Chapter 8 Short-term Development Plan

8.1 Planning Requirements for Main Facilities

The core facility of the urgent development project is a new multipurpose terminal which can provide an optimum transportation services in the Southern Area. In this chapter the requirements of port facilities is examined prior to formulating alternative port facility layout plans. The size of design vessel and dimensions of main facilities such as berths, storage facilities, roads and water facilities are determined.

8.1.1 Cargo Forecast

Future cargo handled at Galle Port is estimated in Chapter 3. Demand Forecast. Results of the cargo forecast are summarized in Table 8.1.1 and Table 8.1.2.

Table 8.1.1 All Cargoes

(thousand tons)

	1999	2005	2010	Remarks
Discharged				
Container	0	158	205	
Break bulk				
Bagged cement	119	100	140	
Bagged fertilizer	0	119	129	
Bagged flour	34	105	109	Coastal service
Bagged sugar	0	87	96	
Iron / steel	0	36	61	
Other break bulk	3	0	0	
(sub-total)	156	447	535	
Dry bulk				
Bulk cement	87	400	560	
Clinker	174	475	950	
Gypsum	9	25	50	
Maize	0	27	33	
(sub-total)	270	927	1593	
Liquid bulk				
Petroleum Product	13	300	500	Coastal service
Discharged Total	438	1,832	2,833	
Loaded				
Container	0	112	148	
Break bulk	1	1	1	
Loaded Total	1	113	149	
Total	439	1,945	2,982	

Table 8.1.2 Container Cargo

(TEUs)

	2005	2010
Import container	14,040	18,210
Laden	11,790	15,300
Empty	2,250	2,910
Export container	14,040	18,210
Laden	9,330	12,330
Empty	4,710	5,880
Total	28,080	36,420

8.1.2 Optimum Number of New Berths

Optimum number of new berths is determined by comparison of the total costs consisting of offshore ship waiting cost and new berth construction cost in three cases: construction of one new berth, two new berths, and three new berths.. Ship waiting time is calculated by using a simulation model. The total cost in each case is estimated in terms of NPV assuming a project life of 30 years. The resulting optimum berth number is two.

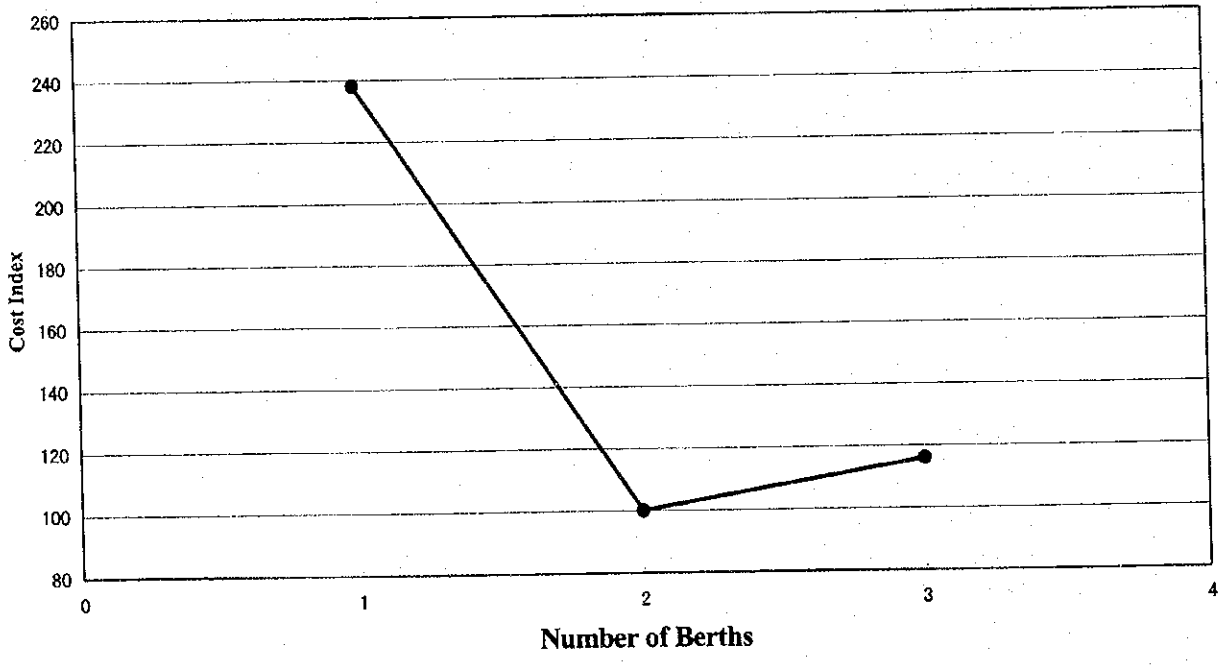


Fig. 8.1.1 Cost Comparison by Number of Berths

8.1.3 Optimum Water Depth of New Berths and Vessel Size

Optimum water depth of new berths is determined by comparison of the total cost consisting of sea transportation cost and new berth construction cost in five cases: depth is set at 10m, 11m, 12m, 13m and 14m respectively. Sea transportation cost depends on vessel size and sea route distance while the water depth of the berth determines the maximum permissible draft of a calling vessel. Transportation cost was calculated by commodity and summed up during the project period (30 years) and converted to NPV. The result is shown in Fig. 8.1.2. Optimum depth of new berths is 11m and 12m. As deeper berths accommodate larger vessels, berths with 12m depth, which can accommodate 30,000DWT in vessel size under full draft condition, are recommended.

Vessel size for port facilities is as follows

Type of vessel	Cargo Vessel
DWT	30,000DWT
Overall Length	185m
Molded Breadth	27.5m
Full-Load Draft	11.0m

Even now, cargo vessels greater than 30,000 DWT call at Colombo Port by reducing their draft. Once deep berths are constructed in the Galle Port, the possibility that 30,000 DWT vessels will call at Galle Port with full draft is considered to be high.

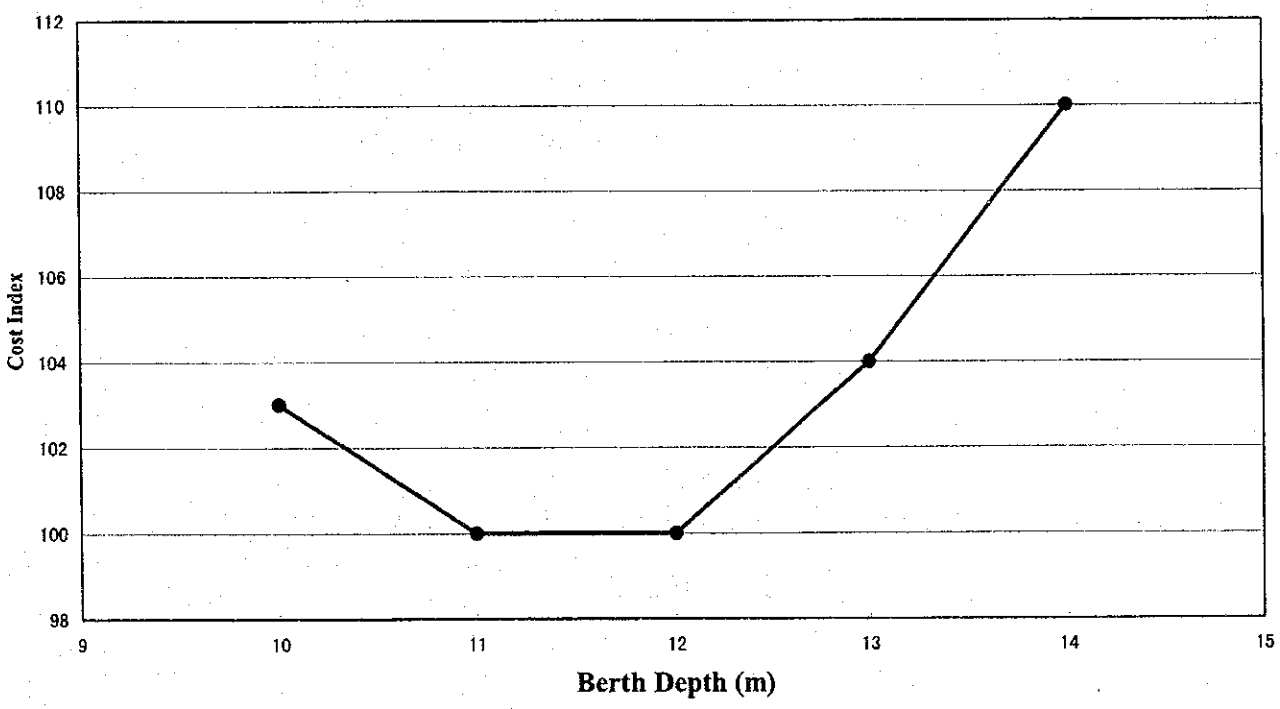


Fig. 8.1.2 Cost Comparison by Berth Depth

8.1.4 Storage Facilities

(1) Shed

The required dimensions of sheds were estimated using the following formula for the storage of the bagged cargo. Required area of sheds is calculated at 8,000 sq.m.

$A=(\lambda \times \delta \times V/T)/(\mu \times \xi \times \varepsilon)$

Where,

V	:	304,000	Annual cargo throughput of conventional cargo at new berths (tons)
T	:	363	Annual working days
λ	:	1.5	Peaking factor to the daily average handling demand
δ	:	7	Average dwelling time (days)
μ	:	3.0	Unit load for storage (tons/sq. m)
ξ	:	0.5	Passage ratio
ε	:	0.75	Operational factor
A	:	7,816	Floor space (sq. m)

(2) Open Yard

The required dimensions of open stock yards were estimated using the following formula for Iron / Steel. Considering the need of marshaling yard for enhancement of cargo handling productivity, area of open yards is proposed at 10,000 sq.m.

$A=(\lambda \times \delta \times V/T)/(\mu \times \xi \times \varepsilon)$

Where,

V	36,000	Annual cargo throughput of conventional cargo (tons)
T	363	Annual working days
λ	1.5	Peaking factor to the daily average handling demand
δ	7	Average dwelling time (days)
μ	1.0	Unit load for storage (tons/sq.m)
ξ	0.5	Passage ratio
ε	0.75	Operational factor
A	2,777	Open stock yard space (sq.m)

(3) Container Yard

◆ **Container handling system in container yard**

There are several container-handling systems including those of transfer crane, straddle carrier and forklift. Since there is a limited container volume for the time being, the forklift system, which requires the minimum investment, is recommended.

◆ **Area of container yard**

By computer simulation, number of containers to be handled at the new terminal at peak time in the target year was estimated and the result is shown below.

Loaded container	441	TEUs
Export	422	TEUs
Import	409	TEUs
Empty container	437	TEUs

Containers are stacked in the container yard in the following manner,

Import container	2 layers and 3 rows
Export container	4 layers and 4 rows
Empty container	4 layers and 4 rows

Required number of slots is calculated as follows,

Export and import container	215
Empty container	110

The estimated area of container yard is 2.9 ha.

(4) CFS

Required floor space of CFS is estimated using the following formula. Number of containers at peak time was estimated by computer simulation. As the required floor space of CFS is small at the initial stage, it is proposed to allocate same space for the CFS cargoes in the new shed to be used mainly for the storage of conventional cargo.

$$A = \Sigma V \times T / (\mu \times \xi \times \varepsilon)$$

Where,

Ve	9	TEUs of export containers at peak time
Vi	22	TEUs of import containers at peak time
T	13.1	Tons/teu(laden)
μ	2.0	Unit load per square meter for storage
ξ	0.7	Passage ratio
ε	0.75	Operational factor
Ae	112	Square meter for export container
Ai	275	Square meter for import container
At	387	=Ae+Ai

8.1.5 Approach Channel

Number of vessels calling at Galle New Berths is estimated at 200 in the year 2005 and 230 in the year 2010. Two ships will use the approach channel on average per day. One way channel is enough to handle this traffic level. The width of the approach channel is determined using methods proposed by PIANC[1] and UNCTAD[2].

[1] Approach Channels, A Guide for Design, Final Report of the Joint PIANC-IAPH Working Group II-30 in cooperation with IMPA and IALA, June 1997

[2] Port Development, A Handbook for Planners in Developing Countries, United Nations Conference on Trade and Development,1985

According to PIANC proposal, the bottom width of the approach channel is given for a one way channel by:

$$W = Wbm + \Sigma Wi + Wbr + Wbg$$

where,

Additional width	Items	Characteristics of Galle Port	Width
Wbm	Ship maneuverability	Poor	1.8B
W1	Vessel speed	Slow	0.0B
W2	Prevailing cross winds	Moderate	0.5B
W3	Prevailing cross current	Negligible	0.0B
W4	Prevailing longitudinal current	Low	0.0B
W5	Significant wave height and length	1 < Hs < 3	0.5B
W6	Aids to navigation	Moderate and infrequent poor visibility	0.2B
W7	Bottom surface	Rough and hard	0.2B
W8	Depth of waterway	<1.25T	0.4B
W9	Cargo hazard level	Low	0.0B
Wbr	Bank clearance (red side)	Steep and hard embankments,	0.5B
Wbg	Bank clearance (green side)	structures	0.5B
Total			4.7B

B: beam of vessel, Hs: significant wave height, T: draught of vessel

On the other hand, UNCTAD proposes 5B (B is beam of vessel) for the width of a one way channel. 5B for the bottom width of the approach channel is proposed. As many kinds of cargo vessels such as bulk carrier, general cargo ship and container ship will use the approach channel, 32m is adapted as B taking account of possible beam range of vessels calling at the new berths covering bulk carrier, container vessels and general cargo vessels. Difficulty of further expansion of channel width especially at port entrance after completion is also considered.

Width of approach channel = 5.0 × 32m = 160m

8.1.6 Turning Basin

Turning basin is to be located in front of new berths and has a diameter of two times of the overall length of design vessel.

8.1.7 Main Access Road

The main access road will be constructed from Galle - Matara Road (A2 road) to the new multipurpose terminal through reclaimed land. The traffic volume generated by port activities was estimated by applying the following equation.

$$V = \upsilon / 24 \times \sigma \times (1 + \delta) / \varepsilon$$

Where,

υ	1,215	Number of trucks at peak day
σ	4.0	Variation ratio per hour
δ	0.2	Cargo related vehicle ratio

ε	0.5	Ratio of vehicle with load
V	486	Number of vehicles at peak hour

Considering the estimated traffic volume, necessity of parking lanes and flexibility for future demand, a four-lane road is proposed.

8.2 Alternatives of Port Facility Layout Plan

8.2.1 Alternatives of Port Facility Layout Plan

Based on field surveys, future cargo demand forecast and other study results, four (4) alternative port facility layout plans are proposed (see Fig. 8.2.1 to Fig. 8.2.4). There are two main concerns in formulating these alternatives, that is, how to minimize the construction cost and how to harmonize new facilities with the environment. As for construction cost, positioning breakwaters so that they sufficiently protect berths and water facilities from severe wave conditions while also maintaining economical viability and how to layout new berths and water facilities which involve hard rock dredging works are crucial matters.

8.2.2 Alternative-1

In Alternative-1, new berths and a new approach channel are constructed in the east part of Galle Bay. The new berths are located in the south of Gibbet Island and they lie from north to south. Outer breakwater and inner breakwater protect berths and water facilities.

8.2.3 Alternative-2

Alternative-2 is a derivative of Alternative-1. In this plan, the length of breakwaters is reduced by sacrificing the calm sea area. Breakwaters do not protect the channel. This situation is the same as the existing Galle Port.

8.2.4 Alternative-3

Alternative-3 is also a derivative of Alternative-1. The direction of berths is different from Alternative-1 and –2. And the area of reclaimed land is reduced.

8.2.5 Alternative-4

Alternative-4 is a plan that uses the west part of Galle Bay. The new berths are constructed next to the entrance of the existing port. The new approach channel is constructed and is commonly used by vessels calling at existing berths and new berths.

8.3 Comparison of Alternatives

8.3.1 Calmness

The wave height in front of the quay is a key factor affecting cargo handling efficiency. The degree

of calmness of water in front of quays is calculated for Alternatives-1, -2 and -3 in a preliminary manner and the result is shown in Table 8.2.1. Among the three Alternatives, Alternative-1 is the best as the non-excess probability under 0.5m in wave height is almost 100% in both berths. The limitation of 0.5m in alongside cargo handling is generally adopted for ordinary cargo handling. The east berth of Alternative-3 does not satisfy the criteria (95%).

Table 8.3.1 Degree of Calmness

Wave height	< 0.3m	< 0.4m	< 0.5m	< 0.7m
Alternative 1				
Berth 1	77%	96%	100%	100%
Berth 2	70%	91%	99%	100%
Alternative 2				
Berth 1	76%	96%	100%	100%
Berth 2	60%	84%	97%	100%
Alternative 3				
Berth 1	72%	93%	99%	100%
Berth 2	43%	72%	81%	99%

8.3.2 Navigation Safety

◆ **Stopping distance**

A vessel requires a "stopping distance" of five times her length to stop safely after reducing her speed. As for Alternative-2 and -3, adequate stopping distance protected by breakwaters is not provided.

◆ **Wave on Vessel**

It becomes more difficult to maneuver vessels when wave flows from their stern, in particular for vessels at low speed. In Alternative-2 and -3, the direction of approach channel is coincident with the main direction of waves in the southwest monsoon season and thus these alternatives are not recommendable.

◆ **Alignment**

The straight channel alignment is preferable. Alternative-4 is not recommendable, because the approach channel has a bend to the right by about 40 degrees.

As for Alternative-2 and -3, vessels have to move in the direction of the shallow water area in the east part of the Galle Bay in open sea area when they enter the Port. It might be very dangerous because predominant wave and wind from the southwest pushes vessels to the east shallow area and when vessels reverse their engines to stop they tend to bend to the right. This is known as the "lee shore" problem. Alternative-2 and -3 are not recommendable.

8.3.3 Interference with activities of the existing port

As for alternative-4, the construction work of breakwater and approach channel would inconvenience vessels entering and departing the existing port. And it is desirable to retain the present approach channel into the existing Port because small vessels can freely renter the existing

Port, even when larger vessels are calling at the new berths.

8.3.4 Future Development

In Alternative-1 and in Alternative-2 other berths can be constructed without additional breakwater and approach channel. In Alternative-3, however, additional breakwaters would be needed for expansion of berths.

8.3.5 Construction Cost

Construction costs of Alternative-1, -2 and -3 are shown in Table 8.3.2 and Table 8.3.3. The difference in construction costs among the alternatives comes from the difference in length of breakwaters and revetments and volume of dredging materials. The cost of Alternative-2 is lowest while that of Alternative-1 is highest. But the difference of cost is within 15% of the total construction cost.

Table 8.3.2 Construction Cost

(million)

	Alternative-1	Alternative-2	Alternative-3
Total cost (in Yen)	15,538	13,431	14,104
Total cost (in Rs.)	11,654	10,073	10,578
Cost index	115	100	105

(conversion rate ¥1=Rs.0.75)

8.3.6 Harmonization with Environment

Impacts on environment elements caused by alternatives were assessed and the results are shown in Table 8.3.4. Alterantive-1 is considered as the most suitable and preferable alternative.

8.3.7 Evaluation of Alternatives and Recommendation

Table 8.3.5 summarizes the evaluation result of Alternatives from many aspects. Although the construction cost of Alternative-1 is higher than Alternative-2 by 15%, in other evaluation items Alterntive-1 performs better. Alternative-1 is recommended as the short-term development plan of Galle Port.

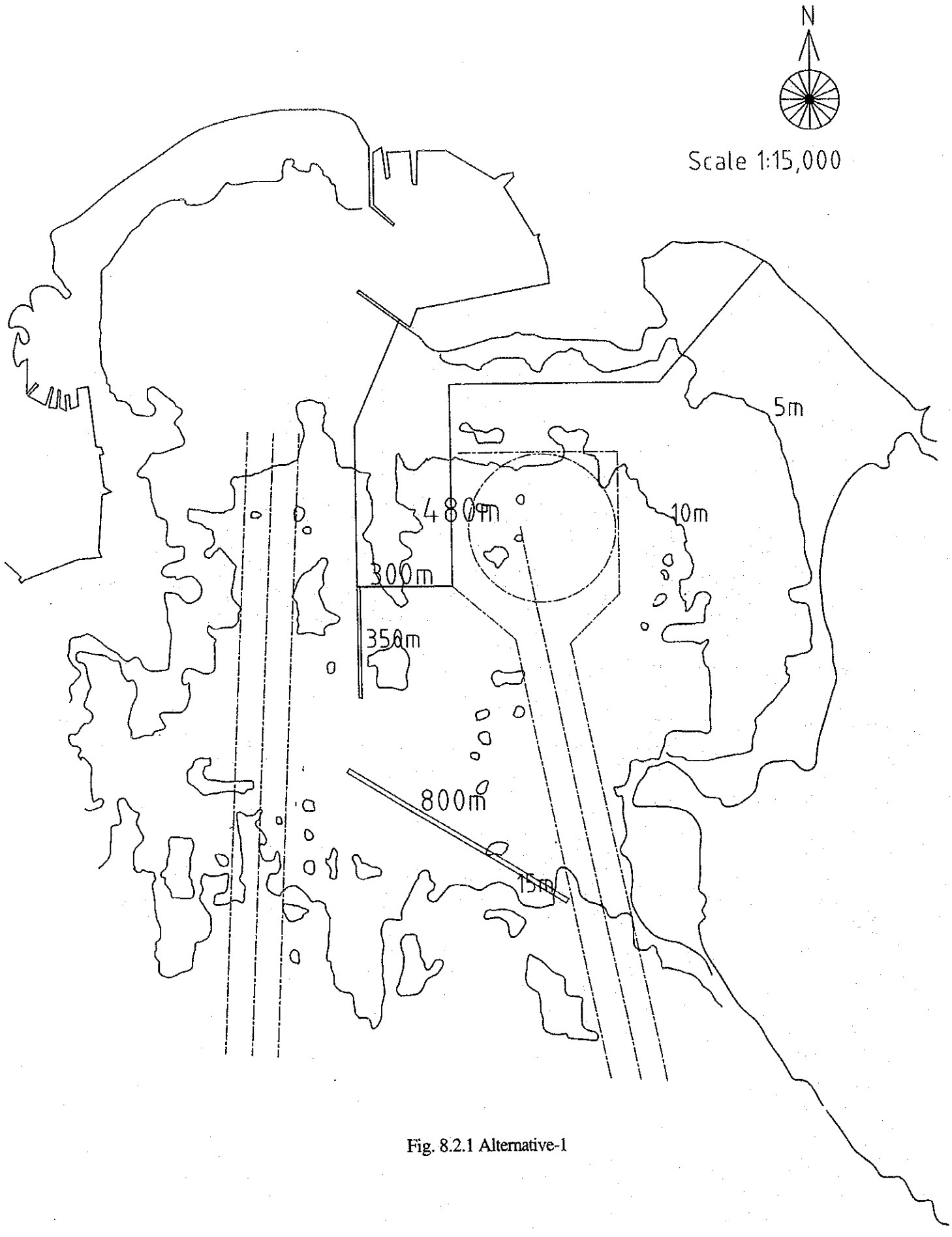


Fig. 8.2.1 Alternative-1

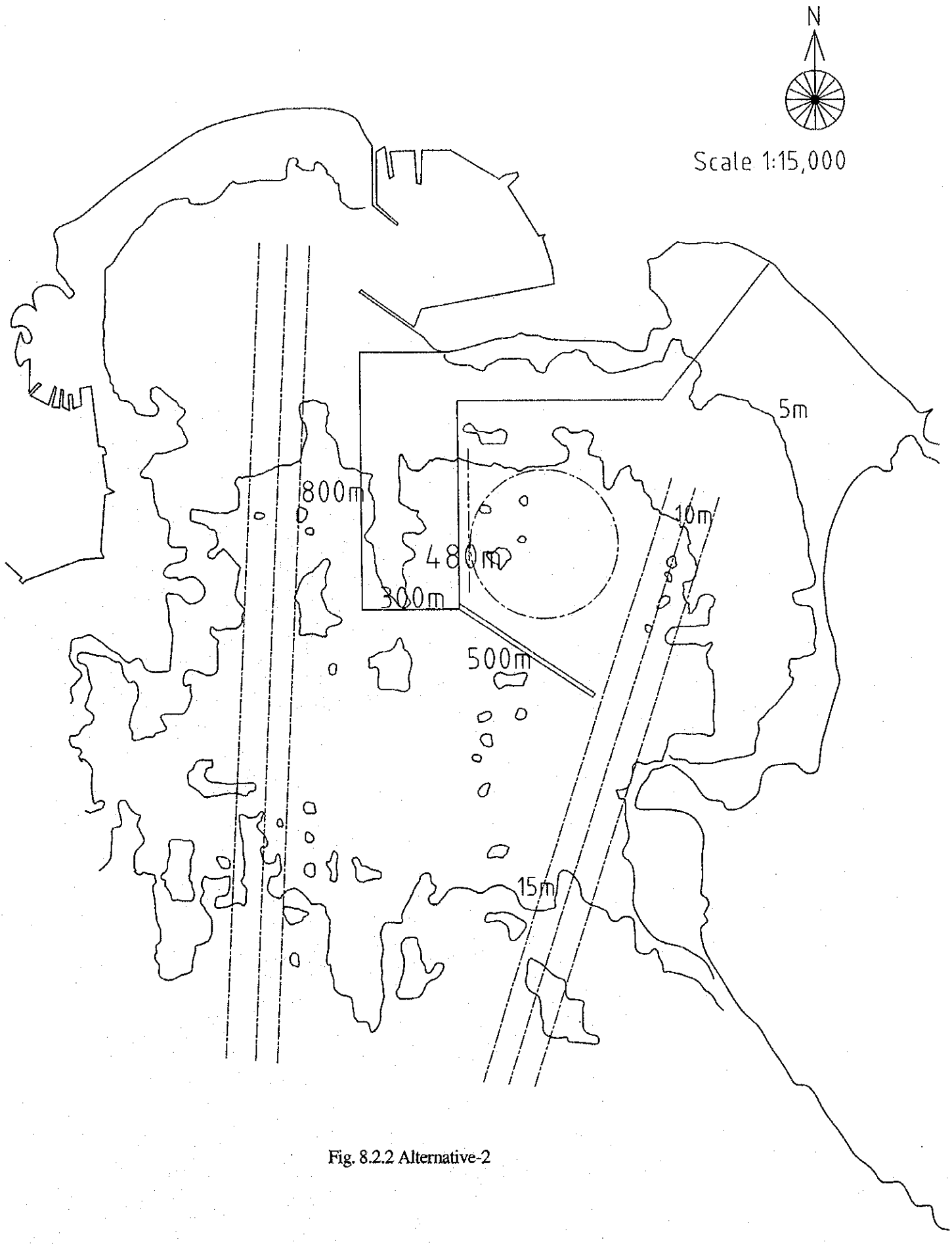


Fig. 8.2.2 Alternative-2

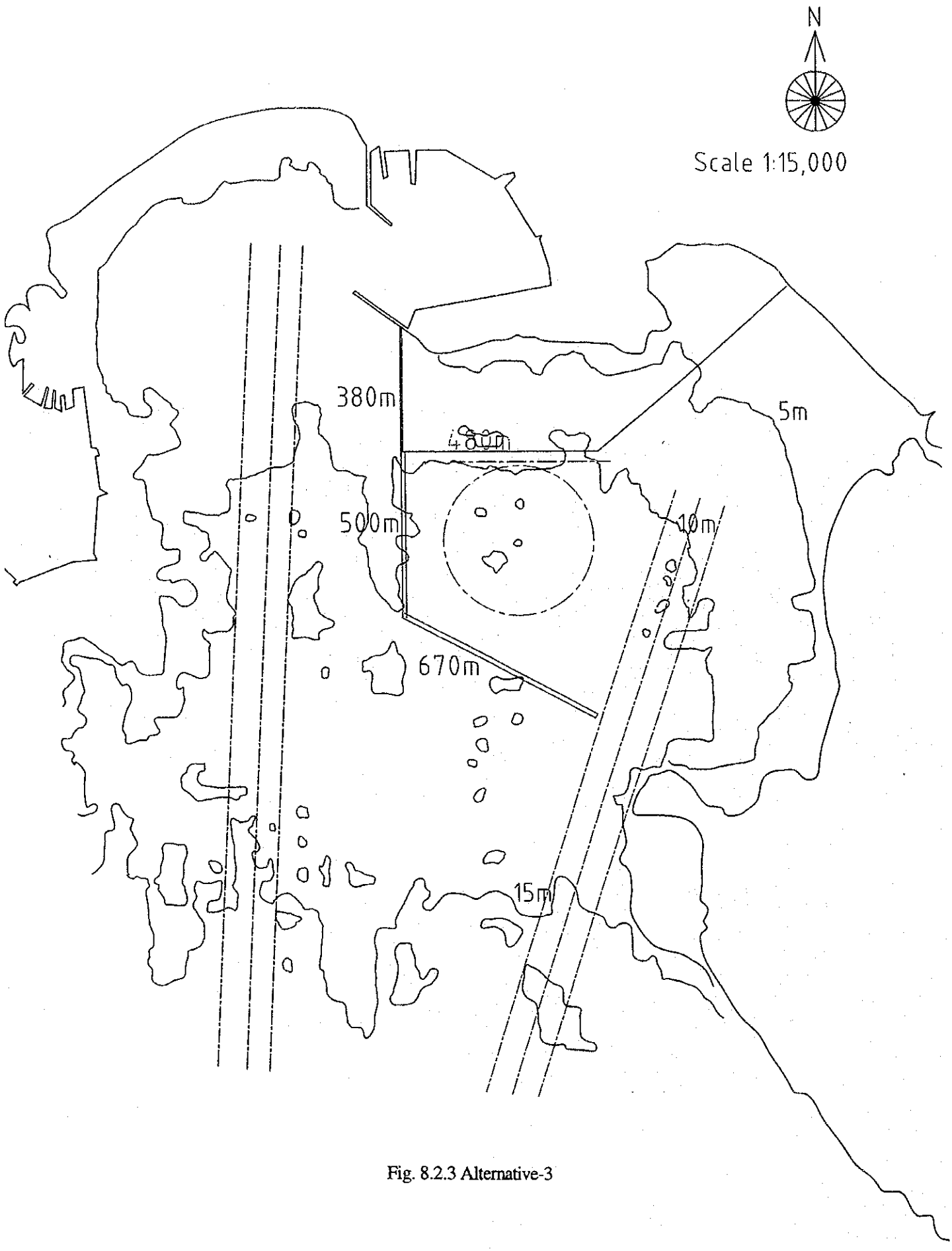


Fig. 8.2.3 Alternative-3

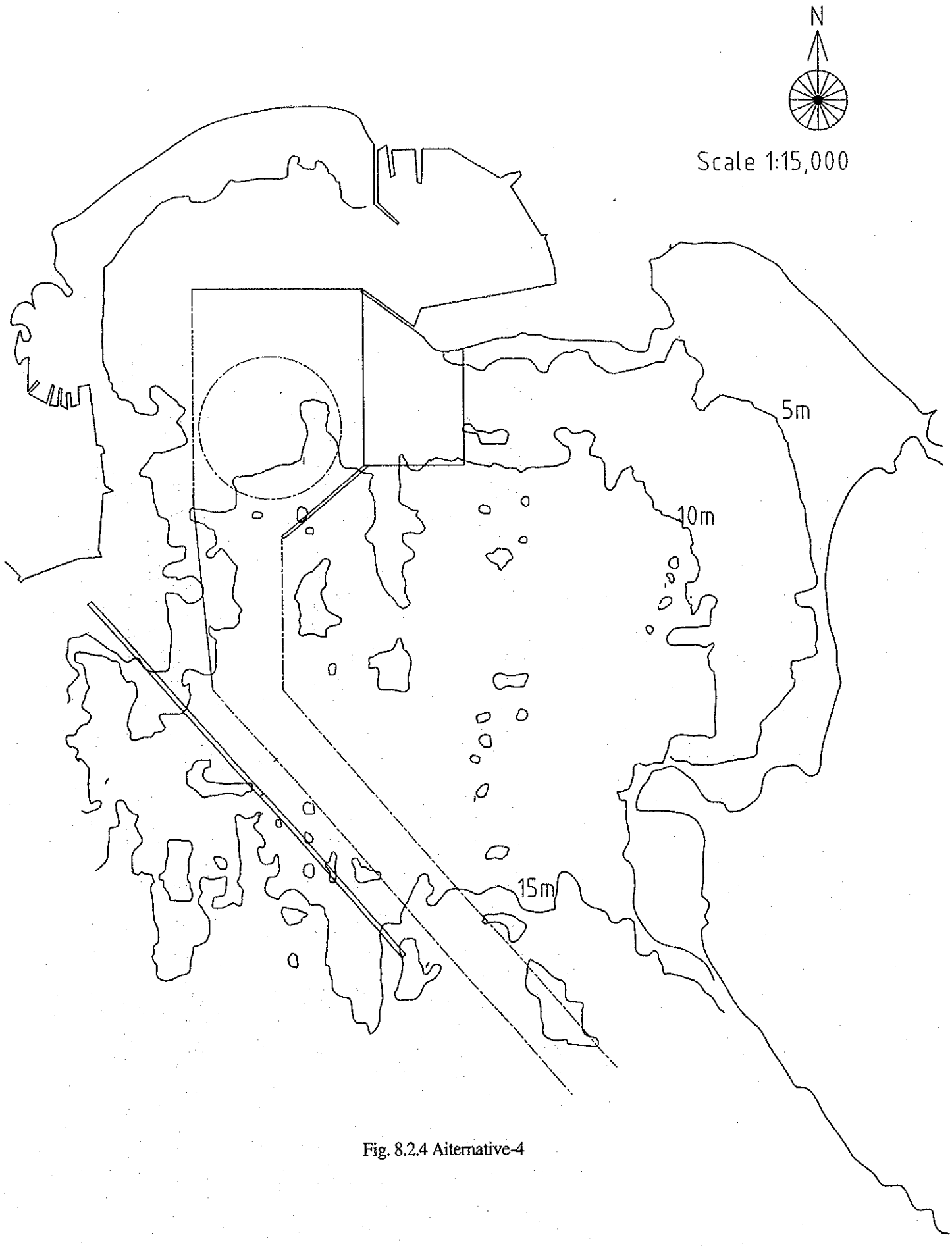


Fig. 8.2.4 Aiternative-4

Table 8.3.3 Comparison of Construction Cost

Unit : 1,000x¥

Description	Alternative I	Alternative II	Alternative III
1. Construction Works			
Mob./Demob.	620,399	620,399	620,399
Temporary Works	234,454	234,454	234,454
Dredging Works	344,847	355,094	451,254
Reclamation	1,042,142	1,278,533	707,957
Outer Breakwater	3,336,704	2,150,436	3,164,259
Inner Breakwater	1,617,806	-	1,787,341
Revetment (1)	781,759	1,166,984	554,318
Revetment (1')	-	224,033	-
Revetment (2)	351,042	791,207	-
Revetment (3)	498,526	206,362	145,667
Revetment (4)	280,407	264,094	196,184
-12.0m Berth	1,568,458	1,568,458	1,568,458
Navigational Aids	170,748	170,748	170,748
Road Pavement	305,747	305,747	245,853
Yard Pavement	496,276	496,276	566,117
Administration Building	77,818	77,818	77,818
Transit Shed	388,683	388,683	388,683
Maintenance Shop	32,117	32,117	32,117
Electrical Sub-Station	11,308	11,308	11,308
Water Tower	18,334	18,334	18,334
Gate Office	62,985	62,985	62,985
Utility (Electrical Works)	361,483	361,483	361,483
Utility Works (Mechanical Works)	40,904	40,904	40,904
Total of Construction Works	12,642,945	10,826,456	11,406,640
2. Procurement of equipment	**800,000**	**800,000**	**800,000**
3. Consulting Service	**806,577**	**697,587**	**732,398**
Total of 1+2+3	**14,249,521**	**12,324,044**	**12,939,038**
4. Contingency (Construction10% Procurement 3%)	**1,288,294**	**1,106,646**	**1,164,664**
Grand Total	**15,537,816**	**13,430,689**	**14,103,702**

Table. 8.3.4 Degree of impact caused by all alternatives on environmental elements

Environmental Element	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Water quality of Galle Bay	L	L	L	L
Sediment quality of Galle Bay	L	L	L	L
Water quality of recreational Activity area	L	L	L	L
Noise levels	L	L	L	L
Air quality	L	L	L	L
Availability of reclamation material (sea sand)	L	L	L	L
Sewage, drainage and other waste water systems	L	L	L	L
Solid waste disposal	L	L	L	L
Hazardous ship cargo during discharges	L	L	L	L
Flora of Rummassala	L	L	L	L
Coral reef and its associated fauna	M	M	M	L
Marine Archeology	L	L	L	H
Fishing Ground	L	M	M	L
Fishing activities	M	M	M	L
Tourism	L	L	L	L
Transportation of Quarry Products	M	M	M	M
Galle Fort	L	L	L	H
Overall evaluation	Good	Medium	Medium	Bad

Note: L - Low; M – Medium ; H – High

Table 8.3.5 Comparison of Alternatives

Evaluation item	Alternative-1	Alternative-2	Alternative-3	Alternative-4
Calmness	***	***	**	*
Navigation safety	***	**	*	**
Stopping distance	***	*	*	**
Wave on vessel	***	*	*	**
Alignment	***	*	*	**
Turning basin	***	***	***	***
Disturbing existing port activity	***	***	***	*
Access to inland	***	***	***	**
Future development	***	**	*	*
Cost Index	115	100	105	170
Harmonization with environment	***	**	**	*
Over all evaluation	***	**	**	*

Note

***	Good
**	Fair
*	Poor

8.4 Other Facilities

8.4.1 Navigational aids

It is proposed that buoys be installed as shown in Fig. 8.4.1 so as to allo vessels to enter and departure from new berths even at nighttime. The list of navigational aids is shown in Table 8.4.1.

Table 8.4.1 Proposed Navigational Aids

No	Position	Kind	Color	Light	Top-mark
1	Off the approach channel	Safe Water Mark Light Buoy	R.W.V.S	Occulting	Single red sphere
2	East end of the outer B.W.	Lateral Mark Light Beacon	Red	Flashing	Single red cylinder
3	West end of the outer B.W.	Lateral Mark Light Beacon	Green	Flashing	Single green cone
4	South end of the inner B.W.	Lateral Mark Light Beacon	Red	Flashing	Single red cylinder
5	Off the White Tower Head	Starboard Hand Mark Light Buoy	Green	Flashing	Single green cone
6	Off the SE end of new wharf	Port Hand Mark Light Buoy	Red	Flashing	Single red cylinder
7	SE end of the new wharf	Light Beacon	White	Fixed	-
8	North end of the turning basin	Light Buoy	White	Flashing	-
9	East end of the turning basin	Light Buoy	White	Flashing	-
10	Gibbet island	Leading Light (front)	White	Flashing	-
11	Gibbet island	Leading Light (rear)	White	Fixed	-

8.4.2 Tugboats

The maximum thrust is required when moving a mother vessel athwart direction, and an empirical formula on the thrust based on vessels' deadweight and external force (mainly by wind force) is shown in Fig. 8.4.2.

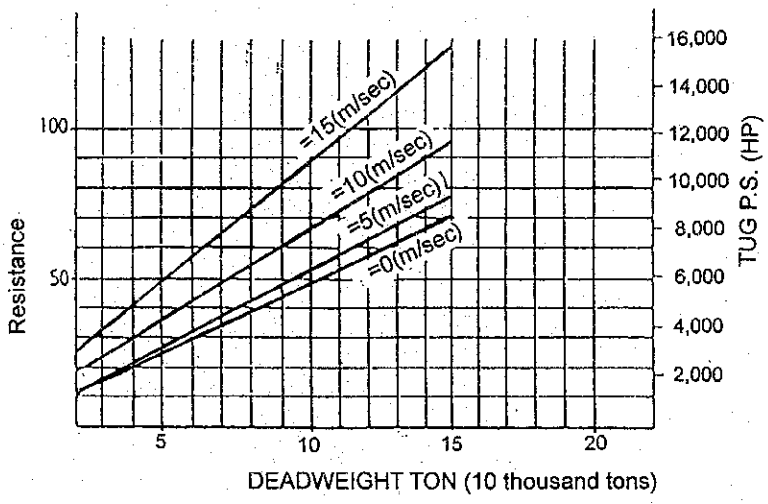


Fig. 8.4.5 Necessary Tug Boat(s) Thrust against Vessel's DWT and Winds

According to Fig. 8.4.2, assisting a 30,000 DWT mother vessel against a wind of 10 m/s (probability of exceeding 10 m/s at Galle area is less than 1 %) requires a total of 3,000 ps (2 tugs 1,500 ps each).

According to information from SLPA, 5 tugboats including 2 tugboats for Galle Port have already been ordered. Each tugboat for Galle Port has two 720 kW engines which are equivalent to 1,960 ps and so these two tugboats have enough power to move a 30,000 DWT mother vessel.

8.4.3 Miscellaneous Facilities

(1) Berths for working vessels

Berths for working vessels such as tugboats, barges and ship chandler's crafts is allocated north of the new berths. The depth of the berths is 4.5m and the length is 170m.

(2)Bunkering facility

Presently, at Galle Port, bunkering service is not available due to small requirement and non-existence of supply facilities including storage tanks and loading facilities. In the future, after operation of the new berths begins, along with the increase of calling vessels, bunkering service is likely to be required at Galle Port. Bunkerling service is expected to be served by a petroleum company. Thus, it is advisable to make a bunkering facility plan upon the request of a possible bunker service operator at the right timing.

8.5 List and Layout of Port Facilities

Table 8.5.1 shows the list of main facilities of short-term development plan and Fig. 8.5.1 shows the detailed layout plan of port facilities

Table 8.5.1 List of Main Facilities

Facility	No.	Dimension / Capacity
Multipurpose berths	2	Length 240m, depth 12m
Approach channel	1	One way, width 160m
Turning basin	1	Diameter 240m, depth 12m
Navigational aids	1	5 Buoys, 4 Beacons, 2 Leading light
Berth for small crafts	1	Length 170m, depth 4.5m
Shed	2	4,000 m^2, one story
Open yard	1	10,000 m^2
Container yard	1	2.9 ha
CFS	—	A part of shed is allocated
Outer breakwater	1	Length 800m
Inner breakwater	1	Length 350m
Revetment	4	Length 500m, 350m, 470m, 1,050m
Main road	1	4-lane, 1.2 km
Connecting road	1	2-lane, 300m
Multipurpose crane	1	35 tons
Top lifter	3	2 x 35 tons, 1 x 15 tons
Folk lift	8	4 x 8 tons, 2 x 2 tons
Tractor head	10	For container cargo
Trailer	14	For container cargo

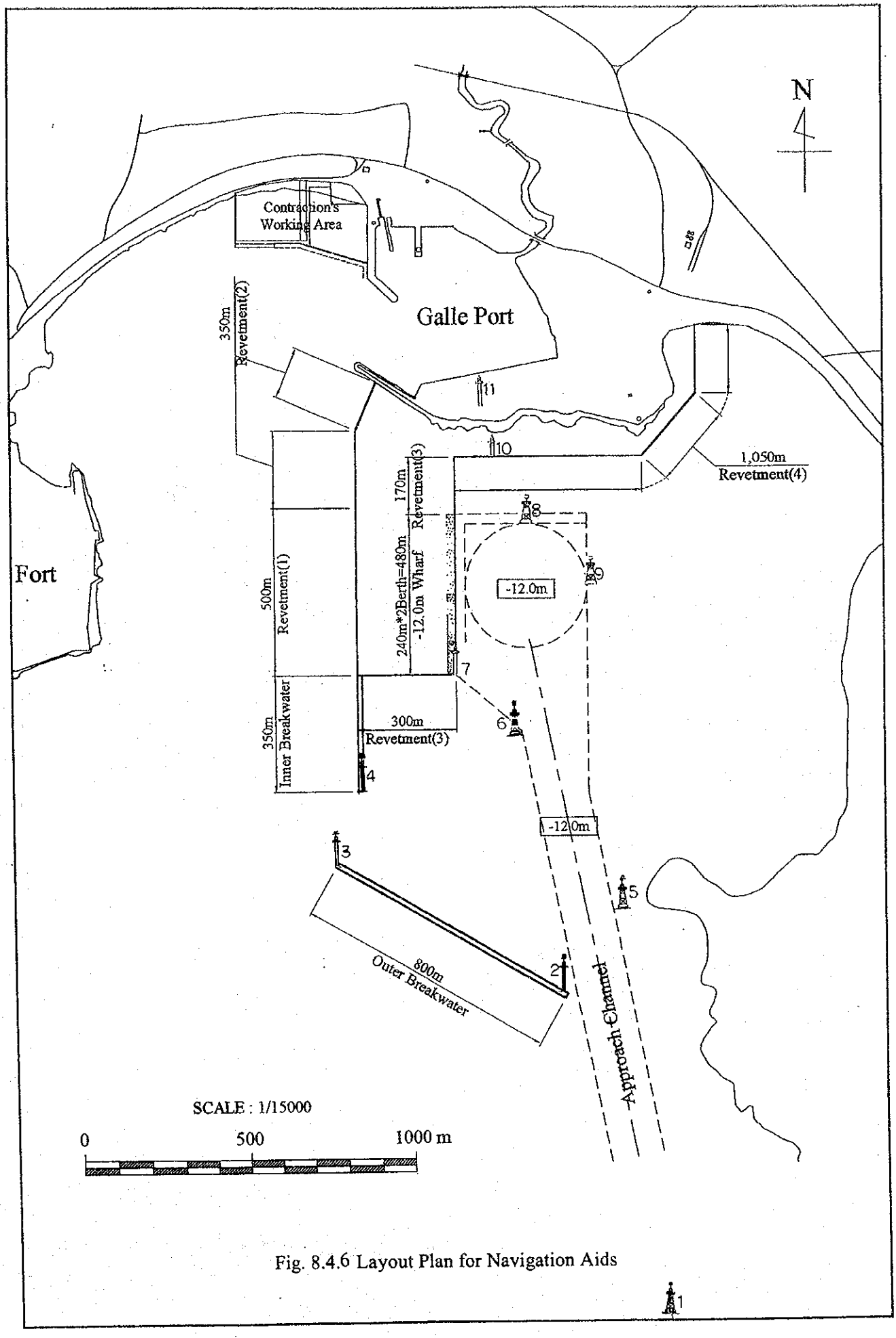


Fig. 8.4.6 Layout Plan for Navigation Aids

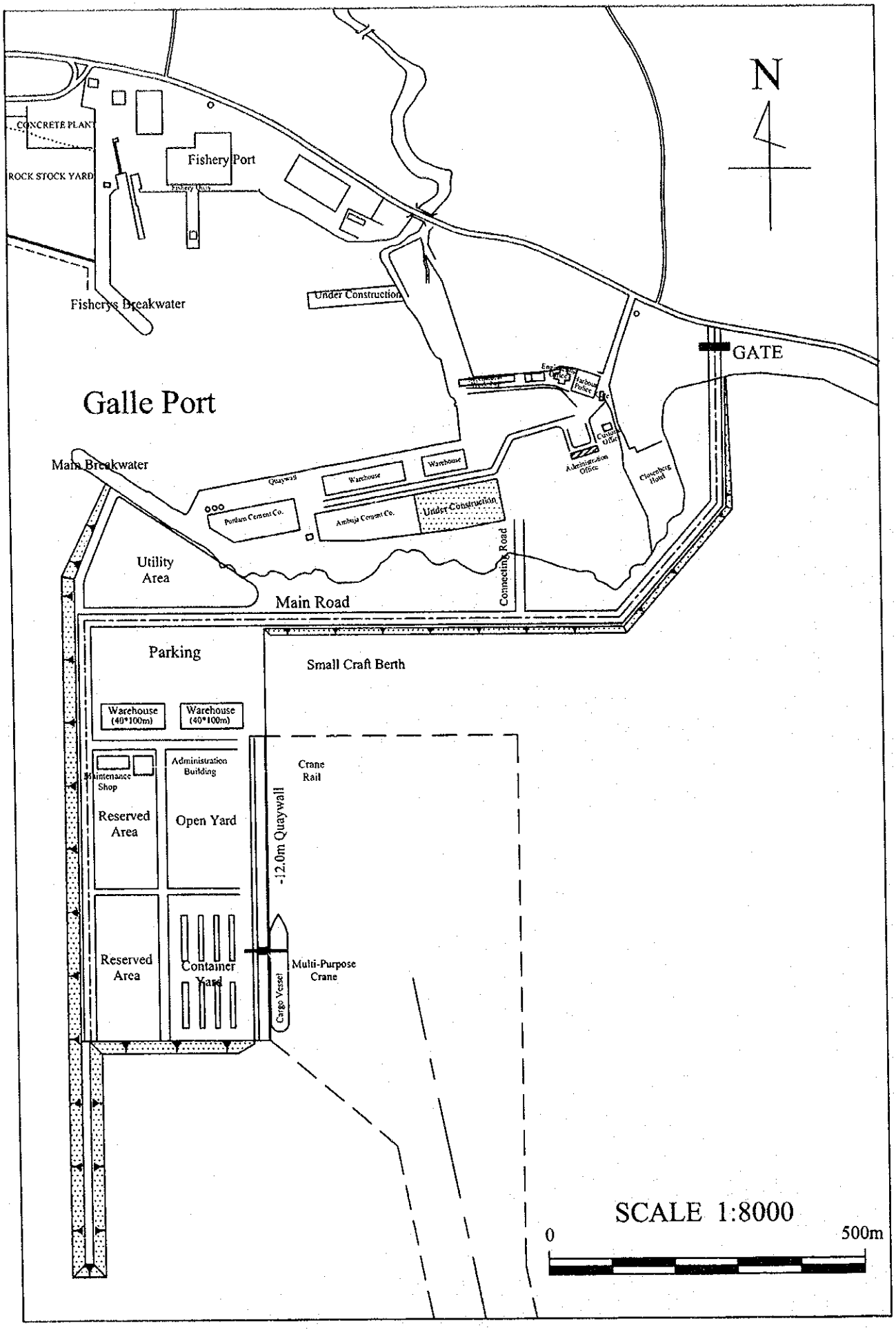


Fig. 8.5.1 Detailed Layout Plan of Port Facilities

Chapter 9 Preliminary Design

9.1 Design Criteria

This sub-clause describes the design criteria established on the basis of the data contained in Part I, Chapter 3 Natural Conditions of Coastal Area Adjacent to Galle Bay and additional information obtained through the site investigations conducted as part of the Study.

(1) Tidal Level

The tide levels in Galle Port are as given below:

Mean High Water Level	+0.60 m
Mean Sea Level	+0.34 m
Mean Low Water Level	+0.10 m
Datum Level	±0.00 m

(2) A sounding survey was carried out in the Port of Galle on June 16, 2000. The survey results are shown in Figure 3.4.6. A sonic survey was also carried out in the same manner as the sounding survey. A contour map of hard strata prepared from these surveys are as shown in Figure 3.4.7.

(3) Waves

The design wave characteristics with a 50-year return period have been defined as follows:

Direction	Height ($H_{1/3}$)	Height (H_{max})	Period
WSW	6.2 m	10.7 m	12.3 sec

(4) Geology

The geology of the Port and Bay of Galle and adjacent areas consists primarily of a gneiss formation as the bedrock which is partly overlain by laterite layers. Generally, the gneiss layer occurs at a limited depth in the North and Gibbet Island and its outcrops are seen at many places on both sitsides of the Central Channel. In the eastern part of the Bay, the gneiss layer is formed at greater depths with loose sand, silty sand, cohesive clay and laterite layers overlaying the layer.

At the location where the outer and inner breakwaters are to be constructed, sediments are formed to a limited extent and the substratum consists primarily of relatively well graded sand and gravel. At the proposed construction sites of the Multi-Purpose Cargo Wharf, however, the substratum is composed primarily of silty sand and cohesive clay layers (N-value = 0~ 1) of about 10 m thick.

(5) Earthquakes

Earthquakes are not considered in the design of the project facilities.

(6) Wind

A wind speed of 40 m/sec has been adopted for design purposes.

(7) Design Ship Characteristics

The proposed quay will be designed for receiving cargo vessels of 30,000 D.W.T which are 185 m in overall length, 27.5 m in molded breadth, and 11.0 m in full-load draft.

(8) Crown Height of Quay

Basically, the same crown heights as for the existing quays in the Port of Galle will be taken for the proposed quay structures. Therefore it is designed as +2.50m.

(9) Surcharge on Quay Faceline

The surcharge load considered is in principle 3.0 tons/m^2 (uniformly distributed load).

Special cargo handling vehicles and crane wheel loads are considered where appropriate.

9.2 Preliminary Design

(1) Basic Plan of Port Facilities

Preliminary designs have been prepared in respect of the following port facilities proposed under the Project. The layout plan is shown in Figure 9.2.1.

Table 9.2.1 Proposed Port Facilities

Facilities	Length (m)	Depth of Construction (m)
Breakwater		
Outer breakwater	800	On existing water depth
Inner breakwater	350	On existing water depth
General cargo berths		
Berth 1	240	-12.0 m
Berth 2	240	-12.0 m
Revetment		
Revetment (1)	500	On existing water depth
Revetment (2)	350	On existing water depth
Revetment (3)	470	On existing water depth
Revetment (4)	1,050	On existing water depth

Notes:
1) One unit of multipurpose crane will be installed on the general cargo berth.
2) The breakwaters and all the revetments will be constructed on the existing seabed.

(2) Structural Type of Breakwater

An appropriate structural type has been selected for the outer and inner breakwaters with the following factors taken into consideration.

1) With 50-year waves taken for design purposes, their heights are assumed as follows:

For Outer Breakwater:
$H_{1/3}$: 6.2 m
$T_{1/3}$: 12.3 sec
Direction : WSW
For Inner Breakwater:
$H_{1/3}$: 4.9 m
$T_{1/3}$: 12.3 sec
Direction : SW

2) Necessity of rapid construction in non-monsoon periods

3) Necessity of minimizing possibility of having to re-do finished work

4) Necessity of minimizing possibility of wave transmission due to permeability of the breakwater structures

5) Necessity of providing fabrication and temporary storage yards for caissons

6) Necessity of providing fabrication and temporary storage yards for concrete blocks and various sizes of stone

7) Need for maximum possible utilization of materials from local sources

8) Need for cost-effective construction of the breakwater structures

In respect of various structural types considered for the planned breakwaters, comparative evaluation was undertaken in terms of the above factors. In consequence, the rubble mound type with wave-dissipating concrete blocks protected by Tetrapod or Accropode was chosen for reasons of its capability for rapid and reliable construction under severe marine conditions and its higher cost-effectiveness.

The major characteristics of the basic design section of the breakwaters are summarized below.

1) Riprap work protected by armor stone of 1 to 2 tons will form the core of the breakwaters.

2) The major consideration in determining the crown height of the breakwater was that it should be higher than the high water level (H.W.L) by $H_{1/3}$ x 0.6. The crown height was finally determined as given below with an appropriate rate of wave transmission taken into account.

Outer breakwater	:	+5.5 m
Inner breakwater	:	+5.0 m

3) The front of the breakwaters will be protected with wave-breaking blocks down to a depth of 1.5 $\times$ $H_{1/3}$, while its back will be armored with wave-breaking blocks having a weight of nearly half that of the front blocks.

4) The breakwaters will be capped with coping concrete to reduce wave transmission. A light beacon will be installed at both ends of the breakwaters.

5) No foundation soil improvement is needed for the outer and inner breakwaters and revetments which are to rest on a thin layer of sand immediately underlain by the bedrock.

The typical cross sections of the outer and inner breakwater are shown in Figure 9.2.2 and Figure 9.2.3.

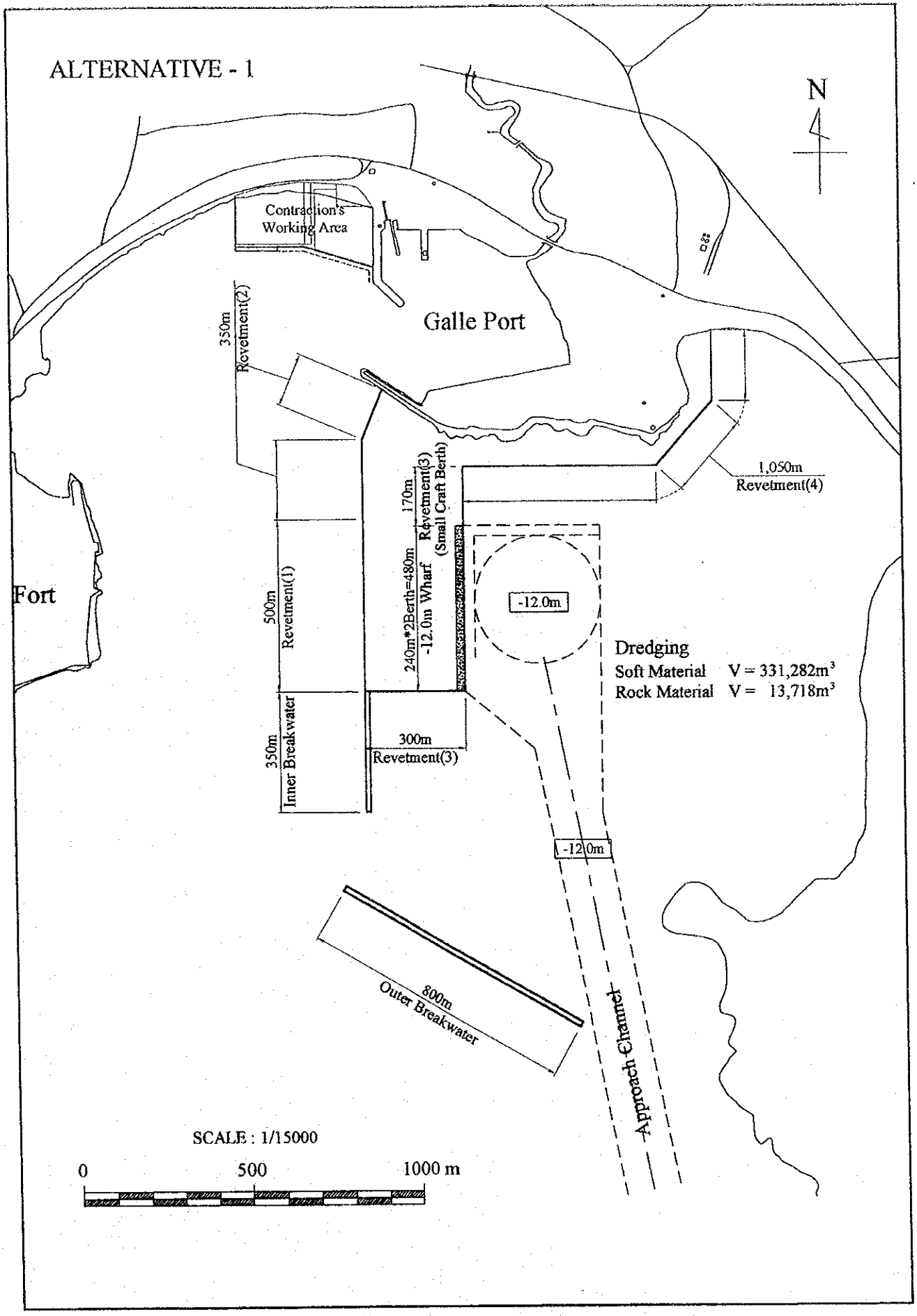


Figure 9.2.1 Port Facility Layout Plan

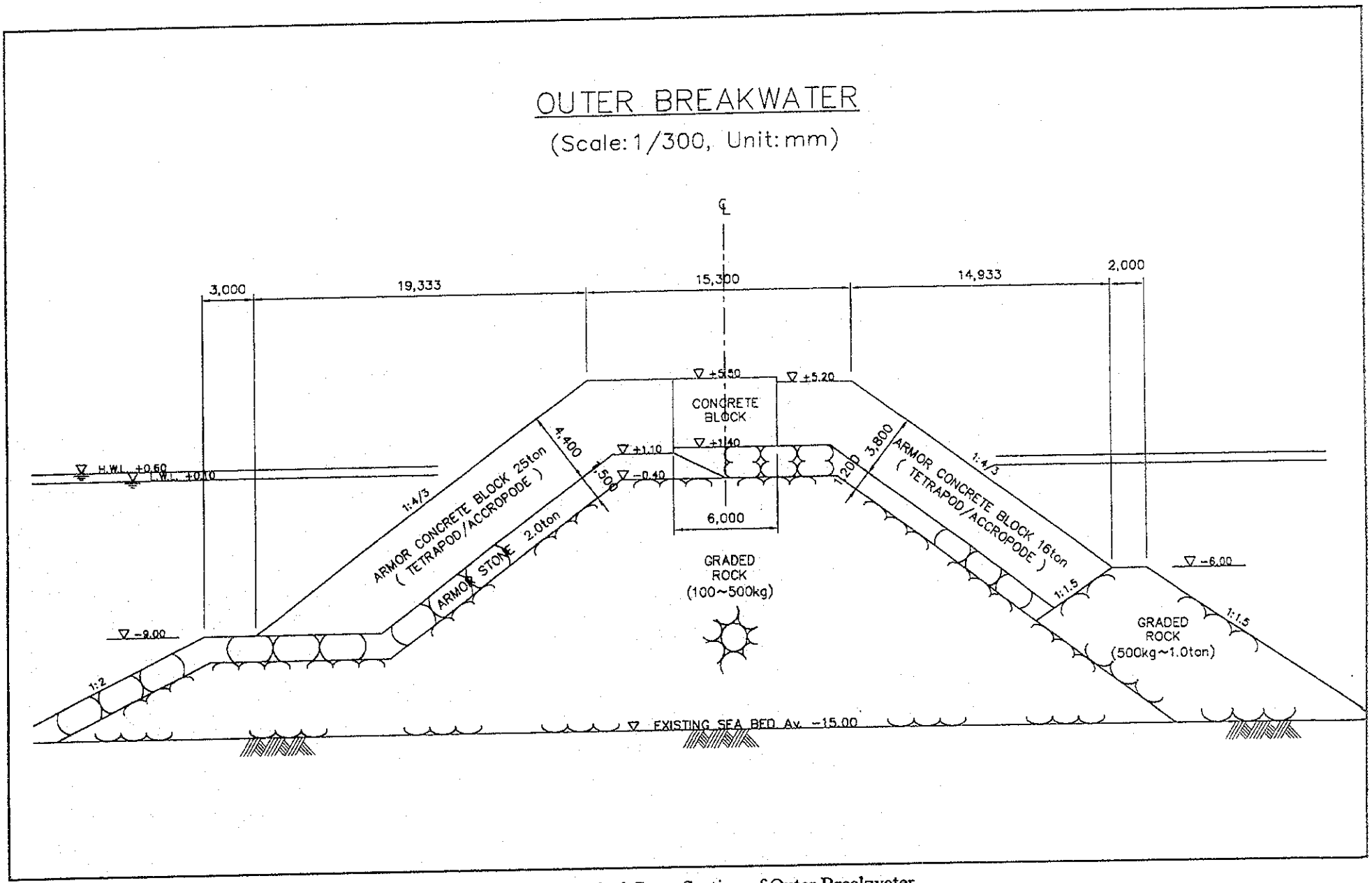


Figure 9.2.2 Typical Cross Section of Outer Breakwater

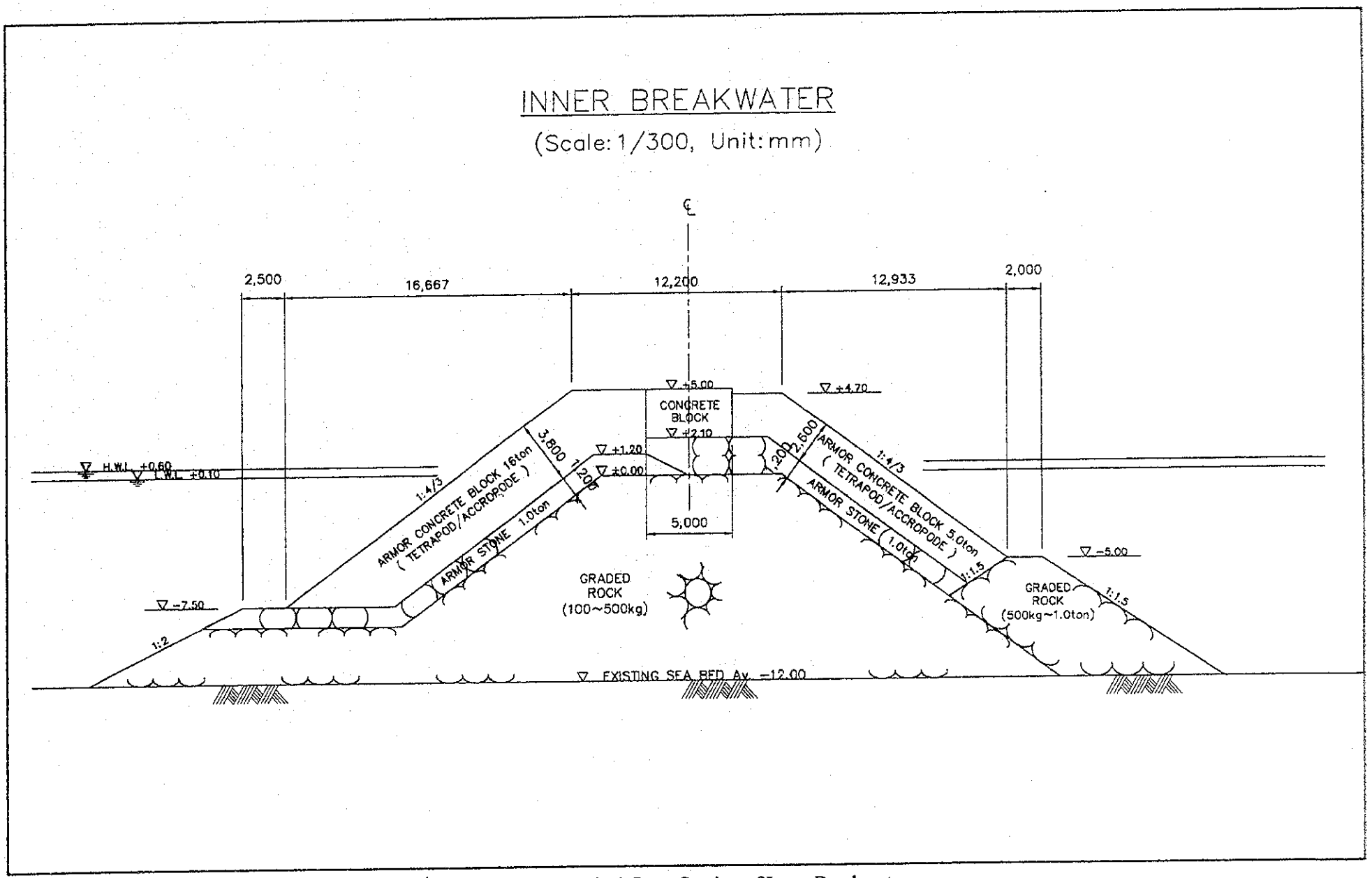


Figure 9.2.3 Typical Cross Section of Inner Breakwater

(3) Selection of Structural Type for Quays

For the selection of the appropriate structural type for the proposed quays evaluation was made of such factors as structural strength, environmental impact, and the cost, time and relative ease of construction.

The comparative evaluation was undertaken with respect to two alternative types, namely, gravity type quay and piled open type pier, on the following assumptions:

1) In view of the fact that the depth of the bearing stratum generally is a major factor influencing the choice of the construction type of port structures, the available boring data from an area close to the quay construction site were examined.

2) Soft soils will be replaced as necessary.

3) The design water depth is 12.0 m and the design ship size is 30,000 D.W.T.

4) Earthquakes are not considered.

The results of the comparative evaluation are presented in Table 9.2.2. The piled open type pier has been selected primarily in terms of such factors as greater cost-effectiveness, the relative ease of construction, and overall construction schedule.

Comparative evaluation was also made in respect of the arrangement and material of piles incorporated in the piled open type pier structure. The following types of piled open pier structure are compared in Table 9.2.3.

Type A : Using vertical steel pipe piles
Type B : Using batter steel pipe piles
Type C : Using batter PHC piles

In consequence, the open type pier incorporating vertical steel pipe piles was selected for reasons of its capability of permitting speedy, reliable and cost-effective construction.

For the revetment backing the piled open type pier structure, the gravity type and the steel sheet-piled type were evaluated on the following assumptions.

- Steel sheet-piled type : Consisting of anchor steel sheet piles with rubble mound built in the front as a counterweight

- Gravity type : Consisting of gently sloping rubble mound involving replacement of soft soils with sand

The evaluation outcome is presented in Table 9.2.4. The steel sheet-piled type revetment was chosen in terms of greater cost-effectiveness and the overall construction schedule. The typical cross section of -12.0m quaywall is shown in Figure 9.2.4.

Table 9.2.2 Comparison of Structural Types for Proposed -12.m Quay in the Port of Galle (1)

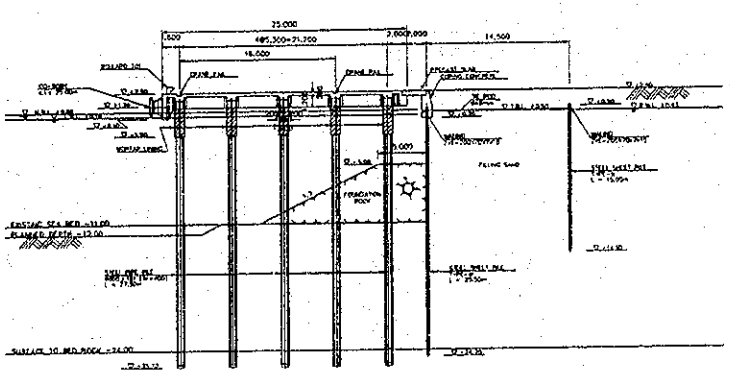
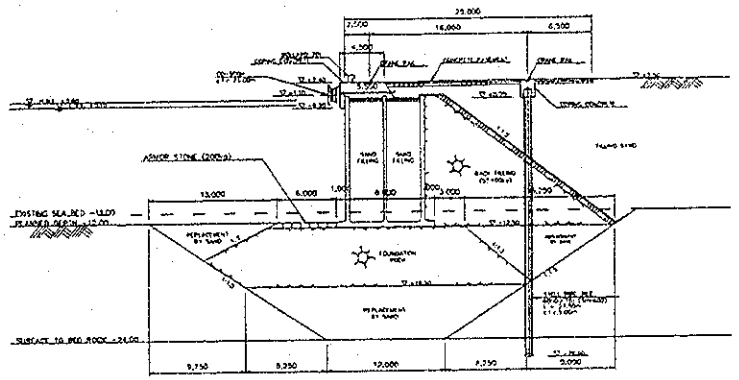
	Type A - Piled Open Type Pier	Type B – Caisson Type Quay
1. Typical Cross Section		
2. Design Conditions	1) Physical conditions Tide : H.W.L +0.60 , L.W.L ±0.00 Soils: Sandy soil (N =10 , -11.00～-15.00), Cohesive soil (N = 1 , -15.00～-20.00), Cohesive soil (N =11 , -20.00～-21.00), Cohesive soil (N = 9 , -21.00～-24.00) , Weathered rock (N ≧50 , -24.00～) 2) Design ship size: 30,000D.W.T cargo vessel (Loa =185m ,B =27.5m ,Df =11.0m), Fender type: CO-900H, Bitt type: 70T 3) Quay dimensions: Berth length = 480 m (240 m*2); apron width = 25 m; exising seabed level = -11.00 m (design depth = -12.00 m) apron crown level = +2.50 m 4) Loading: Dead load of pier superstructure = 2.0 t/m²; Fender reaction = 107 tf (V =15cm/s), Tractive force = 70 tf (all directions); Apron superimposed load = 3.0t/m² ; crane load during operation = 28 t/wheel (sea side), 27 t/wheel (land side); wheel base : 4; No. of wheels per wheel base: 8	
3. Results of Structural Analysis	· Loading case analyzed : During berthing · Steel pipe pile : φ 800×16t , L=27,500 mm · Material of steel pipe pile : SKK400 · Safety factor for pile bearing capacity (compression) : 2.9 > 2.5 (302t) · Max. displacement : 7.6 cm	· Loading case analyzed : At the time of completion of quay (earth pressures assumed to be acting) · Caisson dimensions : 8.0m B×15.0m L×13.5m H · Factor of safety against sliding : 2.5 > 1.3 · Factor of safety against overturning : 4.5 > 1.3 · Bishop factor of safety : 1.45 > 1.2 · Factor of safety against circular slip : 1.38 > 1.3
4. Structural Type	Open type pier supported on vertical steel pipe piles (superstructure formed by reinforced concrete slab system)	Quay constructed of caissons with rubble mound built after removal of soft subsoils by dredging and their replacement with sand.
5. Structural Characteristics	· Bearing capacity can be obtained by driving piles into the bearing stratum. · A retaining wall behind the pier structure will be needed. · Some horizontal displacement will develop duirng berthing of ships. · Effects of reflectd waves will be relatively limited, thus permitting greater ship maneuverability. · Cathodic protection or other appropriate means of maintenance will be required for greater durability.	· Improvement of the soft foundation soils will be needed to provide adequate bearing capacity. · Some residual settlement will develop after soil improvement. · No need for a retaining wall. · The effects of reflected waves will be relatively significant. · Greater durability.
6. Constructional Advantage/Problem		
1) Operational Aspect	· A large fabrication yard will not be necessary. · Reliable pile bearing capacity can be secured through proper control of refusal points. · However, it will be necesary to carry out a detailed pre-driving investigation of the bearing stratum depth. · Field work will be fairly diversified and will involve rather complex procedures of operations.	· A floating dock for caisson production and a quaywall for mooring the dock will be required, but spaces for these facilities can hardly be found in the Port of Galle. · A calm water area required for temporary storage of caissons can hardly be found in the Port. · Rapid execution of the foundation work may increase residual settlement. · Caisson production and foundation work can be carried out simultaneously.
2) Cost	2,971 (Million Yen / Meter)	3,640 (Million Yen / Meter)
7. Maintenance and Repairs	*Cathodic protection will be needed for the steel pipe piles.	No need for maintenance except for repairs which may be necessitated after residual settlement.
8. Overall Evaluation	○	△

Table 9.2.3 Comparison of Structural Types for Piled Open Type Pier for -12.m Quay in the Port of Galle (2)

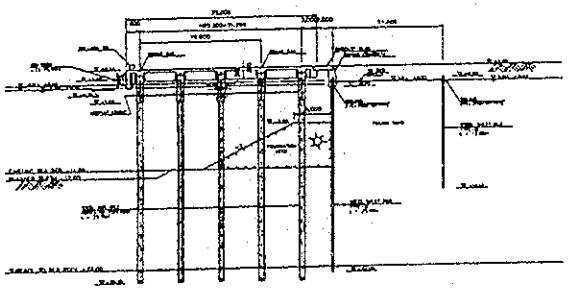
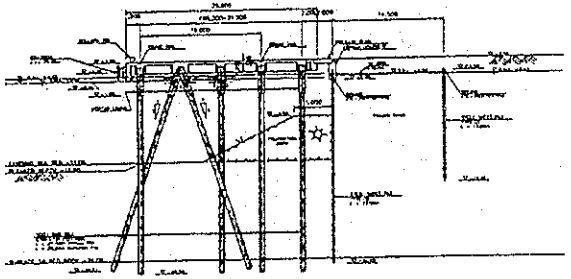
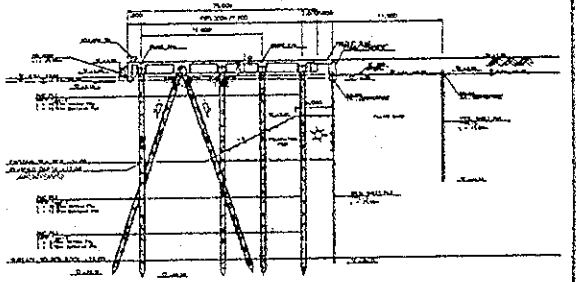
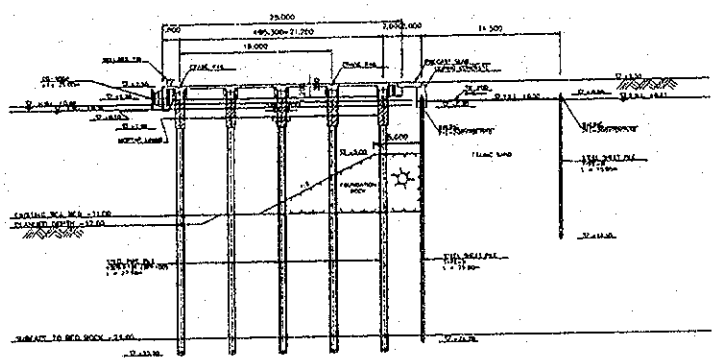
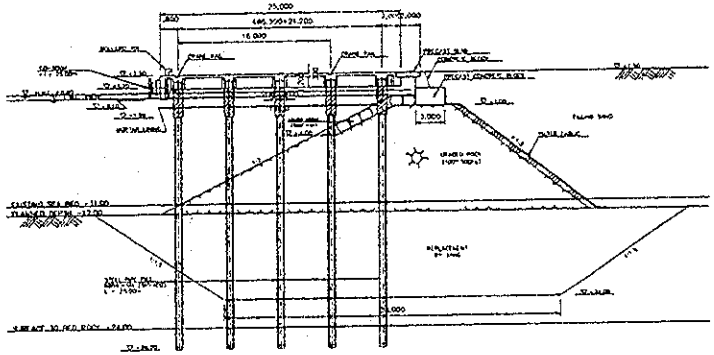
	Type A-A	Type A-B	Type A-C
1 Standard Cross Section			
2 Design Conditions	1) Physical conditions Tide : H.W.L +0.60 , L.W.L ±0.00 Soils: Sandy soil (N =10 , -11.00～-15.00), Cohesive soil (N = 1 , -15.00～-20.00), Cohesive soil (N =11 , -20.00～-21.00), Cohesive soil (N = 9 , -21.00～-24.00) , Weathered rock (N ≧50 , -24.00～) 2) Design ship size: 30,000D.W.T cargo vessel (Loa =185m ,B =27.5m ,Df =11.0 m), Fender type: CO-900H, Bitt type: 70T 3) Quay dimensions: Berth length = 480 m (240 m*2); apron width = 25 m; existing seabed level = -11.00 m (design depth = -12.00 m) apron crown level = +2.50 m 4) Loading: Dead load of pier superstructure = 2.0 t/m^2; Fender reaction = 107 tf (V =15cm/s), Tractive force = 70 tf (all directions); Apron superimposed load = 3.0t/m^2 ; crane load during operation = 28 t/wheel (sea side), 27 t/wheel (land side); wheel base : 4; No. of wheels per wheel base: 8		
3 Results of Structural Analysis	· Loading case analyzed : During berthing · Steel pipe pile dimensions : φ 800×16t, L=27,500mm · Material of steel pipe pile : SKK400 · Safety factor for pile bearing capacity (compression) : 2.9 > 2.5 (302 t only end bearing capacity considered) · Max. displacement : 7.6cm	· Loading case analyzed : During crane operation · Pile dimensions : Vertical pile φ 700×16 t; L=27,500 mm Batter pile φ 700×16 t; L=28,500 mm · Pile material : SKK400 · Safety factor for pile bearing capacity (compresssion): 2.9 > 2.5 (285 t including skin friction) · Max. displacement : 1.2 cm	· Loading case analyzed : During crane operation · Pile dimensions : PHC vertical pile φ 800; L=28,000 mm (Class B : 8,000 mm; Class C : 10,000 mm×2) PHC batter Pile φ 800, L=29,000 mm (Class B : 9,000 mm; Class C : 10,000 mm×2) · Safety factor for pile bearing capacity (compression): 2.8 >2.5 (285 t including skin friction) · Max. displacement : 1.3 cm
4 Structural Type	Open type pier supported on vertical steel pipe piles	Open type pier supported on batter steel pipe piles	Open type pier supported on PHC batter piles
5 Structural Characteristics	· This is a structure designed such that horizontal forces are resisted by bending rigidity. · This type of structure develops a greater displacement than Type A-B supported on batter steel pipe piles. · The number of piles required is smaller than Type A-B, but a larger pile section is needed. · The pile interconnection provides high reliability.	· This is a structure designed such that horizontal forces can be transmitted and absorbed as axial force of the pile. · This type of structure develops a smaller displacement than Type A-A supported on vertical steel pipe piles. · The pile section is a smaller, but the number of piles required is larger. · The pile interconnection provides high reliability.	· This is a structure designed such that horizontal forces can be transmitted and absorbed as axial force of the pile. · This structure develops a smaller displacement than Type A-A supported on vertical piles. · This type of structure needs a larger number of piles than Type A-A. · The pile head interconnection provides a rather low degree of reliability.
6 Constructional Advantage/Problem			
1) Operational Aspect	· The vertical steel pipe piles are lighter than PHC batter piles and are easier to carry, pitch, and otherwise handle. · It is relatively easy to drive the piles into the bearing stratum. · Preparation of the pile head is an easy job.	· The batter piles are lighter than PHC piles and are easier to carry, pitch and otherwise handle. · It is relatively easy to drive the piles into the bearing stratum. · Preparation of the pile head is an easy job.	· The piles are heavy and prone to cracking and are thus not easy to carry, store and otherwise handle. · They may not be easy to drive depending on the hardness of the bearing stratum. · Preparation of the pile head is a rather troublesome job.
2) Cost	2,971 (Million Yen / Meter)	3,060 (Million Yen / Meter)	3,238 (Million Yen / Meter)
7 Maintenance and Repairs	The steel pipe piles need cathodic protection.	The batter piles need cathodic protection.	No particular maintenance requirements
8 Overall Evaluation	○	△	△

Table 9.2 4 Comparison of Structural Types for Revetment Backing Open Type Pier in the Port of Galle (3)

	Type A-A-A	Type A-A-B
1. Typical Cross Section		
2. Design Conditions	1) Physical conditions Tide : H.W.L +0.60 , L.W.L ±0.00 Soils: Sandy soil (N =10 , -11.00～-15.00), Cohesive soil (N = 1 , -15.00～-20.00), Cohesive soil (N =11 , -20.00～-21.00), Cohesive soil (N = 9 , -21.00～-24.00) , Weathered rock (N ≧50 , -24.00～) 2) Design ship size: 30,000 D.W.T cargo vessel (Loa =185 m ,B =27.5 m ,Df =11.0 m), Fender type: CO-900 H, Bitt type: 70 T 3) Quay dimensions: Berth length = 480 m (240 m*2); apron width = 25 m; exising seabed level = -11.00 m (design depth = -12.00 m) apron crown level = +2.50 m 4) Loading: Dead load of pier superstructure = 2.0 t/m^2; Fender reaction = 107 tf (V =15 cm/s), Tractive force = 70 tf (all directions); Apron superimposed load = 3.0 t/m^2 ; crane load during operation = 28 t/wheel (sea side), 27 t/wheel (land side); wheel base : 4;No. of wheels per wheel base: 8	
3. Results of Structuri Analysis	・Loading case analyzed : During application of earth pressures ・Crown level of counterweight rubble mound : -5.00 m ・Crown level of rubble mound : 5.00 m ・Steel shoet pile specifications : Front Type IV (L = 26.50 m) Back Type III (L = 14.00 m) ・Waling : 2×[-200×70×7×10 ・Tierod : ϕ46 mm	・Loading case analyzed : Completion of the open type pier (earth pressure assumed to be acting) ・Crown level of foundation rubble mound : -1.00 m ・Safety factor for circular slip : 1.38 > 1.3
4. Structural Type	Double Steel sheet-pile wall supported on vertical steel pipe piles	Rubble mound with coping concrete supported on vertical steel pipe piles
5. Structural Characteristics	・No soil improvement will be required because of negligible effects of ground settlement and circular failure. ・The quantity of rubbles needed for the construction of this type of revetment will be relatively small. ・The area needed for providing the anchor system will not be available for other uses. ・Cathodic protection will be required for the steel piles.	・The soft foundation soils will require improvement. ・The quantity of rubbles required will be large. ・This type of structure offers high durability. ・The structure is relatively easy to repair.
6. Constructional Advantage/Problem		
1) Operational Aspect	・Construction works on the pier structure and the revetment can be executed simultaneously.	・Residual settlement may develop.
2) Cost	2,971 (Million Yen / Meter)	3,868 (Million Yen / Meter)
7. Maintenance and Repairs	*Cathodic protection will be required for the steel pipe piles.	No particular maintenance requirements except for repairs which may be necessary in case of residual settlement.
8. Overall Evaluation	○	△

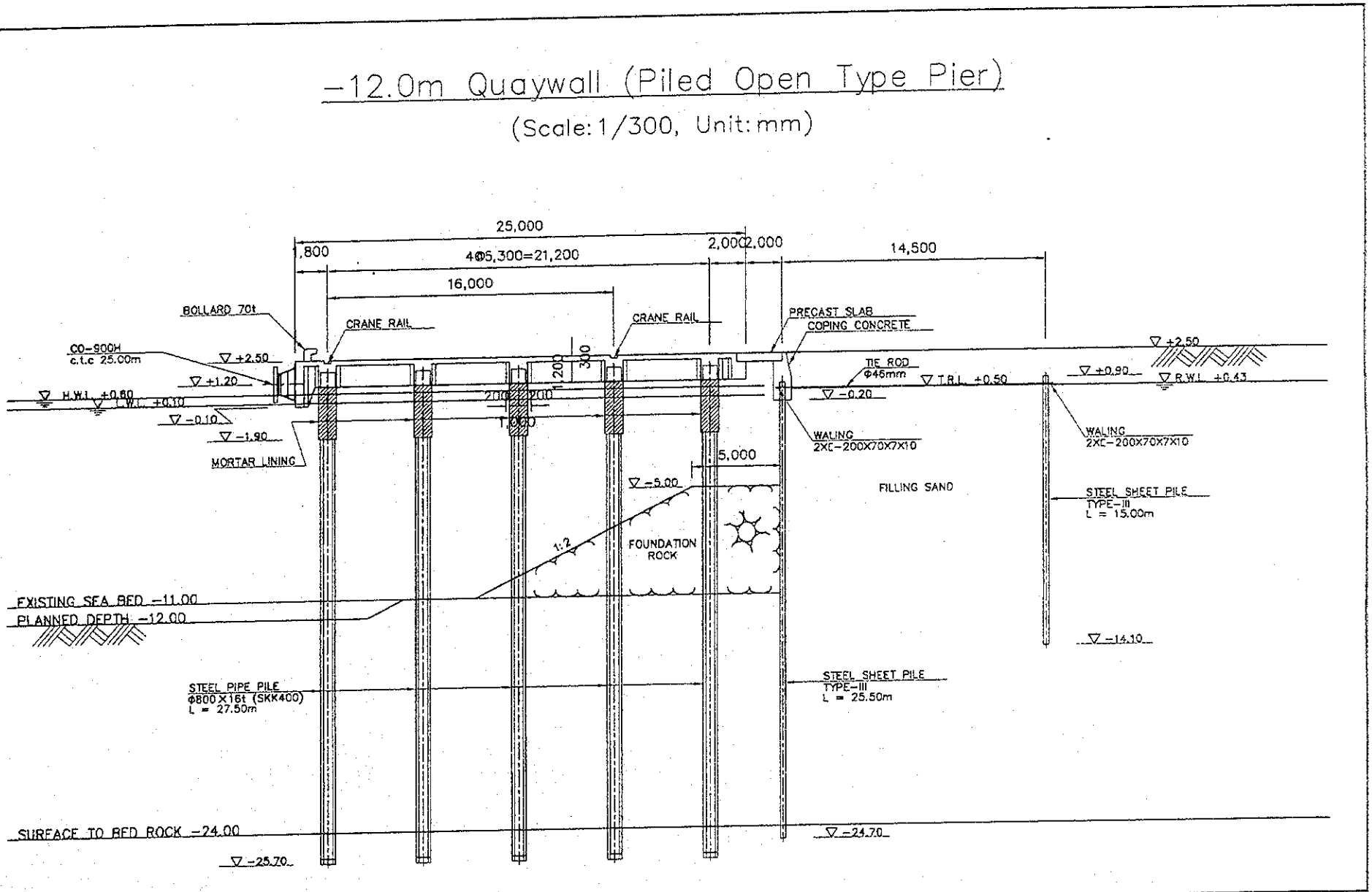


Figure 9.2.4 Typical Cross Section of -12.0m Quay Wall

(4) Revetments for Reclaimed Area

A rubble mound structure (partly armored with wave-breaking blocks) has been selected for the proposed revetments for reasons of the following considerations:

a) Reliability in protecting the reclaimed area against waves and surging storm;

b) Prevention of possible outflow of filling material from the reclaimed area; and

c) Capability of providing greater flexibility in adapting to the uneven ground of the construction site.

Figure 9.2.5 to Figure 9.2.8 show the typical cross sections of the proposed revetments. The major characteristics of the cross sections are listed below.

- The Revetments (1 & 2) with greater wave exposure will be covered with wave-dissipating concrete blocks to reduce the effects of reflected and transmitted waves and will also be provided with a parapet for protection against wave overtopping and with pavements and drainage ditches in the back.

- The Revetment (3) close to the quay will be provided with a superstructure of wave-dissipating concrete blocks and will be brought into alignment with the quay structure.

- The Revetment (4) with lower wave exposure will be of construction as simple as possible.

- The revetments will be spread with geotextile sheets to prevent sand leaks from the reclaimed area.

- Soft soils will be replaced with sand as necessary.

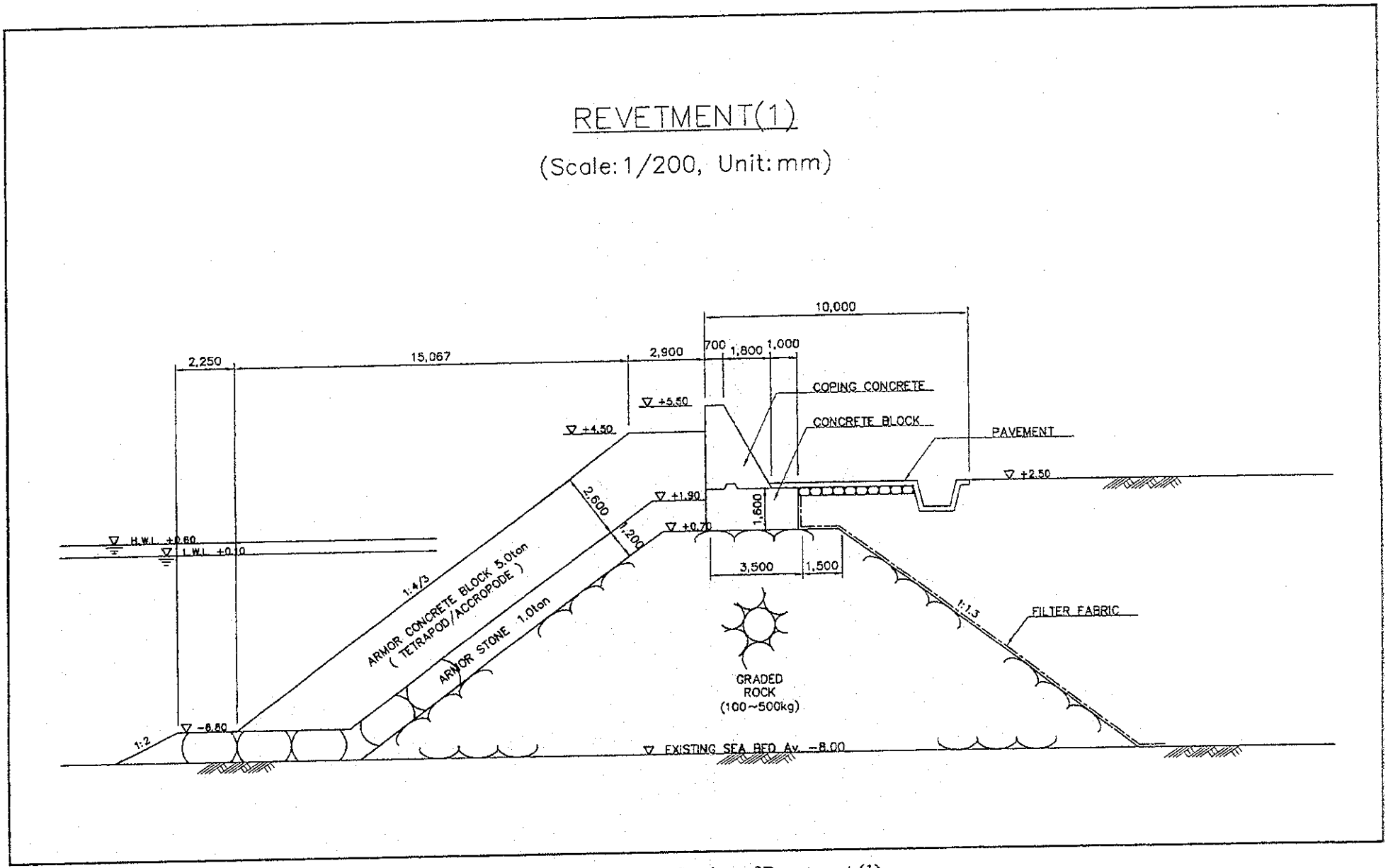


Figure 9.2.5 Typical Cross Section of Revetment (1)

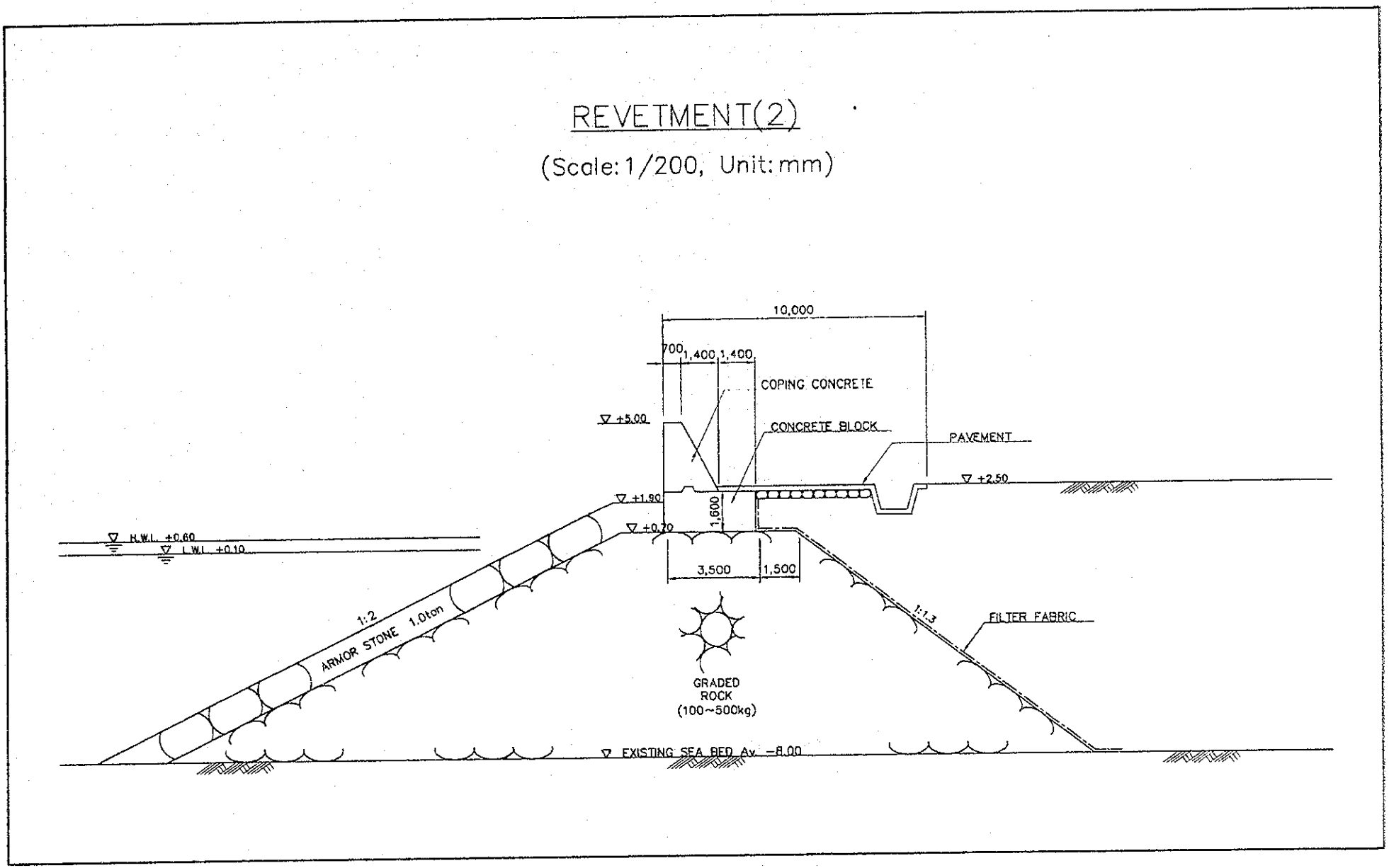


Figure 9.2.6 Typical Cross Section of Revetment (2)

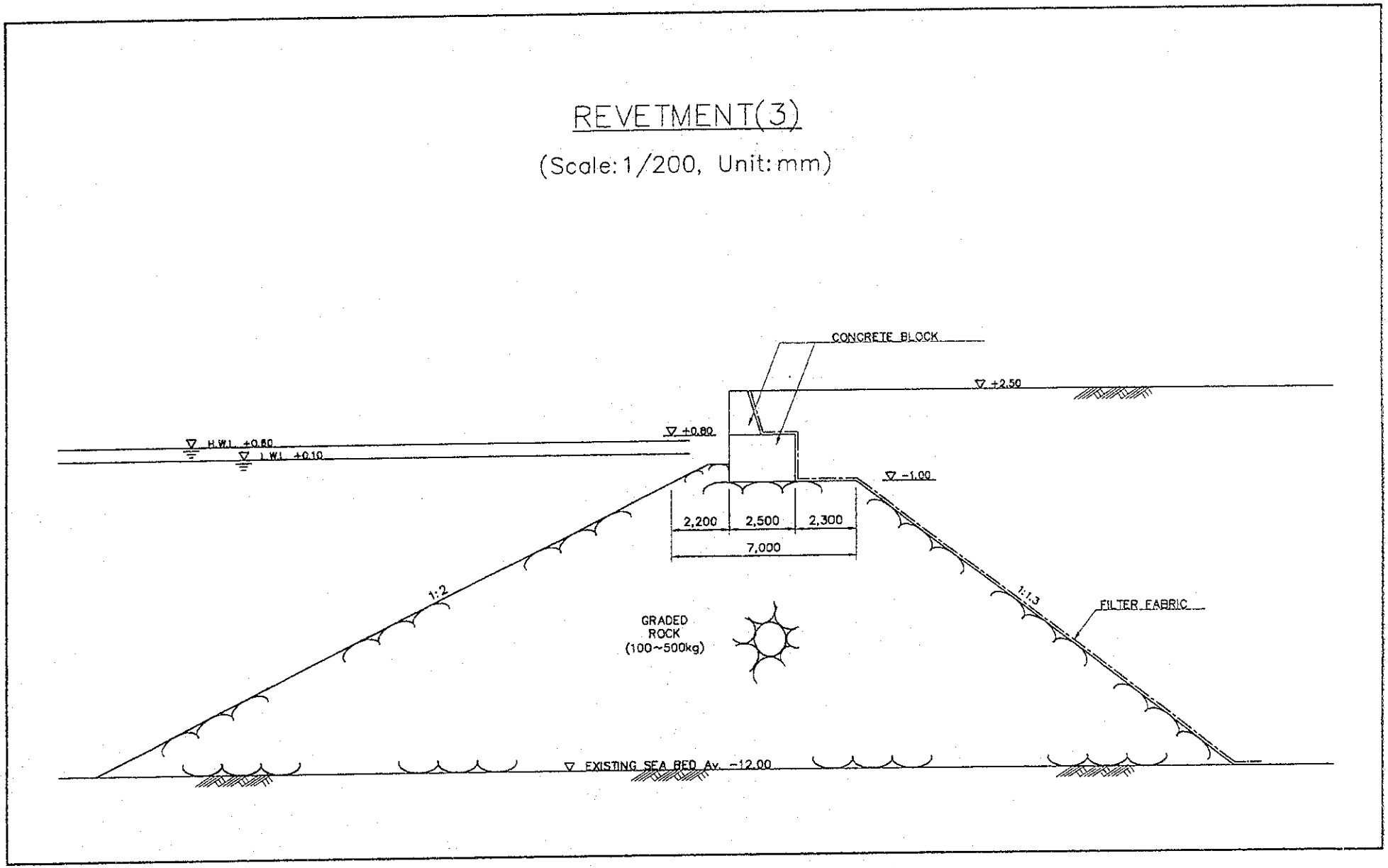


Figure 9.2.7 Typical Cross Section of Revetment (3)

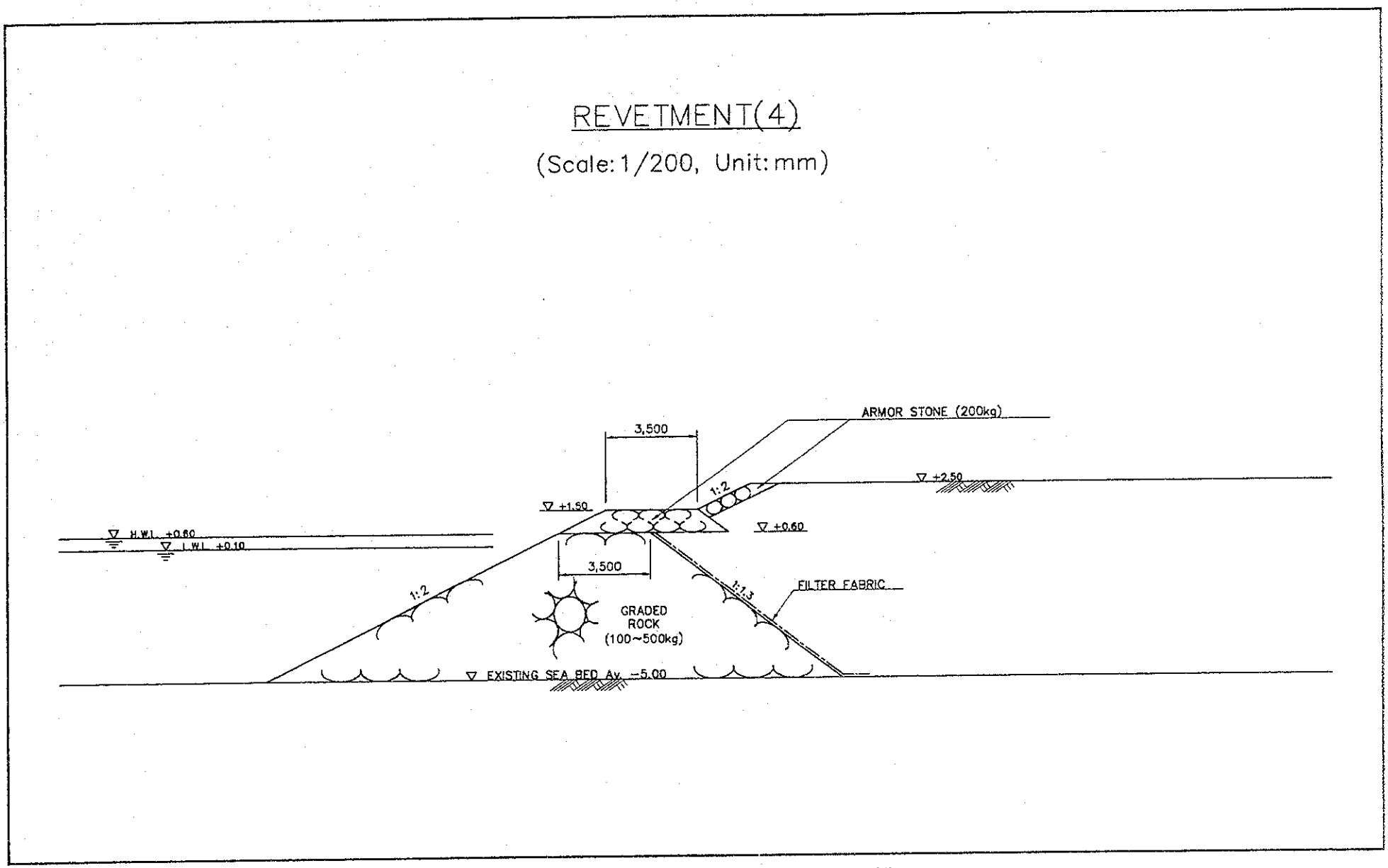


Figure 9.2.8 Typical Cross Section of Revetment (4)

Chapter 10 IMPLEMENTATION PROGRAM AND COST ESTIMATION

10.1 Implementation Program

10.1.1 Construction Schedule

The construction sequences are outlined below for the major elements of the construction works of the Short Term Plan. Detailed construction procedures and schedule are given in Figs. 10.1.1 and 10.1.2. The construction scheduling is based on the precondition that it is advisable in the interest of the overall progress of the works to commence them at the outset of the southwest monsoon period.

(1) Temporary Works

With the commencement of the works the preparation of the storage area for various sizes of rock, fabrication and temporary storage yards for concrete blocks, and operation yard for concrete batching plants and other equipment. The construction of a loading pier for rocks and concrete blocks will also be started. These temporary works are estimated to take five (5) months to complete. On completion of the storage yards stockpiling of rocks will be started.

(2) Dredging Works

Dredging of the access channels and the harbour basin will be started immediately after the first southwest monsoon period following the commencement of the Project construction in an effort to avoid the difficulties expected in dredging operations during that monsoon period due to wind waves and swells. The dredging works will be completed prior to the next southwest monsoon period. The estimated construction time is seven (7) months.

(3) Outer Breakwater

A key element of the Galle Port development, the Outer Breakwater, measuring 800 m east to west, will be constructed of rubbles and concrete wave-breaking blocks. The Port of Galle, located in the Galle Bay opened to the south, is exposed to swells from the Indian Ocean; in particular during the southwest monsoon spanning the May-September period high waves invade the bay. With this taken into full consideration, the Outer Breakwater is designed to provide adequate tranquility for the access channels and mooring basin.

Because of its size and the quantity of work involved, the Outer Breakwater construction will necessarily have to extend over the entire southwest monsoon period from May to September. For this reason, every possible precaution is taken in the design for protecting the breakwater structure in the severe marine environment during that monsoon period. The commencement of the breakwater works will follow the completion of nearly 50% of the Inner Breakwater and of the entire works on the Revetments (1) and (2) which will serve to provide adequate tranquility for the quay construction site and the yard site behind. The estimated construction time for the Outer Breakwater is 24 months.

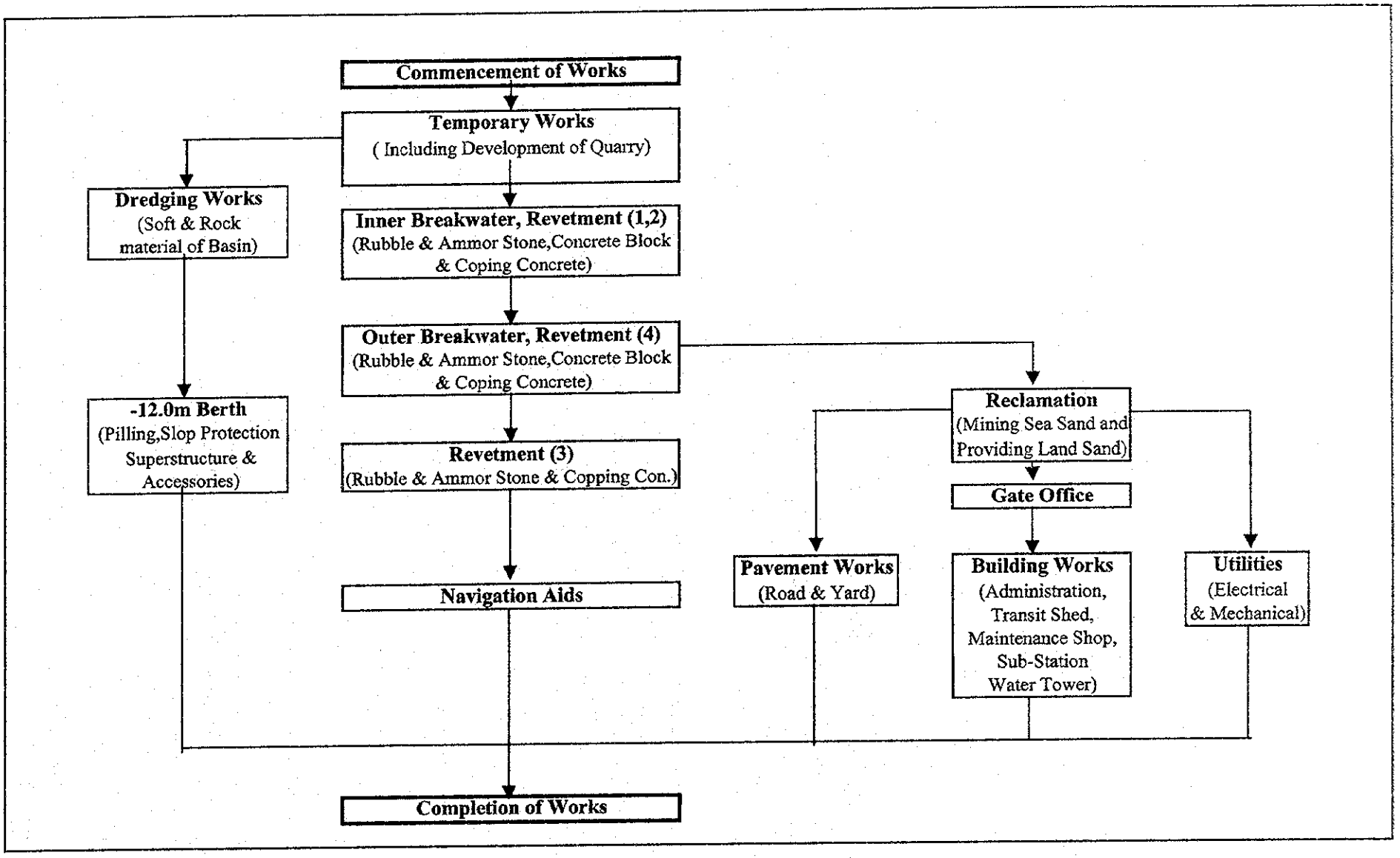


Figure10.1.1 Sequence of Construction

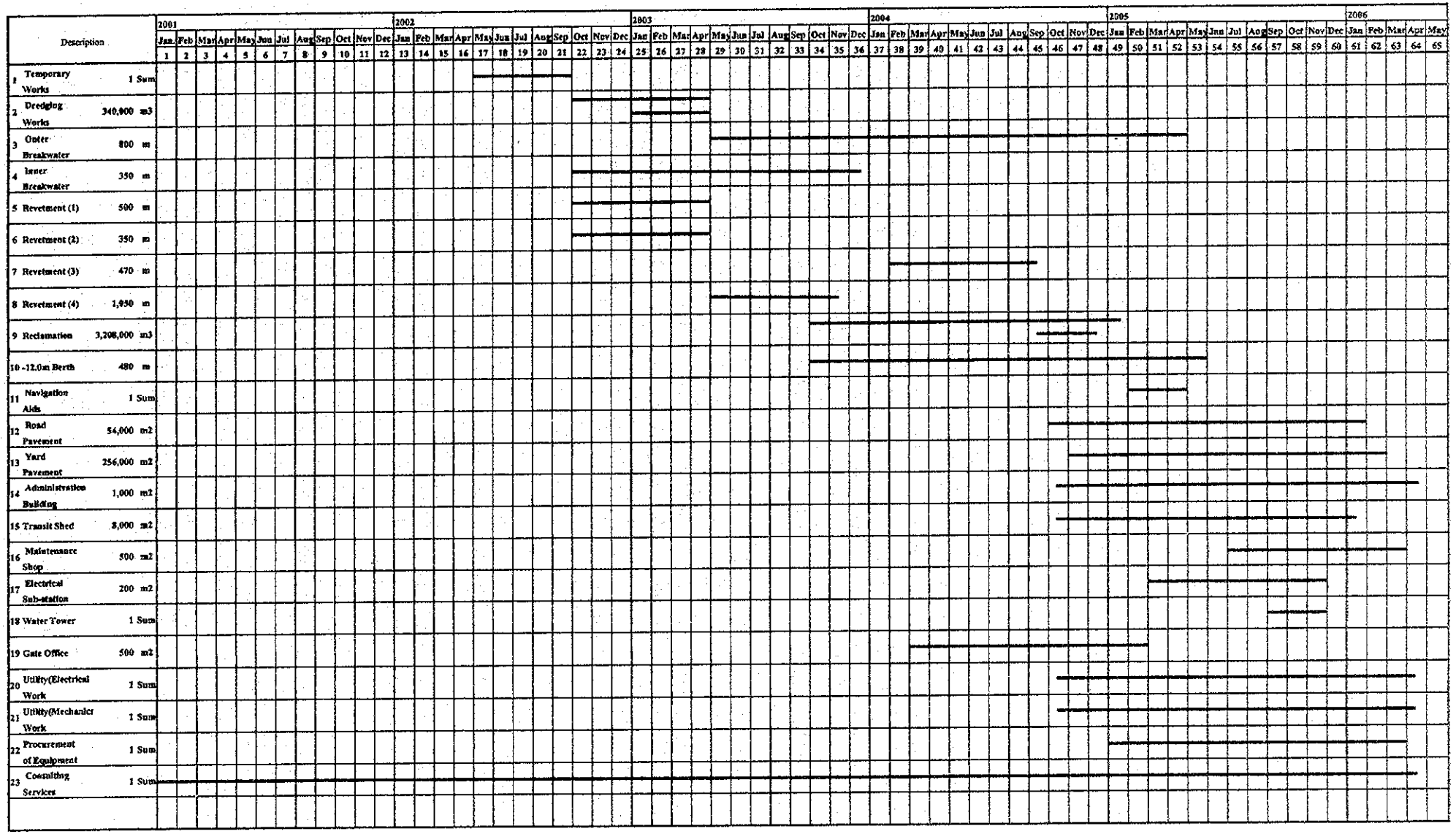


Figure10.1.2 Construction Schedule

(4) Inner Breakwater

Constructed of rubbles and wave-breaking concrete blocks and extending 350 m north-south to adjoin the reclaimed area, the Inner Breakwater is, like Revetments (1) and (2), intended to provide adequate tranquility for the quay and yard construction sites. For this reason, it is necessary to complete the Inner Breakwater in the initial stage of the Project construction.

As in the Outer Breakwater, provision is made in the design for every possible means to protect this structure during its construction which will necessarily have to take place over the entire southwest monsoon period. The construction works are planned to commence upon completion of the Temporary Works. The estimated construction time for the Inner Breakwater is 14.5 months.

(5) Revetments (1) and (2)

Revetments (1) and (2), both built of rubbles and wave-dissipating concrete blocks, will be located on the west of the reclaimed area and will measure a total of 850 m (500 m for Revetment (1) and 350 m for Revetment (2)). Like the Inner Breakwater, both revetments are aimed at ensuring adequate tranquility for the quay and yard construction sites. Their construction is planned to start simultaneously with the Inner Breakwater and to be completed by the 12th month of the Project construction. The estimated construction time is seven (7) months each.

(6) Revetment (3)

Revetment (3), built of rubbles, will measure 300 m on the north of the reclaimed area and 170 m along the approach to the quay. The construction of this structure is planned to proceed simultaneously with the earth retaining revetment in the back of the quay structure. The estimated construction time is 7.5 months

(7) Revetment (4)

Built of rubbles, this revetment will measure 1,050 m along the access road to the existing road. The revetment site is, unlike the other revetment sites already mentioned, located in shallower waters and can be approached from the shore for construction purposes. Its construction is planned for early periods of the Project construction. The estimated construction time is 6.5 months.

This quay (providing two berths), measuring 480 m, will consist of vertical steel pipe piles and coping concrete and will be backed by an earth retaining revetment supported on steel anchor sheet-piles. When adequate tranquility is obtained for the quay construction site with the completion of the Inner Breakwater and Revetments (1) and (2), the construction of the retaining revetment will get under way and will be followed by the driving of steel pipe piles, execution of the slope protection works beneath the quay structure, placing of coping concrete, and finally installation of quay ancillaries. The estimated construction time is 20 months.

(8) Reclamation Works

Taking account of the site condition and with the view of reducing the construction time, the reclamation works will be carried out separately in two areas: yard site and the access area to the existing road. The yard area will be filled up with sand obtained from authorized nearby supply sources in the seabed by means of a trailing suction hopper dredger and sand from onshore borrow pits will be used for the filling of the access area to the existing road. The reclamation is planned to commence immediately after the end of the southwest monsoon period to facilitate obtaining sea sand. The estimated construction time is 15.5 months.

(9) Navigation Aids

The navigation aids planned for procurement for the Project consist of five (5) units of light buoy, four (4) units of light beacon, and two (2) units of leading light. The installation of these navigation aids is planned for completion simultaneously with the -12.0 m quay structure. The estimated completion time is three (3) months.

(10) Road and Yard Pavements

The road and yard will be surfaced with asphalt pavements and part of the yard will remain an open area which will be surfaced with gravel. The paving work is planned to commence when the reclamation work has attained a certain degree of progress. The estimated construction time is 16 months.

(11) Building Works

The building works consist of the administration building, transit shed, maintenance shop, electrical substation, water tower, and gate office. These works with the exception of the gate office will be carried out with due regard for the progress of the reclamation work. The work on the gate office, located near the existing road, will not be affected by the reclamation and can be started in advance of the other buildings so as to facilitate the on-site construction operations. The estimated total construction time is 18 months.

(12) Utility (Electrical and Mechanical) Works

The electrical works comprise power supply, lighting, power receiving, emergency power generation and communication systems and the mechanical works consist of water supply, bunkering, and other necessary utilities for the port. As in the building works, the electrical and mechanical works will be executed having due regard for the progress of the reclamation works. The estimated construction time is 18 months.

(13) Cargo Handling Equipment

The required cargo handling equipment will be procured immediately prior to the completion of the entire construction works of the Project.

10.1.2 Sites for Temporary Construction Facilities

At present, a cement factory building stands behind the existing quay and warehouses in the Port of Galle; there exists very limited land available for the construction of this Project. To make matters worse, increasing cargo volumes handled at the port in recent years have brought about considerable shipping congestion along the existing quay; this situation will likely make it very difficult for construction-related craft to take up temporary moorings alongside the quay.

For this reason, the Study Team has proposed filling up the shore adjacent to the Fishery Harbour along the Marine Drive (National Highway A-2) outside the port for preparing the site for the temporary construction facilities. The temporary storage yards are planned as outlined below with due consideration given to their reuse after the Project completion.

The temporary yards will be enclosed by rubbles and armor stones, filled up with pit material and equipped with a temporary pier 120 m in length and 4.5 m in depth alongside supported on steel sheet-piles and reinforced at the head with rubbles and wave-dissipating concrete blocks for loading working craft with construction materials. Based on the estimated quantities of rock and concrete blocks given below, an area of 27,000 m^2 is planned for the fabrication and temporary storage yard for wave-dissipating concrete blocks, 33,000m^2 for the storage yard for rubbles and armor rocks, and 5,500 m^2 for the operation area for a concrete batching plant.

(1) Rock Volume Required

Offshore Works	Net Volume of Rock
Breakwaters	729,000 m^3
Revetments	381,000 m^3
Quay	24,000 m^3
Total	1,134,000 m^3

(2) Concrete Blocks Required

Type	Quantity Required
Armour concrete block (25t)	4,340 nos
Armour concrete block (16t)	6,920 nos
Armour concrete block (5t)	20,160 nos

The Contractor's Site Office and the Engineer's Office will be established in an unused area within the Galle Port premises for reasons of security and convenience. Figure 10.1.3 shows the proposed layout plan of the temporary yards.

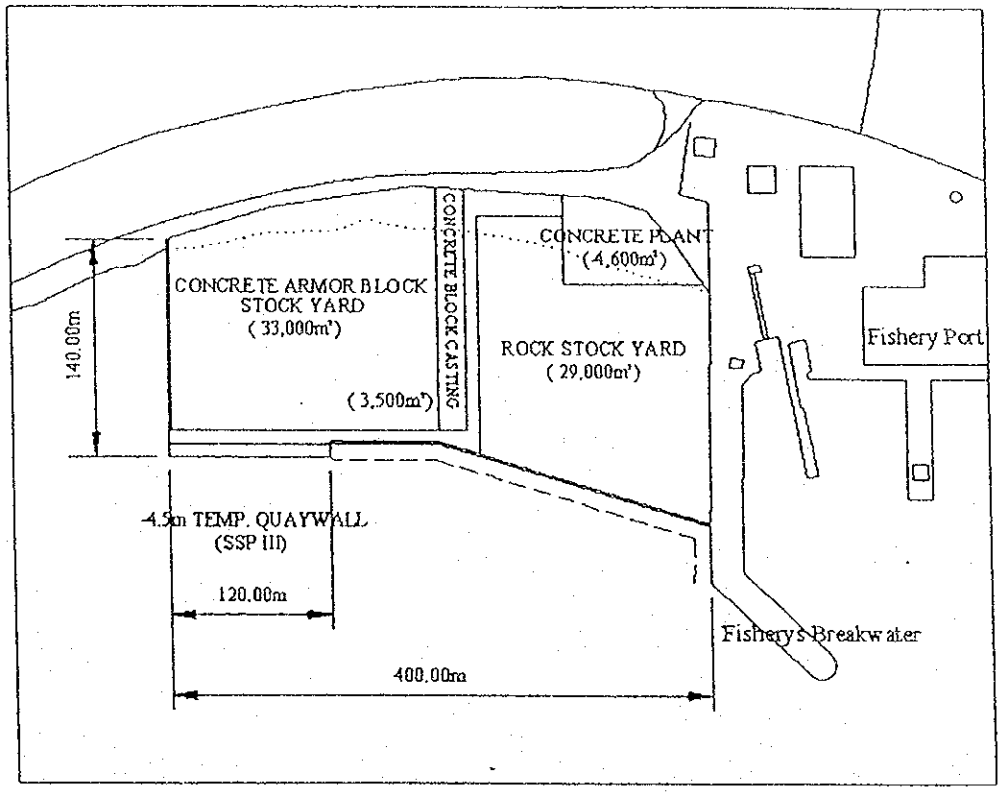


Figure 10.1.3 Layout Plan of the Temporary Yard

10.1.3 Construction Method

(1) Operational Conditions

With the Galle Bay opened to the Indian Ocean, the Port of Galle is directly exposed to waves of 0.5 m or higher waves all the year round. During the southwest monsoon period (May –September), in particular, a wave height of 1.5 m is observed in the Port at a frequency of 70 to 80% because of wind waves and swells entering the bay.

The construction plan and schedule have been drawn up for the various elements of the works under the Short Term Plan on the basis of the number of days available for construction operations computed for the southwest monsoon period and the non-monsoon period, respectively, assuming the following critical wave heights:

Critical wave height for rubble depositing for breakwaters and revetments : 1.5 m

Critical wave height for concrete block placement for breakwaters and revetments : 1.0 m

Table 10.1.1 gives the number of days available for construction operations per month during the southwest monsoon period and the non-monsoon period.

Table 10.1.1 Days Available for Construction Operations

(1) In Case of Wave Height below 1.0m

Month	Wave Height (m)						% below 1.0m	Workable Days/Month
	0-0.49	0.5-0.99	1.0-1.49	1.5-1.99	2.0-2.49	Over2.5m		
January	3.4	88.7	7.5	0.1			92.1	29
February	4.4	84.9	8.8	1.5			89.3	25
March	0.7	70.7	26.4	1.8			71.4	22
April	0.3	38.7	53	7.5	0.1		39	12
May		8.3	45.6	33.3	12.1	0.2	8.3	3
June		0.7	29.5	53.1	13.1	3	0.7	0
July			21.9	63.5	12.5	1.7	0	0
August			27.3	62.3	9.6	0.4	0	0
September		7.6	38.6	44	8.4	0.9	7.6	2
October		23.9	42.1	24.9	7.6	1.2	23.9	7
November		45.6	38.8	12.3	2.3	0.5	45.6	14
December	1.7	75.4	21.8	0.8			77.1	24
Total		37.9				61.7		138

Wave Height below 1.5m

Month	Wave Height (m)						%below 1.5m	Workable Days/Month
	0-0.49	0.5-0.99	1.0-1.49	1.5-1.99	2.0-2.49	Over2.5m		
January	3.4	88.7	7.5	0.1			99.6	31
February	4.4	84.9	8.8	1.5			98.1	27
March	0.7	70.7	26.4	1.8			97.8	30
April	0.3	38.7	53	7.5	0.1		92	28
May		8.3	45.6	33.3	12.1	0.2	53.9	17
June		0.7	29.5	53.1	13.1	3	30.2	9
July			21.9	63.5	12.5	1.7	21.9	7
August			27.3	62.3	9.6	0.4	27.3	8
September		7.6	38.6	44	8.4	0.9	46.2	14
October		23.9	42.1	24.9	7.6	1.2	66	20
November		45.6	38.8	12.3	2.3	0.5	84.4	25
December	1.7	75.4	21.8	0.8			98.9	31
Total			368.0			31.6		247

(2) Execution of Works

1) Dredging

Soft material of the access channel and harbour basin will be dredged by grab dredgers and hauled to the authorized dumping site by hopper barges for dumping. The dumping site will be designated by the competent authorities of Sri Lanka.

For rock excavation self-elevating platform type (SEP) barges will be employed to drill holes for charging explosives and the excavation will be undertaken by grab dredgers and rocks will be dumped by hopper barges.

Table 10.1.1 Days Available for Construction Operations

(1) In Case of Wave Height below 1.0m

Month	Wave Height (m)						% below 1.0m	Workable Days/Month
	0-0.49	0.5-0.99	1.0-1.49	1.5-1.99	2.0-2.49	Over2.5m		
January	3.4	88.7	7.5	0.1			92.1	29
February	4.4	84.9	8.8	1.5			89.3	25
March	0.7	70.7	26.4	1.8			71.4	22
April	0.3	38.7	53	7.5	0.1		39	12
May		8.3	45.6	33.3	12.1	0.2	8.3	3
June		0.7	29.5	53.1	13.1	3	0.7	0
July			21.9	63.5	12.5	1.7	0	0
August			27.3	62.3	9.6	0.4	0	0
September		7.6	38.6	44	8.4	0.9	7.6	2
October		23.9	42.1	24.9	7.6	1.2	23.9	7
November		45.6	38.8	12.3	2.3	0.5	45.6	14
December	1.7	75.4	21.8	0.8			77.1	24
Total		37.9				61.7		138

Wave Height below 1.5m

Month	Wave Height (m)						% below 1.5m	Workable Days/Month
	0-0.49	0.5-0.99	1.0-1.49	1.5-1.99	2.0-2.49	Over2.5m		
January	3.4	88.7	7.5	0.1			99.6	31
February	4.4	84.9	8.8	1.5			98.1	27
March	0.7	70.7	26.4	1.8			97.8	30
April	0.3	38.7	53	7.5	0.1		92	28
May		8.3	45.6	33.3	12.1	0.2	53.9	17
June		0.7	29.5	53.1	13.1	3	30.2	9
July			21.9	63.5	12.5	1.7	21.9	7
August			27.3	62.3	9.6	0.4	27.3	8
September		7.6	38.6	44	8.4	0.9	46.2	14
October		23.9	42.1	24.9	7.6	1.2	66	20
November		45.6	38.8	12.3	2.3	0.5	84.4	25
December	1.7	75.4	21.8	0.8			98.9	31
Total			68.0			31.6		247

(2) Execution of Works

1) Dredging

Soft material of the access channel and harbour basin will be dredged by grab dredgers and hauled to the authorized dumping site by hopper barges for dumping. The dumping site will be designated by the competent authorities of Sri Lanka.

For rock excavation self-elevating platform type (SEP) barges will be employed to drill holes for charging explosives and the excavation will be undertaken by grab dredgers and rocks will be dumped by hopper barges.

2) Breakwaters

As mentioned in Section 10.1.1, the Outer and Inner Breakwaters will be built of rubbles and wave-dissipating concrete blocks. Rubbles will be carried to the construction sites by deck barges of 1,800-ton capacity assisted by pusher barges and will be deposited in place by a wheeled loader mounted on the deck barges. Wave-dissipating concrete blocks will be installed in position by self-propelled floating cranes (barge loading capacity: 750 tons; crane hoisting capacity: 120 tons).

The construction of the Inner Breakwater will be started with the end of the first southwest monsoon period and completed before the onset of the next southwest monsoon.

The Outer Breakwater construction will span two southwest monsoon periods. The entire part of the breakwater structure planned for construction during the off-monsoon season will be completed before the onset of the next southwest monsoon. That part of the structure which will still be under construction will be protected or reinforced in an appropriate manner.

3) Wave-Dissipating Revetments

As in the breakwater construction, rubbles will be carried by 1,800-ton capacity deck barges assisted by pusher barges to the construction sites where they will be deposited in place by a wheeled loader mounted on the deck barges. Wave-dissipating concrete blocks will be installed in position by a self-propelled floating crane of the same type used in the breakwater works. The blocks will be installed at -2.0 m to -3.0 m, the appropriate depths which will ensure their stability against wave pressures. Those concrete blocks intended for covering the revetments will be installed in position from the shore after the reclamation work is completed.

4) -12.0 m Quay

A floating pile driver will be employed for driving vertical steel pipe piles for the quay structure and the earth retaining revetment behind. Immediately after the completion of pile driving for each block, mortar lining combined with cathodic protection will be undertaken for protection of the piles. This will be followed by slope protection, timbering, and coping works. The temporary works for placing the coping concrete will be carried out in offshore-based operations. After the placement of the coping concrete, fenders, bollards, crane rails, and other ancillaries will be fitted to anchor bolts, templates, and other fittings placed during the placement of the coping concrete.

5) Reclamation Works

Reclamation of the yard site and the access area to the existing road will be undertaken after the completion of the revetment for the reclamation area and the earth retaining revetment behind the new quay structure. The reclamation works at both sites will be carried out independently.

Fill material for the yard will be obtained from a nearby offshore site approved in advance by the Coast Conservation Department and other competent government agencies. The material will be discharged into the reclamation area through a hydraulic discharge pipeline and the area will be provided with waste waxes of adequate capacity and silt curtains.

Filling-up of the access area to the existing road will be carried out by spreading fill material from onshore borrow pits by the end-on method.

At both reclamation sites the fill material placed above HWL will be given adequate roller compaction.

6) Navigation Aids

As earlier stated, the navigation aids planned for installation under the Short Term Plan consist of light buoys to be installed in the access channel and the mooring basin, light beacons to be built on the breakwaters and revetments, and a sector light to be installed onshore for providing a good view from the channel center. The installation of these navigation aids will be completed simultaneously with the completion of the quay works.

7) Road and Yard Pavements

Soon after the reclamation works, the road and yard subgrades will be prepared and roller compacted. The base courses will be finished with the material and to the thickness required by the specifications and surfaced with asphalt concrete mixtures. The open area in the yard will be surfaced with gravel.

8) Building Works

The building works will comprise the administration building, transit shed, maintenance shop, electric substation, water tower, and gate office. These building works will be started immediately after the completion of the reclamation works at the respective sites. Structural steel frames, the main building material, will be fabricated to the specified dimensions outside Sri Lanka and imported for incorporation in the building works.

9) Utilities Works

Construction of the utilities works will commence immediately after the completion of the reclamation works. Earth works such as the embedment of power cables and water pipes will be executed in a manner well coordinated with the paving works on the road and yard and the building works so as to achieve smooth progress.

10.2 Cost Estimation

10.2.1 Determination of Unit Costs

The unit costs of labour, plants, equipment, and materials used in preparing cost estimates for the Project construction are based on the information derived from field surveys conducted in April 2000 as part of the present Study.

(1) Exchange Rate

The exchange rate between the foreign (Japanese Yen) and local currencies used in the cost estimation is ¥1 = Rp.0.75.

(2) Import Tax

The cost estimates do not consider any import taxes assessable on construction plants, equipment, and materials from outside sources.

(3) Local Taxes

The cost estimates do not take account of Good and Service Tax (GST), National Security Levy (NSL), or any other local taxes and levies applicable to construction contracts.

(4) Physical Contingency

The physical contingencies are assumed as follows:

Civil and building works	:	10%
Equipment procurement	:	3%

10.2.2 Estimation of Costs

(1) Basic prices of materials and labour and supply capacities

In determining the basic prices of construction materials and labour from local sources and their supply capacities, the Study Team has studied price data from recent or ongoing construction projects in Sri Lanka in addition to the results of a local price survey conducted by the Study Team.

The supply conditions and capacities of locally available major construction materials are outlined below.

1) Rock

Rubble rocks (100 to 500 kg/piece) and armor rocks (500kg to 2 tons/piece) are obtainable from private- or government-owned quarries located within 30 km from the Port of Galle (see Table 10.2.1). However, the production capacities of these quarries are small and their supply is limited. For this reason, it would be necessary to develop other quarries in order to supply the rock needs of the Short Term Plan sufficiently.

2) Aggregates for Concrete

Like rubble rocks, coarse aggregates for concrete production can be supplied by private- and government-owned quarries located within 30 km from the Port of Galle, but their production and supply capacities are limited.

Fine aggregates are obtainable from rivers within 20 km from the Port (see Table 10.2.1), but because of deteriorated river environment resulting from mechanized sand winning operations in the past, restrictions are currently imposed on monthly operations on these rivers and only manual sand winning is permitted. Nevertheless, the estimated fine aggregate requirements of the Project can be supplied.

3) Cement

Private companies have started cement production near the Port of Galle in recent years, and the estimated cement requirements of the Project can be filled.

4) Steel

All major steel products except for some items needed for temporary works would have to be imported.

5) Fill material

Sea sand for filling up the yard site will be obtained from nearby supply sources in the seabed approved in advance by the Coast Conservation Department and other competent government agencies. However, royalties for sand supplies are not considered in the preparation of construction cost estimates.

Table 10.2.1 Quarries and Borrow Sand Points

(1) Quarry Site

No.	Name of Quarry	Distance from	Present Operation	Area	Ownership	Capacity	Remarks
1	Nakiyademiya	22 km	Unopened	10 ha	Private		
2	Kottawa	13 km	Unopened	8 ha	Private		
3	Wakwella	16 km	Under Operation	4 ha	Private	300,000m^3	Aggregate Production
4	Wegrampita	32 km	Under Operation	2 ha	Private	800,000m^3	Aggregate Production
5	Mee Ella	60 km	Under Operation	1.6 ha	Private	200,000m^3	Aggregate Production
6	Galagoda	28 km	Under Operation	15 ha	Private / Road Authority	1,000,000m^3	
7	Wipra Metal Crusher	22 km	Under Operation	8 ha	Private	200,000m^3	Aggregate Production
8	Haupai	13 km	Under Operation (New)	1.5 ha	Private	200,000m^3	Aggregate Production
9	Hailiwara	3 km	Unopened * Difficult Development	4 ha	Government		
10	Indiktiya	19 km	Under Operation	10 ha	Private	1,000,000m^3	
11	Nasvila	23 km *Bad Access	Under Operation * Difficult Development	2 ha	Private	200,000m^3	Aggregate Production
12	Akurresa Div.	30 km * Bad Access	Unopened * Difficult Development		Government		
13	Akumeemana Div.	15 km	Unopened	4 ha	Government		

(2) Site of Fine Sand Collection

No.	Location of Site	Description of Location
1	Upstream of Gin River	Between Baddegama and Udugama
2	Upstream of Polwatta River	Between Yakkalamulla and Nakiyadeniya
3	Upstream of Nilwala River	Between Akuressa and Welihena

Tables 10.2.2 gives the unit costs of labour and fuels and Table 10.2.3 unit costs of locally obtainable major construction materials.

Table 10.2.2 Unit Costs of Local Workers and Fuels

Item	Unit Cost		Remarks
	Basic Wage	Working Wage	
Worker (per day) :			Working Condition :
1. Unskilled	250Rs./day	370Rs./day	27 days per month basis
2. Skilled	300Rs./day	444Rs./day	Normal Working Hour : 8:00-17:00
3. Foreman	550Rs./day	778Rs./day	Overtime : 1hr/day*27 days/month
4. Carpenter	350Rs./day	481Rs./day	
5. Bar Bender	350Rs./day	481Rs./day	
6. Welder	400Rs./day	556Rs./day	
7. Surveyor	1,111Rs./day	1,593Rs./day	
8. Mechanics	550Rs./day	778Rs./day	
9. Operator	400Rs./day	556Rs./day	
10. Driver	325Rs./day	481Rs./day	
11. Crew (High Class)	550Rs./day	778Rs./day	
12. Crew (Normal Class)	450Rs./day	630Rs./day	
13. Diver	1,500Rs./day	2,148Rs./day	
Fuel (per litter) :			
12. Gasoline		50.2Rs./Litter	
13. Light Oil		15.2Rs./Litter	
14. Diesel Oil (Marine)		17.8Rs./Litter	
15. Heavy Oil		16.2Rs./Litter	

Table 10.2.3 Unit Costs of Local Materials

Item	Unit	Net Unit Cost	Remarks
1. Sand for Reclamation	Rs./m^3	168.0	This net unit cost is only for machinery and manpower charges, not included material fee.
2. Stone (100 - 500 kg/pc.)	Rs./m^3	810.0	
3. Stone (500 - 1,000 kg/pc.)	Rs./m^3	810.0	
4. Stone (2 - 5 tons/pc.)	Rs./m^3	810.0	
5. Gravel	Rs./m^3	965.0	
6. Cement	Rs./Ton	4,000.0	
7. Aggregate (Crusher-run)	Rs./m^3	995.0	
8. Fine Aggregate	Rs./m^3	777.0	
9. Admixture	Rs./kg	83.0	
10. Asphalt	Rs./kg	16.8	
11. Asphalt Concrete Hot Mix	Rs./Ton	4,329.0	
12. ICB (Interlocking Con. Block)	Rs./m^2	132.0	(t=10cm)

(2) Foreign and Local Currency Components

The direct construction costs consist of foreign and local currency components. Table 10.2.4 gives the foreign and local currency percentages for the cost items including plants, equipment, materials and labour.

Table 10.2.4 Foreign and Local Currency Components

Item	Foreign (%)	Local (%)
1. Rubble and Other Stones		100
2. Fill Materials		100
3. Cement and Admixture		100
4. Aggregates for Concrete		100
5. Concrete Products from Local Sources		100
6. Labor		100
7. Fuel and Asphalt		100
8. Steel and Reinforcing Bars	100	
9. Floating Equipment	100	
10. Construction Plant and Equipment	70	30
11. Formwork for Concreting	80	20
12. Materials for Temporary Works and Scaffolding	70	30

10.2.3 Project Cost

The estimated construction cost for the Short Term Plan is presented in Table 10.2.5. As seen from the table, the total construction cost is Rs.11,653,361,156 (¥15,537,814,874) which is broken down as follows:

Foreign currency component : ¥11,830,140,753 (76.1%)

Local currency component : Rs.2,780,755,606 (23.9%)

The annual investment plan is given in Table 10.2.6.

Table 10.2.5 Construction Cost

	Description	Quantity	Unit	Construction cost			Remarks
				Foreign Yen(1,000)	Local Rs.(1,000)	Total Yen(1,000)	
Construction of Civil and Building	Temporary Works (Included Mob./Demob.)	1	Sum	717,533	102,990	854,853	
	Dredging Works (Soft : 325,400m3, Rock : 13,725m3)	339,128	m3	309,225	26,717	344,848	
	Outer Breakwater	800	m	2,584,315	758,507	3,595,658	
	Inner Breakwater	350	m	1,003,767	266,314	1,358,852	
	Revetment (1)	500	m	576,800	153,719	781,759	
	Revetment (2)	350	m	252,958	73,563	351,042	
	Revetment (3)	470	m	343,688	116,128	498,525	
	Revetment (4)	1,050	m	165,970	85,828	280,407	
	Reclamation (Road and Yard)	3,208,000	m3	775,260	200,162	1,042,143	
	-12.0m Berth	480	m	1,387,269	135,891	1,568,457	
	Navigation Aids	1	Sum	168,839	1,431	170,747	
	Pavement (Road and Yard)	312,700	m2	334,651	350,529	802,023	
	Administration Building	1,000	m2	64,595	9,918	77,819	
	Transit Shed (4,000m2 : 2Units)	8,000	m2	348,179	30,378	388,683	
	Maintenance Shop	500	m2	26,597	4,140	32,117	
	Electrical Sub-station	200	m2	8,800	1,881	11,308	
	Water Tower	1	Sum	11,000	5,500	18,333	
	Gate Office	500	m2	55,000	5,988	62,984	
	Utility (Electrical Works)	1	Sum	282,260	59,417	361,483	
	Utility (Mechanical Works)	1	Sum	29,966	8,203	40,903	
	Sub-Total (1)			**9,446,672**	**2,397,204**	**12,642,944**	
Procurement	Crane (Mulipurpose) and						
	Cargo Handling Equipment	1	Sum	800,000	0	800,000	
	Sub-Total (2)			**800,000**	**0**	**800,000**	
	Total (1) + (2)			**10,246,672**	**2,397,204**	**13,442,944**	
	Consulting Survice			614,800	143,832	806,577	
	Physical Contingency Sub-Total (1)x10%+(2)x3%			968,667	239,720	1,288,294	
	Ground Total			**11,830,140**	**2,780,757**	**15,537,815**	

Table 10.2.6 Annual Investment Plan

Description	Quantity	Unit	Total Cost			2001			2002			2003			2004			2005			2006			Total			Remarks
			Foreign (\)	Local (Rs.)	Total (\)	Foreign (\)	Local (Rs.)	Total (\)	Foreign (\)	Local (Rs.)	Total (\)	Foreign (\)	Local (Rs.)	Total (\)	Foreign (\)	Local (Rs.)	Total (\)	Foreign (\)	Local (Rs.)	Total (\)	Foreign (\)	Local (Rs.)	Total (\)	Foreign (\)	Local (Rs.)	Total (\)	
1 Temporary Works	1	Sum	717,533	102,990	854,853				273,541	92,691	397,128	186,120	0	186,120	124,080	0	124,080	62,040	0	62,040	71,753	10,299	85,485	717,533	102,990	854,853	
2 Dredging Works	340,000	m^3	309,224	26,717	344,847				89,894	5,216	96,848	219,330	21,501	247,998										309,224	26,717	344,847	
3 Outer Breakwater	806	m	2,584,315	758,507	3,595,658				836,093	247,288	1,165,810	1,350,912	392,113	1,873,729	397,310	119,106	556,117							2,584,315	758,507	3,595,656	
4 Inner Breakwater	350	m	1,003,767	266,314	1,358,852				207,676	55,099	281,142	796,091	211,215	1,077,710										1,003,767	266,314	1,358,852	
5 Revetment (1)	500	m	576,800	153,718	781,758				247,200	65,879	335,039	329,600	87,839	446,719										576,800	153,718	781,758	
6 Revetment (2)	350	m	252,958	73,563	351,042				108,411	31,527	150,446	144,548	42,036	200,595										252,958	73,563	351,042	
7 Revetment (3)	170	m	124,313	42,004	180,318										124,313	42,004	180,318							124,313	42,004	180,318	
8 Revetment (3)	300	m	219,376	74,124	318,208										219,376	74,124	318,208							219,376	74,124	318,208	
9 Revetment (4)	1,050	m	165,969	85,828	280,406							165,969	85,828	280,406										165,969	85,828	280,406	
10 Reclamation	3,208,000	m^3	775,260	200,163	1,042,144							150,050	4,194	155,643	600,201	195,268	860,559	25,010	699	25,942				775,262	200,162	1,042,144	
11 -12.0m Berth	480	m	1,387,269	135,891	1,568,457							693,635	67,945	784,229	554,908	54,356	627,383	138,727	13,589	156,846				1,387,269	135,891	1,568,457	
12 Navigational Aids	1	Sum	168,839	1,431	170,747													168,839	1,431	170,747				168,839	1,431	170,747	
13 Road Pavement	54,360	m^2	107,800	148,460	305,747										13,475	18,558	38,218	87,588	120,624	248,420	6,738	9,279	19,109	107,800	148,460	305,747	
14 Yard Pavement	256,340	m^2	226,851	202,069	496,276										21,267	18,944	46,526	184,316	164,181	403,224	21,267	18,944	46,526	226,851	202,069	496,276	
15 Administration Building	1,000	m^2	64,594	9,918	77,818										8,971	1,377	10,808	46,651	7,163	56,202	8,971	1,377	10,808	64,594	9,918	77,818	
16 Transit Shed	8,000	m^2	348,179	30,378	388,682										116,060	10,126	129,561	220,513	19,239	246,165	11,606	1,013	12,956	348,179	30,378	388,682	
17 Maintenance Shop	500	m^2	26,597	4,140	32,117													23,642	3,680	28,549	2,955	460	3,569	26,597	4,140	32,117	
18 Electrical Sub-station	200	m^2	8,800	1,881	11,308													8,800	1,881	11,308				8,800	1,881	11,308	
19 Water Tower	1	Sum	11,000	5,500	18,333													11,000	5,500	18,333				11,000	5,500	18,333	
20 Gate Office	500	m^2	55,000	5,988	62,985										41,250	4,491	47,238	13,750	1,497	15,746				55,000	5,988	62,985	
21 Utility (Electrical Work)	1	Sum	282,260	59,417	361,482										78,406	16,505	100,412	172,492	36,310	220,906	31,362	6,602	40,165	282,260	59,417	361,482	
22 Utility (Mechanical Work)	1	Sum	29,966	8,204	40,905										8,324	2,279	11,362	18,313	5,013	24,997	3,330	912	4,545	29,966	8,204	40,905	
23 Procurement of Equipment	1	Sum	800,000	0	800,000													533,333	0	533,333	266,667	0	266,667	800,000	0	800,000	
Consulting Services	1	Sum	614,800	143,832	806,576	153,700	35,958	201,644	92,220	21,575	120,986	122,960	28,766	161,315	122,960	28,766	161,315	92,220	21,575	120,986	30,740	7,192	40,329	614,800	143,832	806,576	
Contingency (Construction 10%,Procurement 5%)	1	Sum	968,667	239,720	1,288,294	0	0	0	176,281	49,770	242,641	403,626	91,267	525,315	230,794	55,714	305,079	134,168	38,081	184,943	23,798	4,889	30,316	968,667	239,720	1,288,294	
TOTAL			11,830,140	2,780,755	15,537,813	153,700	35,958	201,644	2,031,316	569,045	2,790,044	4,562,841	1,032,703	5,939,778	2,661,694	641,618	3,517,185	1,941,403	440,464	2,528,687	479,187	60,965	560,474	11,830,140	2,780,755	15,537,813	

Chapter 11 Management and Operation Plan and Port Promotion

11.1 General

A port is an economic infrastructure that should basically served the public. To do this successfully, there should be an efficient system of operation, a system of tariffs appropriate to the content of service provided and a safe and reliable mode for transport of cargo. Consequently, planning of port management and operation has to be done with a view to identifying the most appropriate organization and management scheme that would achieve the above criteria.
Regional ports are prone to be financially unprofitable in their management, while they are vital to the respective regional economic activities. In such regional ports, port-related private sectors are generally reluctant to take the risk of either investing in port infrastructures or starting port operation business including stevedoring, warehousing and forwarding which entail investment in cargo-handling machines and warehouses, especially in an initial stage of large-scale port development. In such case, a public port authority is required to provide port services including cargo-handling operations as the last resort. Generally, at a regional port, the number of berths is comparatively small, while the berths are required to serve on public use basis. In this regard, a public port authority could serve unspecified port users in a fair manner. In the direct cargo-handling operations by a port authority, efficient operations must be achieved by all means by overcoming possible shortcomings compared with private sector operations.

11.1.1 Basic Types of Management and Operation as a Regional Port

Possible private participation in the development and operation of Galle Port is treated in the following section.

The planning and construction of Galle Port are managed by SLPA and the ownership of the land belongs to SLPA. Regarding the management and operation of facilities, three alternative types are considered as follows; (A)SLPA manages and operates directly, (B)SLPA manages and private company operates and (C)facilities are owned by private company which handles both management and operation.

The above three types are summarized in the following table.

Table 11.1.1 Port and Private company Participation

Stage		Type(A)	Type(B)	Type(C)
Planning		SLPA	SLPA	SLPA
Construction		SLPA	SLPA	SLPA
Ownership	Land	SLPA	SLPA	SLPA
	Facility	SLPA	SLPA	Private
Management	Land	SLPA	SLPA	Leased to Private
	Facility	SLPA	SLPA	Private
Operation	Facility	SLPA	Private	Private
Navigation		SLPA	SLPA	SLPA

11.1.2 Comparison of Three Basic Types

Characteristics of the three types of management and operation which are applicable to Galle Port can be defined as follows:
Type (A) is the functional expansion of an existing port. SLPA manages and operates the port directly and there is no fundamental change in the system compared to that at the existing terminal. This type has a high evaluation from the point of view of the employment problem of SLPA and consideration of fairness of service to port users.
Type (B) is managed by SLPA and operated by private company. Private one is in charge of cargo handling, so there is almost no competition between the new terminal and the existing terminal. However, job opportunity benefiting SLPA is low.
Under Type (C), the private sector firm/s manage and operate by entering into leasing contracts with SLPA.

In the next stage, characteristics of the three types described above are compared on the basis of the following three factors in order to ascertain priority due to them.

(1) Job Opportunity within SLPA

Considering presumable excess personnel of SLPA, Type(A) is recommended so as to provide job opportunities for SLPA employees.

(2) Fairness of Service to Port Users

To serve unspecified port users in a fair manner with limited number of berths, Type(A) is considered to be preferable.

(3) Risk-taking by Private Sector

In case of Type(C), investment costs including infrastructure need to be recovered by way of leasing fees to be paid by a private terminal operator. As mentioned already, it is considered that a private company would be reluctant to take the risk of developing Galle Port.

As a result of above comparisons, Type(A) is considered to be the most appropriate type for the new wharf of Galle Port. This is because of two vital considerations, namely, fairness of service essential to a regional port and the large job opportunity so crucial for SLPA in order to absorb excess cadre.

Table 11.1.2 Comparison of Management and Operation by Type

Item	Type(A)	Type(B)	Type(C)
Job Opportunity within SLPA	Yes	Partial	No
Fairness of Service to Port Users	Yes	Yes	Partial
Risk-taking	By SLPA	By SLPA	By Private

11.2 Management and Operation Plan

11.2.1 Basic Policy Regarding the Improvement of Management and Operation System

In general, handling works of all cargoes are to be shifted to the new terminal corresponding to the enlargement of vessel. However, bulk cement is to be handled at the existing terminal, because the factory has already been established there. Furthermore, flour is to be discharging at the same berth, because no possibility of an enlargement due to a domestic transportation and its distribution center of the three southern provinces is located at the existing terminal. And clinker is assigned to new pier. Other major commodities such as container, bagged cement, bagged fertilizer, bagged sugar, steel, maize, clinker and gypsum are planned to be handled at the new terminal.

11.2.2 Organization of the New Terminal

The organization structure of the new terminal shall be headed by the terminal manager and consists of necessary number of workers to manage and operate the new terminal. Six sections, namely administration/finance/commercial/security/engineering and operation, and Harbour Master office shall be established. Necessary number of worker is estimated by function of the new terminal and existing organization. The resulting figure of 340 employees applies to the new organization only. In addition, there are many employees in the existing terminal area.

Table 11.2.1 Number of Employees at Galle Port

Office	Non-labour	Labour
Terminal Manager	1	0
Administration	13	0
Finance	8	0
Commercial	9	0
Security	20	0
Engineering	44	0
Operation	101	111
Harbour Master	33	0
Total	229	111

11.2.3 Cargo Handling System of the New Terminal

(1) Three Shifts System for Cargo Handling Operation

The nightshift which is currently played by low efficiency, shall divided into two shifts in order to increase the handling volume. Three shifts system per day is applied to the new terminal.

(2) Handling System of Container Cargo

One multipurpose crane and one vessel crane are applied to container handling. As for the work efficiency of a crane, the number of handling box per hour is 25 boxes for the former and 15 boxes for the latter. Forklift and trailer are applied for marshalling operation. Cargo handling productivity

of 840 boxes per day is expected.

(3) Handling System of Steel

Iron and steel products are basically handled by three vessel cranes, although a multipurpose crane may be applied for heavy units. Handling productivity of crane is set at 20 times per hour and 2 tons is available as a handling unit weight. Discharged cargo on the quay is stored at designated place by forklift.

(4) Handling System of Bagged Cargo

Pallet system is being introduced to increase handling weight of bagged cargo. One discharged unit typically consists of fifty bags(2.5 tons). And to continue this efficient operation, eight stevedores are assigned for one crane to arrange bagged cargoes on pallets. Also, an increase in vessel size and an increase in crane power can be expected. Therefore, the number of standard operations is planned at 15 per hour. Cargoes on the wharf are stored by forklift. Daily handling volume is set at around 1900 tons.

(5) Handling System of Bulk Cargo

To improve handling productivity, size of grab is enlarged to 5 tons. The increased mechanical power of vessel will result in faster operation: 24 movements per hour. A hopper system shall be introduced to prevent the scattering of cargo and dispersion of dust. Lower side cap can serve as a temporary storage box and a crane can function as simple recycling equipment. As a result, daily handling volume can be set at around 3900 tons.

11.2.4 Improvement Measures on Port Management and Operation at the New Terminal

(1) Localization of Formalities on Port Entry

Port function shall be enhanced by localizing formalities on port entry including bonding.

(2) Introduction of an Information System

The new terminal shall be operated under close coordination among the port operator, ship controller, customs, quarantine, etc.. ETA(Estimated Time of Arrival) information received by the Harbour Master Office shall be delivered to the relevant offices in a timely and efficient manner.

For an efficient handling system, it is important to obtain accurate information on vessels and cargo in a timely manner. An information system which relays above information to relevant parties needs to be introduced. This system will make information on incoming and outgoing vessels to/from the port and storing situation of cargo through a terminal unit available to many users. It will also summarize cargo statistics and also vessel statistics for the previous year. This type of information is essential in formulating a proper investment plan and an effective management.

The information system division of the headquarters shall plan the hardware and software.

(3) Application of Vitalization Plan of the Organization

For vitalization of the organization, not only its reformation but also the improvement of minds of its personnel toward rational and efficient management are important. For this purpose, many private companies adapt a Quality Control (QC) circle and a proposal activity by personnel.

A QC circle is an activity for improvement involving each individual employee. Normally it is carried out by a group of a single division or section. Members of the group identify problems concerning quality, safety, efficiency etc. and voluntarily try to solve the problems with everyone's cooperation. It also has a positive impact on the mindset of personnel since many people take part in the activity and find satisfaction in seeing their suggestions implemented. Many companies hold conferences or award ceremonies in order to promote it and to learn from other activities.

In case of Galle Port, trial and error shall be applied in each post for improving work efficiency, since it is assumed that comparatively many kinds of goods are handled there.

(4) Improvement of the Personnel Management System

In order to carry out the proper management and operation of the port, it is indispensable that the business ability of personnel of SLPA be kept high. For that purpose, the personnel evaluation system is required to be improved as follows.

One of the ways to improve personnel ability is to evaluate their ability properly and fairly with objective standards and reflect that evaluation in promotions and wages. Through this evaluation, the proper personnel transfer according to experience, knowledge and judgement becomes possible. Moreover it also gives personnel the incentive to work hard and to display their ability because they are satisfied with the proper evaluation of their works.

The following points should be kept in mind at the time of the evaluation.

1) Evaluation should be done not only for promotion and wages but also for the nurturing of personnel. So it is important to look at the shortcomings or promising points of each employee and to evaluate his/her efforts to rectify/cultivate them.

2) A manager of each section should make efforts to improve abilities of personnel under him/her through training on the job or through training courses and seminars.

3) Evaluating items should include the contribution and attitude toward efficient business.

(5) Improvement of the Training System

SLPA established the Mahapola Training Institute and it implements all of SLPA training programs which cover various fields of port management. But it is difficult for an employee in Galle Port to enter a training program, because they are held in Colombo. As new handling equipment is planned

to be introduced at Galle Port, training on operation techniques and maintenance engineering is required. This training should be done on site.

11.3 Port Promotion Plan

Strengthening of port sales and marketing is a major theme to be taken as a port promotion plan. To promote use of a port, it is essential to establish a more useful and attractive port in terms of both facilities and management and operation for users such as shipping lines, shipping agent, forwarders, shippers, consignees, etc.. For that purpose, it is necessary to have a real time, broad, systematic grasp of user needs and to reflect their needs in the practical development and management of the port. The port should be marketed positively, providing users with pertinent information.

To make potential users aware that Galle Port is located on an international maritime route, it is necessary for the port to publicize its activities as well as its existence. It is also important to grasp users demands.

Setting up a homepage is an effective means of PR, especially to the many small-scale users.

The administration section shall be in charge of this function with the help of SLPA headquarters.

Chapter 12 Economic Analysis

12.1 Purpose of Economic Analysis

The purpose of the economic analysis is to appraise the economic feasibility of the Urgent Development Plan for the Port of Galle in the target year from the viewpoint of the national economy. The economic analysis is conducted to study the economic benefits as well as the economic costs arising from this project, and to evaluate whether the benefits of the project exceed those that could be obtained from other investment opportunities in Sri Lanka.

12.2 Methodology of Economic Analysis

Economic analysis is carried out according to the following method. The Urgent Development Plan ("With case") is be defined and it is compared to the "Without the project" case (hereinafter referred to as the "Without" case). All benefits and costs in market price of the difference between "With the project" case (hereinafter referred to as the "With" case) and "Without" case is calculated and it is converted to economic price. All benefits and costs are evaluated at economic prices.

In this study, the Net Present Value (NPV), the benefit/cost ratio (B/C ratio) and the economic internal rate of return (EIRR) based on a cost-benefit analysis are used to appraise the feasibility of the project. The EIRR is a discount rate, which makes the costs and the benefits of the project during the project life equal. The benefit/cost ratio is obtained by dividing the benefits by costs based on the present value. The procedure used for the economic analysis is shown in Figure 12.2.1.

12.3 Assumption for the Economic Analysis

(1) Base Year

The "Base Year" here means the standard year when we estimate of costs and benefits. In this study, the year of 2001 is set as the "Base Year". The construction period is assumed to be six years.

(2) Project Life

The period of calculation (project life) in the economic analysis is assumed to be thirty-five years from the starting year, taking the depreciation period of the main facilities into consideration.

(3) Foreign Exchange Rate

The exchange rate adopted for this analysis is US$ 1.00 = Rs. 79.00 and ¥1 = Rs. 0.75 (as of 23 June 2000), the same rate as used in the cost estimation.

(4) "With" Case

As a cost-benefit analysis is conducted on the difference between the "With" case and the "Without" case, it is important to define "With" case and "Without" case.

In an economic analysis, improvement and expansion in cargo handling capacity mainly bring about benefits. Therefore, the "With" case scenario includes improvements in productivity and expansion port facilities in the Urgent Development Plan.

(5) "Without" Case

No investment is made for the Urgent Development Plan. If this project will not be implemented, as the Port of Colombo will not have extra facility to handle the estimated cargo volume in the Port of Galle, new port facilities have to be constructed elsewhere. As Trincomalee Bay could be able to construct a port economically without breakwater and dredging works, the cargo is supposed to be handled at new berths of Trincomalee Port.

12.4 Economic Price

12.4.1 General

For the economic analysis, all prices must be expressed in economic prices, which means the international prices or border prices. Theoretically, the economic price is the opportunity cost of scarce resources. In general, the value of goods quoted at market price do not always represent the value of goods. The market prices often include transfer items, such as customs duties, subsidies, etc., which do not actually reflect any consumption of resources. Therefore, the market prices have to be converted into economic prices by eliminating these.

All costs and benefits will be classified into the following items. The economic prices of each item are calculated by multiplying the market prices by the conversion factor corresponding with each item.

(1) Tradable goods
(2) Non-tradable goods
(3) Labor
Labor is further classified into skilled labor and unskilled labor.

12.4.2 Conversion Factors

(1) Standard Conversion Factor (SCF)

Customs duties create a price difference between the domestic market and the international market. The SCF is used to determine the economic prices of non-tradable goods that have only market prices. The SCF is calculated by the following formula.

$$SCF = (I + E) / \{(I + Di) + (E - De)\}$$

Where, I: Total value of imports (CIF)
E: Total value of exports (FOB)

Di: Total value of import duties
De: Total value of exports duties

In this report, the recent trend of the SCF is shown in Table 12.4.1. There is clear tendency of increasing SCF. Therefore we adopt the averaged SCF (1995-1999) as the SCF instead of longer-term average.

(2) Conversion Factor for Consumption (CFC)

This conversion factor is used to convert the market prices of consumer goods into the border prices. The Conversion Factor for Consumption is usually calculated in the same manner as the standard Conversion Factor, replacing total imports and exports by total imports and exports of consumer goods. The CFC will be calculated by the following formula.

$$CFC = (Ic + Ec) / \{(Ic + Dic) + (Ec - Dec)\}$$

Where, Ic: Total value of consumer goods imports (CIF)
Ec: Total value of consumer goods exports (FOB)
Dic: Total Value of consumer goods import duties
Dec: Total values of consumer goods export duties

As exact statistics for these consumer goods are not available and the country import almost whole categories of consumer and industrial goods, we will substitute CFC with SCF, that is, 0.958.

(3) Conversion Factor for Skilled Labor (CFSL)

The cost of skilled labor is calculated based on actual market wages, assuming that the market mechanism is functioning properly. However, as the data are domestic prices or market prices, they should be converted to border prices by multiplying by the Conversion Factor for Consumption. The Conversion Factor for Skilled Labor (CFSL) is calculated by the following formula.

$$CFSL = \text{Opportunity cost of skilled labor / Actual market wages of skilled labor} \times CFC$$

Where, Opportunity cost of skilled labor / Actual market wages of skilled labor = 1
CFC: Conversion Factor for Consumption (0.958)

(4) Conversion Factor for Unskilled Labor (CFUL)

As the wage rate is controlled by a minimum wage system and other regulations despite the existence of a large amount of unskilled labor, the wage paid to unskilled labors by a project are generally above the opportunity cost. Hence, these wages should not be used for calculation of the economic value of the unskilled labors. Assuming that the inflow of unskilled labors to the project is mainly from agriculture sector, the marginal productivity of an unskilled labor is assumed equal to the per capita GDP of agriculture sector in Sri Lanka. Several appropriate statistics on national GDP give 0.45 to 0.61 as CFUL. Therefore we adopt 0.5 as CFUL.

12.5 Economic Benefits of the Project

12.5.1 Benefit Items

Considering above mentioned "With" and "Without" cases, we can envisage the following economic benefits from the urgent development program for the Port of Galle.

(1) The saving of land transportation cost
(2) The acceleration effect on the regional development of Southern Province
(3) Additional employment and income opportunity induced by the port construction and operation
(4) The additional value added induced by the increase of output in the port related industry and port-dependent industry

Among these four economic benefits, we can evaluate the saving of land transportation cost quantitatively. As for other three benefits, they are mentioned here qualitatively.

12.5.2 Calculation of Benefit

Land transport is carried out by road or by rail. Road transport is usually preferred over rail. In terms of tonkm, rail transport realized a share of only 4.1 % due to delay and unreliability. The tariff of road transport is highlighted in Table 12.5.1. Conversion Factor for tariff is estimated as 0.73 in World Bank Study and from general labor market condition. The land transportation cost in "Without Case" is estimated in Table 12.5.2

As for the cargo, which will be generated in the Southern Province, the estimated land transportation costs from Galle to Trincomalee (road distance 357 km) is assumed as the economic benefit. As for the cargo, which will be the overflow of the Port of Colombo, the economic benefit will be the difference of the estimated land transportation cost between from Colombo to Trincomalee and from Colombo to Galle.

12.6 Economic Costs of the Project

12.6.1 Construction Cost

Construction costs are divided into the categories of foreign currency portion and local currency portion consisting of skilled labor, unskilled labor and non-tradable material. The cost at market prices is converted to the cost at economic price using the conversion factor. Table 12.6.1 shows the construction cost in economic price and Table 12.6.2 shows annual breakdown of construction cost in economic price.

As for the economic construction cost, we have to compare "without case" and "with case". The Port of Trincomalee has calm bay and substantial depth, we need not construct breakwaters and dredging works is not required. Therefore, the cost for breakwaters and dreading works in Galle port construction is considered as the economic cost to be shared by the economic analysis for the Urgent Development Plan. The indirect construction costs such as consulting fee, preparation cost

and contingency etc. were allocated proportionally. Table 12.6.3 shows annual economic cost. In the table, "economic cost" means "the cost to be considered in economic analysis for the project".

12.6.2 Maintenance and Operation Costs

(1) Maintenance cost

As for the annual maintenance cost, the one-percent for civil engineering construction cost and four percent of equipment cost is assumed. Annual maintenance cost will be Rs. 64,930,781, which is same as in following financial analysis.

(2) Re-investment cost

The re-investment cost is not considered as economic cost for economic analysis as this is the common cost for both "without case" and "with case".

(3) Personnel and administration cost

Additional manpower requirement in the Port of Galle operation for the project is determined in this study as the personnel of three hundred and forty at the annual wage cost of Rs. 202,000 on average. The general and administrative cost is considered twenty percent of the personnel cost. The SCF (0.958) is applied on these the personnel and administrative cost. Annual personnel and administration cost at economic price will be Rs. 78,954,528.

(4) Total Maintenance and Operation Costs

Total maintenance and operation costs to be considered in the economic analysis will be Rs. 143,885,309 annually from 7^{th} year during whole operation life.

12.6.3 Total Cost

Total cost is the sum of construction cost and M&O (Maintenance and Operation) evaluated in the economic cost concept. It is shown for whole project life in Table 12.6.4 along with the NPV (Net Present Value), B/C ratio and EIRR.

12.7 Economic Evaluation of the Project

12.7.1 Calculation of the Net Present Value (NPV)

The Net Present Value is calculated by using the following formula.

$$NPV = \Sigma \ (Bi - Ci) / \{(1 + r)^{(i - 1)}\} \quad (i = 1 \text{ to } n)$$

Where, n: Period of economic calculation (project life = 35 years)
Bi: Benefit in i-th year
Ci: Cost in i-th year

r: the discount rate = 7.5 % (prevailing real interest rate at premium lending)

The result of the NPV estimation is shown at Table 12.6.4. It amounts to Rs. 8,113 Million at 2000 Price.

12.7.2 Calculation of the Benefit/Cost ratio (B/C ratio)

The benefit/cost ratio is obtained by dividing the economic benefit by the economic cost. The result of B/C Ratio is shown in Table 12.6.4 also. It is 2.52. The discount rate adopted for calculation of B/C is 7.5 percent, which is same as the one in NPV calculation.

12.7.3 Calculation of the EIRR

The economic internal rate of return (EIRR) based on a cost-benefit analysis is used to appraise the economic feasibility of the project. The EIRR is the discount rate, which makes the costs and benefits of a project life equal.

It is calculated by using the following formula.

$$\Sigma \ (Bi - Ci) / (1+r)^{(i - 1)} = 0 \ (i = 1 \text{ to } n)$$

Where, n: Period of economic calculation (project life = 35 years)
Bi: Benefits in i-th year
Ci: Costs in i-th year
r: discount rate

The result of EIRR estimation is shown in Table 12.6.4 too. The estimated EIRR is 17.32 %.

12.7.4 Sensitivity Analysis

In order to see whether the project is still feasible when some conditions changes, a sensitivity analysis is made for the following three alternatives.

Case A (Table 12.7.1): The construction cost increase by 10%
Case B (Table 12.7.2): The cargo volume decreases by 10%
Case C (Table 12.7.3): Both Case A and Case B occur simultaneously.

The result of the sensitivity analysis is as follows.

Case	NPV (M Rs.)	B/C Ratio	EIRR
Base Case	8,113	2.52	17.32%
Case A	7,696	2.34	16.29%
Case B	6,768	2.27	16.06%
Case C	6,351	2.10	15.08%

The overrun of the construction cost and the decrease of the cargo volume will not affect on the

project feasibility so much. Even the Case A and Case B occur simultaneously, the feasibility of the project is very stable in spite of unfavorable outcomes.

12.7.5 Conclusion

In general, it is said that a project with an EIRR of more than 10 % is economically feasible considering the opportunity cost of capital. As for this study, the estimated EIRR is 17.32% and EIRR for three alternatives are from 15% to 16%. Therefore, the proposed urgent development plan is considered to be feasible and recommendable from the viewpoint of national economy.

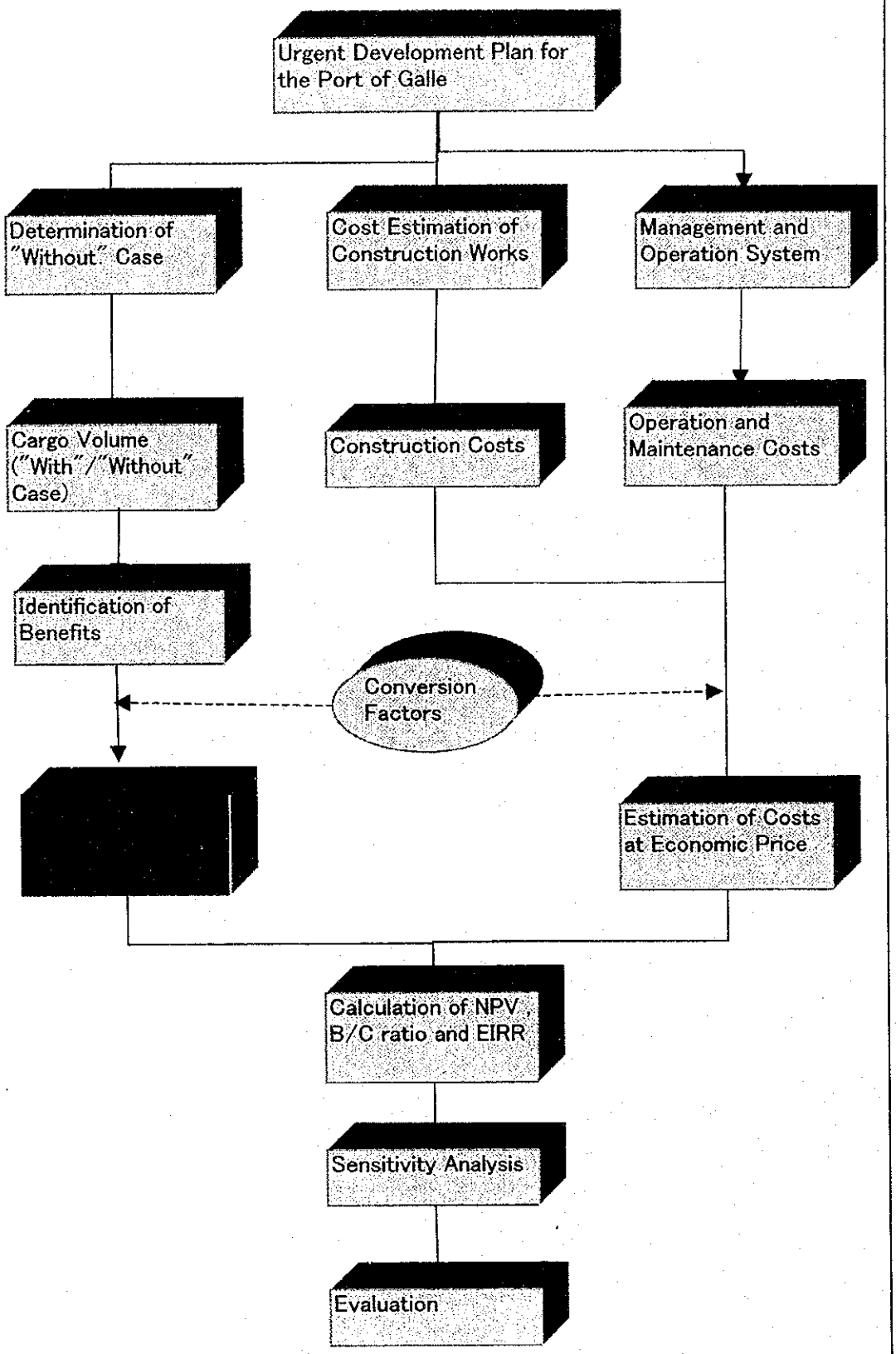


Figure 12.2.1 The Procedure of Economic Analysis

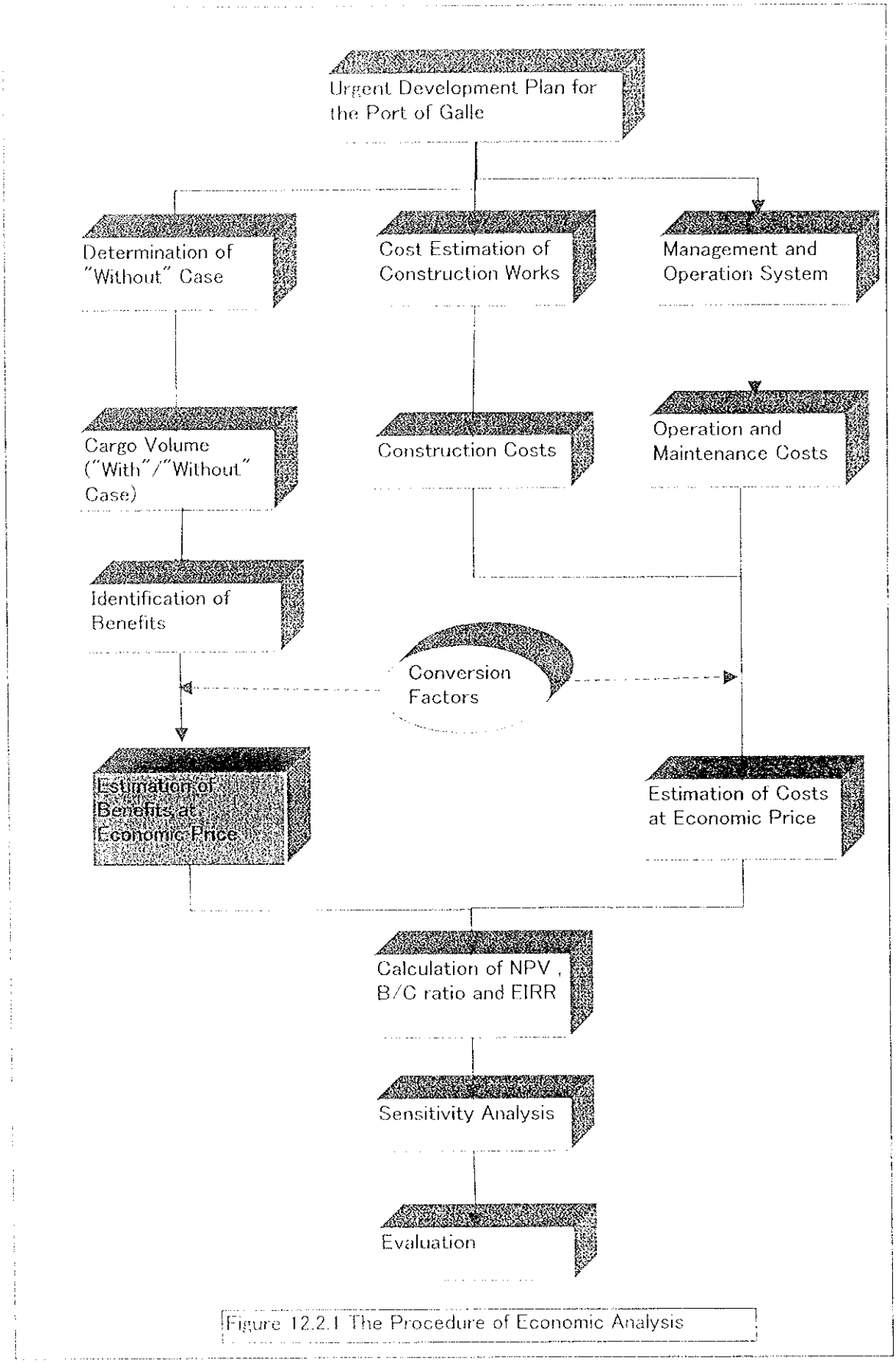


Figure 12.2.1 The Procedure of Economic Analysis

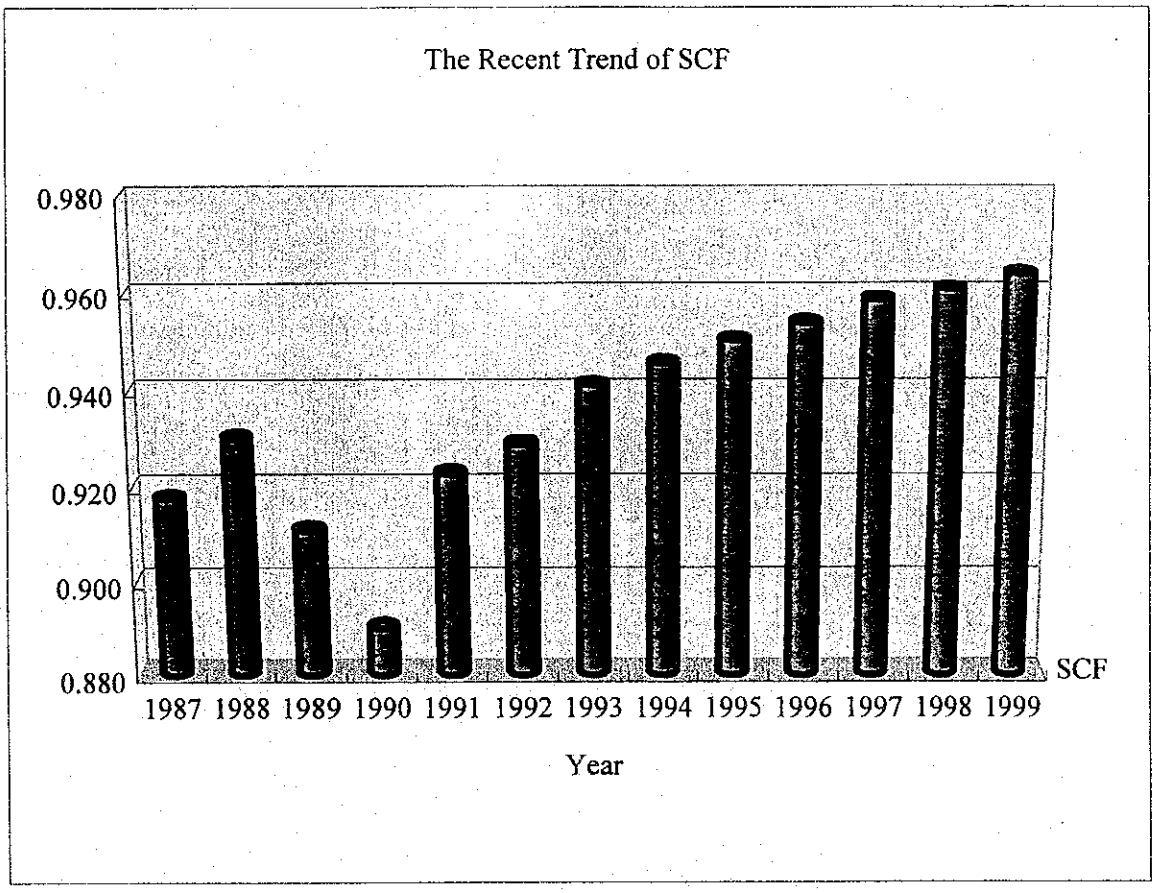
Table 12.4.1 The Recent Trend of Standard Conversion Factor (SCF)

(Million Rs.)

Year	Total Export	Total Import	Export Duties	Import Duties	SCF
1987	41,133	60,528	1,924	11,051	0.918
1988	46,928	71,030	1,830	10,671	0.930
1989	56,175	80,225	1,572	14,923	0.911
1990	7,633	107,728	2,549	16,792	0.890
1991	82,225	126,643	1,137	18,617	0.923
1992	107,885	153,555	821	20,819	0.929
1993	138,175	193,550	57	20,762	0.941
1994	158,554	235,576	0	22,598	0.946
1995	195,092	272,200	8	24,365	0.950
1996	226,801	301,076	5	25,458	0.954
1997	274,193	346,026	4	26,739	0.959
1998	310,398	380,138	0	28,154	0.961
1999	324453	416223	0	27720	0.964
2000			0	26874	

Source: Economic and Social Statistics of Sri Lanka (1999)
Central Bank of Sri Lanka

The Averaged SCF (1987-1999): 0.937
The Averaged SCF (1995-1999): 0.958



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The Recent Trend of SCF

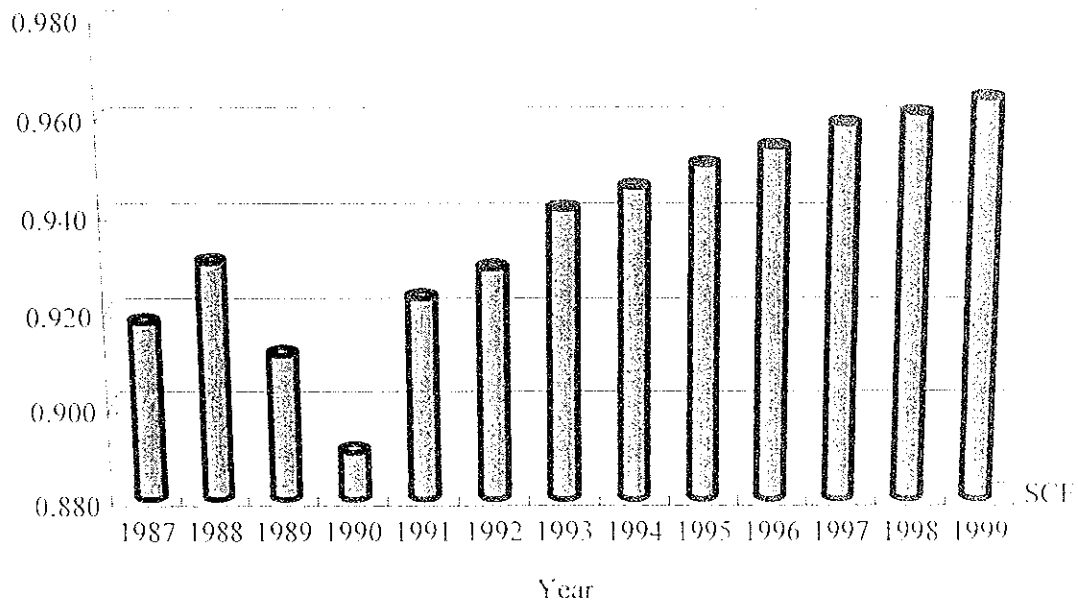

Table 12.5.1 Road Tariff

(Rs. per tonkm)

	Item	Market Price (1995)	Conversion Factor × 0.73	Economic Price (2000) ×1.60
1	bagged cement	2.10	1.53	2.45
2	bagged fertilizer	1.80	1.31	2.10
3	bagged suger	2.80	2.04	3.27
4	iron and steel	2.10	1.53	2.45
5	vehicles	2.80	2.04	3.27
6	clinker	2.10	1.53	2.45
7	gypsum	2.10	1.53	2.45
8	maize	1.95	1.42	2.28
9	containers	2.80	2.04	3.27

Source: Sri Lanka Transport Sector Strategy Study, March 1997, World Bank

Table 12.5.2 The Land Transportation Cost in "Without Case"

(1000 Rs., 2000 Price)

Year	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
General Cargos	667,023	775,264	889,604	991,375	1,099,616	1,284,494
Containers	411,044	435,460	459,877	484,294	508,711	533,127
Total	1,078,067	1,210,725	1,349,481	1,475,669	1,608,326	1,817,621

Colombo - Galle 116 Km,
Colombo - Trincomalee 257 Km,
Galle - Trincomalee 373 Km,

Table 12.6.1 The Construction Cost in Economic Price with Conversion Factor

(2000 Price)

	Description	Total Construction Cost		Foreign Portion	Local Portion	Local Portion					Total Cost	Total Construction Cost
		Market Price	Market Price	Market Price	Market Price					Economic Price	Economic Price	Economic Price
		1000 JPY	1000 Rs.			Skilled Labor	Unskilled Labor	Non-Tradable Material	Equipment			1000 Rs.
	Conversion Factor					0.958	0.500	0.958	0.958			
1	Mobilization/Demo.	620,399	465,299	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	465,299
2	Temporary Works	234,454	175,841	41.00%	59.00%	2.42%	1.16%	43.52%	11.90%	55.99%	96.99%	170,549
3	Dredging Works	344,847	258,635	90.00%	10.00%	0.81%	0.68%	7.59%	0.92%	9.27%	99.27%	256,743
4	Outer Breakwater	3,595,658	2,696,744	72.00%	28.00%	1.81%	1.40%	24.65%	1.14%	27.14%	99.14%	2,673,573
5	Inner Breakwater	1,358,852	1,019,139	74.00%	26.00%	1.60%	1.37%	21.68%	1.34%	24.27%	98.27%	1,001,518
6	Revetment (1)	781,758	586,319	74.00%	26.00%	1.24%	1.12%	22.58%	1.06%	24.40%	98.40%	576,908
7	Revetment (2)	351,042	263,282	72.00%	28.00%	1.16%	1.05%	24.56%	1.23%	26.34%	98.34%	258,919
8	Revetment (3)	180,318	135,239	69.00%	31.00%	1.37%	1.15%	27.23%	1.25%	29.17%	98.17%	132,765
9	Revetment (3)	318,208	238,656	69.00%	31.00%	1.37%	1.15%	27.23%	1.25%	29.17%	98.17%	234,292
10	Revetment (4)	280,406	210,305	59.00%	41.00%	3.51%	4.11%	28.18%	5.30%	37.49%	96.49%	202,926
11	Reclamation	1,042,144	781,608	74.00%	26.00%	1.25%	1.09%	17.81%	5.75%	24.31%	98.31%	768,422
12	-12.0m Berth	1,568,457	1,176,343	88.00%	12.00%	2.17%	2.10%	7.25%	0.49%	10.54%	98.54%	1,159,213
13	Navigation Aids	170,747	128,060	99.00%	1.00%	0.05%	0.05%	0.75%	0.15%	0.94%	99.94%	127,977
14	Road Pavement	305,747	229,310	35.00%	65.00%	2.45%	1.06%	46.63%	14.86%	61.78%	96.78%	221,937
15	Yard Pavement	496,277	372,208	46.00%	54.00%	3.34%	1.62%	38.88%	9.16%	50.03%	96.03%	357,439
16	Administration Building	77,818	58,364	83.00%	17.00%	2.31%	2.84%	10.13%	1.71%	14.98%	97.98%	57,182
17	Transit Shed	388,683	291,512	90.00%	10.00%	1.25%	1.92%	5.66%	1.17%	8.70%	98.70%	287,724
18	Maintenance Shop	32,117	24,088	83.00%	17.00%	3.02%	2.07%	9.64%	2.27%	15.34%	98.34%	23,687
19	Electrical Sub-Station	11,308	8,481	78.00%	22.00%	4.46%	4.78%	9.68%	3.08%	18.89%	96.89%	8,217
20	Water Tower	18,333	13,750	60.00%	40.00%	5.10%	5.91%	23.16%	5.82%	35.60%	95.60%	13,145
21	Gate Office	62,985	47,239	87.00%	13.00%	1.29%	1.98%	5.79%	3.95%	11.56%	98.56%	46,557
22	Utility (Electrical Works)	361,482	271,112	78.00%	22.00%	3.46%	4.48%	10.51%	3.59%	19.06%	97.06%	263,148
23	Utility (Mechanical Works)	40,905	30,679	73.00%	27.00%	2.50%	2.59%	17.99%	3.92%	24.68%	97.68%	29,967
24	Procurement of Equipment	800,000	600,000	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	600,000
25	Consulting Service	806,576	604,932	76.00%	24.00%	18.00%	4.00%	0.00%	0.00%	19.24%	95.24%	576,161
26	Contingency	1,288,294	966,221	75.00%	25.00%	1.20%	1.08%	21.70%	1.02%	23.46%	98.46%	951,296
	Total	15,537,815	11,653,361									11,465,565

Table 12.6.2 Annual Construction Cost in Economic Price

(1000Rs., 2000 Price)

	Description	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
1	Mobilization/Demo.	0	139,590	139,590	93,060	46,530	46,530	465,300
2	Temporary Works	0	153,494	0	0	0	17,055	170,549
3	Dredging Works	0	72,105	184,638	0	0	0	256,743
4	Outer Breakwater	0	858,101	1,379,169	409,333	0	0	2,646,604
5	Inner Breakwater	0	207,211	794,307	0	0	0	1,001,518
6	Revetment (1)	0	247,246	329,662	0	0	0	576,908
7	Revetment (2)	0	110,965	147,954	0	0	0	258,918
8	Revetment (3)	0	0	0	132,765	0	0	132,765
9	Revetment (3)	0	0	0	234,292	0	0	234,292
10	Revetment (4)	0	0	202,926	0	0	0	202,926
11	Reclamation	0	0	114,763	634,531	19,128	0	768,422
12	-12.0m Berth	0	0	579,607	463,685	115,921	0	1,159,213
13	Navigation Aids	0	0	0	0	127,977	0	127,977
14	Road Pavement	0	0	0	27,742	180,324	13,871	221,937
15	Yard Pavement	0	0	0	33,510	290,418	33,510	357,438
16	Administration Building	0	0	0	7,942	41,298	7,942	57,182
17	Transit Shed	0	0	0	95,908	182,225	9,591	287,724
18	Maintenance Shop	0	0	0	0	21,056	2,632	23,688
19	Electrical Sub-Station	0	0	0	0	8,217	0	8,217
20	Water Tower	0	0	0	0	13,145	0	13,145
21	Gate Office	0	0	0	34,917	11,639	0	46,556
22	Utility (Electrical Works)	0	0	0	73,097	160,813	29,239	263,148
23	Utility (Mechanical Works)	0	0	0	8,324	18,313	3,330	29,966
24	Procurement of Equipment	0	0	0	0	400,000	200,000	600,000
25	Consulting Service	144,040	86,424	115,232	115,232	86,424	28,808	576,161
26	Contingency	0	179,171	387,901	225,275	136,565	22,386	951,297
	Total	144,040	2,054,307	4,375,748	2,589,613	1,859,993	414,893	11,438,595

Table 12.6.3 The Economic Construcion Cost and Non-economic Construction Cost by Year

(M Rs., 2000 Price)

Year	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Economic Construction Cost (M Rs.)	60	1,417	2,764	492	0	0
Non-economic Cost (M Rs.)	84	637	1,612	2,098	1,860	415
Total	144	2,054	4,376	2,590	1,860	415

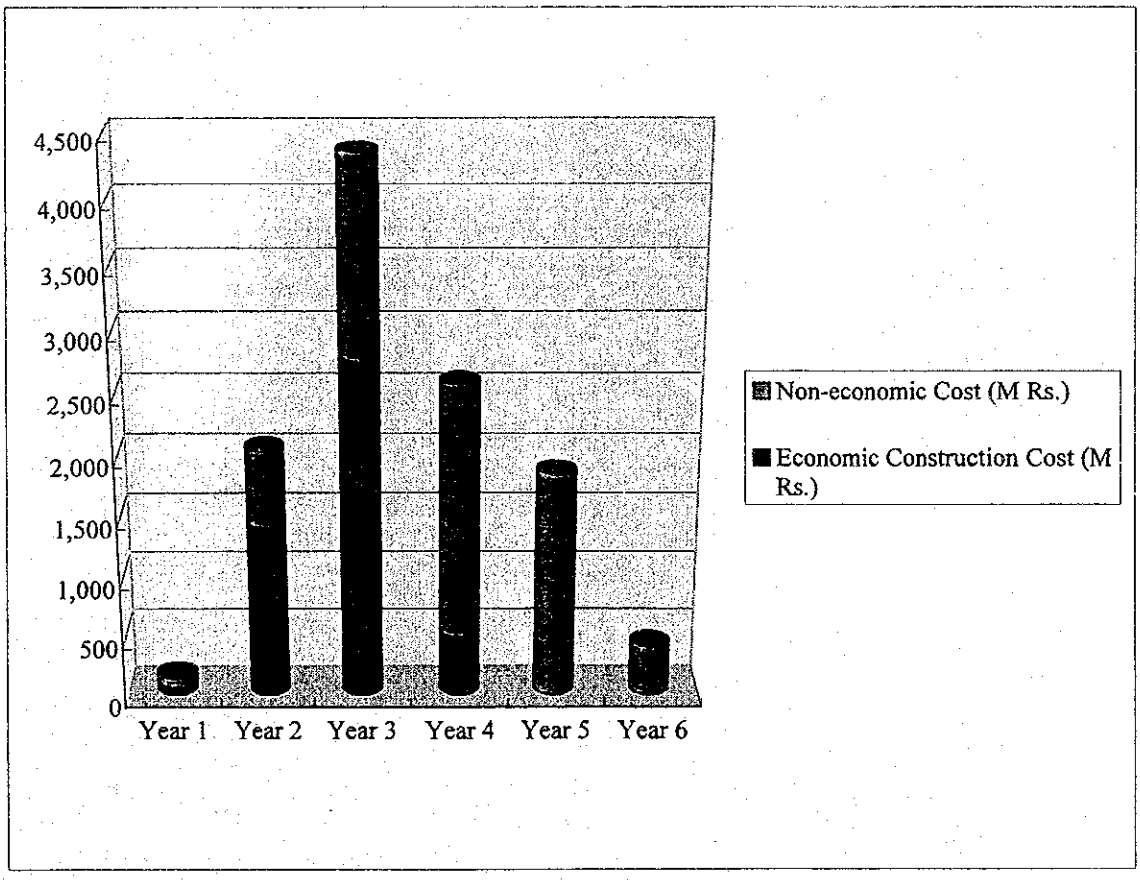

Table 12.6.4 The Estimated NPV, B/C and EIRR of Galle Port Project

(M Rs.,2000 Price)

Year	Benefit	Cost			Difference	Net Present Value (NPV)			EIRR
	Land Transportation Cost	Construction Cost	Maintenance Cost	Total Cost	Benefit - Cost	Benefit	Cost	Benefit - Cost	
1	0	60	0	60	-60	0	60	-60	
2	0	1,417	0	1,417	-1,417	0	1,318	-1,318	
3	0	2,764	0	2,764	-2,764	0	2,392	-2,392	
4	0	492	0	492	-492	0	396	-396	
5	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	
7	1,078		144	144	934	699	93	605	
8	1,211		144	144	1,067	730	87	643	
9	1,349		144	144	1,205	756	81	676	
10	1,476		144	144	1,332	770	75	695	
11	1,668		144	144	1,524	809	70	739	
12	1,818		144	144	1,674	821	65	756	
13	1,818		144	144	1,674	763	60	703	
14	1,818		144	144	1,674	710	56	654	
15	1,818		144	144	1,674	661	52	608	
16	1,818		144	144	1,674	614	49	566	
17	1,818		144	144	1,674	572	45	526	
18	1,818		144	144	1,674	532	42	490	
19	1,818		144	144	1,674	495	39	455	
20	1,818		144	144	1,674	460	36	424	
21	1,818		144	144	1,674	428	34	394	
22	1,818		144	144	1,674	398	32	367	
23	1,818		144	144	1,674	370	29	341	
24	1,818		144	144	1,674	345	27	317	
25	1,818		144	144	1,674	320	25	295	
26	1,818		144	144	1,674	298	24	275	
27	1,818		144	144	1,674	277	22	255	
28	1,818		144	144	1,674	258	20	238	
29	1,818		144	144	1,674	240	19	221	
30	1,818		144	144	1,674	223	18	206	
31	1,818		144	144	1,674	208	16	191	
32	1,818		144	144	1,674	193	15	178	
33	1,818		144	144	1,674	180	14	165	
34	1,818		144	144	1,674	167	13	154	
35	1,818		144	144	1,674	155	12	143	**17.32%**
Total						13,452	5,339	**8,113**	
						B/C=	**2.52**		