### 2.2.2 Master Plan for Project Area

The planned construction of cyclone shelters under the Master Plan for the Multipurpose Cyclone Shelter Programme, in Thanas, subject to the present Basic Design Study, which includes, (Banskhali Thana in the Chittagong District, Chakoria and Moheskhali Thanas in the Cox's Bazar District and Noakhali Sadar, Hatiya and Companiganj Thanas in the Noakhali District), is outlined as follows.

Table 2-2-3 Planned Construction of Cyclone Shelters in the Project Area

| Thana | Population (2002) | Subject Population of Planned Shelters | Number of Planned Shelters | Number of Top Priority Shelters |
|---|---|---|---|---|
| Banskhali | 292,826 | 174,394 | 99 | 54 |
| Chakoria | 353,645 | 209,982 | 121 | 67 |
| Moheskhali | 165,329 | 90,751 | 51 | 25 |
| Noakhali Sadar | 167,496 | 127,222 | 72 | 64 |
| Hatiya | 371,464 | 240,596 | 139 | 131 |
| Companiganj | 56,193 | 28,886 | 16 | 16 |
| Total | 1,406,953 | 871,831 | 498 | 357 |

Approximately 870,000 people in the Project Area are in need of new shelter facilities. The construction of 498 new shelters to accommodate this number of people is necessary while of that number, 357 shelters (more than 70% of the total) are classified as top priority shelters (to be completed in the first 3 years) (Table 2-2-2).

## 2.3 Outline of the Request

### 2.3.1 Background

As described in Chapter 1, Bangladesh is a country likely to suffer extensive damage caused by cyclonic storm surges due to its location and climatic conditions. The inadequate level of national resources has made it difficult for the government to introduce concrete measures to prevent cyclone damage despite the loss of many lives in the past.

Against this background, the cyclone which hit Bangladesh in April, 1991 with a maximum wind velocity of 62.5 m/sec caused a storm surge of 6.0 - 7.5m, claiming some 140,000 lives, inflicting massive damage to both livestock and fishery resources and also causing extensive damage to embankments, roads and houses. The Government of Bangladesh has subsequently requested the assistance of many aid organizations and donor countries for the construction of new cyclone shelters. In response to this request, some donor countries and NGOs are now constructing new cyclone shelters as described in 2.1.

The Government of Bangladesh has also made a request to the Government of Japan for assistance to construct new cyclone shelters on top of killas, the construction of which is currently underway by the LGED at 40 sites with the assistance of the WFP. In response to this request, the Government of Japan dispatched a team consisting mainly of former JOCV members to Bangladesh to conduct preliminary field surveys on the social, economic and technical backgrounds and conditions of the request. Based on the findings of these preliminary field surveys, it was decided to dispatch the Basic Design Study Team for the present Project to Bangladesh.

### 2.3.2 Contents

The cyclone which hit Bangladesh in April, 1991 caused tremendous damage in 119 Thanas in 18 Districts with a death toll as high as 139,000 lives. Crops in 48,000ha of farmland were completely destroyed and those in an additional 300,000ha were partially damaged. The consequent loss of harvest totaled 320,000 tons, including 160,000 tons of rice. The damage to livestock and fisheries was also extensive and included the loss of 224,000 cattle, 218,000 sheep (including goats), 2.4 million domestic fowl (chickens and geese), 2,000 engine-fitted boats, 6,500 fishing boats and 64 modern trawlers. Approximately 30,000ha of prawn culture ponds were also damaged as a result of the cyclone. The list of damaged assets includes 40 factories in the Export Processing Zone (EPZ), port facilities at Port Chittagong, coastal embankments (1,200km), roads, bridges and culverts. The total restoration cost was estimated to be 170 million dollars. The cyclone caused damage to the entire southern coastal area, particularly in a 150km section near Chittagong and on islands near this section.

Those people living in the RZ are aware of the cyclone danger but have no alternatives to their living situation due to socioeconomic reasons. In order to protect the lives of these people, the Government of Bangladesh has requested the implementation of disaster prevention measures through various aid organizations. Many aid organizations have responded to the request and have promised to construct cyclone shelters and killas, some of which are already under construction. The Government of Bangladesh has also started to prepare the Master Plan for the Multipurpose Cyclone Shelter Programme with the assistance of the UNDP. While the report for the Master Plan is expected to be finalized soon, the Government of Bangladesh has decided to continue with the construction of those cyclone shelters which are either firmly committed to or already under construction.

The construction of cyclone shelters on top of 40 killas is planned by the LGED. As the WFP has come forward with assistance for the construction of the killas, the LGED has requested the assistance of the Government of Japan for the construction of the actual cyclone shelters. The completion of this project is expected to not only save human lives but also the lives of animals. The shelters to be constructed will also contribute to the general improvement of local community life by serving as school, clinic or community center buildings in normal times.

## 2.4 Preliminary Study

The study findings of the aforementioned Study Teams are described below.

(1) Access to Sites

All of the 40 sites are located near the coast or on islands in the RZ and are mostly far from urban centers. Road access is generally poor with some access roads being lost due to cyclones and others being just wide enough for people on foot. Many sites have access by boat using a sea way, river or canal although these accesses may be suspended due to tides or strong wind. In short, access to the sites was judged to be generally poor.

(2) Progress of Killa Construction

The construction of killas to protect livestock is underway at various sites and is at different stages of progress. Local inhabitants are recruited as construction workers in exchange for flour. Soil excavated in the neighboring areas is manually raised to create a rectangular mound (60m x 30m) of 6m in height. Rolling compaction is not conducted and, therefore, the porous mounds appear extremely vulnerable to scouring due to storm surge or flooding. It was concluded that the construction of a cyclone shelter directly on top of a killa would be very difficult due to the fragile banking above a vulnerable foundation consisting of mud with a low bearing strength.

(3) Site Locations

The survey of site locations to determine the suitability of the 40 sites for evacuation in which some sites were found to be unsuitable due to various reasons, including (1) lack of residences, (2) long distance (more than 2km) from the nearest inhabitants, (3) location was in a river path and (4) existence of a hill or shelter for evacuation in the vicinity. The sites were consequently classified into the following 2 priority groups based on certain criteria.

- Criteria for Priority Grade A

    (1) strong necessity for a cyclone shelter
    (2) short distance from inhabitants for easy evacuation
    (3) large population in the service area
    (4) no plan by any aid organization to construct a similar shelter in the vicinity

- Criteria for Priority Grade B

    (1) strong necessity for a cyclone shelter but the location is restricted
    (2) lesser necessity for a cyclone shelter

(4) Conclusions

Based on the above criteria, 8 sites from Priority Group A and 10 sites from Priority Group B were identified as possible cyclone shelter sites while the remaining 22 sites were judged to be unsuitable for the introduction of cyclone shelters. As the construction of cyclone shelters directly on top of killas was judged to be inappropriate, it was decided to construct free-standing shelters on stilts next to the killa sites. The LGED agreed to this decision and promised to acquire the necessary land.

Based on initial survey findings, JICA decided to conduct a physical survey on 4 Priority Group A sites to determine the appropriateness of Japan's grant aid. Through subsequent consultations between the Government of Bangladesh and the Basic Design Study Team, it was agreed to increase the number of sites undergoing a physical survey should be increasaed to 10, of which 8 sites would be from Priority Group A and 2 sites from Priority Group B.

# CHAPTER 3

# OUTLINE OF THE PROJECT AREA

# CHAPTER 3 OUTLINE OF THE PROJECT AREA

## 3.1 Project Area

The Project Area includes Banskhali Thana in the Chittagong District, Chakoria and Moheskhali Thanas in the Cox's Bazar District and Noakhali Sadar, Hatiya and Companiganj Thanas in the Noakhali District. A total of 10 project sites are planned in this Project Area as shown in the following table (see the Location Map for their locations).

| No. | District | Thana | Union | Killa |
|---|---|---|---|---|
| 1. 9880980 | Chittagong | Banskhali | Gandamara | Barghona |
| 2. 9880982 | Chittagong | Banskhali | Saral | Saral |
| 3. 9900182 | Cox's Bazar | Chakoria | Badarkhali | Badarkhali near Samsul House |
| 4. 9900183 | Cox's Bazar | Chakoria | Badarkhali | Badarkhali near Abdul Ahmed House |
| 5. 9900185 | Cox's Bazar | Chakoria | Badarkhali | Shab Mea |
| 6. 9900485 | Cox's Bazar | Moheskhali | K.M.Chara | Kaliganj |
| 7. 9840381 | Noakhali | Companiganj | Char-Elahi | Char Ganchil |
| 8. 9840480 | Noakhali | Hatiya | Burir Char | Burir Char |
| 9. 9840481 | Noakhali | Hatiya | Jahajmara | Jahajmara |
| 10. 9840680 | Noakhali | Noakhali-Sadar | Char Clark | Char Clark |

## 3.2 Natural Conditions

### 3.2.1 Climate and Hydrology

The specific climatic conditions relating to the Project are discussed here.

(1) Rainfall

The maximum daily rainfall and maximum hourly rainfall with a 5 year return period are given in the Table 3-2-1.

Table 3-2-1 Maximum Daily Rainfall & Maximum Hourly Rainfall with 5 year return period

(Unit: mm)

| Item/Place | Chittagong | Hatiya | Sandwip |
|---|---|---|---|
| Max. Daily Rainfall (5 year return period) | 280 | 241 | 211 |
| Max. Hourly Rainfall (5 year return period) | 117 | 90 | 106 |

Source: Multipurpose Cyclone Shelter Programme

The total rain duration and the hourly average rainfall recorded by tropical cyclones are given in the Table 3-2-2.

Table 3-2-2 Summary of Rainfall during Tropical Cyclones

| Year | Stations | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Chittagong | | Sandwip | | Hatiya | | Barisal | | |
| | Time (hrs) | Intensity (mm/hr) | Time (hrs) | Intensity (mm/hr) | Time (hrs) | Intensity (mm/hr) | Time (hrs) | Intensity (mm/hr) | |
| 1982 May 4-5 | 3 | 1.67 | 0 | 0 | 0 | 0 | 0 | 0 | cyclone weakened considerably before crossing Bangladesh |
| 1983 Nov. 9-10 | 18 | 2.06 | 18 | 2.06 | 21 | 1.67 | 6 | 7.33 | cyclone hit Kutubdia Island |
| 1984 June 2-3 | 33 | 3.06 | 24 | 3.42 | 30 | 7.4 | 36 | 5.42 | |
| 1985 May 25-26 | 39 | 7.13 | 24 | 7.75 | 15 | 2.4 | 18 | 2.28 | cyclone hit South Chittagong at 21:00 on the 25th |
| 1986 Nov. 8-9 | 30 | 4.03 | 30 | 5.83 | 27 | 8.56 | 36 | 6.36 | cyclone crossed West Bengal coast at 03:00 on the 9th |
| 1987 June 4-5 | 33 | 6.03 | 15 | 9.87 | 27 | 2.81 | 30 | 4.33 | deep depression crossed South-East Patuakhali at 18:00 on the 4th |
| 1988 Nov. 29-30 | 21 | 2.76 | 21 | 1.76 | 12 | 2.25 | 21 | 4.14 | cyclone hit Raimongol river in Khulna at 12:00 on the 29th |
| 1989 | - | - | - | - | - | - | - | - | no major cyclone |
| 1990 Dec. 18-19 | 24 | 1.42 | 21 | 2.38 | 18 | 4.33 | 15 | 2.07 | cyclone weakened considerably |
| 1991 Apr. 29-30 | NA | NA | NA | NA | 27 | 7.63 | 27 | 3.15 | cyclone hit Komira at 22:00 on the 29th |

Source: Multpurpose Cyclone Shelter Programme

(2) Wind Velocity

The cyclonic wind velocities for different return periods (10, 20, 50 and 100 years) in the Bangladesh coastal area are given in Table 3-2-3 based on the relevant records for the period between 1960 and 1991.

Table 3-2-3 Cyclonic Wind Velocities for different return periods

| Wind Velocity | Return Period (years) | | | |
|---|---|---|---|---|
| | 10 | 20 | 50 | 100 |
| km/hour | 194 | 223 | 261 | 287 |
| m/sec | 53.9 | 61.9 | 72.5 | 80.3 |

Source: Multipurpose Cyclone Shelter Programme

The annual maximum wind velocities for different return periods at various observation stations are given in the Table 3-2-4

Table 3-2-4 Annual Maximum Wind Velocities for Different Return Periods

| Observation Station | Observation Period | Wind Velocity for Specific Return Period (km/hr) | | | |
|---|---|---|---|---|---|
| | | 10 years | 20 years | 50 years | 100 years |
| Chittagong | 1971-1990 | 118 | 135 | 156 | 172 |
| Cox's Bazar | 1972-1988 | 135 | 159 | 190 | 214 |
| Hatiya | 1971-1987 | 111 | 128 | 150 | 167 |
| Sandwip | 1971-1988 | 113 | 132 | 156 | 175 |

Source: Multipurpose Cyclone Shelter Programme

## (3) Temperature

The annual maximum and minimum temperatures for different return periods in the Project Area are given in Table 3-2-5.

Table 3-2-5 Annual Maximum and Minimum Temperatures for Different Return Periods

| Observation Station | Maximum/ Minimum | Temperature for Specific Return Period (°C) | | | |
|---|---|---|---|---|---|
| | | 10 years | 20 years | 50 years | 100 years |
| Chittagong | Maximum | 36.46 | 36.78 | 37.13 | 37.37 |
| | Minimum | 9.46 | 9.10 | 8.70 | 8.44 |
| Hatiya | Maximum | 37.58 | 38.18 | 38.87 | 39.33 |
| | Minimum | 10.31 | 9.93 | 9.50 | 9.21 |
| Sandwip | Maximum | 36.15 | 36.48 | 36.85 | 37.10 |
| | Minimum | 10.45 | 10.03 | 9.56 | 9.25 |

Source: Multipurpose Cyclone Shelter Programme

## (4) Tide Level

The prominent storm surge heights recorded by cyclones since 1960 are shown in Table 2-1-2.

The predicted maximum storm surge heights for different return periods in different regions of the Project Area are given in the Table 3-2-6.

Table 3-2-6 Predicted Areal Average for Maximum Surge Heights

| Coastal Region | Predicted Average Surge Height (m) | | | | | |
|---|---|---|---|---|---|---|
| | V=165 T=5 | V=195 T=10 | V=223 T=20 | V=233 T=25 | V=261 T=50 | V=289 T=100 |
| Teknaf - Cox's Bazar | 2.00 | 2.71 | 3.44 | 3.71 | 4.53 | 5.40 |
| Cox's Bazar - Chittagong | 3.18 | 4.25 | 5.38 | 5.80 | 7.04 | 8.36 |
| Chittagong - Noakhali - Bhola | 3.55 | 4.75 | 5.99 | 6.50 | 7.83 | 9.29 |

T = Return Period (years) V = Wind Velocity (km/hr)
Source: Multipurpose Cyclone Shelter Programme

The design surge heights at the beaches of the coastal regions listed in the previous table are given in the Table 3-2-7.

Table 3-2-7 Design Surge Heights at the sea coast (with 90% accuracy limit)

| Region | Design Surge Height at Beaches (with 90% accuracy limit) (m) | | |
|---|---|---|---|
| | 20 Year Return Period | 50 Year Return Period | 100 Year Return Period |
| Teknaf to Cox's Bazar | 2.7 ± 0.7 | 3.7 ± 0.8 | 4.5 ± 1.3 |
| Chakoria to Anwara and Moheskhali-Kutubdia Islands | 4.3 ± 0.9 | 5.8 ± 1.3 | 7.0 ± 1.6 |
| Chittagong to Noakhali | 4.8 ± 1.0 | 6.5 ± 1.4 | 7.8 ± 1.8 |
| Sandwip, Hatiya and all islands in this region | 4.8 ± 1.0 | 6.5 ± 1.4 | 7.8 ± 1.8 |

Source: Multipurpose Cyclone Shelter Programme

The extreme surface water levels at various locations in the coastal area during the monsoon season are given in Table 3-2-8.

Table 3-2-8 Extreme Surface Water Levels at Various Locations of Coastal Areas During Monsoon (Unit: m above PWD Datum)

| Location | 20 Year Return Period | 50 Year Return Period | 100 Year Return Period |
|---|---|---|---|
| Teknaf | 2.19 | 2.33 | 2.44 |
| Cox's Bazar | 3.78 | 3.84 | 3.88 |
| Shaflapur (Chakoria) | 4.23 | 4.67 | 4.87 |
| Lemsikhali | 4.62 | 4.95 | 5.19 |
| Banigram (Banskhali) | 4.80 | 5.05 | 5.24 |
| Chittagong | 4.50 | 4.72 | 4.88 |
| Patenga | 3.98 | 4.08 | 4.16 |
| Sonapur | 6.87 | 7.02 | 7.11 |
| Sandwip | 5.91 | 6.09 | 6.20 |
| Companiganj (Noakhali) | 7.02 | 7.53 | 7.94 |
| Hatiya | 5.28 | 5.55 | 5.76 |

Source: Multipurpose Cyclone Shelter Programme

### 3.2.2 Topography

Bangladesh mainly consists of an alluvial deltaic plain. The northeastern, eastern and southeastern borders are edged by hills. The alluvial plain extends as long as some 400km in the northwest-southeast direction and the elevation at the northeastern corner is 90m, from where the land elevation gradually declines towards the southwest to less than 3m at the line connecting Khulna, Narayanganj, Chandpur and Noakhali. The land to the south of this line and the Chittagong coastal plains located in the southeast form the coastal area of Bangladesh. This coastal area is classified into the following physiographic units based on physical characteristics.

(1) The Chittagong Coastal Plain

This is a narrow area sandwiched between the Chittagong hills and the sea and has several flood plains and offshore islands. The area is characterized by gently sloping piedmont alluvial fans of loamy soil types. The offshore islands mainly consist of clay layers transported and deposited by the sea currents. The area is shown under gray piedmont clay in Fig. 3-2-1.

(2) Estuarine Flood Plains

The estuarine flood plains spreading around the mouth of the old Meghna river contain sediment deposits originating from the Ganges and Brahmaputra rivers. Few undulations are observed and the soil type is silty soil. This area is shown under alluvial deltaic silt deposits in Fig. 3-2-1.

(3) Ganges Tidal Flood Plains

These plains are linked to the Ganges estuarine flood plains upstream but are less undulating down stream. Tidal flood plains differ from the Ganges estuarine flood plains in that a well-developed network of numerous tidal creeks and river channels has been formed in the Ganges tidal flood plains. While deposits are mainly of non-calcareous clay, silt and peat are found in the east and west respectively. The area is shown under grey flood plain clay in Fig. 3-2-1.

(4) The Sundarbans

The Sundarbans are areas covered by mangrove forests which are under the influence of tidal floods of brackish or saline water. The land in this area is virtually flat with numerous tidal creeks and river channels.

The proposed cyclone shelter sites under the Project are located in areas (1) and (2) above. Four sites in the Noakhali District are located in the estuarine flood plains while two sites are in the Chittagong District and four sites are in the Cox's Bazar District which are located in the Chittagong coastal plains.

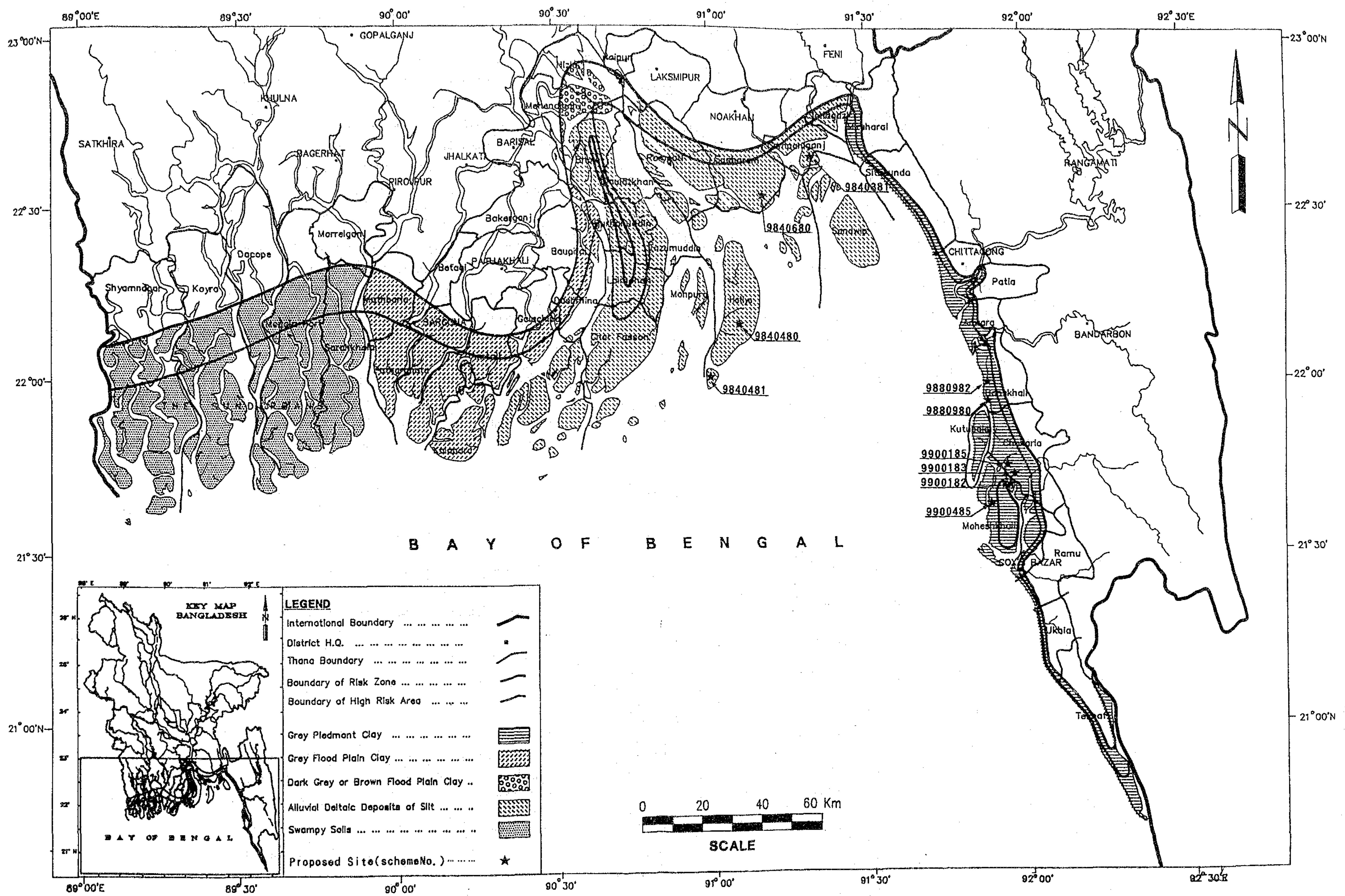



Fig. 3-2-1 Physiographic Units with Similar Soils (after MCSP, Vol. VII)

### 3.2.3 Geology

(1) Geological Formations of Coastal Area

The Bengal basin has been filled in with sediments from north, east and west. During this filling process, the basin has deepened and sea levels has varied considerably from its present position through a series of transgressions and regressions which have occured over a 60 million year period. The alluvial plains and deltas formed in more recent periods by the Ganges, Brahmaputra and Meghna rivers cover the surface of the Bengal basin over a total area of $60,000km^2$. This huge delta is called the Bengal fan and consists of the world's largest-scale fan deposits.

The thickest Bengal basin deposit of some 18,000m is observed at the Patuakhali trough located in the coastal Hatiya, Barisal and Faridpur areas. As most soil studies in the coastal area in the past dealt with the soil types up to approximately 20m below the ground surface, only some of the latest alluvial series have been examined. Figure 3-2-2 shows the presumptive geological sections of the coastal areas of the 3 major rivers based on data collected from deep tube wells in the relevant areas. The surface layer mainly consists of silt and clay and has a thickness of some 50m except at the mouth of Meghna river where the thickness is reduced to some 10m. More detailed examination reveals that the soil texture of the surface layer differs from one area to another in both the horizontal and vertical directions. The grain size, density and consistency (*) also largely differ from one area to another. These differences reflect the sedimentation environment and are caused by frequent changes of the well-developed river and water channel courses. In general, the deposits of the major rivers are coarser than those of sea currents.

The fan deposits from the Chittagong hills and deposits of coastal currents are mixed in a complicated manner in the Chittagong coastal area. The geological formations and soil characteristics of this area are very complicated due to the multifold shallow bedrocks of the above hills.

Note)* Consistency: the property of clayey soil to change its state from liquid, plastic and semi-solid depending on the moisture content.

(2) Groundwater in Coastal Area

Groundwater in the coastal area is strongly influenced by saline water as shown in Figure 3-2-3. Tubewells of more than 200 meters deep are dug in and around the Chittagong hills and the hills near Moheskhali Island to avoid saline water intrusion. Some flowing artesian wells are also observed in these areas.

The well depth in other parts of the coastal area of around 300m is generally much deeper. Some wells near Noakhali are more than 400m.

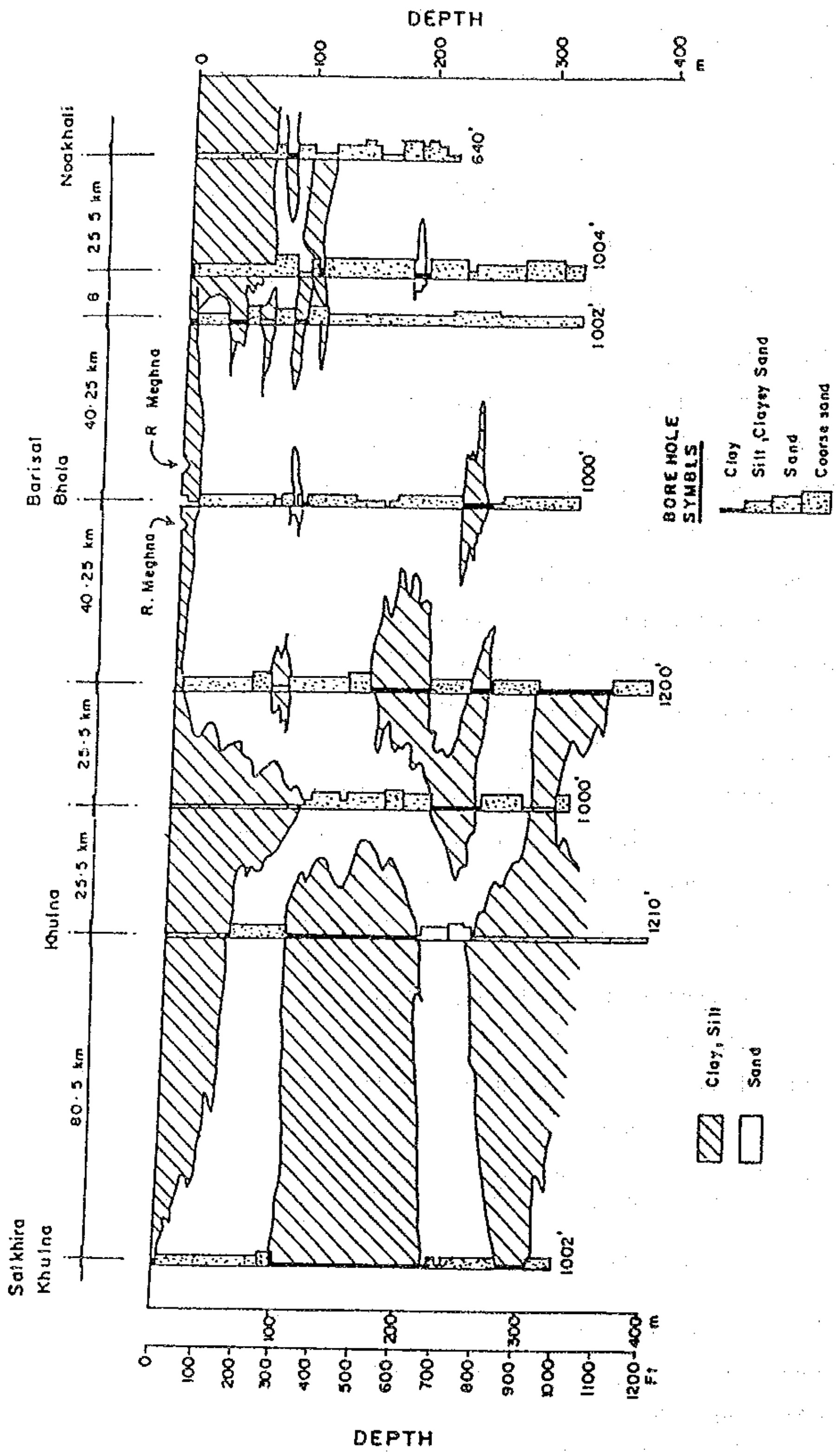



Fig. 3-2-2 Geological Sections of Coastal Area (MPO, 1987)

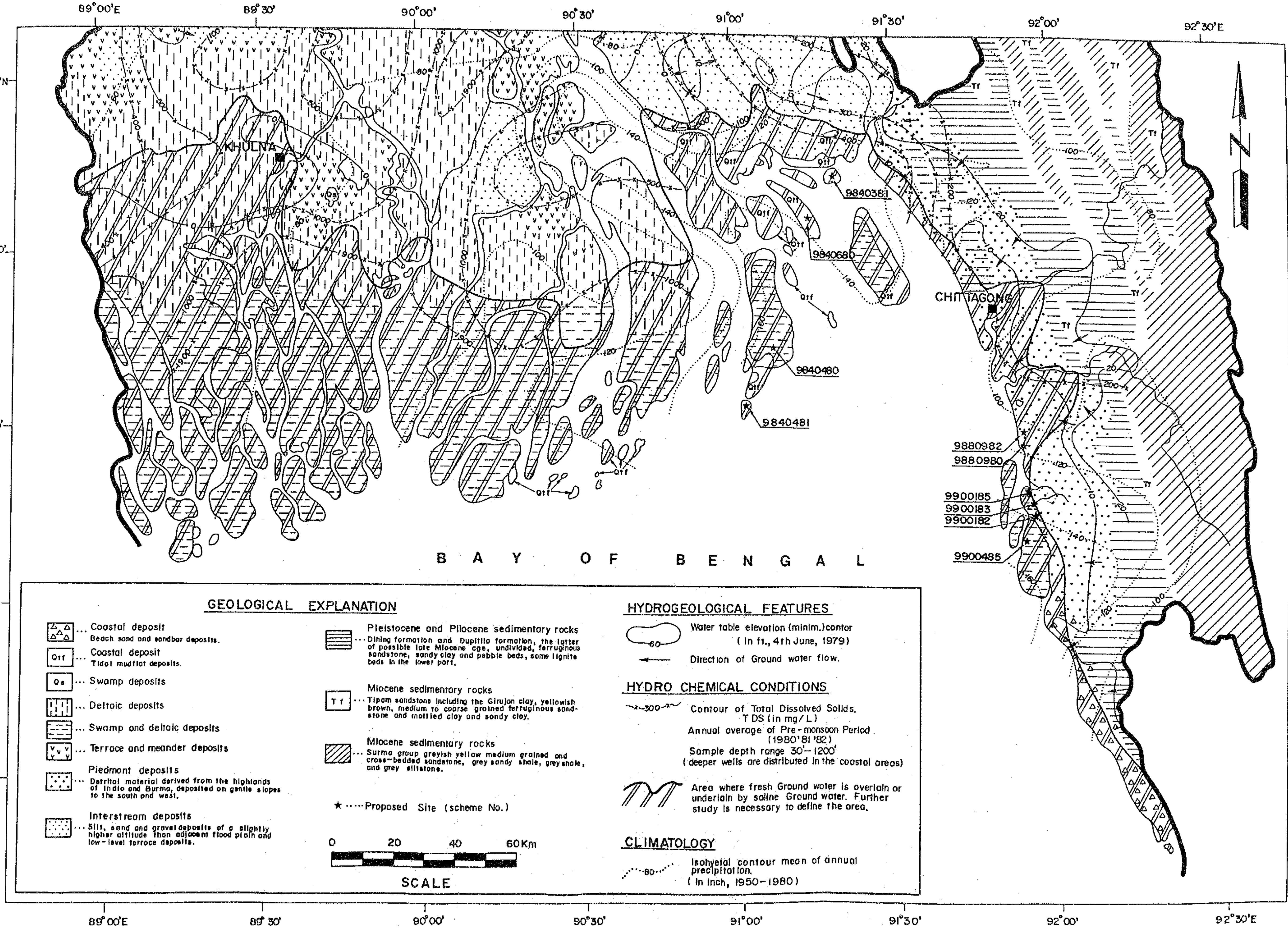



Fig. 3-2-3 Hydrogeological Map of Coastal Area (after BWDB, 1983)

## 3.3 Conditions of Social Infrastructure

### 3.3.1 Current Level of Infrastructure

(1) Roads and Transport

The distance and traveling time by road or water to each of the project sites from either a major city or local city are shown in Fig. 3-3-1. Based on information given in Fig. 3-3-1, the project sites are divided into the following 2 groups.

a) Sites with road access: Nos. 3, 4, 5, 7 and 10
b) Sites with water access only: Nos. 1, 2, 6, 8 and 9

1) Sites with Road Access

Even though these sites have road access, the road conditions are generally extremely poor being accessible by 4 wheel-drive vehicles only. Improvement of road conditions is imperative for most of the sites in view of the need for smooth transportation of construction materials and equipment during the project period and for the proper maintenance of cyclone shelters after their completion. In the case of Site 7, the construction of a bridge is necessary to cross a small stream near the site. At present regular public transport is not available to any of the sites.

2) Sites with Water Access Only

① In the case of Site 1 and Site 2, while there is a regular bus service as far as Banskhali, there is no regular transport service from Banskhali to either site by land or by water via the crossing of Jar Kodar Channel.

② In the case of Site 6, there is a regular passenger boat service from Cox's Bazar to the island. On the island itself, the road conditions to the site are very poor with access by jeeps or trucks only and no regular bus service is available. Several of the existing road bridges which are currently impassable must be repaired to provide a proper road for cyclone shelter construction and maintenance purposes.

③ In the case of Site 8 and Site 9, while there is a public transport service between Noakhali and the harbour, it takes a long time due to the poor road conditions.There is only one bus service on Hatiya Island. A small ferry conducts regular services but can only accommodate 2 heavy vehicles. The transportation capacity of this ferry is restricted by the use of a natural slope as the pier with the ferry's access being dependent the tidal conditions. Nevertheless, the ferry is a possible means by which vehicles can be transporting vehicles to the island. Access to Nijhumdwipi Island from Hatiya Island is possible by small boat although there is currently no regular shipping service.

(2) Electricity

1) With regard to Site 1 and Site 2, electricity supply is available on the mainland side but no electricity is available at the sites due to the absence of transmission facilities across the Jar Kodar Channel.

2) With regard to Site 3, Site 4 and Site 5, electricity supply is available at a densely populated village located some 5km from the sites. However, no electricity is available at the sites.

3) With regard to Site 6, electricity supply using a small generator is available for densely populated areas near Cox's Bazar in the south of the island but is unavailable in the north of the island where the site is located.

4) With regard to Site 7 and Site 10, no electricity supply is currently available due to the sparse population in the area and the long distance from the villages to which electricity is supplied.

5) With regard to Site 8, a small generator is available on the island which supplies electricity for some hours at night. No electricity is currently supplied to the site.

6) With regard to Site 9, no electricity facilities are available nearby.

Given the above-described situation, the local inhabitants use kerosene lamps at night. Few people own battery-operated portable radios even though these are useful to obtain information.

(3) Telecommunications

No telecommunication facilities are available at any of the project sites due to the lack of electricity supply. The telecommunication facilities, including telephone lines, owned by the Thana Offices of government departments and agencies are used for communication with other areas.

(4) Water Supply

No communal water supply facilities are available at any of the project sites. The local inhabitants use groundwater from boreholes which is manually pumped. Because of the location of the project sites near the coast, the groundwater from shallow layers contains salt and, therefore, is unsuitable for drinking. A borehole depth of some 800 - 1,000 feet (240 - 300m) is required to obtain potable groundwater.

(5) Sewage Facilities

There are no communal sewage facilities at any of the project sites due to the sparsely located houses. While some well-built houses have a septic tank, simple houses appear to lack any kind of sewage facilities.

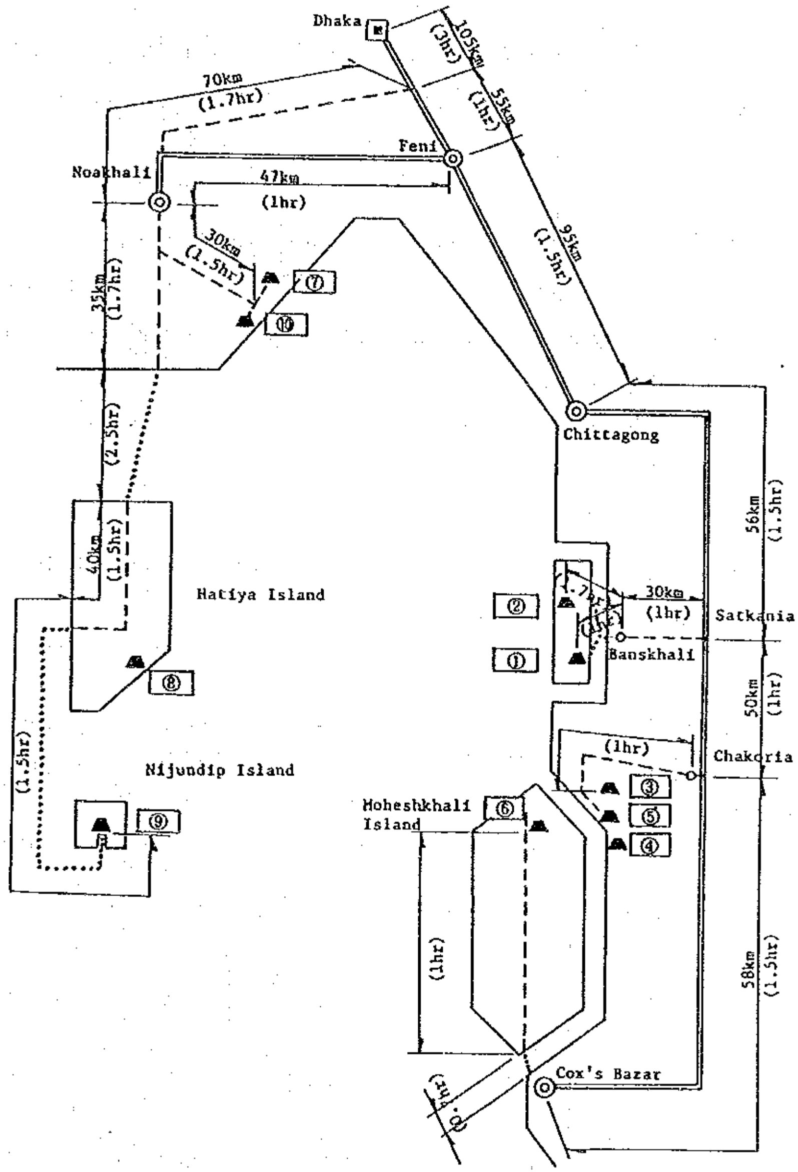



Fig. 3-3-1 Locations of Cyclone Shelter Sites

### 3.3.2 Housing, Population and Livestock

(1) Housing

While some public office buildings and some private houses in the Project Area have a concrete structure, most houses are single story buildings with either wood or bamboo walls and a thatched roof. These houses suffered devastating damage by the cyclone in April, 1991 most, however, have since been restored. The tremendous destructive effects of the cyclone can still be seen in the yet un-prepared, collapsed walls of many public office buildings and exposed damaged banisters of private houses.

As most public office buildings are 2-story reinforced, concrete structures many people avoided the flooding effects of cyclones by evacuating to the second story. This seems to reinforce the advantages as well as the necessity to constructing tall concrete buildings in the RZ.

(2) Population

The population, number of households and number of family members per household are given in Table 3-3-1.

Table 3-3-1 Population, number of dwellings, average family size in the project area

| District | Thana | Population | Number of Households | Number of Family Members/ Household |
|---|---|---|---|---|
| Chittagong | - | 5,729,740 | 998,901 | 5.74 |
| | Banskhali | 239,397 | - | - |
| Cox's Bazar | - | 1,465,022 | 225,928 | 6.48 |
| | Chakoria | 280,623 | - | - |
| | Moheskhali | 128,180 | - | - |
| Noakhali | - | 2,345,713 | 407,321 | 5.76 |
| | Noakhali-Sadar | 129,363 | - | - |
| | Hatiya | 300,277 | - | - |
| | Companiganj | 46,319 | - | - |

Sources: The figures for Districts are cited from the Population Census, 1991 (adjusted) of the Bangladesh Bureau of Statistics.
The figures for Thanas are cited from the Multipurpose Cyclone Shelter Program

(3) Livestock

The number of livestock owned by local inhabitants of the Project Area are given in the Table 3-2-2.

Table 3-3-2 Number of Livestock in project area

| District | Thana | Cattle | Sheep/Goats |
|---|---|---|---|
| Chittagong | - | 199,491 (0.208) | 134,765 (0.128) |
| | Banskhali | 65,907 (0.275) | 45,924 (0.192) |
| Cox's Bazar | - | 160,218 (0.211) | 119,278 (0.157) |
| | Chakoria | 66,538 (0.153) | 49,178 (0.175) |
| | Moheskhali | 19,572 (0.237) | 23,936 (0.187) |
| Noakhali | - | 116,587 (0.245) | 80,356 (0.169) |
| | Noakhali-Sadar | 32,541 (0.252) | 18,851 (0.146) |
| | Hatiya | 72,036 (0.240) | 55,734 (0.186) |
| | Companiganj | 12,010 (0.259) | 5,771 (0.125) |

Note: The figures in brackets are the number of livestock/person.
Source: Multipurpose Cyclone Shelter Programme

Based on the above 2 tables, the average number of livestock per person is as follows:

Cattle : 0.239/person

Sheep/Goats : 0.177/person

## 3.4 Outline of Cyclone Shelters

### 3.4.1 Cyclone Shelters

The number of cyclone shelters (existing, under construction and proposed) in the 6 Thanas in the Project Area and their accommodation capacities are given in the Table 3-4-1.

Table 3-4-1 Number of Cyclone Shelters in the project area (Upper):Number of shelters (Lower):Population

| Thana | Existing Shelters | Shelters Under Construction | Proposed Shelters | Total | Ratio of Total Population |
|---|---|---|---|---|---|
| Banskhali | 12<br>(10,040) | 25<br>(32,680) | 22<br>(30,320) | 59<br>(73,040) | 25%<br>(292,826) |
| Chakoria | 11<br>(10,530) | 26<br>(37,520) | 30<br>(40,880) | 67<br>(88,930) | 25%<br>(353,645) |
| Moheskhali | 11<br>(10,030) | 22<br>(22,000) | 9<br>(12,840) | 42<br>(44,870) | 27%<br>(165,329) |
| Companiganj | 11<br>(11,530) | 0<br>- | 6<br>(6,000) | 17<br>(17,530) | 31%<br>(56,193) |
| Hatiya | 36<br>(39,130) | 18<br>(25,680) | 16<br>(24,320) | 70<br>(89,130) | 24%<br>(371,464) |
| Noakhali-Sadar | 19<br>(20,600) | 0<br>- | 8<br>(8,000) | 27<br>(28,600) | 17%<br>(167,496) |
| Total | 100<br>(101,860) | 91<br>(117,880) | 91<br>(122,360) | 282<br>(342,100) | 24%<br>(1,406,953) |

The Table 3-4-1 indicates a growing awareness in recent years of the necessity to provide cyclone shelters. The table also indicates that the number of shelters under construction or proposed have almost doubled in number. However, the overall capacity of these shelters is equivalent to only 17 - 31% (average: 24%) of the total population. This average ratio would increase to approximately 33% if possible evacuation to both public and private buildings is included. However within the 100 available shelters, 39 are in urgent need of repair.

### 3.4.2 Killas

The number of killas (existing and under construction) for the evacuation of livestock in the Project Area is given in the Table 3-4-2.

Table 3-4-2 Number of Killas in the Project area

| Thana | Existing Killas | Killas Under Construction | Total |
|---|---|---|---|
| Banskhali | 0 | 3 (2) | 3 |
| Chakoria | 0 | 9 (3) | 9 |
| Moheskhali | 1 | 6 (1) | 7 |
| Companiganj | 0 | 2 (1) | 2 |
| Hatiya | 18 | 2 (2) | 20 |
| Noakhali-Sadar | 20 | 2 (1) | 22 |
| Total | 39 | 24 (10) | 63 |

The killas currently under construction are controlled by the LGED of which the figures in brackets indicate the number of project sites in each Thana. Conditions for killas in the project sites are shown in Table 3-4-3.

The state of existing killas, as shown in Table 3-4-2, is examined below in view of overall requirements for total killas. The accommodation capacity of existing cyclone shelters and those under construction in the Project Area is 219,740 as shown in Table 3-4-1. Based on the number of possessions (animals and household belongings) of local inhabitants, each killa appears to be capable of accommodating about 1,700 people and their belongings, (see 4-3-2-(4)). A total of 130 killas are required to accommodate an estimated population of 220,000 evacuees and their possessions. The actual number of killas, either existing or under construction, is only 48% of the required level. It has been reported that the insufficient availability of killas delayed the evacuation of people during the last cyclone to hit Bangladesh, resulting in a large amount of property damage. The Government of Bangladesh's promotion of the urgent construction of killas adjacent to cyclone shelters is, therefore, highly desirable.

Table 3-4-3 State of Killas at Planned Cyclone Shelter Sites

| No. | Thana | Union | Land Owner | Population within 1.5km radius | Primary School Children within 1.5km radius | Storm Surge Height (m) | Banking | | | State of Construction |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Design height (m) | Completion height (m) | Banking Ratio (%) | |
| 1 | Banskhali | Gandamara | Government | 2,000 | 450 | 6.0 | 6.09 | 6.09 | 79.0 | Banking almost completed, slope protection unfinished |
| 2 | Banskhali | Saral | Private | 5,500 | 1,000 | 6.0 | 6.09 | 3.09 | 43.3 | Simple banking without compaction |
| 3 | Chakoria | Badarkhali | Cooperative | 4,000 | 1,200 | 5.5 | 6.10 | 2.03 | 43.3 | Simple banking without compaction |
| 4 | Chakoria | Badarkhali | Cooperative | 3,000 | 600 | 4.0 | 6.10 | 3.13 | 63.9 | Simple banking without compaction |
| 5 | Chakoria | Badarkhali | Cooperative | 3,500 | 650 | 6.0 | 6.10 | 2.64 | 56.2 | Simple banking without compaction |
| 6 | Moheskhali | K.M.Chara | Private | 2,500 | 650 | 3.0 | 6.10 | 2.23 | 25.7 | Simple banking without compaction |
| 7 | Companiganj | Char-Elahi | Government | 5,500 | 600 | 3.0 | 6.10 | 6.10 | 100.0 | Slope protection completed but eroded in parts |
| 8 | Hatiya | Burir Char | Government | 3,000 | 600 | 4.0 | 6.10 | 6.10 | 100.0 | Banking completed, slope protection unfinished |
| 9 | Hatiya | Jahajmara | Government | 4,000 | 800 | 4.5 | 6.10 | 6.10 | 100.0 | Banking completed, slope protection unfinished |
| 10 | Noakhali-Sadar | Char Clark | Government | 6,000 | 1,200 | 3.0 | 6.10 | 5.80 | 81.9 | Slope protection completed, excellent slope conditions |

# CHAPTER 4

# DESCRIPTION OF THE PROJECT

# CHAPTER 4 DESCRIPTION OF THE PROJECT

## 4.1 Objective

Bangladesh suffers from adverse natural conditions which consistently cause natural disasters resulting in a high death toll. To improve this situation, many internationally assisted projects are in progress to prevent the disastrous outcome of natural phenomena such as cyclones. The construction of cyclone shelters is believed to be the most technically and financially feasible disaster prevention measure against cyclones and as such, an official call for the urgent construction of a required number of cyclone shelters to protect human life and livestock has been made. It has been assessed that the required number of cyclone shelters is 2,500 and strong international cooperative efforts will need to be made in order to construct such a large number of shelters.

In response to a request made by the Government of Bangladesh for the construction of new cyclone shelters on top of 40 killas currently under construction by the LGED with the assistance of the WFP, the Government of Japan commissioned JICA to conduct a preliminary study of the request. The study concluded that the original plan to construct cyclone shelters on top of killas was inappropriate and instead proposed free-standing shelters on stilts in neighboring areas of killas. The objectives of the Project are therefore to construct cyclone shelters designed to protect human life during cyclones and to also act as educational facilities during normal weather conditions. The Project also intends the establishment of a reliable maintenance system for the long term up keep of these new cyclone shelters.

## 4.2 Examination of Requested Project Contents

### 4.2.1 Suitability and Necessity of the Project

The Government of Bangladesh is in the middle of finalizing the Master Plan for the Multipurpose Cyclone Shelter Programme as already described in section 2.2, and has requested that aid organizations not arbitrarily select the locations of new cyclone shelters, and to not rely on their own principles and methods when introducing shelters, but refer to the Master Plan for the construction of new cyclone shelters.

When examining the suitability and necessity of the Project, any cyclone shelter construction plan under the Project must be compatible with and connected to the overall implementation of the Master Plan.

(1) Project Area

The Master Plan indicates that new cyclone shelters should be located within the HRA where storm surges can reach a height of 1m and residences might suffer form the effects of flooding. Therefore, it is required that all project sites be located within the HRA.

(2) Suitability of the Project

The present Project is viewed as the most feasible measure to protect the lives of more than 5 million people living in the HRA from both the technical and financial viewpoints and is judged both necessary and suitable from a humanitarian stand point. The feasibility of the Project is supported in terms of the topographical conditions, population density, social infrastructure and all other related factors.

While originally cyclone shelters served as primary schools, clinics, community centers and other public facilities during normal weather conditions, their use has been limited to educational facilities based on the findings of field surveys. The fundamental reason is based on a new educational policy calling for the achievement of compulsory primary school education for all nationals by the year 2000 as described in the Master Plan requiring other shelter uses to be pre-empted by educational needs. More than 3,000 new primary schools, together with 600 new junior high schools, must be constructed in the HRA to achieve this target. The use of the cyclone shelters as school buildings is, therefore, in line with this important national policy.

The fact that the Project is also in line with the objective of the International Decade for Natural Disaster Reduction (IDNDR) is an additional advantage of the Project's implementation in view of its appeal vis-a-vis the international community.

(3) Number of Planned Cyclone Shelters

The Master Plan predicts the total population of 5.2 million people in the HRA in 1992 to increase to 6.4 million in 10 years, which is also the target population for the Master Plan in the year 2002.

The total accommodating capacity of all cyclone shelters (including those currently under construction or planned) and secure public and private buildings (including those planned) is calculated to be 2.16 million, leaving 4.19 million people unprotected. Assuming a capacity of 1,750 people per shelter, the further construction of some 2,500 shelters is called for by the Master Plan.

The number of new cyclone shelters anticipated in the Master Plan for the 6 Thanas in the Project Area is given in Table 4-2-1.

Table 4-2-1 Necessary number of Cyclone Shelters in the Project area

| District | Thana | Shelters Planned by Master Plan | | | Shelters Planned |
|---|---|---|---|---|---|
| | | Priority A | Priority B | Total | Under the Project |
| Chittagong | Banskhali | 54 | 45 | 99 | 2 |
| Cox's Bazar | Chakoria | 67 | 54 | 121 | 3 |
| Cox's Bazar | Moheskhali | 25 | 26 | 51 | 1 |
| Noakhali | Companiganj | 16 | 0 | 16 | 1 |
| Noakhali | Hatiya | 131 | 8 | 139 | 2 |
| Noakhali | Noakhali-Sadar | 64 | 8 | 72 | 1 |
| Total | | 357 | 141 | 498 | 10 |

The required number of new cyclone shelters in the Project Area is 498, of which 357 are Priority Grade A shelters (to be constructed in the 3 year period from 1994 to 1996). The planned shelters under the Project account for only 2% of the total shelter requirement and 2.8% of the Priority Grade A shelter requirement.

Based on the above argument, the Project has significant importance from a humanitarian point of view. The Project which may be part of a program to construct cyclone shelters at a total of 40 sites as originally requested by the Government of Bangladesh, is deemed suitable as a grant aid project of the Government of Japan and its urgent implementation is deemed necessary.

### 4.2.2 Implementation and Operation Plans

(1) Implementing Agency

Given the objective of the Project to provide safe public shelters in cyclone-prone areas to improve local welfare by means of protecting both human and animal life, is deemed appropriate for the Ministry of Local Government, Rural Development and Cooperatives to be assigned the responsibility for the overall implementation of the Project while the LGED, a subordinate organization of the above Ministry and responsible for the technical aspects of regional development, should be assigned the task of actual operation of the Project.

(2) LGED

The LGED is a national organization responsible for regional development as described in (1) above. With its Head Office in Dhaka, the LGED has 64 District Offices and 460 Thana Offices, employing a total of 9,700 people. Each District Office consists of 6 employees, including a manager, while each Thana Office consists of 20 employees, including the manager. The scope of work of the LGED includes the consolidation of local infrastructure, the construction of roads, the construction of government buildings and the construction and/or repair of government-owned school buildings, etc.

Upon completion of the Project, each Thana Office in the Project Area will be responsible for the operation and maintenance of 1 - 3 cyclone shelters. As these cyclone shelters will have a concrete structure, requiring infrequent maintenance, the present staff level of the LGED is deemed adequate for the extra maintenance work.

(3) Budget of LGED

The budget of the LGED for the last 3 years is given below.

| | | | |
|---|---|---|---|
| fiscal 1990/91 | : | 673.80 | Million TK |
| fiscal 1991/92 | : | 3,818.80 | " |
| fiscal 1992/93 | : | 4,398.20 | " |

The large budgetary increase in fiscal 1991/92 was the result of the commencement of budgetary appropriation for development projects by the LGED from the Annual Development Programme Fund. The subsequent increase in fiscal 1992/93 is explained by the steady budgetary increase for development projects, new appropriation to cover the maintenance cost of local infrastructure and increased personnel cost appropriations to permit organizational expansion.

The LGED's budgetary appropriation is increasing in response to its increased role based on official recognition that regional development aiming at the promotion of regional economies is essential for the prosperity of Bangladesh.

Moreover, the LGED is constructing 10 cyclone shelters on Kutubdia Island with the financial assistance of the IFAD and will soon be entrusted with the maintenance responsibility for existing shelters constructed by the PWD, thus becoming the central organization for the operation and maintenance of government-controlled cyclone shelters. These new developments will enable the LGED to efficiently maintain cyclone shelters and as such will be advantageous for the LGED to secure the extra budgetary appropriation necessary to conduct maintenance work.

### 4.2.3 Similar Aid Projects

Some 400 cyclone shelters have been constructed since the 1960's by international aid organizations and NGOs as discussed in 2.1. Despite the wide recognition of the necessity of cyclone shelters, the construction of cyclone shelters has never been pressing international problem and has made only slow progress for recognition. The horrifying death tolls of recent cyclones and the growing concern expressed by the international community had begun to speed up construction of shelters when some 140,000 people were again killed by a violent cyclone in April, 1991. International concern was instantly raised with the result of some 200 new cyclone shelters being completed, under construction or planned as a result of this concern.

The International Red Cross, Islam Development Bank, Government of Saudi Arabia, EC, IFAD and Caritas, etc., have all decided to construct an additional 340 new shelters in addition to planning but not yet committing to financially to an additional 100 shelters. Moreover, many NGOs have expressed their intention to construct more than 150 cyclone shelters in total.

### 4.2.4 Requested Facilities

The requested facilities are described below.

(1) Cyclone Shelters

The planned shelters are single story buildings made of reinforced concrete with pile foundations placed on a killa with a floor area of $216m^2$ (18m x 12m); consisting of 3 classrooms, 1 staff room, 1 medical room and 1 toilet. The provision of a staircase to the roof is also requested.

(2) Access Roads

An access road of some 900m in length at each site is requested to allow easy access for rickshaw vans and light 4-wheel truck traffic.

The preliminary survey for the original project request revealed that construction of cyclone shelters on top of killas would be inappropriate and thus the proposal for construction of free-standing cyclone shelters on stilts, on acquired land near or adjacent to each killa, has been accepted. The resulting shelters are therefore two story buildings with the upper floors being used as schools and the lower floors as open space for community use. The construction of access roads has been excluded from the Project due to the uncertainty of surrounding land acquisition. The Government of Bangladesh will instead bear the cost of constructing access roads at necessary sites using construction machinery granted by the Government of Japan from other aid projects.

The auxiliary facilities approved for the Project include (1) school equipment (desks, chairs, blackboards and storage shelves), (2) toilets (separate toilets for men and women) and septic tanks and (3) water supply facilities (deep set tube wells) as their provision is deemed essential for the operation and maintenance of the cyclone shelters.

### 4.2.5 Basic Principles of Cooperation

The necessity and suitability of cyclone shelters to be constructed under the Project have been verified by examination of the above items. Their requirement from the humanitarian point of view and LGED ability to act as the implementing agency for the Project due to its excellent manpower and expertise among Government of Bangladesh organizations has also been confirmed.

The implementation of the Project as a grant aid project of the Government of Japan is deemed highly appropriate as the expected effects of the Project meet the criteria of Japan's grant aid system. The outline of the Project is examined next based on the provision of Japan's grant aid for the Project, followed by the Basic Design.

## 4.3 Outline of the Project

### 4.3.1 Implementing Agency and Operational Structure

(1) Implementing Agency

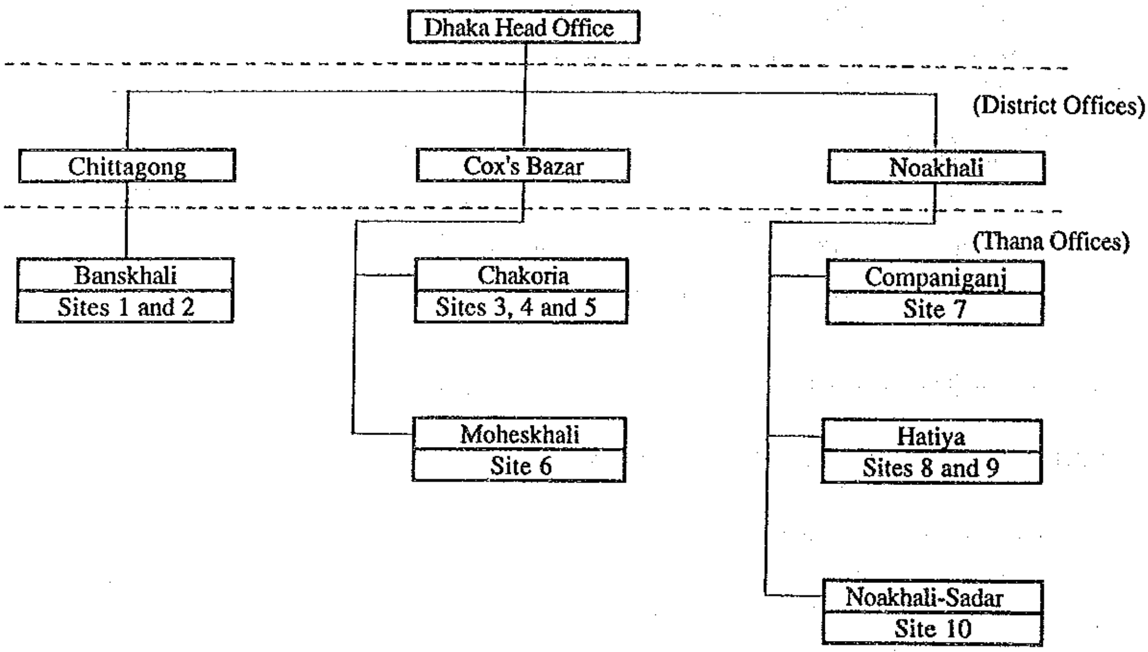
As the Project aims at ensuring the welfare of the inhabitants of the coastal area by means of constructing cyclone shelters, the designation of the Ministry of Local Government, Rural Development and Cooperatives (MLGRD&C) as the project implementing agency is desirable based on the examination of results described in section 4.2.2. The organizational structure of the MLGRD&C is shown in Figure 4-3-1.

(2) Operational Structure

It is desirable that the LGED, which is a subordinate organization of the MLGRD&C and which is responsible for the technical aspects of regional development, be assigned the responsibility to conduct the concrete work for the Project. The organizational structure of the LGED is shown in Fig. 4-3-2.

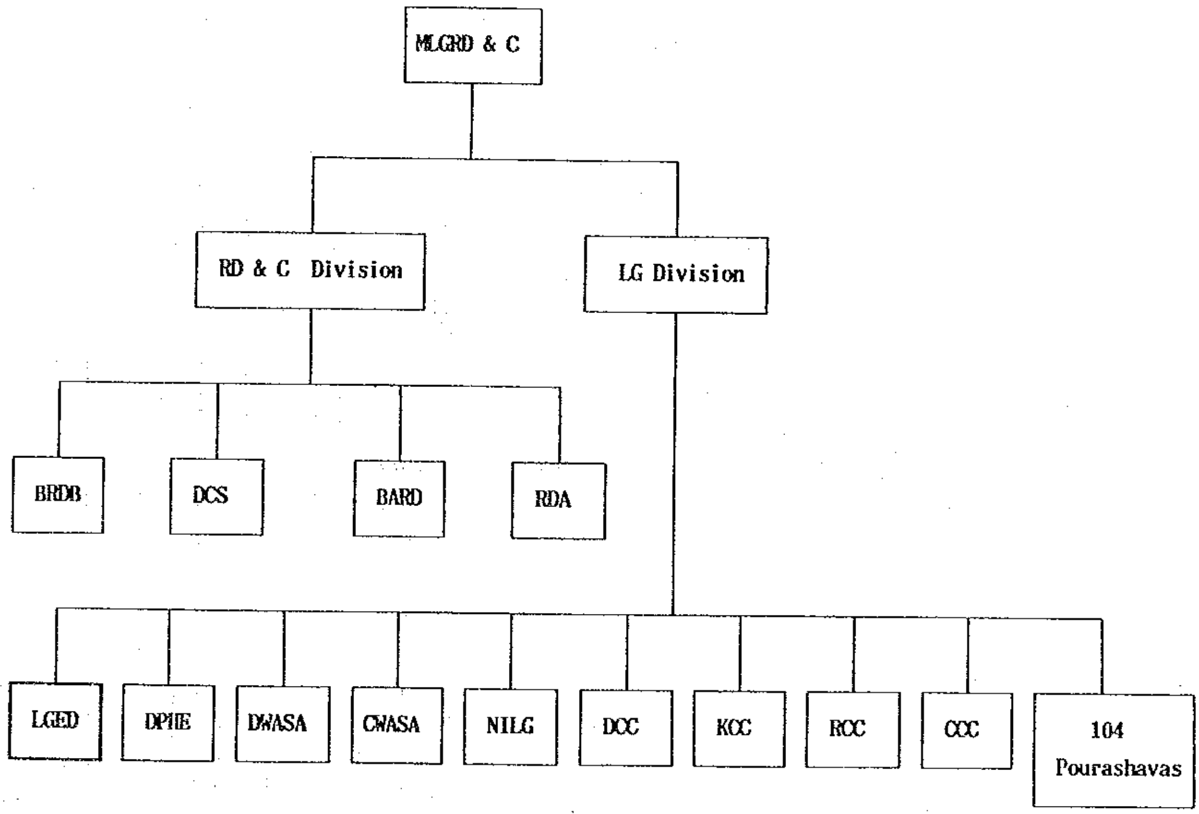
As the planned cyclone shelter sites under this Project are scattered over an extensive area, the actual work should be coordinated by the Dhaka Head Office of the LGED to ensure smooth communication between the relevant District Offices (Chittagong, Cox's Bazar and Noakhali) and Thana Offices. The command structure between the Head Office and Thana Offices responsible for the respective construction sites is shown in Fig. 4-3-3.

Fig. 4-3-3 Command Structure for the Project




The actual work will be conducted by the thana level LGED Offices, the organizational structure of which is shown in Fig. 4-3-4. Each thana level LGED Office has 20 employees, including several technicians. It therefore, it appears possible for these thana level Offices to conduct the assigned work under the Project with its present staff.

In the case of the newly constructed shelters being used as government primary school buildings, these shelters will be managed by the PMED, the organizational structure of which is shown in Fig. 4-3-5. Therefore, the operation of the shelters during normal times will be conducted by the PMED while the LGED will be commissioned to conduct any maintenance or repair work using the budget of the PMED.




BRDB : Bangladesh Rural Development Board, DCS : Directorate of Cooperative Societies,
BARD : Bangladesh Academy for Rural Development, RDA : Rural Development Academy, Bogra,
LGED : Local Government Engineering Department, DPHE : Department of Public Health Engineering,
DWASA : Dhaka Water and Sewage Authorities, CWASA : Chittagong Water and Sewage Authorities,
NILG : National Institute of Local Government, DCC : Dhaka City Corporation,
KCC : Khulna City Corporation, RCC : Rajshahi City Corporation, CCC : Chittagong City Corporation,

Fig. 4-3-1 Organizational Structure of Ministry of Local Government, Rural Development and Cooperatives

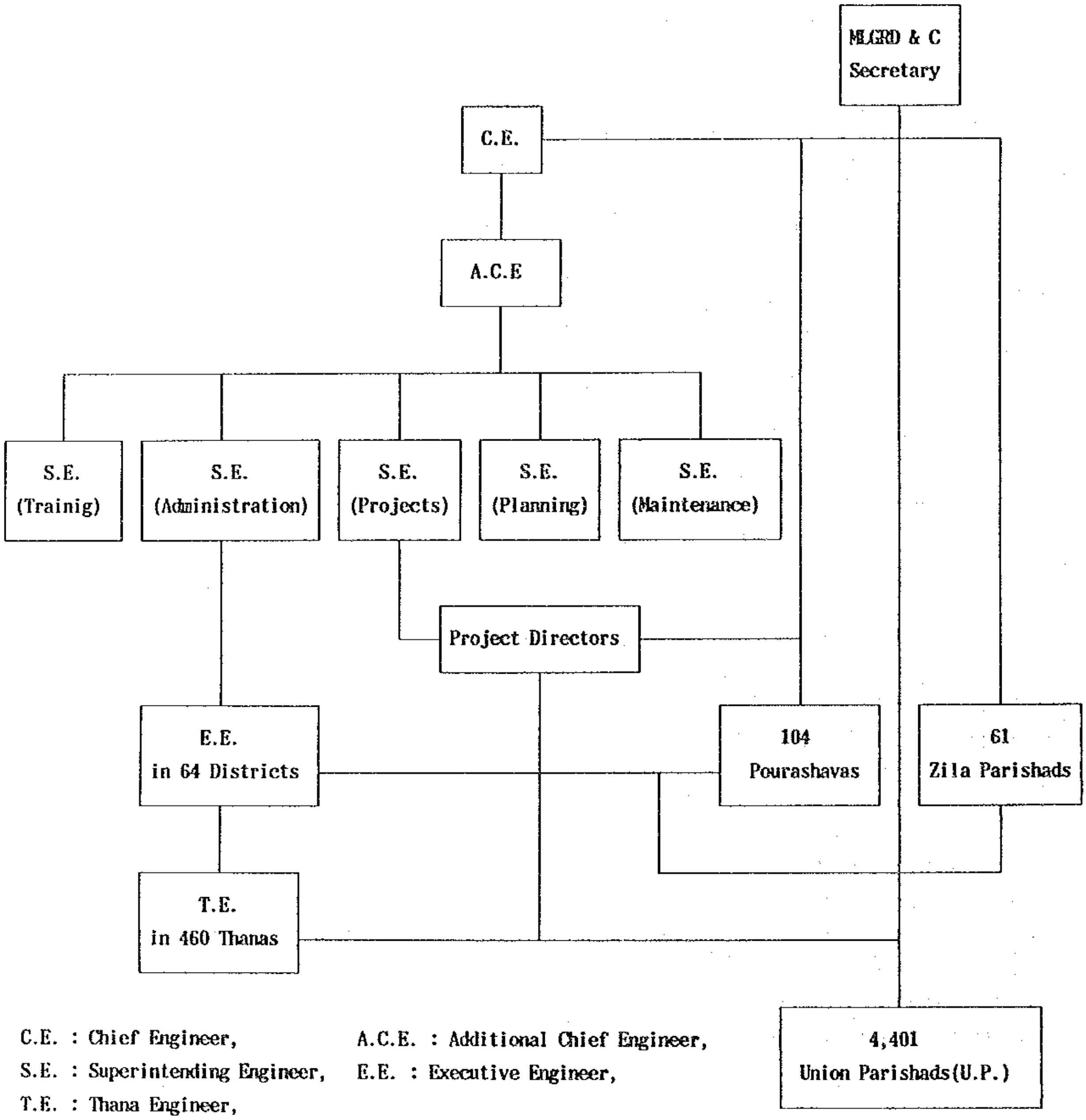



Fig. 4-3-2 Organizational Structure of LGED

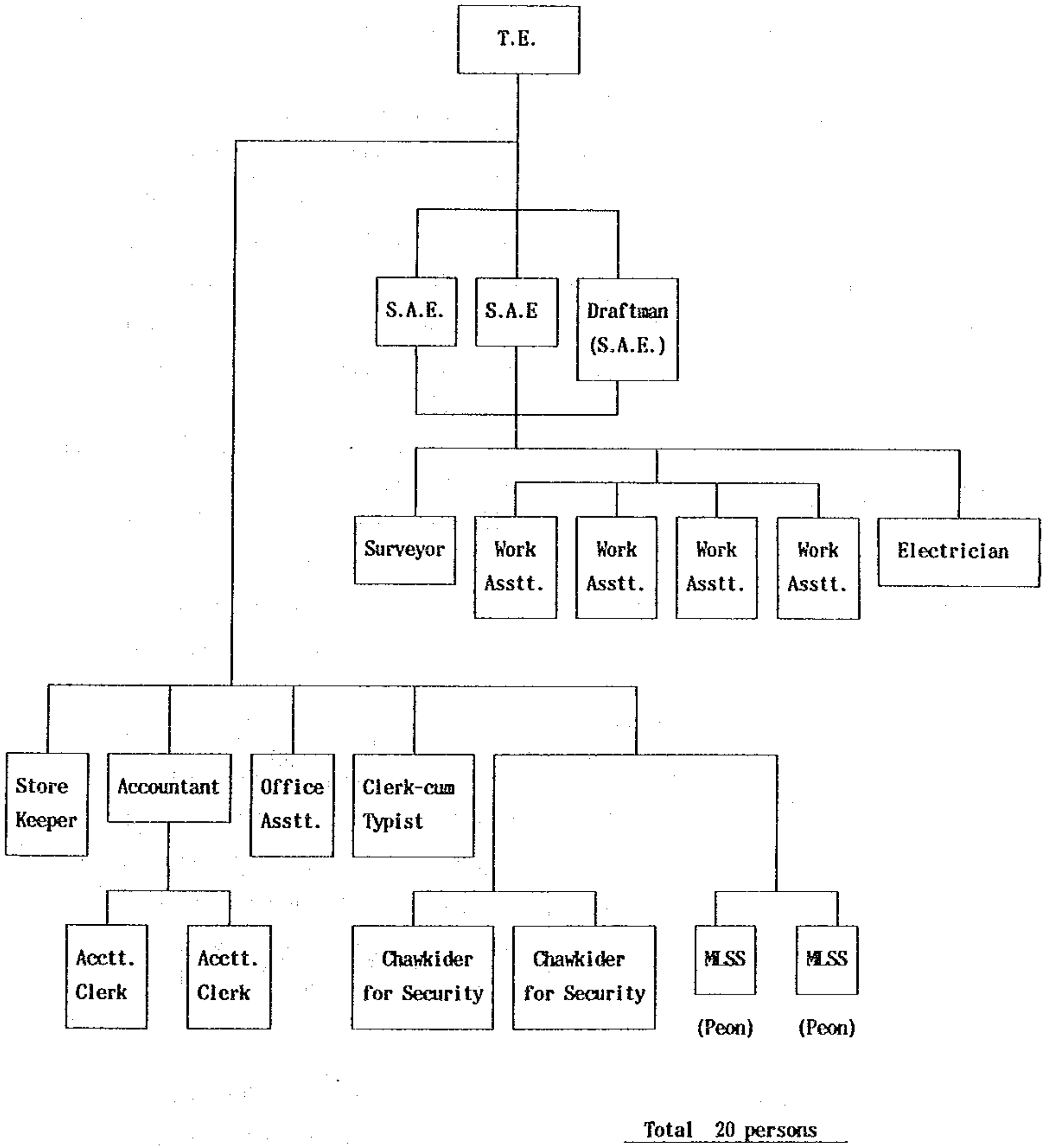



Fig. 4-3-4 Organizational Structure of Thana Level LGED Office

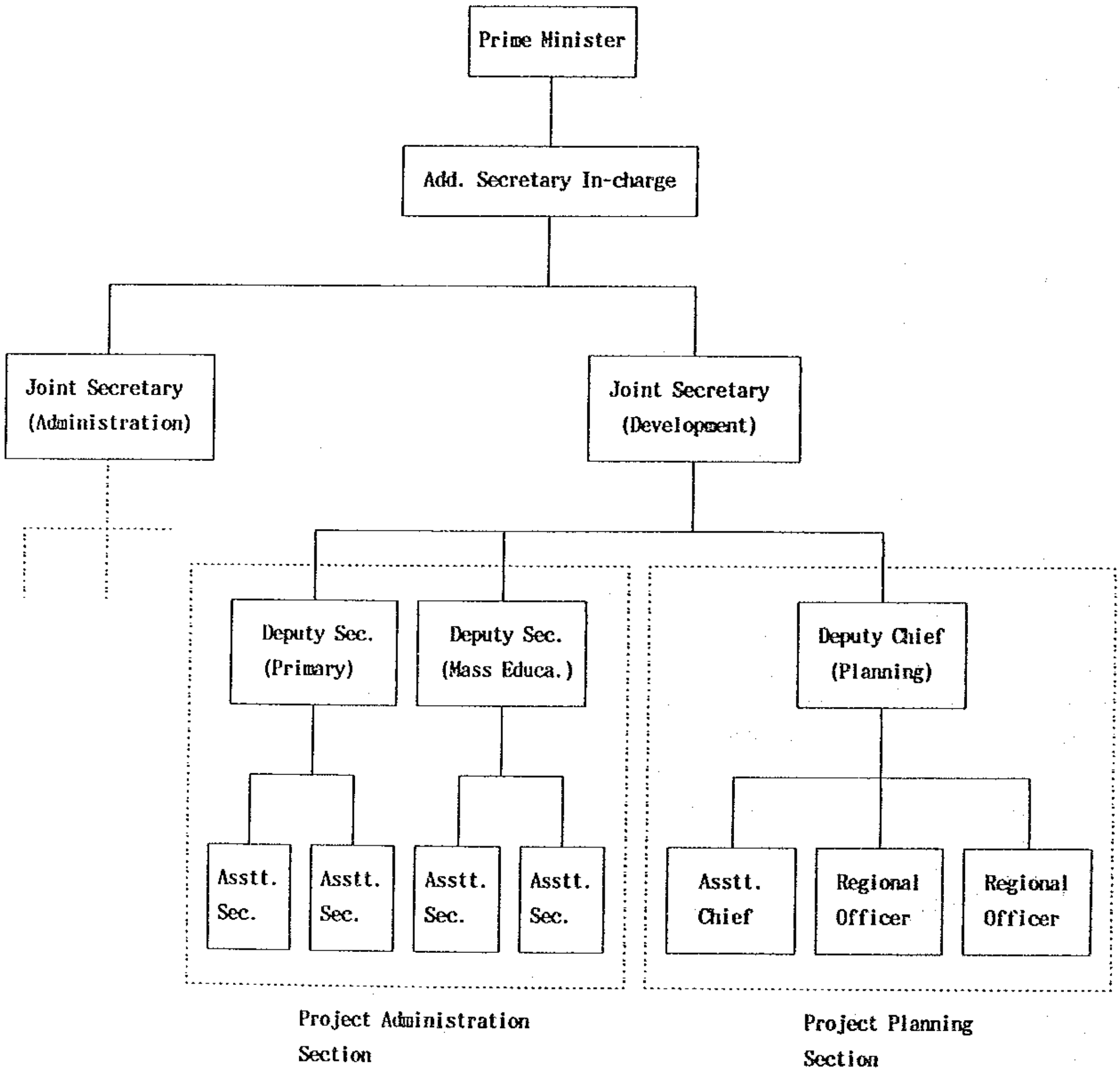



Fig. 4-3-5 Organizational Structure of PMED

### 4.3.2 Project Implementation Plan

(1) Number of Cyclone Shelters to be Constructed

As previously described in section 2.4, it was concluded in the projects Preliminary Study that there were 18 out of a total of 40 possible sites designated as suitable for cyclone shelter construction, (8 sites from Priority Group A and 10 sites from Priority Group B). Based on initial site survey information it was decided that 4 shelters should be built on 4 sites from priority Group A. After further discussions with the Government of Bangladesh in addition to further scrutiny of field data it was decided that a total of 8 cyclone shelters; intended for priority Group A should be constructed. As the distribution of these 8 sites over 3 districts was deemed to be uneven in that Chittagong would have one site, Cox's Bazar would have 4 and Noakhali will have 3 sites, (2 on the mainland and one on the island), 2 additional sites from priority Group B (one for Chittagong and one Noakhali Island), would be appropriate increasing the total number of project sites to ten.

(2) Cyclone Shelter Accommodation Capacity

The cyclone shelter design size depends on the envisaged cyclone shelter accommodation capacity of which there is no uniform standard for the capacity or design of shelters, which have already been constructed, which are under construction, or proposed for construction by various international aid organizations and NGOs.

The Master Plan prepared by the World Bank and UNDP concludes that the construction of 2,500 cyclone shelters, each accommodating 1,750 people, is necessary by the year 2002. The UNDP expects other aid organizations planning to construct cyclone shelters in Bangladesh to refer to the Master Plan as the proper construction manual. Consequently, cyclone shelters to be constructed under the Project will have an accommodation capacity of 1,650 people each which is not far below the figure recommended by the Master Plan.

(3) Use of Cyclone Shelters During Normal Weather Conditions

The proper maintenance of cyclone shelters during normal weather conditions is essential in order to ensure their good condition during times of emergency. Therefore, it is desirable that all cyclone shelters be maintained and used on a daily basis. Given desirable conditions for use during an emergency, which requires orderly and well kept spaces for easy evacuation, their use as educational facilities, mainly as primary school buildings, is planned. The use of cyclone shelters as government primary school buildings must take the following conditions set by the PMED into consideration.

National Guidelines for the building of new schools

① The construction of new school buildings and the allocation of extra teachers is not permitted.

② New school buildings must be constructed on existing school premises.

③ New school buildings may be moved within a 500m radius.

④ The construction of new school buildings is not permitted, even within a 500m radius, if such construction means the crossing of a busy road or river, etc., for pupils to reach the buildings.

Based on these conditions, the scheme for using planned cyclone shelters as non-government primary schools run by local communities, senior high schools, NGO-run primary schools or madrasa, etc., was examined and the prospective uses of the 10 cyclone shelters was finalized as listed below.

| Site No. | Ordinary Use |
|---|---|
| 1 | High School (High School Management Committee) |
| 2 | Madrasa (Madrasa Management Committee) |
| 3 | Primary School (Union Parishad) |
| 4 | Primary School ( " ) |
| 5 | Primary School ( " ) |
| 6 | Governmental Primary School (PMED) |
| 7 | Community Center (Union Parishad) |
| 8 | Governmental Primary School (PMED) |
| 9 | Primary School (School Management Committee) |
| 10 | Primary School (Union Parishad) |

The facilities to be provided in cyclone shelters to allow their use as school buildings are as follows:

- Classrooms (3) : 50 pupils/class
- Staffroom (1) : for 4 teachers
- Storage (1) : for the storage of emergency materials
- Toilets : separate toilets for men and women
- Water Supply Facilities : borehole with hand pump

(4) Installation of Lighting System

1) Proposal for Evening Classes

The Government of Bangladesh introduced a law making primary education compulsory in February, 1990 and has since been making efforts to meet the objectives of the law. In rural areas, however, many primary school age children are engaged in paid labor during the day to help support their families and, therefore, these children are not receiving an appropriate education.

The provision of evening classes for these children, who are generally free from work in the evening, has now been called for. As evening classes also provide the opportunity for education for adults, the educational effects of such classes are expected to prove substantial.

2) Lighting System

While the requirement for evening classes is explained in the previous section, the provision of a lighting system is a precondition for such classes. As none of the planned cyclone shelter sites under the Project, including neighboring areas, are currently supplied with electricity, the power source for a lighting system must be arranged. Given the locational conditions of the planned sites, the following types of power sources are considered.

① Existing power distribution network

② Self-generating unit

③ Solar power generating unit

As it appears difficult for most inhabitants of the Project Area to pay an electricity charge or to bear the cost of power transmission or self-generation given the Project Area's low income level, the selection of a lighting system using a solar unit appears preferable as this could be cheaply run once the initial installation cost has been met.

3) Selection of Subject Site

Considering the site conditions as mentioned in the previous section a lighting system is recommended for introduction at one shelter as a test case. The selection of the subject site for the provision of a lighting system should be based on the following criteria.

① Strong necessity to provide evening classes in an area where the number of primary school age children is large in the cyclone shelter catchment area.

② As the evening classes will be taught by teachers other than the day-time teachers, the provision of evening classes at a primary school run by Union Parishad is preferable.

③ While the solar power generating unit does not involve a high operation and maintenance cost, regular maintenance by an electrical engineer is necessary. Therefore, a site located near a Thana Level Office of the LGED is preferable to other sites.

Based on the above criteria and the data given in Fig. 3-3-1 and Table 3-4-3, Site No. 3 has been selected as the subject site for the installation of a lighting system.

(5) Assessment of Killa Size

1) Number of Livestock Owned

The main function of a cyclone shelter is to facilitate the swift and smooth evacuation of local inhabitants at a time of an approaching cyclone and it is also essential that killas have the capacity of accommodate the livestock and household goods of these inhabitants to achieve swift evacuation. Accordingly, it is necessary for the accommodation capacity of a cyclone shelter and the size of the neighboring killa to be properly coordinated. As described in 3.3.2-(3), the average number of livestock per person in the Project Area is 0.239 cattle and

0.177 sheep/goats. As the killa size is uniform throughout the Project Area, the following largest livestock ownership figures recorded are used to assess the suitability of killa size.

| | | |
|---|---|---|
| cattle | : | 0.279/person |
| sheep/goats | : | 0.192 person |

As the cyclone shelter accommodation capacity is 1,650 people, the number of livestock accompanying these people for evacuation to a killa is calculated below.

| | | |
|---|---|---|
| cattle | : | 0.275 x 1,650 = 453.75 = 454 |
| sheep/goats | : | 0.192 x 1,650 = 316.80 = 317 |

2) Space Required for Livestock

The killa space to be occupied by one animal is assumed to be as follows.

| | | |
|---|---|---|
| cattle | : | 1.5m x 1.0m = $1.5m^2$ |
| sheep/goats | : | 0.8m x 0.5m = $0.4m^2$ |

The space required to accommodate the evacuated livestock is, therefore, as follows.

| | | |
|---|---|---|
| cattle | : | 454 x $1.5m^2$ = $681m^2$ |
| sheep/goats | : | 317 x $0.4m^2$ = $127m^2$ |
| Total | | $808m^2$ = $810m^2$ |

Assuming additional space of 30% is required for passages and other purposes, the total space required for livestock evacuation is approximately $1,050m^2$.

3) Space Required for Household Belongings

Assuming that the people being evacuated carry their household belongings, space must be provided to accommodate these goods. The allocation of $810m^2$, equivalent to the space for livestock, is believed to be sufficient for this purpose.

4) Total Space Required

The total space required for livestock and household belongings are $1,860m^2$.

5) Land Required for Killas

The dimensions of killas currently under construction by the LGED are 200 ft (60.6m) x 300 ft (90.9m) at the bottom and 20 ft (6.1m) in height with a slope gradient of 1:2. Based on these figures, the area at the top of the killa is 2,407$m^2$ (36.2m x 66.5m) which is some 30% larger than the total space required for livestock and household belongings. However, it is impractical to assume that all the top space of the killa is usable and it is safer not to include the slope shoulder areas in the accommodation space. Given the top space and space requirements discussed earlier, it is possible to secure a non-use zone of approximately 2.5m in width all around the edge.

The above arguments suggest that the cyclone shelter accommodation capacity and the killa size are compatible.

### 4.3.3 Outline of Envisaged Facilities

The following facilities to be constructed under the Project in the case implementation is with Japan's grant aid, agreed upon by the two governments; (Bangladesh and Japan), although slight differences in original items were requested are as follows:

(1) Cyclone Shelters

While the primary objective of the cyclone shelters is the protection of local inhabitants from frequent cyclones, their use in a positive manner during normal weather conditions is also important. It has been agreed by the two governments that the cyclone shelters will be used as educational facilities during normal weather conditions to ensure their proper maintenance through continued use.

| | | |
|---|---|---|
| Facilities | - classrooms (3) | : 50 pupils/class |
| | - staffroom (1) | : for 4 teachers |
| | - storage (1) | : for emergency materials |
| | - toilets facilities | : separate toilets for male and female |
| | - others | : verandah |
| Structure | - main body (pillars, beams and floors) | : reinforced concrete |
| | - walls (interior and exterior) | : brick masonry |
| Number of Stories | - 2 | |
| Floor Area (measured between pillar center lines) | - ground floor | : 262$m^2$ |
| | - first floor | : 262$m^2$ |
| | Total | : 524$m^2$ |

| | | | |
|---|---|---|---|
| Floor Height | - first floor | : | GL +5.0m or 6.0m or 7.0m |
| | - roof | : | 4m above the first floor height |
| Fixtures | - "long desks" and chairs (3 pupils each) | : | 51 units |
| | - teachers desks and chairs | : | 7 units |
| | - blackboards | : | 4 |

(2) Auxiliary Facilities

Hand Pump

Borehole (GL -300 to -400m)

Septic Tank

(3) Lighting

One classroom will be provided with lighting at Site - No. 3 as a test case.

### 4.3.4 Maintenance Plan

(1) Maintenance System

In addition to materials control and quality control during the construction period, regular maintenance after the completion of the cyclone shelters is essential to maintain these structures in good condition over a long period of time. The expected life of the cyclone shelters could be reduced if damage is left un-repaired for too long. Many badly damaged existing cyclone shelters were observed during the field surveys, damage probably resulting because of the absence of proper maintenance. If these shelters are left un-repaired, they will soon become incapable of fulfilling their desired purpose. The underlying reason for the poor state of maintenance could be a lack of sufficient maintenance funds on the part of the central government or particular local circumstances.

The adoption of a construction method and materials which do not involve an excessive maintenance cost in the future is, therefore, extremely important. While the management of the cyclone shelters will be the responsibility of a NGO or the LGED except for those shelters which are officially approved by the PMED as primary school buildings, it should prove more practical for the LGED to be assigned the responsibility for the maintenance of all the cyclone shelters by the PMED, including those used as primary school buildings. The direct maintenance responsibility will fall on the District and Thana level LGED Office.

(2) Maintenance Work

The types of maintenance work required and the maintenance intervals are as follows:

| | |
|---|---|
| - Repainting of exterior walls | :every 3 years |
| - Repainting of interior walls | :every 3 years |
| - Repair of damaged mortar finish of pillars beams and walls | :as and when discovered |
| - Inspection of borehole and pump | :monthly |
| - Repair of damaged desks and chairs | :as and when discovered |

The following items are added for Site - No. 3.

| | |
|---|---|
| - Solar Panels | :clean once every month |
| - Solar Battery | :fill or replace fluid once every 3 months |

(3) Maintenance Cost (for 10 Cyclone Shelters)

Although all types of maintenance are not conducted every year, the average annual costs are calculated below for convenience.

| | |
|---|---|
| - Repainting of exterior walls | : 6,469 TK (approx. 20,700 yen) |
| - Repainting of interior walls | : 24,437 TK (approx. 78,200 yen) |
| - Repair of damaged pillars, beams and walls | : 6,719 TK (approx. 21,500 yen) |
| - Repair of damaged desks and chairs | :406 TK (approx. 1,300 yen) |
| - Solar Power System | 10,000 TK (approx. 32,000 yen) |
| Total | 48,031 TK (approx. 153,700 yen) |

The above maintenance cost is not particularly large and no problems are anticipated in regard to the appropriation of the required funds from the budget of the LGED.

(4) Future Operation and Maintenance Organization

The construction of cyclone shelters is expected to gather momentum in the coming years in accordance with the growing assistance from donor countries and NGOs, etc. When the target number of some 3,400 cyclone shelters envisaged by the Master Plan is achieved, their maintenance will be a formidable task. Therefore, the advance preparation of an appropriate maintenance plan is necessary.

The Master Plan calls for the LGED to be made responsible for the maintenance of all cyclone shelters. The Study Team members for the Project also believe that the maintenance work should be assigned to a single organization. For the immediate future, however, the cyclone shelters run by the central government and those run by NGOs will be separately maintained based on the current maintenance arrangements. Government-run shelters will, in principle, be maintained by the LGED.

Those shelters run by the FD will be maintained by the FD for some time on the understanding that the maintenance responsibility will be transferred to the LGED in the future. NGO-run shelters will be maintained under the auspices of the BDRCS in accordance with the relevant management plan prepared by the NGOs concerned. Following the completion of the planned self-management period, the maintenance responsibility will fall on the LGED.

# CHAPTER 5

# BASIC DESIGN

# CHAPTER 5 BASIC DESIGN

## 5.1 Design Policies

### 5.1.1 Natural Conditions

The design policies of the Project vis-a-vis the relevant natural conditions are discussed here.

(1) Wind Velocity

Cyclonic wind velocities recorded in the past and wind velocities with various return periods have already been discussed in section 3.2. Based on the resulting analysis in 3.2, wind velocities with a 50 year return period, of 260 km/hr or 72.0m/sec used as standard design wind velocities in the Master Plan are also used in this report.

(2) Earthquakes

While there are no detailed architectural standards relating to earthquakes in Bangladesh, the country is classified into 3 zones and each zone has a separate standard earthquake factor (F).

| | | |
|---|---|---|
| Zone 1 (North) | : | F = 0.08 |
| Zone 2 (Central and East) | : | F = 0.05 |
| Zone 3 (Central and South) | : | F = 0.04 |

The Chittagong and Cox's Bazar Districts belong to Zone 2 (F = 0.05) while the Noakhali District belongs to Zone 3 (F = 0.04), indicating a general trend of the value of F declining towards the coastal area.

(3) Tide Level

The wave force associated with high tides is not considered here because it has little impact on cyclone shelters on stilts. In comparison, however, the tide level is important to determine the required floor height of these shelters. The method used for the preparation of the Master Plan (based on a tide level with a 50 year return period) is also used here for the analysis of storm surges. The following 2 equations are suggested to calculate the storm surge height at the cyclone shelter sites.

$$H_1 = h_{50} - (X - 1) K + hw \quad \text{.....(5-1-1)}$$

| | |
|---|---|
| $h_{50}$ | : Design surge height with a 50 year return period (m) |
| X | : Distance of shelter from the beach (km) |
| K | : Rate of decrease of surge height (m/km) |
| hw | : Amplitude of local wave in meters from mean water level |
| hw | : $[h_{50} - (X - 1) K]\ 1/4$ hw is 1 if $hw < 1$ |

$$H_2 = Y_{50} - Yg + hf \quad \text{.....(5-1-2)}$$

| | |
|---|---|
| $Y_{50}$ | : 50 year extreme surface water level (m) |
| Yg | : Elevation of ground level at shelter site |
| hf | : Allowance for local wave 1m |

The larger value deriving from the above 2 equations will be used for basic design purposes. The Master Plan uses the values of $h_{50}$ and $Y_{50}$ at the cyclone shelter sites (see Tables 3-2-7 and 3-2-8). The calculation results using these 2 equations are shown in Table 5-1-2.

Table 5-1-1 Value of $h_{50}$ and $Y_{50}$ in Project Area

| Site No. | District | Thana | $h_{50}$ (m) | $Y_{50}$ (m) |
|---|---|---|---|---|
| 1 | Chittagong | Banskhali | 5.8 ± 1.3 | 5.05 |
| 2 | Chittagong | Banskhali | " | " |
| 3 | Cox's Bazar | Chakoria | " | 4.67 |
| 4 | Cox's Bazar | Chakoria | " | " |
| 5 | Cox's Bazar | Chakoria | " | " |
| 6 | Cox's Bazar | Moheskhali | " | " |
| 7 | Noakhali | Companiganj | 6.5 ± 1.4 | 7.53 |
| 8 | Noakhali | Hatiya | " | 5.55 |
| 9 | Noakhali | Hatiya | " | " |
| 10 | Noakhali | Noakhali-Sadar | " | 7.53 |

Table 5-1-2 Tide Level at Cyclone Shelter Sites

(1) Tide Level ($H_1$) Based on Equation 5-1-1, and Tide Depth ($H_s$)

| Site No. | Thana | $h_{50}$ | X | K | $h_{50}$ -(x-1)K | $h_w$ | $H_1$ | ground level | | | $H_s$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | m | km | m/km | m | m | m | coastal | site | hg | |
| 1 | Banskhali | 5.8 | 2.5 | 0.50 | 5.05 | 1.26 | 6.31 | 1.60 | 2.90 | 1.30 | 5.01 |
| 2 | Banskhali | 5.8 | 1.5 | " | 5.25 | 1.31 | 6.56 | 1.60 | 3.10 | 1.50 | 5.06 |
| 3 | Chakoria | 5.8 | 0.6 | " | 5.80 | 1.45 | 7.25 | 0 | 1.70 | 1.70 | 5.55 |
| 4 | Chakoria | 5.8 | 1.5 | " | 5.25 | 1.31 | 6.56 | 0 | 1.40 | 1.40 | 5.16 |
| 5 | Chakoria | 5.8 | 0.8 | " | 5.80 | 1.45 | 7.25 | 0 | 1.30 | 1.30 | 5.95 |
| 6 | Moheskhali | 5.8 | 2.2 | 0.33 | 5.40 | 1.35 | 6.75 | 1.50 | 4.00 | 2.50 | 4.25 |
| 7 | Companigaj | 6.5 | 1.5 | " | 6.34 | 1.59 | 7.93 | 2.50 | 4.10 | 1.60 | 6.33 |
| 8 | Hatiya | 6.5 | 3.0 | " | 5.84 | 1.46 | 7.30 | 1.00 | 2.10 | 1.10 | 6.20 |
| 9 | Hatiya | 6.5 | 1.0 | " | 6.50 | 1.63 | 8.13 | 1.00 | 2.50 | 1.50 | 6.63 |
| 10 | Noakhali-S | 6.5 | 4.5 | " | 5.35 | 1.34 | 6.69 | 2.50 | 3.90 | 1.40 | 5.29 |

(2) Tide Level ($H_2$) Based on Equation 5-1-2

| Site No. | Thana | $Y_{50}$ | $Y_g$ | hf | $H_2$ |
|---|---|---|---|---|---|
| | | m | km | m | m |
| 1 | Banskhali | 5.05 | 2.90 | 1.0 | 3.15 |
| 2 | Banskhali | " | 3.10 | " | 2.95 |
| 3 | Chakoria | 4.67 | 1.70 | " | 3.97 |
| 4 | Chakoria | " | 1.40 | " | 4.27 |
| 5 | Chakoria | " | 1.30 | " | 4.37 |
| 6 | Moheskhali | " | 4.00 | " | 1.67 |
| 7 | Companigaj | 7.53 | 4.10 | " | 4.43 |
| 8 | Hatiya | 5.55 | 2.10 | " | 4.45 |
| 9 | Hatiya | " | 2.50 | " | 4.05 |
| 10 | Noakhali-S | 7.53 | 3.90 | " | 4.63 |

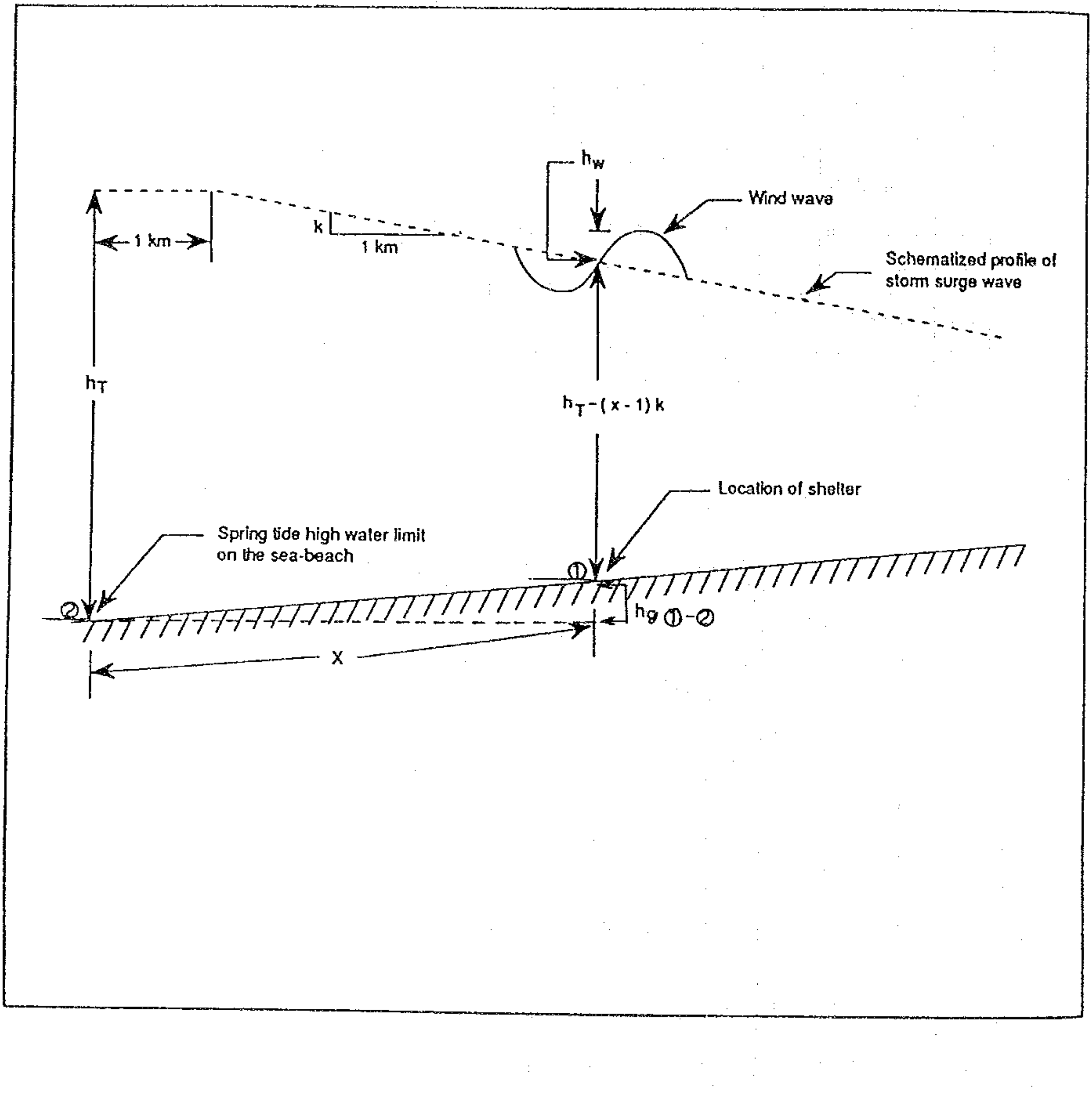



Fig. 5-1-1 Illustration of the parameters of Eqs. 5-1-1 in determining the required height of shelter

While the storm surge height varies from site to site as shown in Table 5-1-2, a design floor height of either 5m or 6m or 7m above the present ground level has been decided upon after taking other calculation results and existing shelter heights into consideration. A floor height of 5m for one shelter,(Site No.6, Moheskhali, Cox's Bazar), 6m for 6 shelters and 7m for 3 shelter sites specifically, (Site No. 7 at Companiganj and Site No. 8 and Site No. 9 at Hatiya in the Noakhali District) has been adopted.

(4) Temperature and Lighting

While the maximum temperature reaches more than 35°C at all the sites, no air-conditioning, mechanical or otherwise, or ventilation system will be provided. As no lighting system will be provided, as many windows as possible will be designed for ventilation and lighting purposes. In view of the possible use of the shelters at night, the installation of a model solar system is also considered at Site No. 3.

(5) Geology

1) Geological Conditions

Soil Investigation

As shown in Table 5-1-3, a boring survey was conducted at 2 points of each shelter site (a total of 20 survey points) and laboratory soil test were conducted on the soil samples taken from each borehole.

Investigation Results

Survey results for each point are shown in the Borehole Log given in Appendix 2 which also includes the soil test data. Based on these results, the Assumed Geological Sections (Fig. 5-1-2) were prepared.

Ground Conditions for Design of Foundations

In deciding the foundation structure for each cyclone shelter, ground conditions for each site were firstly examined to determine the long-term allowable bearing capacity with the view of employing direct foundations with independent footings. The use of pile foundations or other foundation types is considered for those sites which do not meet proper load bearing conditions. The use of pile foundations is also considered for those sites where the consolidation settlement may be so great or so uneven that the superstructure supported on direct foundations may become cracked and damaged.

Table 5-1-3 Geological Survey Points

| Site No. | District | Thana | Union | Boring Point No. | Survey Depth (m) | Sampling Quantity | Remarks |
|---|---|---|---|---|---|---|---|
| 9880980 | CTG | Banskhali | Gandamara | A1-1 | 32 | 3 | Second Survey |
| | | | | A1-2 | 30 | 3 | |
| 9880982 | CTG | Banskhali | Saral | B1-1 | 30 | 2 | Second Survey |
| | | | | B1-2 | 30 | 2 | |
| 9900182 | CXB | Chakoria | Badarkhali | A2-1 | 30 | 2 | Second Survey |
| | | | | A2-2 | 30 | 2 | |
| 9900183 | CXB | Chakoria | Badarkhali | A3-1 | 23 | 2 | First Survey |
| | | | | A3-2 | 28 | 2 | |
| 9900185 | CXB | Chakoria | Badarkhali | A4-1 | 21 | 2 | First Survey |
| | | | | A4-2 | 22 | 2 | |
| 9900485 | CXB | Moheskhali | K.M.Chara | A5-1 | 30 | 2 | Second Survey |
| | | | | A5-2 | 30 | 1 | |
| 9840381 | NKL | Companiganj | Char-Elahi | A6-1 | 10 | 0 | First Survey |
| | | | | A6-2 | 10 | 0 | |
| 9840480 | NKL | Hatiya | Brir Char | B9-1 | 30 | 3 | Second Survey |
| | | | | B9-2 | 30 | 3 | |
| 9840481 | NKL | Hatiya | Jahajimara (Nijhumdwip) | A7-1 | 30 | 3 | Second Survey |
| | | | | A7-2 | 30 | 3 | |
| 9840680 | NKL | Noakhali-Sadar | Char Clark | A8-1 | 13 | 2 | First Survey |
| | | | | A8-2 | 12 | 2 | |
| First Survey Sub-Total | | | | | 139 | 12 | |
| Second Survey Sub-Total | | | | | 362 | 29 | |
| Total | | | | | 401 | 41 | |

CTG: Chittagong
CXB: Cox's Bazar
NKL: Noakhali

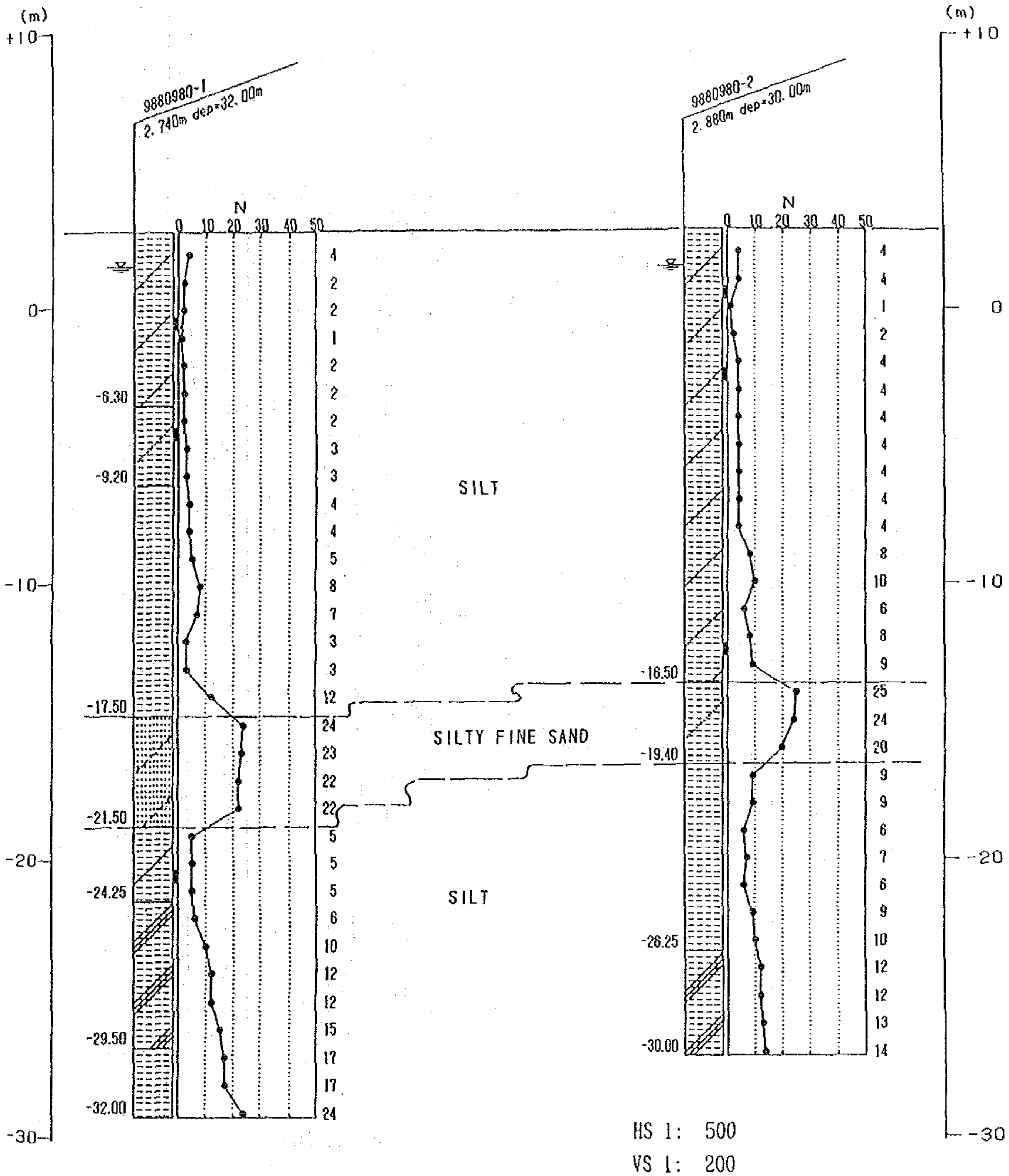



Fig. 5-1-2 (1) Geological Cross Section (9880980)

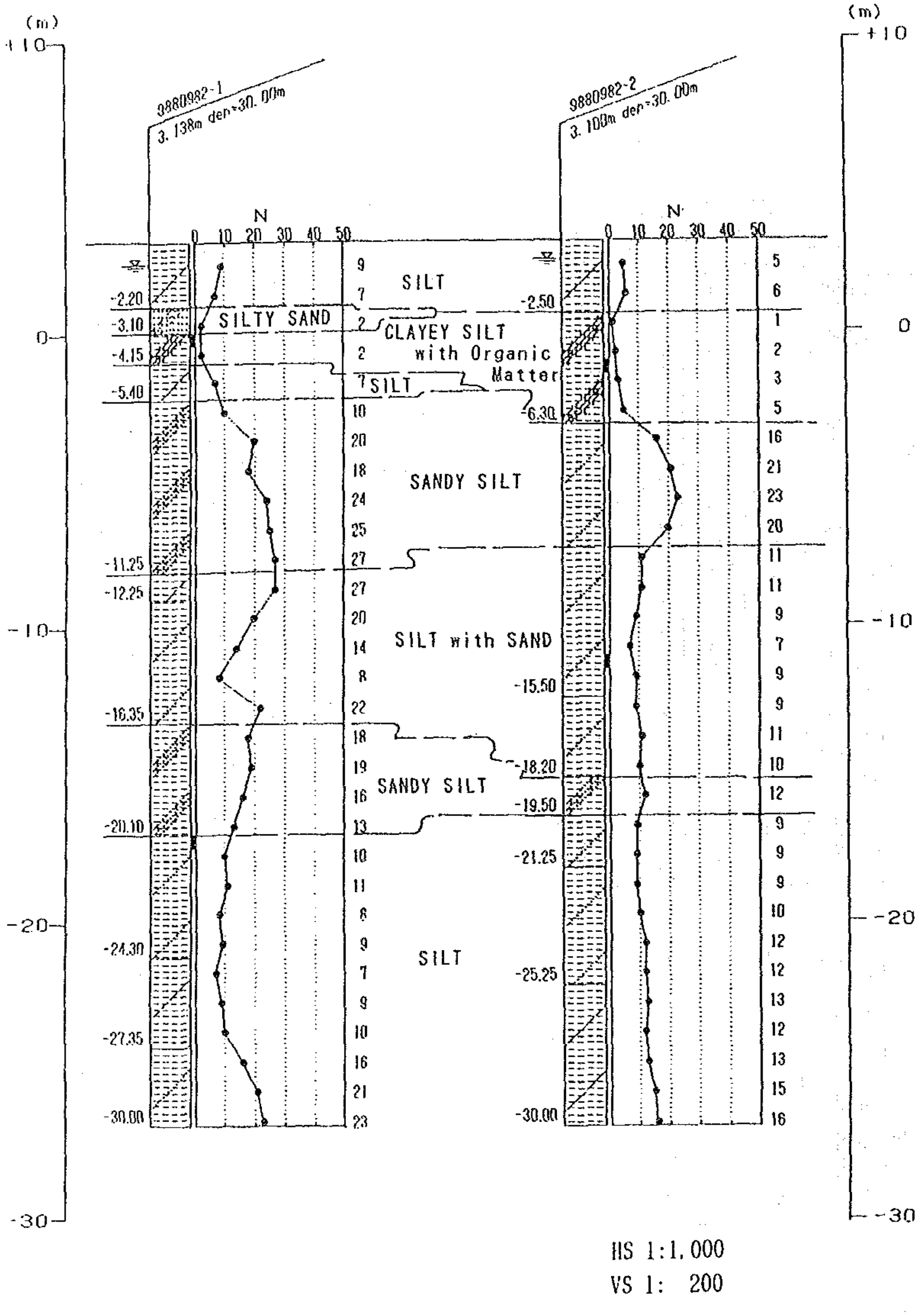



Fig. 5-1-2 (2) Geological Cross Section (9880982)

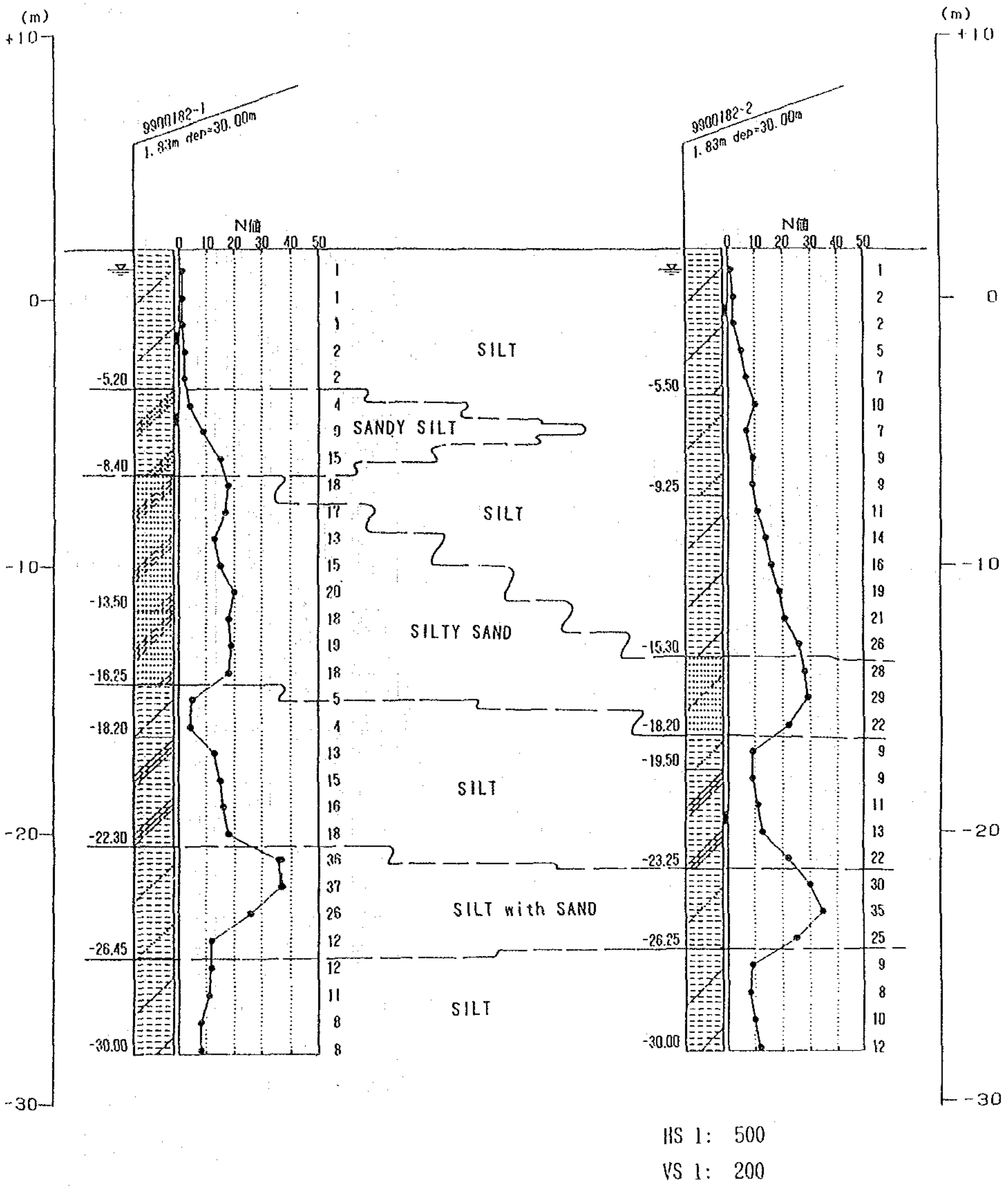



Fig 5-1-2 (3) Geological Cross Section (9900182)

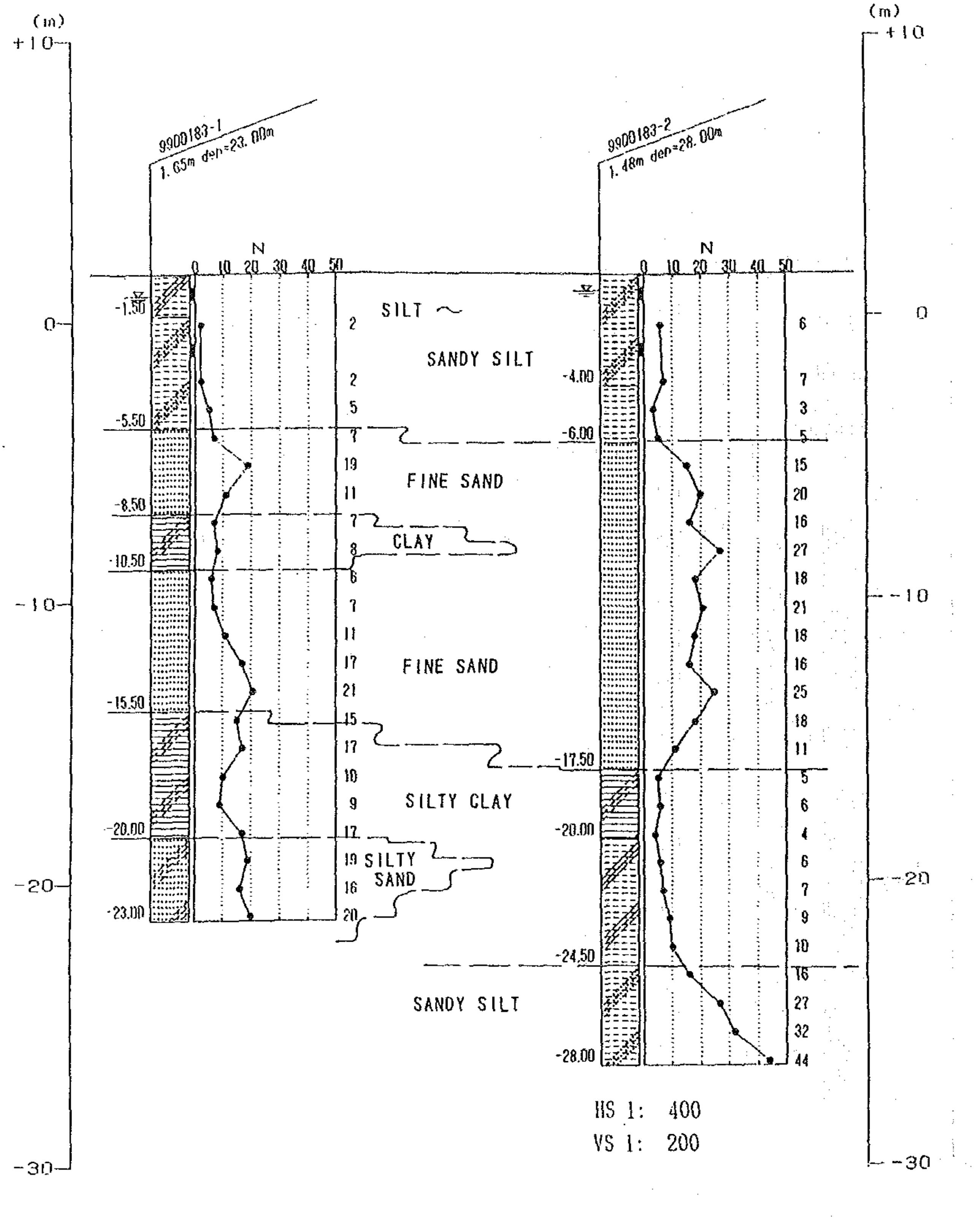



Fig. 5-1-2 (4) Geological Cross Section (9900183)

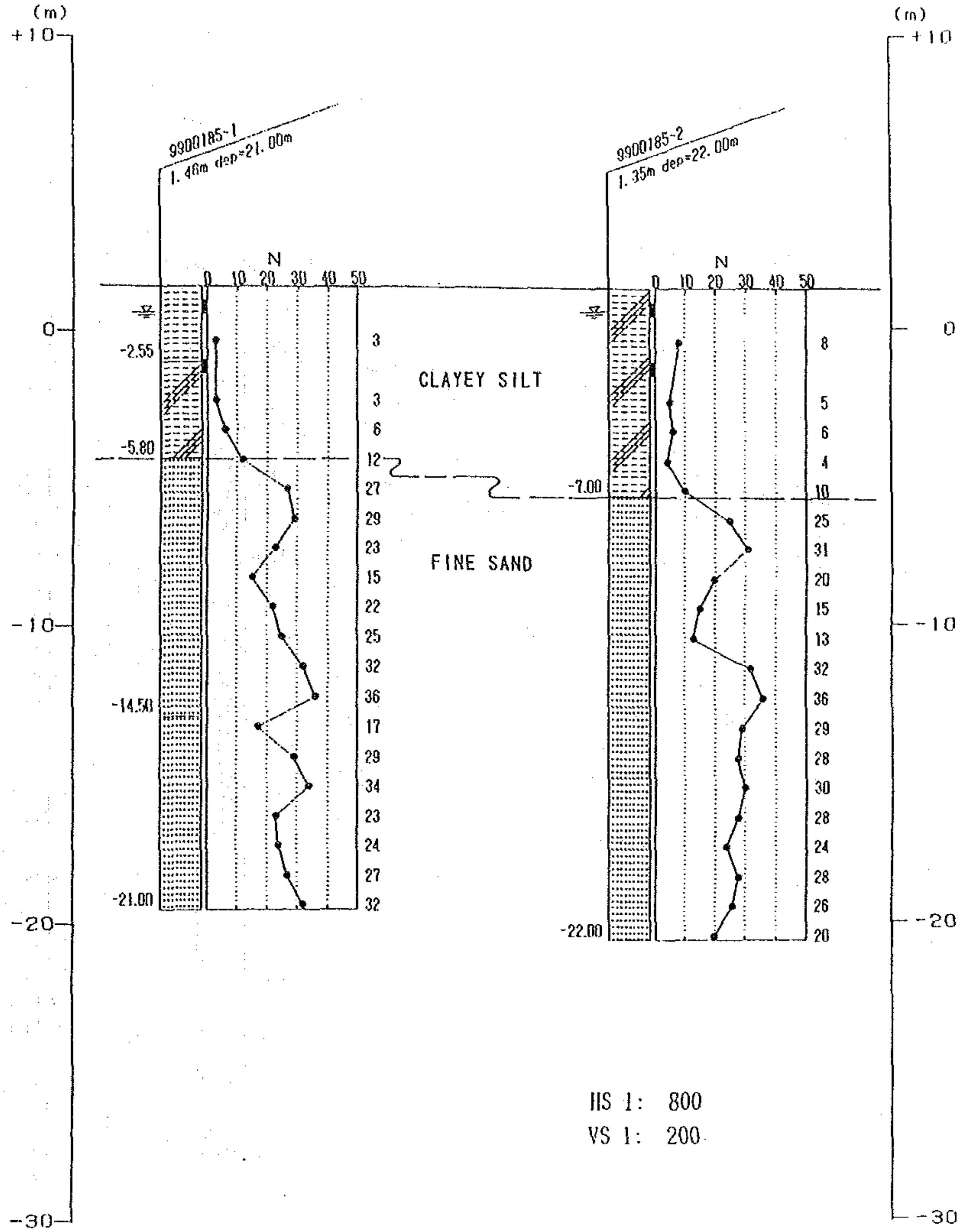



Fig. 5-1-2 (5) Geological Cross Section (9900185)

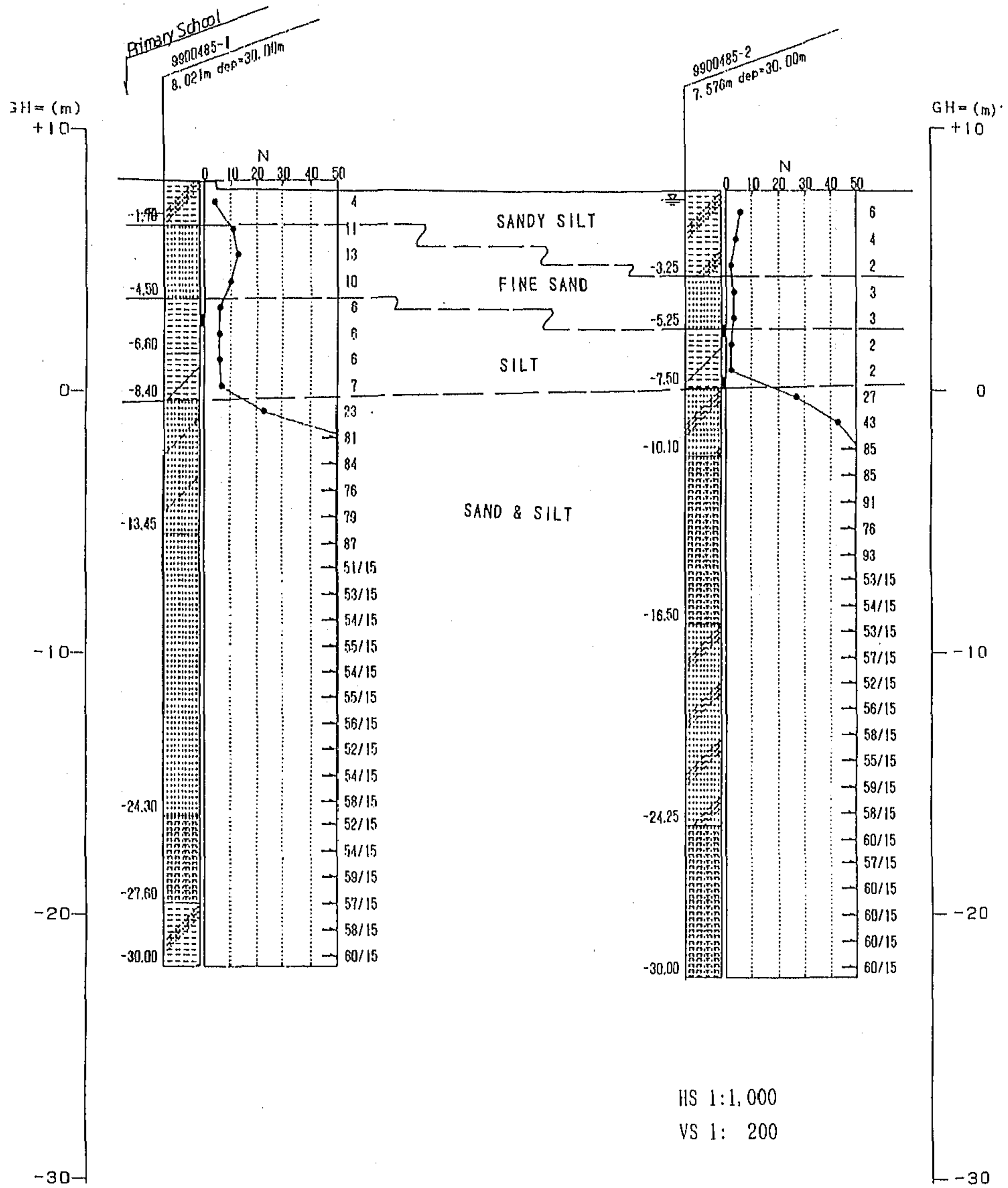



Fig. 5-1-2 (6) Geological Cross Section (9900485)

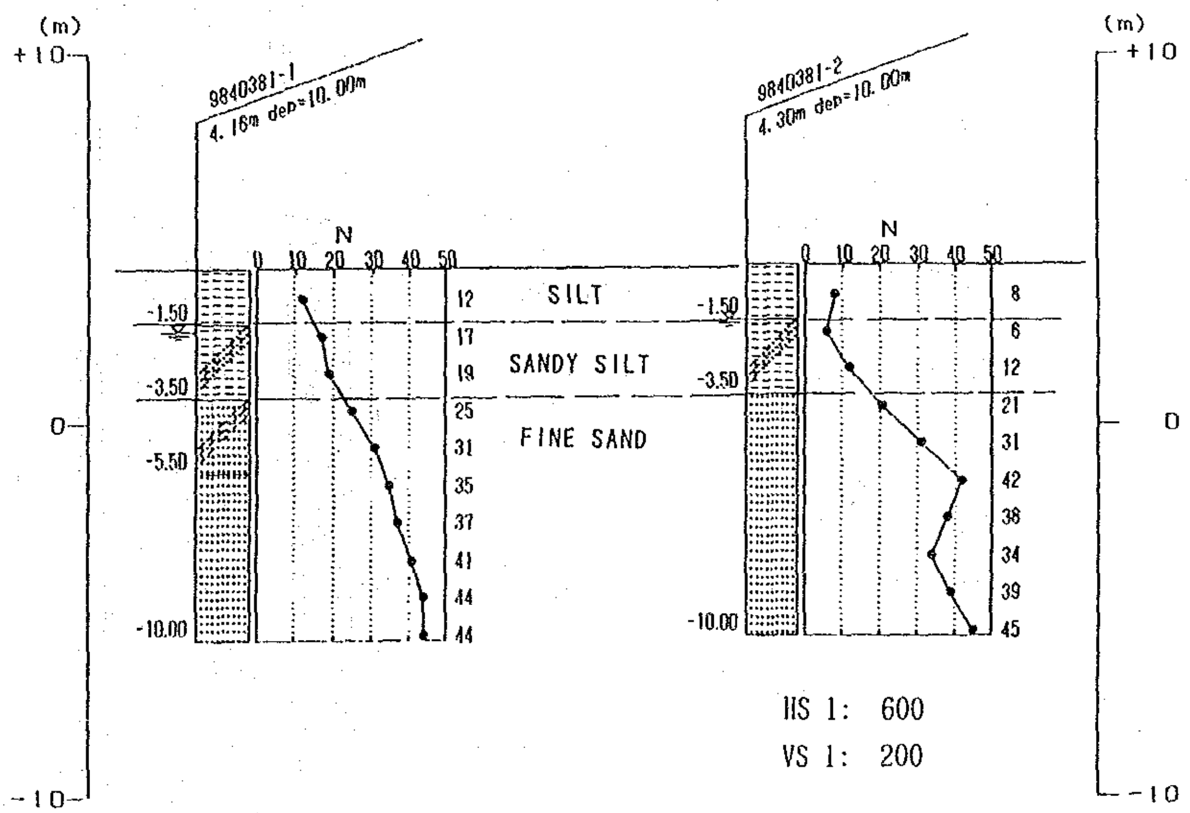



Fig. 5-1-2 (7) Geological Cross Section (9840381)

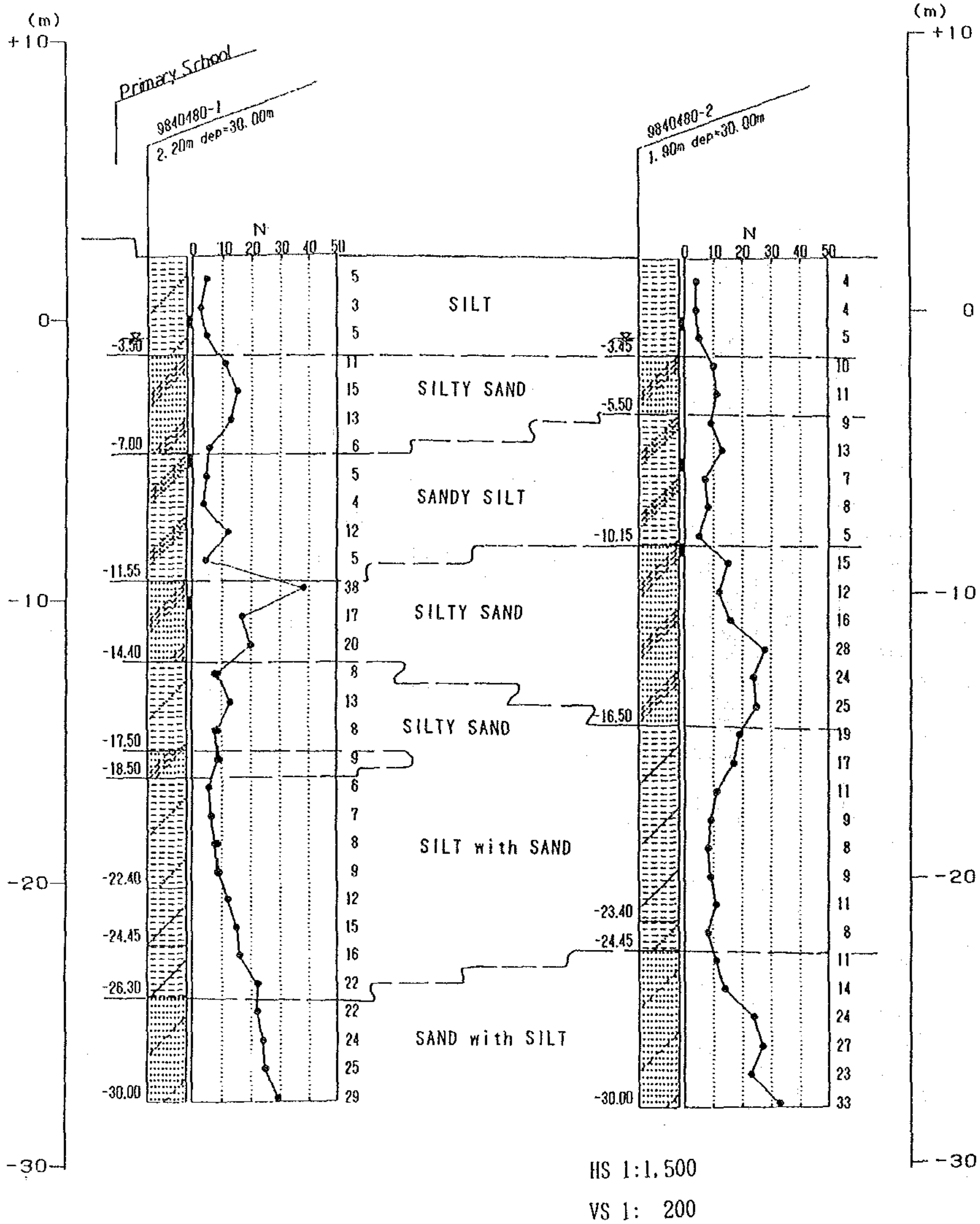



Fig. 5-1-2 (8) Geological Cross Section (9840480)

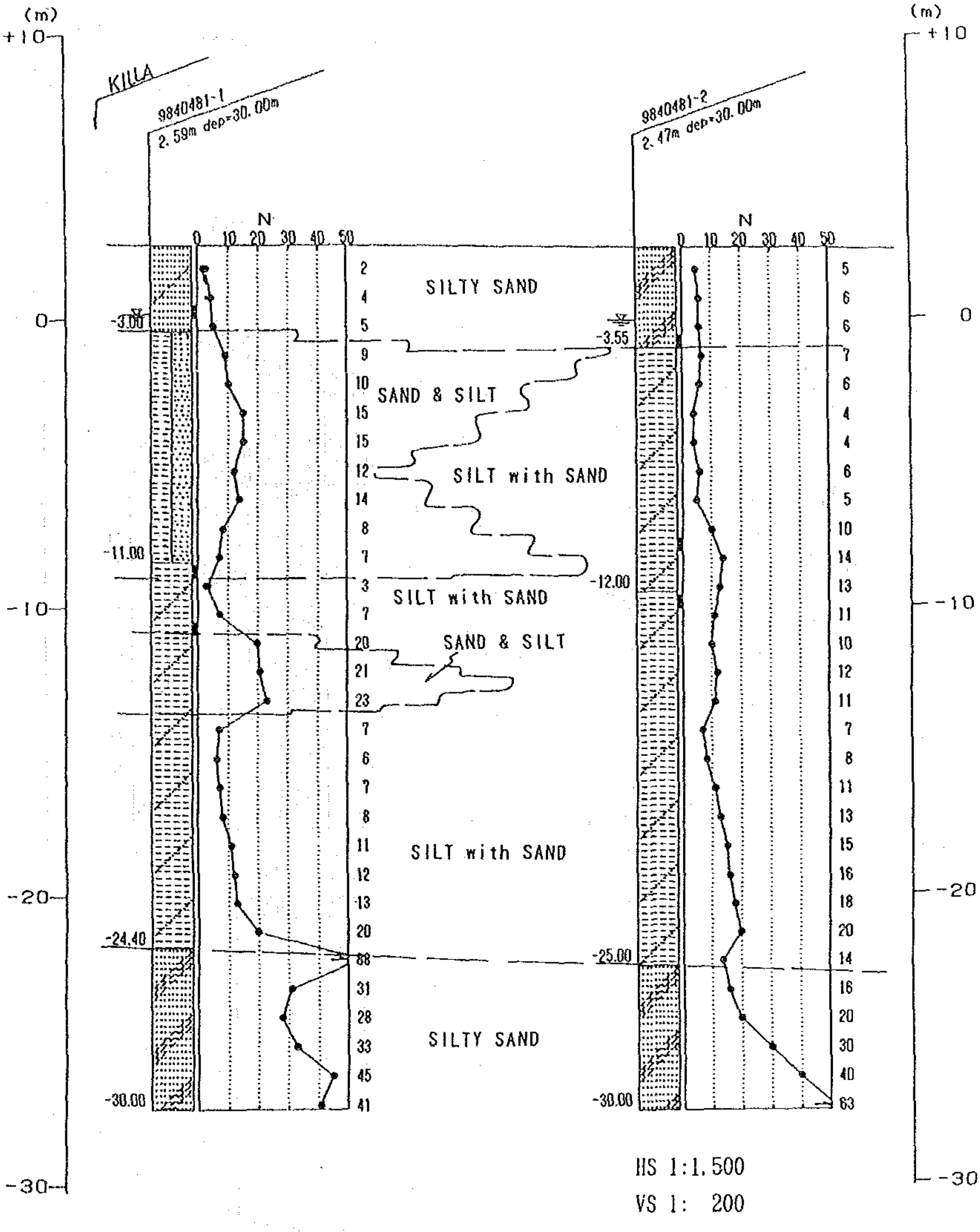



Fig. 5-1-2 (9) Geological Cross Section (9840481)

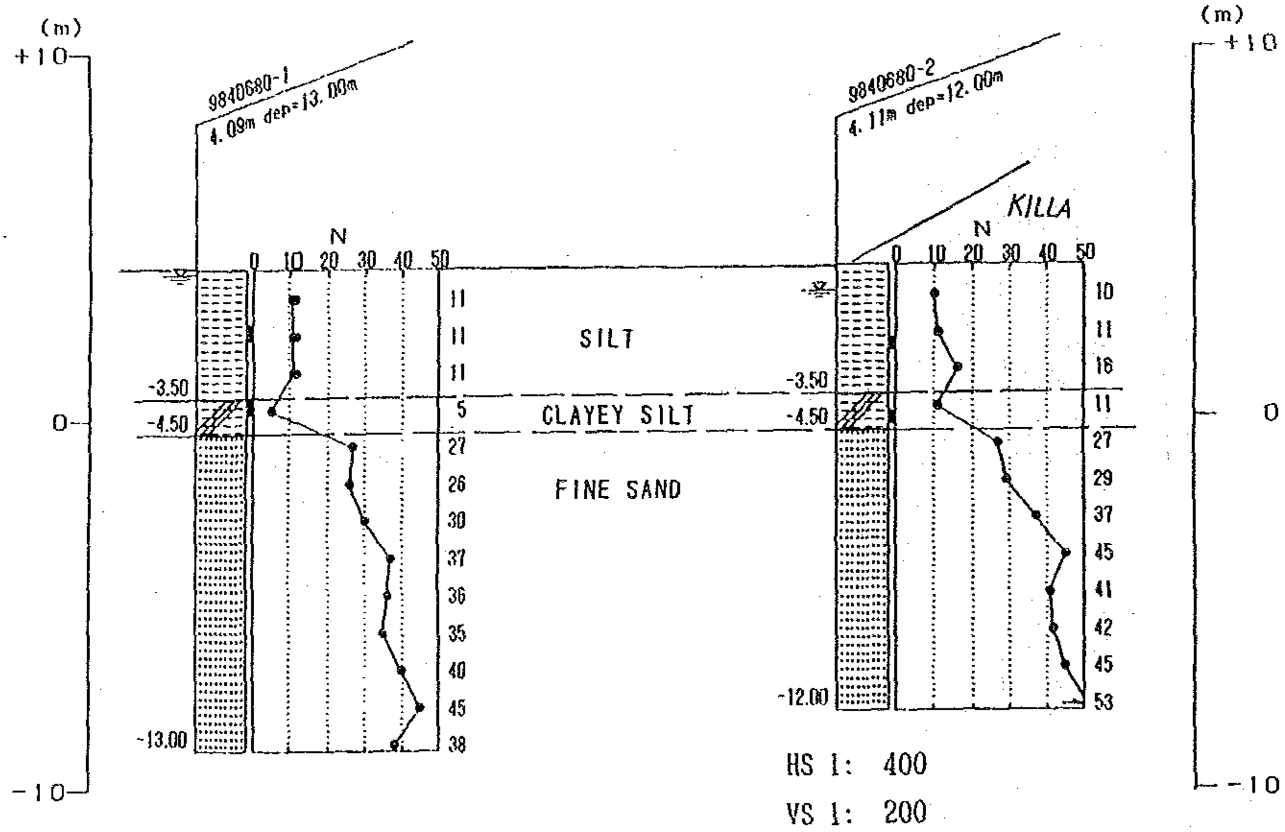



Fig. 5-1-2 (10) Geological Cross Section (9840680)

2) Examination of Direct Foundations

The long-term permissible bearing capacity for independent footing is calculated using the following equation as suggested by Terzaghi soil mechanics practices.

$qa = \frac{1}{3}(\alpha CNc + \beta \gamma 1\, BN\gamma + \gamma 2DfNq)$ ..........................(5-1-3)

qa : Long-term allowable bearing capacity of ground ($tf/m^2$)

C : Cohesion of foundation ground ($tf/m^2$)

$\gamma 1$ : Unit weight of soil below base of foundations ($t/m^3$)
(Submerged unit weight is applied to the soil below ground water level)

$\gamma 2$: Unit weight of soil above base of foundations ($t/m^3$)
(Submerged unit weight is applied to the soil below ground water level)

$\alpha$, $\beta$ shape factor of foundations (square shape: $\alpha$= 1.3, $\beta$ = 0.4)

NcN$\gamma$Nq :
Bearing capacity factor determined by angle of internal friction (ø) of soil (see Table 5-1-4)

Df : Depth of footing(m)

B : Minimum foundation width (m)

Table 5-1-4 Bearing Capacity Factor

| Ø | Nc | N$\gamma$ | Nq |
|---|---|---|---|
| 0° | 5.3 | 0 | 3.0 |
| 5° | 5.3 | 0 | 3.4 |
| 10° | 5.3 | 0 | 3.9 |
| 15° | 6.5 | 1.2 | 4.7 |
| 20° | 7.9 | 2.0 | 5.9 |
| 25° | 9.9 | 3.3 | 7.6 |
| 28° | 11.4 | 4.4 | 9.1 |
| 32° | 20.9 | 10.6 | 16.1 |
| 36° | 42.2 | 30.5 | 33.6 |
| 40° or more | 95.7 | 114.0 | 83.2 |

① Site No. 9880980

Based on soil test results, the following design conditions are adopted together with the depth (Df) of 3.0m.

$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.65 - 1.0 = 0.65$ (t/m$^3$)

C = (1/2) qu = (1/2) x 3.0 = 1.5 (tf/m$^2$)

as : Ø = 0, Nc = 5.3, N$\gamma$ = 0 and Nq = 3.0

where, $\gamma$t: wet unit weight of soil, qu: unconfined compressive strength

Using the equation 5-1-3,

qa =(1/3) (1.3 x 1.5 x 5.3 + 0.4 x 0.65 x B x 0 + 0.65 x 3 x 3) = 5.3 (tf/m$^2$)

Similarly, the value of qa is 4.7 tf/m$^2$ for a Df of 2.0m and 4.0 tf/m$^2$ for a Df of 1.0m.

② Site No. 9880982

Based on soil test results, the following design conditions are adopted together with the depth (Df) of 3.0m.

$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.65 - 1.0 = 0.65$ (t/m$^3$)

C = (1/2) qu = (1/2) x 4.0 = 2.0 (tf/m$^2$)

as : Ø = 0, Nc = 5.3, N$\gamma$ = 0 and Nq = 3.0

where, $\gamma$t: wet unit weight of soil, qu : unconfined compressive strength

Using the equation 5-1-3,

qa =(1/3) (1.3 x 2.0 x 5.3 + 0.4 x 0.65 x B x 0 + 0.65 x 3 x 3) = 6.5 (tf/m$^2$)

Similarly, the value of qa is 5.8 tf/m$^2$ for a Df of 2.0m and 5.2 tf/m$^2$ for a Df of 1.0m.

③ Site No. 9900182

Based on the soil test results, the following design conditions are adopted together with the depth (Df) of 3.0m.

$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.64 - 1.0 = 0.64$ (t/m$^3$)

C = (1/2) qu = (1/2) x 3.0 = 1.5 (tf/m$^2$)

as : Ø = 0, Nc = 5.3, N$\gamma$ = 0 and Nq = 3.0

where, $\gamma$t: wet unit weight of soil, qu: unconfined compressive strength

Using the equation 5-1-3,

qa =(1/3) (1.3 x 1.5 x 5.3 + 0.4 x 0.65 x B x 0 + 0.64 x 3 x 3) = 5.3 (tf/m$^2$)

Similarly, the value of qa is 4.7 $tf/m^2$ for a Df of 2.0m and 4.0 $tf/m^2$ for a Df of 1.0m.

④ Site No. 9900183

Based on soil test results, the following design conditions are adopted together with the depth (Df) of 3.0m.

$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.65 - 1.0 = 0.65\ (t/m^3)$

$C = (1/2)\ qu = (1/2) \times 2.0 = 1.0\ (tf/m^2)$

as: $\emptyset = 0$, $Nc = 5.3$, $N\gamma = 0$ and $Nq = 3.0$

where, $\gamma t$: wet unit weight of soil, qu : unconfined compressive strength

Using the equation 5-1-3,

$$qa = (1/3)\ (1.3 \times 1.0 \times 5.3 + 0.4 \times 0.65 \times B \times 0 + 0.65 \times 3 \times 3) = 4.2\ (tf/m^2)$$

Similarly, the value of qa is 3.5 $tf/m^2$ for a Df of 2.0m and 2.9 $tf/m^2$ for a Df of 1.0m.

⑤ Site No. 9900185

Based on soil test results, the following design conditions are adopted together with the depth (Df) of 3.0m.

$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.65 - 1.0 = 0.65\ (t/m^3)$

$C = (1/2)\ qu = (1/2) \times 1.8 = 0.9\ (tf/m^2)$

as : $\emptyset = 0$, $Nc = 5.3$, $N\gamma = 0$ and $Nq = 3.0$

where, $\gamma t$: wet unit weight of soil, qu : unconfined compressive strength

Using the equation 5-1-3,

$$qa = (1/3)\ (1.3 \times 0.9 \times 5.3 + 0.4 \times 0.65 \times B \times 0 + 0.65 \times 3 \times 3) = 4.1\ (tf/m^2)$$

Similarly, the value of qa is 3.3 $tf/m^2$ for a Df of 2.0m and 2.7 $tf/m^2$ for a Df of 1.0m.

⑥ Site No. 9900485

Soil types of potential foundation ground soils changes from clayey soil to sandy soil at around 3.0 - 3.5m below the ground surface. Consequently, the allowable bearing capacity is calculated for a Df of 3.5m in which sandy soil is the bearing stratum and for a Df of both 2.0m and 1.0m in which the bottom of substructure is placed in clayey soil.

$\gamma 1 = \gamma t - 1.0 = 1.75 - 1.0 = 0.75$ (t/m$^3$)

$\gamma 2 = \gamma t - 1.0 = 1.70 - 1.0 = 0.70$ (t/m$^3$)

C = 0 (tf/m$^2$)

$\emptyset = \sqrt{12N} + 15 = \sqrt{12 \times 7} + 15 = 24°$

Nc = 9.6, Ng = 3.0, Nq = 7.3

Using the equation 5-1-3 , the value for allowable bearing capacity for a foundation width (B) of 2m is calculated below.

$$qa = (1/3)(1.3 \times 0 \times 9.6 + 0.4 \times 0.8 \times 2 \times 3.0 + 0.7 \times 3.5 \times 7.3) = 6.6 \text{ (tf/m}^2\text{)}$$

No mechanical soil test was conducted on the upper clayey soil at this site but the following design conditions for a Df of 2.0m can be adopted based on the value of N and the soil test results for other sites.

$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.7 - 1.0 = 0.7$ (t/m$^3$)

C = (1/2) qu = (1/2) x 3.0 = 1.5 (tf/m$^2$)

as: $\emptyset = 0$, Nc = 5.3, Nr = 0 and Ng = 3.0

where, $\gamma t$: wet unit weight of soil, qu : unconfined compressive strength

Using the equation 5-1-3,

$$qa = (1/3)(1.3 \times 1.5 \times 5.3 + 0.4 \times 0.7 \times B \times 0 + 0.7 \times 2 \times 3) = 4.8 \text{ (tf/m}^2\text{)}$$

Similarly, the value of qa is 4.1 tf/m$^2$ for a Df of 1.0m.

⑦ Site No. 9840381

Soil types of potential foundation ground soils change from clayey soil to sandy soil at around 3.0 - 3.5m below the ground surface. Consequently, the allowable bearing capacity is calculated for a Df of 3.5m in which sandy soil is the bearing stratum and for a Df of both 2.0m and 1.0m in which the bottom of sub structure is placed in clayey soil.

Based on test results, the following design conditions are adopted together with a depth (Df) of 3.5m.

$\gamma 1 = \gamma t - 1.0 = 1.80 - 1.0 = 0.80$ (t/m$^3$)

$\gamma 2 = \gamma t - 1.0 = 1.65 - 1.0 = 0.65$ (t/m$^3$)

C = 0 (tf/m$^2$)

$\emptyset = \sqrt{12N} + 15 = \sqrt{12 \times 21} + 15 = 30°$

Nc = 15.0, N$\gamma$ = 6.8, Nq = 12.0

Using equation 5-1-3, the value of the allowable bearing strength for a foundation width (B) of 2m is calculated below.

$$qa=(1/3)\ (1.3 \times 0 \times 15.0 + 0.4 \times 0.8 \times 2 \times 6.8 + 0.65 \times 3.5 \times 12.0) = 10.5\ (tf/m^2)$$

No mechanical soil test was conducted on the upper clayey soil at this site because of its relatively high stiffness but the following design conditions for a Df of 2.0m are adopted based on the value of N and the soil test results for other sites.

$$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.65 - 1.0 = 0.65\ (t/m^3)$$
$$C = (1/2)\ qu = (1/2) \times 7.0 = 3.5\ (tf/m^2)$$
$$\text{as}: \ \emptyset = 0,\ Nc = 5.3,\ Ng = 0 \text{ and } Nq = 3.0$$

where, $\gamma t$: wet unit weight of soil, qu : unconfined compressive strength

Using the equation 5-1-3,

$$qa = (1/3)\ (1.3 \times 3.5 \times 5.3 + 0.4 \times 0.65 \times B \times 0 + 0.65 \times 2 \times 3) = 9.3\ (tf/m^2)$$

Similarly, the value of qa is 8.6 $tf/m^2$ for a Df of 1.0m.

⑧ Site No. 9840480

Soil types of potential foundation ground soils change from clayey soil to sandy soil at around 3.0 - 3.5m below the ground surface. Consequently, the allowable bearing capacity is calculated for a Df of 3.5m in which sandy soil is the bearing stratum and for a Df of both 2.0m and 1.0m in which the bottom of sub-structure is placed in clayey soil.

Based on test results, the following design conditions are adopted together with the depth (Df) of 3.5m.

$$\gamma 1 = \gamma t - 1.0 = 1.95 - 1.0 = 0.95\ (t/m^3)$$
$$\gamma 2 = \gamma t - 1.0 = 1.90 - 1.0 = 0.90\ (t/m^3)$$
$$C = 0\ (tf/m^2)$$
$$\emptyset = \sqrt{12N} + 15 = \sqrt{12 \times 10} + 15 = 25°$$
$$Nc = 9.9,\ N\gamma = 3.3,\ Nq = 7.6$$

Using the equation 5-1-3, the value of the allowable bearing capacity for a foundation width (B) of 2m is calculated below.

$$qa = (1/3)\ (1.3 \times 0 \times 9.9 + 0.4 \times 0.95 \times 2 \times 3.3 + 0.9 \times 3.5 \times 7.6) = 8.8\ (tf/m^2)$$

No mechanical soil test was conducted on the upper clayey soil at this site but the following design conditions for a Df of 2.0m are adopted based on the value of N and the soil test results for other sites.

$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.9 - 1.0 = 0.9$ (t/m$^3$)
C = (1/2) qu = (1/2) x 4.0 = 2.0 (tf/m$^2$)
as: $\emptyset = 0$, Nc = 5.3, N$\gamma$ = 0 and Nq = 3.0

where, $\gamma t$: wet unit weight of soil, qu: unconfined compressive strength

Using the equation 5-1-3,

qa = (1/3) (1.3 x 2.0 x 5.3 + 0.4 x 0.65 x B x 0 + 0.0 x 2 x 3) = 6.3 (tf/m$^2$)

Similarly, the value of qa is 5.4 tf/m$^2$ for a Df of 1.0m.

⑨ Site No. 9840481

The soil types of potential foundation ground soils change from silty sand to clayey soil at around 3.0 - 3.5m below the ground surface. Consequently, the allowable bearing capacity is calculated for a Df of 3.5m in which clayey soil is the bearing stratum and for a Df of 2.0m in which the bottom of the foundations are placed in sandy soil. The ground up to a depth of 1m should not be used as bearing stratum due to the low value of N (2) because of the looseness of the sand.

Based on test results, the following design conditions are adopted together with the depth (Df) of 3.5m.

$\gamma 1 = \gamma t - 1.0 = 1.80 - 1.0 = 0.80$ (t/m$^3$)
$\gamma 2 = \gamma t - 1.0 = 1.90 - 1.0 = 0.90$ (t/m$^3$)
C = (1/2) qu = (1/2) x 4.0 = 2.0 (tf/m$^2$)
as: $\emptyset = 0$, Nc = 5.3, N$\gamma$ = 0 and Nq = 3.0

where, $\gamma t$: wet unit weight of soil, qu : unconfined compressive strength

Using the equation 5-1-3,

qa = (1/3) (1.3 x 2.0 x 5.3 + 0.4 x 0.8 x B x 0 + 0.9 x 3.5 x 3) = 7.7 (tf/m$^2$)

The following design conditions for a Df of 2.0m are adopted based on the value of N and the soil test results for other sites.

$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.9 - 1.0 = 0.9$ (t/m$^3$)
$C = 0$
$\text{Ø} = \sqrt{12N} + 15 = \sqrt{12 \times 4} + 15 = 21°$
$Nc = 8.3$, $N\gamma = 2.2$, $Nq = 7.3$

Using the equation described in 5-1-3, the value of the allowable bearing capacity for a foundation width (B) of 2m is calculated below.

$$qa = (1/3)(1.3 \times 0 \times 8.3 + 0.4 \times 0.9 \times 2 \times 2.2 + 0.9 \times 2 \times 6.3) = 4.3 \text{ (tf/m}^2)$$

⑩ Site No. 9840680

Based on soil test results, the following design conditions are adopted together with the depth (Df) of 3.0m.

$\gamma 1 = \gamma 2 = \gamma t - 1.0 = 1.85 - 1.0 = 0.85$ (t/m$^3$)
$C = (1/2)\, qu = (1/2) \times 6.0 = 3.0$ (tf/m$^2$)
as: $\text{Ø} = 0$, $Nc = 5.3$, $N\gamma = 0$ and $Nq = 3.0$

where, $\gamma t$: wet unit weight of soil, qu: unconfined compressive strength

Using the equation described in 5-1-3,

$$qa = (1/3)(1.3 \times 3.0 \times 5.3 + 0.4 \times 0.85 \times B \times 0 + 0.85 \times 3 \times 3) = 9.4 \text{ (tf/m}^2)$$

Similarly, the value of qa is 8.5 tf/m$^2$ for a Df of 2.0m and 7.7 tf/m$^2$ for a Df of 1.0m.

All above calculations are for square-shaped independent footings of (2m x 2m) dimensions. As rectangular shapes (2.0m x 4.6m and 2.8m x 5.6m) are also considered as possible options, the relevant allowable bearing capacity can be calculated by inserting the specific foundation width and shape factor into the equations used for the above calculations for each site. The results of the above calculations are compiled in Table 5-1-5.

Table 5-1-5 Long-Term Allowable Bearing Capacity by Foundation Shape and Depth of Footing

| Site No. | Thana/Union | Depth of footing (m) | Soil Type at Bottom of Foundations | Allowable Bearing Capacity ($tf/m^2$) B x L | | |
|---|---|---|---|---|---|---|
| | | | | 2.0x2.0 a = 1.3 b = 0.4 | 2.0x4.6 a = 1.13 b = 0.45 | 2.8x5.6 a = 1.15 b = 0.45 |
| 9880980 | Banskhali Gandamara | 1.0 | clayey soil | 4.0 | 3.6 | 3.6 |
| | | 2.0 | clayey soil | 4.7 | 4.2 | 4.3 |
| | | 3.0 | clayey soil | 5.3 | 4.9 | 4.9 |
| 9880982 | Banskhali Saral | 1.0 | clayey soil | 5.2 | 4.6 | 4.7 |
| | | 2.0 | clayey soil | 5.8 | 5.2 | 5.3 |
| | | 3.0 | organic soil | 6.5 | 6.0 | 6.0 |
| 9900182 | Chakoria Badarkhali | 1.0 | clayey soil | 4.0 | 3.6 | 3.6 |
| | | 2.0 | clayey soil | 4.7 | 4.2 | 4.3 |
| | | 3.0 | clayey soil | 5.3 | 4.9 | 4.9 |
| 9900183 | Chakoria Badarkhali | 1.0 | clayey soil | 2.9 | 2.6 | 2.6 |
| | | 2.0 | clayey soil | 3.5 | 3.2 | 3.3 |
| | | 3.0 | clayey soil | 4.2 | 3.9 | 3.9 |
| 9900185 | Chakoria Badarkhali | 1.0 | clayey soil | 2.7 | 2.4 | 2.4 |
| | | 2.0 | clayey soil | 3.3 | 3.0 | 3.1 |
| | | 3.0 | clayey soil | 4.1 | 3.7 | 3.7 |
| 9900485 | Moheskhali K.M.Chara | 1.0 | mixed sandy & clayey soil | 4.1 | 3.6 | 3.7 |
| | | 2.0 | clayey soil & sand | 4.8 | 4.3 | 4.4 |
| | | 3.5 | sand | 6.6 | 6.6 | 6.8 |
| 9840381 | Companiganj Char-Elahi | 1.0 | clayey soil | 8.6 | 7.6 | 7.7 |
| | | 2.0 | sandy clay | 9.3 | 8.2 | 8.4 |
| | | 3.5 | sandy soil | 10.5 | 10.7 | 11.3 |
| 9840480 | Hatiya Brir Char | 1.0 | clayey soil | 5.4 | 4.8 | 4.9 |
| | | 2.0 | clayey soil | 6.3 | 5.7 | 5.8 |
| | | 3.5 | silty sand | 8.8 | 8.9 | 9.2 |
| 9840481 | Hatiya Jahajimara (Nijhumdwip) | 2.0 | silty sand | 4.3 | 4.3 | 4.7 |
| | | 3.5 | mixed sandy & clayey soil | 7.7 | 7.1 | 7.2 |
| 9840680 | Noakhali-Sadar Char Clark | 1.0 | clayey soil | 7.7 | 6.8 | 6.9 |
| | | 2.0 | clayey soil | 8.5 | 7.6 | 7.7 |
| | | 3.0 | clayey soil | 9.4 | 8.5 | 8.6 |

3) Examination of Consolidation Settlement

When there is a wide distribution of highly compressible clayey soil below the bearing stratum of a direct independent footing or pile foundation, it is possible for consolidation settlement to occur over a long period of time due to the weight of the structure or banking soil. The degree of settlement may vary depending on the changes of the ground, possibly causing the differential settlement of the structure concerned. If this differential settlement exceeds the resisting strength of the structure, cracks and other damage to the structure will occur. Although accurate calculation of differential settlement is extremely difficult, it is generally agreed that the amount of differential settlement is roughly proportional to the total amount of settlement (see Vol. VII of the Master Plan).

Several methods can be used to determine the amount of total settlement based on the consolidation characteristics of the soil. The method given below uses the compression index (Cc) and tends to indicate a slightly exaggerated amount of settlement. Nevertheless, this method is often used to examine the volume of settlement for a soil layer for which a consolidation test is not conducted as the value of Cc which has a relatively good correlation to the liquid limit (WL).

$$Sc = \frac{Cc}{1 + eo} \cdot H \cdot \log \frac{Pz + \Delta P}{Pz} \quad \text{.......(5-1-4)}$$

Where

Sc : Consolidation settlement

eo : initial void ratio of original ground

H : thickness of compressible layer

Cc : Compression index

Pz : effective overburden pressure of original ground

ΔP : incremental vertical stress

The consolidation test conducted for the Master Plan suggests the correlation between Cc and WL shown in Fig. 5-1-3 and also expressed by the following equation.

$$\frac{Cc}{1 + eo} = -0.076 + 0.0049 \text{ WL} \quad \text{.......(5-1-5)}$$

Table 5-1-6 gives the consolidation settlement calculation results based on the soil characteristics, including the value of WL obtained by the soil test conducted at each site and on the above 2 equations. The additional structure load was set at 3.0 $tf/m^2$ which is not uniformly applicable to the rectangular area of 14m x 22m created by the lines connecting the outer sides of the footings.

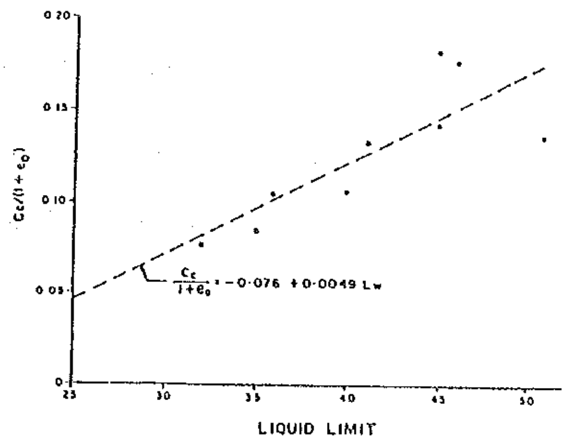



Fig. 5-1-3 Correlation Between Cc and WL

Table 5-1-6 Results of Consolidation Settlement Examination

| | Site No. | Type of Foundation | Df (m) | Bearing Stratum | Thickness of Compressible Layer (m) | Consolidation Settlement (cm) | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 9880980 | Pile | 3.0 | clayey soil | 9.50 | 14.4 | prominent differential settlement |
| 2 | 9880982 | Pile | 2.0 | clayey soil | 4.00 | 16.8 | prominent differential settlement |
| | | | 3.0 | organic soil | 3.00 | 11.8 | prominent differential settlement |
| 3 | 9900182 | Direct | 3.0 | clayey soil | 2.20 | 7.2 | prominent differential settlement |
| 4 | 9900183 | Pile | - | sand | - | - | no compressible layer |
| 5 | 9900185 | Pile | - | sand | - | - | no compressible layer |
| 6 | 9900485 | Direct | 3.5 | sandy soil | 2.25 | 1.5 | stress dispersed by sand layer |
| 7 | 9840381 | Direct | 1.0 | clayey soil | - | - | no compressible layer |
| 8 | 9840480 | Direct | 2.0 | clayey soil | 1.50 | 2.7 | - |
| | | | 3.5 | sandy soil | - | - | no compressible layer |
| 9 | 9840481 | Direct | 3.5 | clayey soil | 2.5 | 1.4 | - |
| | | | 2.0 | sandy soil | 2.5 | < 1.4 | stress dispersed by sand layer |
| 10 | 9900185 | Direct | 1.0 | clayey soil | - | - | no compressible layer |

In the case of Site 1 and Site 2, the bearing capacity is sufficient to support direct footings but there is a high risk of differential settlement due to large consolidation settlement. As the compressible layer is fairly thick, a pile foundation is adopted for these sites because ground improvements may be costly. The soils bearing capacity at Site 4 and Site 5 is insufficient to support direct footings. The consolidation settlement at these two sites was calculated based on the assumption that a pile foundation would be used. The bearing capacity of a foundation pile is calculated by the following equation:

$$Ra = \frac{1}{3} \cdot 15 \cdot \overline{N} \cdot A_p \qquad (5\text{-}1\text{-}5)$$

Where;

$Ra$: Allowable bearing capacity of pile (tons per pile)

$\overline{N}$: Average N - value at the bottom of the pile

$Ap$ Cross-sectional area of pile at the bottom point $m^2$

To get a 30 ton allowable bearing capacity per pile with a diameter of 6mm(as with a cast -in-place concrete pile), the average N-value should be 22 as calculated by the above equation. The soil layer which is has an N- value of more than 22 is thus considered to be the proper pile bearing layer. The length will be determined by evaluating the geological profile at each boring test point.

The proposed foundation type for each site and pile lengths for pile foundation are given in the table below.

Table 5-1-7 Proposed foundation type for each stie

| Site No. | Thana/Union | Foundation Type | Pile Length (m) |
|---|---|---|---|
| 9880980 | Banskhali/Gandamara | pile foundation | 19 |
| 9880982 | Banskhali/Saral | pile foundation | 10 |
| 9900182 | Chakoria/Badarkhali | direct independent footing | - |
| 9900183 | Chakoria/Badarkhali | pile foundation | 15 |
| 9900185 | Chakoria/Badarkhali | pile foundation | 12 |
| 9900485 | Moheskhali/ K.M.Chara | direct independent footing | - |
| 9840381 | Companganj/Char-Elahi | direct independent footing | - |
| 9840480 | Hatiya/Brir Char | direct independent footing | - |
| 9840481 | Hatiya/Jahajirmara (Nijhumdwip) | direct independent footing | - |
| 9840680 | Noakhali-Sadar/Char Clark | direct independent footing | - |

### 5.1.2 Social Conditions

The cyclone shelters with special features constructed for this Project will satisfy basic human and social needs and will satisfy all customs and cultural traditions of the people. Even if these facilities are requested by the local inhabitants to partially serve other purposes, this request can be met by minor changes of the partitions.

### 5.1.3 Construction Conditions

(1) Construction Method

In general, low buildings in Bangladesh are made of brick masonry while larger/taller buildings are made of rigid-frame reinforced concrete with brick masonry walls. The popularity of these methods can be justified by (i) the general availability of the required materials, equipment and skills, (ii) the high cost of other methods due to the necessity to import the required materials (structural steel and timber, etc.) and (iii) the absence of the necessary skills to employ other methods.

The Basic Design Study Team has confirmed that all cyclone shelters constructed or proposed by aid organizations or the Government of Bangladesh be made of reinforced concrete. Given this confirmation, all cyclone shelters to be constructed under the Project will have a rigid-frame reinforced concrete structure.

(2) Project Authorization System

No specific approval or authorization is required for the implementation of a project of this type in Bangladesh.

(3) Relevant Laws and Standards

While there are no specific laws or standards relating to architectural design in Bangladesh, the following provision exists for seismic force.

Horizontal force of inertia F = 0.05 - 0.1
(equivalent to the standard modulus of rigidity in Japan)

The following conditions are adopted for the present basic design purposes based on conditions used in the Master Plan and those commonly used in Japan.

| | |
|---|---|
| Floor Live Load | :480 $kg/m^2$ |
| Wind Load | :mean wind velocity 72 m/sec (50 year return period) |
| Water Load | :revolution coefficient - 1.5 inertia coefficient - 2.5 |

| | |
|---|---|
| Design Concrete Strength | :210 $kg/cm^2$ |
| Tensile Strength of Reinforcing Rods | :2,100 $kg/cm^2$ |

(4) Technical Level of Local Construction Companies

The technical level of local construction companies in the Dhaka metropolitan area is adequate in terms of common construction methods. The cooperation of local construction companies is essential for the successful completion of the Project. Fortunately, there are many companies which have been employed as sub-contractors for Japanese aid projects in the past. The use of local companies is, therefore, assumed for the implementation of the Project.

(5) Quality and Quantity of Local Labor

As few special skills are involved in the construction of the facilities envisaged by the Project, the local construction level is deemed adequate. However, it must be ensured that any construction method employed by the Project can be handled by local workers. With regard to the labor quantity, all general workers can be recruited from near each site although some skilled workers must be recruited from the Dhaka metropolitan area.

(6) Procurement and Quantity of Local Construction Materials and Equipment

The use of locally available construction materials and equipment is planned as long as the quantities and specifications satisfy the design conditions in order to keep the construction cost as low as possible. In short, all construction materials and equipment required for the Project are available locally, the use of which is expected to stimulate the local economy. Nevertheless, the remote locations of the project sites along the Bay of Bengal and the difficult access by transport vehicles to the sites (some of which are located on offshore islands) will increase construction costs due to manual transportation (pushcarts and etc.), of the materials to the sites. The primary materials and planned locations of procurement are listed below.

| Materials | Place of Procurement |
|---|---|
| Cement | Chittagong, Dhaka |
| Sand | North (Sylhet) |
| Pit Sand | North (Sylhet) |
| Cobble Stones | North (Sylhet) |
| Reinforcing Bars | Chittagong, Dhaka |
| Bricks | Chittagong, Noakhali, Cox's Bazar |
| Wooden Forms | Chittagong, Noakhali, Cox's Bazar |
| Paint | Chittagong, Dhaka |
| Fittings | Chittagong, Dhaka |
| Pumps | Chittagong, Dhaka |
| Furnishings | Chittagong, Dhaka |

### 5.1.4 Maintenance of Cyclone Shelters

In the event cyclone shelters to be constructed under the Project are officially recognized as government school buildings by the PMED, they will be directly managed by the PMED and maintenance responsibility will likewise fall under their jurisdiction. In the case that cyclone shelters are used for other purposes, the maintenance responsibility will fall under LGED which is the project implementing agency. In both cases, these facilities should be designed to minimize the maintenance cost through the use of locally available, and high quality materials where possible together with careful quality control during the construction period.

### 5.1.5 Scope and Quality of Cyclone Shelters

(1) Scope

Through consultations, the Governments of Japan and Bangladesh have agreed on the following scope for cyclone shelters.

① In addition to their use as evacuation facilities at the time of a cyclone, the cyclone shelters will be used as educational facility during normal weather conditions.

② The number of subject sites is 10.

③ Each cyclone shelter will have 3 classrooms, 1 staffroom, 1 storage and 2 toilets facilities (1 male and 1 female).

④ Each cyclone shelter will be provided with a water supply system (borehole for deep set tube well and hand pump).

⑤ Any necessary work road or access road will be constructed by the LGED.

These agreements will be reflected in the Basic Design together with the contents of the Master Plan and the particular features of the cyclone shelters constructed or proposed by the Government of Bangladesh and aid organizations.

Scope of the Project

- Construction of 10 cyclone shelters to accommodate some 1,650 people each at the time of a cyclone.
- Provision of sufficient space to allow these cyclone shelters to be used as educational facilities for other purposes during normal weather conditions and provision of the necessary furnishings (desks, chairs and blackboards).
- Provision of a water supply system using boreholes
- Provision of toilets and sewage system using septic tanks which can be used at the time of a cyclone.
- No installation of an electrical system (except for solar generated electrical system for site No.3).
- Preservation of temporary work roads for eventual use as access roads.
- Construction of killas at sites without a killa in the vicinity.

(2) Quality

In principle, the construction materials and equipment to be used for the Project will be procured locally as stated earlier and the building structure will be a rigid-frame concrete structure which is common in Bangladesh. The quality level of the structure and finish work, etc., will be equivalent to that of other cyclone shelters constructed by the Government of Bangladesh and aid organizations. No special materials will be used in regard to the finish and other aspects as long as the intended functions of the cyclone shelters are not compromised in order to keep the maintenance cost low.

(3) Lighting System

The installation of a lighting system, the need for which is discussed in section 4.3.2-(4), is based on the following principles.

① A solar power generating unit which provides the prospect of a relatively low operation and maintenance cost will be installed given the current conditions of electricity supply in the Project Area.

② Lighting will only be provided for one classroom, the staffroom, part of the corridor and the staircase to avoid the prohibitive installation cost associated with the provision of lighting throughout the cyclone shelter.

③ The design luminous intensity is as follows.

- classroom: 100 - 150 lux (half of the JIS requirement)
- staffroom: 100 - 150 lux
- corridor: 10 lux (similar to the intensity required by the Building Standards Act of Japan)

(The luminous intensity level for the classroom is adequate for teaching purposes. The level is set simply to reduce the equipment cost of the solar system.)

### 5.1.6 Construction Schedule

The decision for the construction schedule must take conditions of the local construction industry; (including labor and material supply conditions), and the meteorological conditions in Bangladesh into proper consideration. In addition to the above conditions, the construction schedule will also be largely affected by the building structure and construction method. The fact that the planned construction sites are scattered over a wide area due to the nature of the cyclone shelters must also be taken into consideration in the preparation of the construction schedule.

Based on the above, the allocation of 8 - 10 months for the completion of the planned construction work is necessary and it is essential that the work commences at the beginning of the dry season in either October or November.

## 5.2 Design Criteria

### 5.2.1 Facilities

The main purpose of the facilities to be constructed under the Project is to serve as cyclone shelters for the evacuation of local inhabitants. However, it has been agreed by the Governments of Japan and Bangladesh that these cyclone shelters will also be used as educational facilities, during normal times. Consequently, cyclone shelters are designed with the consideration that they will be used as school facilities with the following features:

<u>Planned Facilities</u>
Cyclone shelters will also be used as educational facilities, especially as school buildings, during normal weather conditions. Consequently, the cyclone shelters are designed here as school facilties.

Planned Facilities

| | | |
|---|---|---|
| Classroom | x 3 (50 pupils each) | $37.6m^2$ each |
| Staffroom | x 1 (3 - 4 teachers) | $18.8m^2$ |
| Storage | x 1 | $12.7m^2$ |
| Toilet | x 2 (male and female) | $9.4m^2$ each |
| Others (corridor, staircase, verandah) | | |

(The minimum standards set by the PMED for a primary school demands 3 classrooms and 1 staffroom.)

### 5.2.2 Estimate of Required Facility Size

The Master Plan adopts a required floor area of 262 - $285m^2$ for each cyclone shelter floor and the minimum requirement of the Master Plan is used as the basic design condition for the Project. The space required to accommodate evacuees is given as follows.

| | | |
|---|---|---|
| Indoor | : | $2ft^2$ ($0.185m^2$)/person |
| On the Roof | : | $8ft^2$ ($0.74m^2$)/person |

The following floor areas for Project purposes have been adopted pursuant to the design criteria set by the Master Plan.

| | | |
|---|---|---|
| Floor Area (First Floor) | : | $240.0m^2$ |
| Staircase | : | $22.0m^2$ |
| Total | : | $262.0m^2$ |
| Roof Top Area | : | $298.0m^2$ |

The cyclone shelter accommodation capacity at the time of a cyclone is calculated as follows.

| | | | | |
|---|---|---|---|---|
| Floor Area | : | $221.0m^2$ (minus toilet area) | | |
| Staircase | : | $11.0m^2$ (half of the normal area) | | |
| Sub-Total | : | $232.0m^2$ | for | 1,254 persons |
| Roof Top Area | : | $298.0m^2$ | for | 402 persons |
| Grand Total | : | | | 1,656 persons |

The official accommodation capacity of each cyclone shelter is, therefore, set at 1,650 persons.

## 5.3 Basic Plan

### 5.3.1 Site Plan

The Preliminary Study Team reported that many lives were lost during cyclones because the public was unwilling to evacuate until the very last moment in order to protect their livestock and/or household belongings. Therefore, the public may not necessarily agree to evacuation simply because of the existence of a cyclone shelter unless a special facility (such as a killa) is also provided near the cyclone shelter for the evacuation of livestock.

Of the 10 sites planned under the Project, 8 sites are proposed next to killas which are currently under construction. There is a clear access road at only 4 sites and access at the remaining 6 sites is provided by only a farming footpath or similar access.. With the construction of a proper access road, however, the locations of these 6 sites are deemed appropriate for the construction of cyclone shelters.

The actual cyclone shelter construction sites should be as close as possible to existing killa sites in order that the evacuees can monitor the evacuation of their livestock to a killa. The cyclone shelter premises should prove sufficiently large if an area of some 2,000m$^2$ is provided. Trees should be planted around the cyclone shelters to protect the premises to a certain extent from the devastating wind and/or waves at the time of a cyclone.

### 5.3.2 Architectural Design

The architectural design of the cyclone shelters (school buildings) is based on the items agreed to by the 2 governments and is in line with the criteria set by the PMED.

(1) Facilities

| | | |
|---|---|---|
| Classroom | x | 3 |
| Staffroom | x | 1 (for 4 teachers) |
| Storage | x | 1 |
| Toilet | x | 2 (for meleand female) |

Others (corridor, staircase, verandah)

(2) Floor Area

| | | |
|---|---|---|
| Classrooms | : | floor area per pupil - $8ft^2$ ($0.743m^2$)<br>classroom capacity - 50 pupils<br>classroom area - 0.743 x 50 = $37.15m^2$ |
| Staffroom | : | floor area per teacher - $50ft^2$ ($4.65m^2$)<br>staffroom area - 4.65 x 4 = $18.6m^2$ |
| Toilets | : | required number of booths -at least 5 ($3.0m^2$each)<br>male's toilet - $3m^2$ x 3 = $9m^2$<br>female's toilet - $3m^2$ x 3 = $9m^2$<br>total toilet area - $18m^2$ |

(3) Floor Plan

The building will have a simple rectangular shape with a central corridor for efficiency. The rooms will be distributed on both sides of the corridor. The verandah will normally be used during breaks but will also provide useful space for evacuation at the time of an emergency.

Separate toilets for mele and female with 3 booths each are provided, meeting the minimum requirement of 5 booths based on 3 booths/100 persons.

The building will have 2 storys and the first floor will be used for school purposes while the open ground floor will be used for communal activities during normal weather conditions.

(4) Cross-Sectional View

The height of the first floor must be high enough not to be inundated by the storm surge caused by a cyclone. Based on past data, it has been decided that the height of the first floor will be 5 - 7m above ground level. The height of the ground floor will be about 1m above ground level to prevent damage due to ordinary flooding.

(5) Lighting Plan

In general, new facilities are supplied with electricity by nearby transmission lines. However, this is not an option for the planned sites due to the total absence of such lines.