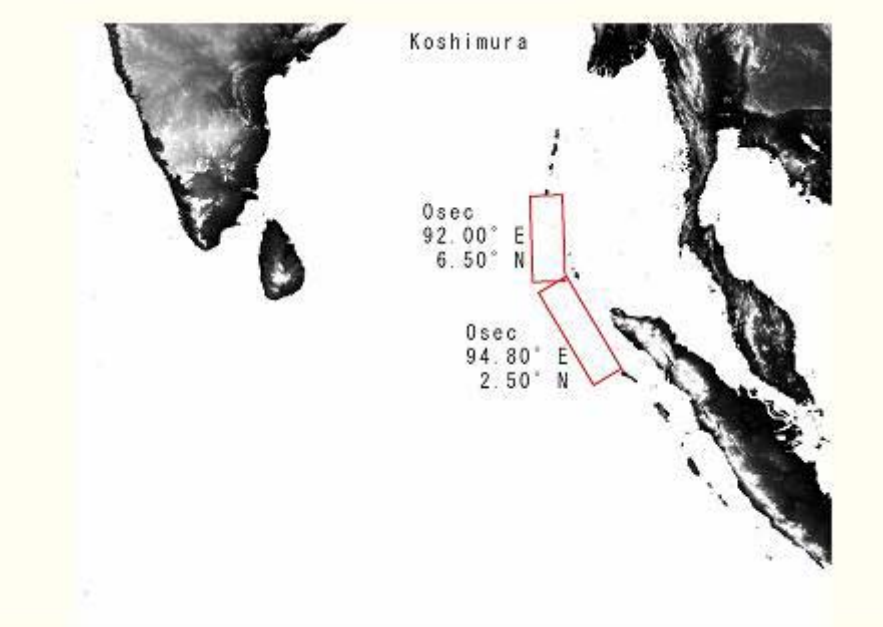
Table Parameter of Fault Model (Akita Univ.)

	Fault plate Upper edge depth	slipping volume	direction	angle of inclination	slipping inclination	Length	width	Base point		Crashing time
	HH(km)	D(m)	TH(°)	DL(°)	RD(°)	L(km)	W(km)	Y0	X0	
6.Akita Univ.								Propagation Velocity Vr=2.3km/s		
1	1	8.9	340	8	112	70	240	2.00	94.60	0
2	1	8.9	340	8	112	70	240	2.61	94.38	30
3	1	8.9	340	8	112	70	240	3.22	94.16	61
4	1	8.9	340	8	112	70	240	3.83	93.94	91
5	1	8.9	340	8	112	70	240	4.44	93.72	122
6	1	8.9	340	8	112	70	240	5.05	93.50	152
7	1	8.9	340	8	112	70	240	5.65	93.27	183
8	1	8.9	340	8	112	70	240	6.26	93.05	213
9	1	8.9	340	8	112	70	240	6.87	92.83	243
10	1	8.9	340	8	112	70	240	7.48	92.61	274
11	1	8.9	340	8	112	70	240	8.09	92.39	304
12	1	8.9	340	8	112	70	240	8.70	92.17	335
13	1	8.9	340	8	112	70	240	9.31	91.95	365
14	1	8.9	340	8	112	70	240	9.92	91.73	396

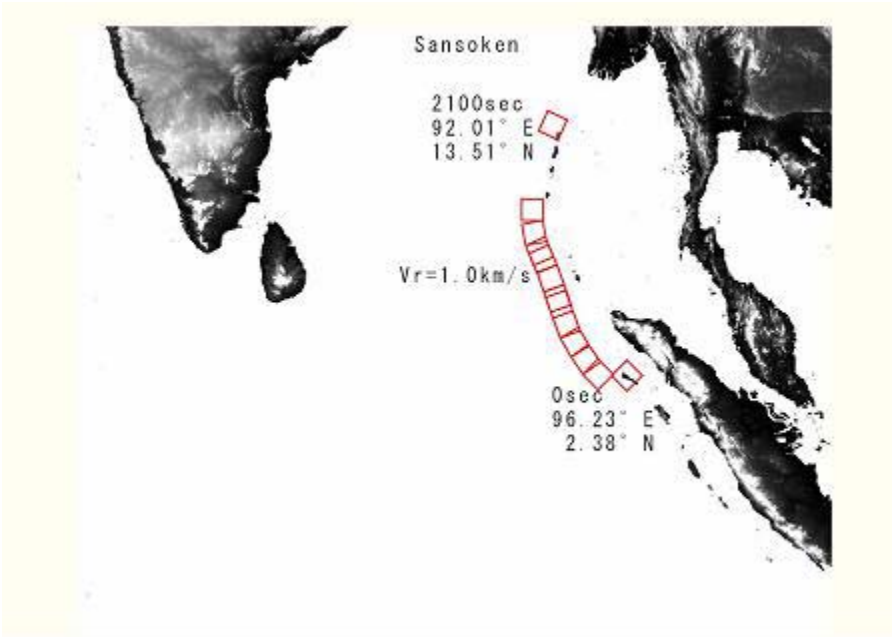
Figure Fault Location Map



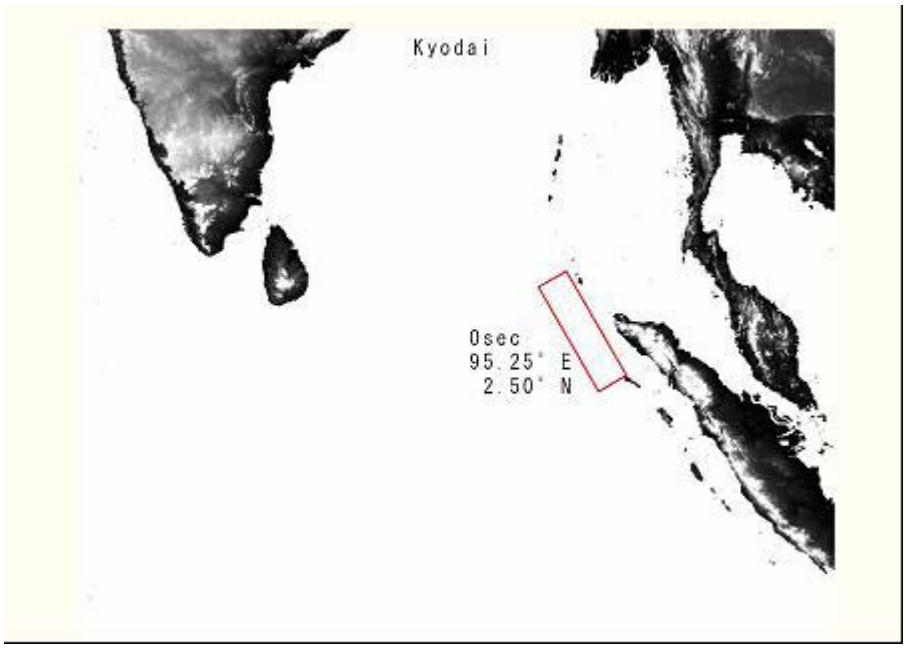
Tohoku Univ.



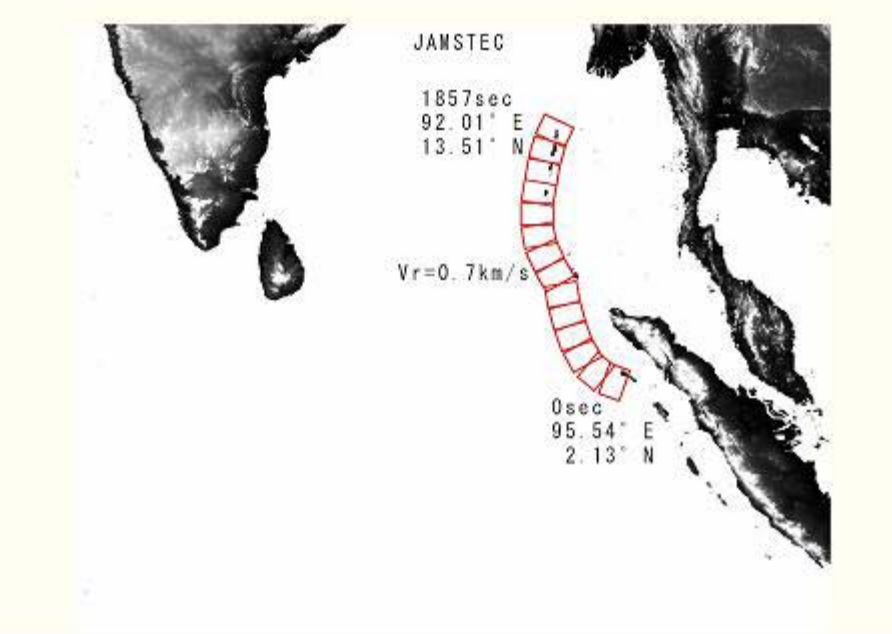
Koshimura (Tohoku Univ.)



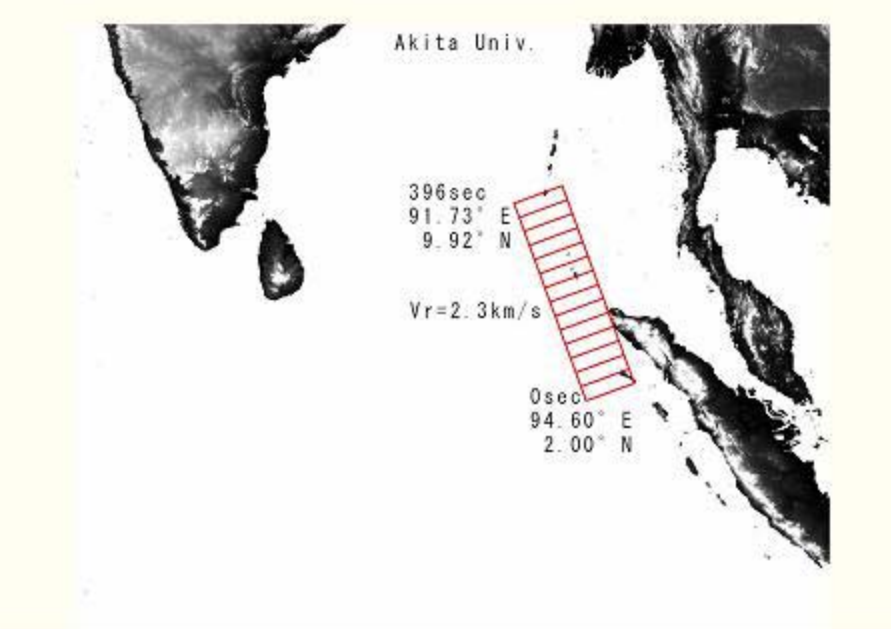
AIST



Kyoto Univ.

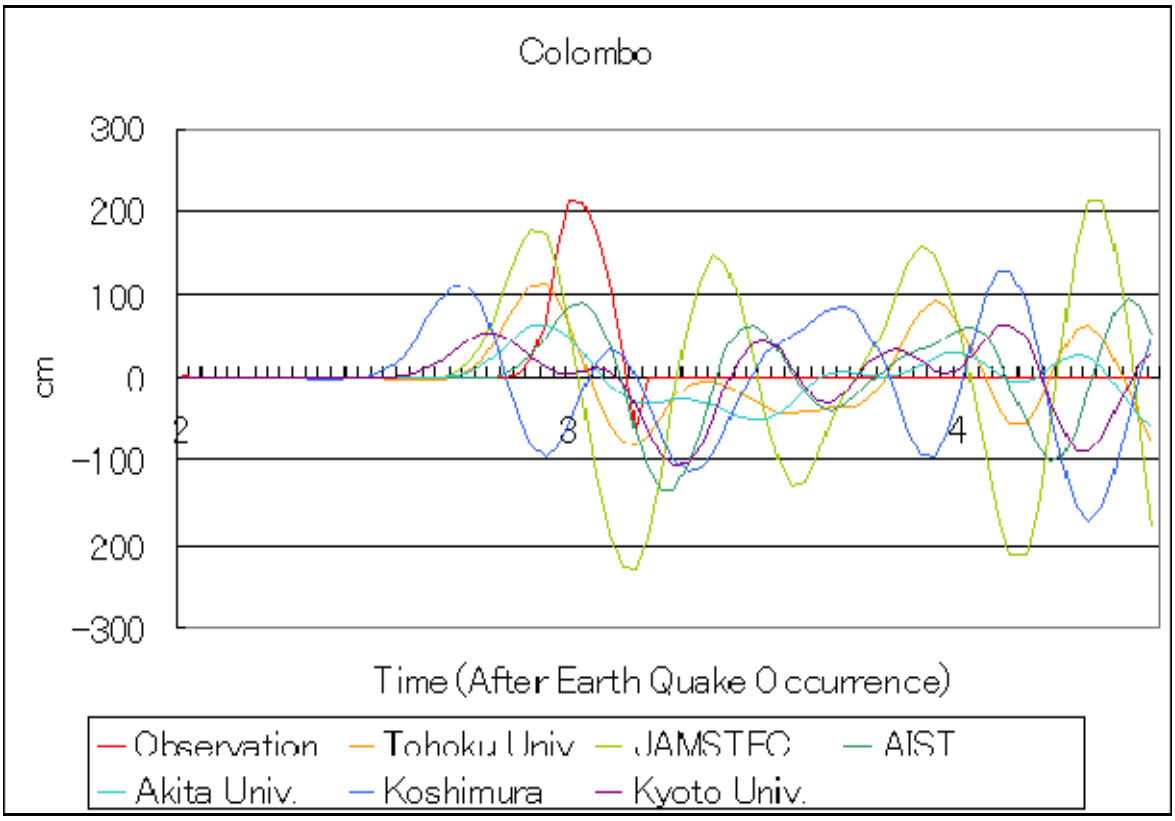


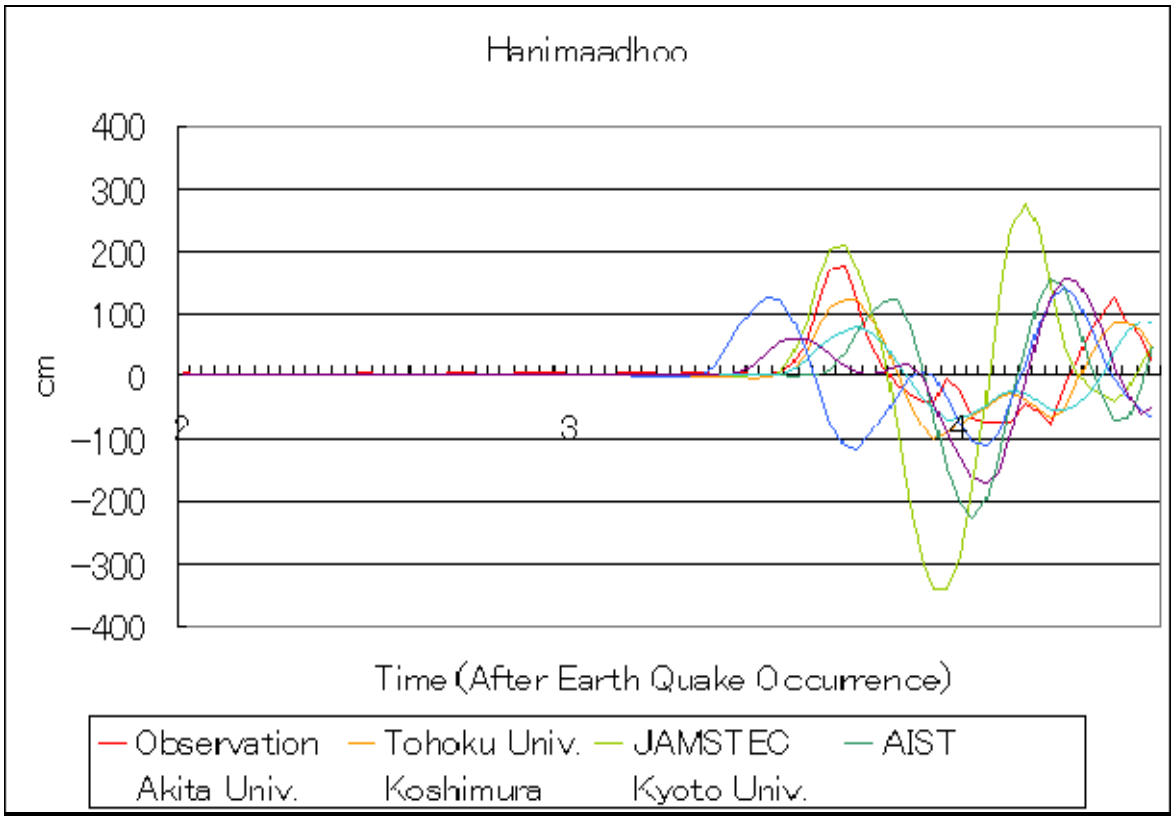
JAMSTEC

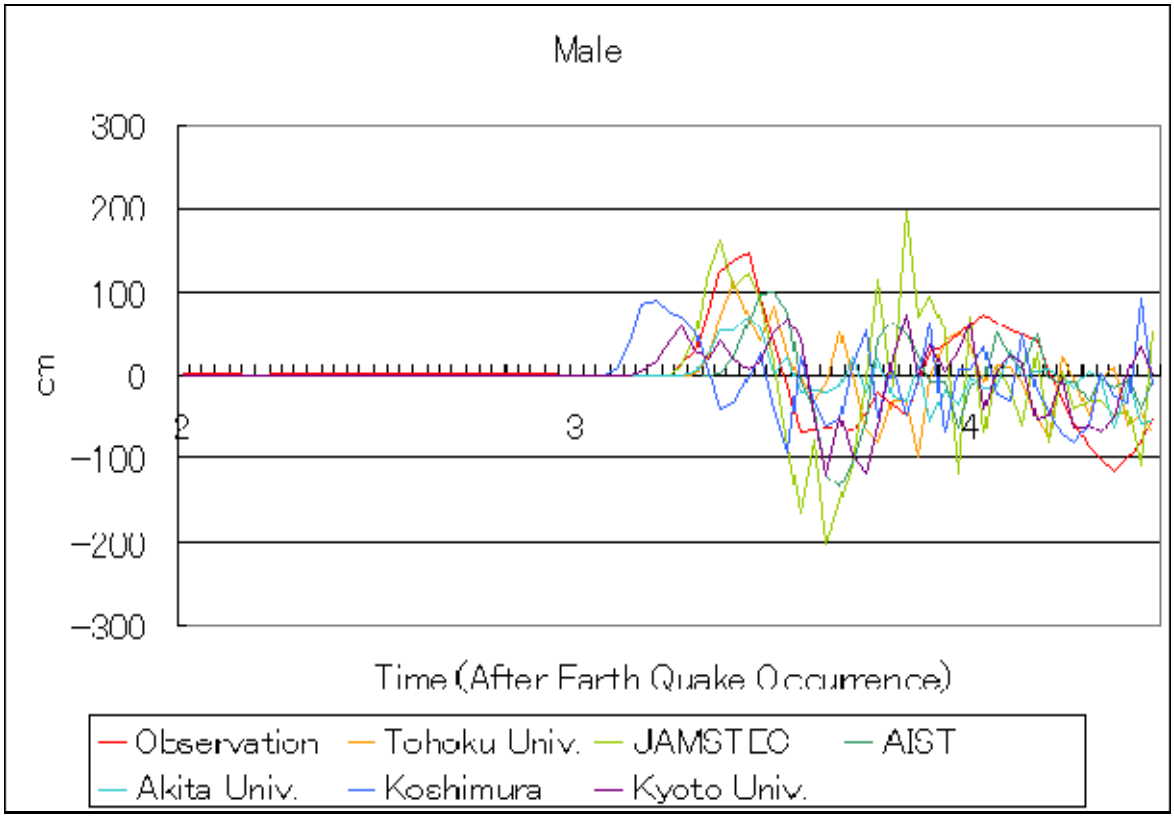


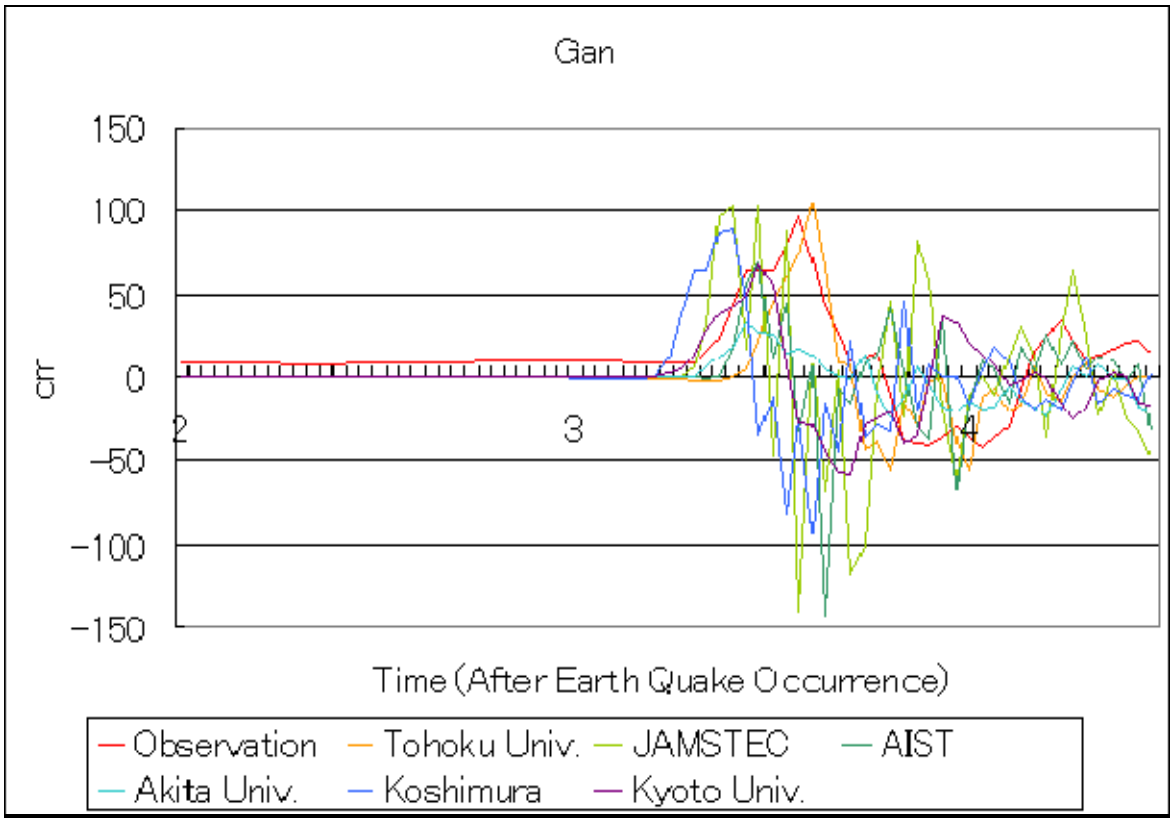
Akita Univ

Result of comparison of re-create simulation with tidal level record






Male
300
200
100
0
−100
−200
−300
cm
2
3
4
Time (After Earth Quake Occurrence)
Observation
Tohoku Univ.
JAMSTEC
AIST
Akita Univ.
Koshimura
Kyoto Univ.


Gan
150
100
50
0
−50
−100
−150
cm
2
3
4
Time (After Earth Quake Occurrence)
Observation
Tohoku Univ.
JAMSTEC
AIST
Akita Univ.
Koshimura
Kyoto Univ.

ANNEX 10-4 Materials for Disaster Management Seminars

The JICA Project Team conducted seminars on disaster management to raise awareness of disaster management for both government staff and community members in March 2006. The details are found in 10.6.2 in the main report. The following shows the materials used for the seminars.

Recovery, Rehabilitation and Development Project for Tsunami Affected Area of Southern Region in Sri Lanka

~For efficient rehabilitation~

JICA Project Team

March 2006

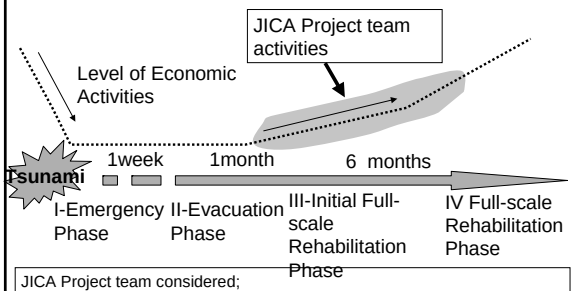
On delivery of Gas cookers for Gurubavilla camp

1

PART 1
Project Approach

2

Phases for Rehabilitation



JICA Project team considered;
What could be bottlenecks for full-scale rehabilitation in the area?
What kind of activities could be effective for quick and steady rehabilitation?

3

Japanese Experiences

Through the Great Kobe earthquake, Japan learned that

- Many bottlenecks were identified that hampered the rehabilitation process

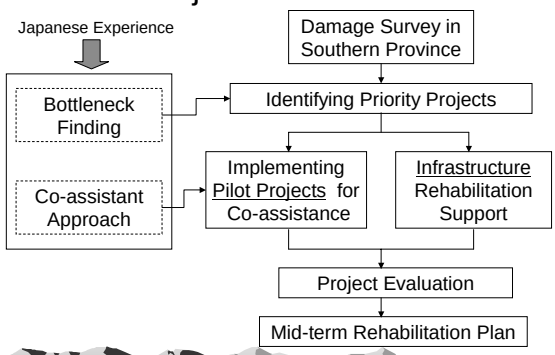
  ⇨ **Bottlenecks Finding Approach**

- Community based organizations were necessary for efficient rehabilitation after the disaster

  ⇨ **Co-assistance Approach**

4

Project Work Flow



5

Selection of Priority Projects

Following project activities were selected based on
-Bottleneck analysis and co-assistance approach
- Discussions with concerned agencies and tsunami victims

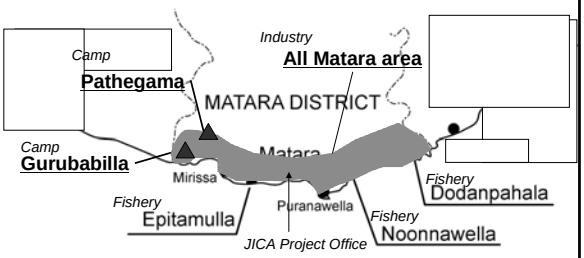
- Pilot Projects for Community Support
  - Refugee camp support,
  - Fishery cooperative rehabilitation, and
  - Small industry support
- Emergency Infrastructure Rehabilitation Support
  - Matara aqueduct rehabilitation
  - Rehabilitation of Galle and Tangalle fishery harbors

6

PART 2
Implementation of Pilot Projects

7

Location of Pilot Projects



8

Refugee Camp Support

- Target Refugee Camps
  Gurubewilla and Pathegama camp were selected out of 22 camps in Matara
- Contents of Pilot Project
  Mutual learning from good practices
  Initiative of camp management and advocacy
  Improvement of living condition through co-assistance
- Achievements
  Needs survey, camp management survey, association setting-up, regular meetings, lending of gas cockers, newsletters, study tours, etc

9

Series of newsletters have been issued for the mutual learning of good rehabilitation practices among tsunami affected people

Semi permanent houses in Pathegama

10

Fishery Cooperative Rehabilitation

- Target Fishery Cooperative Societies (FCS)
  Epitamulla, Noonnawella and Dodanpahala FCS were selected for support
- Contents of Pilot Project
  -Capacity building of the FCSs
  -Seminars for human resource development
  -Construction of office building, storehouse for fishing gear, auction hall, and meeting hall
- Achievements
  Needs survey, regular meetings, workshops, building facilities, seminars, study tours, coordination with concerned authorities and other donors, etc.

11

After the steering committee meeting of a fishery cooperative at JICA project office

These committee members took leadership in the operation of association.

Opening of the reconstructed office building for Epitamulla FCS. Dodanpahala and Noonnawella FCS also received buildings

12

Kirinda Fishery Harbor

Funding Source: This JICA Project

Task: Rehabilitation of the roof of the auction hall (Completed)

Harbor Depth-Sounding Survey (on-going)

13

Small Industry Rehabilitation

- Target Industries
  Food processing industry and ornamental fish industry were selected in collaboration with Industrial Development Board.
- Contents of Pilot Project
  -Establishing association for co-assistance -
  -Lending equipment to re-start business activities -
  -Human resource development for skills and management
- Achievements
  Needs assessment survey, establishing new associations, regular meetings, workshops, lending equipment, coordination with concerned authorities (IBD, etc) and other donors (UNDP, etc.).

14

Small sweet (sesame roll) maker in Matara, which is operated by a local 5-women group

Such weak and localized industries sometimes were ignored in confusion of disaster

A bread factory owner in Matara Most of baking equipment were washed away by Tsunami. However, the oven was rehabilitated by himself.

15

Exhibition of Food Products

The Food Processing Association held an exhibition to demonstrate the revival of their businesses

The exhibition was a very good occasion to promote their products. Product evaluation and business seminar were also held.

16

Support of Infrastructure Rehabilitation Projects

Technical Support for Rehabilitation of
-Matara Aqueduct
-Galle Fishery Harbor
-Tangalle Fishery Harbor
-Roof of Auction Hall in Kirinda Horbor

Construction was funded by Japanese Non-project Grant Aid. JICA Project Team supported in preparing design, assisting tender process, and in monitoring of the construction work

17

Reconstruction of Matara Aqueduct Bridge

Funding Source: Japanese Non-Project Grant Aid

Cost: Rs. 26,364,000

Beneficiary : 78,000 people in the Dondra area

Completed Tasks : Topographic and Geological Investigations
Preparation of Design Work
Preparation of Tender Documents
Tendering Procedure and Evaluation

Uncompleted Tasks :Support of Supervising Civil Work

18

Old bridge base was removed for the new construction

Construction of new aqueduct was in progress

19

Rehabilitation of Fisheries Harbors of Galle and Tangalle

Funding Source: Japanese Non-Project Grant Aid

Cost: JPY 728,302,753

Target : - Galle Fisher Harbor

Construction of a refrigeration ice plant, CFHC office building, an auction hall, a canteen, a welfare shop, a quay wall, a slipway, and a winch hut. Demolishment of useless facilities.

- Tabgalle Fishery Harbor

Repair and provision of port facilities

Completed Tasks : Topographic and Geological Investigations
Preparation of Design Work
Preparation of Tender Documents
Tendering Procedure and Evaluation

Uncompleted Tasks :Support for supervising civil work

20

Galle Fishery Harbor

Tsunami damaged buildings were removed for substitutional construction

Tsunami damaged the harbor quay This damage was rehabilitated

21

Tangalle Fishery Harbor

Damaged office of the harbor. This will be rehabilitated

Damaged break water. This will also be rehabilitated.

22

PART 3
Evaluation

23

Evaluation

- Bottleneck finding approach and Co-assistance approach are the tools to manage disaster rehabilitation
- These approaches were adapted for the project
- Adequacy of these approaches in Sri Lankan setting has been evaluated

24

Bottleneck Finding Approach

Considering the results of evaluation workshops, each item was scored.

Field	Field	Check points	Bottle necks	Implem entation	Missing Check points
Refugee Area Closing and Temporary Housing Provision	7.0	3.9	7.8	8.0	0
Reconstruction of Houses	9.0	5.6	7.3	6.0	-2.0
Township Rehabilitation Planning and Institutional Dev.	7.0	5.3	7.0	6.7	-2.0
Demolition of Damaged Buildings and Debris Disposal	0	1.0	1.0	1.0	0
Industry Rehabilitation	8.0	7.0	7.1	6.4	-2.0

25

Bottleneck Finding Approach

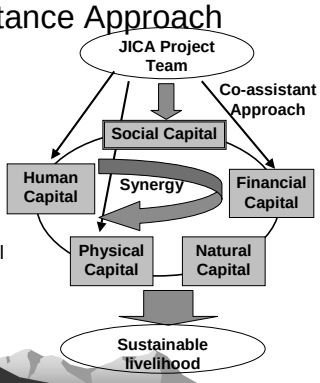
- General effectiveness was proven.
- Some of the bottlenecks did not fit the Sri Lankan reality and priority.
- Sri Lanka should develop its own list of likely bottlenecks reflecting what were done and how in the aftermath of the tsunami.

26

Co-assistance Approach

Changes in social capital in the target societies and associations have been evaluated

Synergy effect with social capital and other capitals was observed



27

Part Ⅳ

Supporting the development of mid-term rehabilitation plan

28

Mid-term Rehabilitation Planning

Assessment

- Evaluation of Priority Projects
- Extraction of Issues

Support for mid-term rehabilitation planning

- Suggestions for Rehabilitation
- \+
- Suggestions for Disaster-proof Town

29

Suggestions on Regional Disaster Management Plan in Matara Urban Area

JICA Project Team

March 2006

1

Background

Existing Plans

- McRAP: An integrated Urban Plan for Matara
- 100m Buffer Zone
- (Establishment of Disaster Management Center)

Japan's Experience and Lessons of this Project

- List of lessons and checkpoints
- Co-Assistance Activities
- Disaster Hazard Mapping

Recommendations on Disaster Management of Matara

2

Suggestions on Disaster Management Measures

1.Measures for Local Authorities

2.Measures for Communities

3.Hazard Map

3

1.Measures for Local Authorities

4

Measures for Local Authorities

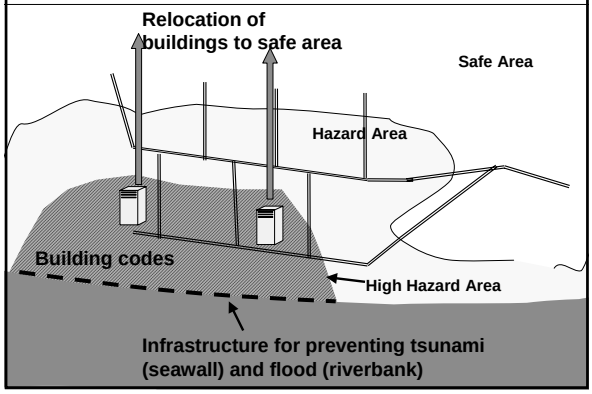
1.Infrastructure Measures

2.Emergency Preparedness and Response

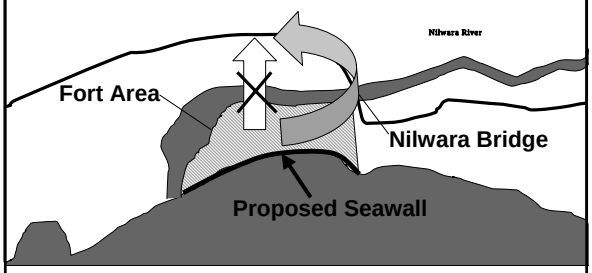
3.Enhancement of Disaster Management

5

Infrastructure Measures



Infrastructure to Prevent Tsunami



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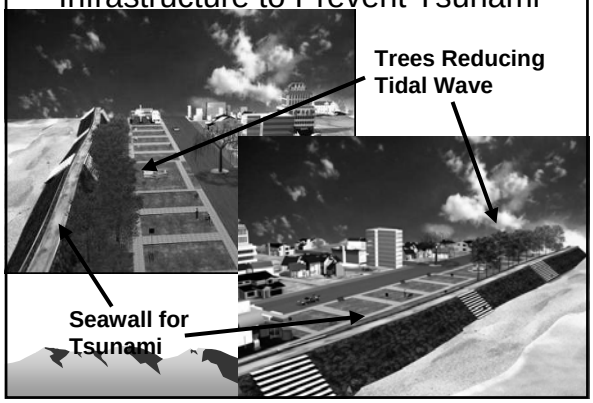
Infrastructure to Prevent Tsunami

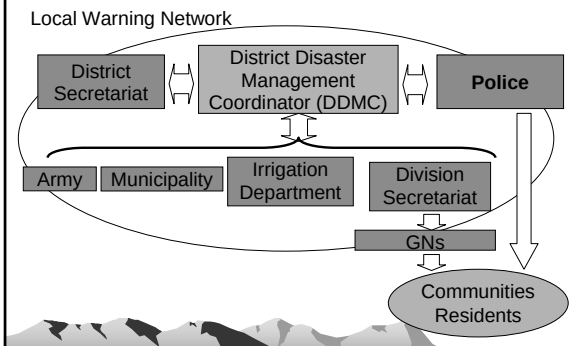


Emergency Preparedness and Response

- **Local Early Warning System**
- **Preparation of Emergency Evacuation Plan**
- **Annual Emergency Drills**

9

Local Early Warning System



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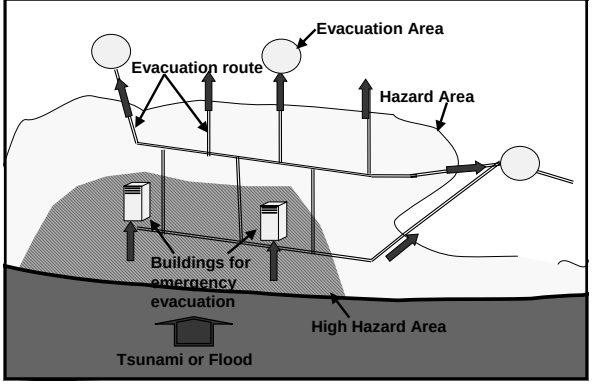
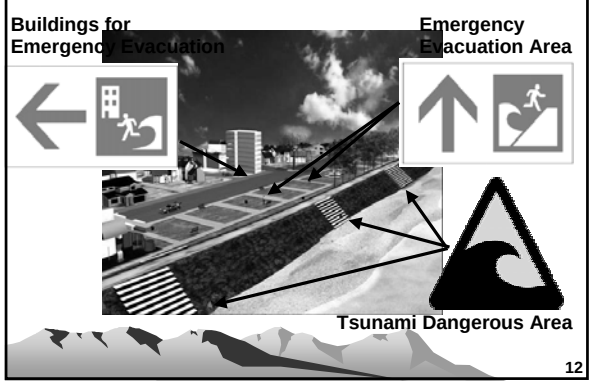
Emergency Evacuation Plan



Evacuation Information



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Annual Emergency Drills

Annual emergency drills for early warning, evacuation, and emergency assistance based on realistic procedures

Annual emergency drills by local government in Japan

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Enhancement of Disaster Management

- **Using a List of Lessons and Checkpoints**
- **Establishment of Disaster Management Committee in Matara**

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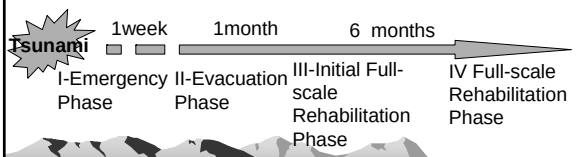
List of Lessons and Checkpoints

- **Collect issues on tsunami rehabilitation**
- **Classify issues into each phase**
- **Lists for floods, landslides or other disaster are also useful**



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Sample of the List

Phase: Initial Rehabilitation Phase
Field: Refugee camp closing and temporary housing provision
Sub-field: Provision of temporary housing
Lessons: **1. Main implementing body of temporary housing was changed to the prefecture agency from the municipality.** **2. Demarcation of roles among the state, prefecture, and municipality needed to be discussed more thoroughly.** **3. Volume of housing demand could not be specified.**
Checkpoints: • **Does institutional coordination for temporary housing work efficiently?**

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Establishment of Disaster Management Committee in Matara

- For implementation of the measures heretofore described, the coordination among related local agencies is essential
- The committee should have regular meetings and coordinate for various measures related to disaster management

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2. Measures for Communities

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Enhancement of Community Activities

Workshops and Drills at Community Level

- ✓Early warning route
- ✓Evacuation routes/areas
- ✓Stocks for emergency

Drills for evacuation at the community level in Japan

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Disaster Awareness

School Program on Disaster Awareness

-History of major disasters

-Mechanism of disaster

-Ways to prevent disaster damage

-Drills of evacuation

Public Relations (Signboards, etc.)

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Disaster Awareness

Sign for Altitude and Warning of Tsunami

Sign showing water levels of past Tsunami disasters

3. Hazard Map

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Hazard Map

The JICA Project Team prepared:

- **Tsunami Record Map**
- **Flood Record Map**
- **Preliminary Tsunami Hazard Map**
- **Tsunami Simulation Results**

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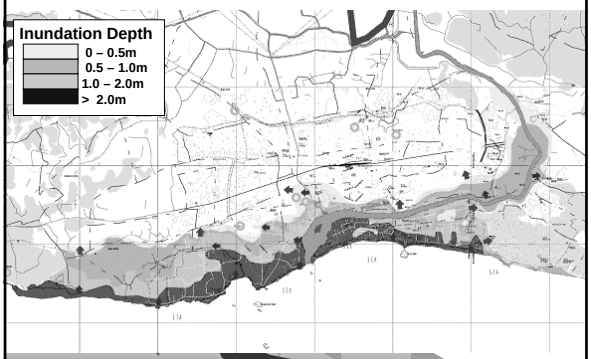
Tsunami Record Map 2004



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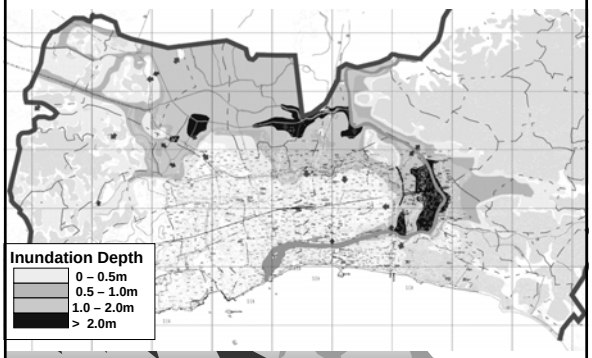
Flood Record Map 2003



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Tsunami Simulation

To be added

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Tsunami Hazard Map

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How to Use Hazard Map

These maps are useful for:

- Identification of disaster hazard areas;
- Provision of information on evacuation sites and routes to there; and
- Enhancement of community preparedness against disaster through distribution of the maps

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