5.3.4 Approach channel and port basin

(1) Depth of approach channel and port basin

The required under keel clearance (UKC) and safety margins are schematically shown in Fig. - 5.3.4-1

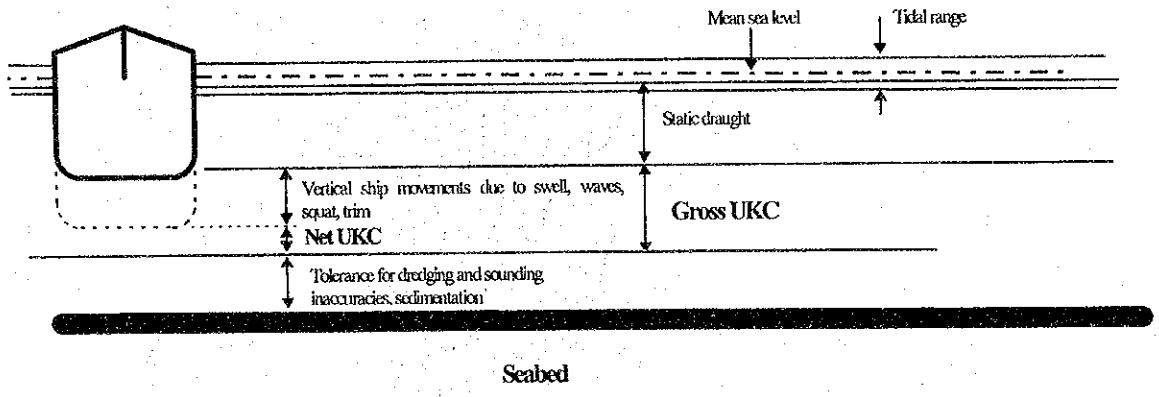


Fig. - 5.3.4-1 Definition of UKC

A necessary UKC by which contact with the seabed is prevented can be determined from the following factors:

a. resultant vertical movements of vessels due to swell and waves, i.e. pitching, rolling and heaving,
b. tendency of nearly parallel sinking with slight trim by the head known as squat, which appears under sailing shallow water,
c. accuracy of chart datum,
d. weather/sea conditions such as air pressure effect to the sea level (1cm/1hPa), a tidal level, a water density change, sedimentation/drift sand, and ground obstacles.

A proper quantity of UKC for safe sailing of a shallow channel is not obtained from a straightforward addition of the above factors. As regards to an open sea channel, the proper UKC shall not be less than the amount which enables the stable steering/maneuverability of the largest vessel expected preventing shallow water effect. At sheltered ports inside, however, vertical movements such as pitch/roll/squat would be negligibly small, thus the UKC shall be considered as the water between a quay and a vessel which allows the smooth flow of water when berthing.

Europe Maritime Pilot Association (EMPA) has made recommendations on the UKC of calling vessels at Rotterdam, Antwerp and Amsterdam as follows:

UKC at open sea passage	20 %	or more of the drift
" off port fairway	15 %	"
" at port inside	10 %	"

However, the updated criteria at Europort are, reportedly, reduced five percent from the above to cope with the increasingly large vessels that are now calling i.e.,

UKC at open sea passage	15 %	or more of the draft
" off port fairway	10 %	"
" at port inside	5 %	"

Also, UNCTAD's handbook, "Port Development Volume", lists three factors to be considered for planning channel depth i.e.,

The transit time of vessels along the channel, both with and against the tidal direction, and the relationship of these times to the tidal cycle;

a. The nature of the sea or riverbed which, if of soft silt, for instance, might lead to a decision to reduce the designed UKC for vessel using the channel;
b. The vessel draught: upon entering an approach channel, the load-line draught of the vessel is modified by such factors as water density changes, which may occur along the length of the channel, the effect of squat and of wave action causing pitch and roll of the vessel, and, mentioned as an example;

A general cargo vessel drawing nine meters at sea would squat 50 cm in narrow channel; pitching would require about a half the wave height in additional draught, and rolling somewhat less.

Thus, allowing 50 cm for UKC if the channel bed is soft, it might be assumed, for preliminary planning purposes, that a vessel drawing nine meters might require some 10.5 m of dredged depth in an approaching channel. A greater depth would be necessary where the channel bed was hard. As suggested above, a minimum clearance of one to one and a half meters might be taken as appropriate for most vessels.

Summing up, an appropriate UKC at the new N channel should be regarded as one and a half meters, and after completion of dredging up to -11 meters at the channel and -10.5 meters at the within port in 2005, then, the possible deepest draught of a vessel would be 9.5 meters.

(2) Width of channel

Channel width depends on the size of the largest vessel expected and the physical conditions of the site. As a typical example, illustrated in Fig. - 5.3.4-2 in a well marked channel, the total width of full-depth channel required for one-way traffic may be taken to comprise, on straight reaches, maneuvering lane of about twice the vessel beam, plus one-and-a-half times the beam for bank clearance each side.

At bends in the channel, greater width is required than on straight stretches because of the tendency of vessels to drift on turning. An additional width, depending upon the radius of curvature of the bend but approximately equal to the beam of each vessel, will be required in order to allow for the projected width of vessels negotiating the bend. This feature of projected width will also occur on straight reaches of channel subject to the action of cross-winds and currents, which also cause vessels to drift.

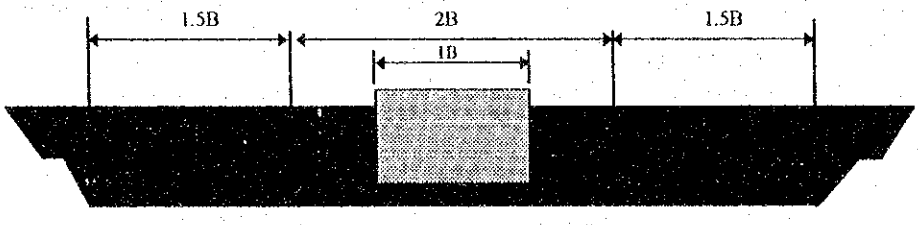


Fig. - 5.3.4-2 Typical width dimensions of channel for one-way traffic

Considering the traffic volume in 2005 together with the expense for channel creation, the new N channel might be planned as an one-way lane which could manage the average forecast number of calling vessels. And hence the appropriate width of the channel would be 150 m which is equivalent to about 5 times the beam of the largest vessel expected in 2015.

(3) Channel layout

The maneuverability of a vessel moving in a confined waterway of limited depth is impaired in two ways:

a. Because the vessel takes longer to respond to the helm, owing to the effects of shallow water; and
b. Because the proximity of the sides of the channel tends to cause the vessel to be drawn towards them.

This attraction or suction experienced by the vessel towards the sides of the channel also

applies between vessels when passing.

Where there are changes of direction in the alignment of a channel these limitations on vessel's maneuverability must therefore be taken into account. Referring to the layout of an approaching channel, UNCTAD's handbook, "Port Development Volume", recommends the following standards:

a. A channel should show as little curvature as possible. Curves should in particular be avoided near the harbor entrance, as this is nautically already a difficult point;
b. A single curve is better than a sequence of smaller curves; distance between curves should be at least 10 L;
c. Curve radius should be greater than or equal to 10 L, or in exceptional cases 5 L;
d. Cross currents should as much as possible be avoided. This applies even more to high cross-current gradients, for instance near the harbor entrance and in curves;
e. Anchorages (normal or emergency) should be provided along the length of the channel, of which the last one should be located close to the port entrance.

Complying with the above standards the new N approach channel for deep draft vessels should be planned from the channel between Rer. Dekcol (10° 38.1'N, 103° 27.1') and -7.5 m reef lying 850 m SE of Rer. Dekcol to the New Port entrance for about 6,000 m with a single curvature of 2,000 m radius, by which standards for expected calling vessels in 2015 would almost be met. The channel layout is schematically shown in Fig. - 5.3.4-3.

(4) Turning basin within the New Port

In the immediate approaches to berths, vessels usually have to make more complicated maneuvers than are necessary in the approach channel. Consequently, appropriately generous water areas must be provided and in most cases the assistance of a tug will be required.

The most basic of these maneuvers is turning the vessel. According to internationally accepted standards (UNDP's Port development handbook), the space required to turn a vessel is a circle with a diameter four times the ship's length where there is no assistance from tugs. Where assistance from tugs is available, a circle half this size is adequate. These are average figures and the actual area needed will depend, in addition, on wind, wave and current conditions in any particular case. The existing turning basin in the New Port should therefore be expanded for the future coming vessels to a circle with a diameter of 600 m and a depth of -10.5 m.

(5) Backup services for calling vessels operation

A remarkable increase of the calling vessels in both number and size has been forecast in the target year 2005/2015, and the vessel traffic will rise about 1.1 to 2.3 times over that of the present condition accordingly. And hence, increasing the number of pilot, reinforcing the tug

fleet , and updating the port traffic regulations would be the essential countermeasures to cope with the coming situation.

a. Additional pilots

Considering that the existing compulsory pilotage should be followed, and the working conditions in terms of service frequency of each pilot will be the same as heretofore, the regular staff of pilots will have to be increased as follows:

Year	No. of vessel	Frequency of piloting	No. of pilots	Frequency/ pilot
1995	606	1,192	6	199
2005	688	1,376	7	200
2015	1,382	2,764	11	250

For the Port Authority's information, piloting staffs at similar and representative ports in Japan are listed below:

Port	No. of vessel	Frequency of piloting	No. of pilots	Frequency/ pilot
Kushiro	-	900	3	300
Tomakomai	-	1,400	5	280
Muroran	-	1,000	3	333
Sendai	-	1,450	5	290
Onahama	-	1,000	3	333
Kashima	-	2,550	8	318
Tokyo	-	8,000	16	500
Niigata	-	1,200	6	200
Shimizu	-	3,000	6	500
Isewan	-	15,000	38	394
Wakayama	-	1,500	6	250
Hakata	-	2,000	5	400
Shimabara	-	1,250	4	313
Entire Japan ports		**216,518**	**709**	**305**

Source: Japan Pilot Association, 1991

The selection and training of a qualified candidate would require a certain period of time, and hence the authority should commence the necessary steps at an adequate time based on a-pre-estimated need for the additional pilots, which could be concluded from the forecast whole service frequency divided by a proper per capita of between annual 200 and 300.

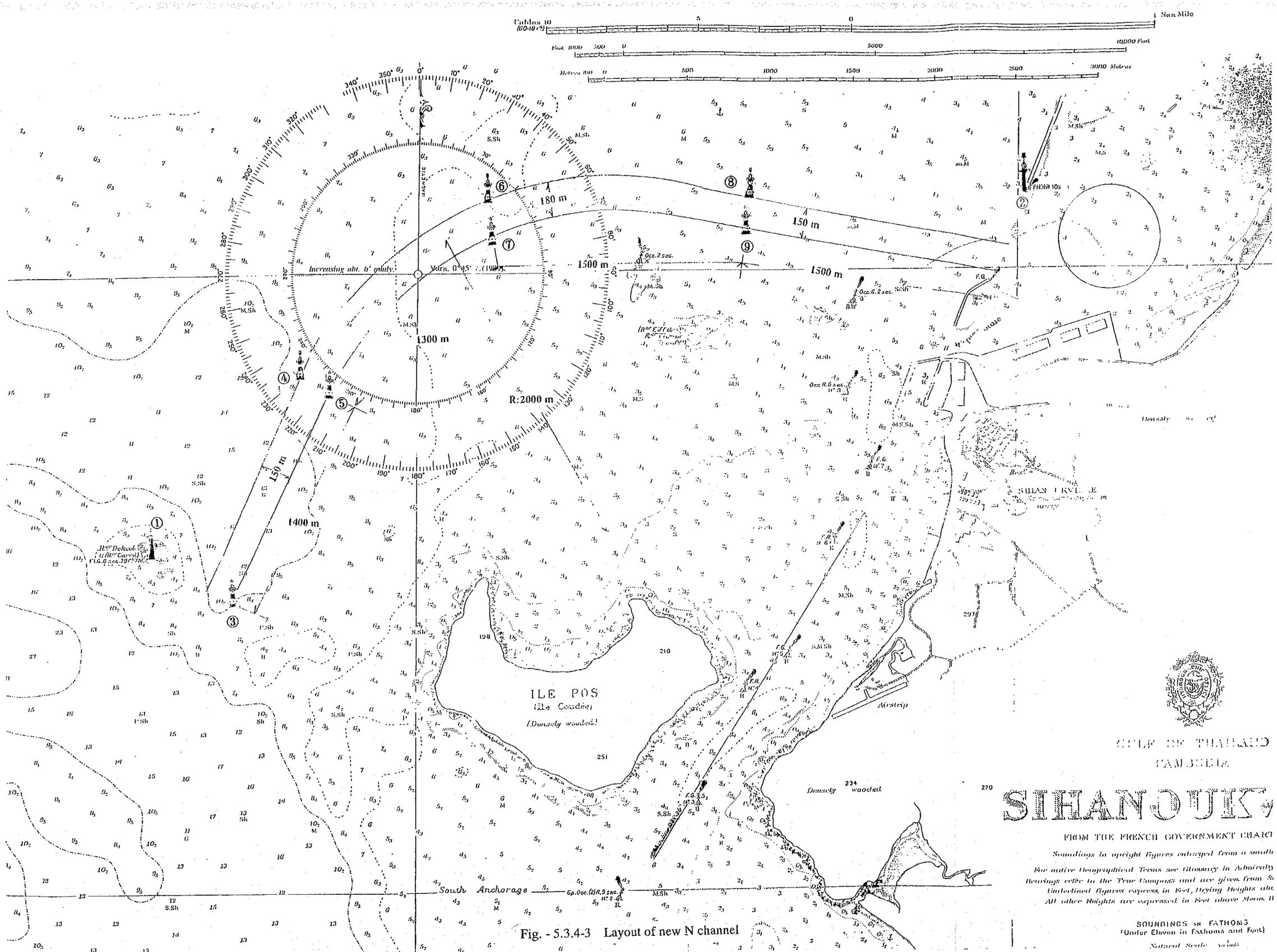


Fig. - 5.3.4-3 Layout of new N channel

b. Reinforcement of tug fleet

The ocean going vessel that reduces her speed under several knots in approaching a berth, normally loses almost all of her rudder function, consequently, the assistance of tug boat(s) is indispensable for turning/berthing the vessel. In addition, the natural features at Sihanoukville Port should be taken in account, i.e., the turning basin of the New Port lies in close proximity to the breakwaters entrance, and the access from the S channel to the New Port bends sharply off the entrance without enough maneuvering area (see Fig. - 5.3.4-3).

A proper number of capable tug boats should thus be provided to secure sound and smooth flow of the calling vessels, especially as the number of vessels is forecast to increase.

1) Required number of tug boats

The number will be assumed from the following factors :

A; total objective mother vessels in the target year (2005, 2015) ;

B; average required tug boat(s) per operation (berthing/unberthing) ;

C; required total tug boat operations in the target year ; A x B

D; average frequency of tug operations per day ; C÷365

E; average frequency per day per boat ; D÷G

F; the ratio of tugs' workdays per year (excluding docking and running repairs) ; 330/365

G; required tug boats in the target year ; C÷E÷F

H; required replacement for over 30 years aged boat(s) ;

I ; required new boat(s) ; G+H−3

Table - 5.3.4-1 Required new tug boats

Year	A	B	C	D	E	F	G	H	I
1995	1,192	1.4	1,706	4.7	1.6	n.a.	3	0	**0**
2000-M	1,488	1.5	2,232	6.1	2.3	330/365	3	2	**2**
2005-H	1,602	1.5	2,403	6.6	2.4	330/365	3	2	**2**
2005-M	1,376	1.5	2,064	5.7	2.1	330/365	3	2	**2**
2005-L	944	1.5	1,416	3.9	1.4	330/365	3	2	**2**
2015-H	3,154	1.6	5,046	13.8	3.1	330/365	5	1	**3**
2015-M	2,764	1.6	4,422	12.1	3.4	330/365	4	1	**2**
2015-L	2,144	1.6	3,430	9.4	3.5	330/365	3	1	**1**

2) Required output of tug boats

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. - 5.3.4-4

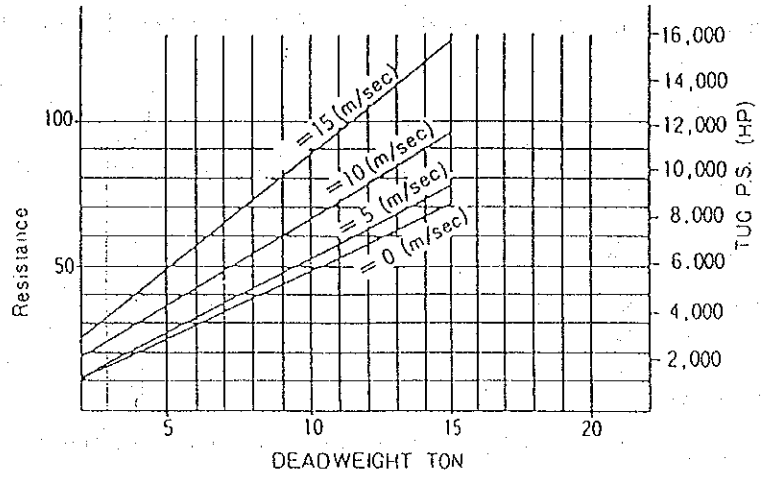


Fig. - 5.3.4-4 Necessary tug boat(s) thrust against vessel's DWT and winds

According to the above figure, as an example, the assisting maneuver for a 24,000 dwt mother vessel under against wind of 10 m/s requires a total of 2,400 ps tug power (2 tugs 1,200 ps each). Another effective formula which requires eight to ten (8 - 10) % of an objective vessel's dwt is in practical use.

The vessels which require tug assistance are not only large mother vessels but are inclusive of some medium or small vessels as 10,000 to 3,000 dwt, and hence powerful tugs are not needed at all times. With reference to this, an example of the tug fleet composition in major ports in Japan is as follows,

PS	No.	%
200 - 1,200	**16**	**5.9**
1,200 - 2,200	**36**	**13.2**
2,200 - 3,200	120	44.1
3,200 over	100	36.8
Total	272	100

Summing up, tug boats should thus be provided, X in 2005 and Y in 2015, each fleet consisting of 800 to 1,000 ps for small/medium mother vessels and 1,200 to 1,500 ps for large vessels. The desired ratio of the former and the latter would be one to two. In addition, it is recommended to replace the existing propulsion devices with a rudder propeller system known as Z

propeller which is widely employed for harbor tug boats for high maneuverability, reliability and powerful performance.

3) Updating port traffic regulations

The revisions of the existing regulations should set new standards to cope with the coming situation in the following points, in particular:

- definition of the Port area, the North Channel, the South Channel, the Designated Anchorage, the Large Vessel and the Other Vessel,
- prior notification of arrival/departure at a special time with certain information of a vessel,
- designation of the sailing channel and the berth,
- priority of the vessels sailing in the channels,
- priority of the large vessel sailing over the other vessel,
- restrictions to cross, overtake, parallel proceed and anchor in the channels,
- maximum speed limitation in specified port area,
- priority of departing vessels in possible meeting at the breakwater entrance,
- other necessary sailing regulations than The International Regulations for Preventing Collision at Sea, and;
- preservation of the environment of the port area.

(6) Comparison of dredging volume of navigation channel

For the purpose of comparative study, two (2) navigation channel alignments of South and North Channels were determined as shown in Fig. - 5.3.4-5. A comparison of dredging volume between the two Channels were made among several dredging depths. For volume estimation purpose, an average allowance of dredging depth of 0.30 m was added to the individual nominal dredging depth. As shown in Fig. - 5.3.4-5, a 1:5 slope (one vertical and 5 horizontal components) was considered at both sides of the navigation channel. As summarized in said Figure, the dredging volume of North Channel is larger than that for the South Channel when the water depth is shallower than -9.0m. The dredging volume is, however, reversed by water depth of -11m, thus the North Cannel will be less on volume than that of the South Cannel. In addition to this result, the seismic survey indicated that an encounter with the rock layer at South Channel area is obvious. The dredging volume of rock layer for South Channel was estimated based on the seismic survey result to be 213 thousand Cu. m. Contrary to expectations, the rock layer of North Channel area is much deeper and the possibility of the existence of the rock layer above -12 m is small. Considering the above conditions, it could be concluded that the North Channel is more feasible than South Channel, cost-wise.

(7) Siltation of navigation channel

As described in Section 2.5.1, prevailing current direction at the proposed navigation channel area is in the north-south direction which crosses perpendicularly to the proposed North Channel, and, therefore, siltation of the navigation channel is anticipated. To determine the volume and duration of the siltation, a simulation study was made for North Channel as shown hereunder.

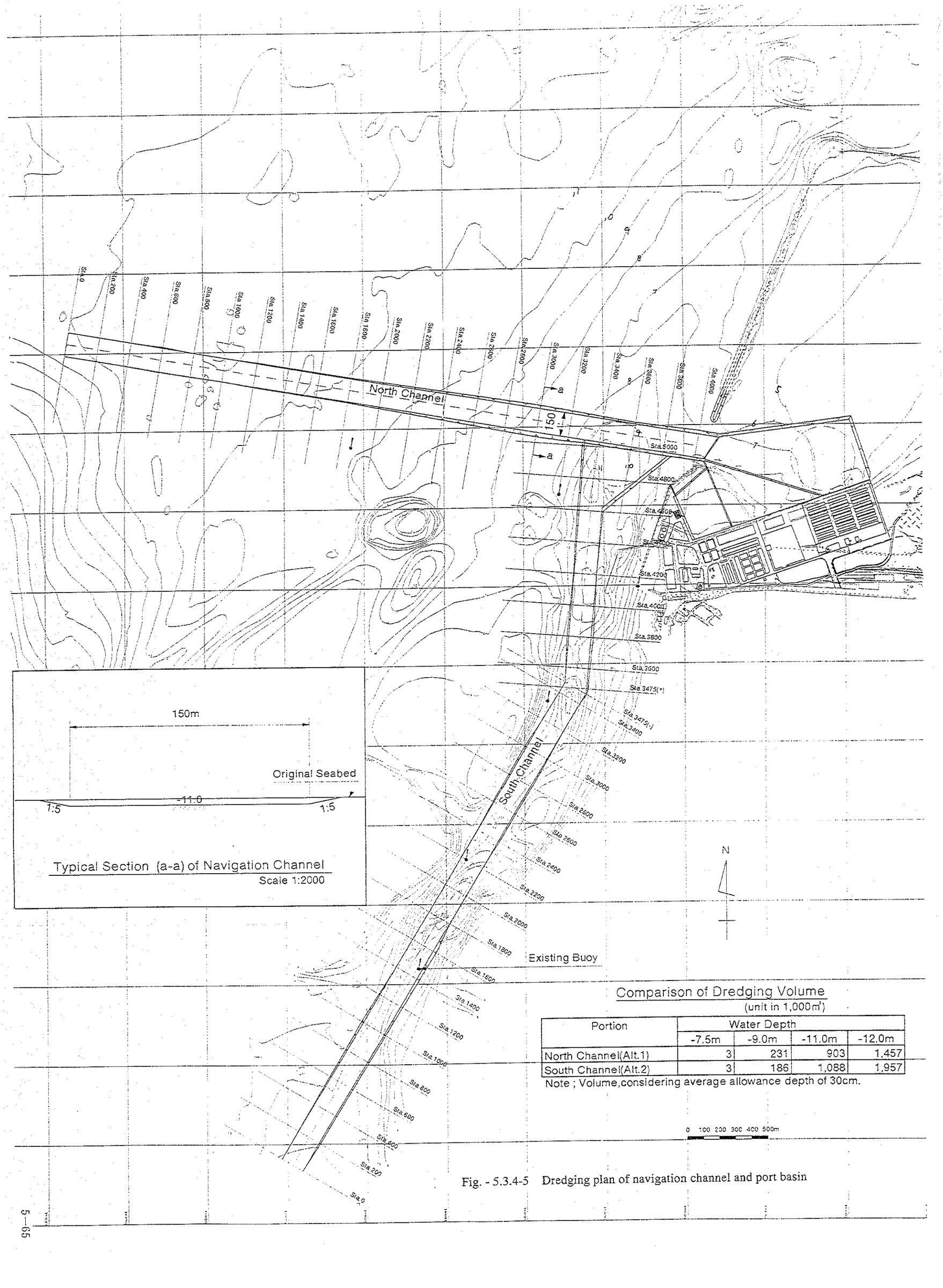
At first, a harmonic analysis on the current survey data taken at Survey Point C-2 was made. The result is summarized in Fig. - 5.3.4-6. By using this result a simulation on the sea-bed soil sedimentation was made for each year of the duration of five (5) years. Fig. - 5.3.4-7 shows the result of simulation i.e. the change of sea-bed depth in the vicinity of the navigation channel. Based on this study, the total volume of siltation for five (5) years along the North Channel with approx. length of 4 km was estimated to be 8×10^4 Cu.m.

(8) Dredged soil disposal

The dredged soil is scheduled to be disposed at the off-shore dumping area. A study is made in a separate volume.

(9) Breakwater

In order to shelter the port basin from the waves as hindcasted in Section 5.3.2, a 200 m long breakwater was considered. The section of the breakwater is determined as against the wave conditions given in the said Section and to be of similar cross section with existing breakwater as shown in Fig. - 5.3.4-8. For the purpose of the cost estimation, a settlement of the seabed soil of 1 m was considered.



Comparison of Dredging Volume

(unit in 1,000m³)

Portion	Water Depth			
	-7.5m	-9.0m	-11.0m	-12.0m
North Channel(Alt.1)	3	231	903	1,457
South Channel(Alt.2)	3	186	1,088	1,957

Note ; Volume,considering average allowance depth of 30cm.

Fig. - 5.3.4-5 Dredging plan of navigation channel and port basin

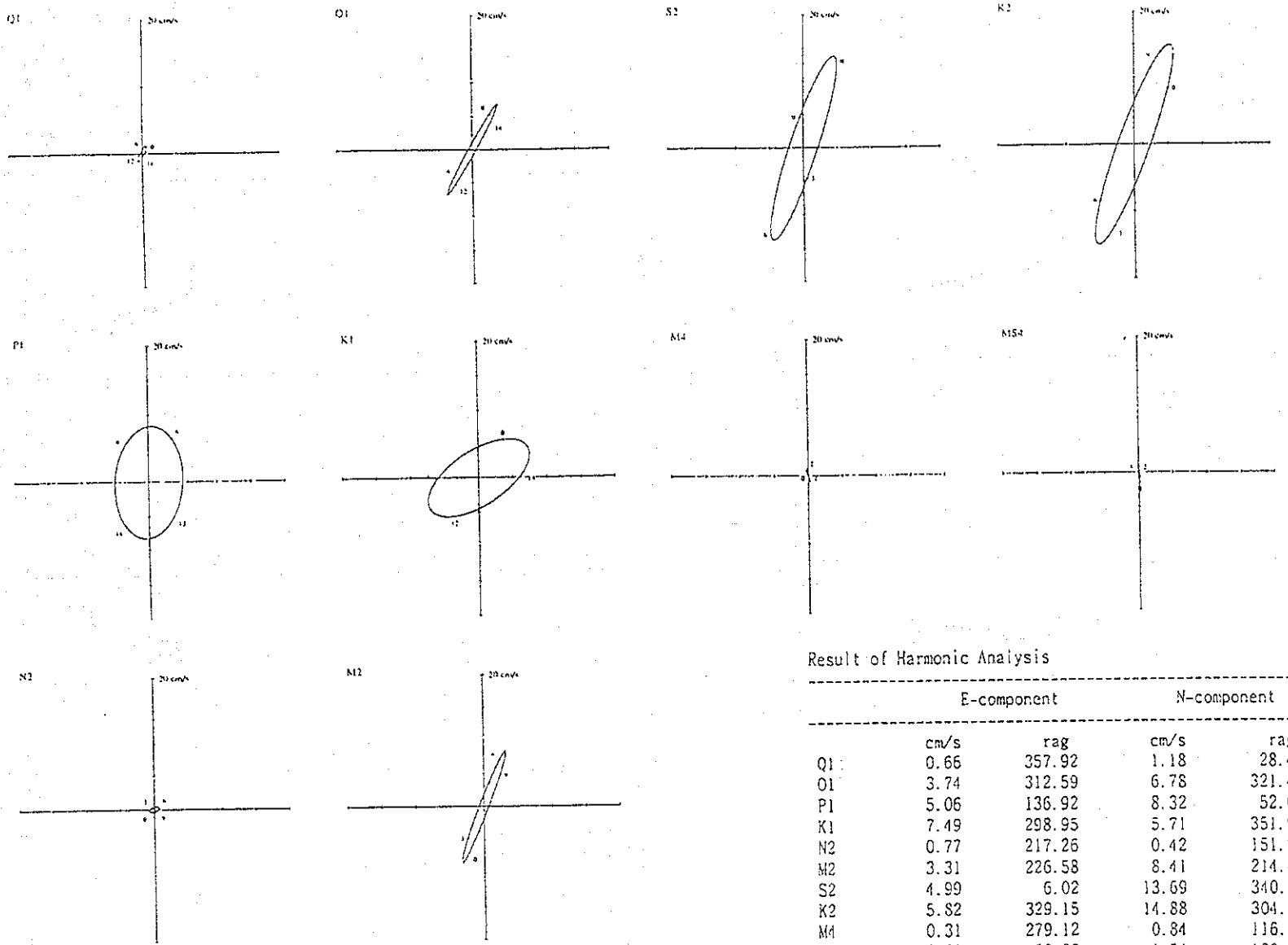
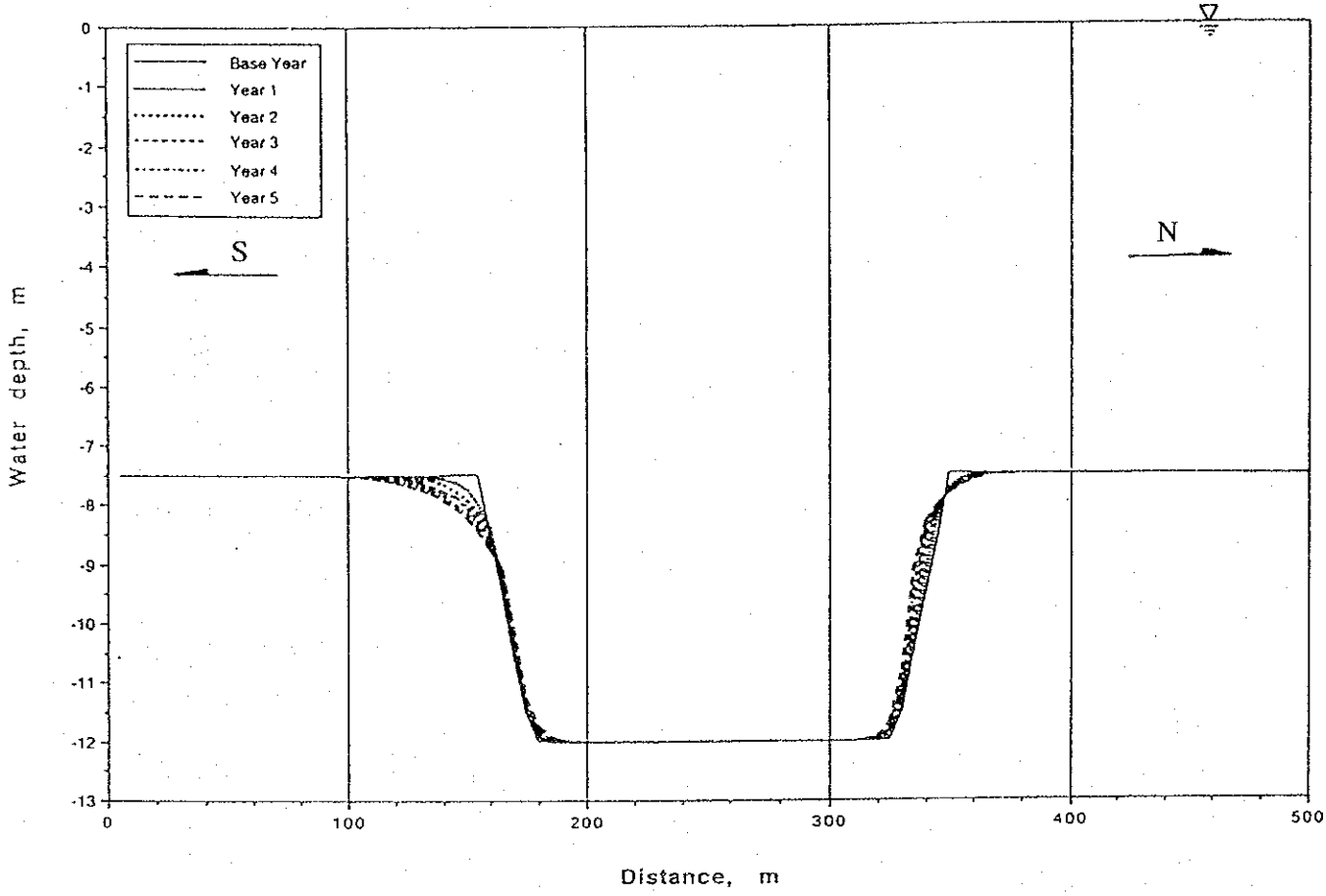


Fig.-5.3.4-6 Harmonic analysis of current survey

Result of Harmonic Analysis

	E-component		N-component	
	cm/s	rag	cm/s	rag
Q1	0.66	357.92	1.18	28.48
O1	3.74	312.59	6.78	321.47
P1	5.06	136.92	8.32	52.00
K1	7.49	298.95	5.71	351.98
N2	0.77	217.26	0.42	151.29
M2	3.31	226.58	8.41	214.41
S2	4.99	6.02	13.69	340.34
K2	5.82	329.15	14.88	304.07
M4	0.31	279.12	0.84	116.64
MS4	0.22	50.83	1.54	180.41
S0	-1.25		-3.93	



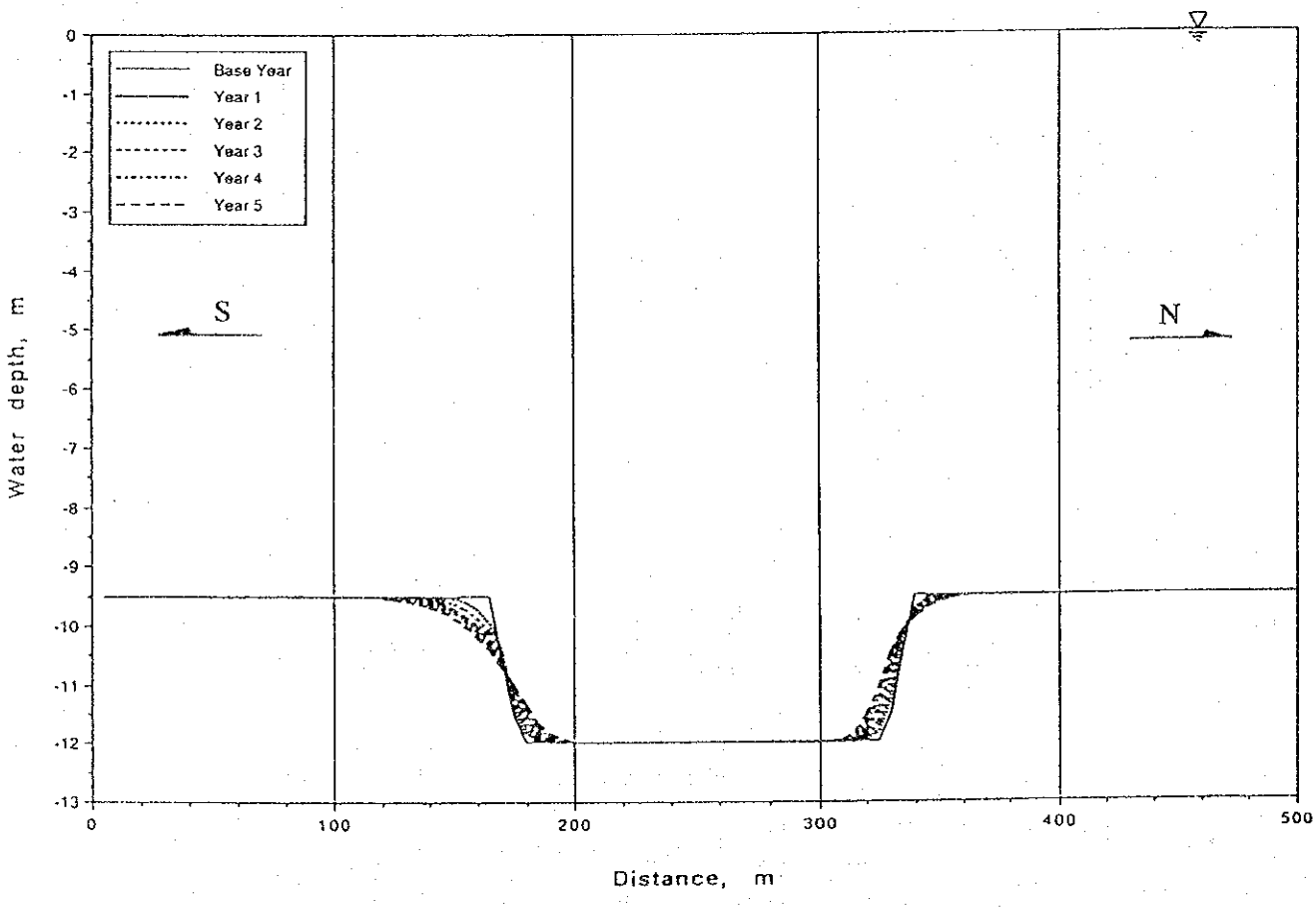
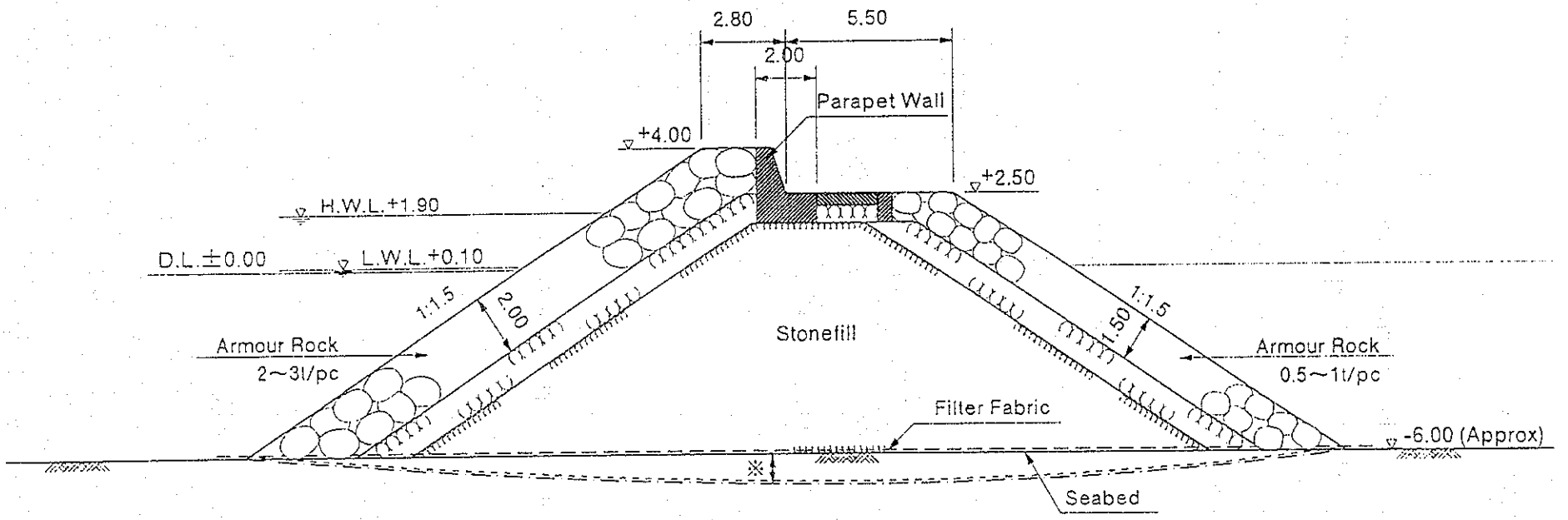


Fig.-5.3.4-7 Simulation on siltation activity of navigation channel



※Presumed Settlement : Aprox 1m

Fig.-5.3.4-8 Typical section of breakwater

S=1/200m

5.3.5 Planning of cargo handling and storage facilities

(1) General cargo handling

The size of cargo handling and storage facilities including the storage yard, transit shed and warehouse has to be decided taking account of the types, quantities of cargoes and the conditions of handling.

According to the demand forecast for the target year of 2015, the volumes of general cargoes through the transit shed and open storage yard area of each case (high, middle and low) are estimated as shown in Table - 5.3.5-1.

Table - 5.3.5-1 Volume of cargoes passing through transit shed and open storage yard in 2015

Commodities	Volume of Cargo (tons)	(tons)		
		Open Storage	Transit Shed	Sub-total
General Cargoes	255,000	25,500	229,500	255,000
Rice	113,000		113,000	113,000
Sugar	322,000		322,000	322,000
Steel Products	250,500	250,500		250,500
Wood Products	39,300	7,860	31,440	39,300
Total (High Case)	979,800	283,860	695,940	979,800
Total (Middle Case)	869,000	247,020	621,980	869,000
Total (Low Case)	703,800	193,110	510,690	703,800

a. Transit shed and open storage yard

The necessary area of the transit shed and open storage yard is determined by the following formula:

$$A = (N \times p / R \times a \times W) / B$$

where, A: Necessary area of transit shed (m2)

N: Annual volume of cargoes handled

R: Turnover of transit shed

a: Utilization rate: 0.5

W: Volume of cargoes per unit area (tons/m2)

P: Peak ratio: 1.3

B: Efficiency storage rate: 0.75

The result of the required size of the transit shed and open storage yard of each case is shown in the following table.

Table - 5.3.5-2 Required size of the transit shed and open storage yard

Volume of Cargo Handled (N) (tons)	Annual Storage Volume R x a x W (tons/m2)			Required Area (N x P / R x a x W) /B (m2)
Transit Shed				
General Cargoes 229,500	122	0.5	2.5	2,609
Rice 113,000	122	0.5	2.5	1,284
Sugar 322,000	122	0.5	2.5	3,660
Wood Products 31,400	37	0.5	1.2	2,452
Total (High Case) 695,900				10,004
Open Storage				
General Cargoes 25,500	122	0.5	2.0	362
Steel Products 250,500	37	0.5	2.0	11,735
Wood Products 7,860	37	0.5	1.2	614
Total (High Case) 283,860				12,711
Total Transit Shed (Middle Case) 621,980				9,044
Total Open Storage (Middle Case) 247,020				#REF!
Total Transit Shed (Low Case) 510,690				7,667
Total Open Storage (low Case) 193,110				#REF!

b. Planning of silo and tank

In planning, the following conditions are set:

1) Cement silo

- The volume of cement through silo in 2015 is 519,000 tons (high case), 454,000 tons (middle case) and 360,100 tons (low case).
- The turnover rate of silos is 20 times.

The silo capacity required in 2015 is calculated to be 25,000 tons (high case), 23,000 tons (middle case) and 18,000 tons (low case).

2) Bitumen tank

- The volume of bitumen through tank of each case in 2015 is 186,200 tons (high case), 162,600 tons (middle case) and 128,200 tons (low case).
- The turnover rate of tank is 20 times.

The tank capacity required in 2015 is calculated to be 9,000 tons (high case), 8,000 tons (middle case) and 6,000 tons (low case).

c. Port traffic facilities

An access road and inner port road connecting to the national road are proposed for the smooth distribution of port traffic generated at the wharves.

1) Determination of traffic volume

The volume of traffic generated at a port is determined by the following formula:

$$\mathbf{T = N \times a / W \times m / 12 \times d / 30 \times (1 + v) / t \times h}$$

where, T: Proposed traffic volume (cars/hour)
N: Annual volume of cargoes handled (t/year)
a: Share of automobile = 1.0
W: Average tonnage/truck
m: Monthly rate of variation = 1.0
d: Daily rate of variation = 1.5
v: Rate of related vehicles = 0.5
t: Rate of loaded truck = 0.5
h: Rate of hourly variation = 0.1

Table - 5.3.5-3 shows generated traffic volume by wharf. Daily port generated traffic volume is 4,600 cars (high case), 4,100 cars (middle case) and 3,300 cars (low case), respectively.

2) Size of parking lot

The required area for parking lots is estimated based on the following formula:

$$\mathbf{A = a \times n \times c \times b}$$

where, a: Required area per vehicle : 30 m^2/car
n: Number of vehicles
c: Rate of concentration (0.8)
b: Rate of fluctuation (1.0)

The maximum number of vehicles of each case is mentioned below, and the area of the parking lot is calculated as follows:

Table - 5.3.5-3 Generated traffic volume in 2015

Type	Cargo Volume (ton)	Cargo weight of loaded (ton/car)	Hourly generated traffic volume (car/hour)
Genral Cargo	255,000	8.0	40
Rice	113,000	8.0	18
Sugar	322,000	8.0	50
Steel products	250,500	8.0	39
Wood product	39,300	8.0	6
Machinery	217,000	1.45	187
Fertilizer	263,000	12.0	27
Cement	519,000	10.5	62
Bitumen	186,200	8.0	29
Total (High Case)	2,165,000		458
Total (MiddleCase)	1,937,000		409
Total (Low Case)	1,597,500		327

High case A: 30 x 462 x 0.8 x 1.0 = 11,000 m^2

Middle case A: 30 x 409 x 0.8 x 1.0 = 10,000 m^2

Low case A: 30 x 327 x 0.8 x 1.0 = 8,000 m^2

(2) Container handling

a. Container handling system

There are many handling methods at container terminals throughout the world including chassis system, straddle carrier system, transfer crane system and others as shown in Fig. - 5.3.5-1.

The most suitable handling system for the terminal will be selected. The items to be considered are as follows:

- Land utilization
- Height of stack
- Efficiency of container crane
- Working hour for taking in/out container
- Damage ratio of container
- Required skill of driver
- Term for training of driver
- Maintenance cost

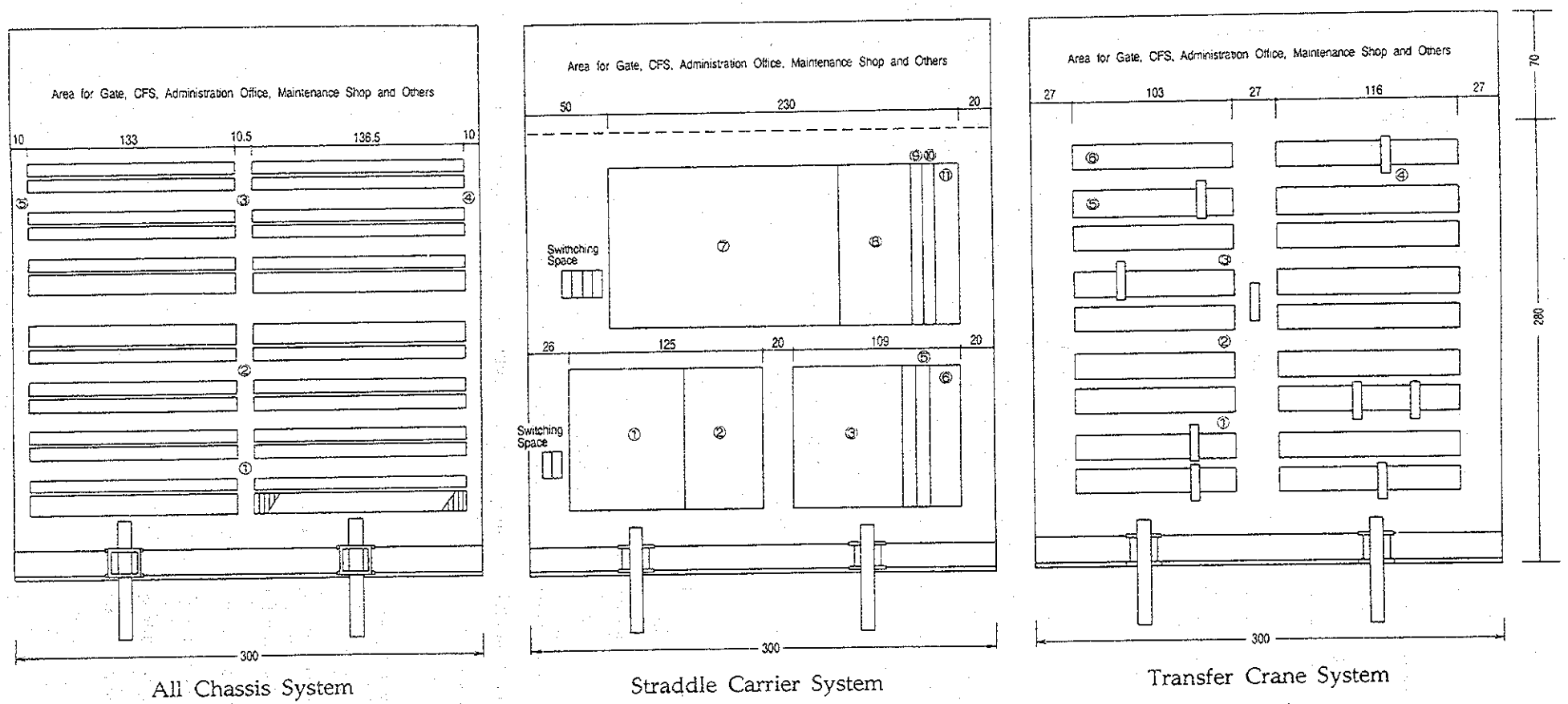


Fig. - 5.3.5-1 Preliminary layout plan for each alternative

- Running cost
- Required skill for repair
- Amount of investment (machinery)
- Amount of investment (container yard)
- Scale of repair shop
- Experience of handling
- Automation of operation

The results of the comparison of handling systems are as shown in Table - 5.3.5-4.

Table - 5.3.5-4 Comparison of handling systems

	Chassis system	Straddle carrier system	Transfer crane system
(a) Land utilization	large	medium	small
(b) Height of stack	low	medium	high
(c) Efficiency of container crane	low	high	long
(d) Working hour for taking in/out container	short	medium	long
(e) Damage ratio of container	low	high	medium
(f) Required skill of driver	low	high	medium
(g) Term for training of driver	none	long	medium
(h) Maintenance cost	small	large	medium
(i) Running cost	low	high	medium
(j) Required skill for repair	low	high	medium
(k) Amount of investment (machinery)	medium	small	large
(l) Amount of investment (container yard)	medium	large	medium
(m) Scale of repair shop	small	large	-
(n) Experience of handling	none	none	yes
(o) Automation of operation	low	medium	high

As can be seen from the foregoing comparison considering the actual circumstances at Sihanoukville Port, in selecting these systems, it is important to consider the condition of cost factors (initial, running and maintenance) and ordinary operation.

Transfer crane system is superior from the view-point of cost and operation and recommended to be adopted in the target year of 2015.

b. Computer system

1) Outline of computerization

At Sihanoukville Port, the container handling operation is managed by inventory card and computer-based container terminal operation has not yet started.

Computerized yard location planning and stowage planning are both popular in many container terminals in different parts of the world. From the historical view, the degree and extent of computerization has generally been as shown in Table - 5.3.5-5.

Table - 5.3.5-5 Degree and extent of computerization

	Approximate annual	Terminal office	Yard opreation
Level 1	-60000TEUs	manual	manual
Level 2	60000-150000TEUs	computerized	manual
Level 3	150000TEUs-	computerized	computerized

Almost all the container terminals in the world have reached Level-2. Some in Europe, USA and Japan have been procceding toward Level-3. The annual container handling volume at Sihanoukville Port has reached Level-1.

2) Introduction of computerized container operation system

As mentioned above, Sihanoukville Port should introduce a computerized container operation system. Since it will be difficult to quickly introduce the total computer system mentioned below, it will thus be necessary to start with a small scale computer system in the near future, which has the following functions:

- Promoting the stacking plan.

- Determining container storage positions.
- Determining re-handling when unloading containers.
- Promoting the shift plan in the yard.
- Promoting the sequence plan of ship loading/discharging.
- Controlling the yard map.

However, the development of a small scale computer system should take into consideration the possibility of extending components of the system for further development. The total computer system is introduced in the target year of 2015, and the basic concept of this system is divided into the following three systems.

(Terminal control system)

This system includes the following two major programs.

- Marshalling yard control program

  Function: Determination of export container locations.
  Determination of import container locations.
  Determination of change of locations; instruction and revision.
  Storage container list inclusive of container locations and status.

- Gate control program

  Function: In-bound container control.
  Out-bound container control.

(Terminal planning system)

This system includes the following three major programs:

- Loading schedule program
  - Function: Inputting and filing the number of loading containers and their status from a specific vessel.
  - Preparing preliminary plans, a bay plan, a stowage plan, a schematic plan, a sequence checklist, etc.
  - Finalization/revision of preliminary plans.
  - Calculation of weight, height of center of gravity of the ships, cargo combinations, monitoring and others.
  - Monitoring of operation
  - Discharging schedule program
  - Function: Inputting and filing the number of containers discharged and their status from a specific vessel.

- Preparing preliminary plans a schematic plan, a sequence checklist and rehandling list.
- Monitoring of operation.

- Program for optimal handling equipment procedure.

(Documentation system)

This system finalizes all the information processed and/or developed in systems described previously. Preparing documentation to submit to the parties concerned and filing the necessary information for port statistics can be carried out with this system.

An outline of the total computer system is given in Fig. - 5.3.5-2.

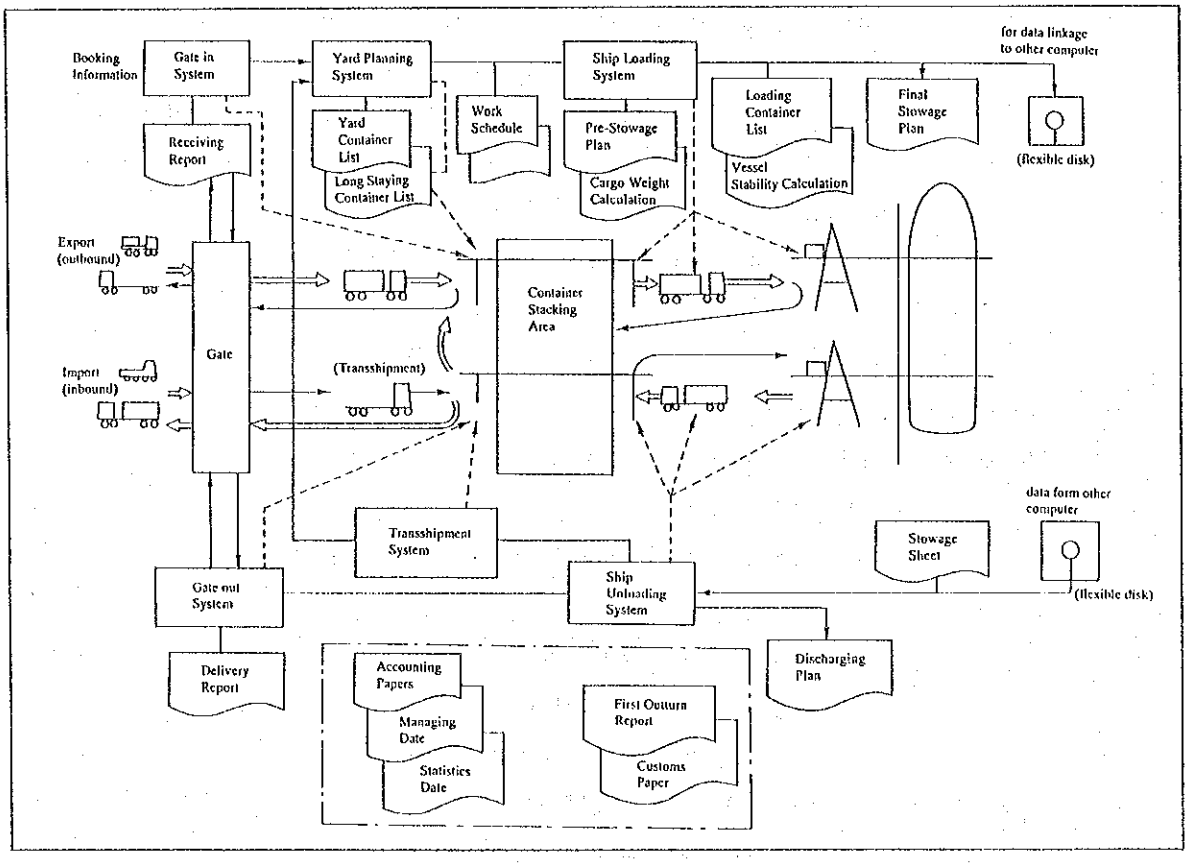


Fig. - 5.3.5-2 Out line of total computer system at terminal

(3) Maintenance and repair system

a. Present conditions

There is no building in the port area used for maintenance and repair facilities for cargo handling equipment which includes a workshop and office. The cargo handling equipment owned by Sihanoukville Port totals 110 units. Thus all cargo handling equipment will have to be maintained, inspected and repaired on a regular basis.

The new workshop is built to provide sufficient space for these activities in the target year of 2015.

b. Development plan

The main purpose of maintenance and repair is to keep equipment in good condition, thereby increasing productivity of handling equipment by minimizing trouble during container handling operation.

The main points of the development plan are outlined as follows:

1) Procurement of spare parts

The insufficient procurement of spare parts is due to lack of budget. It is necessary to consider a systematic purchase scheme based on the analyzed consumption of spare parts as soon as possible. A skilled expert is necessary to carry out the analysis.

2) Planning of replacement plan or disposal plan

Replacement and/or disposal is considered less important than the procurement plan from the point of view of budgetary requirements. However, replacement plan or disposal plan is more important than procurement plan in terms of having the appropriate amount of cargo handling equipment and also in terms of maintaining cargo handling equipment in an economical fashion.

3) Implementing preventive maintenance system

Preventive maintenance is to check and repair equipment before it breaks down or its function deteriorates, and to avoid breakdowns and ensure its original function. On the other hand, corrective maintenance is a passive form of maintenance which restores the original function of the equipment by carrying out repairs after trouble occurs.

4) Training of personnel

The necessity of training port personnel is described in the previous section.

5) Introduction of computerized maintenance and repair

Records related to maintenance and repair can neither be analyzed nor utilized sufficiently. Thus a computerized maintenance and repair system should be introduced at the level of personal computer.

(3) Required scale of storage facilities

a. Container yard

1) Calculation of storage volume

The required storage number of container of each stage is calculated by the following formula:

Ml = (My x Dw / Dy) x P

where, Ml: Required storage number of containers (TEUs)

My: Annual container throughput (TEUs)

Dw: Average dwelling days (days)

Dy: Operating days (330 days)

P: Peak ratio (1.3)

Premises for calculation are as follows:

- Dwelling time in container yard (CY) and container freight station (CFS)

At present, in spite of the free storage periods (7 days) and a lot of valuable cargoes, the average dwelling time of imported container is 6.2 days. As this is rather longer compared with the other ports (Lazaro Cardenas, Mexico: 5 days, Colombo, Sri Lanka: 6 days), many of the shipping agents are sometimes dissatisfied with the port, Therefore, this figure is assumed to be reduced to 6 days for 2015.

Exported container is assumed to stay for 3 days. The present average dwelling time of empty containers is 8.4 days, and will be assumed to be reduced 7 days. Reefer containers (or refrigerated containers) are assumed to be 5 days. The dwelling time in the CFS is set at 5.6 days.

- Stacking height of containers

Import/export containers, excluding loaded reefers, could be stacked at three layers height in the container yard. However, operationally, it is desirable to stack 3.0 high on an average basis. Therefore import container is set at 3.0, however, export container is set at 3.5. The stacking

height of reefers is set at 2.0. As for empty containers, is set 5.0.

- Required number of ground slots

Sl = Ml / L

where, Sl: Required number of ground slots (TEUs)

Ml: Required storage number of containers (TEUs)

L: Stacking height of containers (TEUs)

The results of the calculation are shown in Table - 5.3.5-6.

Table - 5.3.5-6 Required storage capacity in container yard

Target Year 2015	Unit	Laden Container			Empty Container	Total
		Import	Export	Reefer		
High Case						
Annual Container Throughput (My)	TEUs	214,000	49,000	4,500	168,000	435,500
Average Dwelling Days	Days	6.0	3.0	5.0	7.0	
Required Storage Number (Ml)	TEUs	5,058	579	89	4,633	10,359
Average Stacking Height	Layers	3.0	3.5	2.0	5.0	
Required Ground Slots	Slots	1,686	165	44	927	2,822
Required Ground Slots (Midlde Case)	Slots	1,466	150	38	796	2,450
Required Ground Slots (Low Case)	Slots	1,112	127	30	581	1,850

b. Container freight station (CFS)

The required area for the CFS is calculated in the same manner as warehouse, according to the formula below:

A = (Mc x Dw x P) / (w x r x Dy)

where, A: Required floor area of CFS (m2)

Mc: Annual handling volume of container cargo through CFS (tons)

Dw: Dwelling time at CFS (days)

P: Peak ratio (1.3)

w: Volume of cargoes per unit area (1.3 tons/m2)

r: Utilization rate of CFS floor (0.5)

Dy: Operating days of CFS (330 days)

Using the premises mentioned above, the required area of the CFS is calculated as follows:

High case	A:	(89,520 x 5.6 x 1.3)/ (1.3 x 0.5 x 330) = 3,000 m^2
Middle case	A:	(78,000 x 5.6 x 1.3)/ (1.3 x 0.5 x 330) = 2,700 m^2
Low case	A:	(56,000 x 5.6 x 1.3)/ (1.3 x 0.5 x 330) = 2,000 m^2

The required capacity of CFS is 3,000 m^2 (high case), 2,700 m^2 (middle case) and 2,000 m^2 (low case), thus the new CFS will be built for the target year of 2015.

c. Other facilities

1) Gate

The required number of truck lanes is calculated by the following formula:

$$N = Mc \times p / (Dy \times H) \times (S / 60)$$

where, N: Required number of truck lanes

Mc: Annual handling volume of containers

p: Peak ratio (1.3)

Dy: Annual operating days (330 days)

H: Operating hours per day (24 hours)

S: Necessary procedure time per truck (3 min.)

The required number of truck lanes is 4 lanes (high case and middle case) and 3 lanes (low case) for the target year of 2015. As necessary equipment, two truck scales should be equipped at the gate.

2) Terminal Office

The required area for the terminal office will depend on the method of operation and other factors. An area of around 3,000 m^2 will be planned in the target year of 2015 for the terminal office.

3) Others

- Repair of damaged containers

The container terminal will need space to repair damaged containers in the target year of 2015. A container repair yard of around 1,000 m2 is planned in the target year of 2015.

- Fumigation of containers

The container terminal will need a fumigation yard in the target year of 2015. Loaded import container has to be transferred to an exclusive yard for fumigation. A fumigation yard of around 1,000 m2 is planned.

- Washing and Cleaning Containers

For washing and cleaning of empty containers at the container terminal in the target year of 2015, an area of 500 m2 is planned.

- Customs Inspection

Based on the actual situation, the loaded import container for local distribution should be checked at terminal by Customs, thus a Custom inspection yard of about 500 m2 is planned in the target year of 2015.

- Others

Necessary facilities such as an electric station, an oil station, parking areas for yard tractor-chassis, etc. are included in the facility layout in the target year of 2015.

Fig. - 5.3.5-3 shows the layout image of container yard of high case in the target year of 2015.

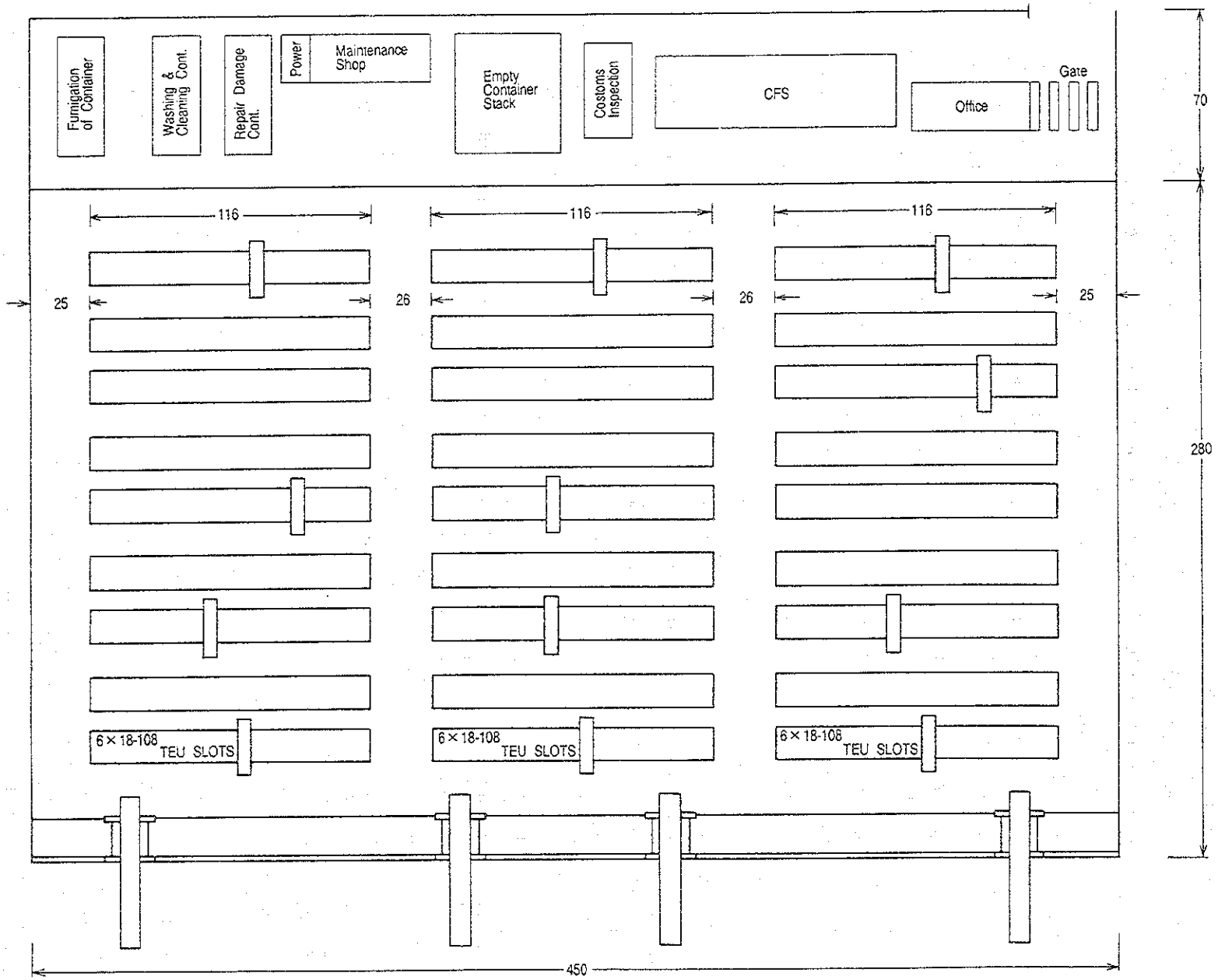


Fig. - 5.3.5-3 Layout of container yard in the target year of 2015

5.3.6 Required scale of cargo handling equipment

(1) General cargo handling equipment

According to the proposed future cargo handling system mentioned above, it is necessary to ensure the cargo handling productivity. Therefore, the introduction of cargo handling equipment from the economic point of view should be carried out to increase the loading/unloading efficiency and the overall functions of port will be enhanced.

a. Forklift

The required number of forklifts for general cargoes is calculated by the following formula:

$$N = Mc \times 2 \times 1.3 / (Dy \times h \times p)$$

where, N: Required number of forklifts

Mc: Annual handling volume of containers through general cargo berth

Dy: Annual operating days of general cargo (330 days)

h: Operating hours per day (18 hours)

p: Handling productivity (tons/hour)

The required number of forklifts is 41 units (high case), 36 units (middle case) and 30 units (low case) for the target year of 2015.

b. Tractor

The required number of tractors for general cargoes is calculated by the following formula:

$$N = Mc \times 1.3 / (Dy \times h \times p)$$

where, N: Required number of tractors

Mc: Annual handling volume of containers through general cargo berth

Dy: Annual operating days of general cargo (330 days)

h: Operating hours per day (18 hours)

p: Handling productivity (tons/hour)

The required number of tractors is 10 units (high case), 8 units (middle case) and 7 units (low case) for the target year of 2015.

c. Trailer

The required trailers for the target year 2015 is eqal to the number of tractors.

Required general cargo handling equipment of each case for the target year of 2015 is proposed as shown in Table - 5.3.6-1.

Table - 5.3.6-1 Required general cargo handling equipment

Equipment	Capacity	Unit	High Case	Middle Case	Low Case
			Quantity	Quantity	Quantity
Tractor	for transport	No.	10	8	7
Trailer	for transport	No.	10	8	7
Forklift	3 tons	No.	27	24	20
	5 tons	No.	14	12	10
Mobile Crane	100 tons	No.	1	1	1
	200 tons	No.	1	1	1
Pneumatic Unloader	for Cement handling 200 tons/hour	No.	1	1	1
Veltconveyor	for Cement handling 200 tons/hour	Sum	1	1	1
Grabe Backet	for Fertilizer handling, 4 m3	No.	3	3	3
2-way Dozer	for Fertilizer on board	No.	2	2	2
Moval Hopper	for Fertilizer at apron, 15 m3	No.	3	3	3
Total			73	64	56

(2) Container handling equipment

The container volume to be handled at the target years of 2015 is as follows:

	Import(loaded)	Export(loaded)	Export(empty)	Reefer	Total(TEU)
High case:	214,000	48,000	166,000	5,000	435,500
Middle case:	186,078	44,322	144,300	3,900	378,600
Low case:	141,200	37,000	105,300	2,904	287,200

a. Gantry crane

The required number of gantry cranes in the target year of 2015 is calculated by the following formula:

$$Nc = My / Ec \times O \times H \times Dy \times (1 + r)$$

where, Nc: Number of crane

My: Annual container throughput (TEUs)

Ec: Handling productivity of crane per hour (Box)

O: Berth occupancy rate

H: Working hours per day

Dy: Working days per year

r: Ratio of 40 footer

The result of calculation of required number of crane is as follows:

High case	Nc:	435,500 / 19.2 x 0.7 x 20 x 320 x (1+0.3) = 4 cranes
Middle case	Nc:	378,600 / 19.2 x 0.7 x 20 x 320 x (1+0.3) = 4 cranes
Low case	Nc:	287,200 / 19.2 x 0.7 x 20 x 320 x (1+0.3) = 3 cranes

b. Transfer crane

The required number of transfer crane and top-loader is calculated from the total handling volume of containers as follows:

- Handling volume at pier.
- Handling volume at yard, which is calculated by the following formula:

Hv = Mc / (Dy x h) x P

where, Hv: Handling volume at yard (TEU/hour)

Mc: Annual handling volume of container (TEU)

Dy: Annual operating days of gate (330 days)

h: Operating hours per day at gate (24 hours)

P: Peak ratio (1.3)

- Average handling capacity of transfer crane is assumed 15 TEU/hour, respectively.

The results of the calculation are shown in Table - 5.3.6-2.

Table - 5.3.6-2 Required number of transfer crane

		Unit	Target Year
			2015
High Case			
Handling Volume at Berth	Gantry Crane	TEU/hour	100
Handling Volume at Yard	Transfer Crane	TEU/hour	72
Total Handling Volume	Transfer Crane	TEU/hour	172
Required Number	Transfer Crane	Units	12
Required Number (Middle Case)	Transfer Crane	Units	11
Required Number (Low Case)	Transfer Crane	Units	8

c. Top loader

The required number of top loaders for reefer containers and others at the berths and container yard is calculated by the same formula with tractor mentioned above.

High case	Mc:	9,000 TEU, Dy: 330 days h: 18 hours
Middle case	Mc:	7,800 TEU, Dy: 330 days h: 18 hours
Low case	Mc:	6,000 TEU, Dy: 330 days h: 18 hours

The required number of top loader of each case is 2 units for the target year of 2015.

d. Chassis

The required number of chassis for shipping is calculated by the following formula:

$$N = (Tc / Tm) \times n$$

where, N: Required number of chassis

Tm: Minimum cycle time of the crane

n: Number of crane

Tc: Cycle time, which is calculated by the following formula:

$$Tc = Tl + Tu + 3600 \times S / V$$

where, Tl: Average loading hours (Sec.)

Tu: Average unloading hours (Sec.)

S: A round-trip distance (Km)

V: Running speed (Km/hour)

The required number of chassis for CFS is calculated by the following formula:

N = Mc / (Dy x g) x 1.3

where N: Required number of chassis

Mc: Annual handling volume of containers through CFS (TEU)

Dy: Annual operating days of CFS (330 days)

g: Number of gangs at CFS (4 gangs)

According to the result of the calculation, 34 units (high case), 33 units (middle case) and 25 units (low case) of chassis are required for the year 2015. The results of the calculation are shown in Table - 5.3.6-3.

Table - 5.3.6-3 Required number of chassis

Target Year 2015	Tl	Tu	S	V	Tc	Tm	n	N (Unit)
High Case								
Berth	20	30	1.3	10	518	100	4	21
CFS								9
Sub-total								30
Total (includ. 15% Total spare)								34
Total (Middle Case)								33
Total (Low Case)								25

e. Tractor

The required number of tractors for the each target year is the same as the number of chassis (excluding number of spare chassis), thus 30 units (high case), 29 units (middle case) and 22 units (low case) are required in the target year 2015.

f. Forklift

- CFS

The required number of forklift for CFS is calculated by the following formula:

N = (Mc x 2 x 1.3) / (Dy x h x p)

where, N: Required number of chassis

Mc: Annual handling volume of containers through CFS (high case: 90,000 tons, middle case: 78,000 tons, low case: 60,000 tons)

Dy: Annual operating days of CFS (330 days)

h: Operating hours per day (18 hours)

p: Handling productivity (10 tons/hour)

The required number of forklift is 4 units (high case and middle case) and 3 units (low case) for the target year of 2015.

g. Specification of gantry cane and tansfer crane

The main specification of cranes mentioned above are as follows:

Gantry Crane:

The main specifications of new gantry cranes are almost the same as the existing gantry cranes.

- Hoisting capacity: 30.5 tons under spreader
- Outreach: 35 m
- Span: 16.0 m
- Backreach: 10.0 m
- Total lifting height: 40.0 m
- Lifting height above rail: 25.0 m
- Lifting height under rail: 15.0 m
- Power source: Supplied from outside
- Approximate working speed:
    - Hoisting speed with 41 tons load: 50 m/min.
    - Hoisting speed with no load: 120 m/min.
    - Trolley traversing speed: 150 m/min.
    - Travel speed: 45 m/min.

Transfer Crane (tire- mounted):

- Hoisting capacity: 30.5 tons under spreader
- Span: 23.47 m
- Lift (9'6" containers 1 over 4): 15.24 m
- Approximate working speeds
    - Hoisting speed with 30.5 tons load: 17 m/min.
    - Trolley traversing speed: 35 m/min.

- Travel speed: 90 m/min.

h. Required number of container handling equipment

The container handling equipment required in each target year is shown in Table - 5.3.6-4.

Table - 5.3.6-4 Required number of container handling equipment

Equipment	Capacity	Unit	High Case	Middle Case	Low Case
			Quantity	Quantity	Quantity
Gantry Crane	30.5 ton	No.	4	4	3
Tranfer Crane	Tire-mount type, 30.5 ton Lift: 1 over 4, Span: 6 + 1	No.	12	11	8
Top-Loader	45 tons	No.	2	2	2
Tractor	for yard	No.	30	29	22
Chassis	for yard (20'-40')	No.	34	33	25
Forklift	2-4 tons	No.	4	4	3
Total			86	83	63

(3) Required number of workers

Required number of workers per gang by commodity each area is proposed considering the grade of handling efficiency as shown in Table - 5.3.6-5.

Table - 5.3.6-5 Required number of workers per gang by commodity

Field	Role	Unitized cargo	General cargo	Bagged cargo	Bulk cargo
On board	Supervisor	0.5	0.5	0.5	0.5
	Foreman	1.0	1.0	1.0	1.0
	Deck man	1.0	1.0	1.0	1.0
	Crane driver	1.0	1.0	1.0	1.0
	Machine driver	1.0	1.0	1.0	1.0
	Hold man	6.0	10.0	14.0	2.0
	Sling man	2.0	2.0	2.0	1.0
On dock	Foreman	0.5	0.5	0.5	0.5
	Worker	2.0	6.0	8.0	1.0
	Machine driver	2.0	2.0	2.0	2.0
	Crane driver	(1)	(1)	(1)	(1)
Warehousing	Foreman	0.5	0.5	0.5	0.5
	Worker	2.0	4.0	6.0	
	Machine driver	1.0	1.0	1.0	2.0
Tallying	Tally man	1.0	1.0	1.0	1.0
Total		22	32	40	15

Container		
Field	Role	
Control tower	Planner	0.5
	Supervisor	0.5
On board	Lasher	6.0
	Signal man	1.0
On dock	Crane driver	1.0
	Cranker	2.0
Container yard	Transtainer driver	3.0
	Signal man	3.0
	Tallying	1.0
	Tractor driver	8.0
Total		26
CFS	Worker	2.0
	Forklift driver	1.0
	Measuring staff	1.0
	Tractor driver	0.2
	Tally man	1.0
Total		5

5.3.7 Navigation aids

The navigation aids, lateral/safe water marks, of the S channel were replaced completely in 1994 with new ones equipped with solar battery and radar reflector, and are now functioning properly. However, with the creation of the N channel a series of navigation aids should be provided at due positions of the new channel. A desired arrangement of those marks is shown in Fig. - 5.3.4-3 and details are listed in Table - 5.3.7-1

Table - 5.3.7-1 List of navigation aids on the N channel

Location	Type	Color	Lamp	Lt range	Top mark	Battery	Remark
1	L't Beacon	White	12 v, 9.2 w	10 N.M.	2 Black spheres	Solar battery	Radar reflector
2	L't Beacon	Red	12 v, 3 w	3.4 N.M.	Single red cylinder	Solar battery	Nil
3	L't Buoy	Green	12 v, 13.8 w	8 N.M.	Single green cone	Solar battery w/ WAG	Radar reflector
4	L't Buoy	Red	12 v, 3 w	3.4 N.M.	Single red cylinder	Solar battery	Radar reflector
5	L't Buoy	Green	12 v, 3 w	3.4 N.M.	Single green cone	Solar battery	Radar reflector
6	L't Buoy	Red	12 v, 3 w	3.4 N.M.	Single red cylinder	Solar battery	Radar reflector
7	L't Buoy	Green	12 v, 3 w	3.4 N.M.	Single green cone	Solar battery	Radar reflector
8	L't Buoy	Red	12 v, 3 w	3.4 N.M.	Single red cylinder	Solar battery	Radar reflector
9	L't Buoy	Green	12 v, 3 w	3.4 N.M.	Single green cone	Solar battery	Radar reflector

WAG: Wave activated generator

5.3.8 Project cost study

(1) General

The project cost is divided into four parts i.e. Construction Cost, Procurement of Equipment, Engineering Services and Contingency.

The construction cost was estimated based on the combined construction cost which consists of the materials cost, depreciation of construction equipment and the labor wages.

As for the procurement of equipment, in principal, such cargo handling equipment as cranes, transtainers forklift trucks, trailer-trucks etc. are to be imported from the manufacturing countries.

(2) Composition of the Project Cost

The composition of the project cost is composed as schematized below by means of certain percentages of the direct construction cost. The ratio was obtained from the cost

estimates for similar projects presently under construction in the country as well as those recently completed.

Composition of the Project Cost

a. Construction Cost (CC) = DC + IC

- Direct Construction Cost (DC)

- Basic Port Facilities:	Dredging of Channels/Basins, Breakwaters, Revetments, Quaywalls, Navigational Aids, etc.
- Civil Works:	Open-sheds, Container-yards, Roads, Drainage, etc.
- Building Works:	Container Freight Station (CFS), Offices, Workshops, Canteen, etc.
- Utilities:	Power Supply, Lighting System, Water Supply, Sewerage, Communication System, Processing System, computer System, etc.

- Indirect Construction Cost (IC=T+M+S+O=33% of "DC")

  - Common Temporary Cost (T=3% of "DC")
  - Mobilization Cost (M=10% of "DC")
  - Site Expenses (S=10% of "DC")
  - Overhead (O=10% of "DC")

b. Procurement of Equipment (PE) =E+I+Me+Oe

- Equipment Cost on CIF basis (E)
- Installation Cost (I=10% of "E")
- Mobilization Cost (Me=10% of "E")
- Overhead (Oe=3.5% of "E")

c. Engineering Services (ES) = BD+DD+SV
- 8% of Civil works + 3% of Procurement

d. Contingency (CG) = PC+PE
- Physical Contingency (CG=10% of "CC")

(3) Basis and exchange rate

In this Study, the following exchange rate was used for the cost estimate. Furthermore, as the US dollar is commonly distributed in Cambodia, the project cost is expressed only in US dollars.

1 US $ =107 Yen = 2,594 Riels as of May 20, 1996 (Sources: Asiaweek, May 31, 1996)

(4) Sources of Unit Prices (U/P) obtained

Since there are no official data regarding the prices for the construction industry in the country, the related prices of materials, equipment available in the country and labor wages are obtained from such various sources as officers of the Ports of Sihanoukville and Phnom Penh, several bid documents, contractors, and local markets.

(5) Estimate of Project Cost

Based on the study results made in the previous sections relevant project costs for long term development plan were estimated for following six (6) cases, i.e.

a. Optimistic forecasts, Plan 1 (Case H-1),
b. Intermediate forecasts, Plan 1 (Case M-1),
c. Conservative forecasts, Plan 1 (Case L-1),
d. Optimistic forecasts, Plan 2 (Case H-2),
e. Intermediate forecasts, Plan 2 (Case M-2),
f. Conservative forecasts, Plan 2 (Case L-2).

The individual total costs are summarized in the table below:

Table - 5.3.8-1 Comparison of project cost

Unit in million U.S.$

	Plan 1	Plan 2
Optimistic forecasts	249.12	234.88
Intermediate forecasts	244.66	228.6
Optimistic forecasts	212.43	191.28

Cost breakdown of each case is shown hereinafter in Tables - 5.3.8-2 to 7.

Table - 5.3.8-2 Cost estimation (Case H-1)

Unit : 1,000 US$

	Description	Unit	Quantity	Unit cost (US$)	Amount	Local Portion	Foreign Portion	Local (%)	Foreign (%)	Remarks
A.	Construction Cost									
	1. Civil Works									
	a. Dredging of Channel (-11.0 m)	cu.m	903,000	10	9,030	632	8,398	7	93	
	b. Dredging of Basin (-10.5 m)	cu.m	1,280,000	10	12,800	896	11,904	7	93	
	c. Dredging of Basin (-9.0 m)	cu.m	493,000	10	4,930	345	4,585	7	93	
	d. Dredging of Basin (-8.5 m)	cu.m	1,253,000	10	12,530	877	11,653	7	93	
	e. Land Reclamation (Container Yard)	cu.m	753,000	11	8,283	3,893	4,390	47	53	
	f. Land Reclamation (Bulk Cargo Yard)	cu.m	753,000	11	8,283	3,893	4,390	47	53	
	g. Land Reclamation (Pond)	cu.m	56,000	11	616	290	326	47	53	
	h. Revetments	l.m	1,050	2,310	2,426	849	1,577	35	65	Container+Bulk Terminals
	i. Revetments	l.m	150	800	120	42	78	35	65	Pond
	j. Container Yard	sq.m	137,000	65	8,905	3,117	5,788	35	65	
	k. Bulk Cargo Yard	sq.m	10,000	58	580	203	377	35	65	
	l. Empty Container Yard Open Storage & Parking Area	sq.m	50,000	58	2,900	1,015	1,885	35	65	
	m. Roads	sq.m	60,000	77	4,620	1,155	3,465	25	75	
	2. Main Port Facilities									
	a. Container Berth (-10.5 m)	l.m	330	48,424	15,980	2,717	13,263	17	83	Type A
	b. Container Berth (-9.0 m)	l.m	70	43,265	3,029	454	2,574	15	85	Type B
	c. Renovation of the New Quay (-9.0 m)	l.m	50	14,000	700	105	595	15	85	Type C-1
	d. Accessories of New Quay (-9.0 m)	l.m	300	2,100	630	63	567	10	90	Type C-2
	e. General Cargo Berth (-9.0 m)	l.m	160	31,215	4,994	749	4,245	15	85	Type E
	f. General Cargo Berth (-8.5 m)	l.m	240	30,279	7,267	1,090	6,177	15	85	Type E
	g. Bulk Cargo Berth (-8.5 m)	l.m	300	30,279	9,084	1,363	7,721	15	85	Type D
	h. Extension of Breakwater	l.m	200	17,757	3,551	1,243	2,308	35	65	
	i. Navigation Aids	unit	9	90,000	810	41	770	5	95	
	j. Cement Silo (25,000 ton)	unit	1	1,598,000	1,598	240	1,358	15	85	
	k. Bitumen Tank (9,000 ton)	L.S	1	3,270,000	3,270	327	2,943	10	90	
	l. Reefer Container Facilities	L.S	1	93,000	93	9	84	10	90	
	3. Building Works									
	a. Administration Office	sq.m	3,000	500	1,500	300	1,200	20	80	20 m x 50 m, 3 stories
	b. 1 Maintenance Workshop	sq.m	1,000	400	400	60	340	15	85	20 m x 50 m, H=4.3 m
	b. 2 Machinery/Equipment	L.S	1	60,000	60		60		100	
	b. 3 Service Truck	unit	1	45,000	45		45		100	
	c. 1 Container Repair Facility	sq.m	600	450	270	54	216	20	80	20 m x 30 m, H=7.2 m
	c. 2 5 ton Hoist Crane	unit	2	280,000	560		560		100	
	c. 3 Others	L.S	1	69,000	69		69		100	
	d. 1 Container Fumigation Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	d. 2 Machinery/Equipment	L.S	1	50,000	50		50		100	
	e. 1 Container Cleaning Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	e. 2 Machinery/Equipment	L.S	1	10,000	10		10		100	
	f. Customs Office	sq.m	50	400	20	4	16	20	80	5 m x 10 m, H=2.5 m
	g. Gate House	unit	4	15,000	60	9	51	15	85	3 m x 6 m
	h. Generator House	sq.m	180	400	72	11	61	15	85	12 m x 15 m, H=3.8 m
	i. Conversion of Exist. Shed (No.3)	sq.m	10,000	30	300	60	240	20	80	
	j. Truck Scale	unit	2	60,000	120	12	108	10	90	incl. weighing machines
	k. CFS	sq.m	3,000	400	1,200	240	960	20	80	40 m x 75 m
	l. Demolition Sheds / Railway	L.S	1	100,000	100	95	5	95	5	
	4. Utilities									
	a. Power Supply	L.S	1	1,860,000	1,860	93	1,767	5	95	
	b. Lighting System	L.S	1	186,000	186	19	167	10	90	
	c. Water Supply	L.S	1	300,000	300	60	240	20	80	
	d. Sewerage	L.S	1	200,000	200	40	160	20	80	
	e. Computer System	L.S	1	5,643,000	5,643	282	5,361	5	95	
	f. Yard Fence	l.m	850	50	43	9	34	20	80	
	h. Fire Fighting System	L.S	1	200,000	200	40	160	20	80	
	Subtotal				140,331	27,001	113,330	19%	81%	
B.	Procurement/Installation of Equipment									
	1. Container Handling Equipment									
	a. Gantry Crane	no.	4	7,000,000	28,000		28,000		100	30.5 ton type
	b. Transfer Crane	no.	12	1,650,000	19,800		19,800		100	30.5 ton RTG
	c. Top-loader	no.	2	550,000	1,100		1,100		100	45 ton type
	d. Tractor	no.	30	90,000	2,700		2,700		100	for Yard
	e. Chassis	no.	34	30,000	1,020		1,020		100	for Yard (20'-40')
	f. Forklift Truck	no.	4	25,000	100		100		100	2 ~ 4 ton type
	2. Other Cargo Handling Equipment									
	a. Tractor	no.	10	30,000	300		300		100	for transport
	b. Trailer	no.	10	15,000	150		150		100	for transport
	c. 1 Forklift Trucks	no.	27	30,000	810		810		100	3 ton type
	c. 2 -ditto-	no.	14	55,000	770		770		100	5 ton type
	d. 1 Mobile Crane	no.	1	1,800,000	1,800		1,800		100	100 ton type
	d. 2 -ditto-	no.	1	3,200,000	3,200		3,200		100	200 ton type
	e. Pneumatic Unloader	no.	1	4,000,000	4,000		4,000		100	200 t/hr, for cement
	f. Belt-conveyor	L.S	1	1,500,000	1,500		1,500		100	200 t/hr, for cement
	g. Grab Bucket	no.	3	13,000	39		39		100	4 cu.m for fertilizer
	h. 2-way Dozer	no.	2	70,000	140		140		100	for fertilizer on board
	i. Movable Hopper	no.	3	100,000	300		300		100	15 cu.m for fertilizer at apron
	3. Tug Boat	no.	4	1,750,000	7,000		7,000		100	1,200 p.s.
	Subtotal				72,729		72,729		100%	
C.	Engineering Services (8% of "A" + 3% of "B")				13,408	2,682	10,727	20%	80%	
D.	Physical Contingency (10 % of "A+B+C")				22,647	2,968	19,679	13%	87%	
	Grand Total				249,115	32,651	216,465	13%	87%	

Table - 5.3.8-3 Cost estimation (Case M-1)

Unit : 1,000 US$

	Description	Unit	Quantity	Unit cost (US$)	Amount	Local Portion	Foreign Portion	Local (%)	Foreign (%)	Remarks
A.	Construction Cost									
	1. Civil Works									
	a. Dredging of Channel (-11.0 m)	cu.m	903,000	10	9,030	632	8,398	7	93	
	b. Dredging of Basin (-10.5 m)	cu.m	1,280,000	10	12,800	896	11,904	7	93	
	c. Dredging of Basin (-9.0 m)	cu.m	493,000	10	4,930	345	4,585	7	93	
	d. Dredging of Basin (-8.5 m)	cu.m	1,253,000	10	12,530	877	11,653	7	93	
	e. Land Reclamation (Container Yard)	cu.m	753,000	11	8,283	3,893	4,390	47	53	
	f. Land Reclamation (Bulk Cargo Yard)	cu.m	753,000	11	8,283	3,893	4,390	47	53	
	g. Land Reclamation (Pond)	cu.m	56,000	11	616	290	326	47	53	
	h. Revetments	l.m	1,050	2,310	2,426	849	1,577	35	65	Container+Bulk Terminals
	i. Revetments	l.m	150	800	120	42	78	35	65	Pond
	j. Container Yard	sq.m	137,000	65	8,905	3,117	5,788	35	65	
	k. Bulk Cargo Yard	sq.m	10,000	58	580	203	377	35	65	
	l. Empty Container Yard Open Storage & Parking Area	sq.m	50,000	58	2,900	1,015	1,885	35	65	
	m. Roads	sq.m	60,000	77	4,620	1,155	3,465	25	75	
	2. Main Port Facilities									
	a. Container Berth (-10.5 m)	l.m	330	48,424	15,980	2,717	13,263	17	83	Type A
	b. Container Berth (-9.0 m)	l.m	70	43,265	3,029	454	2,574	15	85	Type B
	c. Renovation of the New Quay (-9.0 m)	l.m	50	14,000	700	105	595	15	85	Type C-1
	d. Accessories of New Quay (-9.0 m)	l.m	300	2,100	630	63	567	10	90	Type C-2
	e. General Cargo Berth (-9.0 m)	l.m	160	31,215	4,994	749	4,245	15	85	Type E
	f. General Cargo Berth (-8.5 m)	l.m	240	30,279	7,267	1,090	6,177	15	85	Type E
	g. Bulk Cargo Berth (-8.5 m)	l.m	300	30,279	9,084	1,363	7,721	15	85	Type D
	h. Extension of Breakwater	l.m	200	17,757	3,551	1,243	2,308	35	65	
	i. Navigation Aids	unit	9	90,000	810	41	770	5	95	
	j. Cement Silo (25,000 ton)	unit	1	1,598,000	1,598	240	1,358	15	85	
	k. Bitumen Tank (9,000 ton)	L.S	1	3,270,000	3,270	327	2,943	10	90	
	l. Reefer Container Facilities	L.S	1	93,000	93	9	84	10	90	
	3. Building Works									
	a. Administration Office	sq.m	3,000	500	1,500	300	1,200	20	80	20 m x 50 m, 3 stories
	b. 1 Maintenance Workshop	sq.m	1,000	400	400	60	340	15	85	20 m x 50 m, H=4.3 m
	b. 2 Machinery/Equipment	L.S	1	60,000	60		60		100	
	b. 3 Service Truck	unit	1	45,000	45		45		100	
	c. 1 Container Repair Facility	sq.m	600	450	270	54	216	20	80	20 m x 30 m, H=7.2 m
	c. 2 5 ton Hoist Crane	unit	2	280,000	560		560		100	
	c. 3 Others	L.S	1	69,000	69		69		100	
	d. 1 Container Fumigation Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	d. 2 Machinery/Equipment	L.S	1	50,000	50		50		100	
	e. 1 Container Cleaning Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	e. 2 Machinery/Equipment	L.S	1	10,000	10		10		100	
	f. Customs Office	sq.m	50	400	20	4	16	20	80	5 m x 10 m, H=2.5 m
	g. Gate House	unit	4	15,000	60	9	51	15	85	3 m x 6 m
	h. Generator House	sq.m	180	400	72	11	61	15	85	12 m x 15 m, H=3.8 m
	i. Conversion of Exist. Shed (No.3)	sq.m	10,000	30	300	60	240	20	80	
	j. Truck Scale	unit	2	60,000	120	12	108	10	90	incl. weighing machines
	k. CFS	sq.m	2,700	400	1,080	216	864	20	80	40 m x 75 m
	l. Demolition Sheds / Railway	L.S	1	100,000	100	95	5	95	5	
	4. Utilities									
	a. Power Supply	L.S	1	1,860,000	1,860	93	1,767	5	95	
	b. Lighting System	L.S	1	186,000	186	19	167	10	90	
	c. Water Supply	L.S	1	300,000	300	60	240	20	80	
	d. Sewerage	L.S	1	200,000	200	40	160	20	80	
	e. Computer System	L.S	1	5,643,000	5,643	282	5,361	5	95	
	f. Yard Fence	l.m	850	50	43	9	34	20	80	
	h. Fire Fighting System	L.S	1	200,000	200	40	160	20	80	
	Subtotal				140,211	26,977	113,234	19%	81%	
B.	Procurement/Installation of Equipment									
	1. Container Handling Equipment									
	a. Gantry Crane	no.	4	7,000,000	28,000		28,000		100	30.5 ton type
	b. Transfer Crane	no.	11	1,650,000	18,150		18,150		100	30.5 ton RTG
	c. Top-loader	no.	2	550,000	1,100		1,100		100	45 ton type
	d. Tractor	no.	29	90,000	2,610		2,610		100	for Yard
	e. Chassis	no.	33	30,000	990		990		100	for Yard (20'-40')
	f. Forklift Truck	no.	4	25,000	100		100		100	2 ~ 4 ton type
	2. Other Cargo Handling Equipment									
	a. Tractor	no.	8	30,000	240		240		100	for transport
	b. Trailer	no.	8	15,000	120		120		100	for transport
	c. 1 Forklift Trucks	no.	24	30,000	720		720		100	3 ton type
	c. 2 -ditto-	no.	12	55,000	660		660		100	5 ton type
	d. 1 Mobile Crane	no.	1	1,800,000	1,800		1,800		100	100 ton type
	d. 2 -ditto-	no.	1	3,200,000	3,200		3,200		100	200 ton type
	e. Pneumatic Unloader	no.	1	4,000,000	4,000		4,000		100	200 t/hr, for cement
	f. Belt-conveyor	L.S	1	1,500,000	1,500		1,500		100	200 t/hr, for cement
	g. Grab Bucket	no.	3	13,000	39		39		100	4 cu.m for fertilizer
	h. 2-way Dozer	no.	2	70,000	140		140		100	for fertilizer on board
	i. Movable Hopper	no.	3	100,000	300		300		100	15 cu.m for fertilizer at apron
	3. Tug Boat	no.	3	1,750,000	5,250		5,250		100	1,200 p.s.
	Subtotal				68,919		68,919		100%	
C.	Engineering Services (8% of "A" + 3% of "B")				13,284	2,657	10,628	20%	80%	
D.	Physical Contingency (10 % of "A+B+C")				22,241	2,963	19,278	13%	87%	
	Grand Total				244,656	32,597	212,059	13%	87%	

Table - 5.3.8-4 Cost estimation (Case L-1)

Unit : 1,000 US$

	Description	Unit	Quantity	Unit cost (US$)	Amount	Local Portion	Foreign Portion	Local (%)	Foreign (%)	Remarks
A.	Construction Cost									
	1. Civil Works									
	a. Dredging of Channel (-11.0 m)	cu.m	903,000	10	9,030	632	8,398	7	93	
	b. Dredging of Basin (-10.5 m)	cu.m	808,000	10	8,080	566	7,514	7	93	
	c. Dredging of Basin (-9.0 m)	cu.m	176,000	10	1,760	123	1,637	7	93	
	d. Dredging of Basin (-8.5 m)	cu.m	1,722,000	10	17,220	1,205	16,015	7	93	
	e. Land Reclamation (Container Yard)	cu.m	273,000	11	3,003	1,411	1,592	47	53	
	f. Land Reclamation (Bulk Cargo Yard)	cu.m	753,000	11	8,283	3,893	4,390	47	53	
	g. Land Reclamation (Pond)	cu.m	176,000	11	1,936	910	1,026	47	53	
	h. Revetments	l.m	1,274	2,310	2,943	1,030	1,913	35	65	Container+Bulk Terminals
	i. Revetments	l.m	530	800	424	148	276	35	65	Pond
	j. Container Yard	sq.m	90,000	65	5,850	2,048	3,803	35	65	
	k. Bulk Cargo Yard	sq.m	10,000	58	580	203	377	35	65	
	l. Empty Container Yard Open Storage & Parking Area	sq.m	44,000	58	2,552	893	1,659	35	65	
	m. Roads	sq.m	50,000	77	3,850	963	2,888	25	75	
	2. Main Port Facilities									
	a. Container Berth (-10.5 m)	l.m	120	48,424	5,811	988	4,823	17	83	Type A
	b. Container Berth (-10.5 m)	l.m	200	35,000	7,000	1,050	5,950	15	85	Type C-3
	c. General Cargo Berth (-9.0)	l.m	150	34,400	5,160	774	4,386	15	85	Type C-4
	d. General Cargo Berth (-9.0 m)	l.m	160	31,215	4,994	749	4,245	15	85	Type E
	e. General Cargo Berth (-8.5 m)	l.m	240	30,279	7,267	1,090	6,177	15	85	Type E
	f. Bulk Cargo Berth (-8.5 m)	l.m	300	30,279	9,084	1,363	7,721	15	85	Type D
	g. Extension of Breakwater	l.m	200	17,757	3,551	1,243	2,308	35	65	
	h. Navigation Aids	unit	9	90,000	810	41	770	5	95	
	i. Cement Silo (15,000 ton)	unit	1	1,168,000	1,168	175	993	15	85	
	j. Bitumen Tank (6,000 ton)	L.S	1	2,243,000	2,243	224	2,019	10	90	
	k. Reefer Container Facilities	L.S	1	93,000	93	9	84	10	90	
	3. Building Works									
	a. Administration Office	sq.m	3,000	500	1,500	300	1,200	20	80	20 m x 50 m, 3 stories
	b. 1 Maintenance Workshop	sq.m	1,000	400	400	60	340	15	85	20 m x 50 m, H=4.3 m
	b. 2 Machinery/Equipment	L.S	1	60,000	60		60		100	
	b. 3 Service Truck	unit	1	45,000	45		45		100	
	c. 1 Container Repair Facility	sq.m	600	450	270	54	216	20	80	20 m x 30 m, H=7.2 m
	c. 2 5 ton Hoist Crane	unit	2	280,000	560		560		100	
	c. 3 Others	L.S	1	69,000	69		69		100	
	d. 1 Container Fumigation Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	d. 2 Machinery/Equipment	L.S	1	50,000	50		50		100	
	e. 1 Container Cleaning Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	e. 2 Machinery/Equipment	L.S	1	10,000	10		10		100	
	f. Customs Office	sq.m	50	400	20	4	16	20	80	5 m x 10 m, H=2.5 m
	g. Gate House	unit	4	15,000	60	9	51	15	85	3 m x 6 m
	h. Generator House	sq.m	180	400	72	11	61	15	85	12 m x 15 m, H=3.8 m
	i. Conversion of Exist. Shed (No.3)	sq.m	10,000	30	300	60	240	20	80	
	j. Truck Scale	unit	2	60,000	120	12	108	10	90	incl. weighing machines
	k. CFS	sq.m	2,000	400	800	160	640	20	80	40 m x 75 m
	l. Demolition Sheds / Railway	L.S	1	100,000	100	95	5	95	5	
	4. Utilities									
	a. Power Supply	L.S	1	1,860,000	1,860	93	1,767	5	95	
	b. Lighting System	L.S	1	186,000	186	19	167	10	90	
	c. Water Supply	L.S	1	300,000	300	60	240	20	80	
	d. Sewerage	L.S	1	200,000	200	40	160	20	80	
	e. Computer System	L.S	1	5,643,000	5,643	282	5,361	5	95	
	f. Yard Fence	l.m	850	50	43	9	34	20	80	
	h. Fire Fighting System	L.S	1	200,000	200	40	160	20	80	
	Subtotal				125,595	23,045	102,550	18%	82%	
B.	Procurement/Installation of Equipment									
	1. Container Handling Equipment									
	a. Gantry Crane	no.	3	7,000,000	21,000		21,000		100	30.5 ton type
	b. Transfer Crane	no.	8	1,650,000	13,200		13,200		100	30.5 ton RTG
	c. Top-loader	no.	2	550,000	1,100		1,100		100	45 ton type
	d. Tractor	no.	22	90,000	1,980		1,980		100	for Yard
	e. Chassis	no.	25	30,000	750		750		100	for Yard (20'-40')
	f. Forklift Truck	no.	3	25,000	75		75		100	2 ~ 4 ton type
	2. Other Cargo Handling Equipment									
	a. Tractor	no.	7	30,000	210		210		100	for transport
	b. Trailer	no.	7	15,000	105		105		100	for transport
	c. 1 Forklift Trucks	no.	20	30,000	600		600		100	3 ton type
	c. 2 -ditto-	no.	10	55,000	550		550		100	5 ton type
	d. 1 Mobile Crane	no.	1	1,800,000	1,800		1,800		100	100 ton type
	d. 2 -ditto-	no.	1	3,200,000	3,200		3,200		100	200 ton type
	e. Pneumatic Unloader	no.	1	4,000,000	4,000		4,000		100	200 t/hr, for cement
	f. Belt-conveyor	L.S	1	1,500,000	1,500		1,500		100	200 t/hr, for cement
	g. Grab Bucket	no.	3	13,000	39		39		100	4 cu.m for fertilizer
	h. 2-way Dozer	no.	2	70,000	140		140		100	for fertilizer on board
	i. Movable Hopper	no.	3	100,000	300		300		100	15 cu.m for fertilizer at apron
	3. Tug Boat	no.	3	1,750,000	5,250		5,250		100	1,200 p.s.
	Subtotal				55,799		55,799		100%	
C.	Engineering Services (8% of "A" + 3% of "B")				11,722	2,344	9,377	20%	80%	
D.	Physical Contingency (10 % of "A+B+C")				19,312	2,539	16,773	13%	87%	
	Grand Total				212,427	27,928	184,498	13%	87%	

Table - 5.3.8-5 Cost estimation (Case H-2)

Unit : 1,000 US$

	Description	Unit	Quantity	Unit cost (US$)	Amount	Local Portion	Foreign Portion	Local (%)	Foreign (%)	Remarks
A.	Construction Cost									
	1. Civil Works									
	a. Dredging of Channel (-11.0 m)	cu.m	903,000	10	9,030	632	8,398	7	93	
	b. Dredging of Basin (-10.5 m)	cu.m	1,280,000	10	12,800	896	11,904	7	93	
	c. Dredging of Basin (-9.0 m)	cu.m	493,000	10	4,930	345	4,585	7	93	
	d. Dredging of Basin (-8.5 m)	cu.m	324,000	10	3,240	227	3,013	7	93	
	e. Land Reclamation (Container Yard)	cu.m	753,000	11	8,283	3,893	4,390	47	53	
	f. Land Reclamation (Bulk Cargo Yard)	cu.m	320,000	11	3,520	1,654	1,866	47	53	
	g. Land Reclamation (Pond)	cu.m	176,000	11	1,936	910	1,026	47	53	
	h. Revetments	l.m	370	2,310	855	299	556	35	65	Container+Bulk Terminals
	i. Revetments	l.m	680	800	544	190	354	35	65	Pond
	j. Container Yard	sq.m	137,000	65	8,905	3,117	5,788	35	65	
	k. Bulk Cargo Yard	sq.m	10,000	58	580	203	377	35	65	
	l. Empty Container Yard Open Storage & Parking Area	sq.m	50,000	58	2,900	1,015	1,885	35	65	
	m. Roads	sq.m	40,000	77	3,080	770	2,310	25	75	
	2. Main Port Facilities									
	a. Container Berth (-10.5 m)	l.m	330	48,424	15,980	2,717	13,263	17	83	Type A
	b. Container Berth (-9.0 m)	l.m	70	43,265	3,029	454	2,574	15	85	Type B
	c. Renovation of the New Quay (-9.0 m)	l.m	50	14,000	700	105	595	15	85	Type C-1
	d. Accessories of New Quay (-9.0 m)	l.m	300	2,100	630	63	567	10	90	Type C-2
	e. General Cargo Berth (-9.0 m)	l.m	160	31,215	4,994	749	4,245	15	85	Type E
	f. General Cargo Berth (-8.5 m)	l.m	240	30,279	7,267	1,090	6,177	15	85	Type E
	g. Bulk Cargo Berth (-8.5 m)	l.m	335	37,383	12,523	1,878	10,645	15	85	Type F
	h. Extension of Breakwater	l.m	200	17,757	3,551	1,243	2,308	35	65	
	i. Navigation Aids	unit	9	90,000	810	41	770	5	95	
	j. Cement Silo (25,000 ton)	unit	1	1,598,000	1,598	240	1,358	15	85	
	k. Bitumen Tank (9,000 ton)	L.S	1	3,270,000	3,270	327	2,943	10	90	
	l. Reefer Container Facilities	L.S	1	93,000	93	9	84	10	90	
	3. Building Works									
	a. Administration Office	sq.m	3,000	500	1,500	300	1,200	20	80	20 m x 50 m, 3 stories
	b. 1 Maintenance Workshop	sq.m	1,000	400	400	60	340	15	85	20 m x 50 m, H=4.3 m
	b. 2 Machinery/Equipment	L.S	1	60,000	60		60		100	
	b. 3 Service Truck	unit	1	45,000	45		45		100	
	c. 1 Container Repair Facility	sq.m	600	450	270	54	216	20	80	20 m x 30 m, H=7.2 m
	c. 2 5 ton Hoist Crane	unit	2	280,000	560		560		100	
	c. 3 Others	L.S	1	69,000	69		69		100	
	d. 1 Container Fumigation Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	d. 2 Machinery/Equipment	L.S	1	50,000	50		50		100	
	e. 1 Container Cleaning Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	e. 2 Machinery/Equipment	L.S	1	10,000	10		10		100	
	f. Customs Office	sq.m	50	400	20	4	16	20	80	5 m x 10 m, H=2.5 m
	g. Gate House	unit	4	15,000	60	9	51	15	85	3 m x 6 m
	h. Generator House	sq.m	180	400	72	11	61	15	85	12 m x 15 m, H=3.8 m
	i. Conversion of Exist. Shed (No.3)	sq.m	10,000	30	300	60	240	20	80	
	j. Truck Scale	unit	2	60,000	120	12	108	10	90	incl. weighing machines
	k. CFS	sq.m	3,000	400	1,200	240	960	20	80	40 m x 75 m
	l. Demolition Sheds / Railway	L.S	1	100,000	100	95	5	95	5	
	4. Utilities									
	a. Power Supply	L.S	1	1,860,000	1,860	93	1,767	5	95	
	b. Lighting System	L.S	1	186,000	186	19	167	10	90	
	c. Water Supply	L.S	1	300,000	300	60	240	20	80	
	d. Sewerage	L.S	1	200,000	200	40	160	20	80	
	e. Computer System	L.S	1	5,643,000	5,643	282	5,361	5	95	
	f. Yard Fence	l.m	850	50	43	9	34	20	80	
	h. Fire Fighting System	L.S	1	200,000	200	40	160	20	80	
	Subtotal				128,351	24,462	103,889	19%	81%	
B.	Procurement/Installation of Equipment									
	1. Container Handling Equipment									
	a. Gantry Crane	no.	4	7,000,000	28,000		28,000		100	30.5 ton type
	b. Transfer Crane	no.	12	1,650,000	19,800		19,800		100	30.5 ton RTG
	c. Top-loader	no.	2	550,000	1,100		1,100		100	45 ton type
	d. Tractor	no.	30	90,000	2,700		2,700		100	for Yard
	e. Chassis	no.	34	30,000	1,020		1,020		100	for Yard (20'-40')
	f. Forklift Truck	no.	4	25,000	100		100		100	2 - 4 ton type
	2. Other Cargo Handling Equipment									
	a. Tractor	no.	10	30,000	300		300		100	for transport
	b. Trailer	no.	10	15,000	150		150		100	for transport
	c. 1 Forklift Trucks	no.	27	30,000	810		810		100	3 ton type
	c. 2 -ditto-	no.	14	55,000	770		770		100	5 ton type
	d. 1 Mobile Crane	no.	1	1,800,000	1,800		1,800		100	100 ton type
	d. 2 -ditto-	no.	1	3,200,000	3,200		3,200		100	200 ton type
	e. Pneumatic Unloader	no.	1	4,000,000	4,000		4,000		100	200 t/hr, for cement
	f. Belt-conveyor	L.S	1	1,500,000	1,500		1,500		100	200 t/hr, for cement
	g. Grab Bucket	no.	3	13,000	39		39		100	4 cu.m for fertilizer
	h. 2-way Dozer	no.	2	70,000	140		140		100	for fertilizer on board
	i. Movable Hopper	no.	3	100,000	300		300		100	15 cu.m for fertilizer at apron
	3. Tug Boat	no.	4	1,750,000	7,000		7,000		100	1,200 p.s.
	Subtotal				72,729		72,729		100%	
C.	Engineering Services (8% of "A" + 3% of "B")				12,450	2,490	9,960	20%	80%	
D.	Physical Contingency (10 % of "A+B+C")				21,353	2,695	18,658	13%	87%	
	Grand Total				234,883	29,647	205,236	13%	87%	

Table - 5.3.8-6 Cost estimation (Case M-2)

Unit : 1,000 US$

	Description	Unit	Quantity	Unit cost (US$)	Amount	Local Portion	Foreign Portion	Local (%)	Foreign (%)	Remarks
A.	Construction Cost									
	1. Civil Works									
	a. Dredging of Channel (-11.0 m)	cu.m	903,000	10	9,030	632	8,398	7	93	
	b. Dredging of Basin (-10.5 m)	cu.m	1,280,000	10	12,800	896	11,904	7	93	
	c. Dredging of Basin (-9.0 m)	cu.m	493,000	10	4,930	345	4,585	7	93	
	d. Dredging of Basin (-8.5 m)	cu.m	324,000	10	3,240	227	3,013	7	93	
	e. Land Reclamation (Container Yard)	cu.m	753,000	11	8,283	3,893	4,390	47	53	
	f. Land Reclamation (Bulk Cargo Yard)	cu.m	320,000	11	3,520	1,654	1,866	47	53	
	g. Land Reclamation (Pond)	cu.m	176,000	11	1,936	910	1,026	47	53	
	h. Revetments	l.m	370	2,310	855	299	556	35	65	Container+Bulk Terminals
	i. Revetments	l.m	680	800	544	190	354	35	65	Pond
	j. Container Yard	sq.m	137,000	65	8,905	3,117	5,788	35	65	
	k. Bulk Cargo Yard	sq.m	10,000	58	580	203	377	35	65	
	l. Empty Container Yard Open Storage & Parking Area	sq.m	45,000	58	2,610	914	1,697	35	65	
	m. Roads	sq.m	30,000	77	2,310	578	1,733	25	75	
	2. Main Port Facilities									
	a. Container Berth (-10.5 m)	l.m	330	48,424	15,980	2,717	13,263	17	83	Type A
	b. Container Berth (-9.0 m)	l.m	70	43,265	3,029	454	2,574	15	85	Type B
	c. Renovation of the New Quay (-9.0 m)	l.m	50	14,000	700	105	595	15	85	Type C-1
	d. Accessories of New Quay (-9.0 m)	l.m	300	2,100	630	63	567	10	90	Type C-2
	e. General Cargo Berth (-9.0 m)	l.m	160	31,215	4,994	749	4,245	15	85	Type E
	f. General Cargo Berth (-8.5 m)	l.m	240	30,279	7,267	1,090	6,177	15	85	Type E
	g. Bulk Cargo Berth (-8.5 m)	l.m	335	37,383	12,523	1,878	10,645	15	85	Type F
	h. Extension of Breakwater	l.m	200	17,757	3,551	1,243	2,308	35	65	
	i. Navigation Aids	unit	9	90,000	810	41	770	5	95	
	j. Cement Silo (23,000 ton)	unit	1	1,495,000	1,495	224	1,271	15	85	
	k. Bitumen Tank (8,000 ton)	L.S	1	2,897,000	2,897	290	2,607	10	90	
	l. Reefer Container Facilities	L.S	1	93,000	93	9	84	10	90	
	3. Building Works									
	a. Administration Office	sq.m	3,000	500	1,500	300	1,200	20	80	20 m x 50 m, 3 stories
	b. 1 Maintenance Workshop	sq.m	1,000	400	400	60	340	15	85	20 m x 50 m, H=4.3 m
	b. 2 Machinery/Equipment	L.S	1	60,000	60		60		100	
	b. 3 Service Truck	unit	1	45,000	45		45		100	
	c. 1 Container Repair Facility	sq.m	600	450	270	54	216	20	80	20 m x 30 m, H=7.2 m
	c. 2 5 ton Hoist Crane	unit	2	280,000	560		560		100	
	c. 3 Others	L.S	1	69,000	69		69		100	
	d. 1 Container Fumigation Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	d. 2 Machinery/Equipment	L.S	1	50,000	50		50		100	
	e. 1 Container Cleaning Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	e. 2 Machinery/Equipment	L.S	1	10,000	10		10		100	
	f. Customs Office	sq.m	50	400	20	4	16	20	80	5 m x 10 m, H=2.5 m
	g. Gate House	unit	4	15,000	60	9	51	15	85	3 m x 6 m
	h. Generator House	sq.m	180	400	72	11	61	15	85	12 m x 15 m, H=3.8 m
	i. Conversion of Exist. Shed (No.3)	sq.m	10,000	30	300	60	240	20	80	
	j. Truck Scale	unit	2	60,000	120	12	108	10	90	incl. weighing machines
	k. CFS	sq.m	2,700	400	1,080	216	864	20	80	40 m x 75 m
	l. Demolition Sheds / Railway	L.S	1	100,000	100	95	5	95	5	
	4. Utilities									
	a. Power Supply	L.S	1	1,860,000	1,860	93	1,767	5	95	
	b. Lighting System	L.S	1	186,000	186	19	167	10	90	
	c. Water Supply	L.S	1	300,000	300	60	240	20	80	
	d. Sewerage	L.S	1	200,000	200	40	160	20	80	
	e. Computer System	L.S	1	5,643,000	5,643	282	5,361	5	95	
	f. Yard Fence	l.m	850	50	43	9	34	20	80	
	h. Fire Fighting System	L.S	1	200,000	200	40	160	20	80	
	Subtotal				126,695	24,091	102,604	19%	81%	
B.	Procurement/Installation of Equipment									
	1. Container Handling Equipment									
	a. Gantry Crane	no.	4	7,000,000	28,000		28,000		100	30.5 ton type
	b. Transfer Crane	no.	11	1,650,000	18,150		18,150		100	30.5 ton RTG
	c. Top-loader	no.	2	550,000	1,100		1,100		100	45 ton type
	d. Tractor	no.	29	90,000	2,610		2,610		100	for Yard
	e. Chassis	no.	33	30,000	990		990		100	for Yard (20'-40')
	f. Forklift Truck	no.	4	25,000	100		100		100	2 - 4 ton type
	2. Other Cargo Handling Equipment									
	a. Tractor	no.	8	30,000	240		240		100	for transport
	b. Trailer	no.	8	15,000	120		120		100	for transport
	c. 1 Forklift Trucks	no.	24	30,000	720		720		100	3 ton type
	c. 2 -ditto-	no.	12	55,000	660		660		100	5 ton type
	d. 1 Mobile Crane	no.	1	1,800,000	1,800		1,800		100	100 ton type
	d. 2 -ditto-	no.	1	3,200,000	3,200		3,200		100	200 ton type
	e. Pneumatic Unloader	no.	1	4,000,000	4,000		4,000		100	200 t/hr, for cement
	f. Belt-conveyor	L.S	1	1,500,000	1,500		1,500		100	200 t/hr, for cement
	g. Grab Bucket	no.	3	13,000	39		39		100	4 cu.m for fertilizer
	h. 2-way Dozer	no.	2	70,000	140		140		100	for fertilizer on board
	i. Movable Hopper	no.	3	100,000	300		300		100	15 cu.m for fertilizer at apron
	3. Tug Boat	no.	3	1,750,000	5,250		5,250		100	1,200 p.s.
	Subtotal				68,919		68,919		100%	
C.	Engineering Services (8% of "A" + 3% of "B")				12,203	2,441	9,763	20%	80%	
D.	Physical Contingency (10 % of "A+B+C")				20,782	2,653	18,129	13%	87%	
	Grand Total				228,599	29,185	199,414	13%	87%	

Table - 5.3.8-7 Cost estimation (Case L-2)

Unit : 1,000 US$

	Description	Unit	Quantity	Unit cost (US$)	Amount	Local Portion	Foreign Portion	Local (%)	Foreign (%)	Remarks
A.	Construction Cost									
	1. Civil Works									
	a. Dredging of Channel (-11.0 m)	cu.m	903,000	10	9,030	632	8,398	7	93	
	b. Dredging of Basin (-10.5 m)	cu.m	847,000	10	8,470	593	7,877	7	93	
	c. Dredging of Basin (-9.0 m)	cu.m	176,000	10	1,760	123	1,637	7	93	
	d. Dredging of Basin (-8.5 m)	cu.m	331,000	10	3,310	232	3,078	7	93	
	e. Land Reclamation (Container Yard)	cu.m	273,000	11	3,003	1,411	1,592	47	53	
	f. Land Reclamation (Bulk Cargo Yard)	cu.m	320,000	11	3,520	1,654	1,866	47	53	
	g. Land Reclamation (Pond)	cu.m	176,000	11	1,936	910	1,026	47	53	
	h. Revetments	l.m	610	2,310	1,409	493	916	35	65	Container+Bulk Terminals
	i. Revetments	l.m	680	800	544	190	354	35	65	Pond
	j. Container Yard	sq.m	90,000	65	5,850	2,048	3,803	35	65	
	k. Bulk Cargo Yard	sq.m	10,000	58	580	203	377	35	65	
	l. Empty Container Yard Open Storage & Parking Area	sq.m	44,000	58	2,552	893	1,659	35	65	
	m. Roads	sq.m	30,000	77	2,310	578	1,733	25	75	
	2. Main Port Facilities									
	a. Container Berth (-10.5 m)	l.m	120	48,424	5,811	988	4,823	17	83	Type A
	b. Container Berth (-10.5 m)	l.m	200	35,000	7,000	1,050	5,950	15	85	Type C-3
	c. General Cargo Berth (-9.0 m)	l.m	150	34,400	5,160	774	4,386	15	85	Type C-4
	d. General Cargo Berth (-9.0 m)	l.m	160	31,215	4,994	749	4,245	15	85	Type E
	e. General Cargo Berth (-8.5 m)	l.m	240	30,279	7,267	1,090	6,177	15	85	Type E
	f. Bulk Cargo Berth (-8.5 m)	l.m	335	37,383	12,523	1,878	10,645	15	85	Type F
	g. Extension of Breakwater	l.m	200	17,757	3,551	1,243	2,308	35	65	
	h. Navigation Aids	unit	9	90,000	810	41	770	5	95	
	i. Cement Silo (18000 ton)	unit	1	1,168,000	1,168	175	993	15	85	
	j. Bitumen Tank (6000 ton)	L.S	1	2,243,000	2,243	224	2,019	10	90	
	k. Reefer Container Facilities	L.S	1	93,000	93	9	84	10	90	
	3. Building Works									
	a. Administration Office	sq.m	3,000	500	1,500	300	1,200	20	80	20 m x 50 m, 3 stories
	b. 1 Maintenance Workshop	sq.m	1,000	400	400	60	340	15	85	20 m x 50 m, H=4.3 m
	b. 2 Machinery/Equipment	L.S	1	60,000	60		60		100	
	b. 3 Service Truck	unit	1	45,000	45		45		100	
	c. 1 Container Repair Facility	sq.m	600	450	270	54	216	20	80	20 m x 30 m, H=7.2 m
	c. 2 5 ton Hoist Crane	unit	2	280,000	560		560		100	
	c. 3 Others	L.S	1	69,000	69		69		100	
	d. 1 Container Fumigation Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	d. 2 Machinery/Equipment	L.S	1	50,000	50		50		100	
	e. 1 Container Cleaning Facility	sq.m	50	350	18	4	14	20	80	5 m x 10 m, H=2.5 m
	e. 2 Machinery/Equipment	L.S	1	10,000	10		10		100	
	f. Customs Office	sq.m	50	400	20	4	16	20	80	5 m x 10 m, H=2.5 m
	g. Gate House	unit	4	15,000	60	9	51	15	85	3 m x 6 m
	h. Generator House	sq.m	180	400	72	11	61	15	85	12 m x 15 m, H=3.8 m
	i. Conversion of Exist. Shed (No.3)	sq.m	10,000	30	300	60	240	20	80	
	j. Truck Scale	unit	2	60,000	120	12	108	10	90	incl. weighing machines
	k. CFS	sq.m	2,000	400	800	160	640	20	80	40 m x 75 m
	l. Demolition Sheds / Railway	L.S	1	100,000	100	95	5	95	5	
	4. Utilities									
	a. Power Supply	L.S	1	1,860,000	1,860	93	1,767	5	95	
	b. Lighting System	L.S	1	186,000	186	19	167	10	90	
	c. Water Supply	L.S	1	300,000	300	60	240	20	80	
	d. Sewerage	L.S	1	200,000	200	40	160	20	80	
	e. Computer System	L.S	1	5,643,000	5,643	282	5,361	5	95	
	f. Yard Fence	l.m	850	50	43	9	34	20	80	
	h. Fire Fighting System	L.S	1	200,000	200	40	160	20	80	
	Subtotal				107,798	19,496	88,301	18%	82%	
B.	Procurement/Installation of Equipment									
	1. Container Handling Equipment									
	a. Gantry Crane	no.	3	7,000,000	21,000		21,000		100	30.5 ton type
	b. Transfer Crane	no.	8	1,650,000	13,200		13,200		100	30.5 ton RTG
	c. Top-loader	no.	2	550,000	1,100		1,100		100	45 ton type
	d. Tractor	no.	22	90,000	1,980		1,980		100	for Yard
	e. Chassis	no.	25	30,000	750		750		100	for Yard (20'-40')
	f. Forklift Truck	no.	3	25,000	75		75		100	2 ~ 4 ton type
	2. Other Cargo Handling Equipment									
	a. Tractor	no.	7	30,000	210		210		100	for transport
	b. Trailer	no.	7	15,000	105		105		100	for transport
	c. 1 Forklift Trucks	no.	20	30,000	600		600		100	3 ton type
	c. 2 -ditto-	no.	10	55,000	550		550		100	5 ton type
	d. 1 Mobile Crane	no.	1	1,800,000	1,800		1,800		100	100 ton type
	d. 2 -ditto-	no.	1	3,200,000	3,200		3,200		100	200 ton type
	e. Pneumatic Unloader	no.	1	4,000,000	4,000		4,000		100	200 t/hr, for cement
	f. Belt-conveyor	L.S	1	1,500,000	1,500		1,500		100	200 t/hr, for cement
	g. Grab Bucket	no.	3	13,000	39		39		100	4 cu.m for fertilizer
	h. 2-way Dozer	no.	2	70,000	140		140		100	for fertilizer on board
	i. Movable Hopper	no.	3	100,000	300		300		100	15 cu.m for fertilizer at apron
	3. Tug Boat	no.	3	1,750,000	5,250		5,250		100	1,200 p.s.
	Subtotal				55,799		55,799		100%	
C.	Engineering Services (8% of "A" + 3% of "B")				10,298	2,060	8,238	20%	80%	
D.	Physical Contingency (10 % of "A+B+C")				17,389	2,156	15,234	12%	88%	
	Grand Total				191,284	23,711	167,572	12%	88%	

5.4 Initial environmental evaluation

5.4.1 General

There are presently two international trading ports in the Kingdom of Cambodia. One is Phnom Penh Port and the other is Sihanoukville Port. Phnom Penh Port is located at the right bank of the Tonle Sap River and is 332 km away from the mouth of Mekong River in the capital. It was the only trading port until the start of operation of Sihanoukville Port in1959.

Phnom Penh Port deals mainly in general cargo and oil products as the key port for international trading and is situated in the highest consumption area of the country. Phnom Penh Port is an inland river port and has the capability for 2,000WT ships in dry seasons. Being a river port and with the water depth in the river mouth being not so deep, ships of maximum 6,000WT are unable to enter this port.

On the other hand, Sihanoukville Port is an outport and faces the Gulf of Thailand. It was constructed in 1959 and is accessible to 10,000WT class ships. The National Route No.4 (235km) and a railroad (262.6km) connects this port with Phnom Penh . Sihanoukville Port is comprised of a New Port, an Old Port, and an Oil Port, and deals in miscellaneous goods, bulk cargo and containers. It has a cargo capability of 1,600,000 tons per year.

Considering the positive results of the election held under UNTAC operations, which are the political stabilization and reconstruction of economy, it is foreseen that cargo volume will increase rapidly in the country. Consequently, a master plan is urgently required which would include measures to increment its cargo capability as well as a study of life for the Old Port .

Based on this background, the Government of Cambodia requested a feasibility study for short term plan and preparation of master plan for Sihanoukville Port to the Government of Japan in 1994.

The objectives of the study are;

(1) To formulate a Master Plan for Sihanoukville Port over the period up to Year 2015.
(2) To conducted a feasibility study for the short term plan for Sihanoukville Port over the period up to Year 2005 within the framework of the Master plan, and
(3) To propose urgent measures to be done prior to the implementation of the short term plan, are deemed to be necessary .

Based on the above objectives, the JICA survey team prepared a report for both the short-term plan (2005) and the long term plan (2015) including urgent measures

after the team's completion of field survey.

The IEE report prepared by JICA and which is presented in this section describes the environmental impact of the port project based on the above master plan (Long-term Plan).

5.4.2 Initial environmental evaluation

Refer to attached IEE report.

5.5 Preliminary economic analysis

5.5.1 Methodology

(1) Purpose

The purpose of the preliminary economic analysis is to appraise the economic feasibility of the master plan for the study ports before a feasibility study on the short term plan can proceed. The preliminary economic evaluation of a project should show whether the project is justifiable from the viewpoint of the national economy by assessing its contribution to the national economy.

(2) Methodology

An economic analysis will be carried out according to the following method. Master plan will be defined and it will be compared to the "Without" case. All benefits and costs of it in market price for the difference from "With" case will be calculated and evaluated.

There are various methods to evaluate the feasibility of this type of development project. Here, the economic internal rate of return (EIRR) based on a cost-benefit analysis is 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.

5.5.2 Prerequisites of analysis

(1) Base Year

The "Base Year" here means the standard year in the estimation of costs and benefits. Taking into consideration the base year in cost estimation of construction, 1996 is set as the "Base Year" for this study.

(2) Project life

Taking into consideration the depreciation period of the main facilities of 30 years and the construction period of 5 years, the period of calculation (project life) in the economic analysis is assumed to be 35 years from the beginning of construction.

(3) Foreign exchange rate

The exchange rate adopted for this analysis is US$ 1.00 = 107 yen = 2,594 Riels (May. 1996), the same rate as used in the cost estimation.

(4) "With" case

In an economic analysis, benefits are mainly brought about by improvements and expansions in handling capacity. Therefore, the "With" case scenario includes all improvements

in productivity and all expansions of port facilities for the master plan.

(5) "Without" case

A cost-benefit analysis is conducted on the difference between the "With" and "Without" investment cases. In this study, the following conditions are adopted as the "Without" case.

i) No investment is made for the port
ii) When handling volume reaches the maximum volume of handling capacity of the port, the cargoes which can not be handled in the port are assumed to be handled in foreign ports and then transported to Cambodian provinces through Phnom Penh by trucks.
iii) Bitumen is handled at Sihanoukville Port.
iv) The size of vessels and the working efficiency of cargo handling are not the same as "With" case.

The size of ships and the working efficiency of cargo handling in the "With" and "Without" cases are shown in Table - 5.5.2-1.

Table - 5.5.2-1 Size of ship and working efficiency of cargo handling in both cases

Commodity	WITHOUT			WITH		
	Ship Type	DWT	Efficiency (/ day)	Ship Type	DWT	Efficiency (/ day)
Fertilizer	General	5000	434 ton	Bulk	7000	1,613 ton
Cement	General	5000	276 ton	Bulk	7000	2,880 ton
Rice	General	5000	372 ton	General	7000	1,296 ton
Sugar	General	5000	288 ton	General	5000	864 ton
Bitumen	Tanker	5000	1,056 ton	Tanker	7000	10,800 ton
Machinery	General	5000	314 ton	Ro-Ro	7000	1,670 ton
Steel Product	General	5000	480 ton	General	5000	1,728 ton
Wood Product	General	5000	348 ton	General	7000	1,152 ton
General Cargo	General	5000	156 ton	General	7000	756 ton
Container	General	5000	280 TEU	Container	7000	998 TEU

5.5.3 Costs of the projects

The items that should be considered as costs of the projects are construction costs and maintenance costs as shown in Table - 5.5.3-1.

(1) Construction costs

Construction costs are divided into such categories as civil costs and mechanical costs. Main mechanical costs are purchasing of handling equipment.

(2) Maintenance costs

The costs of maintaining the port facilities are estimated as a fixed proportion (1 % for structures, 4 % for handling equipment) of the original construction costs excluding the costs of dredging and reclamation costs.

Table - 5.5.3-1 Costs of the projects in Sihanoukville Port

(Unit: million US$)

		Construction Cost			Maintenance Cost		
		Structure	Equipment	Total	Structure	Equipment	Total
High Case	Plan H-1	166.7	82.4	249.1	1.7	3.3	5.0
	Plan H-2	152.5	82.4	234.9	1.5	3.3	4.8
Middle Case	Plan M-1	166.6	78.1	244.7	1.7	3.1	4.8
	Plan M-2	150.5	78.1	228.6	1.5	3.1	4.6
Low Case	Plan L-1	149.2	63.2	212.4	1.5	2.5	4.0
	Plan L-2	128.1	63.2	191.3	1.3	2.5	3.8

5.5.4 Benefits of the projects

(1) Benefit Items

As benefits brought about by the master plan of the study port, the following items are identified.

i) Savings in waiting costs of ships
ii) Savings in water transportation cost by enlargement of ship size
iii) Savings in land transportation costs
iv) Savings of cost in cargo handling
v) Savings in interest of cargo costs
vi) Reduction of cargo damage and accidents at the port
vii) Promotion of regional economic development
viii) Increase in employment opportunities and incomes

Items i), ii), iii), iv) and v) are considered countable and in this study the monetary benefits of items i), ii) and iii) are calculated.

(2) Calculation of benefits

a. Savings in waiting costs of ships

In accordance with the implementation of the projects, the total ship staying time, namely ship waiting time for berthing and ship mooring time for unloading / loading in the port, will be greatly decreased. The reduction of the ship staying time under the "With" case is one of the major benefits of the projects. The benefits that will accrue to Cambodia from the projects can be calculated by the following formula.

Savings in ships' waiting costs

= Difference in waiting time between "With" and "Without" cases

× Ship's staying cost (unit cost)

× Share of benefits accruing to Cambodia (= 0.5)

b. Savings in water transportation cost by enlargement of ship size

When the size of calling ships becomes larger to capitalize on mass transportation, large ship can call at deep berths but can not call at existing shallow and short berths. The water transportation cost per ton of cargo will become cheaper by enlargement of ship size. The benefit that will accrue to Cambodia from the projects can be calculated by the following formula.

Savings in water transportation cost by enlargement of ship size

= Difference in water transportation cost between "With" and "Without" cases (unit cost)

× Handling cargo volume

× Share of benefits accruing to Cambodia (= 0.5)

c. Savings in land transportation costs

When that handling volume exceeds the handling capacity of the port, the excess cargoes which can not be handled in the port will be handled in other foreign ports and then be transported to Cambodia by trucks. In accordance with the implementation of the projects, all cargos will be transported to destination in Cambodia by trucks. The benefit that will accrue to Cambodia from the projects can be calculated by the following formula.

Savings in land transportation costs

= Difference in handling cargo volume between "With" and "Without" cases

× Difference in land transportation cost (unit cost)

d. Summary of benefit

Table - 5.5.4-1 shows the results of the benefits by above method.

Table - 5.5.4-1 Benefits of the projects

(Unit: million US$)

CASE	PLAN	Waiting Cost	Water Transportation Cost	Land Transportation Cost	Total
High Case	Plan H-1 & H-2	21.4	4.0	39.3	64.7
Middle Case	Plan M-1 & M-2	21.1	3.5	33.3	57.9
Low Case	Plan L-1 & L-2	17.1	2.7	24.1	44.0

5.5.5 Evaluation of the projects

(1) 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 during the project life equal. It is calculated by using the following formula.

$$\sum_{i=1}^{n} = \frac{B_i - C_i}{(1+r)^{i-1}} = 0$$

where, n: Period of economic calculation (project life)

Bi: Benefits in i-th year

Ci: Costs in i-th year

r: Discount rate

The results of EIRR calculation are shown in Table - 5.5.5-1.

Table - 5.5.5-1 EIRR of Master Plan

CASE	PLAN	EIRR
High Case	Plan H-1	17.0%
	Plan H-2	17.8%
Middle Case	Plan M-1	15.7%
	Plan M-2	16.6%
Low Case	Plan L-1	14.0%
	Plan L-2	15.3%

(2) Evaluation

The leading view is that the project is feasible if the EIRR exceeds the opportunity cost of capital. In general, the opportunity cost of capital is considered to range from 8 % to 10 % according to the degree of development in each country. It is generally considered that a project with an EIRR of more than 10 % is economically feasible for infrastructure or social service projects.

As for this project, even though the economic calculation only takes into account the items which are easily quantified, the EIRR exceeds 10 %. Therefore, this master plan development project is feasible from the viewpoint of the national economy.

5.6 Over-all evaluation of the proposed alternative plans

The characteristic of the two alternative plans, i.e. Plan-1 and Plan-2 are summarized as shown in Table - 5.6.1.

On the basis of overall evaluation, the study team recommend Plan-1, because the plan has more directly indicate the concept of the port expansion toward the future, and would encourage the private investment in the port area. The project cost is slightly higher than Plan-2 and thus the EIRR is slightly lower, but yet the project is economically viable.

Table - 5.6.1 Evaluation of the alternative plans

Long-term Plan	Plan-1			Plan-2		
Scenario	High	Middle	Low	High	Middle	Low
Total cargo Volume (1,000 tons)	4,740	4,191	3,340	4,740	4,191	3,340
Facility Layout Plan	Fig. - 5.1.3-1	Fig. - 5.1.3-1	Fig.- 5.2.3-3	Fig.- 5.1.3-2	Fig.- 5.1.3-2	Fig.- 5.1.3-4
(1) Total Cost(US$ Million)	249.1	244.7	212.4	234.9	228.6	191.3
(2) Rough estimate EIRR (%)	17.0	15.7	14.0	17.8	16.6	15.3
(3) Engineering soundness	No technical difficulty is foreseen			do		
(4) Port operation	Port operation will not be not inconvenienced by the separation of the bulk terminal from other facilities, because the operation of these wharves are independent from each other. The road traffic at the port gates is eased by the separation of the bulk terminal.			All the road traffic is concentrated at the port area.		
(5) Potential for future expansion	No restriction for the expansion of industrial zone near the bulk terminal			Expansion of bulk terminal is restricted in terms of land space.		
(6) Flexibility in the planning of further expansion	The plan indicates the concept and direction of future expansion northward. Thus, further expansion of the port shall follow the concept.			With the long-term plan, the development of western zone of the port is completed. Full in the further expansion is fully reserved, in other word, the plan does not indicate the orientation of further expansion.		

(7) Impact on natural environment	Sedimentation is expected in the water area bounded by the new container terminal and the existing groin. The circulation of tidal current inside breakwater may change due to the new reclamation of the bulk terminal.	Sedimentation is expected in the water area bounded by the new container terminal and the existing groin. No substantial impact on the tidal current in the water area bounded by the breakwaters.
(8) Impact on the socioeconomic environment	No relocation of fishing village or residents is needed. Access road to the village shall be rerouted.	No relocation of fishing village or residents is needed. Access road to the village will remain unchanged with miner rerouting.
(10) Impact on the promotion of regional economy	The plan may promote the establishment of import and export oriented industries in the port area, by providing new access road.	The plan also may promote establishment of industries as Plan-1. However, these industries must find the site outside of port area.
Overall evaluation	The plan has no fatal shortcoming to be implemented. This plan shows advantages in items (5),(6), and (10), even though the cost is slightly higher and the EIRR is slightly lower.	The plan has no fatal shortcoming to be implemented. The Plan requires less total project cost than Pla-1. No impact is anticipated on the socioecomomic environment: neither physical nor emotional to the residents near by.