## 6.6 Cargo Throughput of Master Plan

### 6.6.1 Cargo Throughput of Danang Bay

Total cargo throughput of the three ports in Danang Bay, namely, Danang Port (Tien Sa Area and Song Ha Area), My Khe Port, and Lien Chieu Port which is the study target port is shown in Table 6.6.1(1).

**Table 6.6.1(1) Cargo Throughput of Danang Bay in 2020**

Unit: Ton

| Commodities | Foreign | | Domestic | |
|---|---|---|---|---|
| | Export | Import | Loading | Unloading |
| Oil Products | 0 | 534,700 | 282,900 | 0 |
| Agriculture, Fishery and Forest Products | 75,600 | 0 | 0 | 70,900 |
| Bulk (Silica Sand, Coal, Clinker) | 320,900 | 1,000,000 | 0 | 541,700 |
| Break bulk (Fertilizer, Wood Chip, Tar) | 300,000 | 757,900 | 0 | 0 |
| Steel and Scrap | 0 | 575,000 | 280,000 | 0 |
| Cement | 240,000 | 0 | 560,000 | 0 |
| Manufacturing Products and Consumer Goods | 872,900 | 2,364,100 | 349,600 | 329,900 |
| International Transit Cargo | 608,000 | 680,000 | - | - |
| (Sub Total) | 2,417,400 | 5,911,700 | 1,472,500 | 942,500 |
| (Total) | 10,744,100 | | | |

Allocation of each port is estimated based on location of port, cargo handling capacity, facilities and future development plan as shown in Table 6.6.1(2), (3).

Present handling cargo at Danang Port could be allotted to Danang Port in future. Cargo from/to industrial zone and overflowed cargo of Danang Port could be allotted to Lien Chieu Port. Furthermore, liquid cargo could be also allotted to Lien Chieu Ports since there is a plan to move oil handling port, My Khe Port, to Lien Chieu Area or Thanh Khe Area.

**Table 6.6.1(2) Cargo Throughput of Danang Port in 2020**

Unit: Ton

| Commodities | Foreign | | Domestic | |
|---|---|---|---|---|
| | Export | Import | Loading | Unloading |
| Oil Products | 0 | 0 | 0 | 0 |
| Agriculture, Fishery and Forest Products | 31,100 | 0 | 0 | 0 |
| Bulk (Silica Sand, Coal, Clinker) | 103,300 | 0 | 0 | 174,400 |
| Break bulk (Fertilizer, Wood Chip, Tar) | 247,000 | 442,000 | 0 | 0 |
| Steel and Scrap | 0 | 0 | 0 | 0 |
| Cement | 120,000 | 0 | 280,000 | 0 |
| Manufacturing Products and Consumer Goods | 148,800 | 712,000 | 0 | 0 |
| International Transit Cargo | 0 | 0 | - | - |
| (Sub Total) | 650,200 | 1,154,000 | 280,000 | 174,400 |
| (Total) | 2,258,600 | | | |

**Table 6.6.1(3) Cargo Throughput of Lien Chieu Port in 2020**

Unit: Ton

| Commodities | Foreign | | Domestic | |
|---|---|---|---|---|
| | Export | Import | Loading | Unloading |
| Oil Products | 0 | 534,700 | 282,900 | 0 |
| Agriculture, Fishery and Forest Products | 44,500 | 0 | 0 | 70,900 |
| Bulk (Silica Sand, Coal, Clinker) | 217,600 | 1,000,000 | 0 | 367,300 |
| Break bulk (Fertilizer, Wood Chip, Tar) | 53,000 | 315,900 | 0 | 0 |
| Steel and Scrap | 0 | 575,000 | 280,000 | 0 |
| Cement | 120,000 | 0 | 280,000 | 0 |
| Manufacturing Products and Consumer Goods | 724,100 | 1,652,100 | 349,600 | 329,900 |
| International Transit Cargo | 608,000 | 680,000 | - | - |
| (Sub Total) | 1,767,200 | 4,757,700 | 1,192,500 | 768,100 |
| (Total) | 8,485,500 | | | |

# 7. Master Plan for Port Development

## 7.1 Port Development Policy

### 7.1.1 Basic Concept of Port Development of the Key Area in the Central Region

(1) The final goal of the port development of the region is to realize a well balanced national development by creating the third core of social and economic activity of the country following the other two advanced areas, namely Hanoi and Ho Chi Minh.

(2) In order to achieve the above objective, an effective port development strategy that leads to the promotion of regional development through the various port activities should be designed.

(3) The functional allotment among the ports in the three sites designated by the Scope of the Study should be clearly identified considering the geographical, social, political and economic conditions of each site, which means that unreasonable duplication of the port functions among these ports should be avoided.

(4) By building up a well conceived functional network, the three ports could function as one port which would contribute greatly to the expected regional development.

(5) Improvement of the port related infrastructures such as road, railway, power/water supply, industrial estate and so on should be planned and executed in principle according to the scale and function of the port development and construction planning/schedule of each target port. In actual planning works on the target ports of the Study, however, the existing plans or concepts on the development of port related infrastructures announced officially by the Vietnamese authorities shall be recognized as the status quo.

(6) Careful attention shall be paid to reasonable preservation of social and natural conditions.

(7) The full-scale development of the port function for the cargo traffic from/to the neighboring countries including Laos, Cambodia and Thailand needs to be planned generally from a medium/long term point of view, considering the uncertain situations of the countries in terms of economic and transport policies, or perspectives of future improvement of road / rail systems and cross border facilities.

(8) The actual construction of the required port facilities should be commenced only after relevant conditions such as industrial location, improvement of related infrastructures, social/ economic situations, official decision on each target site of the region and so on, are satisfied and confirmed.

(9) Considering the scale of economy and financial capability of Vietnam, the initial scale of port development needs to be planned and adjusted accordingly.

### 7.1.2 Functions of Lien Chieu Port

After the completion of Hai Van Tunnel, expected in the year 2004, the distance between Chan May Port and Lien Chieu Port becomes 28 km. Both ports will play a complementary role if functions of both ports are well demarcated, however, both ports will be in cutthroat competition if the demarcation of functions is not taken into consideration.

Requirements for a commercial hub port are to accommodate post Panamax container ships and to have a large volume of cargo to enable shipping lines to make frequent calls at the port. It is therefore important that the Key Area of the Central region should have a large port complex to attract shipping lines and consequently cargoes from a wider hinterland. It should also be noted that maritime freight rate between large ports remains at a low level due to competition between shipping lines. However, maritime freight rates between small ports or between a large port and a small port are kept at a high level due to less competition between shipping lines. Shippers and consignees are therefore liable to choose a large port for their imports and exports.

Furthermore, port needs the accumulation of maritime services supporting trade and port activities. Since Danang Port is recognized as a commercial hub in the Central region, new commercial port in the Key Area should be built in close connection with Danang Port and should form a port complex in the area.

In terms of commercial port function, Lien Chieu is located in a good position to form a port complex in Danang Bay. Since the present port, Tien Sa Port, has little space for further development, Lien Chieu Port shall serve as an outer port of Tien Sa with modern container handling facilities. Lin Chieu Port is also requested to accommodate bulk cargo vessels and conventional break bulk carriers as a gateway to Lien Chieu-Hoa Khanh Industrial Estate. Summarizing the above mentioned idea, following core functions will be adequate for Lien Chieu Port.

1) Lien Chieu Port shall be a commercial port serving the Key Area of Central Vietnam after the saturation of Tien Sa Port.

2) Lien Chieu Port can serve for industrial cargoes from/to Lien Chieu-Hoa Khanh Industrial Estate.

### 7.1.3 Function of Tien Sa Port

Tien Sa Port is the deepest commercial port in Vietnam with an alongside depth of 10.6 meters (No.4 Berth as of July 1996). The port used to be the gateway to Lao PDR during the 1980's, however transit cargo to Lao PDR has almost disappeared due to political changes in Eastern countries. Since 1990, Tien Sa Port has mainly handled imports and exports of the central region, particularly cargoes in Danang area.

The two piers were built by the US Navy during the war period, and piles and the surface of the piers have deteriorated considerably. Its backyard is confined by Son Tra mountain, making it difficult to expand land areas. Access road to the port passes a densely populated area. Therefore, it will be appropriate that Tien Sa Port will serve for the urgent demand of maritime transportation in the region .

Since Danang port complex is expected to serve as a gateway to the East West Transport Corridor, Tien Sa Port shall play a role of commercial port until a new port will enter into service. It is therefore necessary to rehabilitate the present piers and to upgrade cargo handling facilities to meet the urgent demand for international transit cargo as well as for the regional seaborne cargo.

## 7.2 Requirements for New Port

### 7.2.1 Commercial Port

Seeking economies of scale, shipping lines deploy larger vessels and form groups for utilizing their capacities. In particular, container carriers introduced new alliances in 1996 and will bring larger vessels into operation in major shipping services, which will result in the reduction of calling ports of mother vessels. Consequently, ports are requested to cope with deep draft vessels or to remain as small feeder ports. In this regard, efforts should be made to attract shipping lines through economies of scale of port.

A new commercial port development should comply with the following requirements with a view to expanding the capacity of existing port and meeting the demand for economic development in the Central Region of Vietnam.

- To enable the port to accommodate post Panamax container ships on a long-term basis and to cope with urgent demand for feeder container services on a short-term basis.
- To ensure the calmness of the port waters;
- To upgrade and modernize cargo handling equipment so as to improve the cargo handling productivity, and to comply with an urgent need for increasing the capacity of container handling;
- To be flexible enough to cope with unforeseen changes in future demand;
- To improve the situation of present ports and to utilize the capacity of the present ports;
- To be competitive with ports in Thailand, namely Bangkok Port and Laem Chabang Port so as to attract export and import from/to Lao PDR and the Northwest Thailand;
- To have a certain amount of cargo throughput (containers) to attract shipping lines and to enable liner vessels to serve frequently, at least one service a week, on a short-term basis;
- To encourage the participation of shipping companies in the development of port;
- To ensure easy access from the hinterland.

### 7.2.2 Industrial Port

Providing the region with a maritime transportation means, port plays a key role in encouraging investors to select the area for the development of their manufacturing factories, warehouse, cargo distribution center and other transportation facilities. However, the development of a new port requires a large amount of investment and a long period of construction. Hence, strategic development of ports is required from the viewpoint of early completion of facilities to cater to industries planned in the hinterland.

A new industrial port should fulfill the following requirements in compliance with the development of the hinterland.

- To mitigate adverse effects on the environment caused by industries;
- To provide factories and importers & exporters in the hinterland with easy access to the waterfront;
- To minimize the cost and period of breakwater construction so as to encourage private investors to establish their facilities in the hinterland.

### 7.2.3 Target Ship Size

#### (1) Possible Size of Mother Container Vessels

The largest container ship in operation has dimensions of 318 m in length, 14 m in draft and 42 m in width, with a capacity of more than 6,200 TEUs. With the formation of new alliances, such as Global Alliance and Grand Alliance, shipping lines are deploying 5,000-6,000 TEU vessels on the trunk liner services. While only a few ports can accommodate this class vessel, hub ports are requested to cater to this class.

On a long-term basis, hub ports in Vietnam may be required to accommodate this class so that a container berth should have an alongside length of 330 m or more. It will therefore be necessary to design the container berths with this length or more, however, it will not be necessary to cater to this class on a short-term basis as the container throughput is limited. Taking into account container vessels seldom have full draft in actual operation, it will be adequate to deepen the basin if it becomes necessary. Port development plan should be flexible enough to cope with this demand.

#### (2) Dry Bulk Carriers and Tankers

Maximum DWT of ore/coal carries, oil tankers, and other bulk carriers are much bigger than container vessels, however, these are used only for low material transportation for heavy industries. Since Lien Chieu is planned as a gateway port to the industrial parks in their hinterland, it will be adequate to cope with the cargoes originated from or destined to light industries.

In accordance with industrial development plans in Lien Chieu area, design ship size will be 40,000 DWT for dry bulk carriers, 20,000 DWT for break bulk carriers, and 12,000 DWT for cement ships.

#### (3) Coastal Ships

Conventional coastal ships will be gradually replaced by Ro/Ro and ferry boats on a long-term basis. Car carriers and other specialized vessels will be introduced in the near future. Sizes of typical coastal ships are listed in Table 7.2.1 and, therefore, deep berths for coastal ships are designed at a depth of 8-9 meters.

TABLE 7.2.1 Dimensions of Possible Calling Vessels

| Vessel Type | L | B | d | |
|---|---|---|---|---|
| Container Vessel | m | m | m | Container |
| 50,000 GT (58,000 DWT) | 280 | 32 | 13.0 | 3,600-4,000 TEUs |
| 48,000 GT (47,000 DWT) | 275 | 32 | 12.0 | 3,200-3,700 TEUs |
| 43,000 GT (38,000 DWT) | 250 | 32 | 11.5 | 2,400-2,800 TEUs |
| 37,000 GT (30,000 DWT) | 216 | 32 | 11.5 | 1,600-2,000 TEUs |
| 32,000 GT (29,000 DWT) | 222 | 32 | 11.3 | 1,500-1,800 TEUs |
| Car Carrier | | | | |
| 42,000 GT (17,000 DWT) | 185 | 29 | 9.0 | |
| 32,000 GT (15,000 DWT) | 180 | 32 | 9.8 | |
| 31,000 GT (16,000 DWT) | 190 | 32 | 8.2 | |
| 31,000 GT (27,000 DWT) | 196 | 32 | 8.5 | |
| Bulk Carrier | | | | |
| 36,000 DWT | 183 | 29 | 10.9 | |
| Ro/Ro | | | | |
| 7,000 DWT | 140 | | 7.5 | |
| 6,000 DWT | 150 | | 7.0 | |
| 5,700 DWT | 140 | | 6.9 | |
| Product Oil Carrier | | | | |
| 6,000 DWT | 106 | 16 | 6.9 | |
| 5,000 DWT | 104 | 16 | 6.5 | |
| 3,000 DWT | 92 | 14 | 5.7 | |
| Cement Carrier | | | | |
| 12,000 DWT | 135 | | 8.0 | |
| 9,000 DWT | 123 | | 7.3 | |
| General Cargo Ship | | | | |
| 10,000 DWT | 140 | 20 | 8.4 | |
| 7,000 DWT | 129 | 18 | 7.5 | |
| 5,000 DWT | 103 | 15 | 6.8 | |
| 3,000 DWT | 86 | 13 | 5.9 | |
| 2,000 DWT | 74 | 12 | 4.9 | |
| Passenger Ship (Ocean Going) | | | | Passengers |
| 77,000 GT | 261 | 32 | 7.9 | 1,950 |
| 49,000 GT | 241 | 30 | 7.5 | 960 |
| 29,000 GT | 193 | 25 | 6.6 | 600 |
| Ferry Boat (Long Distance) | | | | |
| 20,000 GT | 200 | 30 | 6.8 | |
| 15,000 GT | 190 | 29 | 6.8 | |
| 12,000 GT | 185 | 24 | 6.5 | |
| 9,500 GT | 160 | 22 | 6.2 | |

Note 1/ GT: Gross Tonnage
2/ DWT: Deadweight Tonnage
3/ L:Length over all, B:Moulded breadth; d:Moulded draft

## 7.3 Capacity of Tien Sa Port

### (1) Outline of POSIM

The capacity of Tien Sa Port is estimated by computer simulation using POSIM (Port Simulation Model). POSIM is a stochastic simulation model, developed to simulate complex port operations. The objective of the model is to assess the adequacy of the port infrastructure and operations given the forecast trade and shipping levels.

Inputs for the POSIM simulation are (a) Ship types, and description of each ship type (length, draft, number and pattern of arrival, etc.) and (b) Berth names, and description of each berth (length, depth, etc.)

Outputs of the POSIM simulation are (a) Berth time information; (b) Waiting times by ship type; (c) Berth occupancies; and (d) Others

Each ship type has two random variables: interval time and service time. Both distributions are specified as Erlang distributions with a fixed phase "k" given by the user. After generating the calling ships based on the inter-arrival time distribution by each ship type, all calling ship data are rearranged in accordance with the order of their arrival time. The form of the probability density function of the Erlang distribution is expressed as follows.

$$f(t) = \frac{(\lambda k)^k (t)^{k-1}}{(k-1)!} (e)^{-\lambda kt}$$

where, t : random number

k : fixed order of Erlang distribution

$\lambda$ : rate of ships arrival or servicing

### (2) Prerequisites

Port Conditions

In addition to the existing 4 berths, No.5 berth is now under construction and No.6 berth is planned along the new breakwater. Quay length of each berth from No.1 to No.4 is 184 m and No.5 will be 160 m. No.6 is planned to have a length of 200m. The water depth, operating days per year and other basic data are shown in Table 7.3.1.

Productivity

The handling productivity of each kind of cargo is estimated using existing records of Vietnamese ports. Also, it is assumed that 2 gangs are applied to loading and unloading work of each commodity.

Number of Ship Calls

The number of ship calls is estimated using calling records of Tien Sa Port in 1995. The number of ship calls is forecasted to increase by three times the number recorded in 1995 after Berth No.6 is completed. Basic data for POSIM Simulation are shown in Table 7.3.1

**(3) Results of POSIM Simulation**

Average Berth Occupancy in 1995

Calculated berth occupancy rate in 1995 is 37.2%. This value does not include non-operation time.

Capacity of Tien Sa Port

Handling capacity of the existing port is estimated at about 1.7 million tons per annum (including container cargo). In this case, the average berth occupancy is 79%. If Berth No.5 will be completed, the port will be able to handle 2.2 million tons of cargo. In addition, once Berth No.6, which will serve for general cargo trampers and container vessels, is completed, the Tien Sa port will be able to handle an additional 0.9-1.1 million tons and the total handling cargo volume will reach about 3.1-3.3 million tons at that time. Outputs are shown in Table 7.3.2.

## Table 7.3.1 Inputs for POSIM Simulation

| | | | |
|---|---|---|---|
| Number of Berths | | 4(existing)+1(under construction)+1(plan) | |
| Length of each Berth | | No.1-4: 184 m | |
| | | No.5: 160 m, No.6: 200 m | |
| Water Depth | | -10m (No.6 : -12m MSL) | |
| Operating days of per year | | 317 days (365-8 holidays - 40 rough sea days) | |
| Port Open/Close Time | | 6:00/22:00 hours | |
| Berth Operation Begin/End | | 0:00/24:00 (net operation time 18hours) | |
| Productivity | Break Bulk | 38 tons/hour/gang | x2gangs |
| | General Bulk | 30 t/h/g | x2gangs |
| | Steel | 56 t/h/g | x2gangs |
| | Dry Bulk(Chip) | 140 t/h/g | x2gangs |
| | Dry Bulk(Others) | 39 t/h/g | x2gangs |
| | Container | 7 TEU/hour/gang | x2gangs |
| Number of Calling Vessels | Break Bulk | 94 /year | |
| | General Bulk | 14 /year | |
| | Steel | 4 /year | |
| | Dry Bulk(Chip) | 16 /year | |
| | Dry Bulk(Others) | 7 /year | |
| | Container | 50 /year | |
| | | (150 /year : Berth No.6 completed) | |

**Table 7.3.2 Result of POSIM Simulation**

| | | Cargo Volume (1000ton/year) | Average Wating Time (hour/min.) | Berth Occupancies (%) |
|---|---|---|---|---|
| Evaluation of 1995's Record | Break Bulk | 530 | 2/42 | |
| | General Bulk | 79 | 2/13 | |
| | Steel | 25 | 2/51 | 37.2 |
| | Dry Bulk(chip) | 91 | 2/41 | |
| | Dry Bulk(others) | 39 | 1/50 | |
| | Container | 4,000TEU | 2/36 | |
| | Total | 804 | | |
| Evaluation of Port Capacity (existing) | Break Bulk | 840 | 4/09 | |
| | General Bulk | 114 | 4/34 | |
| | Steel | 28 | 3/02 | 83.2 |
| | Dry Bulk(chip) | 149 | 8/18 | |
| | Dry Bulk(others) | 61 | 5/51 | |
| | Container | 80,000TEU | 4/17 | |
| | Total | 1,712 | | |
| Port Capacity (Berth No.5 completed) | Break Bulk | 1,097 | 3/16 | |
| | General Bulk | 162 | 3/18 | |
| | Steel | 44 | 4/31 | 77.0 |
| | Dry Bulk(chip) | 182 | 2/35 | |
| | Dry Bulk(others) | 71 | 4/49 | |
| | Container | 95,000TEU | 3/11 | |
| | Total | 2,176 | | |
| Port Capacity (Berth No.5 and No.6 completed) | Break Bulk | 1,554 | 5/01 | |
| | General Bulk | 234 | 3/38 | |
| | Steel | 75 | 5/55 | 79.1 |
| | Dry Bulk(chip) | 259 | 3/59 | |
| | Dry Bulk(others) | 117 | 4/52 | |
| | Container | 131,000TEU | 2/33 | |
| | Total | 3,089 | | |

**7.4 Port Facilities**

The physical capacity of the Tien Sa Port and Song Han Port is estimated at about 2.2 million tons and 0.2 million tons respectively. Development scenario of Lien Chieu Port is based on the assumption that Tien Sa Port will be utilized up to its capacity with five berths and Song Han Port will not handle cargoes but passengers.

In case that new breakwater and the sixth berth would be developed in Tien Sa, it can increase the capacity of Tien Sa Port beyond 2.2 million tons and the development of Lien Chieu can therefore be deferred accordingly.

As shown in the Chapter 6, the cargo transportation demand through Lien Chieu Port is estimated at about 7.7 million tons in the year 2020 inclusive of container throughput of 330,000 TEUs.

Coping with these cargo throughputs, requirements for new berths in Lien Chieu Port are estimated at about two full size container berths (660 m), one multipurpose berths (270 m) and conventional general cargo berths (1,020 m). Bulk cargo jetty is now under construction by Hai Van Cement Co., Ltd. and part of which will be completed in the near future. All requirements for the new port of Lien Chieu are summarized in Table 7.4.1

**TABLE 7.4.1 Requirement for New Berths (in 2020)**

| Location | Berth | Length (m) | Alongside depth (m) | Target Ship Size |
|---|---|---|---|---|
| E1 | Multi purpose | 270 | -12 | 30,000 DWT class container vessels; 40,000 GT class car carriers; 20,000DWT class general trampers |
| E2-3 | Container | 660 | -13 | 47,000 DWT class container vessel (up to 58,000 DWT class with an ordinary operational draft) |
| W1-2 | General cargo | 320 | -9 | 10,000 DWT class general trampers |
| W3-5 | General cargo | 300 | -8 | 7,000 DWT class general trampers |
| W5-8 | General cargo/Liquid | 400 | -5.5 | 2,000 DWT class conventional vessels |
| W1 side and E1 side | Small crafts | 250 | -4 | Tug boats, Pilot boats, Customs' ships, others |

Cargo handing capacity of a berth is estimated by the standard performance of cargo handling operations at each berth, i.e. 3,000 tons/year per one meter of 2,000 DWT class conventional berths, 3,750 tons/year per one meter of 5,000-10,000 DWT class conventional berths, and 4,500 tons/year per one meter of deep water berths for general trampers. Container handling capacity of a full size container terminal is estimated at 150,000-200,000 TEUs per year. Because large portion of container throughput is domestic import and export and transit cargo to Laos and Northeast Thailand. Transhipment from a mother vessel to a feeder vessel is very few in Danang area, therefore, container handling performance cannot be so high as that of a transhipment port.

Each of full size container berth is planned to have an alongside length of 330 meters, an area of 10.5 ha for container yard, and two Panamax type gantry cranes. Multi-purpose berth is planned to accommodate container vessels, general cargoes vessels and car carriers with an alongside length of 270 meters, an area of 9.5 ha, and two gantry cranes. Conventional cargo berths are planned to have an alongside depth of 5.5-9.0 meters and a total length of 1,020 meters. Back yard has a total area of 40 ha for open yard, transit sheds, warehouses, truck pools and other port related land use.

Here, to determined the scale of berth, vessel type and sizes will first be explained. Cargo forecast is carried out by commodity basis, and as a result the vessel type can be specified for each cargo, for example a container vessel, a bulk carrier, and so on. Once the vessel type is specified, the alternative dimensions of each type of vessels can easily be found. These are general dimensions of each type and not necessarily applicable to the vessels which will possibly call the studied ports. The sizes of the possible vessels calling the specific port are to be examined. The most desirable and probable vessel sizes are examined taking into account the following issues;

- status of the port , that is, distinction between a mother port and a feeder port etc.
- cargo volume, that is, large vessels cannot call for a small amount of cargo and on the other hand small vessels are inadequate and inefficient for a large amount of cargo.
- calling conditions, that is, loading factors of vessels depend on their sea route.
- natural conditions, that is, the depth of berthing facilities largely depends on the atural conditions in the actual planning.

In the next step, the scale of berth, such as length and depth is determined according to the standard size of ships shown in Table A 7.4.1 as to add some allowance depending on ship size.

Four lane road will be necessary for port access from the hinterland. Port access road will be firstly built as a construction work road from Route No.1 near the Lien Chieu Station. Additional access road from Lien Chieu Industrial Park to the port will be necessary to avoid congestion on Route No.1.

Access channel is designed to have a length of 2,700 m, a width of 300 m and a depth of -13 m. Dredging of the access channel and turning basin will amount to 8 million $m^3$. (see Table 7.4.2)

**TABLE 7.4.2 Port Facilities in Master Plan**

| Facilities | Quantity | Remarks |
|---|---|---|
| Main Breakwater | 1,450 m | Depth at the top: -9.3 m |
| Berths | 1,950 m (-5.5 to -13 m) | See Table 7.4.1 for details |
| Land Reclamation | 962,000 $m^2$ | East & west wharves |
| Dredging | 8,160,000 $m^3$ | Channel depth: -13 m |
| Groin | 200 m | Mouth of Cu De River |

## 7.5 Port Development Options

### 7.5.1 Tien Sa Port

Tien Sa Port is located 9 km north of Danang City serving as the only gateway to the Central Region of Vietnam and to the East-West Transportation Corridor. Distance from Savannakhet, Lao PDR, to Danang is about 500 km, making it difficult for the port to attract transit cargo from/to Lao PDR and Northeast Thailand.

While the Port is located in a sheltered area in Danang Bay, N waves disturb ship mooring in NE monsoon season. Tien Sa Port is expected to handle up to about 2,200,000 tons of general/container cargo, but the backyard of the port is limited and its expansion is difficult due to its location. Consequently, it is difficult to expand the port to cope with full containerization. Access road to the port passes through a densely inhabited area, which is a disadvantage for large scale development.

Two platform jetties of Tien Sa Port have deteriorated and need rehabilitation in the near future. Tien Sa Port will be expanded to meet the urgent demand for containerization, however, the land area is not wide enough to develop a modern spacious container terminal. Cost-benefit of the development of a new deep berth does not seem favorable due to the fact that a new deep berth needs a shelter, water area for the development is limited and the back yard is also limited.

### 7.5.2 Song Han Port

Song Han Port is a river port developed in the Song Han River and serves for coastal shipping vessels. This port is planned to cater to passenger ships and not to cargo ships after the completion of a new port in the bay. As the port is close to the city center, the port will serve for small passenger ships and ferries with a water depth of 4 meters.

### 7.5.3 Lien Chieu (Option 1)

Lien Chieu area, the north water of the estuary of Cu De River, can be a development site for the new port as well as Nam O area and Song Han River Estuary areas. Although these development sites are located in Danang Bay, the water area is exposed to NE waves, so that the construction of a new port needs larger shelter.

Lien Chieu area is located 15 km west of Danang center and 24 km from Tien Sa Port. There are Road No.1 and railway truck behind the possible port area and part of backyard has already been urbanized.

Water area is partly sheltered by lien Chieu Cape and the contour line of minus 13 meters is 2,700 meters offshore from the planned breakwater. To shelter harbor waters from NNE, NE, ENE waves, breakwater with a length of 1,450 m is necessary. Nam O Cape will function as the headland to prevent sand drift into harbor waters. Port development plan in Lien Chieu area is shown in Figure A7.5.1.

### 7.5.4 Nam O (Option 2)

Nam O area is located in the south estuary of Cu De River and the south area from the Nam O Cape may be a development site for a new port. Port development plan for Nam O area is illustrated in Figure A7.5.2. As the area is exposed to NE monsoon waves directly, the option 2 has the longest breakwater among the proposed options. Second breakwater is also necessary to protect the basin from littoral sand drift.

### 7.5.5 Song Han Estuary West (Option 3)

The west side of the estuary of Han River may be a possible development site for a new port, where harbor waters are sheltered from NE waves by Tien Sa Cape. However, it is necessary to shelter the harbor water from N and NNE waves. Water depth of the area is minus 1-5 meters and a large volume of dredging is necessary to develop a deep sea port.

The West side of the estuary is just in front of the downtown of Danang City so that the development of a new coast road from Route No.1 is necessary for the transportation to the hinterland. (see Figure A7.5.3)

### 7.5.6 Song Han Estuary East (Option 4)

East Estuary of the Song Han River is also a possible development site. While the average depth of the development water area is less than 1 meter, the area is well sheltered from waves from all directions. Breakwater is not necessary in this development site, but a large volume of dredging is required for deep water berths. Access channel is planned to have a depth of -13 m and a length of about 2,200 m. North waters of this site are used by the Navy.

Since the port access road passes through the urban area, development of a bypass road or expansion of the existing road is necessary to meet the demand of port related traffic. It is also necessary to upgrade Nguyen Van Troi Bridge to allow heavy traffic or build a new bridge over the Han River. Danang City has a redevelopment plan of the East Bach Dang area. (see Figure A7.5.4)

### 7.5.7 Comparative Evaluation of Options

Among the four development options, Option 2 (Nam O) has a difficulty in developing breakwaters to shelter the harbour waters. Since the area is exposed to offshore waves directly, port development requires a lot of investment in the construction of breakwaters, which is costly and time consuming compared with other options.

Option 3 (Son Han West) has a disadvantage in location and dredging volume. The area is located in front of the heavily populated city center so that it would not be appropriate to reclaim land in the area. Direction of the littoral sand drift is from west to east on the coast of Danag Bay, therefore, harbor water may require a considerable amount of maintenance dredging.

Option 4 (Son Han East) may be an appropriate site for port development next to Option 1 (Lien Chieu), however, a difficulty is foreseen in the location of the Navy Base, the volume of capital dredging, and heavily populated surroundings. Since the site has an average depth of 1 meter, it requires a huge volume of initial dredging. Many residents will be obliged to relocate to develop a port access road. Advantages in this option are well sheltered water areas, and close connection to the existing Tien Sa Port.

The location of Option 1 will have the least impact on the beach in front of the Danang City among the options 1-3.

Taking into consideration the comparative evaluation of the alternatives shown in Table 7.5.1, Option 1 is recommended for the development of the new port in Danang Bay. (see Figure A7.5.5)

**TABLE 7.5.1 Comparative Evaluation of Alternatives**

| Items | Option 1 Lien Chieu | Option 2 Nam O | Option 3 Song Han West | Option 4 Song Han East |
|---|---|---|---|---|
| Waves in the development site | ○ Fair | △ Strong | ○ Fair | ◎ None |
| Period required for the first stage of the development | ◎ Short | △ Long | △ Long | △ Long |
| Depth of main breakwater | ○ Fair -10m | ○ Fair -10m | ○ Fair -2~8m | ◎ No Breakwater |
| Volume of dredging | △ Large | △ Large | △△ Larger | △△△ Very Large |
| Construction cost | ○ Medium | ○ Medium | ○ Medium | ◎ Smaller |
| Possibility for future development | ○ Fair | ○ Fair | ○ Fair | ○ Fair |
| Impacts on sand drift along the coast | ○ Medium | △ Fairly Large | ○ Medium | ◎ None |
| Port access from Route No.1 | ◎ Good | ◎ Good | ○ Fair | △ Poor |
| Overall Evaluation | ◎ Good | △ Fairly Poor | △ Fairly Poor | ○ Medium |

Note:
◎ Good, Reasonable
○ Fair, Medium
△ Poor

## 7.6 Port Development Master Plan

### 7.6.1 Port Layout Plan

Maximum size of calling vessels at Lien Chieu is deemed to be Panamax type container vessels, whose tonnage is about 58,000 DWT with a length of 270-290 meters, a design draft of minus 13 meters and an operational draft of 11-12 meters. Mother container vessels are usually operated with shallower draft than its design draft due to empty containers and less cargo volume than its capacity. Two container berths are designed with a length of 660 meters and a depth of 13 meters.

To cater to conventional cargo vessels, Ro/Ro vessels, container feeder vessels and other coastal vessels, 9 alongside berths are designed with a total length of 1,290 m and a depth of 5.5, 8 or 9 meters.

A breakwater is extended from the Lien Chieu Cape to south east with a length of 1,450 m. Water depth of the breakwater site is 8-9 m. Most part of the breakwater is utilized as the seawall to reclaim land from the sea. A 200 meter long groin is planned at the mouth of Cu De River to prevent the blockage of the river mouth.

Access channel has a length of 2,700 m and a width of 300 m, which is 1L of the largest calling vessel. Turing basin has a diameter of 2L of the largest calling vessel at each berth. Port facilities layout of Master Plan is shown in Figure 7.6.1. Location of the new port in Danang Bay is shown in Figure A7.6.1 (Appendix) and Port Development Master Plan of Lien Chieu area is shown Figure A.7.6.2 and (Appendix).

### 7.6.2 Calmness of Harbor Waters

(Offshore Waves)

Direction-wise wave height occurrences are estimated from wind data obtained by European Center for Medium Range Weather Forecast, which covers all the sea by every 2.5 degrees. Offshore wave heights at N17.5° E107.5° (Quang Tri offshore) and N15° E110° (Quang Nagi offshore) are estimated as shown in Table A7.6.1 and A7.6.2 in Appendix. Since Danang is located in the middle of two provinces, wave heights at Danang offshore are deemed to be the middle of the two estimates, which indicates that more than 60 percent of the waves height occurrences are from NE, ENE and E.

(Wave Refraction and Shoaling)

Energy of offshore waves decreases in approaching the shoreline due to refraction, shoaling and diffraction. Reduction ratio of offshore waves is estimated by means of computer simulation. At the mouth of the planned new port, offshore waves are estimated to decrease to 70% in Lien Chieu. Wave refraction diagram from offshore to the development site is shown in Figure A7.6.3 - A7.6.8 (Appendix).

Maximum wave height during a period of two years[1] is assessed at 2.7 m from ENE at the planned entrance of Lien Chieu Port. Offshore waves change their directions to ENE when approaching the development site of Lien Chieu (see Table 7.6.2).

(Wave Diffraction in Harbor Waters)

Wave disturbance to berths is checked by calculating wave diffraction in the harbor waters. Reflection factor used in the simulation is 0.9 at upright quaywalls or seawalls, 0.5 at low reflection structures and 0.1 at natural beach.

Wave height in front of the planned deep sea container berth (E3) is estimated at about 1.0 m against the above mentioned maximum offshore wave. (see Table 7.6.3.) A large ship can safely receives waves up to 1 m from the bow or astern and waves up to 0.7 m from the side. For cargo handling operations, wave disturbance should be less than 0.5 m and this level will be assured throughout 95 percent of a year. Wind speed should also be less than 10 m for cargo operations. Details of wave diffraction are shown in Figures A7.6.9-A7.6.11.

**TABLE 7.6.3 Wave Heights[1] in Harbor**

(meters)

| Wave Direction / Area | NE | ENE | E |
|---|---|---|---|
| Off Breakwater | 2.4 | 2.7 | 1.5 |
| Berth E3 | 0.8 | 1.0 | 0.6 |
| Berth W4 | 0.6 | 0.8 | 0.5 |

Note 1/ High wave height which may occur once every two years

[1]/ From 1 January 1993 to 31 December 1994, Swells are estimated based on Pierson and Moskowitz Spectrum and wind waves are based on Wilson's Equation

### 7.6.3 Ship Maneuvering

Approach channel is designed to have a width of 300 meters, approximately 1L of the maximum calling vessel. Turning basin is also designed to have a diameter of 600 meters, approximately 2L of the maximum calling vessel, assuming tug boat services. Figure A7.6.12 illustrates ship maneuvering for port entry and berthing.

### 7.6.4 Port Access Road

Port related traffic is estimated at about 2,070 per hour in the year 2020. Breakdowns are 1,380 per hour of trucks and 690 per hour of passenger cars. As the traffic capacity is 650 per hour for two lane road and 2,400 per hour for four lane road, port access road is designed to have 4 lanes with a width of 22 meters or more.

### 7.6.5 Optional Port Layout Plan (Off Lien Chieu Cape)

Supposing a case that Lien Chieu Cape is reserved, an alternative development plan for Lien Chieu area is designed as shown in Figure A7.6.13. Same number of container berths are planned in the Optional Port Layout Plan and the capacity of port will be the same as the proposed Master Plan. Optional plan needs the replacement of Hai Van Cement jetty, and four alongside berths are designed in addition to the berths of the Master Plan. Optional Plan will be more costly than the Master Plan and will need longer construction period for the initial stage development.

**TABLE 7.6.2 Maximum Significant Wave Height and Direction During a Period of Two Years**

Lien Chieu Offshore

| Direction | Height (m) | Frequency (sec) |
|---|---|---|
| NNW | 1.9 | 5.6 |
| N | 3.9 | 7.8 |
| NNE | 3.5 | 7.6 |
| NE | 3.6 | 8.0 |
| ENE | 3.8 | 8.5 |
| E | 3.2 | 7.9 |

Lien Chieu Port Entrance

| Direction | Height | Frequency | Change in the WaveDirection |
|---|---|---|---|
| | (m) | (sec) | (dgree) |
| NNW | 0.5 | 5.3 | △66 |
| N | 1.5 | 7.9 | △54 |
| NNE | 1.9 | 7.9 | △36 |
| NE | 2.4 | 8.6 | △18 |
| ENE | 2.7 | 8.8 | 0 |
| E | 1.5 | 7.8 | ▲18 |

△ Clock-wise

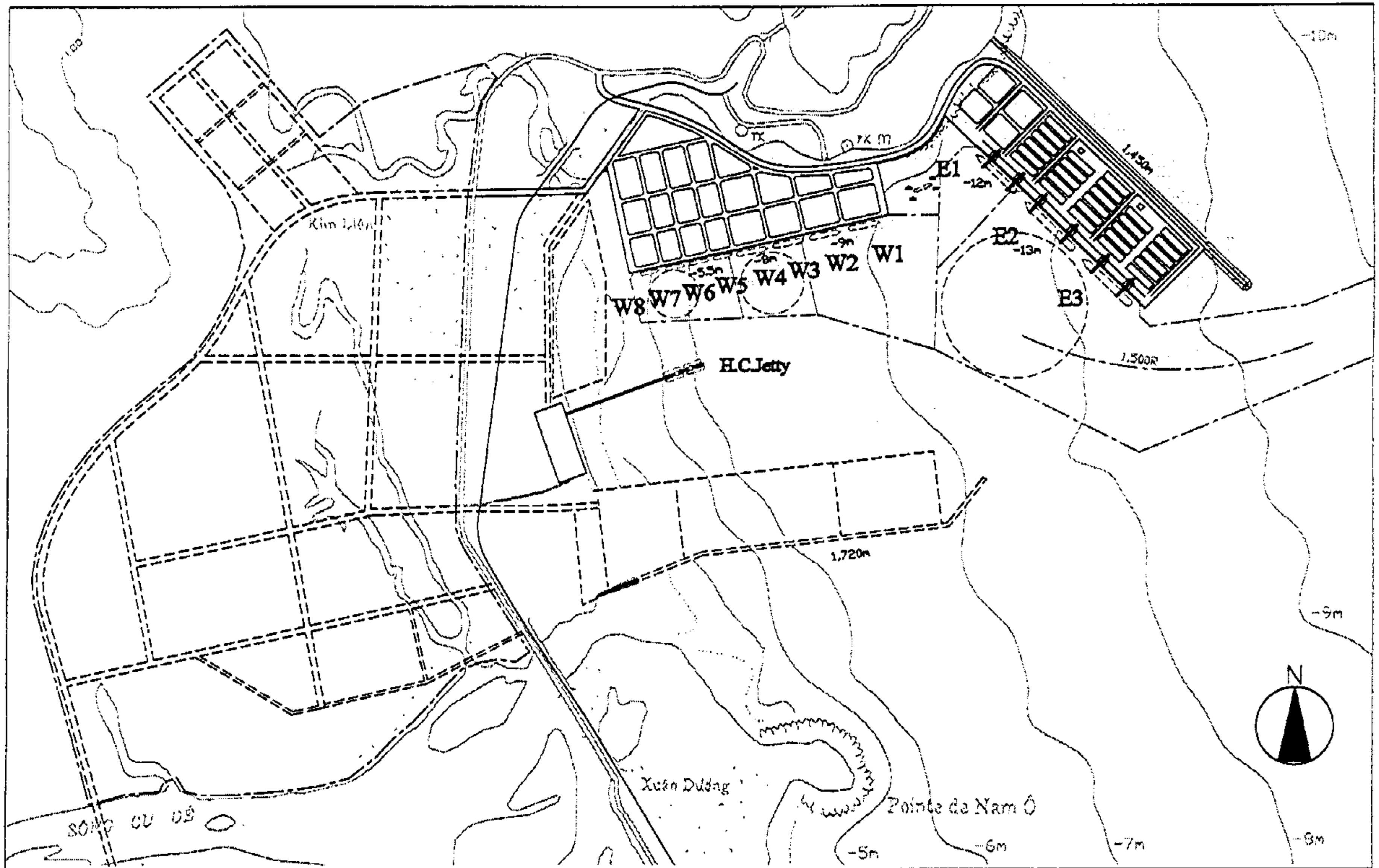
▲ Anti Clock-wise

Shoaling Coefficient

| Direction | Height | Frequency | Change in the WaveDirection |
|---|---|---|---|
| | | | (degree) |
| NNW | 0.24 | 0.94 | △66 |
| N | 0.39 | 1.01 | △54 |
| NNE | 0.55 | 1.04 | △36 |
| NE | 0.66 | 1.07 | △18 |
| ENE | 0.70 | 1.04 | 0 |
| E | 0.48 | 0.99 | ▲18 |

△ Clock-wise

▲ Anti Clock-wise




| JICA Port Development Study in Central Region | Figure 7.6.1 | Final Report 1998 |
|---|---|---|
| Lien Chieu Port Development Masterplan | | FILE LC-DF-MP-A4 |

# 8. Initial Stage Development Plan (Short-term Development Plan)

## 8.1 Industrial Development

There are four industrial zones in Danang City and Quang Nam Province, namely, Danang Export Processing Zone, Lien Chieu IZ, Hoa Khanh IZ, Dien Nam-Dien Ngoc IZ. These industrial zones are assumed to be fully occupied with factories in 2020 in accordance with economic growth and advancement of transportation. Some factories in these industrial zones except for Dien Nam-Dien Ngoc IZ are already operating. Occupancy ratio of IZ in 2010 is assumed based on present situation of IZ, factory invitation policy of Quangnam-Danang Export Processing and Industrial Zones Authority as shown in Table 8.1.

**Table 8.1.1 Occupancy Ratio of IZ in 2010**

| Name of Industrial Zone | Occupancy Ratio |
|---|---|
| Danang Export Processing Zone | 62% |
| Lien Chieu and Hoa Khanh IZ | 67% |
| Dien Nam-Dien Ngoc IZ | 52% |

## 8.2 Cargo Throughput

Cargo throughput of Danang Bay is estimated by micro forecast method as explained in 6.4 Commodity-wise Forecast and allocation of ports is estimated based on location of port, cargo handling capacity, facilities and future development plan. Results are shown in Table 8.2.1～8.2.3.

**Table 8.2.1 Cargo Throughput of Danang Bay in 2010**

Unit: Ton

| Commodities | Foreign | | Domestic | |
|---|---|---|---|---|
| | Export | Import | Loading | Unloading |
| Oil Products | 0 | 295,500 | 143,800 | 0 |
| Agriculture, Fishery and Forest Products | 40,500 | 0 | 0 | 37,700 |
| Bulk (Silica Sand, Coal, Clinker) | 103,300 | 780,000 | 0 | 174,400 |
| Break bulk (Fertilizer, Wood Chip, Tar) | 247,000 | 442,000 | 0 | 0 |
| Steel and Scrap | 0 | 485,000 | 240,000 | 0 |
| Cement | 187,200 | 0 | 436,800 | 0 |
| Manufacturing Products and Consumer Goods | 419,400 | 1,203,100 | 195,300 | 181,600 |
| International Transit Cargo | 343,000 | 286,000 | - | - |
| (Sub Total) | 1,340,400 | 3,491,600 | 1,015,900 | 393,700 |
| (Total) | | 6,241,600 | | |

**Table 8.2.2 Cargo Throughput of Danang Port in 2010**

Unit: Ton

| Commodities | Foreign | | Domestic | |
|---|---|---|---|---|
| | Export | Import | Loading | Unloading |
| Oil Products | 0 | 0 | 0 | 0 |
| Agriculture, Fishery and Forest Products | 40,500 | 0 | 0 | 37,700 |
| Bulk (Silica Sand, Coal, Clinker) | 103,300 | 0 | 0 | 174,400 |
| Break bulk (Fertilizer, Wood Chip, Tar) | 247,000 | 442,000 | 0 | 0 |
| Steel and Scrap | 0 | 0 | 0 | 0 |
| Cement | 93,600 | 0 | 218,400 | 0 |
| Manufacturing Products and Consumer Goods | 208,800 | 715,100 | 87,800 | 90,800 |
| International Transit Cargo | 0 | 0 | - | - |
| (Sub Total) | 693,200 | 1,157,100 | 306,200 | 302,900 |
| (Total) | | 2,459,400 | | |

**Table 8.2.3 Cargo Throughput of Lien Chieu Port in 2010**

Unit: Ton

| Commodities | Foreign | | Domestic | |
|---|---|---|---|---|
| | Export | Import | Loading | Unloading |
| Oil Products | | 295,500 | 143,800 | |
| Agriculture, Fishery and Forest Products | 0 | 0 | 0 | 0 |
| Bulk (Silica Sand, Coal, Clinker) | 0 | 780,000 | 0 | 0 |
| Break bulk (Fertilizer, Wood Chip, Tar) | 0 | 0 | 0 | 0 |
| Steel and Scrap | 0 | 485,000 | 240,000 | 0 |
| Cement | 93,600 | 0 | 218,400 | 0 |
| Manufacturing Products and Consumer Goods | 210,600 | 488,000 | 107,500 | 90,800 |
| International Transit Cargo | 343,000 | 286,000 | - | - |
| (Sub Total) | 647,200 | 2,334,500 | 709,700 | 90,800 |
| (Total) | | 3,782,200 | | |

Furthermore, cargo throughput of Danang Bay and allocation of ports are estimated on the assumption that development will be slow as shown in Table 8.2.4～8.2.6.

**Table 8.2.4 Cargo Throughput of Danang Bay in 2010**

(Low Growth Case)

Unit: Ton

| Commodities | Foreign | | Domestic | |
|---|---|---|---|---|
| | Export | Import | Loading | Unloading |
| Oil Products | 0 | 240,300 | 119,600 | 0 |
| Agriculture, Fishery and Forest Products | 35,800 | 0 | 0 | 18,900 |
| Bulk (Silica Sand, Coal, Clinker) | 52,100 | 780,000 | 0 | 104,200 |
| Break bulk (Fertilizer, Wood Chip, Tar) | 247,000 | 416,400 | 0 | 0 |
| Steel and Scrap | 0 | 35,000 | 40,000 | 0 |
| Cement | 187,200 | 0 | 436,800 | 0 |
| Manufacturing Products and Consumer Goods | 284,100 | 894,200 | 97,700 | 90,700 |
| International Transit Cargo | 129,000 | 125,000 | - | - |
| (Sub Total) | 935,200 | 2,490,900 | 694,100 | 213,800 |
| (Total) | 4,334,000 | | | |

**Table 8.2.5 Cargo Throughput of Danang Port in 2010**

(Low Growth Case)

Unit: Ton

| Commodities | Foreign | | Domestic | |
|---|---|---|---|---|
| | Export | Import | Loading | Unloading |
| Oil Products | 0 | 0 | 0 | 0 |
| Agriculture, Fishery and Forest Products | 31,100 | 0 | 0 | 0 |
| Bulk (Silica Sand, Coal, Clinker) | 52,100 | 0 | 0 | 104,200 |
| Break bulk (Fertilizer, Wood Chip, Tar) | 247,000 | 416,400 | 0 | 0 |
| Steel and Scrap | 0 | 0 | 0 | 0 |
| Cement | 93,600 | 0 | 218,400 | 0 |
| Manufacturing Products and Consumer Goods | 148,800 | 562,400 | 0 | 0 |
| International Transit Cargo | 0 | 0 | - | - |
| (Sub Total) | 572,600 | 978,800 | 218,400 | 104,200 |
| (Total) | 1,874,000 | | | |

**Table 8.2.6 Cargo Throughput of Lien Chieu Port in 2010**

(Low Growth Case)

Unit: Ton

| Commodities | Foreign | | Domestic | |
|---|---|---|---|---|
| | Export | Import | Loading | Unloading |
| Oil Products | 0 | 240,300 | 119,600 | 0 |
| Agriculture, Fishery and Forest Products | 4,700 | 0 | 0 | 18,900 |
| Bulk (Silica Sand, Coal, Clinker) | 0 | 780,000 | 0 | 0 |
| Break bulk (Fertilizer, Wood Chip, Tar) | 0 | 0 | 0 | 0 |
| Steel and Scrap | 0 | 35,000 | 40,000 | 0 |
| Cement | 93,600 | 0 | 218,400 | 0 |
| Manufacturing Products and Consumer Goods | 135,300 | 331,800 | 97,700 | 90,700 |
| International Transit Cargo | 129,000 | 125,000 | - | - |
| (Sub Total) | 362,600 | 1,512,100 | 475,700 | 109,600 |
| (Total) | 2,460,000 | | | |

## 8.3 Ship Calls

Based on trends of the past net tonnage of calling vessels and future cargo volume, future number of calling vessels in 2010 is estimated for each ship type. The number of each vessel type in past four years of Danang Port is shown in Table 8.3 1.

**Table 8.3.1 Number of Ship Calls of Danang Port**

| Type of Ship | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|
| Cargo Ship (Foreign) | 152 | 173 | 217 | 229 |
| Cargo Ship (Domestic) | 95 | 60 | 64 | 147 |
| Passenger Ship | 31 | 28 | 36 | 35 |
| (Total) | 278 | 261 | 317 | 411 |

Source: Danang Port Authority

The projected vessel calls in 2010 are estimated as follows.

**Table 8.3.2 Number of Ship Calls in 2010**

| Type of Ship (DWT) | | | Number of ships /year |
|---|---|---|---|
| Container | Foreign | 20,000 | 122 |
| General Cargo (Construction Materials) | Coastal | 10,000-5,000 | 10 |
| General Cargo (Others) | Foreign | 3,000-10,000 | 30 |
| General Cargo | Coastal | 1,000-3,000 | 33 |
| Bulk Cargo (Clinker) | Foreign | 2,000-5,000 | 650 |
| Bulk Cargo (Cement) | Foreign | 5,000 | 23 |
| Bulk Cargo (Scrap) | Foreign | 5,000-30,000 | 61 |
| Bulk Cargo | Coastal | 3,000 | 191 |
| Car Carrier | | 40,000 | 56 |
| Ro / Ro | Coastal | 4,000-7,000 | 63 |
| Oil Tanker | Coastal | 5,000 | 7 |
| Total | | | 1,248 |

## 8.4 Port Facilities and Layout for ISP (Short term development plan)

### 8.4.1 Stage-wise Development

Scale of development affects the viability of port development project, in particular at the first stage of the development. Special attention should therefore be paid to the scale of economy. Industrial port usually has a base cargo and can invite regular ship calls. Industrial development projects in the hinterland may bear part of the port construction cost. However, commercial port has no guarantee of regular ship calls. A new commercial port also requires a close connection with city to provide shippers, consignees and shipping service agents with offices, bank services, telecommunication services and other city services.

Initial stage development plan (Short term development plan) should therefore be carefully designed from a view point of the scale of initial investment and the timing of completion of the project. Stage-wise development plan of Lien Chieu Port is shown in Figure 8.4.1, in which the construction works start from the main breakwater from Lien Chieu Cape. Three alongside berths (E1 & W1-2) will be developed at the initial stage. The main breakwater will be built with a length of 830 m to shelter these three berths. A groin will be necessary at the mouth of Cu De River to prevent the blockage of river flow. Dredging of channel and basin will be carried out up to - 11 m and be deepened to -13 m at the next stage.

### 8.4.2 Port Facilities for ISP (Short term development plan)

Taking into consideration that container throughput is not large enough to attract mother container vessels in the initial stage, maximum size of calling container vessel is considered at about 30,000 DWT in the initial stage. Berth E1 is designed as a multi-purpose berth with an alongside depth of −12 m (under CDL) to cater to 30,000 DWT class container vessels, 40,000 GT class car carriers, 20,000 DWT class general cargo trampers and others. As the call of such size ships are expected not to be so frequent, the design depth of channel and turning basin is −11 m and the pocket dredging to −12 m is planned in the front of the Berth E1.

Two conventional cargo berths, W1 and W2, are included in ISP with a provisional alongside depth of −8.0 m, which are deepened to −9.0 m in the Master Plan. Quay wall between the berth E1 and W1 can be used by small port service boats.

Main breakwater has a length of 830 m, which is extended to shelter the berths against waves from ENE. A 150 m groin is planned in the north end of the mouth of Cu De river to protect the river mouth. While the basin is planned to have a depth of –13 m in the Master Plan, it is assumed that the basin has a depth of –11 m in the initial stage and can be deepened up to –13 m in the next stage of the development. Port facilities planned for the ISP are summarized in Table 8.4.1 and port facilities layout plan is shown in Figure 8.4.2. Initial Stage Development Plan of Lien Chieu is shown in Figure A.8.4.1 (Appendix).

Besides port facilities planned for ISP, it is assumed that the pier of Hai Van Cement Co. will be completed in the near future with a capacity to handle their materials and products. It is also assumed that Petrolimex will shift their buoy berth from My Khe Port to Danang Bay, and will handle certain amount of oil products at their own capacity. However, redistribution of oil products will be done through Lien Chieu area.

**TABLE 8.4.1 Port facilities planned for ISP (Short term development plan)**

| Port Facilities | Sizes | Remarks |
|---|---|---|
| Berths | | |
| E1 | L 270 m, D –12m | Multi-purpose berth for up to 30,000 DWT class container vessels, up to 40,000GT class car carrier, up to 20,000 DWT class general trampers |
| W1 and W2 | L 160 m, D –8 m (to be deepened to –9.0 m in the next stage) | Conventional berths for 5,000DWT class general cargo ships and others. |
| Small craft berths | L 250 m (end of No.1 and side of No.4 ) | Tug boats, Pilot boats, Customs ships and others |
| Land Reclamation | 287,000 m2 | East and West Wharves |
| Breakwater/Seawall | L 830 m | Deepest seabed –8.5 m |
| Channel & Turning Basin | D –11 m, (partly -12) Volume 2,960,000 m3 | Provisional depth of turning basin is -11 m (pocket dredging -12 m) |

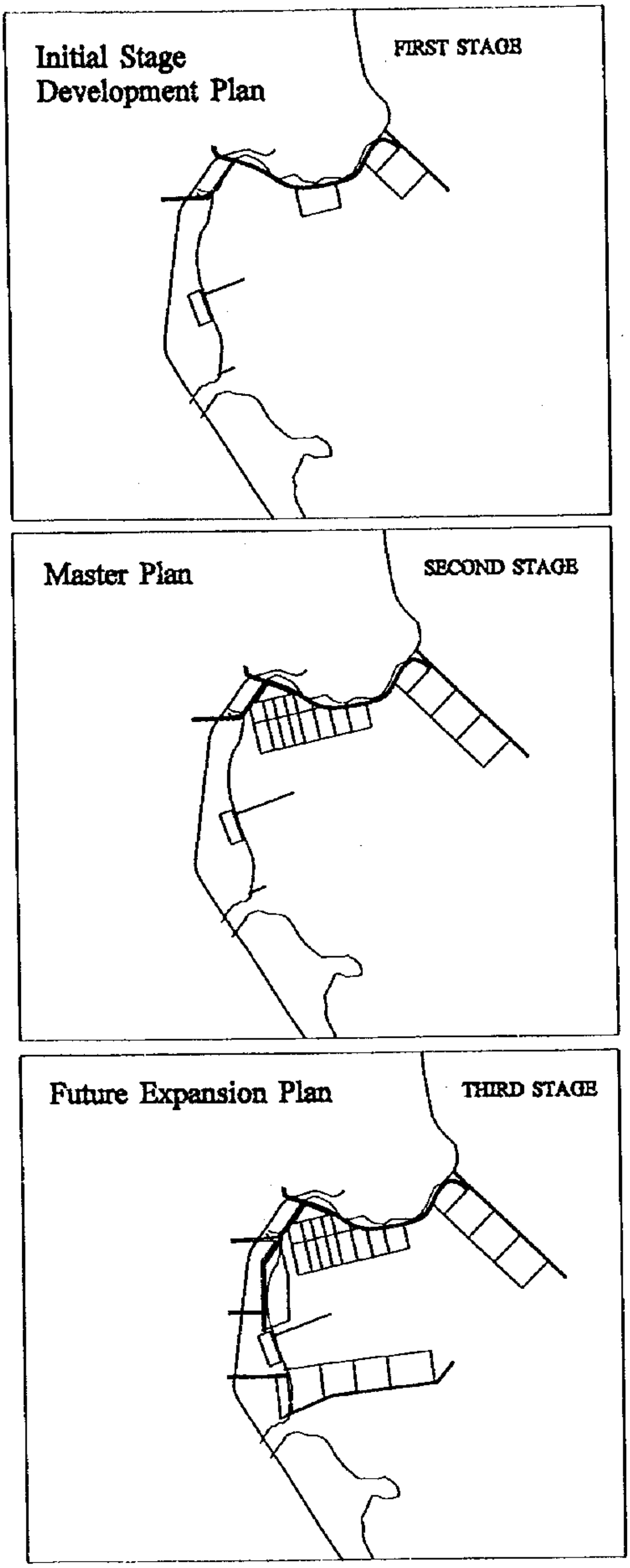
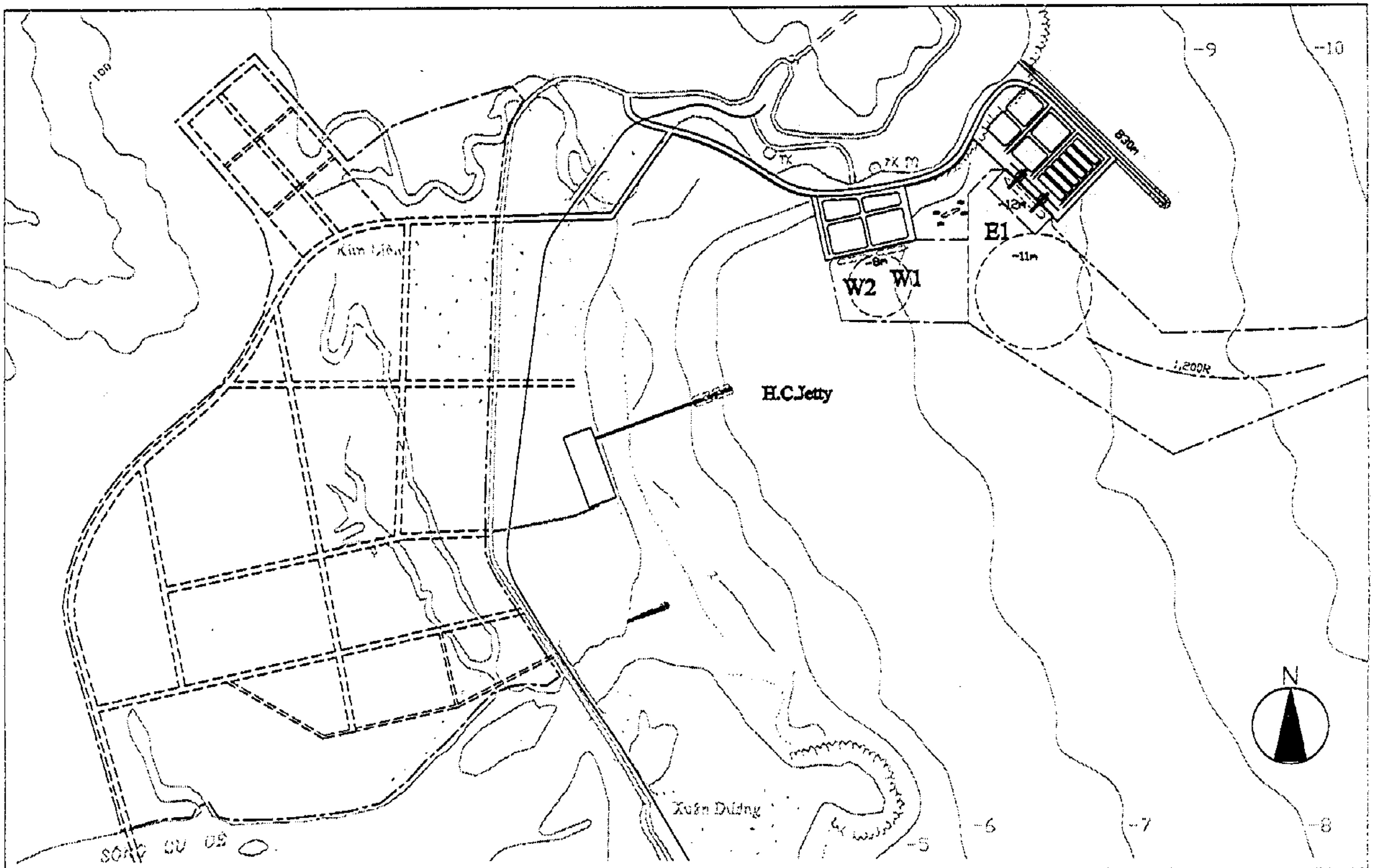



Figure 8.4.1 Lien Chieu Development Stage Plan




| | | |
|---|---|---|
| JICA Port Development Study in Central Region | Figure 8.4.2 | Final Report 1998 |
| Lien Chieu Port Development Masterplan | 0 200 400 600 800 1,000m | FILE LC-ISP-A4 |

## 8.5 Implementation Plan

The development work will start from the construction of access road from Route No.1 to the site of main breakwater, which will be extended from Lien Chieu Cape to SE direction. The section between the berth E1 and the access road, revetment with a length of 140 m, can be used as a work site during the construction stage.

Existing oil tanker buoys may be replaced if necessary. Berths W1 and W2 will be developed following the completion of the berth E1. Construction schedule of each berth is planned to cover the cargo throughput demand for the high growth case and low growth case.

Scenarios for the development are deemed as follows:

Scenario 1:

Besides the rehabilitation of Tien Sa No.1-4 berths and the upgrade of port access road and Nguyen Van Troi bridge, Tien Sa No.6 berth will be developed. In high growth case of cargo throughput, it will require the development of Tien Sa No.6 by 2004 and then Lien Chieu E1 by 2006. In low cargo growth case, it will become necessary to develop Tien Sa No.6 by 2007 and Lien Chieu E1 by 2010. (see Figure 8.5.1 and 8.5.2)

Furthermore, in medium cargo growth case, it will become necessary to develop Tien Sa No.6 by 2005 and Lien Chieu E1 by 2007 shown in figure A 8.5.1.

Scenario 2:

Tien Sa will remain with five berths, in which No.1-4 will be rehabilitated and No.5 will be completed by the end of 1998. Lien Chieu will be developed to meet the demand exceeding the capacity of Tien Sa Port. Under this scenario, it will become necessary to develop Lien Chieu E1 berth by 2004 in high growth case and by 2007 in low growth case. (see Figures 8.5.3 and 8.5.4)

In both scenarios, it will be necessary to rehabilitate the existing No.1-4 berths and upgrade a 11 km access road and Nguyen Van Troi Bridge. These work should be completed in the near future.

Scenario 3:

No investment will be made in Tien Sa Port and access road/bridge and efforts are made to develop Lien Chieu area. This scenario will have a difficulty in coping with cargo demand in the near future.

**TABLE 8.5.1 Possible Development Scenarios**

| Tien Sa \ Lien Chieu | Implementation of ISP | No development |
|---|---|---|
| Additional Berth (Development of No.6 berth; Rehabilitation of existing berths; Upgrade of access road and bridge) | Scenario 1 | Not applicable after the year 2006/2010[1/] |
| Upgrade (Rehabilitation of existing berths; Upgrade of access road and bridge; No additional berth) | Scenario 2 | Not applicable after the year 2004/2007[2/] |
| No development; No upgrade | Scenario 3 | Not applicable |

Note 1/ 2006 in the high growth case and 2010 in the low growth case
2/ 2004 in the high growth case and 2007 in the low growth case

There will be an additional option to Tien Sa that new breakwater is developed to improve the calmness of Tien Sa port and an additional berth is not developed along the breakwater. This option will be able to improve the capacity of the port to some extent but far from the demand anticipated in the future. Therefore, the development of new berth will be required in the same manner as the Scenario 2.

## 8.6 Development Suitability of Tien Sa and Lien Chieu

Two development sites have following characteristics from the viewpoint of land transportation, economic/social impact, environmental conditions, demand for seaborne cargo transportation, and port development. (see Table 8.6.1)

Development of Tien Sa Port requires the improvement of access road from Route No.1, of which 6 km between Nguyen Van Troi Bridge and Route No.1 will be completed by early 1998. However, the improvement of 11 km between Nguyen Van Troi Bridge and Tien Sa Port and the rehabilitation of the Bridge are necessary as a package of the development of Tien Sa Port.

Lien Chieu Port needs the development of breakwater and an access channel at the first stage, which requires a fairly large initial investment and relatively long construction period. However, the development of the second stage requires less investment and a shorter construction period.

Advantages of the development of Tien Sa No.6 are 1) less investment in the initial stage and 2) improvement of calmness in the basin of the existing No.1-No.4 Berths. However, the development of Tien Sa has disadvantages in 1) less space for the future expansion; 2) limited yard space, narrow basin and insufficient length of quaywall; 3) long access road through urbanized area (Tien Sa - Nguyen Van Troi Bridge 11 km); 4) additional investment in the rehabilitation of the Bridge; and 5) long transportation to main industrial zones in Danang City.

On the contrary, advantages of the development of Lien Chieu are 1) development of full size container terminals and sufficient yards for the cargo operations; 2) easy access to the highway Route No.1 and a new bypass through Hai Van Tunnel; 3) connection to industrial zones in Danang City; 4) land/water space for the future development. However, disadvantages are 1) fairly large initial investment; 2) large volume of dredging; and 3) existing oil tanker mooring buoys.

Accordingly, the development of the Tien Sa area should be sufficient to meet the urgent demand and yet the scale of development should be minimized to the extent possible. Scenario 2 is therefore recommended to expand the capacity of Danang port while scenario 1 is given second priority (in the event that economic turmoil in Asian countries affects economic development of Vietnam severely, the development of the Lien Chieu would be deferred). Since this study did not include a detailed development plan of the Tien Sa area due to another on-going study, more detailed study on the improvement of the Tien Sa area may be helpful to clarify the development strategy.

**TABLE 8.6.1 Development Suitability of Tien Sa and Lien Chieu**

| Items | Tien Sa | Lien Chieu |
|---|---|---|
| **Land Transportation** | | |
| Distance to the Route No.1 | △<br>18 km from the Route No.1, and more distance from the planned new route[1/] | ○<br>2 km from the present Route No.1, and 7 km from the planned new route[1/] through Hai Van Tunnel |
| Road Development | △<br>The upgrade of Nguyen Van Troi bridge and/or the development of a new bridge at Tuyen Son site, and the upgrade of the 11 km access road will be necessary | ○<br>Connection to the present Route No.1 and its future bypass[1/] will be easier. Crossing the railroad will need a flyover in the future. |
| **Economic/Social Impact** | | |
| Trigger for Industrial Development | △<br>Tien Sa is not suitable for the transportation of bulky cargo, and can not help the development of factories which needs bulk cargo handling | ○<br>New port can encourage the development of industrial zones adjacent to the hinterland |
| Traffic Load on City Area | △<br>Port access traffic passes through areas of dense population in Danang City | ○<br>Port access road runs through areas of sparse population in Danang City and port traffic will give less impact on the surroundings |
| **Environment** | | |
| Condition of the surroundings | ○<br>Tien Sa is located in the west coast of Son Tra peninsula, which is designated as a conservation area. Development , mountain he area is | ○<br>The areas are currently low value, low populated land with few commercial activities |
| **Demand for Seaborne Cargo** | | |
| Origin and Destination of Seaborne Cargo | △<br>If Tien Sa No.6 berth is developed, some portion of handling cargo will be from/to the Lien Chieu Hoa Khanh Industrial Zone | ○<br>The new port in Lien Chieu area is convenient for cargo from/to the industrial zones |

Note ○ suitable; △ not so suitable, not so appropriate

1/ Planned North South Highway through Hai Van Tunnel

| Items | Tien Sa | Lien Chieu |
|---|---|---|
| **Port Development** | | |
| Construction of Marine Facilities | ○<br>Water area is deeper and the seabed has enough bearing capacity | △<br>Water depth is shallower and the replacement of soft clay with sand will be necessary to build a breakwater and seawall |
| Water Area | △<br>The scale of development is limited to one berth due to the width of water area available | ○<br>Wider water area is available for the development of a new port |
| Land Area | △<br>Back yard is limited and has a difficulty in developing a full size container berth | ○<br>Land reclamation can provide enough land area for port facilities and Lien Chieu Industrial Zone can also provide additional area |
| Initial Investment | ○<br>Less investment to develop an additional berth (Tien Sa No.6) | △<br>Initial investment is higher due to the dredging and breakwater construction, which are common infrastructure for the whole new port |
| Total Investment | △<br>Even in case that Tien Sa No.6 berth will be build by the year 2004-2006, the first berth in Lien Chieu becomes necessary by 2007-2010. A large scale investment in the both sites will not so cost-effective | ○<br>From the view point of long-term development, it will be effective to invest in Lien Chieu |
| Estimated Capacity | △<br>Tien Sa No.6 Berth and upgraded port access road will increase the capacity of the port by 0.9-1.1 million tons2/ (to a total capacity will be 3.1-3.3 million tons). Total land area of Tien Sa is 23 ha after the completion of No.6 | ○<br>Masterplan has a capacity of about 8.3 million tons3/ with 11 berths (including 2 full size container berths and 1 multi-purpose berth) and a land area of 100 ha |
| Estimated Cost | - | Three berths are planned to have a total capacity of about 2.6 million tons2/ to cope with the demand up to the year 2010. Necessary investment is about US$160 million. |

Note 2/ Based on the assumption that No.6 is a multi-purpose berth

3/ Exclusive of the capacity of Hai Van Cement Jetty

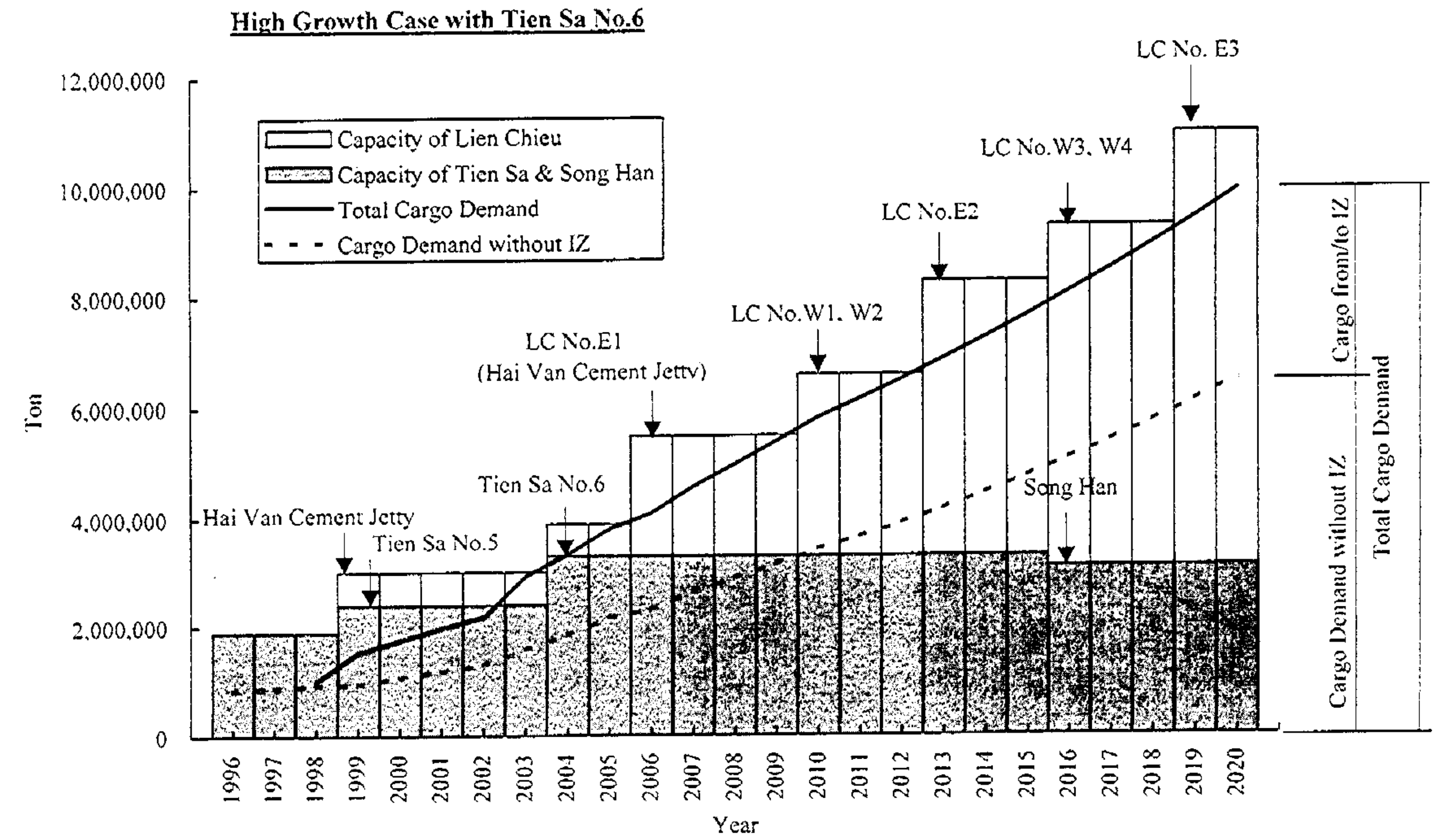



**Figure 8.5.1 Capacity and Cargo Throughput in Danang Port (Tien Sa, Song Han and Lien Chieu Area)**

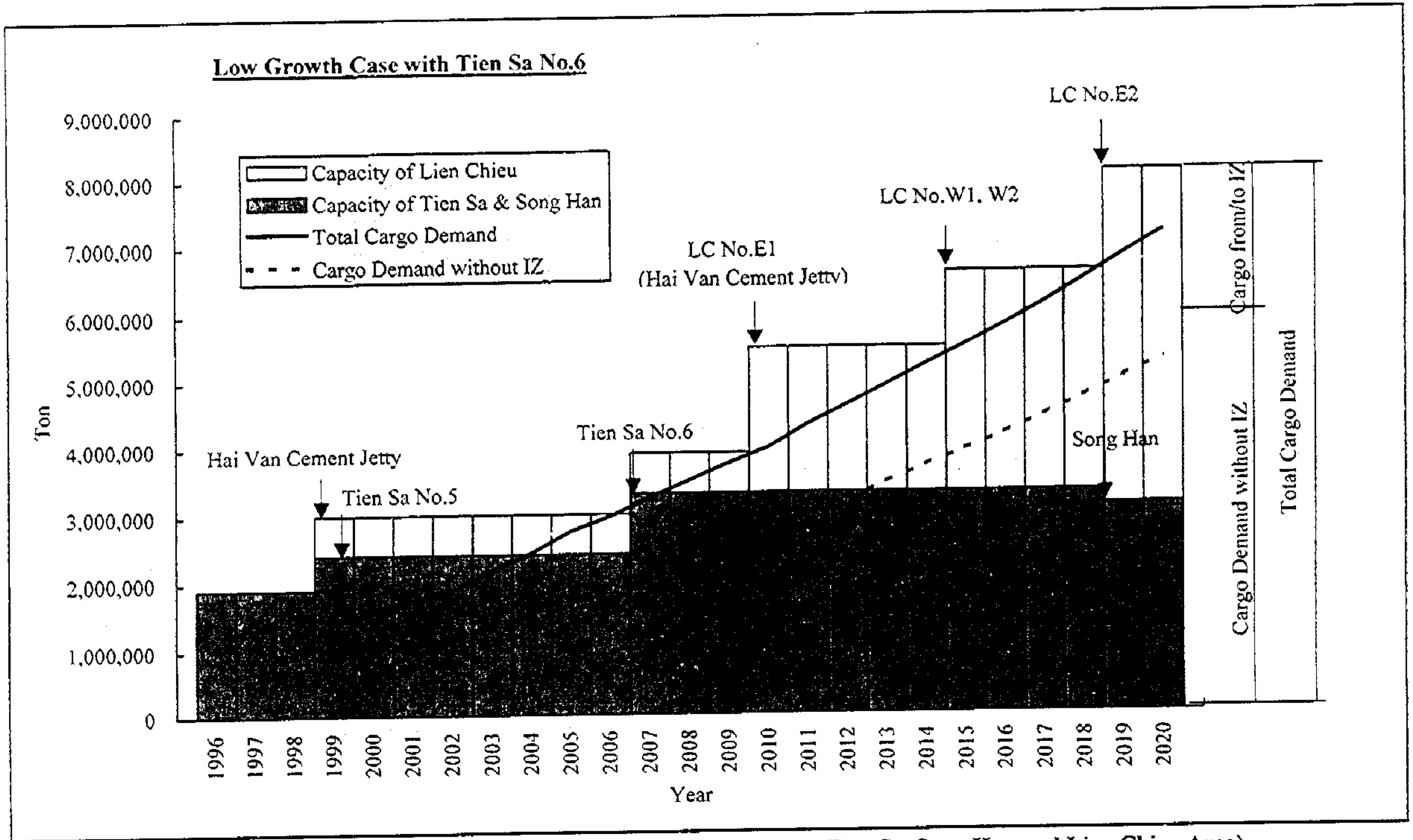



**Figure 8.5.2 Capacity and Cargo Throughput in Danang Port (Tien Sa, Song Han and Lien Chieu Area)**

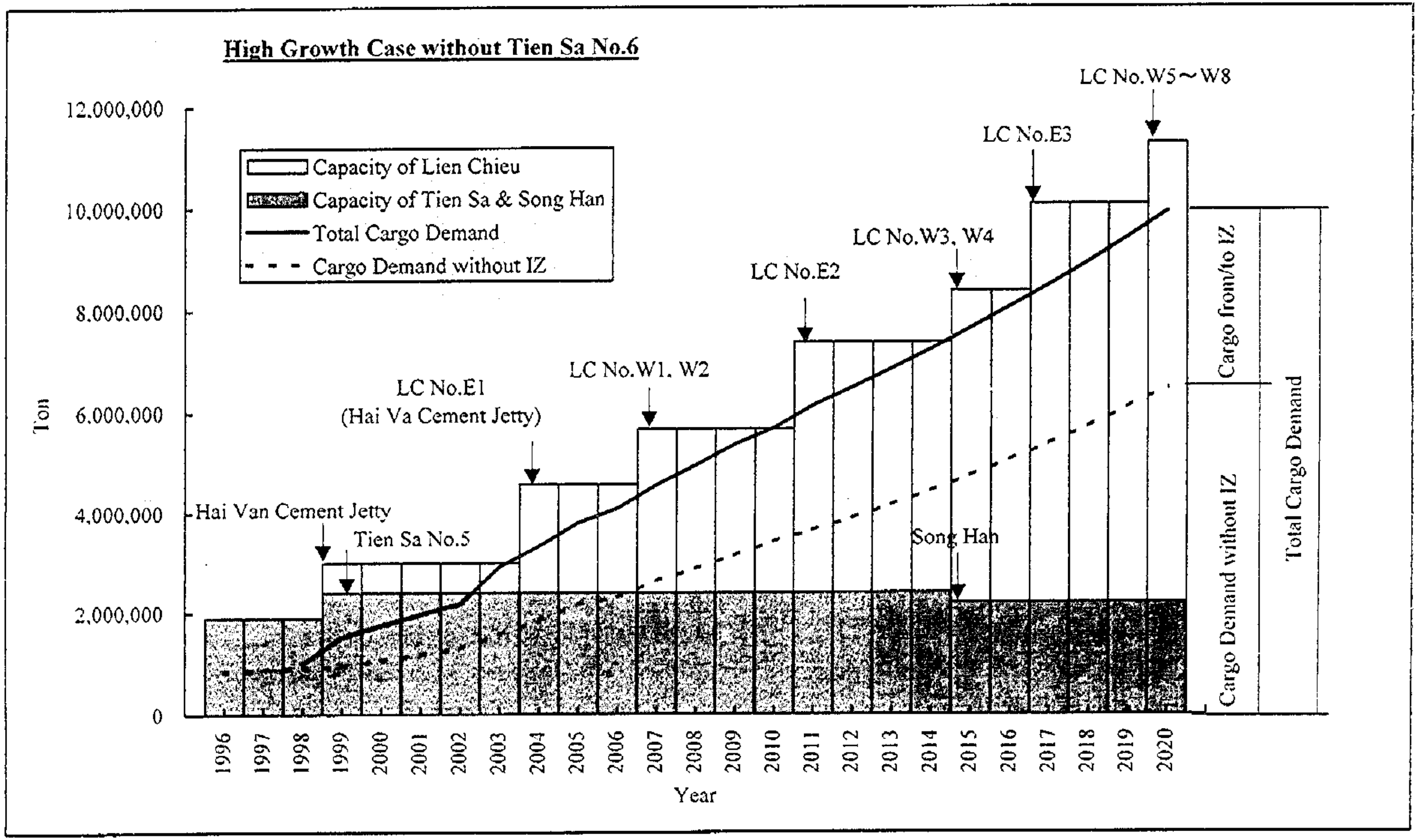



Figure 8.5.3 Capacity and Cargo Throughput in Danang Port (Tien Sa, Song Han and Lien Chieu Area)

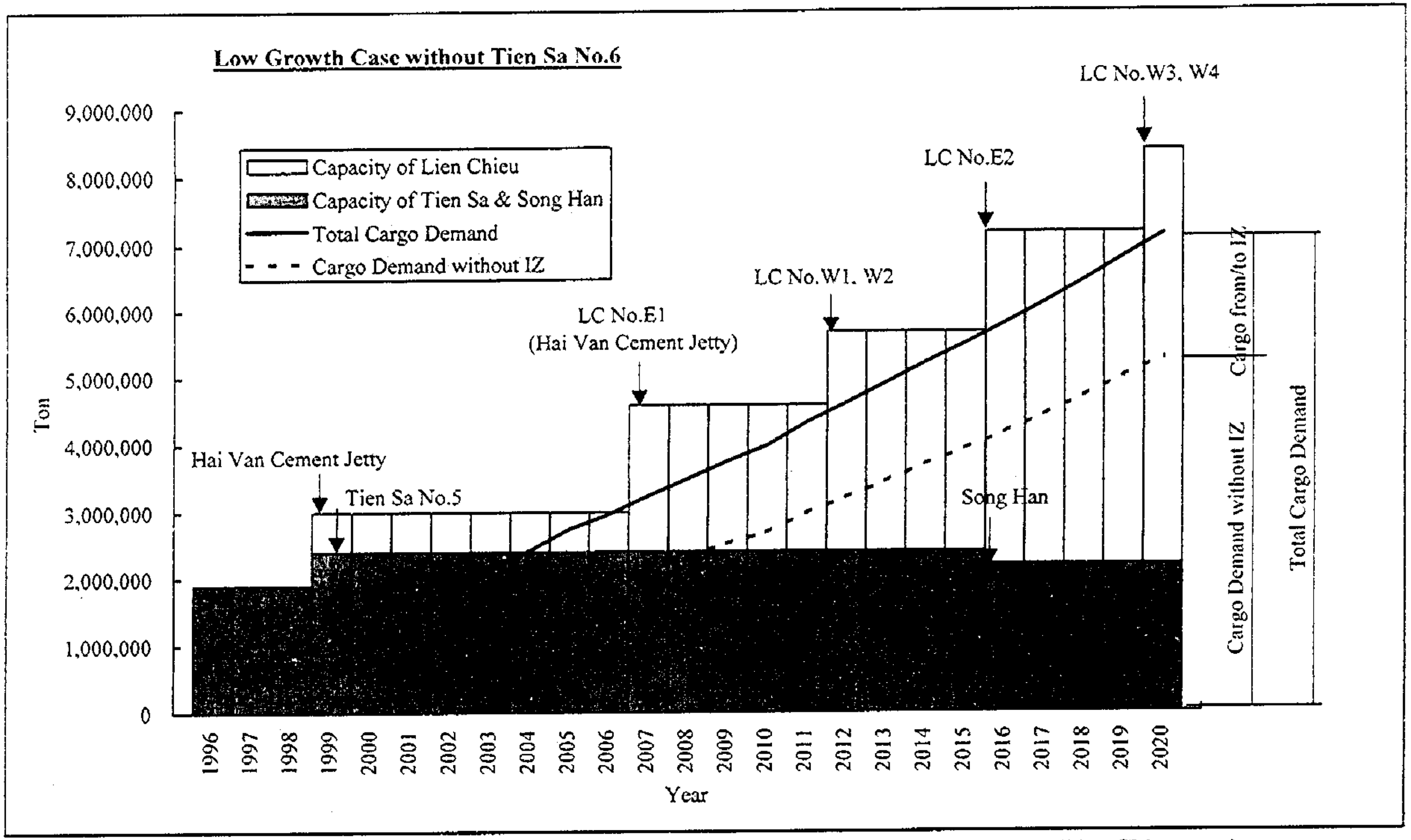



**Figure 8.5.4 Capacity and Cargo Throughput in Danang Port (Tien Sa, Song Han and Lien Chieu Area)**

# 9. Preliminary Port Facilities Design

## 9.1 General

According to the Initial Stage Development Plan(Short Term Development Plan) of Lien Chieu New Port shown in the Chapter 8, preliminary design work of such main port facilities as breakwater, seawall, quaywall, revetment etc. has been carried out. Through this preliminary design work technical feasibility can be assured or the results of preliminary design work are used for calculating the cost of the Initial Stage Development Plan(Short Term Development Plan) of Lien Chieu New Port.

Usually design conditions should be fixed on three categories. These are natural conditions, so-called available or utilized conditions and material or structural conditions including allowable stress of materials and safety factor to evaluate stability. The design conditions hereinafter has been set mainly basing on the results of surveys done by JICA /POWECO Study Team and Japanese Technical Standards of Port and Harbor Facilities for the sake of convenience using the existing computer programs.

## 9.2 Objective Port Facilities for Preliminary Design

The objective port facilities for preliminary design are listed bellow as Table 9.2.1

**Table 9.2.1 Objective Port Facilities for Preliminary Design**

| Name of Facility | Design Depth(m) | Length(m) | Remarks |
|---|---|---|---|
| Breakwater | -8.5 | 265 | Seawall in Master Plan |
| Seawall | -8.0 | 565 | |
| Revetment R1 | -6.0 | 130 | |
| Revetment R2 | -8.0 | 350 | |
| Revetment R3 | -6.0 | 220 | |
| Revetment R4 | -6.0 | 370 | |
| Revetment for Road | -2.5 | 665 | |
| Training Wall | -0.5 | 200 | |
| Quaywall E1 | -12.0 | 270 | 1 Berth |
| Quaywall W1,W2 | -9.0(-8.0) | 320 | 2 Berth -9.0m in Master Plan |

## 9.3 Design Conditions

### 9.3.1 Natural Conditions

Natural conditions using for the preliminary design mostly have been derived from such surveys and analysis as tide, wave, and soil which were conducted by JICA/POWECO Study Team during the study period. These are shown as follows.

**(1) Tide**

H.W.L.= C.D.L. +1.4 m
L.W.L. = C.D.L. ±0.0 m

**(2) Wave**

Breakwater : $H_{1/3}$ = 5.9m $H_{max}$ = 7.8m $H_D$ = 8.0m T =13.9sec
Offshore Wave Direction : NE, Incident Wave Angle : 3.5°

Seawall : $H_{1/3}$ = 5.9m $H_{max}$ = 7.7m $H_D$ = 7.9m T =13.9sec
Offshore Wave Direction : NE, Incident Wave Angle : 3.5°

**(3) Soil Conditions**

Soil Conditions are decided like as Figure 9.3.1 (1)~(2) by each facilities described in the column of the Design Facility and Soil Condition analyzing the soil borings and test results.

**(4) Seismic Coefficient**

$K_H$ = 0.05
$K_V$ = 0.00

### 9.3.2 Utilized Conditions

**(1) Berth Dimension**

Such berth dimension as berth length, berth depth and ship size, etc. are tabulated
bellow.

**Table9.3.1 Berth Dimension**

| Berth No. | Number of Berth | Berth Length | Berth Depth | Objective Ship | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Kind | DWT | Length | Width | Draft |
| E1 | 1 | 270m | -12.0m | Container | 30,000 | 216m | 32m | 11.5m |
| W1,W2 | 2 | 320m | -9.0m | Ro-Ro | 7,000 | 140m | 20m | 7.5m |
| | -- | 280m | -4.0m | Small Vessel | -- | -- | -- | -- |

Note : W1,W2 Berth are temporally –8.0 m in Short Term Plan

**(2) Crown Height of Quaywall**

+ 3.0m (H.W.L. +1.4 +1.6m)

**(3) Ship Berthing Speed**

15cm/sec

**(4) Surcharge**

2.0 t f/m² (ordinary case)
1.0 t f/m² (in case of earth quake)

**(5) Live Load ( Berth W1,W2,)**

| | |
|---|---|
| Wheel Load 25tf | 10tf/wheel |
| Tractor Trailer Load | 5tf/wheel |
| Fork Lift Truck(35t) | 45tf/wheel |
| Truck Crane (50t) | 50tf/outrigger |

**(6) Crane Load( Berth E1)**

| | |
|---|---|
| Total Weight | 600t |
| Wheel Span | 16.0m |
| Wheel Base | 12.0m |
| Wheel Load | 25tf/Wheel |

### 9.3.3 Material Condition

**(1) Coefficients of Material**

Coefficients of Material for Design are summarized bellow.

**Table 9.3.2 Coefficient of Material for Design**

| Material | Friction Angle | Friction Angle to Wall | Unit Weight | Unit Weight in Water |
|---|---|---|---|---|
| Rubble Stone | 45° | ----- | 1.8 tf/m³ | 1.0 tf/m³ |
| Backing Stone | 40° | +15° | 1.8 tf/m³ | 1.0 tf/m³ |
| Backing Sand | 30° | +15° | 1.8 tf/m³ | 1.0 tf/m³ |

**(2) Coefficient of Friction**

Coefficients of Static friction using stability calculation are shown bellow.

**Table 9.3.3 Coefficient of Static Friction**

| Material | Coefficients of Static Friction |
|---|---|
| Concrete against Concrete | .0.5 |
| Concrete against Rubble | 0.6 |
| Concrete against Asphalt Mat | 0.7 |
| Rubble against Rubble | 0.8 |

Source : Technical Standards for Port and Harbor Facilities in Japan

### (3) Allowable Stress

Allowable Stresses are in accordance with following Table 9.3.4

**Table 9.3.4 Allowable Stress**

| Material | Standard Design Strength | Compressive Stress | Bending Compressive Stress | Remarks |
|---|---|---|---|---|
| Plain Concrete | 180 kgf/cm² | 45 kg/cm² | --- | For Concrete Block |
| Reinforced Concrete | 240 kgf/cm² | --- | 90 kg/ cm² | For H.B. or Concrete Caisson, L-shape Block |
| **Material** | **Axial Compression Stress** | **Axial Tensile Stress** | **Bending Stress** | **Remarks** |
| Steel SS 41 | 1400 kg/cm² | 1400 kg/cm² | 1400 kg/cm² | Reinforced Bar |
| SD35 | 1800 kg/cm² | 1800 kg/cm² | 1800 kg/cm² | Deformed Bar |
| SY30 | 1800 kg/cm² | 1800 kg/cm² | 1800 kg/cm² | Steel Sheet Pile |
| SKK41 | 1400 kg/cm² | 1400 kg/cm² | 1400 kg/cm² | Steel Pile Pipe |

Source : Technical Standards for Port and Harbor Facilities in Japan

### (4) Safety Factor

Safety Factors on checking stability are listed bellow.

**Table 9.3.5 Safety Factor**

| Calculation Item | Ordinary Case | Unordinary Case |
|---|---|---|
| Circular Failure | 1.2 | 1.0 |
| Overturn of Wall | 1.2 | 1.0 |
| Sliding | 1.2 | 1.0 |
| Tow Pressure against Rubble Mound | 60tf/m² | 90tf/m² |

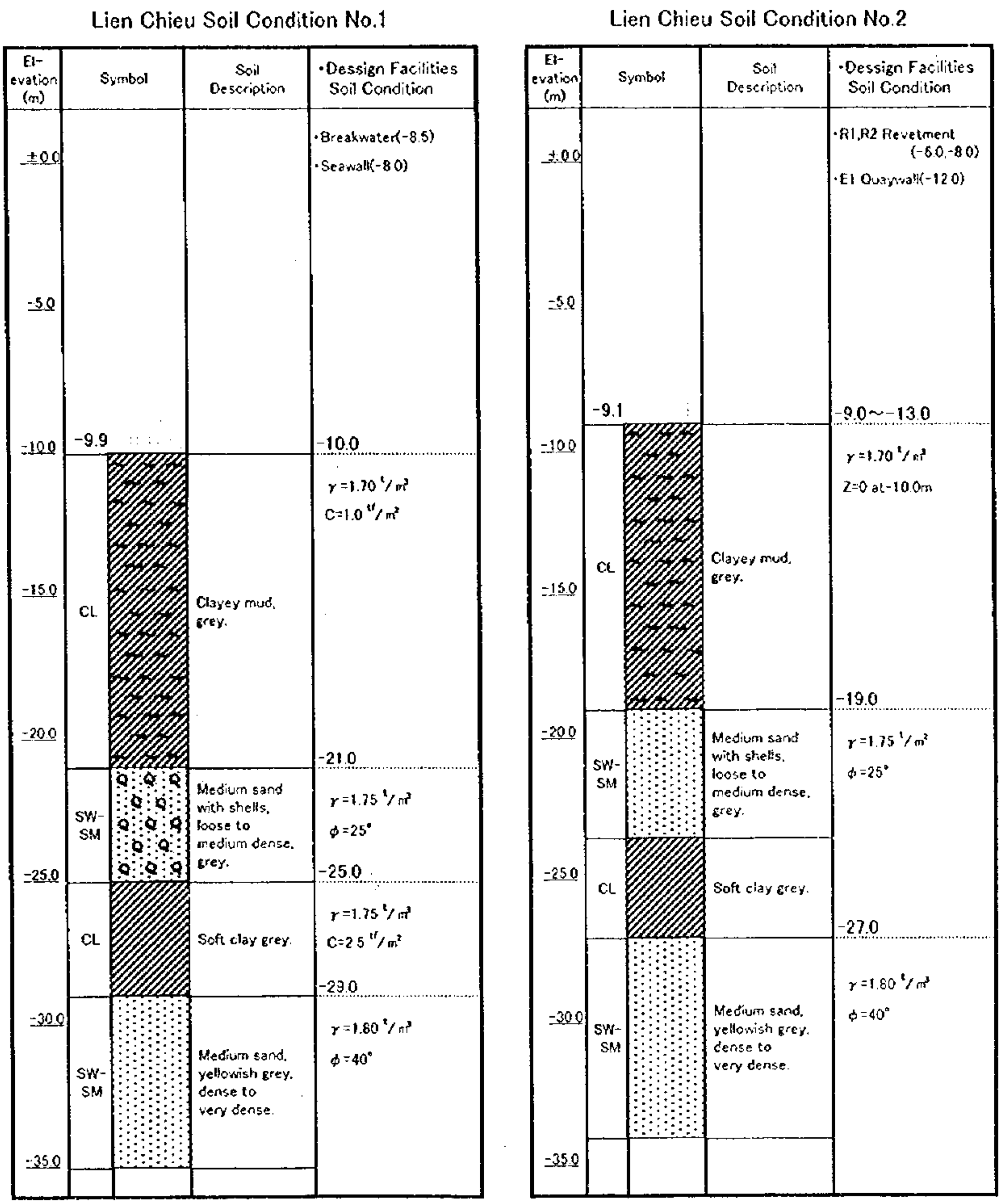



**Figure 9.3.1(1) Soil Conditions for Preliminary Design**

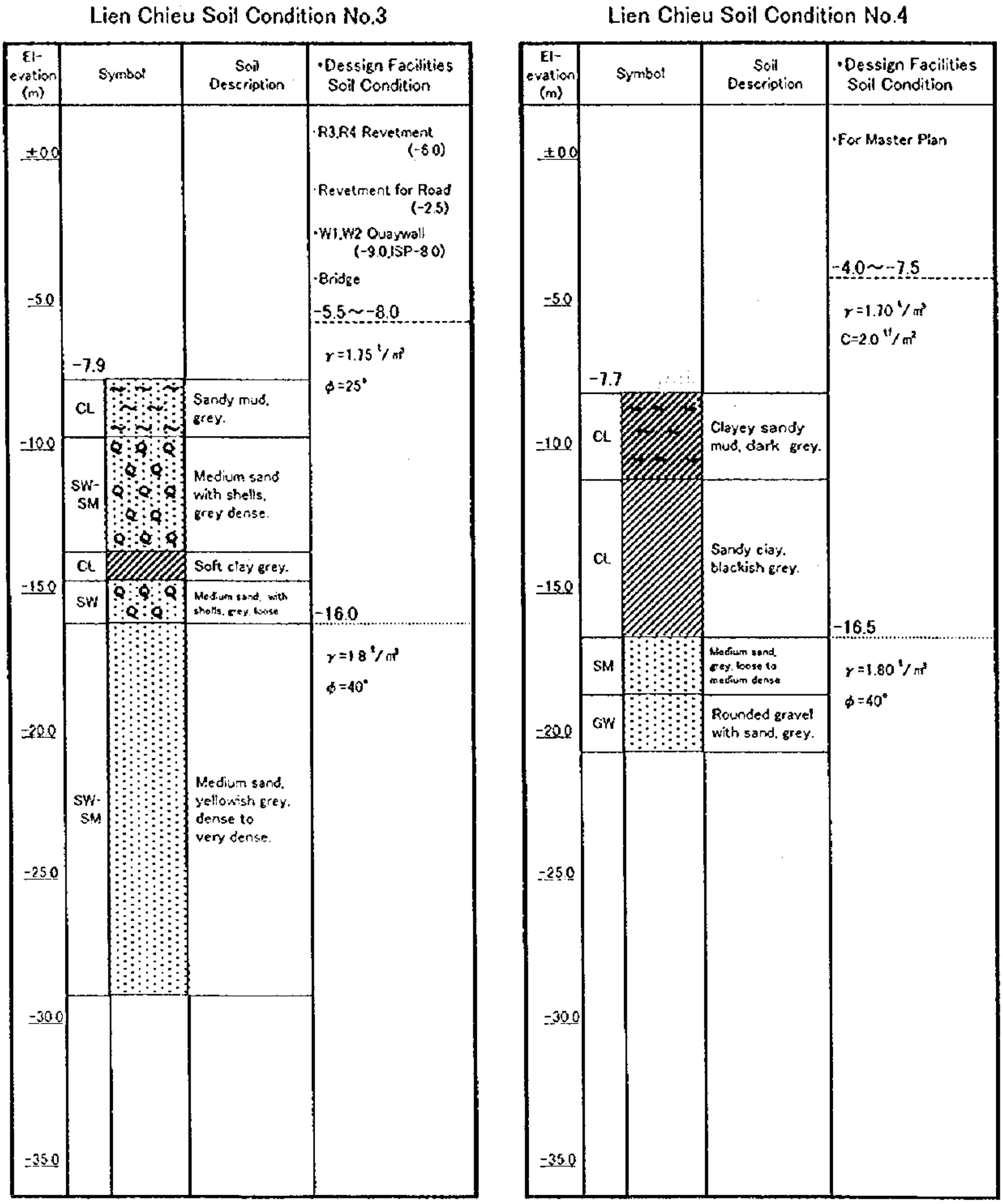



**Figure 9.3.1(2) Soil Conditions for Preliminary Design**

## 9.4 Structural Type of Breakwater and Quaywall

### 9.4.1 Breakwater

The features of the location where the breakwater will be constructed in Lien Chieu Port is deep area as –8.5m with relatively high waves and soft foundation. It means that rather large structure against high waves is necessary and in order to procure the stability of the structure, improving the soft ground layer for foundation is indispensable as well.

There are several methods to improve the soft soil layer, however, considering the thickness of the soft soil layer, the easiness of work and cost, replacement of the soft soil to the sand can be chosen.

To prevent waves, generally, sloping ,upright and composite type of breakwaters can be used. Considering the depth and soft soil foundation, sloping type and upright type of breakwaters is not suitable then composite type of breakwaters shall be selected.

As an upper structure of composite type of breakwater, we can use mass or block concrete, cellular block and caisson. However in case of Lien Chieu Port the width of upper structure must be over 10m to have enough resistance force against high wave pressure so a caisson can be selected from economical point of view as far as a yard or other facilities to produce caisson can be prepared.

Evaluation of structural type of breakwater by each checking factor is tabulated.

**Table 9.4.1 Selection of Structural Type for Breakwater**

| Type | Sloping B. | Upright B. | Composite Breakwater | | |
|---|---|---|---|---|---|
| Structure | Rubble, Concrete Block | Same as Composite Type | Mass or Block Concrete | Cellular Concrete Block | Concrete or Hybrid Caisson |
| 1. Technical Suitability For High Wave and Soft Foundation | △ | △ | ◇ | ○ | ◎ |
| 2. Easiness of Material Procurement | ○ | ○ | ○ | ○ | ○ |
| 3. Easiness of Design and Construction | ◎ | ○ | ○ | ◇ | ◇ |
| 4. Preparation of yard or Equipment | ○ | ◇ | ○ | ◇ | ◇ |
| 5. Experience of Local Contractor | ◎ | ○ | ○ | ◇ | △ |
| 6. Necessity of Maintenance | △ | ◇ | ○ | ○ | ○ |
| 7. Economical Construction Cost | △ | △ | ◇ | ○ | ◎ |
| Comprehensive Evaluation | △ | △ | ◇ | ◇ | ◎ |

◎ Excellent ○ Good ◇ Fair △ Poor

### 9.4.2 Mooring Facilities

The structural types of mooring facilities should be selected by considering natural conditions particularly soil foundation. As described in design condition, upper subsoil layers in the location of mooring facilities planned are soft with expecting cohesion of 1.0tf/m². Then circular failure analysis shows that such structure as quaywalls cannot be constructed without improving these soft layers.

In case of a pier type quaywall with retaining wall for Berth E1, it needs over 60m wide section to prevent circular failure without any improvement of soil layers. This is not practical design. (cf. Figure A9.5.5(1)) Whilst a pier type jetty without a retaining wall will be a possible structure because of not so thick soft layer as over 30m.

As before mentioned in case of a breakwater, for an improving method of soft soil layers is recommendable to replace soft soil layers to stiff soil such as sand or rubble as the most reliable and economical way.

Among several possible types of quaywalls, concrete or hybrid caisson will be selected for deep quaywalls (over-8m depth) through the evaluation shown in Table 9.4.2.

**Table 9.4.2 Selection of Structural Type for Quaywall**

| Type | Pier with Retaining Wall | Steel Sheet or Pile | Gravity type | | |
|---|---|---|---|---|---|
| Structure | Steel Pile | Steel Sheet or Pile | L-type or Block Concrete | Cellular Concrete Block | Concrete or Hybrid Caisson |
| 1.Technical Suitability for Soft Foundation | △ | △ | ◇ | ○ | ◎ |
| 2.Easiness of Material Procurement | △ | △ | ○ | ○ | ○ |
| 3.Easiness of Design and Construction | ◇ | ○ | ○ | ◇ | ◇ |
| 4.Preparation of yard or Equipment | ○ | ◇ | ○ | ◇ | ◇ |
| 5.Experience of Local Contractor | ○ | △ | ○ | ◇ | △ |
| 6.Necessity of Maintenance | ◇ | ◇ | ○ | ○ | ○ |
| 7.Economical Construction Cost | △ | ◇ | ◇ | ○ | ◎ |
| Comprehensive Evaluation | △ | △ | ◇ | ◇ | ◎ |

◎ Excellent ○ Good ◇ Fair △ Poor

## 9.5 Selected Structure for Protective and Mooring Facilities

### 9.5.1 Breakwater

Through the discussion to select suitable structural type of breakwater in previous section, the composite type of breakwater with concrete or hybrid caisson has been decided. Regarding the foundation, replacement level of the soft layers under the rubble mound for the caisson is determined by an analysis of circular failure showing necessary depth as -21.0m under which level there appear yellowish and grey medium or dense sand layers. In order to increase horizontal resistance force against high wave pressure the asphalt mat between rubble mound and caisson is introduced.

For upper structure normal reinforced concrete and hybrid caisson have been compared. Figure A9.5.1(1) shows normal caisson case and Figure A9.5.1(2) is hybrid caisson case. Merits of hybrid caisson comparing with normal reinforced concrete caisson are as follows.

(1) Hybrid caissons consist of composite slab plates and steel reinforced concrete which have high member strength. So we can make such long footings for basement of caisson as 5.0m which can reduce total weight of caisson a great deal.

(2) The hybrid caisson showing in Figure A9.5.1(2) weighs 43t/m, while the reinforced concrete caisson in Figure A9.5.1(1) becomes 67t/m. It means that we do not need a deep access channel to tow the hybrid caisson toward offshore from a caisson yard because of shallow drought or we can more easier to lift down the hybrid caisson to the sea from land area by any means.

(3) Steel shells inside the hybrid caisson wall function as both form plates and reinforced bars in case of reinforced concrete caisson, then we can reduce concrete work. As a result it contributes to get economical cost.

To stand against large wave energy, the enough weight acting as resistance force is necessary. In this sense lightness of hybrid caisson is demerit. However by making a slope wall of the outside upper concrete above the hybrid caisson, we can change horizontal wave force to vertical force partially to supplement weight of the hybrid caisson. When we adopt a slope wall it needs higher crown height than in case of upright wall to prevent transmitted wave inside of a breakwater. Usually the crown height of a breakwater is $0.6H_{1/3}$ over design water level permitting design wave overtopping. While the crown height of a breakwater with slope wall one to one needs $1.0H_{1/3}$ to procure the same calmness in the basin behind breakwater.

Cost analysis of these two structures shows that the hybrid caisson breakwater is at least 10% cheaper than the reinforced concrete caisson breakwater even though adding a new caisson yard investment. At moment for the candidates of new caisson yard Danang Bay or Ky Ha port are listed.(cf. Chapter 10) As a conclusion the hybrid caisson shown in Figure A9.5.1(2) is recommendable for the Breakwater in Lien Chieu.

### 9.5.2 Other Protective Facilities

**(1) Seawall**

The seawall is constructed continuously with the breakwater. Therefore before sand filling work is finished behind the seawall, the seawall itself should stand safely against large wave energy on the soft foundation. So the same consideration as to select the breakwater structure should be taken.

Figure A9.5.2(1) shows the typical cross section of reinforced concrete caisson and Figure A9.5.2(2) is in case of the hybrid caisson. Differently from the breakwater as the seawall needs the function to prevent wave overtopping, a slope wall of crown concrete is not suitable. The crown height +7.3m is decided as the following figure. +7.3m(1.25 $H_{1/3}$+H.W.L.=1.0×4.7+1.4≒7.3 : It means that within significant wave height as 4.7m the seawall can prevent wave overtopping. )

Cost estimation indicates the section shown in Figure A9.5.2(2) is less than 20% that of the section shown in Figure A9.5.2(1). We can choose Figure A9.5.2(2) section naturally.

**(2) Revetment**

The reasonable structure of revetments can be decided mostly from the depth where the revetments are located. Whether the location is deep or shallow we do not need to consider wave pressure for design in Lien Chieu' case. If the depth is shallower than -2.0～-3.0m, a rubble mound revetment is recommendable. When the depth is -4.0m ～-6.0m. (height of structure 2.0m～ 4.0m with rubble mound) concrete block is suitable and if the depth changes -6.0m～-8.0m( height of structure 4.0m～ 6.0m with rubble mound) L-shape reinforced block is adaptable. For more than -8.0m (height of structure over 6.0m with rubble mound) deep area, a concrete caisson is an appropriate structure.

According to the above mentioned principle we can choose each revetment as shown in Figure A9.5.3(1),(2),(3)

**(3) Training Wall**

The function of the training wall is to lead the current to offshore and to prevent sedimentation caused by literal sand drift and maintain estuary flow or stabilize shore line. There are two types of structure. One is permeable type and the other is not permeable type.
A permeable type can transmit wave and sand partially, therefore, not motivate surrounding seabed or shoreline to be turbulent. Considering that river current, sand drift and wave action in the location are not so severe, rubble mound with wave dissipating concrete block which is the ordinary permeable type has been selected. (cf. Figure A9.5.4)

The head of training wall will be extended to -4.0～-5.0m deep area across the wave breaking zone as usual. However to monitor the effect and influence of the training wall at the first stage, the depth of the head is decided around -2.0m.

### 9.5.3 Mooring Facility

In the previous section, the structure of quaywall has been selected concrete caisson or hybrid caisson for deep quaywalls and as for the foundation, replacement of soft soil method recommended. As same as on the breakwater an analysis of circular failure showed that necessary depth of replacement is –21.0m under which level there appear medium and dense sand layers. An open pier type quaywall with the retaining wall can be one of the alternative structure and it is possible without improvement of soft foundation. However to prevent circular failure caused by the retaining wall it needs more gentle slope as nearly one to four which resulted so broad width as 60m with high cost.(c.f. Figure A9.5.5(1) Open pier type is more than double in cost compared with hybrid caisson.)

For upper structure normal reinforced concrete and hybrid caisson have been compared. Figure A9.5.5(2) is hybrid caisson for the –12m quaywall. Merits of hybrid caisson comparing with normal reinforced concrete caisson are as follows.

(1) Hybrid caissons consist of composite slab plates and steel reinforced concrete which have high member strength. So we can make long footing for basement of caisson which contributes enlarging the supposing width of the wall when we calculate stability against earth pressure in spite of narrow width of caisson.

(2) The hybrid caisson showing in Figure A9.5.5(2) weighs 28t/m, while the reinforced concrete caisson equivalent with hybrid caisson becomes 74t/m. It means that we do not need a deep access channel to tow the hybrid caisson toward offshore from a caisson yard because of shallow drought or we can more easier to lift down the hybrid caisson to the sea from land area by any means.

(3) Steel shells inside the hybrid caisson wall function as both form plates and reinforced bars in case of reinforced concrete caisson, then we can reduce concrete work. As a result it contributes to get economical cost.

Cost analysis of these two structures shows that the hybrid caisson quaywall is more than 5% cheaper comparing with the reinforced concrete caisson case even though adding a new caisson yard investment. At moment for the candidates of new caisson yard Danang Bay or Ky Ha port are listed.(cf. Chapter 10) As a conclusion the hybrid caisson shown in Figure A9.5.5(2)is recommendable for the quaywall in Lien Chieu.

The reasonable structure of other quaywall can be decided mostly from the depth where the quaywall are located. If the quaywall depth is smaller than -4.0m (height of structure 3.0m～ 5.0m ) concrete block is suitable and if the depth changes -4.0m～-6.0m (height of structure 4.0m～ 6.0m ) L-shape reinforced block is adaptable. For more than –8.0m (height of structure over 6.0m ) deep area, a concrete caisson is an appropriate structure.

According to the above mentioned principle we can choose each quaywall as shown in Figure A9.5.5(2),(3),(4).

### 9.5.4 Conclusion

Based on the study examined so far each facilities selected for the initial stage development plan are tabulated in Table 9.5.1. This study is not aimed at the ultimate design work because of now preliminary design phase. For example the facilities indicated in each figure are typical cross section when the whole initial stage plan(short term plan) implemented solely. In other word there is less consideration how to continue works toward the master plan. It needs surely more precise design work toward getting the most reasonable and economical structures in next phase. However the purpose of preliminary design work firstly mentioned is enough achieved because basic and fundamental items has been examined. Then there might be no room to choose other particular structure type in detail design phase.

**Table 9.5.1 List of Selected Structure**

| Facility | Structural Type | Depth(m) | | Crown Height (m) | Planned Quantity (m) | Remarks |
|---|---|---|---|---|---|---|
| | | Existing | Design | | | |
| Protective Fa. | | | | | | |
| Breakwater | HB Caisson | -8.5 | -8.5 | +7.3 | 265 | Fig.A9.5.1(2) |
| Seawall | HB Caisson | -8.5～-7.5 | -8.0 | +7.5 | 565 | Fig.A9.5.2(2) |
| Revetment R1 | L-Shaped Co. Block | -7.5～-5.0 | -6.0 | +3.0 | 130 | Fig.A9.5.3(1) |
| Revetment R2 | RC Caisson | -8.5～-7.5 - | -8.0 | +3.0 | 350 | Fig.A9.5.3(2) |
| Revetment R3 | L-Shaped Co. Block | 7.5～-5.0 - | -6.0 | +3.0 | 220 | Fig.A9.5.3(1) |
| Revetment R4 | L-Shaped Co. Block | 7.5～-5.0 - | -6.0 | +3.0 | 370 | Fig.A9.5.3(1) |
| Revetment for Road | Concrete Block | 5.0～ 0.0 | -2.5 | +3.0 | 665 | Fig.A9.5.3(3) |
| Training Wall | Rubble Mound with Dissipating Co.Block | -1.0～0.0 | -0.5 | +3.0 | 200 | Fig.A9.5.4 |
| Mooring Fa. | | | | | | |
| Quaywall E1 | HB Caisson | -8.0～-7.0 | -12.0 | +3.0 | 270 | Fig.A9.5.5(3) |
| Quaywall W1 | RC Caisson | -6.5～- 4.5 | -9.0 | +3.0 | 160 | Fig.A9.5.5(4) |
| Quaywall W2 | RC Caisson | -4.0～- 3.0 | -9.0 | +3.0 | 160 | Fig.A9.5.5(4) |
| Bridge | From the scale and popularity, Steel Pile with P.C Girder is selected. | -3.0～0.0 | 3 span | +4.8 | 75 | Fig.A9.5.6 |

# 10. Construction Plan

## 10.1 Production and Procurement of Construction Materials

In general, construction materials for earthworks are available in the nearby hinterland. In principle, steel materials should be imported except iron bars. Cement can also be procured locally.

Major construction materials of ISP are shown in the Table 10.1.1. Locations of each structure are shown in the Figure 10.1.1 below.
Among the necessary materials, the largest quantity required is sand and stones which amount to more than 200,000 cubic meters for ISP. They can be obtained from quarries at Mt. Phuoc Tuong and some other sites, including mountains in the upper catchement of the Cu De River, which consists of granite suitable for the structures.

Location map of quarries and productivity of quarries are respectively shown in Figure 10.1.2 and Table 10.1.2.

## 10.2 Availability of Work Vessels, Equipment and Machinery

The required formation of work vessels may include, with ample capacity, cutter suction dredgers, grab dredgers, floating crane (F/C), a pile driving barge, a floating mixer plants, barges, and tugs, etc. Most of large capacity work vessels will have to be brought in from abroad. It will probably be necessary to employ floating cranes, capable of lifting 1,000 tones or more, although floating cranes up to a capacity of lifting 600 tons are available in Vietnam.

Construction equipment and machinery are required primarily for earthworks such as crawler cranes, bulldozers, dump trucks, macadam rollers, graders, scrapers, and others. Most of them can be obtained from local construction companies.

Equipment and expected unit cost for construction work available in Vietnam are shown in Tables 10.2.1 to 10.2.4.

**Table 10.1.1 Major Construction Materials for ISP (Short-term Development Plan) — Lien Chieu**

| Description | Breakwater | Seawall | Revetment R1 | Revetment R2 | Revetment R3,R4 |
|---|---|---|---|---|---|
| Excavation of soft layer ($m^3$)* | 122,600 | 411,300 | - | 105,000 | - |
| Stone ($m^3$) | 16,500 | 36,300 | 1,900 | 43,500 | 35,000 |
| Sand ($m^3$) | 161,600 | 536,100 | - | 145,600 | 4,800 |
| Concrete ($m^3$) | 17,600 | 23,000 | 2,300 | 4,700 | 4,200 |
| Soil for Reclamation ($m^3$) | - | - | - | - | - |
| Reinforced bar(ton) | 420 | 920 | 215 | 460 | 380 |
| Steel (ton) | 1,100 | 2,200 | 620 | - | - |

| Description | Revetment for road | Training jetty | Quaywall E1 (-12.0m) | Quaywall W1,W2 (-8.0m) | Total |
|---|---|---|---|---|---|
| Excavation of soft layer ($m^3$)* | - | 1,300 | 58,400 | 30,000 | 728,600 |
| Stone ($m^3$) | 4,200 | 1,300 | 13,300 | 51,200 | 203.200 |
| Sand ($m^3$) | - | - | 63,000 | 19,500 | 930,600 |
| Concrete ($m^3$) | 500 | 2,000 | 4,800 | 8,200 | 67,300 |
| Soil for Reclamation ($m^3$) | - | - | - | - | 2,850,000 |
| Reinforced bar(ton) | 50 | - | 290 | 750 | 3,500 |
| Steel (ton) | 140 | - | 2,930 | - | 7,000 |

* Removal of soft weak foundation underneath the upper structure.

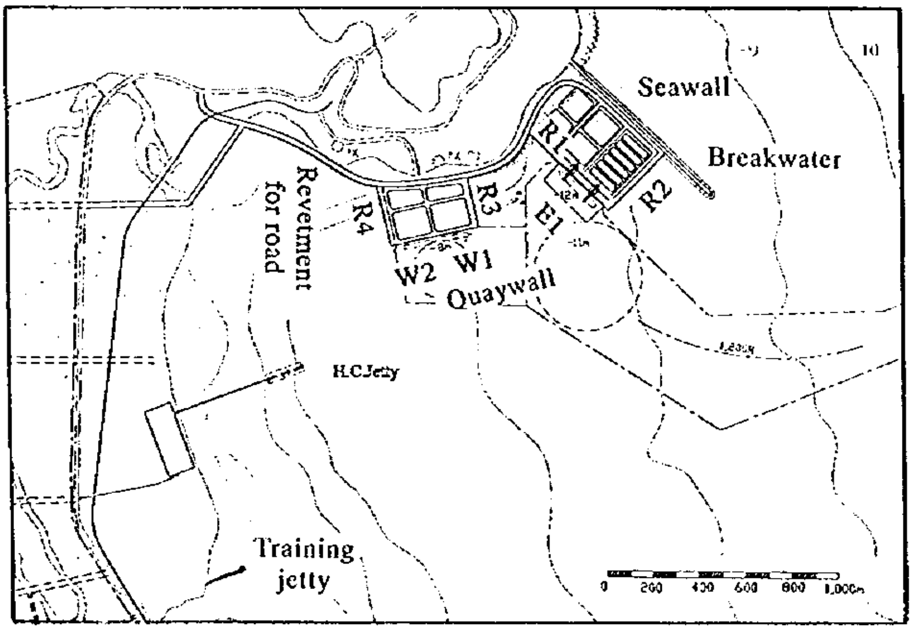



**Figure 10.1.1 Locations and Abbreviations of Facilities — Lien Chieu**

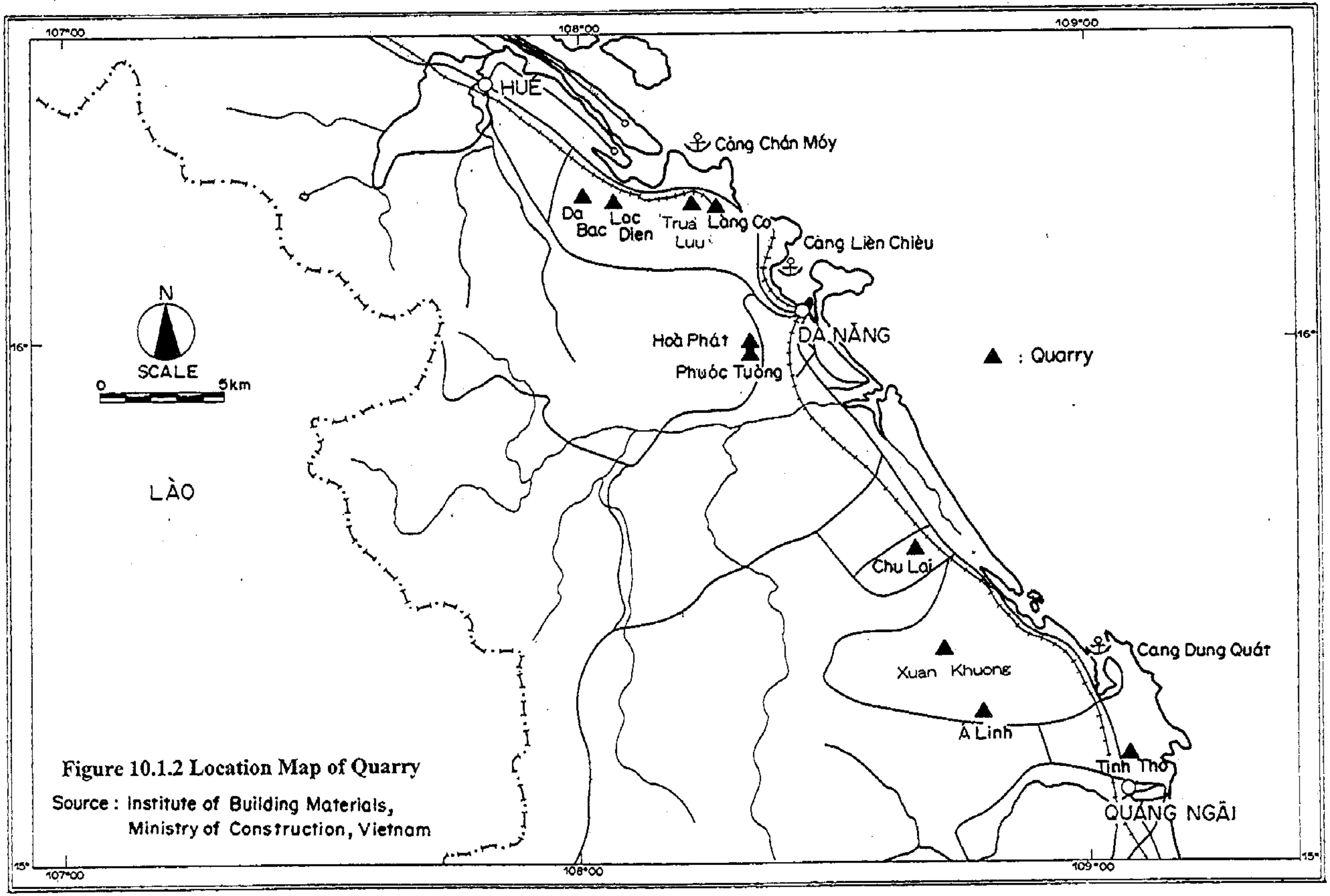



Figure 10.1.2 Location Map of Quarry

Source : Institute of Building Materials, Ministry of Construction, Vietnam

**Table10.1.2 Site and Characteristic of Quarry - Danang Province**

| Site Name | Hoa Phat | Phuoc Tuong |
|---|---|---|
| 1. Management Unit | Danang Cement-Construction Material Company which belongs to Vietnam General Cement Corporation. | Ministry of Transportation |
| 2. Exploiting Capacity | 50,000m$^3$/year. In 1996, Consulting Building Company for Material Construction studied feasibility of expanding the capacity to 150,000m$^3$/year. | 30,000m$^3$/year. According to "Material Construction Plan for South and Central of Vietnam to 2010" by Ministry of Construction in 1996. It has a plan of investment to expand the capacity to 100,000m$^3$/year. |
| 3. Raw Material | Granite | Granite |
| 4. Geographic Location | The quarry belongs to Phuoc Tuong village, Hoa Vang District. Distance is from Lien Chieu Port approximately 14km to the southeast. | The quarry belongs to Phuoc Tuong village, Hoa Phat Commune, Hoa Vang District. Dintance is from Lien Chieu Port is approximately 14.5km to the southeast, and about 12km from the center of Danang City. |

Source: Institute of Building Material, Ministry of Construction, Vietnam, and JICA Study Team

**Table 10.2.1 Construction Equipment and Cost for Onshore Works**

1 US$ = 11,600 VND

| No. | Type of Machine | Capacity | Unit | VND (1,000) | US$ |
|---|---|---|---|---|---|
| 1 | Cranes | | | | |
| | Tire-wheeled Crane | 16ton | Shift | 1,740 | 150 |
| | Tire-wheeled Crane | 25ton | Shift | 2,088 | 180 |
| | Tire-wheeled Crane | 40ton | Shift | 2,436 | 210 |
| | Chain-wheeled Crane | 16ton | Shift | 1,392 | 120 |
| | Chain-wheeled Crane | 25ton | Shift | 1,856 | 160 |
| | Chain-wheeled Crane | 28ton | Shift | 2,030 | 175 |
| | Chain-wheeled Crane | 40ton | Shift | 2,552 | 220 |
| | Crawler Crane | 30ton | Shift | 2,088 | 180 |
| | Crawler Crane | 60ton | Shift | 3,480 | 300 |
| | Crawler Crane | 100ton | Shift | 4,408 | 380 |
| 2 | Trucks | | | | |
| | Dump truck | 10ton | Shift | 1,218 | 105 |
| | Dump truck | 11ton | Shift | 1,276 | 110 |
| | Dump truck | 12ton | Shift | 1,392 | 120 |
| | Dump truck | 15ton | Shift | 1,566 | 135 |
| | Truck | 10ton | Shift | 1,160 | 100 |
| | Truck | 12ton | Shift | 1,276 | 110 |
| | Trailer | 20ton | Shift | 2,320 | 200 |
| 3 | Earthwork equipment | | | | |
| | Bulldozer | 6ton | Shift | 557 | 48 |
| | Bulldozer | 8ton | Shift | 1,299 | 112 |
| | Bulldozer | 11ton | Shift | 1,682 | 145 |
| | Bulldozer | 15ton | Shift | 1,798 | 155 |
| | Tire-wheeled roller | 8~20t | Shift | 1,046 | 90 |
| | Front loader | 1.4m³ | Shift | 1,392 | 120 |
| | Backhoe | 0.1m³ | Shift | 650 | 56 |
| | Backhoe | 0.2m³ | Shift | 835 | 72 |
| | Backhoe | 0.5m³ | Shift | 928 | 80 |
| | Backhoe | 0.7m³ | Shift | 1,150 | 100 |
| | Backhoe | 1.0m³ | Shift | 1,346 | 116 |

Notes: One "Shift" is equivalent to 8 working hours. Exchange Rate is as of March '97.

Source : JICA Study Team

**Table 10.2.2 Construction Equipment and Cost for Onshore Works**

1 US$ = 11,600 VND

| No. | Type of Machine | Capacity | Unit | VND (1,000) | US$ |
|---|---|---|---|---|---|
| 4 | Paving works equip. | | | | |
| | Wheeled roller | 8.5ton | Shift | 638 | 55 |
| | Wheeled roller | 10ton | Shift | 754 | 65 |
| | Wheeled roller | 12ton | Shift | 835 | 72 |
| | Mixing plant | 60m$^3$/hr | Shift | 2,320 | 200 |
| | Cement pump | 4m$^3$/hr | Shift | 580 | 50 |
| | Cement pump | 6m$^3$/hr | Shift | 731 | 63 |
| | Cement pump | 9m$^3$/hr | Shift | 928 | 80 |
| 5 | Concrete mixer | | | | |
| | Concrete mixer | 250 liters/hr | Shift | 1,200 | 103 |
| | Concrete mixer | 425 liters/hr | Shift | 1,508 | 130 |
| 6 | Concrete pump truck | 50m$^3$/hr | Shift | 5,568 | 480 |
| 7 | Compressor | 17m$^3$/min | Shift | 510 | 44 |
| 8 | Generator | | | | |
| | Generator | 112KVA | Shift | 1,218 | 105 |
| | Generator | 125KVA | Shift | 1,299 | 112 |
| | Generator | 300KVA | Shift | 4,640 | 400 |
| 9 | Asphalt concrete spreader | 190ps | Shift | 1,624 | 140 |
| 10 | Asphalt concrete Mixing plant | | | | |
| | Capacity | 20ton/hr | Shift | 14,964 | 1,290 |
| | Capacity | 80ton/hr | Shift | 22,968 | 1,980 |
| | Capacity | 150ton/hr | Shift | 27,492 | 2,370 |
| 11 | Diesel hammer | 3.5ton | Shift | 2,784 | 240 |

Notes : One "Shift" is equivalent to 8 working hours. Exchange Rate is as of March '97.

Source : JICA Study Team

## Table 10.2.3 Floating Equipment and Cost

1 US$ = 11,600 VND

| No. | Equipment | Capacity | Unit | VND (1,000) | US$ |
|---|---|---|---|---|---|
| 1 | Cutter Suction Dredger for River Dredging | 300 ps | Shift | 6,380 | 550 |
| 2 | Cutter Suction for Dredger for Off-shore Dredging | | Shift | 8,120 | 700 |
| 3 | Sea Muluti-scuff Dredger for Channel | | Shift | 11,000 | 950 |
| 4 | Berth Bottom excavator (inside ports) | | Shift | 4,060 | 350 |
| 5 | Tug Boat | | | | |
| | Tug Boat | 150 ps | Shift | 2,900 | 250 |
| | Tug Boat | 360 ps | Shift | 3,600 | 310 |
| | Tug Boat | 400 ps | Shift | 4,000 | 345 |
| | Tug Boat | 600 ps | Shift | 6,000 | 517 |
| | Tug Boat | 1,000 ps | Shift | 10,000 | 862 |
| 6 | Barge | | | | |
| | Barge | 100 ton | Shift | 640 | 55 |
| | Barge | 200 ton | Shift | 1,218 | 105 |
| | Barge | 250 ton | Shift | 1,450 | 125 |
| | Barge | 300 ton | Shift | 1,914 | 165 |
| | Barge | 400 ton | Shift | 2,900 | 250 |
| | Barge | 500 ton | Shift | 3,190 | 275 |
| | Barge | 800 ton | Shift | 4,060 | 350 |
| | Barge | 1,000 ton | Shift | 4,350 | 375 |
| 7 | Piling Barge with Hammer | weight: 2.5 ton | Shift | 4,350 | 375 |
| 8 | Floating Crane | | | | |
| | Floating Crane | 30 ton | Shift | 4,524 | 390 |
| | Floating Crane | 35 ton | Shift | 4,640 | 400 |
| | Floating Crane | 100 ton | Shift | 6,500 | 560 |
| 9 | Floating Concrete Mixer Plant | | Shift | 3,248 | 280 |
| 10 | Floating Excavator with bucket | 1.2~1.5 $m^3$ | Shift | 3,480 | 300 |
| 11 | Diving Boat | | Shift | 4,060 | 350 |
| 12 | Anchor Barge | | Shift | 1,624 | 140 |

Notes : One "Shift" is equivalent to 8 working hours. Exchange Rate is as of March '97.

Source : JICA Study Team

## Table 10.2.4 Available Dredgers in Vietnam

| Description | Trailing Hopper Suction Dredger | Cutter Suction Dredger | Cutter Suction Dredger | Bucket Dredger |
|---|---|---|---|---|
| Capacity | 5,000 ton | 3,800 ps | 4,170 ps | - |
| Hopper capacity | 3,200 $m^3$ | - | - | - |
| Dredging capacity | 3,200 $m^3$/hr | 1,500 $m^3$/hr | 1,500 $m^3$/hr | 800 $m^3$/hr |
| Dredging depth | 4~21 m | max. 17 m | max. 17.7 m | 16 m |
| Discharging distance | - | 5,000 m | 6,000 m | - |

Source : JICA Study Team

## 10.3 Construction Bases

Preparation of construction bases are necessary for provision of ample apace for construction of project facilities; storage and supply of construction materials, fabrication of concrete blocks and caissons; and mooring of small harbor crafts and work vessels such as tug boats, floating cranes, barges equipped with pile driving hammer and the like.

Such spaces will have to be secured near the proposed location of the project for ordinary construction works as well as for manufacturing of large-scale structures such as concrete caissons and H.B. caissons. Two of other candidate places are Danang Port area and Ky Ha where ample space for such fabricating yard is available near berthing facilities for work vessels. There are some medium sized shipyards in the Bay of Danang and along the river banks of Son Han River, where open spaces are available for caisson yards at near of those shipyards. Water depth of - 11 meters can be maintained in Tien Sa Port, where a floating dock can be moored and caissons and the like can be fabricated on it. Ky Ha also has an enough yard space is available in Ky Ha Port in the vicinity of an iron reinforcing bar factory (DSSCO). Location of Ky Ha is shown in Figure 10.3.1.

Required area for the yard will be about 2.0ha, namely, 200 meters along the shoreline and 100 meters land-wards. The surface of leveled ground for the yard shall be paved with concrete. On the shoreline a 50-meters wide slipway shall be constructed to launch caisson which are to be lifted with a floating crane (capable of lifting about 1,000 tons) and pulled out until the floating crane can maintain enough clearance under her keel, where the hauling line is to be wound around the caisson and with its end tied to a tug boat for towing to the designated point.

Thorough investigations in those are necessary to choice the most appropriate base prior to execution of the project.

## 10.4 Dredging and Disposal of Dredged Materials

As those materials to be dredged from the channels, mooring basins and foundation of various facilities are, according to the result of soil investigation, mostly not suitable for reclamation of wharfs and filling as structure foundation. They should be dumped in the offshore. Dredging work for channels, mooring basins will be carried out by a trailing suction hopper dredger, capable of dredging without being much swayed by the wave. Excavation for foundation will be carried out by a grab dredger or cutter suction pump dredger (or similar type of dredger), and the dredged materials are to be transported by hopper barge for offshore dumping. Approximate volume of dredged materials are tabulated below.

**Table 10.4.1 Volume to be Dredged**

| Source | Volume ($m^3$) |
|---|---|
| Channel and Basins | 2,960,00 |
| Excavation for foundation | 730,000 |
| Total | 3,690,000 |

However, good quality sand deposited on the surface layer of near-shore area should be collected into sand pits by employing a small pump dredger and bulldozers or the like. Such sandy soils should be saved for replacement work of foundation or similar

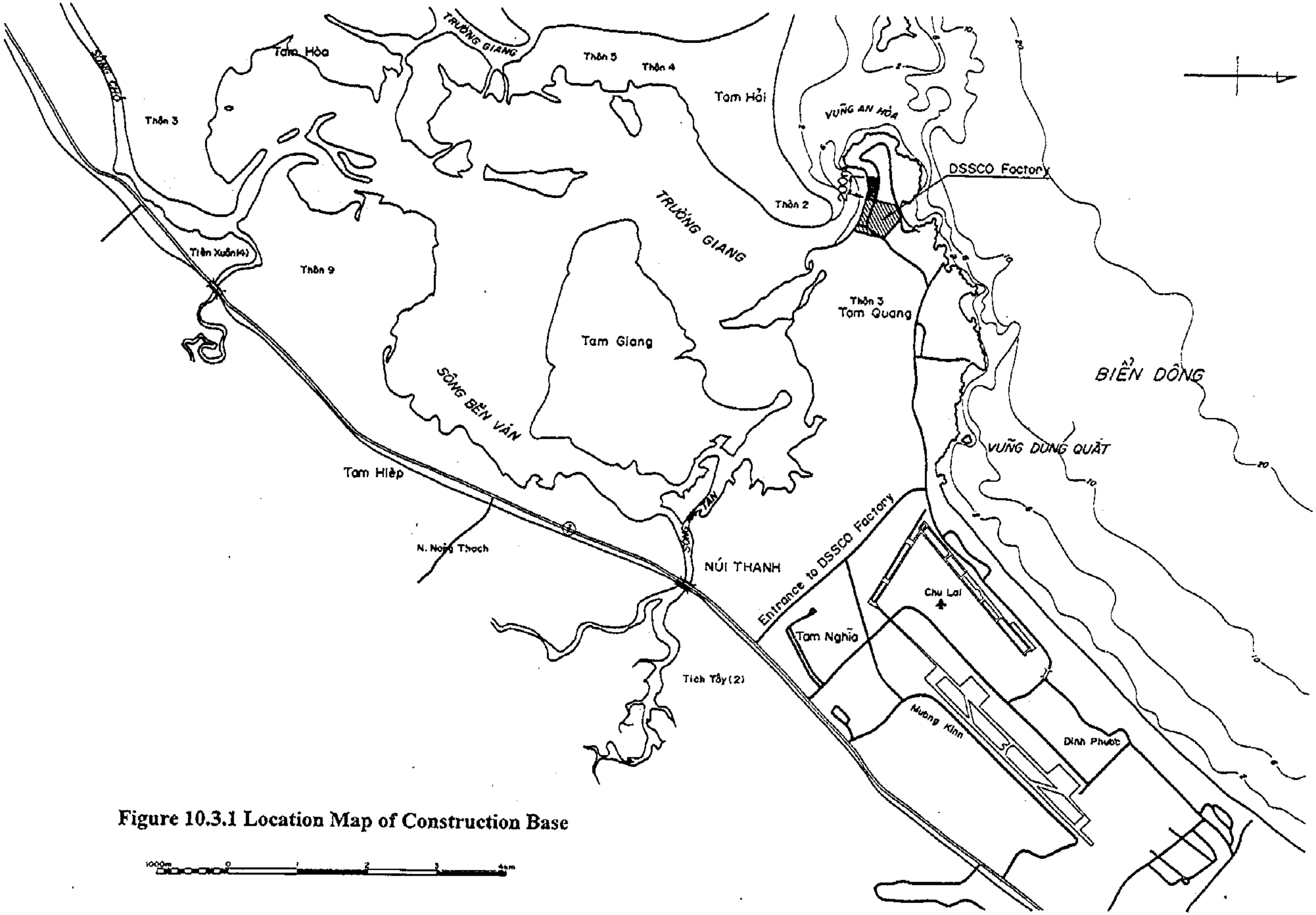



Figure 10.3.1 Location Map of Construction Base

purpose and help reduce the construction costs. The side trailing suction hopper dredger to be employed for dredging the access channel and mooring basin is of self-propeller type, capable of dredging while along predetermined courses.

The dredged materials are pumped into the strong hold through the drag head and arms and they are dumped through the bottom doors over a specified area of sea. The outline of proposed dredging plan of the channel and basin by side trailing suction hopper dredgers is as follows:

- Volume of spoil: 2,960,000 m
- Capacity of dredger : 3,240 $m^3$
- Dredging capacity: 3,000 $m^3$/hr
- Dredging depth : 4~12 m
- Service speed : 12 knots (8 knots)
- Distance to the dumping site: 15 km (from the site)
- Time required with load: 1.0 hr
  without load: 40 min
- Volume of spoil per day: 5,200 $m^3$/day
- Nos. of workable days : 720 days
- Dredging capacity : 2,960,000/5,200 = 570 days

## 10.5 Construction Time Scheduling

In order to prepare a proper construction schedule, local natural conditions, such as wave and wind, records should be thoroughly examined and taken into account. Statistics show that wave heights off the Danang Bay would exceed 1 meter for more than 50 percent of occurrence. Rainfall and wind velocity as well as the wave height affect the progress of construction work on the sea and on the land. Therefore, in the execution stage these natural phenomena should be taken into consideration and the result of examinations should be reflected in the detailed construction schedule.

Particularly, it is to be noted that the construction works should be carefully scheduled so as to avoid or at least minimize possible damage to the facilities or structure under construction due to high waves and strong wind during the typhoon season.

In order to complete the project within seven years, an integrated long-range program should be prepared to carry out all types of construction works, mobilize and demobilize construction plants, procure necessary machines and equipments, and timely supply various construction materials.

The proposed construction schedule is shown in Table 10.5.1. Constructing this time schedule, it is supposed that various procedures will be done smoothly and quickly for, for example, fund arrangement, execution of engineering services and conclusion of contracts. The schedule in general should be understood to be rather tight specifically in the case of ISP.

# Table 10.5.1 Construction Schedule for I S P ( Short-term Development Plan )- Lien Chieu

| Description | Quantity | 1998 1stYear | 1999 2ndYear | 2000 3rdYear | 2001 4thYear | 2002 5thYear | 2003 6thYear | 2004 7thYear | 2005 8thYear | 2006 9thYear | 2007 10thYear | 2008 11thYear | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Finance Arrangement | | | | | | | | | | | | | |
| 2 Selection of Consultant | | | | | | | | | | | | | |
| 3 Protective Facility | | | | | | | | | | | | | |
| 1) Breakwater | 265 m | | | | | | | | | | | | |
| 2) Seawall | 565 m | | | | | | | | | | | | |
| 3) Revetment R2 | 350 m | | | | | | | | | | | | |
| 5) Revetment R3 | 220 m | | | | | | | | | | | | |
| 6) Revetment R4 | 370 m | | | | | | | | | | | | |
| 7) Revetment for Road | 665 m | | | | | | | | | | | | |
| 8) Training Jetty | 200 m | | | | | | | | | | | | |
| 4 Dredging | 2,960,000 m³ | | | | | | | | | | | | |
| 1) Channel (-11m) | 2,535,000 m³ | | | | | | | | | | | | |
| 2) Basins (-12m) | 159,000 m³ | | | | | | | | | | | | |
| 3) Basins (-8m) | 266,000 m³ | | | | | | | | | | | | |
| 5 Bridge | T-25, L=75m | | | | | | | | | | | | |
| 6 Berthing Facility | | | | | | | | | | | | | |
| 1) Quaywall E1 | -12m 300 m | | | | | | | | | | | | |
| 2) Revetment R1/ Tentative Berth | -6m 130 m | | | | | | | | | | | | |
| 3) Quaywall W1 & W2 | -8m 380 m | | | | | | | | | | | | |
| 7 Yard | 287,000 m² | | | | | | | | | | | | |
| East wharf | 106,000 m² | | | | | | | | | | | | |
| West wharf | 181,000 m² | | | | | | | | | | | | |
| 8 Access Road | 63140 m²<br>L=2,870m | | | | | | | | | | | | |
| 9 Buildings & Utilities | | | | | | | | | | | | | |
| 1) CFS | 80m*25m | | | | | | | | | | | | |
| 2) Gate | 27.5m*24.0m | | | | | | | | | | | | |
| 3) Others | L.S. | | | | | | | | | | | | |
| 10 Cargo Handling Equip. | | | | | | | | | | | | | |
| 1) Container Cranes | 2 nos. | | | | | | | | | | | | |
| 2) Transfer Cranes | 3 nos. | | | | | | | | | | | | |
| 3) Chassis | 10 nos. | | | | | | | | | | | | |
| 4) Yard Tractors | 7 nos. | | | | | | | | | | | | |
| 5) Others | L.S. | | | | | | | | | | | | |
| 11 Navigation System | | | | | | | | | | | | | |
| 1) Tug Boats | 2 nos. | | | | | | | | | | | | |
| 2) Buoys & Beacons | L.S. | | | | | | | | | | | | |
| 12 Engineering Services | | | | | | | | | | | | | |
| Note: | | | | | | | | | | | | | |

Apr. 2,000. Commencement of Construction

Jly. 2,004. Commencement of QuayWall E1 (-12m)

Dec. 2,006. Completion of Quaywall W1 & W2 (-8m)

## 10.6 Other Important Points to be Noted

In order to implement the construction works nationally and smoothly, there are several points be taken into account. Among other items, the following are most important:

### (1) Prudent and In-depth Surveys

Various site surveys should be planned and carried out prior to and during the construction works. One of the most important is examination of soil characteristic with closer intervals than those of this Study. The result of the soil investigation should be reflected in the detailed design, planning of the process of construction in order to avoid unexpected accidents such as failure of the structure.

Other important surveys include monitoring of behavior of the structures, reclaimed land, etc. To manage the construction schedule or to discuss, for example, change in construction method.

One of the subjects to be carefully followed during construction period is the monitoring of the effect of the training jetty, which is to protect the channel and harbor basins from siltation and sedimentation of solids. If an adverse effect is observed, appropriate measures should be taken, for example, extension of the jetty.

### (2) Execution of Foundation Construction

The quality of the replacement works of soft soils by sand affect the stability of, for example, quaywall very critically. Full attention should be paid not to remain soft muds in the bottom ditches.

### (3) Necessity of Details Planning of Reclamation Works

After obtaining detailed soil data, execution method of reclamation should be discussed so as to avoid, if any, excessive settlement, flow out of fluid mud, etc.

### (4) Construction Safety Measures and Environment Protection

In planning construction methods, full attention shall be paid to safety of workers and works both on the land and sea throughout the execution to completion of the works. All the reasonable steps shall be taken to protect the environment of construction site to avoid damage or nuisance to persons or to property of the public, resulting from pollution which arises as a consequence of, for example, dredging work.

### (5) Necessity of Vocational Training of Local Laborers

Port construction works require, besides engineers, many skilled, specialized and qualified laborers such as operators of various equipment, welders, divers, and mechanics. During the course of port construction, ways and means of training of local workers should be sought to upgrade their capability to get them to adapt themselves to any grade of works involved in the construction.

In order to implement the construction works rationally and smoothly, there are several points to be taken into account. Among other items, the following are most important.

# 11 Cost Estimates

## 11.1 Basic Condition of Cost Estimates

Bases of the preliminary cost estimates of construction costs are as follows:

(1) Cost of construction have been estimated using the prices and exchange rates in December, 1997.

(2) The inflation factor is excluded from estimates.

(3) The estimated costs of construction are expressed both in respect of foreign currency and local currency portions using the exchange rates as follows:
US$ 1.00= JPY 130= VND12,280( as of December, 1997 ).

(4) The cost of foreign portion includes the following:

1) Foreign currency portion of operation includes depreciation costs and products cost for imported equipment,
2) Cost for imported equipments,
3) Imported materials and products,

(5) Turnover and Profit taxes are 6% of contract price.

(6) Physical contingency for civil work is 8% and that for equipment is 3%.

(7) Estimate engineering services are base on necessary items.

## 11.2 Cost Estimates of Master Plan

Table 11.2.1 presents the result of preliminary cost estimates for the construction of the individual elements of the project for the implementation of Master Plan, the total of which is abut US$ 359million, inclusive of the cost of cargo handling equipment and navigation aids.

## 11.3 Cost Estimates of Initial Stage Development Plan

Table 11.3.1 presents the results of preliminary cost estimates for the construction of the individual elements the project. Cost for the implementation of Initial Stage Development Plan is estimated at about US$ 158 million, inclusive of the cost of cargo handling equipment and navigation aids.

The disbursement schedule of the project is shown in Table 11.3.2 based on the time schedule and the cost breakdown in foreign/local currencies.

## 11.4 Summary on Cost Estimates

The cost of construction for the implementation of the Master Plan Project is US$ 341 million and that of ISP is estimated at US$150 million, except for taxes, resettlement and compensation costs. The total construction cost directly related to the civil and building works amount to US$241 million or 71 % of the total project cost of the Master Plan Project, and the said works amount to US$126 million or 84 % of the entire cost of the ISP.

The above costs were estimated based on market surveys of unit costs, surveys of the breakdown of actual tendered costs of similar port construction projects, and confirmation of them from relevant authorities in the government by the Study Team.

It should be noted, however, that prior to the execution stage the above cost estimates will have to be reviewed and revised through detailed surveys and estimates, reflecting the results of finalized detailed design and, among other factors, inflation rate and taxation system at that time.

## Table 11.2.1 Preliminary Cost Estimate for M S P ( Lien Chieu )

| Facility | Structure | Depth (m) | Length/ Quantity | Unit Cost (US$) | Amount (Thous.US$) | Remarks |
|---|---|---|---|---|---|---|
| 1.Protective Facility | | | | | 64,380 | |
| 1) North Breakwater | H.B Caisson | -9.5 | 225 m | 35,000 | 7,880 | Crown Height+7.5m |
| 2) Seawall | Ditto | -8.5 | 395 m | 38,000 | 15,010 | 〃 +7.5m |
| 3) Ditto | Ditto | -8.5 | 265 m | 33,800 | 8,960 | 〃 +7.5m |
| 4) Ditto | Ditto | -8.0 | 565 m | 40,000 | 22,600 | 〃 +7.5m |
| 5) Revetment | R.C Caisson | -9.0 | 350 m | 11,050 | 3,870 | 〃 +3.0m |
| 6) Revetment for Road | L-Shaped block | -6.0 | 400 m | 5,700 | 2,280 | 〃 +3.0m |
| 7) Revetment | Ditto | -6.0 | 180 m | 5,700 | 1,030 | 〃 +3.0m |
| 8) Revetment for Road | Concrete block | -3.0 | 430 m | 4,200 | 1,810 | 〃 +3.0m |
| 9) Training Wall | Wave Dissipating Concrete block | -0.5 | 200 m | 4,700 | 940 | 〃 +2.0m |
| 2.Dredging | | | | | 40,790 | |
| Channel & Basins | (-5.5m,-8.0m,-9.0m,-12.0m,-13.0m) | | 8,157,000 $m^3$ | 5 | 40,790 | |
| 3.Bridge | P.C.Beams,Class:T-25 | | L.S. | 1,880 | 1,880 | W=22m,L=75m |
| 4.Berthing Facility | | | | | 51,260 | |
| 1) Quaywall | H.B Caisson | -13.0 | 690 m | 35,300 | 24,360 | Crown Height+3.0m |
| 2) Ditto | Ditto | -12.0 | 300 m | 42,400 | 12,720 | 〃 +3.0m |
| 3) Revetment | L-Shaped block | -6.0 | 130 m | 5,100 | 660 | 〃 +3.0m |
| 4) Quaywall | R.C Caisson | -9.0 | 350 m | 14,300 | 5,010 | 〃 +3.0m |
| 5) Ditto | Ditto | -8.0 | 300 m | 12,600 | 3,780 | 〃 +3.0m |
| 6) Ditto | Ditto | -5.5 | 430 m | 11,000 | 4,730 | 〃 +2.0m |
| 5.Yard | | | | | 67,340 | |
| | | | 962,000 $m^2$ | 70 | 67,340 | |
| 6.Road | | | | | 4,420 | |
| | Surface : Asphalt<br>Base : Rubble | | 63,140 $m^2$ | 70 | 4,420 | W= 22m<br>L=2,870m |
| 7.Buildings & Utilities | | | | | 10,600 | |
| 1) CFS(Steel frame) | Steel frame 80m*25m | | 2nos. | | 1,600 | Single-story |
| 2) Gate(Steel frame) | Steel frame 27.5m*24m | | 2nos. | | 1,000 | Single-story |
| 3) Others | | | L.s. | | 8,000 | Adm.Building, Maintenance Shop, Generator Building, Substation ,etc. |
| Sub Total (1) | | | | | 240,670 | |
| 8.Cargo Handling Equip. | | | | | 44,580 | |
| 1) Container Cranes | | | 6nos. | 4,500,000 | 27,000 | |
| 2) Transfer Cranes | | | 12nos. | 1,100,000 | 13,200 | |
| 3) Chassis | | | 26nos. | 50,000 | 1,300 | |
| 4) Yard Tractors | | | 19nos. | 122,000 | 2,320 | |
| 5) Others | | | L.S. | | 760 | |
| 9.Navigation System | | | | | 4,430 | |
| 1) Tug Boats | 2,500HP | | 2nos. | | 4,000 | |
| 2) Buoys & Beacons | | | L.S. | | 430 | |
| Sub Total (2) | | | | | 49,010 | |
| Total | (Sub-Total(1)+Sub-Total(2)) | | | | 289,680 | |
| Physical Contingency | (8% of Sub-Total(1)+3%of Sub-Total(2)) | | | | 20,720 | |
| Engineering Services | Estimate base on necessary items | | | | 30,800 | |
| Tax | 6% of Total | | | | 17,380 | Turnover and Profit Taxes |
| Resettlement and Compensation Costs | | | | | 100 | |
| Grand Total | | | | | 358,580 | |

Notes:1)Based on costs in December,1997. Exchange rate : US$1.00=JPY130=VND12,280
2) Excludes Price Contingency

## Table 11.3.1 Preliminary Cost Estimate for I S P ( Short-term Development Plan)-Lien Chieu

| Facility | Structure | Depth (m) | Length/ Quantity | Unit Cost (US$) | Amount (Thous.US$) | Remarks |
|---|---|---|---|---|---|---|
| 1 Protective Facility | | | | | 42,170 | |
| 1) Breakwater | H.B. Caisson | -8.5 | 265 m | 33,800 | 8,960 | Crown Height+7.5m |
| 2) Seawall | Ditto | -8.0 | 565 m | 40,000 | 22,600 | 〃 +7.5m |
| 3) Revetment R2 | R.C. Caisson | -8.0 | 350 m | 11,050 | 3,870 | 〃 +3.0m |
| 4) Revetment R3 | L-Shaped Block | -6.0 | 220 m | 5,100 | 1,120 | 〃 +3.0m |
| 5) Revetment R4 | L-Shaped Block | -6.0 | 370 m | 5,100 | 1,890 | 〃 +3.0m |
| 6) Revetment for Road | Concrete Block | -2.5 | 665 m | 4,200 | 2,790 | 〃 +3.0m |
| 7) Training Jetty | Wave Dissipating Concrete Block | -0.5 | 200 m | 4,700 | 940 | 〃 +2.0m |
| 2 Dredging | | | 2,960,000 $m^3$ | | 14,810 | |
| 1) Channel | | -11.0 | 2,535,000 $m^3$ | 5 | 12,680 | |
| 2) Basins | | -12.0 | 159,000 $m^3$ | 5 | 800 | |
| 3) Basins | | -8.0 | 266,000 $m^3$ | 5 | 1,330 | |
| 3 Bridge | P.C.Beams,Class:T-25 | | L.S. | 1,880 | 1,880 | W=22m,L=75m |
| 4 Berthing Facility | | | | | 18,400 | |
| 1) Quaywall E1 | H.B. Caisson | -12.0 | 300 m | 42,300 | 12,690 | Crown Height+3.0m |
| 2) Revetment R1/ Tentative Berth | L-Shaped Block | -6.0 | 130 m | 5,100 | 660 | 〃 +3.0m |
| 3) Quaywall W1 & W2 | R.C. Caisson | -8.0 | 380 m | 13,300 | 5,050 | 〃 +3.0m |
| 5 Yard | | | 287,000 $m^2$ | | 20,090 | |
| 1) East wharf | | | 106,000 $m^2$ | 70 | 7,420 | |
| 2) West wharf | | | 181,000 $m^2$ | 70 | 12,670 | |
| 6 Access Road | | | | | 4,420 | W=22m |
| | Surface : Asphalt<br>Base : Rubble | | 63,140 $m^2$ | 70 | 4,420 | L=2,870m |
| 7 Buildings & Utilities | | | | | 5,300 | |
| 1) CFS | Steel frame 80m*25m | | 1 no. | | 800 | Single-story |
| 2) Gate | Steel frame 27.5m*24.0m | | 1 no. | | 500 | Single-story |
| 3) Others | | | L.S. | | 4,000 | Adm.Building, Maintenance Shop, Generator Building, Substation ,etc. |
| Sub-total (1) | | | | | 107,070 | |
| 8 Cargo Handling Equip. | | | | | 14,080 | |
| 1) Container Cranes | | | 2 nos. | 4,500,000 | 9,000 | |
| 2) Transfer Cranes | | | 3 nos. | 1,100,000 | 3,300 | |
| 3) Chassis | | | 10 nos. | 50,000 | 500 | 40' |
| 4) Yard Tractors | | | 7 nos. | 122,000 | 850 | |
| 5) Others | | | L.S. | | 430 | |
| 9 Navigation System | | | | | 4,380 | |
| 1) Tug Boats | 2,500HP | | 2 nos. | | 4,000 | |
| 2) Buoys & Beacons | | | L.S. | | 380 | |
| Sub-total (2) | | | | | 18,460 | |
| Total | (Sub-total(1)+Sub-total(2)) | | | | 125,530 | |
| Physical Contingency | (8% of Sub-total(1)+3% of Sub-total(2)) | | | | 9,120 | |
| Engineering Services | Estimate base on necessary items | | | | 15,380 | |
| Tax | 6% of Total | | | | 7,530 | Turnover and Profit Taxes |
| Resettlement and Compensation Costs | | | | | 100 | |
| Grand Total | | | | | 157,660 | |

Notes: 1)Based on costs in December,1997. Exchange rate : US$1.00=JPY130=VND12,280
2) Excludes Price Contingency

## Table 11.3.2 Disbursement Schedule for I S P ( Short-term Development Plan )- Lien Chieu

Unit:'000US$

| Description | Quantity | Amont | | | 1998 | | | 1999 | | | 2000 | | | 2001 | | | 2002 | | | 2003 | | | 2004 | | | 2005 | | | 2006 | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Construction Cost | | | 1stYear | | | 2ndYear | | | 3rdYear | | | 4thYear | | | 5thYear | | | 6thYear | | | 7thYear | | | 8thYear | | | 9thYear | | | |
| | | Forign | Local | Total | Forign | Local | Total | Forign | Local | Total | Forign | Local | Total | Forign | Local | Total | Forign | Local | Total | Forign | Local | Total | Forign | Local | Total | Forign | Local | Total | Forign | Local | Total | |
| 1 Finance Arrangement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 Selection of Consultant | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 Facility | | 18,446 | 23,724 | 42,170 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) Breakwater | 265 m | 4,032 | 4,928 | 8,960 | | | | | | | | | | 2,016 | 2,464 | 4,480 | 2,016 | 2,464 | 4,480 | | | | | | | | | | | | | |
| 2) Seawall | 565 m | 10,170 | 12,430 | 22,600 | | | | | | | 6,102 | 7,458 | 13,560 | 4,068 | 4,972 | 9,040 | | | | | | | | | | | | | | | | |
| 3) Revetment R2 | 350 m | 1,548 | 2,322 | 3,870 | | | | | | | | | | | | | 1,161 | 1,742 | 2,903 | 387 | 581 | 968 | | | | | | | | | | |
| 4) Revetment R3 | 220 m | 448 | 672 | 1,120 | | | | | | | | | | | | | | | | 448 | 672 | 1,120 | | | | | | | | | | |
| 5) Revetment R4 | 370 m | 756 | 1,134 | 1,890 | | | | | | | | | | | | | | | | 252 | 378 | 630 | 504 | 756 | 1,260 | | | | | | | |
| 6) Revetment for Road | 665 m | 1,116 | 1,674 | 2,790 | | | | | | | 670 | 1,004 | 1,674 | 446 | 670 | 1,116 | | | | | | | | | | | | | | | | |
| 7) Training Jetty | 200 m | 376 | 564 | 940 | | | | | | | 376 | 564 | 940 | | | | | | | | | | | | | | | | | | | |
| 4 Dredging | 2,960,000 m3 | 5,924 | 8,886 | 14,810 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) Channel | 2,535,000 m3 | 5,072 | 7,608 | 12,680 | | | | | | | | | | | | | | | | 3,381 | 5,072 | 8,453 | 1,691 | 2,536 | 4,227 | | | | | | | |
| 2) Basins | 159,000 m3 | 320 | 480 | 800 | | | | | | | | | | | | | 320 | 480 | 800 | | | | | | | | | | | | | |
| 3) Basins | 266,000 m3 | 532 | 798 | 1,330 | | | | | | | | | | | | | | | | | | | | | | | | | 532 | 798 | 1,330 | |
| 5 Bridge | L.S. | 1,692 | 188 | 1,880 | | | | | | | 423 | 47 | 470 | 1,269 | 141 | 1,410 | | | | | | | | | | | | | | | | |
| 6 Berthing Facility | | 8,280 | 10,120 | 18,400 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) Quaywall E1 | 300 m | 5,711 | 6,979 | 12,690 | | | | | | | | | | 1,904 | 2,326 | 4,230 | 3,807 | 4,653 | 8,460 | | | | | | | | | | | | | |
| 2) Revetment R1/ Tentative Berth | 130 m | 297 | 363 | 660 | | | | | | | 99 | 121 | 220 | 198 | 242 | 440 | | | | | | | | | | | | | | | | |
| 3) Quaywall W1 & W2 | 380 m | 2,273 | 2,777 | 5,050 | | | | | | | | | | | | | | | | | | | 1,137 | 1,389 | 2,526 | 1,137 | 1,389 | 2,526 | | | | |
| 7 Yard | 287,000 m2 | 14,063 | 6,027 | 20,090 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) East wharf | 106,000 m2 | 5,194 | 2,226 | 7,420 | | | | | | | | | | | | | 3,895 | 1,670 | 5,565 | 1,298 | 557 | 1,855 | | | | | | | | | | |
| 2) West wharf | 181,000 m2 | 8,869 | 3,801 | 12,670 | | | | | | | | | | | | | | | | | | | | | | 2,956 | 1,267 | 4,223 | 5,913 | 2,534 | 8,447 | |
| 8 Access Road | 63,140 m2 | 1,768 | 2,652 | 4,420 | | | | | | | 884 | 1,326 | 2,210 | 884 | 1,326 | 2,210 | | | | | | | | | | | | | | | | |
| | L=2,870m | 1,768 | 2,652 | 4,420 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 Buildings & Utilities | | 4,770 | 530 | 5,300 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) CFS | 1 no. | 720 | 80 | 800 | | | | | | | | | | | | | | | | 360 | 40 | 400 | 360 | 40 | 400 | | | | | | | |
| 2) Gate | 1 no. | 450 | 50 | 500 | | | | | | | | | | | | | | | | 150 | 17 | 167 | 300 | 33 | 333 | | | | | | | |
| 3) Others | L.S. | 3,600 | 400 | 4,000 | | | | | | | | | | | | | | | | | | | 3,600 | 400 | 4,000 | | | | | | | |
| 10 Sub-total (1) | | 54,944 | 52,126 | 107,070 | | | | | | | 8,554 | 10,520 | 19,074 | 10,785 | 12,141 | 22,926 | 11,199 | 11,009 | 22,208 | 6,276 | 7,317 | 13,593 | 7,592 | 5,154 | 12,746 | 4,093 | 2,656 | 6,749 | 6,445 | 3,332 | 9,777 | |
| 11 Cargo Handling Equip. | | 14,080 | | 14,080 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) Container Cranes | 2 nos. | 9,000 | | 9,000 | | | | | | | | | | | | | | | | 2,700 | | 2,700 | 1,800 | | 1,800 | 900 | | 900 | 3,600 | | 3,600 | |
| 2) Transfer Cranes | 3 nos. | 3,300 | | 3,300 | | | | | | | | | | | | | | | | 825 | | 825 | 825 | | 825 | | | | 1,650 | | 1,650 | |
| 3) Chassis | 10 nos. | 500 | | 500 | | | | | | | | | | | | | | | | 83 | | 83 | 167 | | 167 | | | | 250 | | 250 | |
| 4) Yard Tractors | 7 nos. | 850 | | 850 | | | | | | | | | | | | | | | | 142 | | 142 | 283 | | 283 | | | | 425 | | 425 | |
| 5) Others | L.S. | 430 | | 430 | | | | | | | | | | | | | | | | | | | 215 | | 215 | | | | 215 | | 215 | |
| 12 Navigation System | | 4,380 | | 4,380 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) Tug Boats | 2 nos. | 4,000 | | 4,000 | | | | | | | | | | | | | | | | 2,000 | | 2,000 | 2,000 | | 2,000 | | | | | | | |
| 2) Buoys & Beacons | L.S. | 380 | | 380 | | | | | | | | | | | | | | | | | | | 190 | | 190 | | | | 190 | | 190 | |
| 13 Sub-total (2) | | 18,460 | | 18,460 | | | | | | | | | | | | | | | | 5,750 | | 5,750 | 5,480 | | 5,480 | 900 | | 900 | 6,330 | | 6,330 | |
| 14 Total | | 73,404 | 52,126 | 125,530 | | | | | | | 8,554 | 10,520 | 19,074 | 10,785 | 12,141 | 22,926 | 11,199 | 11,009 | 22,208 | 12,026 | 7,317 | 19,343 | 13,072 | 5,154 | 18,226 | 4,993 | 2,656 | 7,649 | 12,775 | 3,332 | 16,107 | |
| 15 Physical Contingency | | 7,296 | 1,824 | 9,120 | | | | | | | 684 | 842 | 1,526 | 863 | 971 | 1,834 | 896 | 881 | 1,777 | 675 | 585 | 1,260 | 772 | 412 | 1,184 | 354 | 212 | 567 | 706 | 267 | 972 | |
| 16 Engineering Services | | 12,304 | 3,076 | 15,380 | | | | | | | 1,367 | 342 | 1,709 | 1,823 | 456 | 2,279 | 1,823 | 456 | 2,279 | 1,823 | 456 | 2,279 | 1,823 | 456 | 2,279 | 1,823 | 456 | 2,279 | 1,823 | 456 | 2,279 | |
| 17 Tax | | 7,530 | | 7,530 | | | | | | | 513 | 631 | 1,144 | 647 | 728 | 1,376 | 672 | 661 | 1,332 | 722 | 439 | 1,161 | 784 | 309 | 1,094 | 300 | 159 | 459 | 767 | 200 | 966 | |
| 18 Resettlement and Compensation Costs | | | 100 | 100 | | | | | | | | 11 | 11 | | 15 | 15 | | 15 | 15 | | 15 | 15 | | 15 | 15 | | 15 | 15 | | 15 | 15 | |
| 19 Grand Total | | 100,534 | 57,126 | 157,660 | | | | | | | 11,118 | 12,346 | 23,464 | 14,118 | 14,311 | 28,430 | 14,590 | 13,022 | 27,611 | 15,246 | 8,812 | 24,058 | 16,451 | 5,316 | 22,798 | 7,470 | 3,498 | 10,969 | 16,071 | 4,270 | 20,339 | |

Note:

Apr. 2,000. Commencement of Construction

Dec. 2,006. Completion of Quaywall W1 & W2 (-8m)

Jly. 2,004. Commencement of Quaywall E1 (-12m)