3.3.2 Export Cargo

Compared with imported cargo, the amount of which has greatly fluctuated, the amount of cargo exported from Mina Qaboos has been steadily increasing in the last decade. The future cargo volume of exports can be estimated by a time series correlation analysis.

$$Y = 5.613t + 5.75 \quad (r = 0.962)$$

Where, Y : Cargo volume of exports ('000 tons)

t : Number of years from 1978

However, the estimate obtained from this equation does not consider the increase of the share of the ports that will be caused by the improvement and extension of Mina Qaboos and the development of a new port.

Table 3-3-6 shows the quantity of exports by points of exit from 1986 to 1988.

Table 3-3-6 Quantity of Exports by Points of Exit

(Unit: '000 tonnes, %)

Point of Exit	1988		1987		1986	
I. By Seaports	72.5	31.2%	60.8	35.0%	54.4	42.2%
A. Mina Qaboos	67.3	28.9%	57.7	33.3%	50.0	38.8%
B. Raysut	2.3	1.0%	1.2	0.7%	1.3	1.0%
C. Al Fahal	2.0	0.9%	1.1	0.6%	2.5	1.9%
D. Other Ports	0.9	0.4%	0.8	0.5%	0.6	0.5%
II. By Land (on the border of)	127.8	54.9%	90.5	52.2%	64.3	49.8%
A. Katmat Milaha (UAE)	6.6	2.8%	4.8	2.8%	5.2	4.0%
B. Wajaja (UAE)	88.5	38.0%	58.4	33.7%	34.5	26.7%
C. Wadi Al Jizzi (UAE)	9.9	4.3%	10.0	5.8%	8.8	6.8%
D. Hafeet (UAE)	22.3	9.6%	17.2	9.9%	15.8	12.2%
E. Others	0.5	0.2%	0.1	0.1%	0.0	0.0%
III. By Air	32.4	13.9%	22.2	12.8%	10.3	8.0%
A. Seeb	32.4	13.9%	22.2	12.8%	10.3	8.0%
Total	232.7	100%	173.5	100%	129.0	100%

Base upon: "Foreign Trade Statistics 1986 - 1988" (Royal Oman Police) and data from the PSC

Note : Since the figures of Mina Qaboos in "Foreign Trade Statistics (Royal Oman Police)" are much different from the actual figures provided by the PSC, the Study Team has modified the figures in the above table.

This table shows that only 30 - 40% of all the exports handled at Mina Qaboos and about 50% went by road to the UAE (mainly to Dubai).

Since the major export-trading partners of Oman are the GCC countries, overland transport has an advantage over ocean transport and it is not likely that the share of road transport will be reduced a great deal. However, taking into consideration that some Omani exports are re-exported from Dubai (Port Rashid, Jebel Ali Port) to other countries, there is still a possibility for the share of the ports to rise to 50% after the improvement and extensions of Mina Qaboos and the development of a new port.

The export cargo volume that will be handled at Mina Qaboos and a new port in 1995, 2000, 2010 and 2015 is shown in Table 3-3-7. (The share of the ports is assumed to be 40% for 1995 and 50% after 2000):

Table 3-3-7 Export Cargo Volume in 1995, 2000, 2010 and 2015

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Cargo volume	148	233	330	393

These results for imports and exports do not consider the cargo volume that will be provided by Free Trade Zone (FTZ) or some large-scale projects to be located near a new port. If such kinds of projects were to be planned, these figures would have to be revised.

3.3.3 Transshipment Cargo

The volume of transshipment cargo has been on the rise in recent years (annual growth rate between 1985 and 1988 recorded 46.3%) and accounted for 37.2% of the total cargo handled at Mina Qaboos in 1988. However, it is impossible that transshipments will continue increasing at such a high rate in the future.

At present the French shipping line, "Compagnie Maritime d'Affretement" (CMA), is the only major shipping line using Mina Qaboos as a transshipment base in the Gulf. It handles more than 80% of the total transshipment cargo at Mina Qaboos. In 1986 CMA started its Far-Eastern Services, which bring containers from Europe/Mediterranean/Red Sea to the

Far East via Mina Qaboos, with feeder services to Gulf countries. In addition to this, the firm started feeder services to Karachi, Bombay and Colombo in June 1989.

The role of Gulf as transshipment bases for major shipping lines with feeder services between Gulf and the sub-continent (Karachi, Bombay), East Africa and Australia has increased over the past decade. Among Gulf ports, Port Rashid (Dubai) is overwhelming the other ports and almost all major shipping lines use Port Rashid as a transshipment base. Even newly developed and efficient ports like Port Khor Fakkan and Port Fujairah are patronized only by specific shipping lines (e.g., APL for Fujairah).

The key factors for transshipment are less deviation from great circle routes, quicker dispatch and reduced operating costs. Of these, less deviation from the great circle line is the main sales point of Mina Qaboos, which is located outside the Persian Gulf, considering that it is 317 nautical miles and takes nearly twenty hours to travel from Muscat to Dubai. It is clear that Oman has an absolute geographical advantage over other Gulf countries as a transshipment base. If CMA still remains the only major user of Oman's ports, it cannot be expected that the volume of transshipment cargo will increase. However, when there are superior ports in Oman with enough capacity, high efficiency, price competitiveness and less bureaucratic red tape, there is a great possibility that other shipping lines will use Oman's ports instead of Dubai ports as transshipment bases, even though some will remain in Dubai, which is the Middle East's trading center. In that case, transshipment throughputs will make rapid progress in Oman.

Table 3-3-8 shows the container throughputs in Oman and UAE ports between 1980 and 1988. Although a breakdown into imports, exports or transshipments is not available, part of this container movement undoubtedly comprises latent demand for transshipment in Oman.

Table 3-3-8 Container Throughputs in Oman and UAE Ports

(Unit: TEU, %)

Year		1980	1981	1982	1983	1984	1985	1986	1987	1988
Mina Qaboos (Oman)	Total TEU	18,537	28,908	44,112	65,901	90,175	111,596	110,635	139,256	148,182
	% gain	55.16%	55.95%	52.59%	49.39%	36.83%	23.75%	-0.86%	25.87%	6.41%
Port Zayed (Abu Dhabi)	Total TEU	12,289	22,667	30,319	30,737	30,051	25,633	21,226	29,901	N.A
	% gain	100.93%	84.45%	33.76%	1.38%	-2.23%	-14.70%	-17.19%	40.87%	
Jebel Ali (Dubai)	Total TEU	64,221	108,231	102,304	124,569	151,968	144,693	146,073	72,471	69,771
	% gain	116.88%	68.53%	-5.48%	21.76%	22.00%	-4.79%	0.95%	-50.39%	-3.73%
Port Rashid (Dubai)	Total TEU	208,941	237,020	221,372	296,826	294,648	371,632	383,189	523,145	557,521
	% gain	23.03%	13.44%	-6.60%	34.08%	-0.73%	26.13%	3.11%	36.52%	6.57%
Fujairah (Fujairah)	Total TEU	0	0	0	636	87,096	132,910	138,558	188,129	202,893
	% gain	—	—	—	—	—	52.60%	4.25%	35.78%	7.85%
Khor Fakkan (Sharjah)	Total TEU	21,238	N.A	N.A	N.A	79,000	122,000	183,000	70,400	124,218
	% gain	—	—	—	—	—	54.43%	50.0%	-61.53%	76.45%
Port Khalid (Sharjah)	Total TEU	30,532	37,812	57,385	49,893	34,274	36,784	53,657	70,328	40,381
	% gain	-39.94%	23.84%	51.76%	-13.06%	-31.30%	7.32%	45.87%	31.07%	-42.58%
Grand Total	Total TEU	355,758	434,638	455,492	568,562	767,212	945,248	1,036,338	1,093,630	1,142,966
	% gain	31.41%	22.17%	4.80%	24.82%	34.94%	23.21%	9.64%	5.53%	4.51%

Source: "Containerization International Year Book 1980-89", PSC and Port Authorities in each port

The future container throughputs in Oman and UAE ports can be estimated by a time series correlation analysis.

$$Y = 111,069.77t + 200,189.4 \quad (r = 0.9823)$$

Where, Y : container throughputs in UAE and Oman (TEUs)
t : Number of years from 1980

However, the results of this equation show that the annual growth rate of container throughputs in the UAE and Oman will be 6.86% between 1988 and 2000, which is apparently too high considering the present situation of Gulf countries in which oil prices will remain low and where the boom of the early 1980's is not likely to happen again. Hence, the Study Team has estimated the annual growth rate to be 5% in the future. Table 3-3-9 shows the estimated result of container throughputs in Oman and UAE ports in 1995, 2000 and 2010.

Table 3-3-9 Container Throughputs in Oman and UAE Ports in 1995, 2000 and 2010

(Unit: TEUs)

Year	1995	2000	2010
Total TEU	1,608,268	2,052,603	3,343,474

In 1987 and 1988, the share of transshipment containers at Mina Qaboos of the total container throughputs in Oman and UAE ports was about 7% (Before the great increase in transshipments, Mina Qaboos had accounted for only 1 - 2%). It is very difficult to forecast the volume of transshipment cargo on a long term basis because the flow of transshipment cargo can be changed easily and rapidly. But based on the premises mentioned in the above paragraph, there is a possibility that Mina Qaboos and a new port will obtain a share of 10%. Table 3-3-10 shows the transshipment cargo volume which will be handled at Mina Qaboos and the new port in 1995, 2000, 2010 and 2015. (The share in 1995 is estimated to be 8%.)

Table 3-3-10 Transshipment Cargo Volume in 1995, 2000, 2010 and 2015

(Unit: TEUs, '000 tonnes)

Year	1995	2000	2010	2015
Total TEU	128,662	205,260	334,348	426,722
Tonnage	978	1,560	2,541	3,243

Note: Weight per TEU is estimated 7.6 tons/TEU, the same as in 1988

(4) Results of the Total Demand Forecast

Table 3-3-11 shows the results of the total demand forecast.

Table 3-3-11 Results of Total Demand Forecast

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Imports	1,459	1,967	2,774	3,295
Exports	148	233	330	393
Sub-total	1,607	2,200	3,104	3,688
Transshipments	978	1,560	2,541	3,243
Total	2,585	3,760	5,645	6,931

3.4 Commodity-wise Demand Forecast

The volume of each major commodity group is individually forecast and the total cargo volume is then calculated by the summation of these volumes.

Based upon classification by the PSC, the major commodity groups are categorized as follows:

Imports: Rice, Wheat, Other Grains, Sugar, Other Foodstuffs, Timber, Steel, Cement, Other Building Materials, Vehicles, Livestock, Other General Cargo

Exports: Fish, Copper, Chromite, Vehicles, Other General Cargo

3.4.1 Imports

(1) Rice

Since there is no production of rice in Oman, all the rice consumed in the country is imported.

Table 3-4-1 shows the import volume of rice in Oman and the cargo volume handled at Mina Qaboos from 1983 to 1988.

Table 3-4-1 Import of Rice

(Unit: '000 tonnes)

Year	Import Volume of Rice in Oman	Handled at Mina Qaboos
1983	62.8	48.7
1984	83.0	55.7
1985	69.8	61.8
1986	80.8	60.1
1987	83.4	60.5
1988	102.4	82.3

Source: "Foreign Trade Statistics 1986-88" (ROP)
PSC

Calculated based upon an estimated population of 1.45 million, per capita consumption of rice in Oman for 1988 is estimated to have been 70.7kg. Per capita consumption of wheat, which will be mentioned in the next section, is 69.0kg/year, which means that per capita consumption of rice and wheat totals 139.7kg/year in Oman.

Table 3-4-2 shows per capita consumption of rice and wheat in some Arabian countries and some other countries in the world.

Table 3-4-2 Per Capita Consumption of Rice & Wheat (1979-81)

(Unit: kg/year)

Country	Rice Consumption per Capita	Wheat Consumption per Capita	Total	GNP per Capita 1981 (US$)
UAE	68.6	62.2	130.8	30,520
Kuwait	81.8	87.7	169.5	20,590
Egypt	46.3	148.3	194.6	530
Libya	21.3	172.0	193.3	9,150
Saudi Arabia	56.2	86.3	142.5	14,360
Tunisia	0.9	183.4	184.3	1,390
India	103.3	44.5	147.8	270
Malaysia	152.9	33.8	186.7	1,890
United Kingdom	2.7	83.3	86.0	9,270
United States	6.2	71.0	77.2	13,270

Source: "Food Balance Sheets 1979-81 Average" (FAO, 1984)

Although the consumption of food depends upon the eating habits in the region and cannot be generalized, it seems that there is some room for per capita consumption of rice to increase in the future. Therefore, in this Study, it is assumed that per capita consumption of rice will increase by 1% per annum during the planning period.

The consumption of rice, i.e., the import of rice, is then estimated by multiplying per capita consumption by the population in the future.

Per capita consumption of rice and the volume of rice imports are shown in Table 3-4-3.

Table 3-4-3 Per Capita Consumption of Rice and Import Volume

Year	1995	2000	2010
Per Capita Consumption of Rice (kg/year)	75.8	79.7	88.0
Volume of Rice Imports ('000 Tonnes)	139.8	174.5	271.8

Approximately 70 - 80% of rice imports have been handled at Mina Qaboos in the last few years. After the development of the nation's ports, the share of the ports will rise to 90% by the year 2000. (85% is estimated for 1995.) The figure for the year 2015 is extrapolated from the figures for 2000 and 2010.

The results of the forecast are shown in Table 3-4-4:

Table 3-4-4 Forecast Cargo Volume of Rice at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	118.8	157.1	244.6	305.2

(2) Wheat

Almost all wheat imports are handled by Oman Flour Mills Company Ltd. (S.A.O.). The firm imports all of the wheat through Mina Qaboos.

Wheat is used for: 1) production of flour, 2) animal feed, 3) exports to Saudi Arabia and the UAE, 4) supply to the countryside as wheat itself or semi-products.

According to an interview with Oman Flour Mills Co., approximately 25,000 - 30,000 tons of wheat are used for the items 2) - 4). It is not likely that wheat consumption for these purposes will increase greatly in the future. Therefore, only a slight increase is assumed in this Study. (The results are: 30,000 tons in 1995, 35,000 tons in 2000 and 45,000 tons in 2010. All of the wheat consumed will be imported.)

The production capacity of Oman Flour Mills Co. is 100,000 tons a year, which seems to satisfy domestic demand in Oman. As with rice, per capita consumption of wheat for 1988 can be estimated at 69.0kg/year in Oman and is assumed to increase an estimated 1% per annum during the planning period.

The consumption, i.e., the import volume of wheat for flour production, is then estimated by multiplying per capita consumption by the future population. The results are shown in Table 3-4-5:

Table 3-4-5 Per Capita Consumption of Wheat and Import Volume

Year	1995	2000	2010
Per Capita Consumption of Wheat (kg/year)	74.0	77.8	85.9
Volume of Wheat Imports ('000 Tonnes)	136.5	170.4	265.3

These results show that the total per capita consumption of rice and wheat will be 173.9kg/year in 2010. This figure seems to be reasonable, given the figures in Table 3-4-2.

The summation of the figures in Table 3-4-5 and the consumption for uses of other than flour production gives the total import volume of wheat in Oman. As concerns wheat, all the import will be through Mina Qaboos and a new port.

The results of the forecast are shown in Table 3-4-6.

Table 3-4-6 Forecast Cargo Volume of Wheat at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	166.5	205.4	310.3	381.4

(3) Other Grains

Other grains consist of grains for animal feed such as barley, maize and other cereals. In the absence of output projection for animal feed, it is difficult to forecast the future cargo volume of other grains. Therefore, in this Study it is assumed that the growth rate of cargo volume in this category is the same that of the GDP.

The cargo volume of other grains in 1995, 2000, 2010 and 2015 is shown in Table 3-4-7.

Table 3-4-7 Forecast Cargo Volume of Other Grains at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	37.8	44.9	63.3	75.2

(4) Sugar

Table 3-4-8 shows the import volume of sugar in Oman and the cargo volume handled at Mina Qaboos from 1981 to 1988.

Table 3-4-8 Import of Sugar

(Unit: '000 tonnes)

Year	Import Volume of Sugar in Oman	Handled at Mina Qaboos
1981	21.4	4.8
1982	17.7	4.3
1983	25.4	6.0
1984	37.8	19.4
1985	22.1	7.5
1986	25.6	17.1
1987	31.1	16.0
1988	36.6	22.7

Source: "Statistical Year Book" (DC), PSC

Calculated based on the estimated population, per capita consumption of sugar in Oman in 1988 is estimated to have been 25.3kg/year. (All the sugar consumed in Oman is imported.)

Per capita consumption of sugar in some Arabian countries and some other countries in the world is shown in Table 3-4-9.

Table 3-4-9 Per Capita Consumption of Sugar (1979-81)

(Unit: kg/year)

Country	Sugar Consumption per Capita	GNP per Capita 1981 (US$)
UAE	41.7	30,520
Kuwait	49.7	20,590
Egypt	59.1	530
Libya	43.8	9,150
Saudi Arabia	29.0	14,360
Tunisia	26.4	1,390
Turkey	26.1	1,450
Singapore	47.8	5,450
Philippines	24.5	770
India	20.2	270
Mexico	43.7	3,000
United Kingdom	44.9	9,270
United States	60.0	13,270
Japan	26.6	10,390

Source: "Food Balance Sheets 1979-81 Average" (FAO, 1984)

This table shows that per capita consumption of sugar in Oman is still at a lower level than other countries with high GNPs like Oman. Therefore, in this Study, it is assumed that per capita consumption of sugar will increase to 40kg/year by the year 2010.

The consumption of sugar, i.e., the import of sugar is then estimated by multiplying per capita consumption by the future population.

Per capita consumption of sugar and the import volume of sugar are shown in Table 3-4-10.

Table 3-4-10 Per Capita Consumption of Sugar and Import Volume

Year	1995	2000	2010
Per Capita Consumption of Sugar (kg/year)	29.3	32.5	40.0
Volume of Wheat Imports ('000 Tonnes)	54.0	71.2	123.6

Nearly 30% of the sugar imported by Oman has entered through Wajaja from the UAE and only 50 - 60% has been handled at Mina Qaboos in the last few years. After the development of the ports, the share of the ports will rise to 80% by the year 2000. (70% is estimated for 1995.)

The result of the forecast is shown in Table 3-4-11.

Table 3-4-11 Forecast Cargo Volume of Sugar at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	37.8	57.0	98.9	130.3

(5) Other Foodstuffs

Other major foodstuff commodities are chilled/frozen foods such as lamb and poultry, milk, dairy food, vegetables, fruit, coffee and so forth.

The correlation equation between the import volume of other foodstuffs and GDP(R) is as follows:

$$Y = 0.1846X - 205.3 \quad (r = 0.9182)$$

Where, Y: Import volume of other foodstuffs ('000 tons)

X: GDP(R) (Million RO)

The results of the calculation are shown in Table 3-4-12.

Table 3-4-12 Import Volume of Other Foodstuffs

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	340.7	432.5	637.7

More than 30% of all the other foodstuffs are accounted for by fresh fruit and vegetables, 85% of which enters by road, mainly from Dubai. Considering that Dubai is established as a distribution center of the Middle East for perishable foods, it is difficult to imagine that this route will change easily in the future. Therefore, it is assumed that the share of the ports will be 65% by the year 2000. (55% is estimated for 1995.)

Taking into consideration the past record of chilled/frozen foodstuffs handled at Mina Qaboos, the percentage of chilled/frozen foodstuffs to other foodstuffs is assumed to be 40%.

The result of the forecast is shown in Table 3-4-13:

Table 3-4-13 Forecast Cargo Volume of Other Foodstuffs at Mina Qaboos & New Port

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Chilled & Frozen Foodstuffs	75.0	112.4	165.8	201.4
Other Foodstuffs	112.4	168.7	248.7	302.0

(6) Timber

The elasticity coefficient of the growth rate of timber imports to that of the GDP of the construction sector was 0.72 from 1981 to 1984 and 0.84 from 1985 to 1988.

Considering the above, it is assumed that the elasticity coefficient will be 0.8 for the planning period.

The import volume of timber in Oman is shown in Table 3-4-14.

Table 3-4-14 Import Volume of Timber

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	118.2	130.5	159.1

The share of Mina Qaboos has been 60 - 70% for the last few years, which seems to be rather low considering that timber is suitable for sea transport. Therefore, in this Study it is assumed that the share of the ports will rise to 95% by the year 2000. (85% is estimated for 1995.)

The results of the forecast are shown in Table 3-4-15:

Table 3-4-15 Forecast Cargo Volume of Timber at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	100.5	124.0	151.1	166.8

(7) Steel & Pipes

The correlation equation between the import volume of steel & pipes and GDP(R) is as follows:

$$Y = 0.22924X_1 - 162.38X_2 - 228.05$$

Where, Y : Import volume of steel & pipes ('000 tons)

X_1: GDP(R) (Million RO)

X_2: Dummy variable (=1 from 1986 on)

$r = 0.9122$

$F - \text{value} = 17.344 > F(2,7:0.005) = 12.404$

Durbin - Watson's ratio = 2.517

The results of the calculation are shown in Table 3-4-16.

Table 3-4-16 Import Volume of Steel

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	287.7	401.6	656.5

Only 50 - 60% of the total amount of imports has been handled at Mina Qaboos and it is obvious from interviews with some of the Omani road transport companies that what should be imported through Mina Qaboos has actually entered by road via the UAE owing to problems concerning port capacity, high tariffs and red tape.

On the other hand, some of the imported steel has originated from GCC countries such as Qatar and Kuwait, where sea transport does not seem to have an advantage.

Considering the above situation, it is assumed that the share of the ports will increase to 90% by the year 2000. (80% is estimated for 1995.)

The results of the forecast are shown in Table 3-4-17:

Table 3-4-17 Forecast Cargo Volume of Steel at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	230.2	361.4	590.9	755.6

(8) Cement

There are two cement companies in Oman at present:

(i) Oman Cement Co. (production capacity : 600,000 tons/year)

(ii) Raysut Cement Co. (production capacity : 220,000 tons/year)

The capacity of the factories is enough to satisfy the domestic demand for cement in Oman. They also have a plan to increase their production to meet revived demand in future.

However, Oman has imported special kinds of cement such as white Portland cement and supersulphate cement which Oman has no projects for producing and will continue to be imported in the future.

For the estimation of the import of cement, it is assumed that the growth rate of imports will be the same as that of the GDP of the construction sector.

The estimated volume of cement imports in Oman is shown in Table 3-4-18:

Table 3-4-18 Import Volume of Cement

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	22.5	25.5	32.6

Only 40 - 50% of the imports has been handled at Mina Qaboos and the rest has entered by road, because more than 50% of the imported cement comes form the UAE. Therefore, in this Study it is assumed that the share of the ports will be 50%.

The results of the forecast are shown in Table 3-4-19:

Table 3-4-19 Forecast Cargo Volume of Cement at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	11.3	12.8	16.3	18.4

(9) Other Building Materials

Other building materials consist of paints, asbestos, tiles & bricks, etc.

The correlation equation between the import volume of other building materials and the GDP of the construction sector is as follows:

$$Y = 0.6179X - 23.67 \qquad (r = 0.9210)$$

Where, Y : Import volume of other building materials ('000 tons)
X : GDP of construction sector (Million RO)

The results of the calculation are shown in Table 3-4-20.

Table 3-4-20 Import Volume of Other Building Materials

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	65.1	76.7	104.9

The share of Mina Qaboos is only 40 - 50% at present. However, because of the development of Oman's ports, it is assumed that the share of the ports will increase to 80% by the year 2000. (60% is estimated for 1995.)

The results of the forecast are shown in Table 3-4-21:

Table 3-4-21 Forecast Cargo Volume of Other Building Materials at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	39.1	61.4	83.9	98.1

(10) Vehicles

Statistics concerning vehicle registration in 1987 and 1988 are shown in Table 3-4-22.

Table 3-4-22 Vehicle Registration in 1987 and 1988

Year	1987	1988
Newly Registered Vehicles	13,740	14,710
Cancelled Vehicles	3,895	7,712
Total Number of Vehicles	178,638	185,636

Source: "Statistical Year Book 1987-1988" (DC)

The volume of the import of vehicles is forecast on the assumption that:

* the ownership ratio of vehicles will reach the level of one unit to seven persons in 2000.
* the cancellation ratio will also rise to 10% in 1995.
* all of the newly registered vehicles will be imported.
* weight per unit is two tons (the average weight for the past eight years).

The estimated import volume of vehicles in Oman is shown in Table 3-4-23.

Table 3-4-23 Import Volume of Vehicles

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	69.9	88.1	140.0
(Numbers)	(34,929)	(44,041)	(70,017)

More than 90% of all the imported vehicles are handled at Mina Qaboos at present. Therefore, it is assumed that the share of the ports will be 95% for the planning period.

The results of the forecast are shown in Table 3-4-24:

Table 3-4-24 Forecast Cargo Volume of Vehicles at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	66.4	83.7	133.0	167.7
(Numbers)	(33,183)	(41,839)	(66,516)	(83,868)

(11) Livestock

For the estimation of the import of livestock, the future annual growth rate of Oman's population and the volume of imported livestock in 1988 are used.

The estimated volume of livestock imports in Oman is shown in Table 3-4-25:

Table 3-4-25 Volume of Livestock Imports

(Unit: '000 tonnes)

Year	1995	2000	2010
Import Volume	17.8	21.2	29.8

The share of Mina Qaboos at present is quite high and very little livestock enters Oman by road. Therefore, it is assumed that the share of the port will be 98%.

The results of the forecast are shown in Table 3-4-26. (Weight per head is assumed at 50kg, which is the average weight for the past five years.)

Table 3-4-26 Forecast Cargo Volume of Livestock at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	17.4	20.8	29.2	34.6
(Heads)	(349)	(416)	(584)	(692)

(12) Other General Cargo

The correlation equation between the volume of the other general cargo handled at Mina Qaboos and GDP(R) is as follows.

$$Y = 0.1702X - 93.45 \qquad (r = 0.9279)$$

Where, Y : Volume of other general cargo handled at Mina Qaboos ('000 tons)

X : GDP(R) (Million RO)

According to the statistics for 1987 and 1988, nearly 90% of all the other general cargo is imported through Mina Qaboos and it is not likely that the share of the ports will rise in the future. Therefore, the increase of the share of the ports is not taken into account.

The results of the forecast are shown in Table 3-4-27:

Table 3-4-27 Forecast Cargo Volume of Other General Cargo at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	410.0	494.6	683.8	804.0

3.4.2 Exports

(1) Fish

Fishery is a sector on which the Government of Oman has put an emphasis in past Five-Year plans. It will likely continue to do so in the future, as well as emphasizing agriculture and manufacturing. In this Study, it is assumed that fish exports will increase at the same rate as that of the GDP of the agriculture/fishery sector.

Table 3-4-28 shows the export volume of fish of Oman in 1995, 2000 and 2010.

Table 3-4-28 Export Volume of Fish

(Unit: '000 tonnes)

Year	1995	2000	2010
Export Volume	57.2	84.0	150.4

The share of Mina Qaboos in recent years has been around 50%. After the development of the ports, it is possible that this share will rise to 70% by the year 2000. (60% is estimated for 1995.)

The results of the forecast are shown in Table 3-4-29:

Table 3-4-29 Forecast Cargo Volume of Fish
at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	34.3	58.8	105.3	140.9

(2) Copper

Since there is no increased production schedule of copper in Oman, 15,000 tons are assumed to be exported through the ports hereafter, taking into consideration the past record of copper exports and the present production capacity of 20,000 tons.

(3) Chromite

A feasibility study on chrome ore is now under implementation by the United Nations Industrial Development Organization (UNIDO) and no chromite is now produced. It is impossible to forecast the cargo volume without the result of this study. However, this F/S by UNIDO will take so long that the result will not be available for our Study. Therefore, in this Study, taking into account that there is a possibility for chromite to become one of Oman's staple exports, the cargo volume of chromite is estimated as shown in Table 3-4-30:

Table 3-4-30 Forecast Cargo Volume of Chromite at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	10.0	50.0	50.0	50.0

(4) Vehicles

A small number of vehicles are re-exported to the other GCC countries from Oman. Considering the trend in recent years, the future export volumes are estimated as shown in Table 3-4-31. (Weight per unit is estimated at two tons, the same figure used for imports.)

Table 3-4-31 Forecast Cargo Volume of Vehicles (Re-export) at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	9.0	12.0	20.0	25.8
(Number)	(4,500)	(6,000)	(10,000)	(12,900)

(5) Other General Cargo

The future cargo volume of the other general cargo is obtained using a time series analysis.

As mentioned in the total demand forecast, the share of the ports will increase to some extent after the development of Oman's ports and this factor should be taken into account.

The results of the forecast are shown in Table 3-4-32.

Table 3-4-32 Forecast Cargo Volume of Other General Cargo at Mina Qaboos & New Port

(Unit: '0000 tonnes)

Year	1995	2000	2010	2015
Cargo Volume	62.6	95.7	137.0	163.9

3.4.3 Results of the Commodity-wise Demand Forecast

Table 3-4-33 shows the results of the commodity-wise demand forecast.

Table 3-4-33 Results of Commodity-wise Demand Forecast (Import and Export Cargo Volume at Mina Qaboos & New Port by Commodity)

(Unit: '000 tonnes)

	1995	2000	2010	2015
(Imports)				
Rice	118.8	157.1	244.6	305.2
Wheat & Flour	166.5	205.4	310.3	381.4
Other Grains	37.8	44.9	63.3	75.2
Sugar	37.8	57.0	98.9	130.3
Chilled & Frozen Foodstuffs	75.0	112.4	165.8	201.4
Other Foodstuffs	112.4	168.7	248.7	302.0
Timber	100.5	124.0	151.1	166.8
Steel & Pipes	230.2	361.4	590.9	755.6
Cement (bagged)	11.3	12.8	16.3	18.4
Other Building Materials	39.1	61.4	83.9	98.1
Vehicles	66.4	83.7	133.0	167.7
Livestock	17.4	20.8	29.2	34.6
Other General Cargo	410.0	494.6	683.8	804.0
Total	1,423.2	1,904.2	2,819.8	3,440.5
(Exports)				
Fish	34.3	58.8	105.3	140.9
Copper	15.0	15.0	15.0	15.0
Chromite	10.0	50.0	50.0	50.0
Vehicles	9.0	12.0	20.0	25.8
Other General Cargo	62.6	95.7	137.0	163.9
Total	130.9	231.5	327.3	395.7

Compared with the results of the total demand forecast, these results seem to be fairly reasonable. Therefore, the level of future cargo volumes obtained by the commodity-wise demand forecast are adopted for the development plans for Mina Qaboos and a new port in this Study.

3.5 Summary of the Forecast

The future cargo volume to be handled at Mina Qaboos and a new port during the planning period is shown in Table 3-5-1.

Fig. 3-5-1 shows the past trend and the forecast of the total cargo volume at Mina Qaboos and a new port.

Table 3-5-1 Summary of the Forecast

(Unit: '000 tonnes)

Year	1995	2000	2010	2015
Imports	1,423	1,904	2,820	3,440
Exports	131	232	327	396
Sub-total	1,554	2,136	3,147	3,836
Transshipments	978	1,560	2,541	3,243
Total	2,532	3,696	5,688	7,079

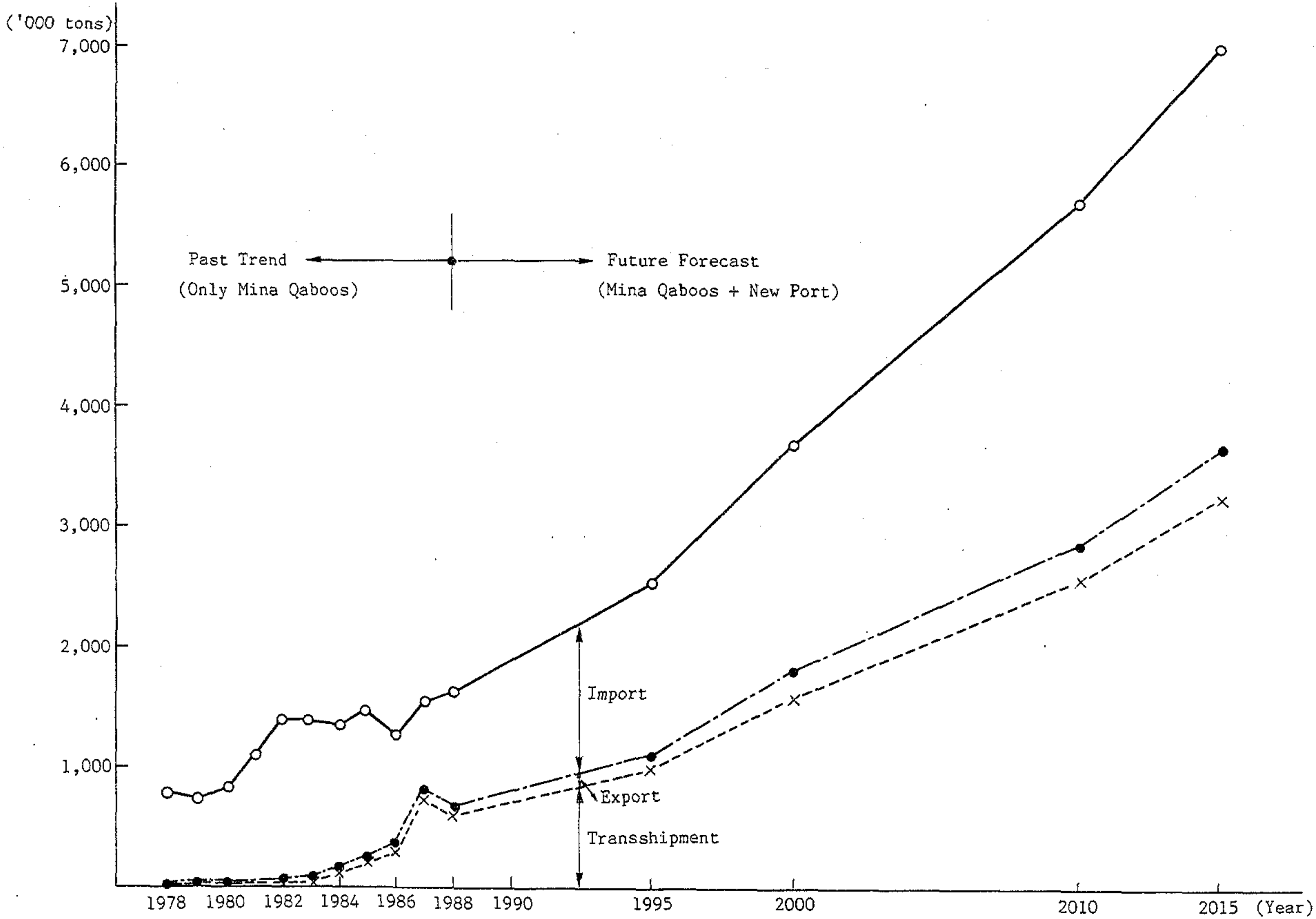

Fig. 3-5-1 Past Trend and Future Forecast of Total Cargo at Mina Qaboos & New Port

3.6 Cargo Volume by Handling Mode

(1) Bulk Cargo

Major bulk cargo commodities are wheat and other grains in terms of imports, and chromite in terms of exports. The cargo volume of these commodities is forecast by commodity in the last section.

In addition to these, other bulk cargoes are handled at Mina Qaboos, such as vegetable oil and bitumen. Since no detailed data on the other bulk cargoes are available, the forecast is carried out by the ratio of the volume of the other bulk cargo to the summation of other foodstuffs and other general cargo. (The ratio is estimated at 6%, based upon the average ratio for the last several years.)

(2) Container Cargo

The volume of container cargo and the number of containers are forecast by using the following procedure:

(a) Selection of containerizable cargo
(b) Estimation of the ratio of container cargo to containerizable cargo
(c) Estimation of the volume of container cargo and the number of containers

(a) Containerizable Cargo

Containerizable import cargo in Oman is composed of rice, sugar, chilled & frozen foodstuffs, other foodstuffs, bagged cement, other building materials and other general cargo excluding bulk cargo.

The volume of containerizable cargo is calculated as the sum of these commodities.

As regards export cargo, all the cargo, except chromite, is considered as containerizable cargo.

(b) Ratio of Containerization

Table 3-6-1 shows the past trend of the ratio of container cargo volume to containerizable cargo volume.

Table 3-6-1 Ratio of Containerization at Mina Qaboos

(Unit: '000 tonnes, %)

Year	Imports			Exports		
	Containerizable Cargo Volume	Container Cargo Volume	Ratio of Containerization	Containerizable Cargo Volume	Container Cargo Volume	Ratio of Containerization
1981	636.2	155.5	24.44%	21.6	2.8	12.96%
1982	651.7	220.0	33.75%	31.8	6.3	19.81%
1983	591.2	322.1	54.48%	38.8	12.3	31.70%
1984	653.7	412.3	63.07%	45.2	34.5	76.33%
1985	687.7	471.0	68.49%	60.9	32.3	53.04%
1986	574.3	416.6	72.54%	45.1	43.5	96.45%
1987	471.8	360.3	76.37%	57.7	50.5	87.52%
1988	530.3	385.9	72.77%	67.2	60.2	89.57%

The maximum limit of the ratio of containerization for import cargo is assumed to be 80% after estimating the containerized ratio of each commodity.

The ratio of containerization during the planning period is expressed by the following equation:

$$Y = \frac{80}{1+e^{(1031.774-0.5206t)}} \qquad (r = 0.9486)$$

Where, Y : Ratio of containerization (%)
t : Year

Fig. 3-6-1 shows the logistic curve and the past records of the ratio of containerization for import cargoes.

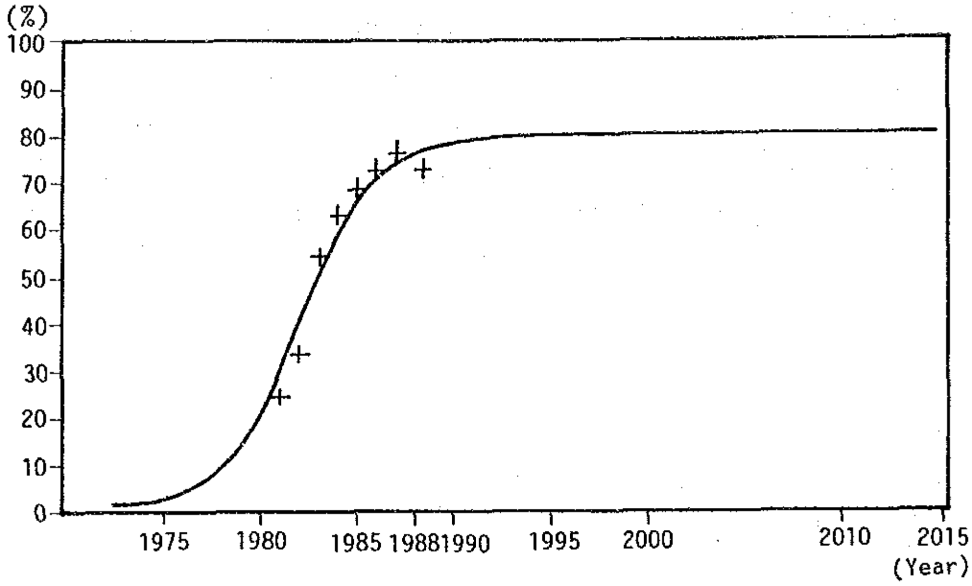

Fig. 3-6-1 Ratio of Containerization

As concerns exports, the ratio of containerization has reached nearly 90%, which seems to be the maximum. Therefore, it is assumed that the ratio of containerization for export cargo will remain at 90% during the planning period.

(c) Container Cargo Volume and Number of Containers

The cargo volume of containers for import and export is calculated by multiplying the containerizable cargo volume estimated in (a) by the ratio of containerization mentioned in (b).

The cargo volume in TEUs is then estimated by dividing the container cargo volume above by the tonnage per TEU of 11.8 tons and 11.0 tons for imports and exports, respectively. However, this result does not consider empty containers. Therefore, after the TEUs of empty containers, the ratio of which is assumed to be 3% for import containers, is added, the final amount of TEUs is obtained. (The tonnage per TEU and the ratio of empty containers is assumed based upon the actual figures for the last few years.)

As regards transshipment containers, weight per TEU is assumed to be 7.6 tons, as mentioned in the total demand forecast.

In calculating the number of containers, the ratio of 20-foot containers and 40-foot ones is assumed to be fifty-fifty during the planning period.

Table 3-6-2 shows the future cargo volume by handling mode and Table 3-6-3 shows the future cargo volume of containers.

Table 3-6-2 Cargo Volume at Mina Qaboos & New Port by Handling Mode

(Unit: '000 tonnes)

	1995	2000	2010	2015
(Imports)				
Bulk Grain	204.3	250.3	373.6	456.6
Other Bulk	31.3	39.8	56.0	66.4
Vehicles	66.4	83.7	133.0	167.7
Livestock	17.4	20.8	29.2	34.6
Timber	100.5	124.0	151.1	166.8
Steel & Pipes	230.2	361.4	590.9	755.6
Other Break-bulk	155.3	204.9	297.2	358.6
Containers	617.7	819.3	1,188.8	1,434.4
Total	1,423.2	1,904.2	2,819.8	3,440.5
(Exports)				
Containers	108.8	163.4	249.6	311.1
Break-bulk	12.1	18.2	27.7	34.6
Bulk	10.0	50.0	50.0	50.0
Total	130.9	231.5	327.3	395.7

Table 3-6-3 Future Container Cargo at Mina Qaboos & New Port

(Import)

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total (TEU)	Boxes of 20ft.	Boxes of 40ft.	Boxes of Containers
1995	52,352	97.0	1,619	3.0	53,971	26,986	13,493	40,478
2000	69,429	97.0	2,147	3.0	71,576	35,788	17,894	53,682
2010	100,749	97.0	3,116	3.0	103,865	51,933	25,966	77,899
2015	121,556	97.0	3,759	3.0	125,315	62,658	31,329	93,986

(Export)

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total (TEU)	Boxes of 20ft.	Boxes of 40ft.	Boxes of Containers
1995	9,892	18.3	44,079	81.7	53,971	29,986	13,493	40,478
2000	14,850	20.7	56,726	79.3	71,576	35,788	17,894	53,682
2010	22,688	21.8	81,177	78.2	103,865	51,933	25,966	77,899
2015	28,281	22.6	97,034	77.4	125,315	62,658	31,329	93,986

(Transshipment)

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total (TEU)	Boxes of 20ft.	Boxes of 40ft.	Boxes of Containers
1995	64,331	50	64,331	50	128,662	64,330	32,166	96,496
2000	102,630	50	102,630	50	205,260	102,630	51,315	153,945
2010	167,174	50	167,174	50	334,348	167,174	83,587	250,761
2015	213,361	50	213,361	50	426,722	213,360	106,681	320,041

The summary of the cargo volume by handling mode is shown in Table 3-6-4.

Table 3-6-4 Summary of Cargo Volume by Handling Mode

(Unit: '000 tonnes)

Year	Bulk	Break-bulk	Container (TEUs)	Total
1995	246	582	1,705 (236,604)	2,532
2000	340	813	2,543 (348,412)	3,696
2010	480	1,229	3,979 (542,078)	5,688
2015	573	1,518	4,988 (677,352)	7,079

CHAPTER 4 A NEW PORT CONSTRUCTION AND ITS CHARACTERISTICS

Chapter 4 A NEW PORT CONSTRUCTION AND ITS CHARCTERISTICS

4.1 Necessity of a New Port in the Northern Part of Oman

(1) Present Port Capacity of Mina Qaboos

Mina Qaboos handled about 1.62 million tons of cargoes which comprised import, export and transshipment cargoes, in 1988. The proportion of import cargoes was about 58.5 percent of the total cargo volume, that of export cargoes was about 4.3 percent and that of transshipment cargoes was about 37.1 percent.

The total cargo throughput at Mina Qaboos during these 7 years was almost always around 1.5 million tons. The average waiting time was found to be 0.22 day in 1988 according to the analysis of our own study. Some vessels waited due to the draft restriction and others waited due to the non-availability of suitable berths. Judging from the present average waiting time, present port operation conditions and the annual throughput, the present capacity of Mina Qaboos seems to be around 1.5 million tons.

(2) Future Cargo Demand in the Northern Part of Oman

The projected cargo volumes in the Northern Part of Oman are about 3.7 million tons is 2000 and 7.1 million tons in 2015, In 2000, the proportion of import cargoes will be 51.5 percent of the total project cargoes, that of exports will be 6.3 percent and that of transshipment cargoes will be 42.2 percent. In 2015, the import cargo rate will be 48.6 percent, the export cargo rate will be 5.6 percent and the transshipment cargo rate will be 45.6 percent.

(3) Future Port Capacity of Mina Qaboos

The cargo handling capacity of Mina Qaboos is estimated to be about 2.6 million tons in 2000 after the economically feasible expansion and improvement which comprise the reclamation in Shutaify Bay and the strengthening of cargo handling equipment and manpower, and the improvement of the operating system including the introduction of an effective 3-shift system. The capacity is defined under the precondition that the average vessel waiting time should be less than 3 hours/vessel. Excessively long waiting times deter container liners, especially liners trading transshipment containers from using Mina Qaboos and eventually the future container throughput would decrease. The further expansion of Mina Qaboos which CES had suggested was not economical because the construction cost of breakwaters up to the depth of 35 m seemed to be extraordinarily expensive compared with the expandable quay length. The revised cost estimates are listed in Appendix 4-1-1. Moreover, there would be no further possible way of expanding Mina Qaboos after lengthening the breakwaters.

4.1.1 A Supplementary Port of Mina Qaboos

Comparing the forecast cargo throughput in 2000 with the capacity of Mina Qaboos in 2000, 1.1 million tons of cargo will overflow from Mina Qaboos. The transshipment cargo volume was about 0.6 million tons in 1988. The forecast transshipment cargo volume in 2000 is 1.6 million tons, and even if the transshipment cargo volume remains at the same level as in 1988, the total cargo throughput would be 2.7 million tons in 2000. If Oman intends to increase its handling of transshipment cargoes, the need for a new port in the Northern Part of Oman is clear. Even if Oman stops handling transshipment cargoes, a capacity of 2.6 million tons would seem very small for Oman.

4.1.2 Spearhead to Develop Industries and Regional Development

The government of Oman is now promoting the development of non-oil industries in order to diversify the sources of national income to augment and eventually replace oil resources which is said to be exhausted within 20 years. The policy will be fruitful, if strong aggressive strategies are adopted and promoted by the government and the private sector.

In order to develop new industries a new port in the Northern Part of Oman is indispensable, as stated later in 4.3.3.

The population of Oman was estimated at 1.5 million in 1989. The population is projected to increase at a rate of 3.5 percent for at least the next 10 years. The government of Oman has a basic policy of giving due attention to local human resources and improving their capabilities of contributing to the national economy in order to prevent consentration to already densely populated urban centers and to promote regional development. In order to promote regional development, a new port in the

Northern Part of Oman is indispensable, as stated later in 4.3.3 and 4.3.4.

As of 1988, the export cargo share is now only about 4 percent of the total amount of cargo handled at Mina Qaboos. The government of Oman is now adopting policies to promote non-oil industries and seeking income sources other than oil. The government of Oman has already developed the Rusayle Industrial Estate and is now planning other four Industrial Estates. As analyzed later in 4.3.3, the industries in the Rusayl Industrial Estate are also export industries as well as import substitute industries. In order to develop new Industrial Estates in the area far from Mina Qaboos, a new port in the Northern Part of Oman is also indispensable to export products.

4.2 Timing of New Port Development

4.2.1 Comparison of Expanded Capacity of Mina Qaboos with the Future Cargo Demand in the Northern Part of Oman

The forecast cargo demand in the Northern Part of Oman is as follows, according to our own estimation;

Table 4-2-1 Forecast Cargo Demand

(Unit: '000 tonnes)

Year	1988	1995	2000	2010	2015
Imports	951	1,423	1,904	2,820	3,440
Exports	70	131	232	327	396
Sub-total	1,021	1,554	2,136	3,147	3,836
Transshipments	604	978	1,560	2,541	3,243
TOTAL	1,625	2,532	3,696	5,688	7,079

As the capacity of Mina Qaboos is estimated at 2.6 million tons (4.1(3)), the forecast cargo volume will be at the upper limit of Mina Qaboos in 1995.

In 2000, Mina Qaboos will not be able to handle the forecast cargo volume, accordingly, a new port must be in operation in 2000 at the latest.

4.2.2 Timing of New Port Development from the Viewpoint of Other Factors

From the viewpoint of a spearhead to develop industry and regional development, it is hoped that a new port in the Northern Part of Oman will be in operation as soon as possible, because there is no possible way to develop industries without a port in the area far from Mina Qaboos as presented later in 4.3.3.

Judging from the amount of construction costs needed to expand Mina Qaboos as presetned in Chapter 9 of Volume II, and the construction costs of a new port presented later in Chapter 9, the construction of a new port will not be possible between 1991 and 1995.

Judging from the implementation schedule which is presented later in 11.2.4, the required construction period is at least 4 years, so the commission date of a new port would be at the end of 1999 if construction were to start at the beginning of 1996.

Before starting construction, detailed design of the various facilities and detailed site investigation in support of detailed design work must be completed. The budget for implementing the detailed site investigation and detailed design must be taken account of in the next five-year plan in order to ensure the new port is in operation at the end of 1999.

According to the scope of the study, the target year to formulate a master plan of a new port is 2015.

4.3 Potential Functions of a New Port

Mina Qaboos is now the only commercial port in the Northern Part of Oman, so the hinterland includes almost the whole of the national land area, except Mussandum and the Southern Region. Accordingly, a new port in the Northern Part of Oman will have the same potential functions as Mina Qaboos.

On the other hand, the government of Oman is now promoting industrialization to replace oil resources and regional development outside the Capital Area to reduce overcentralization. In Appendix 4-3-1, the long-term targets and policies of the Omani government are summarized. New port development can frequently play a role in spearheading industrial and regional development.

Modern ports can play various roles not only as a node between land and sea transportation but also as a core of regional, socio-economic, industrial and tourism development. In considering the potential functions of a new port, we selected the following port functions and analyzed their respective potentials:

(1) Import Cargo Handling Function
(2) Transshipment Cargo Handling Function
(3) Industrial Port Function
(4) Free Trade Zone Function
(5) Fishery Port Function
(6) Other Functions

4.3.1 Import Cargo Handling Function

According to the share of import cargoes by point of entry, as shown in Appendix 4-3-2, the import cargo share of Mina Qaboos was only 58.3 percent of Oman's total import cargoes in 1988. The import cargo share by road occupied 29.6 percent in 1988. This suggests that some portion of import cargoes is handled in Dubai Port and transported by road to the Northern Part of Oman.

According to the Report on the "Batinah Regional Plan" which was conducted by Weidleplan in 1989, the limit of influential area from Dubai in Al-Batinah was shown to be up to Suweiq. This illustrates that there are some potential cargo demands for a new port along the Batinah coast.

According to the analysis of population distribution and population growth rate as shown in Appendix 4-3-2, it seems that the population in Al-Batinah has a big share of the total population and that this will increase in the future. Most of the import cargoes in Oman are consumer's goods. So the area in which population will increase in the future can be said to have good potential for import cargo handling ports.

4.3.2 Transshipment Cargo Handling Function

Mina Qaboos handled transshipment cargoes totaling 80,000 TEUs (604,000 tons) in 1988. Port Rashid, located in Dubai, UAE, handled transshipment cargoes totaling 3,069,000 tons between January and October 1989. Compared with transshipment cargo volumes handled at other ports in the Arabian Gulf, Port Rashid has the overwhelming share at present. But Oman occupies a geographically advantageous location as a transshipment base for other ports in the Arabian Gulf. The following table shows the required time for the voyage to various sites from Jeddah and Singapore.

Table 4-3-1 Required Time from Jeddah and Singapore

Hub Port	Vessel Speed	Required Time (Jeddah-Hub Port)	Required Time (Hub Port-Singapore)
Qaboos	17.5knots	4.7days	7.7days
	15.0knots	5.4days	8.8days
Majis	17.5knots	5.0days(+0.3day)	8.0days(+0.3day)
	15.0knots	5.8days(+0.4day)	9.2days(+0.1day)
Haradi	17.5knots	4.8days(+0.1day)	7.8days(+0.1day)
	15.0knots	5.5days(+0.1day)	8.9days(+0.1day)
Dubai	17.5knots	5.5days(+0.8day)	8.4days(+0.7day)
	15.0knots	6.3days(+0.9day)	9.7days(+0.9day)

Mina Qaboos has the locational benefit of a voyage about one day shorter for mother vessels compared with Dubai.

A new port located at Majis or Haradi in the Batinah coast would have a locational benefit of about 0.5 day for mother vessels compared with Dubai. Accordingly, there is a possibility of locating a new port on the Batinah coast as a transshipment base.

The locational advantages of the Northern Part of Oman are calculated in Appendix 4-3-3. The results can be summarized as follows:

(1) Even if Mina Qaboos cannot collect container cargoes to the same extent as Dubai, Mina Qaboos could become a Hub Port.

(2) If the difference of collectable container cargoes between Mina Qaboos and Dubai is less than 158 TEUs/vessel, Mina Qaboos could

become a Hub Port.

(3) If the difference of collectable container cargoes between a new port in Haradi and Dubai is less than 138 TEUs/vessel, the new port in Haradi could become a Hub Port.

(4) If the difference of collectable container cargoes between a new port in Majis and Dubai is less than 93 TEUs/vessel, the new port in Majis could become a Hub Port.

(5) The collectability of container cargoes in Dubai is greater than other ports in the Arabian Gulf. Efforts to colect cargoes for a new port must be made in order to make the new port a Hub Port. But it is easer for the new port to become a Hub Port than Dubai from the viewpoint of location. Accordingly, there is a possibility of locating a new port in the Batinah coast as a transshipment base.

4.3.3 Industrial Port Function

As described in Appendix 4-3-4, the economy of the Sultanate of Oman depends greatly on crude petroleum production. In order to make the economy of the Sultanate more independent of the oil-based economy, the government of Oman has made efforts to promote non-oil industries for the past two decades.

The first policy is to promote import substitution industries, such as a petroleum refinery, and cement factories, while the second policy is to develop industries based on indigenous mineral resources, such as a copper mine. Thirdly, the government has made a plan to develop Industrial Estates to promote the manufacturing sector. In order to make progress in industrialization, the government has commissioned various feasibility studies, but clear conclusions have not yet been obtained.

As described in Appendix 4-3-4, the developed industries in the Rusayl Estate import various kinds of materials and even export their products because the market in Oman is not big enough for it to be economical to build factories on a scale that can easily fulfill the domestic market in Oman. So it is very important to develop industries especially in the new Industrial Estates, taking into account both import substitution and export promotion.

To develop import substitution industries, materials of half-finished goods must be imported before the related industries can be developed in Oman. Accordingly, it is very important to develop a new port in the vicinity of the envisaged new Industrial Estates.

After the related industries which produce half-finished good have been well developed in Oman, the need for heavy industries which produce basic products will be considerable. At that stage, feasibility studies to introduce heavy industries should be implemented. The feasibility studies to utilize the minerals available in Oman should be continued, but it is not clear whether they are economically feasible projects. The results of the feasibility study examined by Shell Corporation are not clear to the Team, but they seem to be encouraging, based on our examination, as described in Appendix 4-3-5.

Other feasible industries are fish-related and light industries, as listed in Appendix 4-3-4.

The policy of attracting foreign investors that the government of Oman is now undertaking should be continued and encouraged. The policy will be useful in terms of stimulating foreign investment because industrial investment from overseas will become a leverage for technology transfer and transfer of management skills. The policy to establish free trade zones in the vicinity of port areas is one of the best policies in terms of attracting foreign investment in Oman. The potential for FTZ(Free Trade Zones) shall be examined in the next section

The policy of developing industries in vicinity of some local centers should be continued in future, because the concentration in the capital area of Oman will not only create some problems,such as traffic conggestion and high real estate prices, but also inefficient land utilization in rural areas.

There are many policies and strategies that can be used to convert the economy of the Sultanate of Oman from an oil-dependent economy to one based on various industries. These will also be promoted in the future.

Judging from the government's policies and strategies and the on-going projects in Oman, the industrial sectors which should be studies in the future are found to be as follows:

a. Industries Based on Indigenous Mineral Resources

The government of Oman is promoting the development of indigenous mineral resources in Oman. In 1990, a world ophiolite seminar was held in Muscat. At the seminar, some reports suggested that there is a possibility of finding precious mineral depots in Oman. There have been many discoveries of mineral resources in Oman, but most mineral deposits are still at the research level. So far, only industrialized mine is a copper one, and it is estimated that its reserves will be consumed within 10 years at the most. The government is now studying the possibility of developing chromite in the vicinity of the copper mining corporation from the viewpoint of economic viability.

b. Industries Based on Natural Gas Resources

The government of Oman commissioned a feasibility study from the Shell Corporation to examine utilizing natural gas resources. The detailed results were not given to the Team but as shown in Appendix 4-3-5 the project to produce fertilizer and methanol, etc., seem viable and also a natural gas separation plant seems necessary.

c. Agro-related Industries

The government of Oman intends to upgrade the agricultural and livestock sectors. The other JICA team is now carrying out a study on agricultural development in Oman. The result of their development plan are not yet available to the Team. The fish-processing industry is one of the sectors in Oman for which there are great hopes. Its potential will be discussed in a 4.3.5. Agro-related industries in Oman have good potential. Cooperative organizations such as farmers' and fishermen's co-operatives are recommended in order to upgrade and modernize the agricultural and fishery sectors. It is recommended that distribution centers for Argo-related products be located in the vicinity of the new port.

d. Other Industries

There are various kinds of traditional industries in Oman. A large number of skilled artisans are scattered all over the country. Their skills could be integrated for the industrialization of Oman. The traditional industries are wearing industries, pottery industries, farming tools manufacturing, blacksmithing, the non-ferrous handicrafts industry, grass mat weaving, wooden handicrafts and wooden shipbuilding.

Metal-working technology is the base of all manufacturing and processing industries. Unless this subsector is developed, industrialization may not be achieved. The potential metal-working industries are the casting industry, the forging and tool-making industries, the metal fabrication industry, the electric appliances repairing industry and the ship repairing industry.

4.3.4 Free Trade Zone Function

By introducing free trade zones, the trade potential of export-oriented industries can be expected to increase. As described in Appendix 4-3-6, the various benefits that are likely to be created in Oman area as follows:

(1) Promotion of Export-Oriented Industries
(2) Diversification of National and Regional Economies
(3) Regional Development
(4) Incresed Employment Opportunities
(5) Improvement of Technical and Managerial Skills
(6) Technology Transfer
(7) Improvement of Accessibility of International Markets
(8) Direct Generation of Wealth such as
   a. Income from Port Charges Including Cargo Handling Charges
   b. Income from Rent of Land and Facilities
   c. Income from Utility Consumption of Electricrty, Gas and Water
   d. Generation of Additional Foreign Exchange Earnings.

But introducing FTZs should be handled very carefully in order not to depress the existing domestic industries. Thus the strategies of giving incentives to potential investers to free trade zones and domestic potential investors should be carefully examined.

Although there are lots of issues to be solve, the potential for free trade zones in the Northern Part of Oman might be high because of the following advantagaes:

(1) The Northern Part of Oman is located at the entrance of the Arabian Gulf. It is very convenient for approaching Iran and Iraq.
(2) The Sultanate of Oman is politically stable and there seems to be no risk to investment.
(3) There are not so many export goods compared with the amount of imported consumer goods and space for exports by sea to Europe and the Far East is available at a comparatively low cost .

(4) There is a well-developed international airport and a good highway along the Batinah Coast. It is very easy to approach the airport within 2 hours.

The potential industries in a free trade zone in the Northern Part of Oman are as follows:

1) Entrepot Trade as Transshipment, Re-export
   a. Food-Related Production Distribution Centers such as Cereal and Cereal Products and Beverage (Including the Expansion of the Existing Flour Mill)
   b. Petroleum Products Distribution Centers
   c. Iron and Other Metals Distribution Centers
   d. Chemical Products Distribution Centers
   e. Distribution Centers for Various Kinds of Machinery
2) Export Processing
   a. Derivative Petrochemical Industries such as Manufacturing Using Synthetic Resins and Rubber
   b. Iron and Other Metal Manufacturing

The introduction of free trade zones seems to be very beneficial and Oman has good potential in this respect. A well-developed new port should be equipped with good infrastructure and utilities such as electricity, gas and water.

4.3.5 Fishery Port Function

The Oman Gulf is abundant in various kinds of fishes, as described in Appendix 4-3-7. This is very clear from the fact that Korean fleets are now catching fish in the Oman Gulf.

The Omani fishery industry remains a traditional inshore fishery using small boats. It is necessary to change from traditional fishing to modernized fishing, as described in Appendix 4-3-7. The introduction of deep-sea fishing would be very beneficial for Oman.

The increase of fish exports, including processed fish, is expected in the future. Increased in frozen fish exports can be expected with the introduction of modern freezing equipment. The potential to establish fish processing plants in the Northern Part of Oman seems very high.

In order to strengthen the fishery sector in Oman, the introduction of fishery cooperatives would be effective.

In order to develop a deep-sea fishing industry, port facilities for deep sea fishing boats are indispensable.

In order to promote fish processing industries, land areas for fish processing factories must be reserved in any new port area.

4.3.6 Other Functions

We can imagine various other functions for ports. Ship repairing, passenger terminal, berthing facilities for small recreation boats and working vessels, marine promenades and marine parks, a bunkering facility, a water supply for vessels and offshore oil platforms, ship chandlers, etc., are some that come to mind.

1) Ship repairing functions should be taken into account in a small scale. Repairing big ships may not be possible, considering the existing huge ship repairing facilities in Dubai and Bahrain as shown in Appendix 4-3-8. Repairing middle class ships such as 3,000 DWT ships may also not be possible, because slipways for small ships can not be used for repairing the middle class ships and dry dock facilities, of which cost amounts to over one million R.O, are required.

   In view of gathering the scattering facilities owned by various Government organizations and fisheries, and taking into account the locational advantage, further consideration should be given to the ship repairing facilities sometime in future.

2) Passenger terminals might be possible, considering the close location to Iran. But the relationship between two countries is not still clear. And the passenger terminals should be palnned at first at Mina Qaboos, when the demand becomes clear. So this function shall be excluded in the master plan, but space for possible expansion will be taken into consideration.

3) Berthing facilities for small recreational boats and working vessels may be taken into consideration. But the demand forecast for small recreational boats is very difficult to make at present. And the priority for such facilities is with Mina Qaboos. So the area for expansion is taken into consideration in a new port. The facilities for working vessels shall be examined.

4) Marine promenades and marine parks shall be treated as part of the environmental aspect of the industrial zone's development.

5) Bunkering facilities and other supply should be taken into consideration. But the supply of offshore platforms will not be taken into consideration, because the feasibility of off-shore oil production is not clear at present.

4.4 Allocation of Functions between Mina Qaboos and a New Port

The schedule of respective ports is as follows:

(1) 1991 to 1995: This will be the period for the improvement of Mina Qaboos and the preparation of a new port.

(2) 1996 to 2000: This will be the period for the utilization of Mina Qaboos and the construction of a new port.

(3) 2000: The new port will mainly handle the overflow of cargoes from Mina Qaboos. Mina Qaboos will be handling the same kinds of cargoes as present.

(4) 2015: This is the target year of a master plan of a new port. The functions of the respective ports are considered to be as follows:

1) Import cargoes will be handled in both ports.

2) Export cargoes will be also handled in both ports.

3) Transshipment cargoes will also be handled in both ports, but in order to handle more import and export cargoes in Mina Qaboos, a policy of giving up transshipment cargo handling in Mina Qaboos might be considered. Nevertheless, judging from the present combination of container movements for each ship call, the container ships which are carrying only transshipment containers are 3.2 per cent of 436 calling ships and 51.7 per cent ships are carrying transshipment and import/export containers. So, it is very difficult to allocate only transshipment containers to a new port, some of import/export containers will also be allocated to the new port and the containre volume at Mina Qaboos will be half of the allocated volume.

4) Industry-related cargoes will be handled in both ports. But it

seems very difficult for Mina Qaboos to handle cargoes generated by heavy industries because of the lack of open space for the development of heavy industry.

5) Cargoes generated for free trade zones shall be allocated to the New Port because there are no available open spaces for free trade zones in the vicinity of Mina Qaboos.

6) There are various kinds of bulk cargoes, as follows:

   a. Wheat is handled by the Oman Flour Mill Corporation. They intend to use 50,000 DWT type carriers, but it is impossible to berth 50,000 DWT type carriers at berth No.3 in Mina Qaboos. The Oman Flour Mill Corporation expanded the capacity of the silos in Mina Qaboos in 1989 from 60,000 tons to 120,000 tons. So there are two alternative ways of handling wheat: only at Mina Qaboos or at both ports.

   b. Logs are carried by rather large vessels in Mina Qaboos. Logs should be dealt with mainly at the New Port, which has a big space around the port area. But the purpose of log imports is for producing consumer goods, so they will be handled at both ports.

   c. Steal is not a bulk cargo, but imports of steel are very much related to the various functions of the new port. It is very important to import steel to upgrade various industries in Oman, such as the industries which have already developed on the Rusayl Industrial Estate. So steel must be handled at both ports, but heavy cargoes should be treated in the new port, which will have deeper berths than Mina Qaboos.

   d. Imports of petrochemical products will be handled in both ports, but export cargoes will be handled in the new port.

   e. After establishment of a fertilizer plant, imports of fertilizer will decrease. But if imports of fertilizer continues in future, the cargoes will be handled at the new port. Export fertilizer cargoes will be handled in the new port.

   f. Bulk cargoes should be handled principally at the new port.

7) Fishery-related cargoes will be handled at both ports. But unloading of fish from the deep sea fishery will be carried out at the new port.

8) The base port of His Majesty's Vessel will continue to be Mina

Qaboos, but we will take into account of the usage of the new port by Royal fleets.

9) Large scale ship repairing facilities would not be viable in Oman. But small scale ship repairing facilities should be furnished at the new port.

10) A passenger terminal for passenger boats and ferry boats between Oman and Iran might be needed in future

Functional allocation between Mina Qaboos and the New Port is summarized in the following table:

Table 4-4-1 Functional Allocation between Mina Qaboos and a New Port

Functions	Mina Qaboos	New Port
1)Import Cargo Handling		
a. Break Cargo	X	X
b. Container Cargo	X	X
2)Export Cargo Handling		
a. Break Cargo	X	X
b. Container Cargo	X	X
3)Transshipment		
Mainly Container Cargo	X	X
4)Industry Related Cargo		
a. Light Industry	X	X
b. Heavy Industry		X
5)Free Trade Zone Related Cargo		X
6)Bulk Cargo		
a. Wheat	X	X
b. Log/Timber	X	X
c. Steel(Light)	X	X
(Heavy)		X
d. Petrochemicals(Import)	X	X
(Export)		X
e. Fertilizer(Break Bulk)		X
(Bulk)		X
f. Others		X
7)Fishery-Related Cargo		
a. Coastal Fishery	X	X
b. Deep Sea Fishery		X
8)His Majesty's Vessel	X	X
9)Ship Repairing		
a. Small Craft		X
10)Passenger		
a. Passenger Boats	(X)	(X)
b. Ferry Boats		(X)
11)Small Boat		
a. Working Boats	X	X
b. Recreation Boats	(X)	(X)
12)Bunkering Facilities		
a. Bunker Oil	X	X
b. Supply for Vessels	X	X
c. Offshore Supply		(X)
13)Marine Park etc.	X	(X)

Note: Marks in parentheses show that the functions will not be included in the master plan in 2015 and should be planned when the demand of the functions becomes clear.

4.5 New Port Development Policy

1) Through the analysis of port functions, we have concluded that the new port must be planned by taking account of various functions.

2) As for major functions, the proposed port development policies are as follows:

a. Import Cargo Handling

i. A new port must function as a supplementary port for Mina Qaboos.

ii. Efforts to become independent of UAE ports must be carried out.

b. Transshipment

i. A new port must be equipped with well-developed container facilities to attract regular shipping liners.

ii. Aggresive marketing must be carried out by emphasizing to ship operating corporations the locational benefits of Oman.

c. Industry Port

i. A new port must be equipped with well-developed infrastructures, utilities and land necessary for industrial development.

ii. Efforts to develop the potential industries must be carried out.

iii. Feasibility studies to introduce beavy industries must be carried out.

iv. Import substitution industries must be introduced in the vicinity of the new port area.

v. Not only industries based on indigenous mineral resources but also processing industries must be promoted.

vi. Industries based on natural gas resources must be promoted.

vii. Measures to strengthen the agro-related sector must be carried out.

d. Free-Trade Zone

i. A new port must be equipped with free trade zones.

ii. Efforts to introduce overseas corporations to the free trade zones must be carried out.

iii. The measures to harmonize the corporations in the free trade zone with the domestic industries must be carried out.

e. Fishery Port

i. A new port must be equipped with fishery port facilities necessary for the deep sea fishing and fish processing industries.

ii. Measures to strengthen the fishery sector must be carried out.

4.6 Site Selection of a New Port

We held a meeting on January 21, 1990, regarding site selection of a new port. The document papers are attached in Appendix 4-6-1. The procedure of selection is summarized as follows:

We selected the following new port development site alternatives at first:

a. Majis
b. Sohar
c. Saham
d. Khaburah
e. Suweiq
f. Masnaah
g. Murayasi
h. Haradi
i. Quriyat
j. Sur
k. Other sites(k.Shinas, l.Liwa, m.Azaiba, n.Bandar Jissah, o.Bandar Khayran and p.As Sifah)

Based upon the criterion of space availability, we excluded the following sites: b.Sohar c.Saham n.Bandar Jissah o.Bandar Khayran p.As Sifah

Based upon the criterion of rock exposure, we excluded the following sites:

e.Suweiq j.Sur

Based upon the criterion of location, we excluded the following sites:

k.Shinas l.Liwa(Too close to UAE)

m.Azaiba(Too close to Muscat)

Other sites that seem to be suitable for new port development are as follows:

a.Majis d.Khaburah f.Masnaah g.Murayashi h.Haradi i.Quriyat

The revised cost estimation for Quriyat subject to the construction cost of dredging and 2,500m long quay wall and breakwater is 115.4 million RO. This does not include the cost of the associated road works. The cost for the associated road works is estimated by Maunsell Consultants as 169.9 million RO. The comparable cost for a new port in Quriyat with our conceptual plan is 285.3 million RO. Accordingly, the site of Quriyat should be excluded.

From the cost comparison, as described in Appendiz 2-6-2 the cheapest site is Majis, followed by Haradi.

The following table shows the comparison of Majis and Haradi from the future port functions:

a.Import Cargo Handling	Majis is more economical than Haradi.
b.Transshipment	The locational potential of Haradi is a little bit greater than that of Majis. The locational advantage of Majis is still big. The new port in Haradi might become competitive with Mina Qaboos.
c.Industrial Development	The new port in Majis is very effective for regional development. The new port in Haradi can not give incentives to regional development.
d.Free Trade Zone	Both Majis and Haradi have a high potential for being developed as free trade zones. A free trade zone in Majis would provide good incentives to regional development.
e.Fishery Port	Majis has a higher labour force potential than Haradi. Majis has a higher marketing potential than Haradi of raw fish exports.

Therefore, we would like to recommend Majis as the best new port site. The following figure shows the summarization of selecting procedure.

New port development site alternatives	1.SpaceAvailability	2.Rock Exposure	3.Location	4.Cost Comparison	5.Import Cargo Handling	6.Transshipment	7.Free trade zone	8.Fishery port	9.Industrial Develpment
a.Majis	○	○	○	◎	◎	○	○	◎	○
b.Sohar	×								
c.Saham	×								
d.Khaburah	○	○	○	×					
e.Suweiq	○	×							
f.Masnaah	○	○	○	×					
g.Murayashi	○	○	○	×					
h.Haradi	○	○	○	○	○	◎	○	○	△
i.Quriyat	○	○	○	×					
j.Sur	○	×							
k.Shinas	○	○	×						
l.Liwa	○	○	×						
m.Azaiba	○	○	×						
n.Bander Jissah	×								
o.BanderKhayran	×								
p.As Sifa	×								

Fig. 4-6-1 Site Selection of a New Port

4.7 Environmental Aspect

When a large project, due consideration should be given to environmental aspect, and in this regard frola and fauna should be attached to a particular importance.

The study team visited the proposed site of a natural reservation area on Jun 21st, 1990, and took photographs at the place where is about one km west of the existing jetty. The following photographs show the present situation of the site.

Photo. 4-7-1 Present Situation at Majis

As the photograph apparently shows, there is no mangrove at the project site, and a long jetty exists already. These facts give enough reason to judge that impact to the environment is very small.

CHAPTER 5 FORMULATION OF A MASTER PLAN FOR THE NEW PORT

Chapter 5 FORMULATION OF THE MASTER PLAN OF THE NEW PORT

5.1 Planning Premises

5.1.1 Cargo Volume in the Future

From the result of the demand forecast described in Chapter 3 and the functional allocation between Mina Qaboos and the New Port described in Chapter 4, the future cargo volume in the New Port is summarized in the following table:

Table 5-1-1 Future Cargo Volume in the New Port

	2000	2010	2015
1. Total Container Cargo	102,354TEUs 747,894tons	296,482TEUs 2,176,154tons	432,080TEUs 3,181,258tons
2. Bulk Grains	-	123,400tons	153.600tons
3. Total General Cargo	336,600tons	711,500tons	972,000tons
(Iron and Steel)	(141,200tons)	(370,700tons)	(535,400tons)
(Timber)	(54,000tons)	(81,000tons)	(96,800tons)
(Other General Cargo)	(141,400tons)	(259,700tons)	(339,800tons)
4. Vehicles	-	51,100tons	87,000tons
5. Livestock	-	8,400tons	13,810tons
Total	1,084,494tons	3,080,494tons	4,423,194tons

The functions that should be taken into consideration to develop in and around the New Port are as follows:

(1) Import Cargo Handling Function
(2) Export Cargo Handling Function
(3) Transshipment Cargo Handling Function
(4) Industrial Port Function
(5) Free Trade Zone Function
(6) Fishery Port Function
(7) Other Functions

In forecasting the future cargoes, the Free Trade Zone function was not taken into consideration, so the cargoes generating from a free trade zone may be added to the above cargo volume. But the possible industries in the free-trade zone are distribution centers and export promoting industries, as described in Chapter 4, and cannot be clearly identified at present. So, in the formulation of a Master Plan of the new port, we exclude the cargoes from the Free Trade Zone.

In forecasting the future cargoes, some parts of industrialization were already envisaged. The development of the Sohar Industrial Estate was taken into consideration, but the petrochemical products that were studied by Shell Corporation were not included because the expected export cargo volume was over 1 million tons and the total forecast export cargoes were only about 400,000tons, even in 2015. So we will take into consideration the following cargo volumes in formulating the Master Plan:

1) Ammonia ; 57,000tons(Export)
2) Urea ;174,000tons(Export)
3) Methanol ;500,000tons(Export)
4) MTBE ;100,000tons(Export)
5) SMDS ;500,000tons(Export)

In forecasting the future cargoes, exports of processed fish cargo were taken into consideration, but the volume of unloaded fishes was not included. The volume of unloaded fishes was analyzed in Appendix 4-3-8. We intend to use this analysis only as the maximum estimates in formulating fishery port plans.

5.1.2 Vessel Size and Berth Dimensions

Sizes and berth dimensions of the various vessels used for the plan are as follows:

(1) General Cargo Vessels

From the analysis described in Appendix 5-1-1, the objective vessel sizes are as follows:

a. Maximum Vessel Size;

Overall Length : 198m
Breadth : 28.2m
Full Load Draft : 11.7m

b. Objective Vessel Size for Continuous Berths;

Overall Length : 175m
Breadth : 24.4m

The required berth dimensions are as follows:

a. Single Berth : Length : 250m ; Depth : -13,0m

b. Continuous Berth : Length : 220m ; Depth : -13.0m

(2) Container Vessels

From the analysis described in Appendix 5-1-2, the objective vessel sizes are as follows :

a. Maximum Mother Vessel Size;

Overall Length : 290m

Breadth : 32.2m

Full Load Draft : 12.7m

b. Maximum Feeder Vessel Size;

Overall Length : 175m

The berth dimensions are as follows:

a. Minimum Length : 320 + 160 = 480m ; Depth : -14.0m

b. Standard Length : 320m ; Depth : -14.0m

(3) Other Special Vessels

a. Bulk Grain Carriers

From the analysis described in Appendix 5-1-3 the maximum vessel size and berth dimensions are as follows:

i) Maximum Vessel Size : 50,000DWT

(L, B, Dr) = (208.0m, 32.2m, 11.2m)

ii) Required Single Berth Dimensions :

Length = 250m, Depth = -13.0m

iii) Required Dimensions of Continuous Berths :

Length = 220m, Depth = -13.0m

b. Ro-Ro Vessels

From the analysis described in Appendix 5-1-4, the maximum vessel size and berth dimensions are as follows :

i) Maximum Vessel Size : 30,000DWT

(L, B, Dr) = (200m, 32.2m, 10.0m)

ii) Required Single Berth Dimensions :

Length = 240m, Depth = -11.0m

iii) Required Dimensions of Continuous Berths :

Length = 220m; Depth = -11.0m

c. Livestock Carriers

From the analysis described in Appendix 5-1-5, the maximum vessel size and berth dimensions are as follows :

Maximum Livestock Carriers : 34,000 GRT

Length : 195.0m

Full-load Draft : 10.7m

Required Berth Dimensions : Length : 220m

Depth : -12.0m

Ro-Ro vessels and livestock carriers use general cargo berths, so the actual berth depth will be -13.0m.

d. Petrochemical product carriers

From the analysis described in Appendix 5-1-6, the vessel size and berth dimensions are as follows:

Vessel Size

i) Ammonia ; 5,000GRT Chemical Tankers

(L, B, Dr) = (123.0m, 8.3m, 7.8m)

ii) Urea ; 25,000DWT General Cargo Vessels

(L, B, Dr) = (174m, 24.4m, 10.9m)

iii) Methanol, MTBE and SMDS ; 50,000DWT Product Tankers

(L, B, Dr) = (170.7m, 32.2m, 11.3m)

Required Berth Dimensions :

i) Ammonia Tankers : Length : 135m; Depth: -8.6m

ii) Urea : Length : 200m; Depth : -12.0m

iii) Products Tankers : Length : 200m; Depth : -12.5m

Actually, ammonia tankers will use the existing jetty. And urea vessels use the general cargo berths, so the depth will be -13.0m. Considering the frequency of product tankers, one berth should be allocated to oil products tankers along the breakwater.

e. Fishery Boats and Vessels

From the analysis described in Appendix 5-1-7, the vessel sizes and required berth dimensions are as follows:

Vessel Size:

		(L, B, Dr)
1~2GT Boats	:	(7.0m, 2.0m, 0.7m)
30GT Dhows	:	(20.0m, 4.2m, 2.3m)
Trawling Vessels	:	(30.0m, 8.0m, 4.0m)

Number of Vessels

		in 2000	in 2015
1~2GT Boats	:	34	–
30GT Dhows	:	8	13
Trawling Vessels	:	7	14

Required Berth Dimensions :

In 2000	Depth	Unloading	Preparation	Sub-total	Laying	Total
1~2GT Boats	:-1.5m	24.5m	16.5m	41.0m	102.0m	143.0m
30GT Dhows	:-3.0m	23.0m	23.0m	46.0m	50.4m	96.4m
Trawling Vessels	:-5.5m	34.5m	34.5m	69.0m	84.0m	153.0m
Total	:	82.0m	74.0m	156.0m	236.4m	392.4m

In 2015						
30GT Dhows	:-3.0m	23.0m	23.0m	46.0m	82.0m	128.0m
Trawling Vessels	:-5.5m	92.0m	92.0m	184.0m	168.0m	352.0m
		115.0m	115.0m	230.0m	250.0m	480.0m

5.2 Alternative Formulation Plans

Before formulating a Master Plan, reclamation plans and excavation plans should be compared considering future expansion beyond 2015.

5.2.1 Reclamation Plan Alternatives

Fig.5-2-1 shows various alternative plans. Taking into consideration the soil volume balance as examined in Appendix 5-2-1, the alternative plans are formulated. The required quay length in 2015 is assumed to be about 3km, and the final quay length is assumed to be about 10km beyond 2015. The concepts of the alternative formulations are as follows:

Alternative 1 : This plan is formulated by considering the development of the westernmost area, where there is a huge open space. But the Ministry of the Environment intends to designate this area as a natural reservation area (NRA)[1]. In this plan, the port area would intrude into 3.7km in the long run. The distance from the existing jetty to the densely populated area of Majis is only 2km. So the right side of the port should be used for "clean" industries such as a FTZ and light industry.

Alternative 2 : This plan is formulated by considering the utilization of the existing jetty. In this plan, the distance of intrusion to NRA would be reduced to 2.7km.

Alternative 3 : This plan is formulated by considering the east side development of the existing jetty. In this plan, the distance of intrusion to NRA would be reduced to 1.7km.

5.2.2 Excavation Plan Alternative

If it is not necessary to reclaim the sea area, breakwaters must be constructed to shelter the turning basin. Two alternatives are worth considering. One is on the west side of the existing jetty, the other is on its east side. But the latter plan is not suitable, because the outer channel will cross the existing jetty. So the former plan is the only feasible alternative. The concept of the alternative formulation is as follows.

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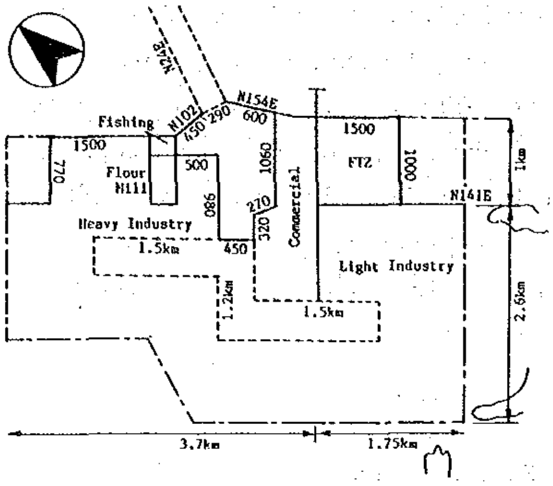
1) We visited the poposed site of NRA, but were not be able to recognize any mangroves there as illustarated in Appendix 5-2-2.

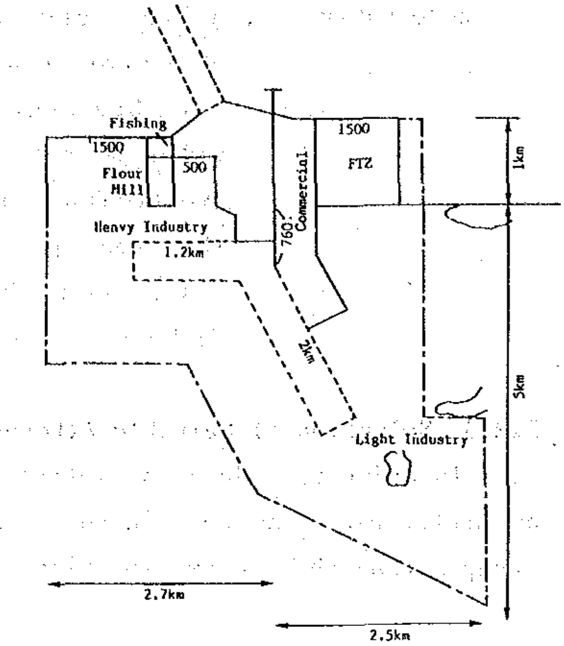
Alternative 4 : A breakwater of insufficient length would not be effective in decreasing wave height, so we planned the main breakwater to be 600m long. To obtain 290m width in the entrance channel, the distance between two breakwaters should be 860m. In order to utilize the open space, the inner channel veers to the east side. From this plan the intrusion distance will be 2.3km in the long term.

5.2.3 Selection of Suitable Alternative

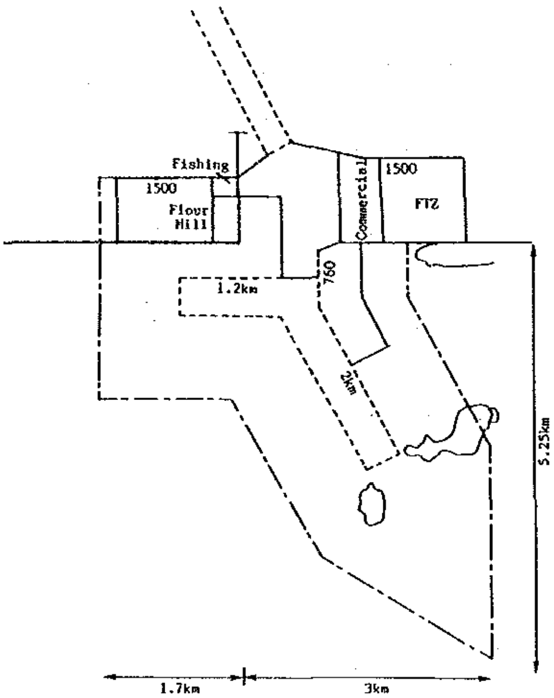
In order to reduce the intrusion to NRA, alternatives 3 and 4 seem to be preferable. As calculated in Appendix 5-2-3, the excavation plan is cheaper than the reclamation plan. So we have selected Alternative 4.



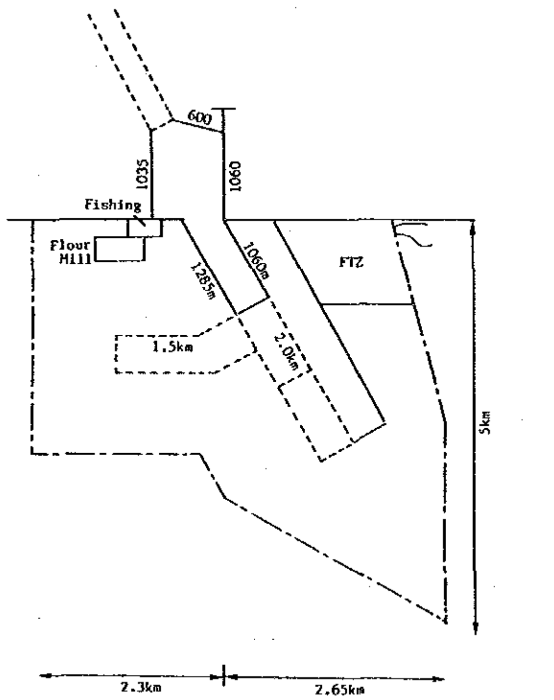
Alternative 1



Alternative 2



Alternative 3



Alternative 4

Fig. 5-2-1 Alternatives of Reclamation Plans

5.3 Required Scale of Port Facilities

5.3.1 Container Berths

The volume of container cargoes will be 432,080 TEUs in 2015. The average cargo handling volume per container vessel calling at Mina Qaboos was 368 TEUs in 1988. If the volume does not change in the future, the number of the calling container vessels would be 1,174. The number of vessels arriving per day will be 3.2168 vessels/day. The cargo handling productivity is assumed to be 25 units/hour/gang, and the service time for one vessel is assumed to be 0.33 day. The berth occupancy rate and the average waiting time can be calculated as follows:

Number of Berths	Berth Occupancy Rate	Average Waiting Time
2	0.5308	3.15 hr
3	0.3538	0.43 hr

If we adopt 3 berths, the average waiting time would be reduced to less than 1 hour. Comparing the service time (7.92hrs) with the average waiting time, we would recommend the adoption of 3 berths.

The volume of container cargoes will be 102,458 TEUs in 2000. The number of the calling container vessels will be 278.4. The number of vessels arriving per day will be 0.7628 vessels/day. The berth occupancy rate and the average waiting time can be calculated as follows:

Number of Berths	Berth Occupancy Rate	Average Waiting Time
1	0.2517	2.7 hr

The number of berths required is only one, but since we envisage transshipment, the minimum number required is 2 berths for a mother vessel and a feeder vessel. Judging from the overall lenght of both vessels, 1.5 standard container berths will be required in 2000.

5.3.2 General Cargo Berth

We have planned multi-purpose berths which can be used for general cargo vessels, Ro-Ro vessels and livestock carriers. In 2015, the cargo volumes of iron and steel, timber, vehicles, livestock and other general cargoes will be 535,400 tons, 96,800 tons, 87,000 tons, 13,800 tons and 339,800 tons, respectively. Assuming that the cargo volume per vessel for these cargoes are 2,420 tons/vessel, 2,080 tons/vessel, 300 tons/vessel, 460 tons/vessel and 950 tons/vessel, respectively, the numbers of calling vessels will be 221.2, 46.5, 290, 30 and 538.4, respectively. Accordingly, the arrival rates per day are 0.6061, 0.1275, 0.7945, 0.0822 and 1.4751, respectively. The combined arrival rate can be calculated as 3.0852. On the other hand, the service times per vessel for these cargoes are assumed to be 0.9926, 1.0630, 0.2645, 0.4142 and 0.6278 day/vessel respectvely. The combined service time can be calculated as 0.6176. The berth occupancy rate and the average waiting time can be calculated as follows:

Number of Berths	Berth Occupancy Rate	Average Waiting Time
3	0.635	5.5 hr
4	0.476	1.1 hr

The number of multi-purpose berths required will be 4 in 2015.

In 2000, the cargo volumes of iron and steel, timber and other general cargoes will be 141,200 tons, 54,000 tons and 141,400 tons respectively. Taking the same procedure in 2015, the berth occupany rate and the average waiting time can be calculated as follows:

		N 1)	λ 2)	$1/\mu$ 3)
1) Iron and Steel	:	58.3	0.1599	0.9926
2) Timber	:	26.0	0.07113	1.0630
3) Other General Cargoes	:	148.8	0.4078	0.6278
Combined		233.1	0.6386	0.7745

---

1) N : the number of calling vessels

2) λ : the arrival rates of the vessels per day

3) $1/\mu$:the average service time per vessel

Number of Berths	Berth Occupancy Rate	Average Waiting Time
1	0.4946	18.2 hr
2	0.2473	1.2 hr

The number of multi-purpose berths required will be 2 in 2000.

5.3.3 Bulk Grain Berths

In 2015, Mina Qaboos will not be able to handle the total forecast amount of bulk grains. So we plan one berth for bulk grain carriers in 2015.

5.3.4 Petrochemical Berths

As described in 5.1.2, if this project is adopted by the government of Oman, one liquid petro chemical berth will be necessary. The location of this berth will be at the main breakwater. The berth for chemical tankers carrying ammonia will be at the existing jetty.

5.3.5 Other Berths

The required berth length for the fishery port is described in 5.1.2. We did not plan berths exclusively used for the Royal Fleet. But it is possible to berth His Majesty's Vessels the general cargo berths, considering the projected berth occupancy rates for 2000 and 2015.

A bunkering berth should be constructed at the breakwater.

The selected development plans are shown in Figs.5-3-1 and 5-3-2.

Fig.5-3-3 shows the degree of calmness in the port area based on the analysis described in Appendix 5-3-1.

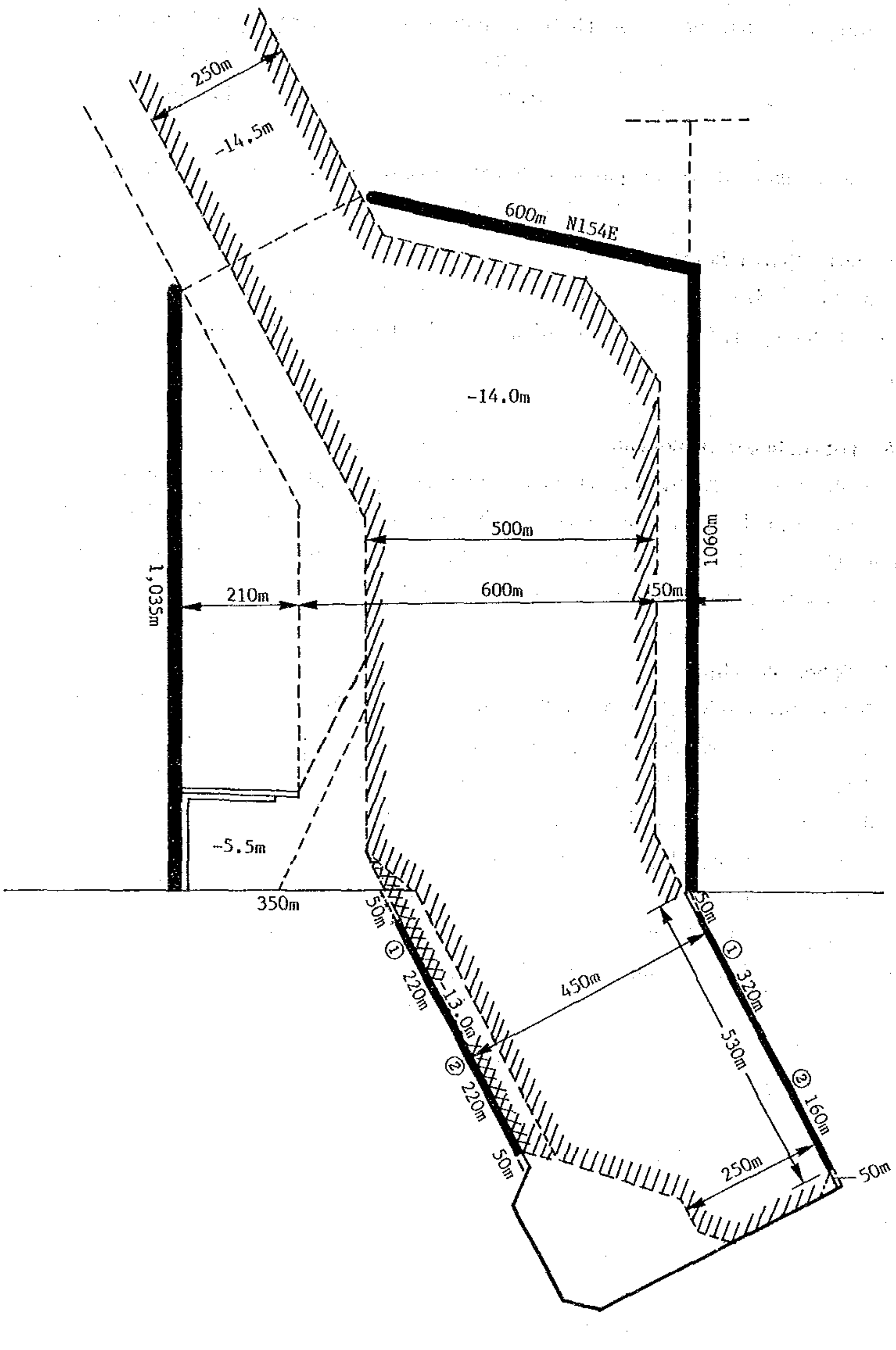


Fig. 5-3-1 Selected Plan in 2000

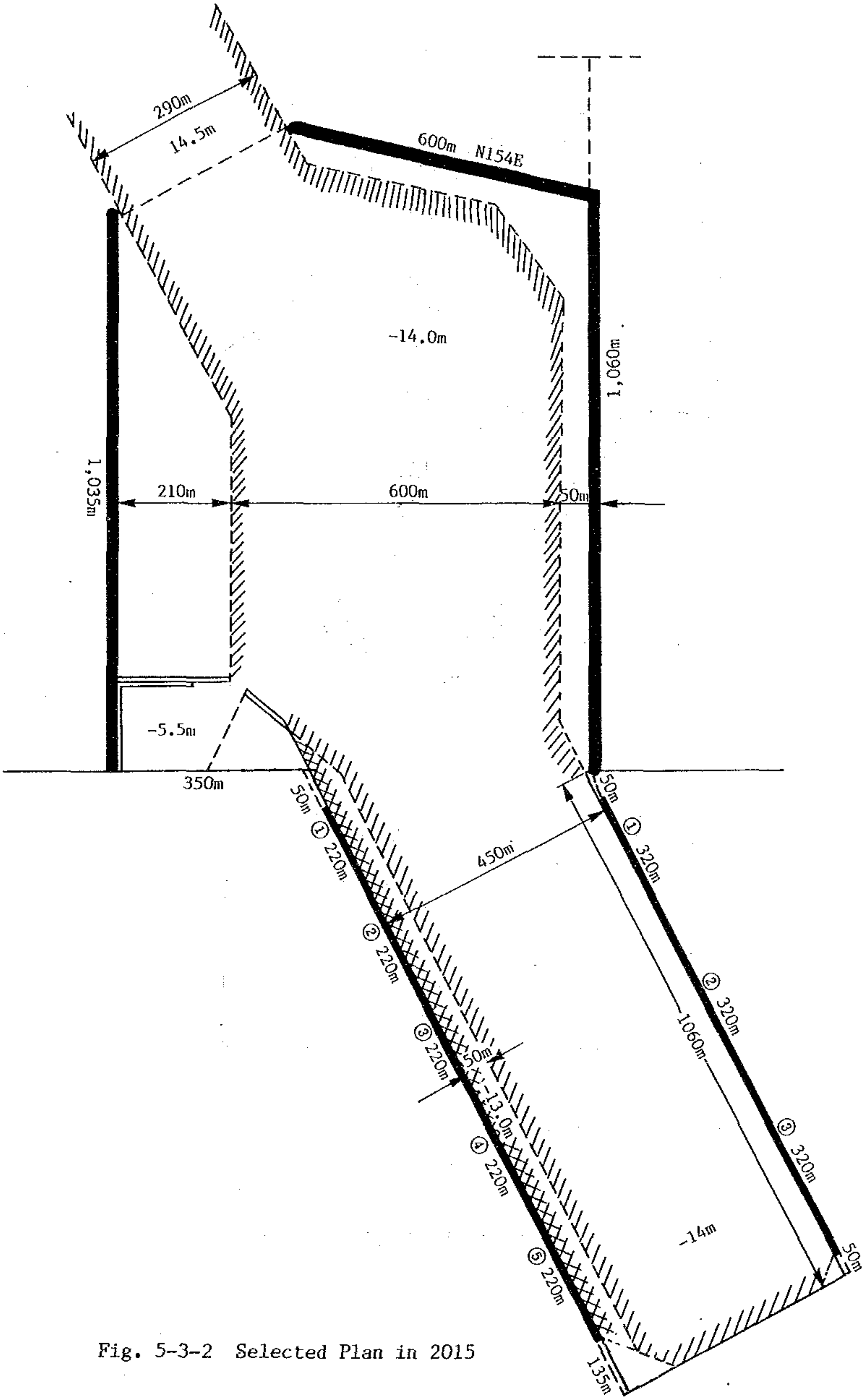
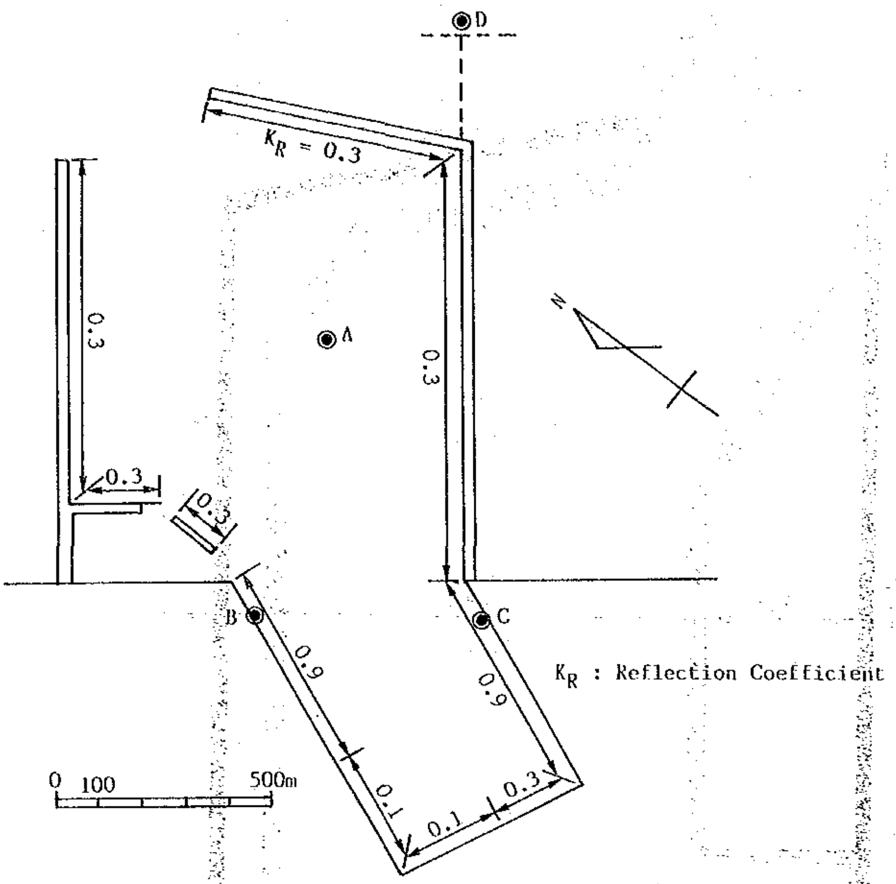


Fig. 5-3-2 Selected Plan in 2015



(%)

Point	Unexceeding Probability (lines of wave height : 0.5m)
A	96.9
B	98.5
C	98.7
D	67.7

Note ; The figures were calculated based on observation wave record from 1986 to 1989.
The point D is in front of the existing jetty.

Fig. 5-3-3 Degrees of Calmness in the Port Area

5.4 Required Scale of Cargo Handling Equipment

5.4.1 Handling Systems for the New Port

The cargo handling work of the new port will comprise four(4) main items:

(1) Break bulk cargo
(2) Container cargo
(3) Vehicles and livestock
(4) Grain and others

(1) Break bulk cargo

Loading and unloading of break bulk cargo will be done by ship's gear, and fork-lifts will be used between the apron and the shed. Generally, fork-lifts operate within a 150m driving distance. Between the apron and the outside open storage area, transportation will be carried out by trucks or tractor-trailers. The expected layout of the general cargo berth is as shown below;

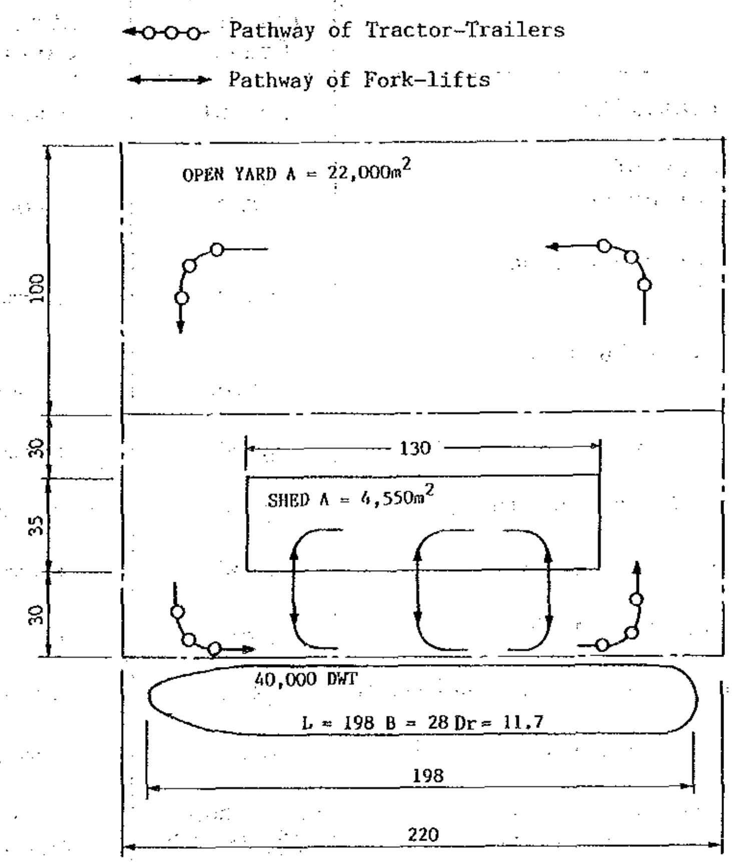


Fig. 5-4-1 Layout of General Cargo Berth

(2) Container Cargo

(a) There are two different approaches to container handling when loading and discharging, one is roll-on, roll-off, and the other is lift-on, lift-off. Roll-on, roll-off, however will only be used in special cases. At the new port, the lift-on, lift-off system by container crane on a quay will be used.

(b) At terminal

There are many handling systems; transfer crane, straddle carrier, chassis system, and others at the terminal. The handling system recommended by the team for Mina Qaboos is the transfer crane system. Similarly, at the new port, a transfer crane system is recommended. A comparison of the transfer crane and straddle carrier is provided below:

Table 5-4-1 Comparison of Handling Systems

	Transfer Crane	Straddle Carrier
(1) Maneuverability	normal	good
(2) Efficiency of container crane	normal	good
(3) Height of stack/land utilization	good	normal
(4) Facility of handling containers	normal	good
(5) Damage ratio of machinery	good	normal
(6) Maintenance of machinery	good	normal
(7) Automation of operation	good	normal
(8) Training of drivers	good	normal
(9) Amount of investment(machinery)	good	normal
(10) Amount of investment (yard)	normal	good
(11) Kind/type terminal for or which system is best suited	more than 100,000 TEU mainly for LCL/empty containers	around 100,000 TEU LCL/FCL well balanced

(3) Vehicles and livestock

These goods use a ramp or passage way, and do not need any handling equipment.

(4) Grain and others

Handling of grain will be carried out by a pneumatic unloader system and conveyer from the ship to the silo. A pump and pipeline system will be used in future for Petroleum Products and Chemicals.

5.4.2 Required Numbers of Handling Equipment

(1) General cargo berth

(a) Break bulk (bagged, palletized, others)

Fork-Lifts

One gang .... 2 units

Three gangs per ship(2units x 3) 6 units

for back yard work .... 2 units

for spare .... 2 units

total number per berth..........10 units

(b) Dry bulk (Steel, timber, etc.)

1) Tractor-trailers (Truck)

One gang .... 2 units

Two gangs per ship (2units x 2).. 4 units

2) Mobile-cranes

Two units per berth............. 2 units

(2) Container Cargo berth

1) Container Cranes (Fig.5-4-2)

	2000	2015
Containers to be Handled (TEU)	102,354	431,294
Number of Berths Available	1.5	3
Number of Container Cranes	3 units	6 units
Reference: Handling Capacity per annum (TEU)	225,000	450,000

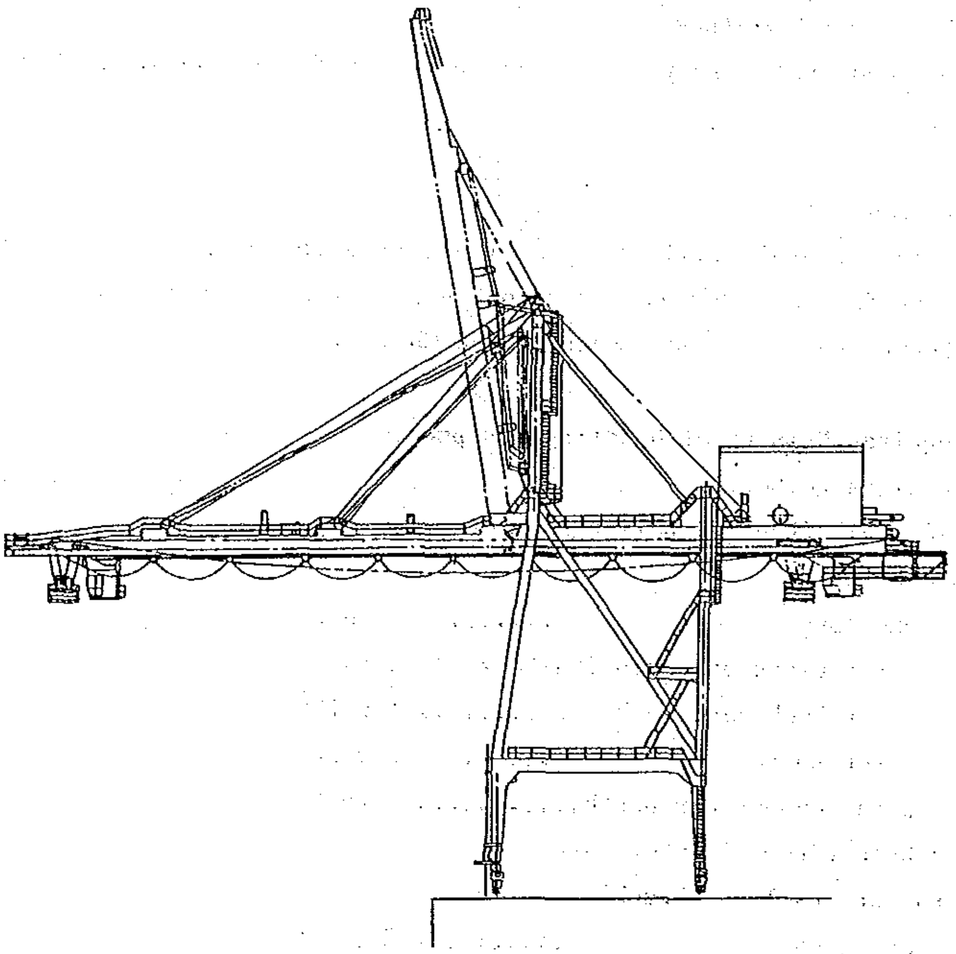


Fig. 5-4-2 Container Cranes

2) Transfer Cranes (Fig. 5-4-3)

The required number of the transfer cranes at a berth is usually calculated using the following expression,

NTR = 2NC + 1 or 2

NTR: Required number of transfer cranes

NC: Number of Container Cranes

Each container berth will have two container cranes.

NTR = 2 x 3 cranes + 2 = 8 units

The new port will use one and a half container berths in 2000 year. Therefore, there should be eight Transfer Cranes in the Container Yard.

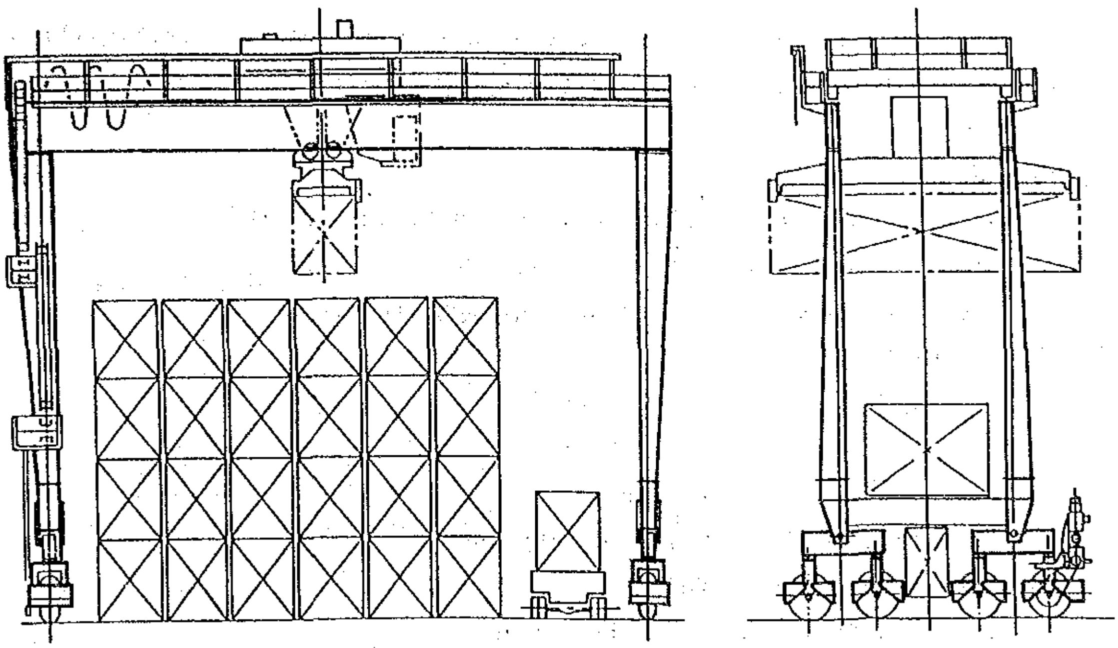


Fig. 5-4-3 Transfer Cranes

3) Tractor-trailer chassis at the yard

The required number of tractor-trailer chassis for transportation between the container cranes and the transfer cranes is determined by the following formula:

NTTC = 6NC

NTTC: Required number of tractor-trailer chassis

NC : number of Container Cranes

Therefore NTTC = 6 x 3 = 18 units

4) Tractor-trailers at the Container Fright Station (C.F.S.)

The required number of tractor-trailers at the C.F.S is usually calculated by the number of berths of the C.F.S.

$$Bc = \frac{T \times \rho}{W \times C \times \eta}$$

Bc = number of berths of C.F.S.
T = Container throughput (TEU/year)
W = working day
ρ = peak factor
η = allowance factor
C = number of containers carried per day

$$= \frac{16.159 \times 1.3}{300 \times 3.5 \times 0.8} = 25$$

Therefore, the required number of tractor-trailer at the C.F.S. will be five(5) tractor-trailer sets and twenty(20) trailers (chassis)

(3) Bulk Grain

The storage equipment for the bulk grain berth (in 2015)

Import volume of Grain (N):154,300ton

required capacity of Storage equipment(c) tons

The calculation formula is

$C = N/W/\eta$ C: capacity (ton)

W: Rate of turn over

η: efficiency

$= 154,300 / 4 / 0.7 = 60,000$(ton)

Capacity of unit silo (Va)

$Va = \pi/4\ D^2 \times h \times \eta$ D = 10 m/

h = 45 m

$\eta = 0.7$

$= \pi/4\ 10^2 \times 45 \times 0.7 = 2,470\ (m^3)$

Required number of silos

(60,000/0.75)/2,470 = 32 (No.) Density of grain = 0.75

Comparison of handling equipment

(number of Pneumatic unloaders and capacity)

Table 5-4-2 Comparison Table of Berthing Hours

	PLAN A	PLAN B
1) Number of Pneumatic unloaders and capacity	400ton/hr x 2 sets 800 ton/hr	400ton/hr x 1 set 400 ton/hr
2) Unloading hours 50,000ton/ 1)	62.5hr	125hr
3) Berthing hours 2) + 10 hr	72.5hr	135hr

Table 5-4-3 Cost Comparison

unit: x 1000 R.O

	PLAN A	PLAN B
4) Pneumatic unloader	2,000	1,000
5) Conveyer system	1,500	800
6) Dust collector	750	750
7) Electric Equipment	750	750
8) Subtotal	5,000	3,300
9) SILOS	3,500	3,500
10) Buildings	2,000	2,000
11) Subtotal	5,500	5,500
12) Total 8)+11)	10,500	8,800
13) Economic life	25 years	
14) Annual cost 12)/13)	420	352
15) Ship cost per day	3.75/day	0.156/hr
16) Ship cost in Port 15)x3)	11.31	21.06
17) Ship cost per year 16)x3	33.93	63.18
18) Total annual cost 14)+17)	453.93	415.18
19) Difference, A-B	+41.75	

Conclusion: The annual cost of PLAN B (Pneumatic unloader 400ton/hr x 1 set) is less than that of PLAN A by 41,750 RIAL. Therefore PLAN B in recommended by the JICA TEAM.

(4) Total numbers of equipment

A list of the cargo handling equipment required for the new port is listed below in Table 5-4-4.

Table 5-4-4 Cargo Handling Equipment

DISCRIPTION	2000	2015
Container Cranes	3	3
Transfer Cranes	8	7
Tractor-Trailers	27	20
Trailers	20	-
Mobil Cranes	2	2
Fork Lifts	30	10
Truck Scales	1	1
Tug Boats	2	1

5.5 Required Scale of Storage facilities

5.5.1 Estimation of Area Required for General Cargo

The required storage area can be calculated by using the following simple formula:

(1) formula

$$A = \frac{T \times p \times a}{W/D \times S}$$

A: Required Storage Area (m^2)

T: Cargo Throughput (Tons/year)

W: Working Days(Days/year)

D: Dwelling time (Days)

s: Stacking Density (t/m^2)

p: Peak Factor

a: Allowance Factor

(2) required area by storage mode

Table 5-5-1 Required Area by Storage Mode

Open area

year (2000)	throughput (ton)	dwell time (day)	working days/year	stacking density (t/m^2)	peak factor	allowance	required area(m^2)
timber	54000	8.05	300	2.5	1.6	1.4	1298
steel	141200	7.00	300	1.3	1.6	1.4	5677
vehicles (unit)	0	5.30	300	0.0625	1.8	1.2	0
others	81918	12.80	300	0.75	1.6	1.4	10439
sum	277118						

Stacking density of vehicles: 1/16 ($16m^2$/unit)

Covered

year (2000)	throughput (ton)	dwell time (day)	working days/year	stacking density (t/m^2)	peak factor	allowance	required area(m^2)
rice*5	7090	10	300	2.5	1.5	1.4	199
sugar*5	2615	12.8	300	2.5	1.5	1.4	94
cement*5	580	12.8	300	2.5	1.5	1.4	21
others	28682	12.8	300	0.75	1.5	1.4	3427
sum	38967						3740

Open area

year (2015)	throughput (ton)	dwell time (day)	working days/year	stacking density (t/m^2)	peak factor	allowance	required area(m^2)
timber	96800	8.05	300	2.5	1.6	1.4	2327
steel	535400	7.00	300	1.3	1.6	1.4	21526
vehicle							
(unit)	43500	5.30	300	0.0625	1.8	1.2	26559
others	182402	12.80	300	0.75	1.6	1.4	23244
sum	858102						73656

stacking density of vehicle: 1/16 (16m2/unit)

Covered

year (2015)	throughput (ton)	dwell time (day)	working days/year	stacking density (t/m^2)	peak factor	allowance	required area(m^2)
rice*.5	20295	10	300	2.5	1.5	1.4	568
sugar*.5	9045	12.8	300	2.5	1.5	1.4	324
cement*.5	1225	12.8	300	2.5	1.5	1.4	44
others	69658	12.8	300	0.75	1.5	1.4	8322
sum	100223						9258

Amount directly delivered 30565

(3) Relationship between required Area and available Area.

Table 5-5-2 Required Area and Available Area (Open Area)

Unit: m^2

	2000	2015
Required Area	17,414	73,656
Available Area		
No.1 Berth	47,000	47,000
No.2 Berth	22,000	22,000
No.3 Berth		22,000
No.4 Berth		15,000
No.5 Berth		47,000
Sum	69,000	153,000
Balance	51,586	79,344

Table 5-5-3 Requried Area and Available Area (Covered)

Unit: m^2

	2000	2015
Required Area	3,740	9,258
Available Area		
No.2 Berth	4,550	4,550
No.3 Berth		4,550
Sum	4,550	9,100
Balance	810	-158

The area for open and covered (Shed) are introduced in the tables, 5-5-2, 5-5-3.

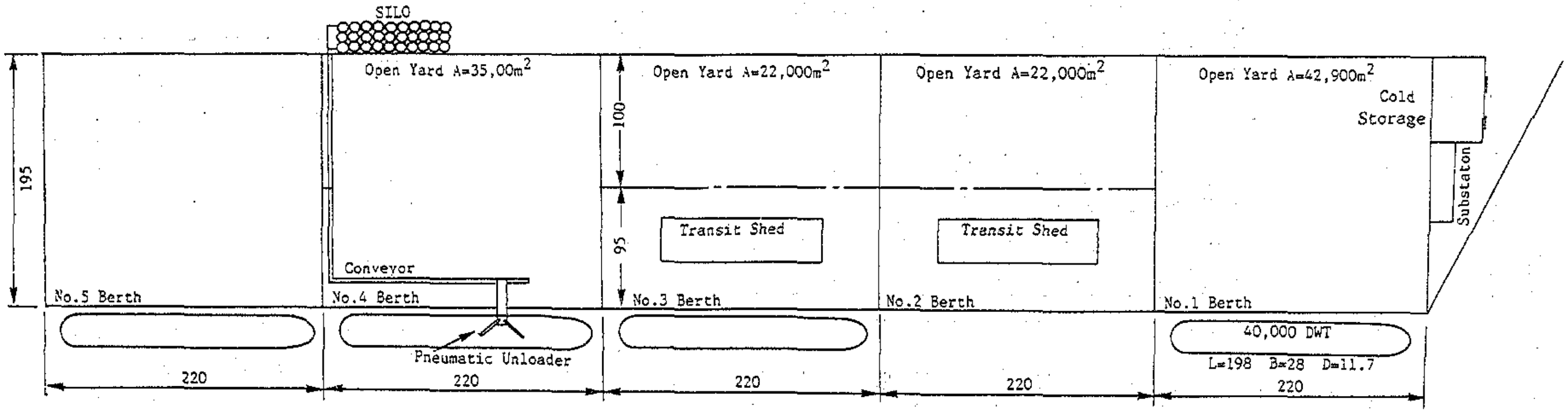


Fig. 5-5-1 Layout of Genral Cargo Berth

5.5.2 Estimation Area of Required for Container Cargo

(1) The number of ground spots required for each container mode is estimated as out-lined in the tables below:

Table 5-5-4 The Number of Ground Spots (For the Year 2000)

For the year 2000

		g.spot	dwell time	stack height	efficiency	peak fact.	serv.day (day)	throughput
(a)	export(l)	114	7.0	4.0	0.80	1.3	365.0	14632
(b)	transship		6.9	4.0	0.80	1.3	365.0	0
(c)	import	228	8.6	3.0	0.75	1.3	365.0	16748
(d)	export(e)	198	21.0	4.0	0.80	1.3	365.0	8471
(e)	export(e)	300	21.0	4.0	0.80	1.3	365.0	12835
(f)	export(e)	228	21.0	4.0	0.80	1.3	365.0	12322
(g)	export(e)		21.0	4.0	0.80	1.3	365.0	16748
(h)	import(r)	276	6.9	4.0	0.80	1.3	365.0	35938
(i)	import		21.0	4.0	0.80	1.3	365.0	0
(j)	transship	276	6.9	4.0	0.80	1.3	365.0	35938
(a)	export(e)		21.0	4.0	0.80	1.3	365.0	0
(g)	import		8.6	3.0	0.75	1.3	365.0	0
(d)	transship	264	6.9	4.0	0.80	1.3	365.0	34376
sum		2112						161168

Table 5-5-5 Numnber of Ground Spots (Based on the Year 2000)

Based on the year 2000

summary	storage cap.(TEUs)	required slot 2000	balance 2000	additional g.spots
import(r)	9097	3949	5148	122
import	33496	18648	14848	202
export(l)	14632	2793	11839	92
export(e)	33628	16665	16963	396
transship	70314	30150	40164	308
sum	161168	72205		1122

Table 5-5-6 The Number of Ground Spots (For the Year 2010)

For the year 2010

		g.spot	dwell time	stack height	efficiency	peak fact.	serv.day (day)	throughput
(a)	export(1)	114	7.0	4.0	0.70	1.3	365.0	12803
(b)	tranship	618	6.9	4.0	0.70	1.3	365.0	70412
(c)	import	684	8.6	3.0	0.60	1.3	365.0	40196
(d)	export(e)	426	21.0	4.0	0.70	1.3	365.0	15948
(e)	export(e)	642	21.0	4.0	0.70	1.3	365.0	24034
(f)	export(e)	630	21.0	4.0	0.70	1.3	365.0	23585
(g)	export(e)		21.0	4.0	0.70	1.3	365.0	0
(h)	import(r)	540	10.0	2.0	0.60	1.3	365.0	18194
(i)	import	570	8.6	3.0	0.60	1.3	365.0	33496
(j)	tranship	606	6.9	4.0	0.70	1.3	365.0	69045
(a)	export(e)		21.0	4.0	0.70	1.3	365.0	0
(g)	import		8.6	3.0	0.60	1.3	365.0	0
(d)	tranship		6.9	4.0	0.70	1.3	365.0	0
sum		4830						307712

Table 5-5-7 The Number of Ground Spots (Based on the Year 2010)

Based on the year 2010

summary	storage cap.(TEUs)	required slot 2000	balance 2000	additional g.spots
import(r)	18194	11979	6215	184
import	73692	49968	23724	404
export(1)	12803	7162	5641	50
export(e)	63566	44329	19237	514
tranship	139457	91291	48166	423
sum	307712	204729		1575

Table 5-5-8 The Number of Ground Spots (For the Year 2015)

For the year 2015

		g.spot	dwell time	stack height	efficiency	peak fact.	serv.day (day)	throughput
(a)	export(l)	342	7.0	4.0	0.80	1.3	365.0	43896
(b)	transship	618	6.9	4.0	0.80	1.3	365.0	80471
(c)	import	570	8.6	3.0	0.75	1.3	365.0	41871
(d)	export(e)	312	21.0	4.0	0.80	1.3	365.0	13349
(e)	export(e)	642	21.0	4.0	0.80	1.3	365.0	27467
(f)	export(e)	630	21.0	4.0	0.80	1.3	365.0	26957
(g)	export(e)		21.0	4.0	0.80	1.3	365.0	0
(h)	import(r)	540	10.0	2.0	0.75	1.3	365.0	22742
(i)	import	570	8.6	3.0	0.75	1.3	365.0	41871
(j)	transship	606	6.9	4.0	0.80	1.3	365.0	78908
(a)	export(e)		21.0	4.0	0.80	1.3	365.0	0
(g)	import		8.6	3.0	0.75	1.3	365.0	0
(d)	transship		6.9	4.0	0.80	1.3	365.0	0
sum		4830						377529

Table 5-5-9 The Number of Ground Spots (Based on the Year 2000)

Based on the year 2000

summary	storage cap.(TEUs)	required slot 2015	balance 2015	additional g.spot
import(r)	22742	17937	4805	114
import	83741	70011	13730	187
export(l)	43896	9852	34044	265
export(e)	67770	61785	5985	140
transship	159370	135854	23525	181
sum	377529	295439		887

(2) For the year 2000

The container berth configuration shown in Fig.5-5-2 was planned with the data given above and three (3) cranes to be installed.

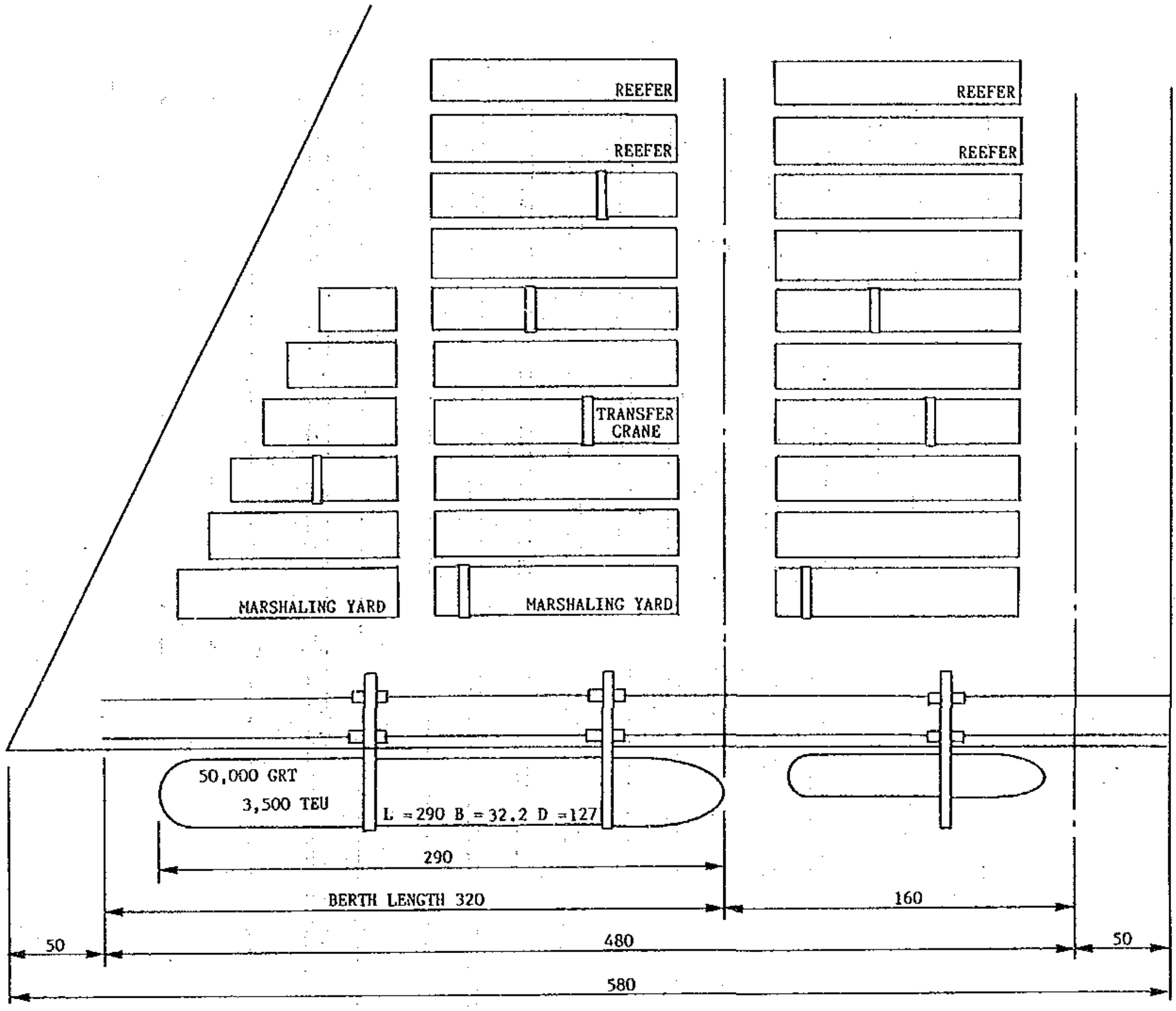


Fig. 5-5-2 Container Berth Layout in the Year 2000

(3) For the year 2015

The layout of the final three container berths in the year 2015 is shown in Fig.5-5-3.

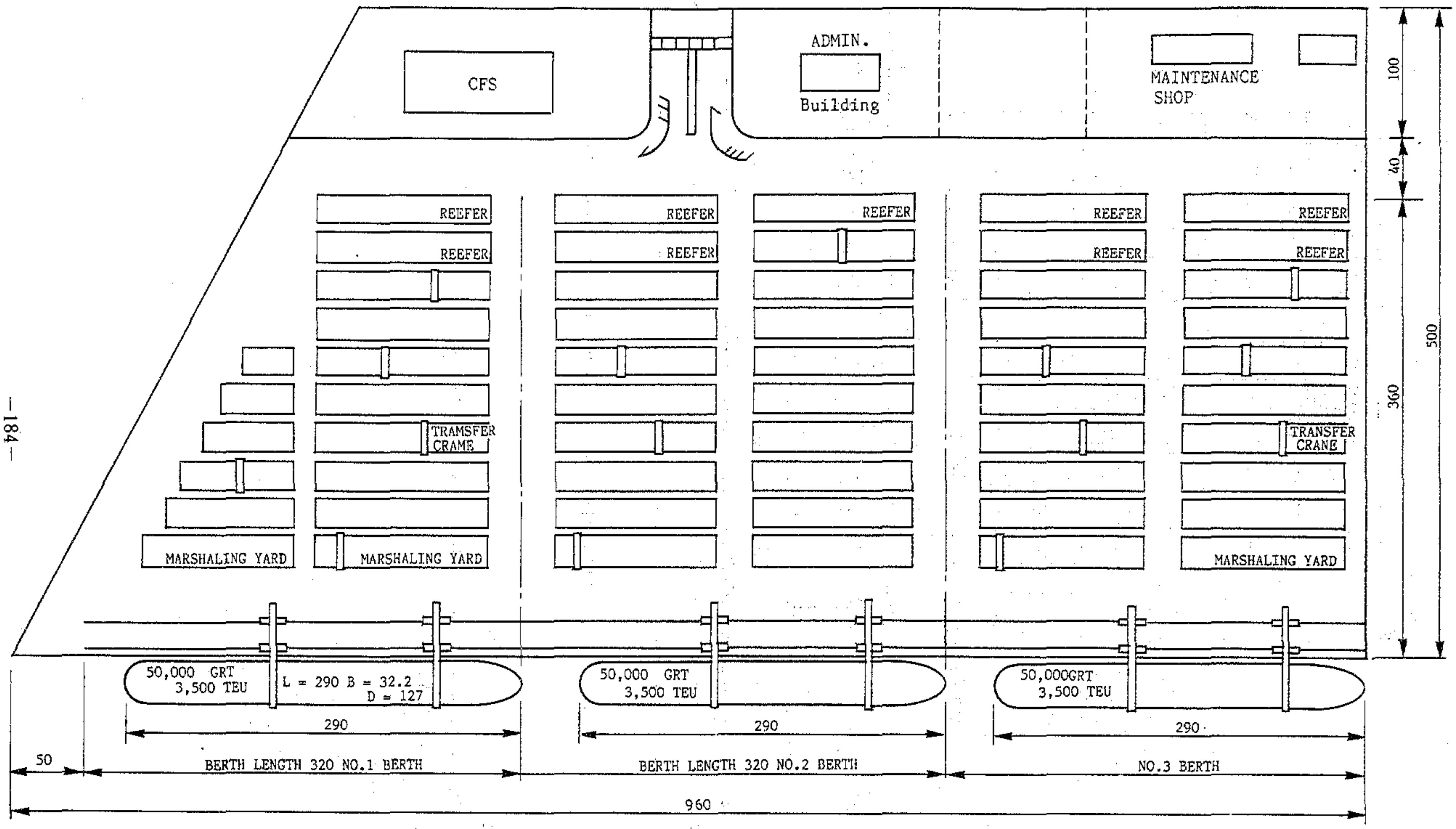


Fig. 5-5-3 Final Layout of Container Berth in the Year 2015

5.5.3 Other Facilities

(1) C.F.S.

a) Expected number of Containers

The expected number of Containers and Cargo tonnage throughput at C.F.S. are: 10% of loaded import containers and 25% of loaded export Containers in the year 2015. These numbers are shown in Table 5-5-10.

Table 5-5-10 Expected Number and Cargoes of Containers

	Container(TEU)	Cargo (ton)
Import	7,000	82,612
Export	2,460	27,100
Sum	9,460	109,712

b) Area of C.F.S.

The area required for the C.F.S. is calculated using the following formula:

$$A = \frac{T \times \eta \times D \times \alpha}{W \times S \times h}$$

$= 5170\ m^2$

A: Area required for CFS.....m^2
T: Cargo throughput .....ton
η: peak factor 1.3
D: Dwelling time .....7 days
α: Alleyway Against 1.4
W: Annual working days .....300 days
S: Stacking density .....$0.6t/m^2$
h: Stacking height 1.5m

therefore,
The dimension of the C.F.S. is 50m in width and 110m of frontage.

(2) Container berth administration building

An administration building will be required to control the container operations. This building will have three stories; on the ground floor will be the canteen and rest room; on the first floor will be offices; and on the second floor will be the operations control room and the computer room. The building will be $800m^2$ in area, 20m x 40m.

(3) Maintenance shop

A maintenance shop for repair and maintenance work on the handling equipment and damaged containers is required at the container berth.

The required shop area will be 1,700m^2 (1200m^2 for maintenance, plus 500m^2 for damaged containers) with a width of 25m and a length of 70m. An overhead crane, steam cleaners, press machines, wheel dollies and other repair tools as well as a store of spare parts will be provided in the maintenance shop.

A further 3,000m^2 or so of open working and storage area will be needed for damaged containers, handling equipment etc.

5.6 Other Facilities

5.6.1 Electric Transformer Substation

Two electric transformer substation will be needed at the new port facility. One will be required beside the container berth to serve as a power source for the cranes, reefer containers, yard lighting and other facilities. Another substation will be needed at the general cargo berth for yard lighting, the silos and other facilities.

5.6.2 Cold Storage

The annual amount of imported chilled and frozen food stuffs will reach 89,000ton by 2015.

A cold storage facility will be required at the general cargo berth near the fishery port and No.1 berth in the new port. The area of cold storage can be calculated using the formula below:

$$A = \frac{T \times \eta \times d \times \alpha}{W \times S} = 1860m^2$$

Say 40m x 50m

A: Required area	.....m^2
T: Throughput	.....ton
η: peak factor	.....1.6
D: Dwelling time	.....7day
W: Working day	.....300 day
S: Stacking density	.....2.5ton/m^2
α: Allowance	.....1.4

5.6.3 Grain Silos

Grain silos with a capacity of 60,000 tons will be built behind No.4 general cargo berth. Handling of grain from ship to silo will require a pneumatic unloader and a belt conveyer of 400t/hr capacity.

The layout of No.4 berth including silos, unloader and conveyer are shown below.

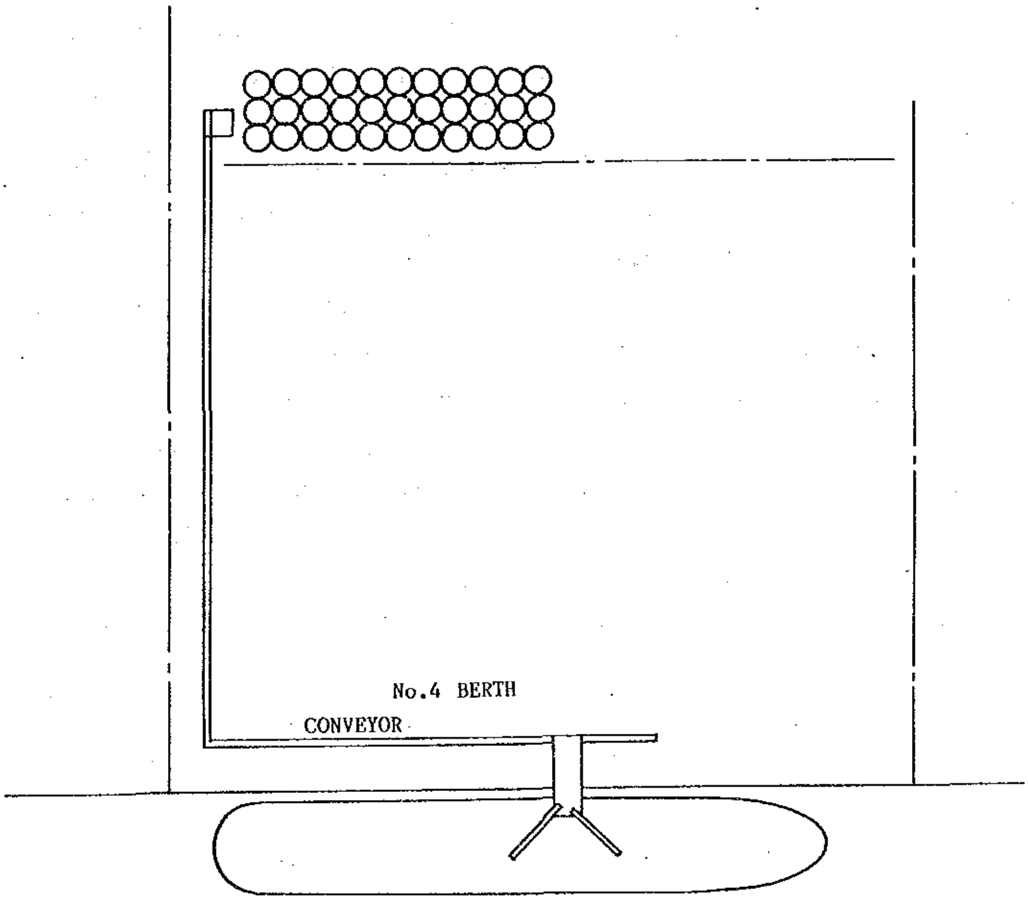


Fig. 5-5-4 Layout of No.4 Berth

5.7 Proposed Land Use Plan

As described in 5.2.1, the east side of the port should be developed for the FTZ and light industry. According to the Sohar Structure Plan, the government of Oman intends to formulate a new district center at Falaj al Qabail. The government also intends to develop a major local center in the vicinity of the existing Majis town. The development of a major new road to connect these two centers is also planned.

In 2015, both side terminals will be used for commercial cargoes. But in the long term beyond 2015, the east terminal should be used for commercial cargoes and the west terminal should be used for industrial cargoes.

In the Master Plan for 2015, two main roads, of which one wil be behind the container berths and another behind the general cargo berths, should be connected to the existing road. The entrance to the port should be located at the crossing of the existing trunk road and the existing branch road. The proposed land use plan is illustrated in Figs.5-7-1 and 5-7-2. We have described in 5.2.1 that the total quay length in the long term would be about 10km, but the reservation of such a huge land area seems to be unnecessary considering the required berth length in 2015. The expansion of the west channel may not be necessary. So in the land use plan for 2015, we exclude the west channel and reduce the heavy industrial area to the area surrounded by the boundary, that is, 1,250m from the quay line.

In the Sohar Structure Plan, a desalination/power plant is planned at the container terminal of our plan as shown in Appendix 5-7-1. The demand for electricity is estimated to be about 75MW by 2005. In our plan the desalination/power plant should be located in the heavy industrial area.

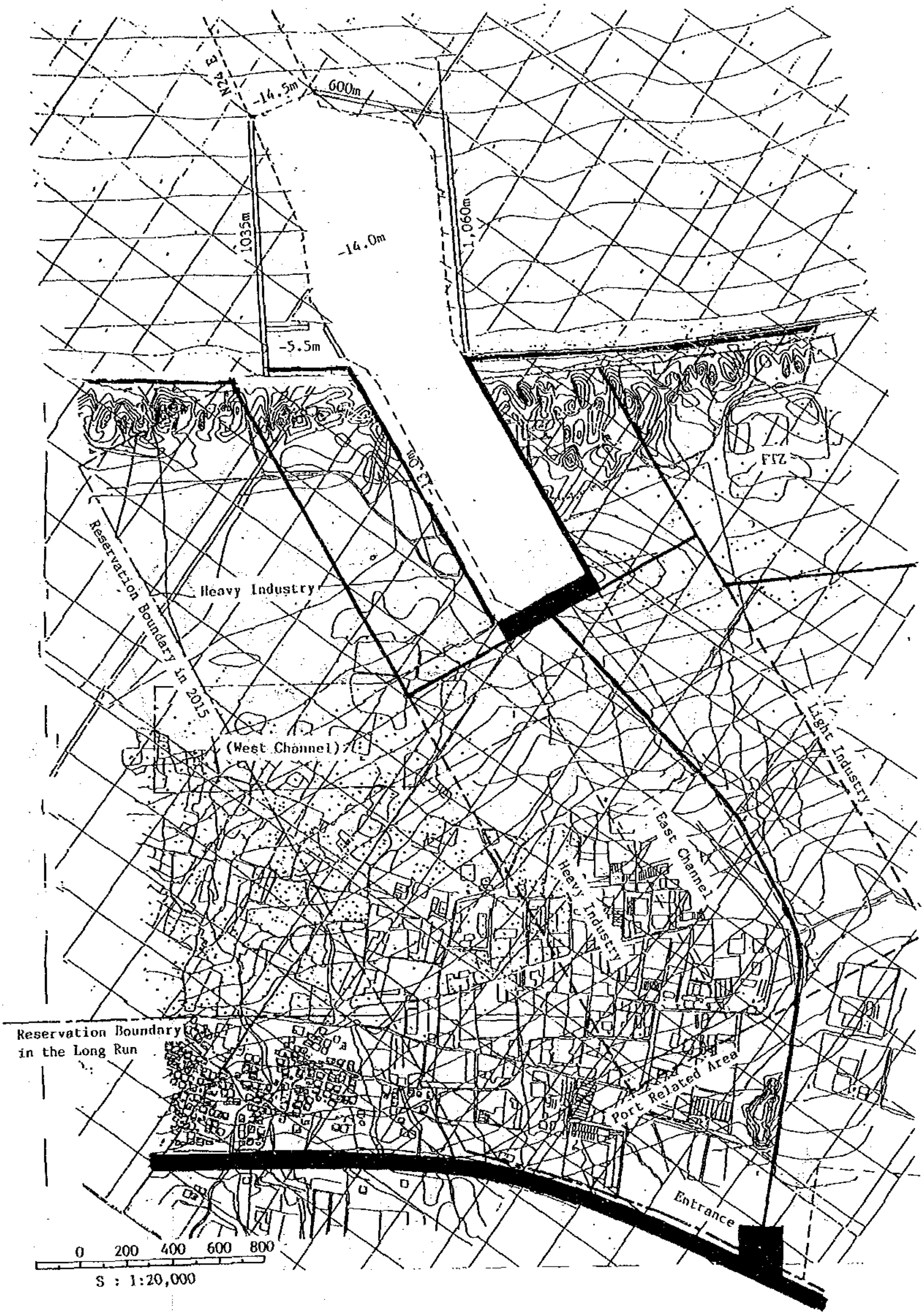
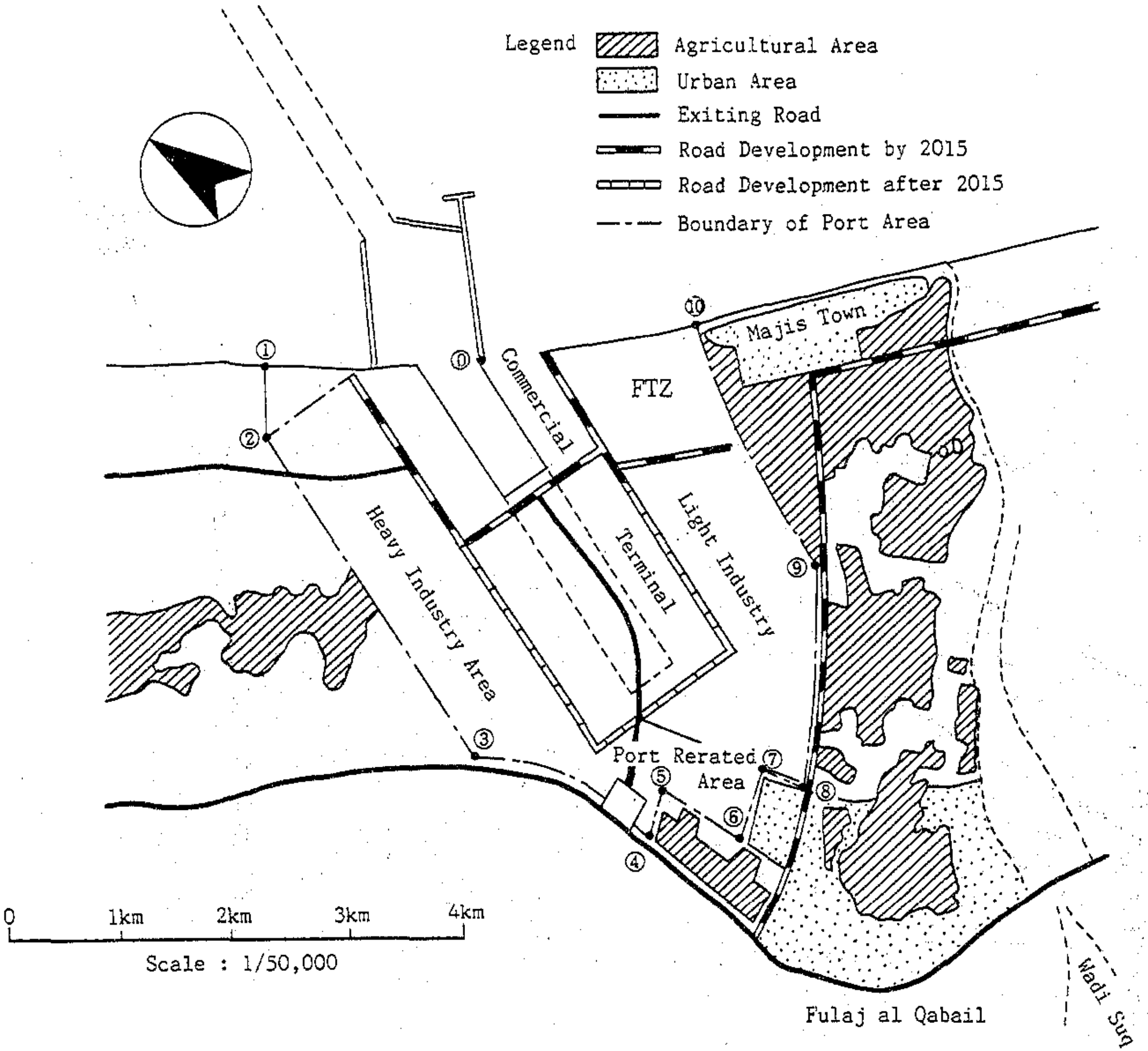


Fig. 5-7-1 Land Utilization Plan (1)



Point Coordinate

Point	East	North
⓪	56°38'02"	24°28'41"
①	56°37'25"	24°29'31"
②	56°37'06"	24°29'20"
③	56°36'18"	24°27'40"
④	56°36'24"	24°26'49"
⑤	56°36'39"	24°26'53"
⑥	56°36'39"	24°26'28"
⑦	56°37'01"	24°26'33"
⑧	56°37'03"	24°26'21"
⑨	56°38'27"	24°26'52"
⑩	56°38'45"	24°27'56"

Fig. 5-7-2 Land Utilization Plan (2)

CHAPTER 6 PRELIMINARY DESIGN AND COST ESTIMATE

Chapter 6 PRELIMINARY DESIGN AND COST ESTIMATE

The port facilities needed to meet the future traffic demand were discussed in the previous chapter. In this chapter their structural designs and cost estimates are discussed.

6.1 Preliminary Design

The location of the port facilities designed is shown in Fig. 6-1-1.

6.1.1 Breakwaters

Breakwaters with a total length of 3,045m are planned from the shore line to a point with a depth of -7.5m offshore. These breakwaters are to prevent the channel from shoring, and serve to secure the calmness needed for ship activities with regard to ordinary sea condition or storms. Furthermore, another breakwaters are planned in the inner port area. These breakwaters will make a water basin for small vessels.

(1) Design Conditions

The design conditions of the breakwaters are determined based on the results of the hydraulic analyses.

(a) Tidal Plane

H.W.L	+2.4m
M.S.L	+1.5m
L.W.L	+0.8m
D.L	+0.0m

(b) Design Waves

Design Wave heights at the depths of the planned breakwater are estimated as follows.

Table 6-1-1 Design Deep Water Wave

Wave Direction	E
Wave Height	Ho=5.9m
Wave Period	T=12.0see
Wave Length	Co=225m
Slope of Sea Bottom	tan α =1/200

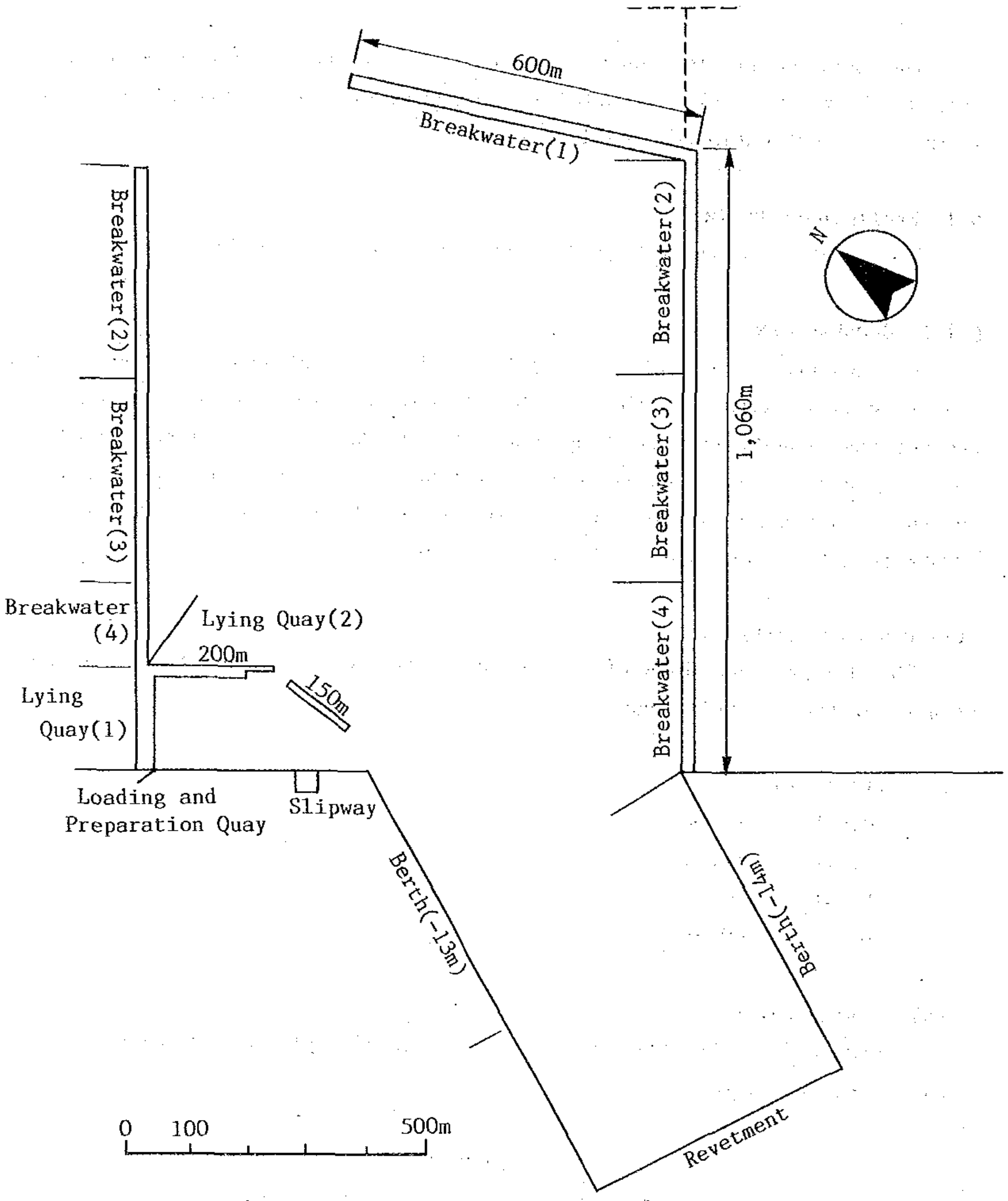


Fig. 6-1-1 Location of Facilities

Table 6-1-2 Design Waves

depth (m)	Ho' (m)	H1/3 (m)	Hmax (m)	β (degree)
-7.5	5.07	5.2	7.6	N64
-7.0		5.2	7.3	
-6.0		4.9	6.6	
-5.0		4.5	6.0	
-4.0		4.0	5.7	
-3.0		3.5	4.6	
-2.0		3.0	3.9	
(-2.0)		(2.9)	(3.7)	

( ): inner port area

Ho : Deep water height
T : Wave period
Co : Wave length
Ho' : Equivalent deep water wave height
H1/3 : Significant wave height
Hmax : Maximum wave height
β : Incident wave angle

(2) Structural Design

(a) Determination of Cross Section

The breakwaters are designed by taking appropriate account of safety and broad economic implications. In determining the cross sections of the breakwaters, the following premises are taken into consideration.

i) A rubble mound type breakwater with armored concrete block is selected, since the materials suitable for this structure can be produced at the quarry near the Majis site.

ii) The crown height of the breakwater is determined to be about 0.6 times the design significant wave height above H.W.L. This crown height may allow overtopping to some extent, but overtopping has little effect, according to the wave observation data.

iii) The weight of armored concrete block is calculated using the formula by Hudson, R.Y.

iv) The gradients of the slope are 1:4/3 in the case of blocks and

1:1.5 in the case of stones.

v) The crown width of the wave dissipating works using in situ concrete is determined to be equal to the equivalent width of 2 lanes of vehicle considering the construction method and the maintenance after completion.

(b) Weight of Armor Blocks

The weight of concrete blocks covering the slope surface of a structure receiving the action of wave force is calculated using the following formula:

$$W=\frac{\gamma H^3}{Kp(Sr-1)^3 \cot\alpha} \quad *$$

W : Minimum weight of concrete blocks (t)
γr: Unit weight of block in air (t/m^3)
Sr: Specific gravity of block to sea water
α : Angle of the slope to horizontal plane (degrees)
H : Significant wave height at the water depth at which the structure is constructed (m)
Kp: Constant determined by the armoring material and damage rate

* Hudson, R.Y, "Laboratory investigation of rubble-mound breakwater", Proc. ASCE, Vol.85.

The standard cross sections of the breakwater are shown in Fig. 6-1-2(1) - (4).

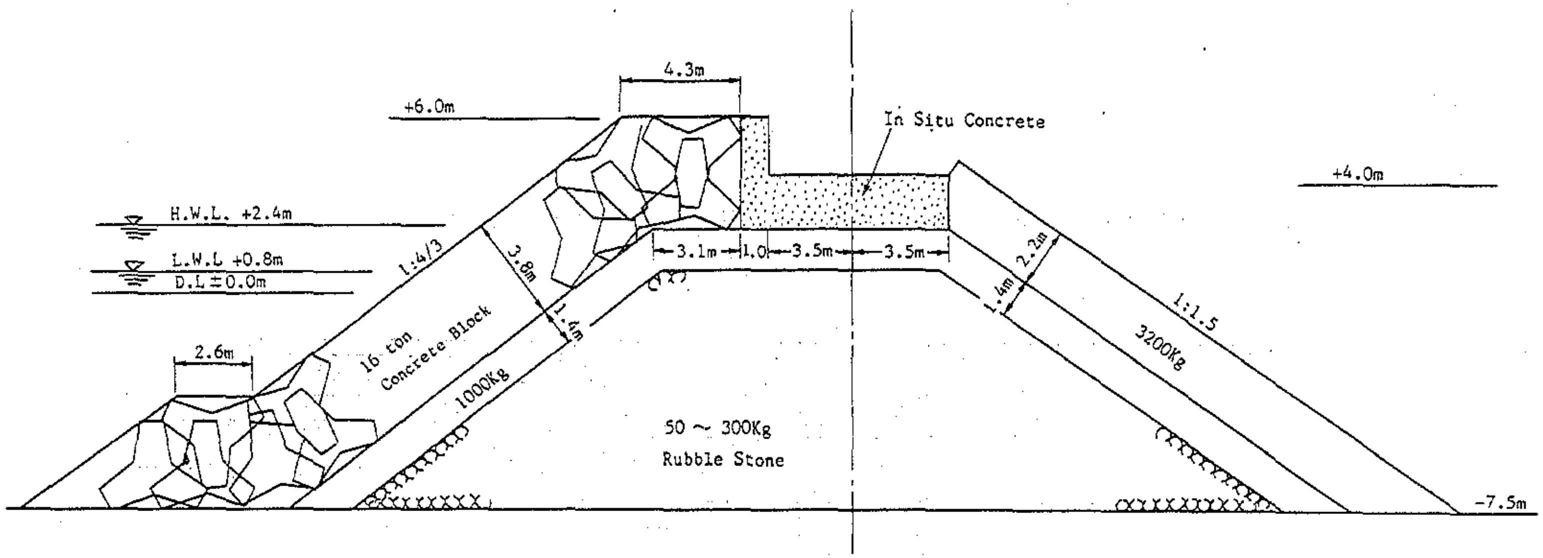


Fig. 6-1-2(1) Standard Cross Section of the Breakwater(1)

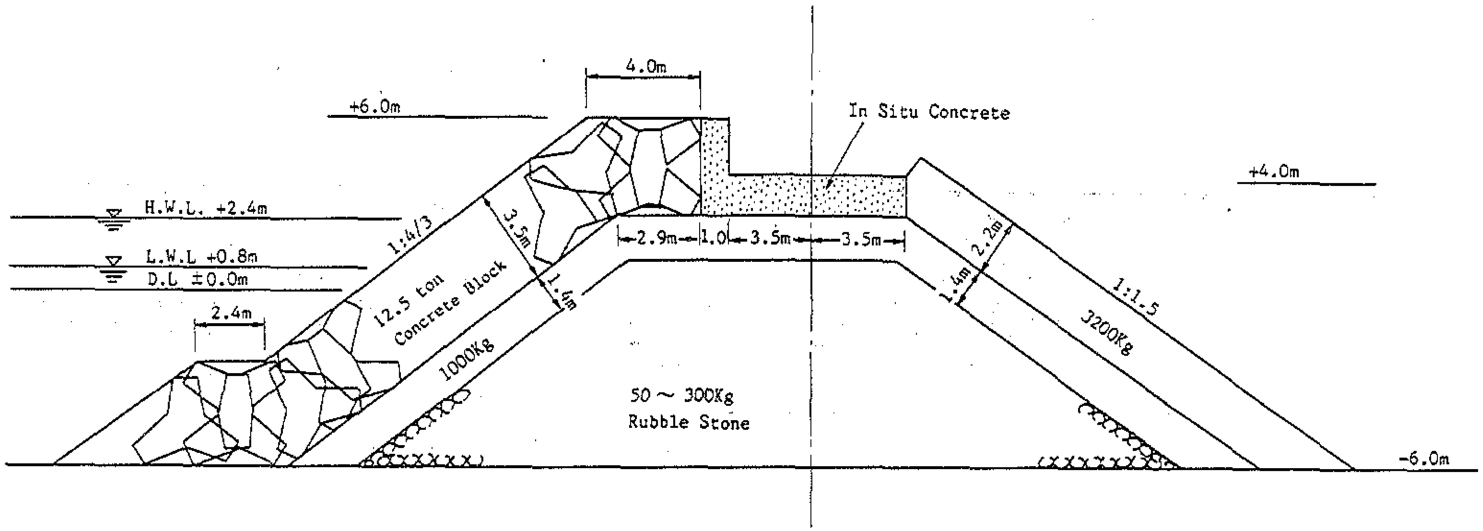


Fig. 6-1-2(2) Standard Cross Section of the Breakwater(2)

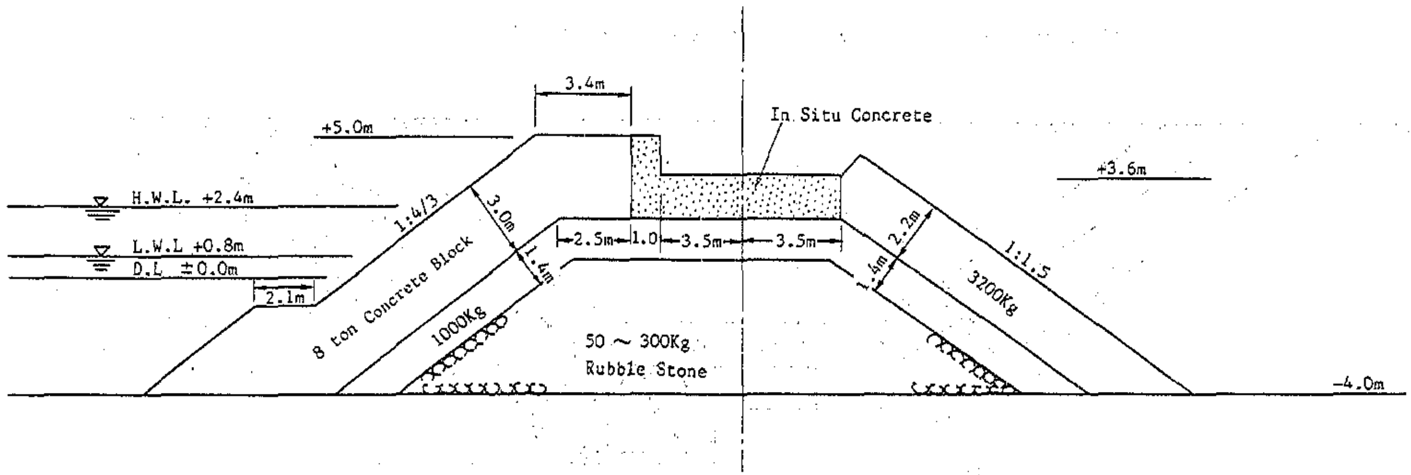


Fig. 6-1-2(3) Standard Cross Section of the Breakwater(3)

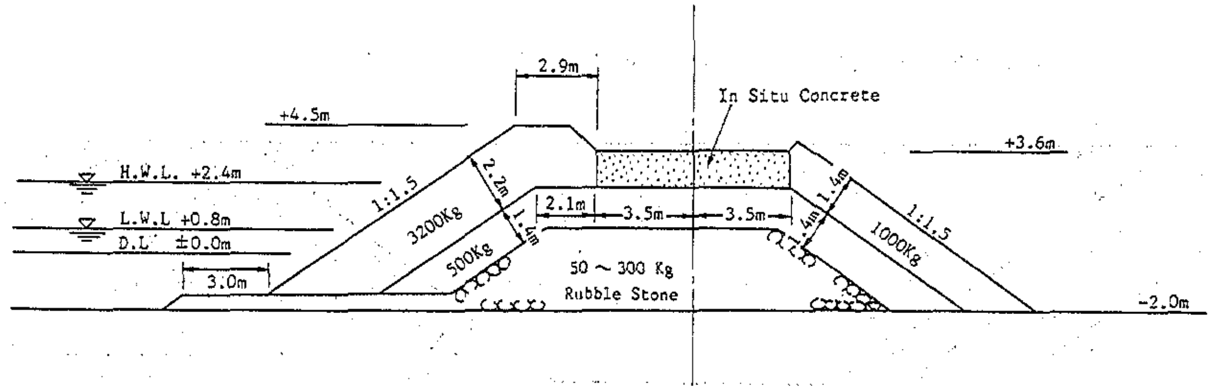


Fig. 6-1-2(4) Standard Cross Section of the Breakwater(4)

6.1.2 Berths

The container berth is designed with a water depth of -14m, and the general cargo berth is designed with a water depth of -13m, deep enough to accommodate 50,000 DWT ships, 40,000 DWT ship respectively. The water depth of berths in the inner port is -5.5m, which can accommodate small size ship such as fishing boats.

(1) Design Conditions

The design conditions are based on the results of the sub-soil surveys and requirements for future port planning, as detailed below.

(a) Soil Conditions

The soil conditions in the Majis area are described in Chapter 2. On the sea bottom there is a very loose, silty sand layer about 5m thickness, which shows an N-value of less than 5.

Beneath this layer, weakly cemented silty sand layers and dense cemented ones appear by turns within a thickness of about 10m. N-values range largely from 10 to 50.

After to these layers, there appears a sand-gravel layer with an N-value of more than 50, which seems to be the bearing stratum.

But in the land area, there are no loose layer and beneath the -10m depth the bearing stratum appears. (cf. BH-8,9)

The soil conditions for the design at the berths planned area are determined as shown in Fig. 6-1-3.

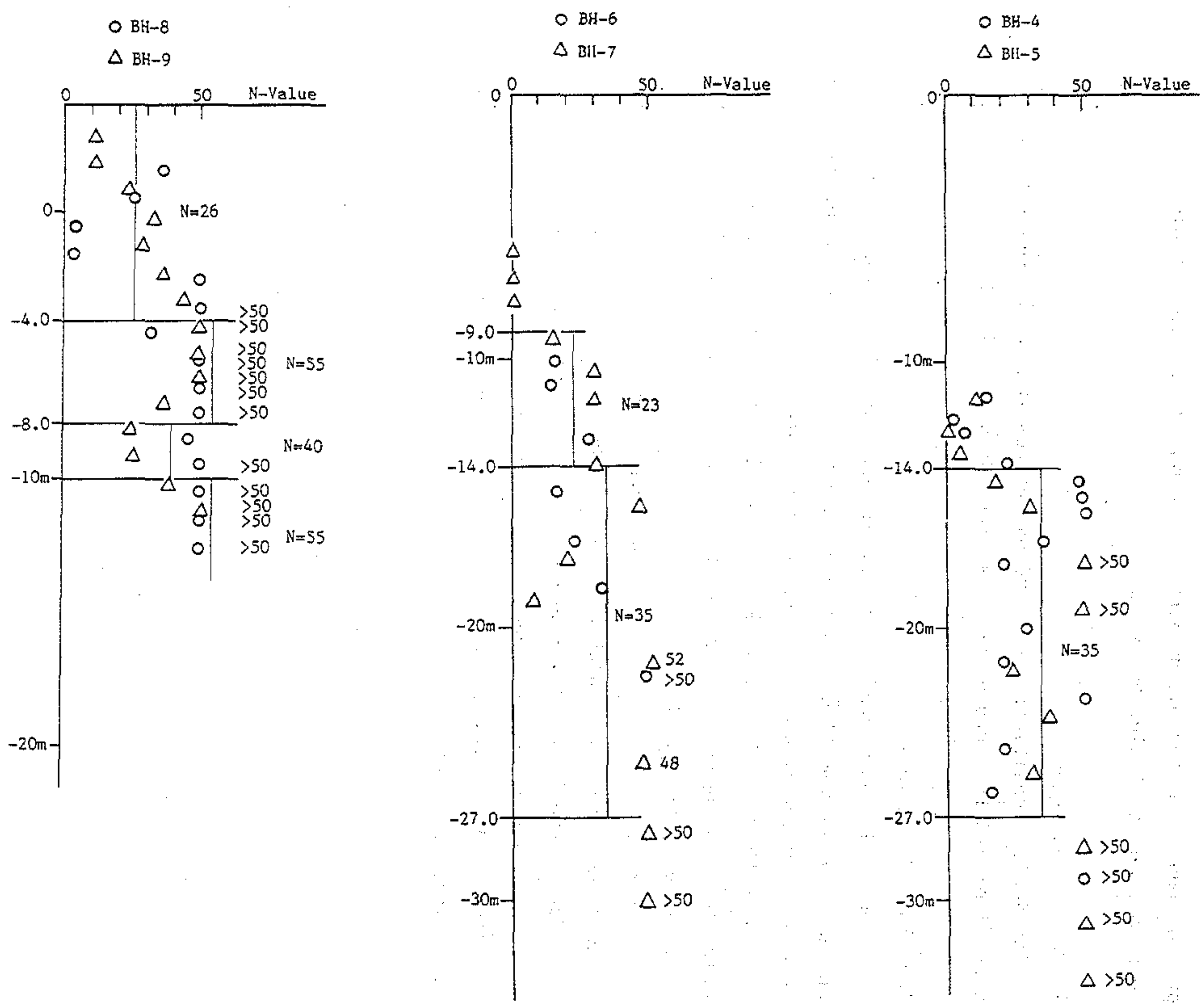


Fig. 6-1-3 N-Values for Facilities Design

(b) Design Conditions of Berths

The berths are designed under the conditions described in Table 6-1-3.

Table 6-1-3 Design Conditions of Berths

1)	Design Ship Size	50,000 DWT	40,000 DWT	300 GWT
2)	Water Depth	- 14.0 m	- 13.0 m	- 5.5 m
3)	Quay Cope Level	+ 4.2 m	+ 4.2 m	+ 3.6 m
4)	Tidal Plane			
	H.W.L	+ 2.40 m	+ 2.40 m	+ 2.40 m
	M.S.L	+ 1.50 m	+ 1.50 m	+ 1.50 m
	L.W.L	+ 0.60 m	+ 0.60 m	+ 0.60 m
	DL	+ 0.00 m	+ 0.00 m	+ 0.00 m
5)	Surcharge			
	Ordinary	2.0 t/m^2	2.0 t/m^2	1.0 t/m^2
	Extra-ordinary	1.0 t/m^2	1.0 t/m^2	0.5 t/m^2
	Cargo Handling Equipment	Gantry Crane	not considered	not considered
6)	Seismic Force	not considered	not considered	not considered
7)	Berthing Velocity	0.10 m/sec	0.10 m/sec	0.30 m/sec
8)	Tractive Force	35 t	10 t	10 t
9)	Wave Force	not considered	not considered	not considered
10)	Service Life	50 years	50 years	50 years

Gantry Crane

Total Weight : 800 t

Wheel Load :

Items / Wheel	No of Wheels	Wheel Load (ton)	
		Wind Speed 20 m/s	Wind Speed 60 m/s
Sea-side Wheel	16	35	60
Land-side Wheel	16	28	48

Wind Force : 160 t

(2) Structural Design

(a) Comparison of the Structural Type of Berths

The following three structural types can be considered as possible structural types applicable for the large berths planned in this project. (Fig. 6-1-4)

-- Caisson type berth

-- Concrete Block type berth

-- Steel pile open type berth

The advantages and disadvantages of the above three types are compared, as shown in Table 6-1-4 and summarized as follows.

Table 6-1-4 Comparison of Structural Types

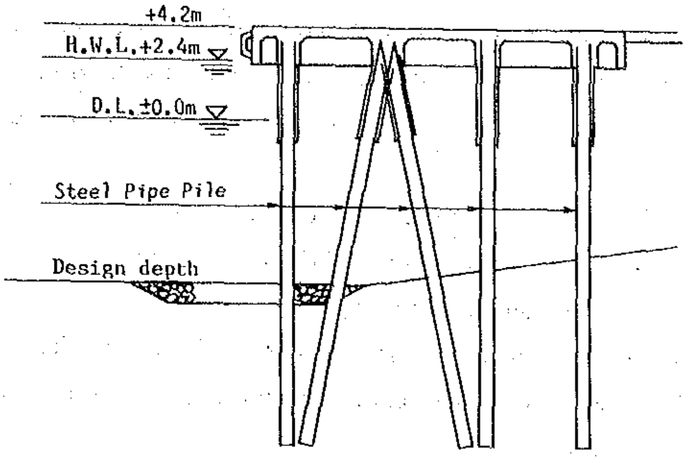
Type / Item	Steel Pile Open Type	Concrete Block Type	Caisson Type
Required Work	Pile driving	Concrete Block	Reinforced Concrete Caisson
Vessel	Pile Driving Barge	Barge with Crane	Floating Dock Barge with Crane
Workability	Difficult	Easy	Ordinary
Construction Speed	Low	High	High
Suitability to Sub-soil Condition	Poor	Good	Good
Effect of Current	Lowest	High	High
Construction Cost	1.2	1.0	1.1

Soil conditions are one of the most important factors in determination of the structural type. In this project, large berths are planned for the present land area. It is clear from the sub-soil survey that there is a hard layer under -10m and this layer has sufficient bearing capacity for large berths.

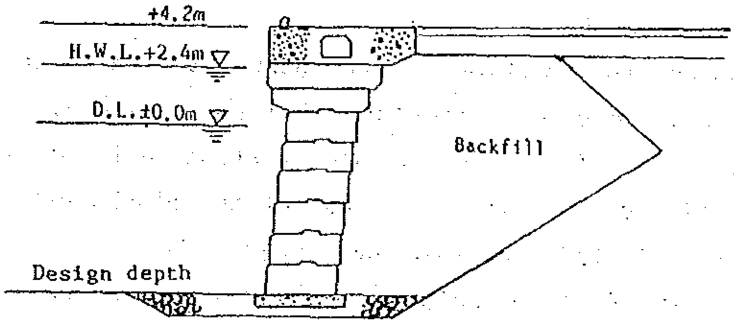
Therefore, the gravity types of berth such as the caisson type or the concrete block type are the most applicable type for this site.

There are wide construction areas for the caisson yard or block yard

Steel Pile Open Type



Concrete Block Type



Caisson Type

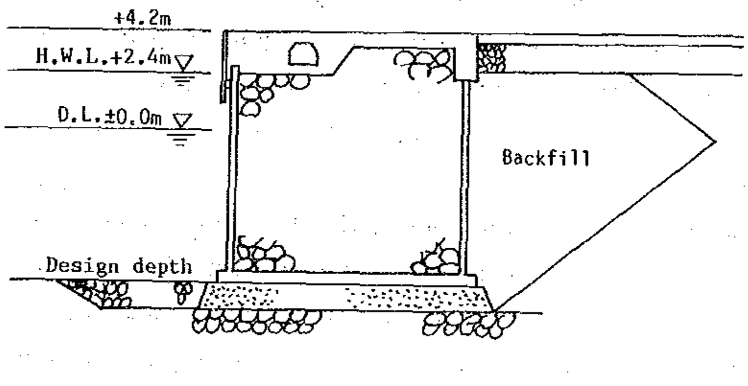


Fig. 6-1-4 Structural Types of Berth

at the site, but in the case of caisson type, a construction yard with slip-way or floating dock is needed for construction of caissons. Consequently, the construction cost of this type is higher than in the cost of the concrete block type because of the construction equipment mentioned above.

In general, the construction method of concrete block type is simpler and easier compared with other types.

The open type has the advantage of preventing wave reflection within the narrow channel caused by invading waves. But, at this site, it is estimated that N-values are more than 60 under the -10m level and pile driving will be difficult.

Hence, the concrete block type is selected for large berths by judging comprehensively.

(b) Structure of Berths

The proposed cross-sections of the berths are shown in Fig. 6-1-5 - 6. The alternative cross-sections are also shown in Fig. 6-1-7 - 8. As shown in Fig. 6-1-5 - 6, the berths are constructed by stacking the pre-cast concrete blocks. The rear portions of the blocks are excavated and backfilled with selected materials such as gravel.

The tractive force of ships is resisted by anchored blocks, and berths will be provided with adequate fender systems.

(c) Fishing Port

A loading and preparation quay with a depth of -5.5m is planned taking the trawling vessels into account. The apron width of the quay does not need to be as wide as on a general cargo berth. A width of about 10m is sufficient as no large packages or pieces of equipment are to be handled. The surface should have a steep slope towards the waterfront, 1:30, for easy washing of the quay as soon as daily unloading is completed.

When the fish catch has been unloaded, each boat should be shifted to another place for cleaning and preparation for the next trip. Idle boats are berthed at the lying quay along the breakwater where they often have to remain for a long time during periods of bad weather or seasonal interruptions of fishing.

Electric lights and water supplies are needed on each quay. Open space on each quay is also needed for drying nets.

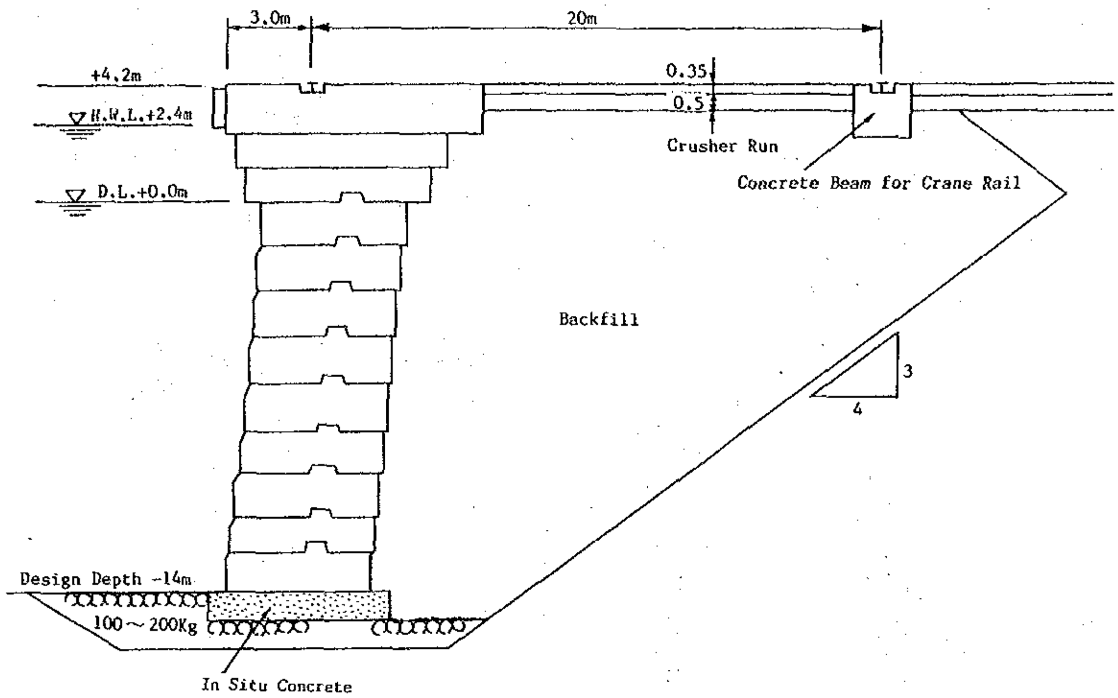


Fig. 6-1-5 Proposed Cross Section of the Berth (-14m)

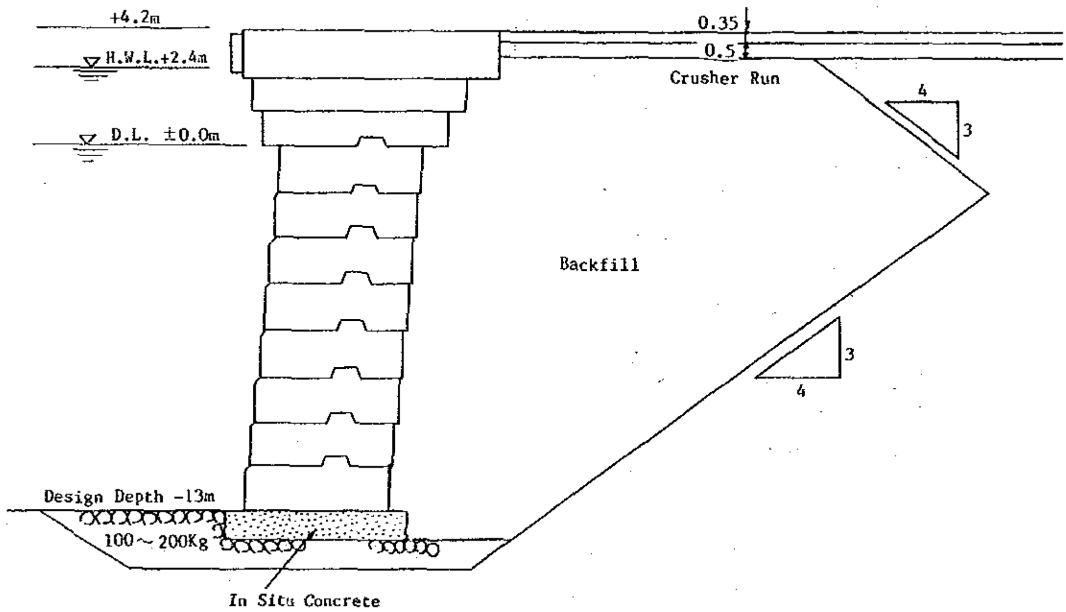


Fig. 6-1-6 Proposed Cross Section of the Berth (-13m)

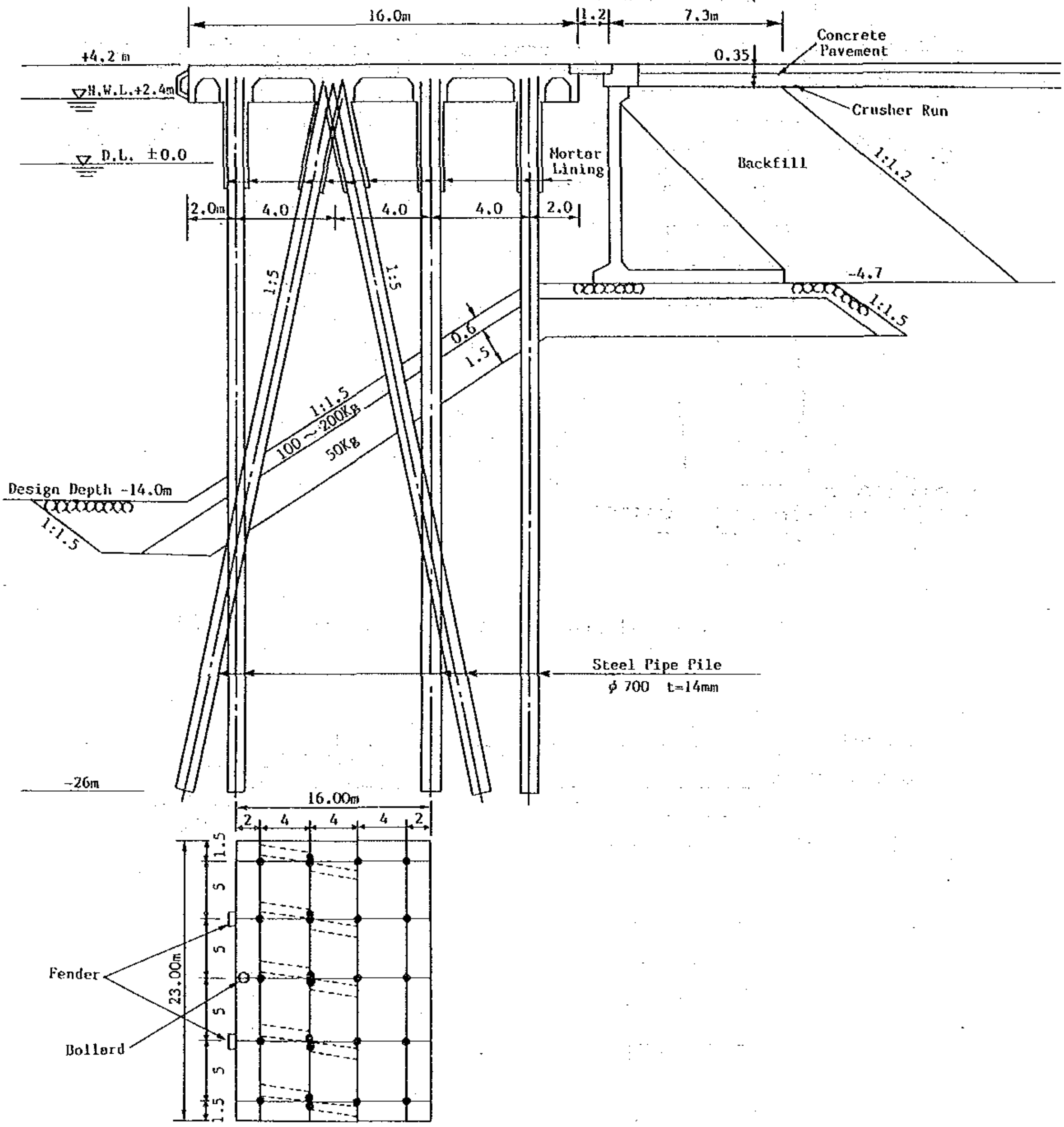


Fig. 6-1-7 Proposed Cross Section of the Berth (-14m)
(Alternative)

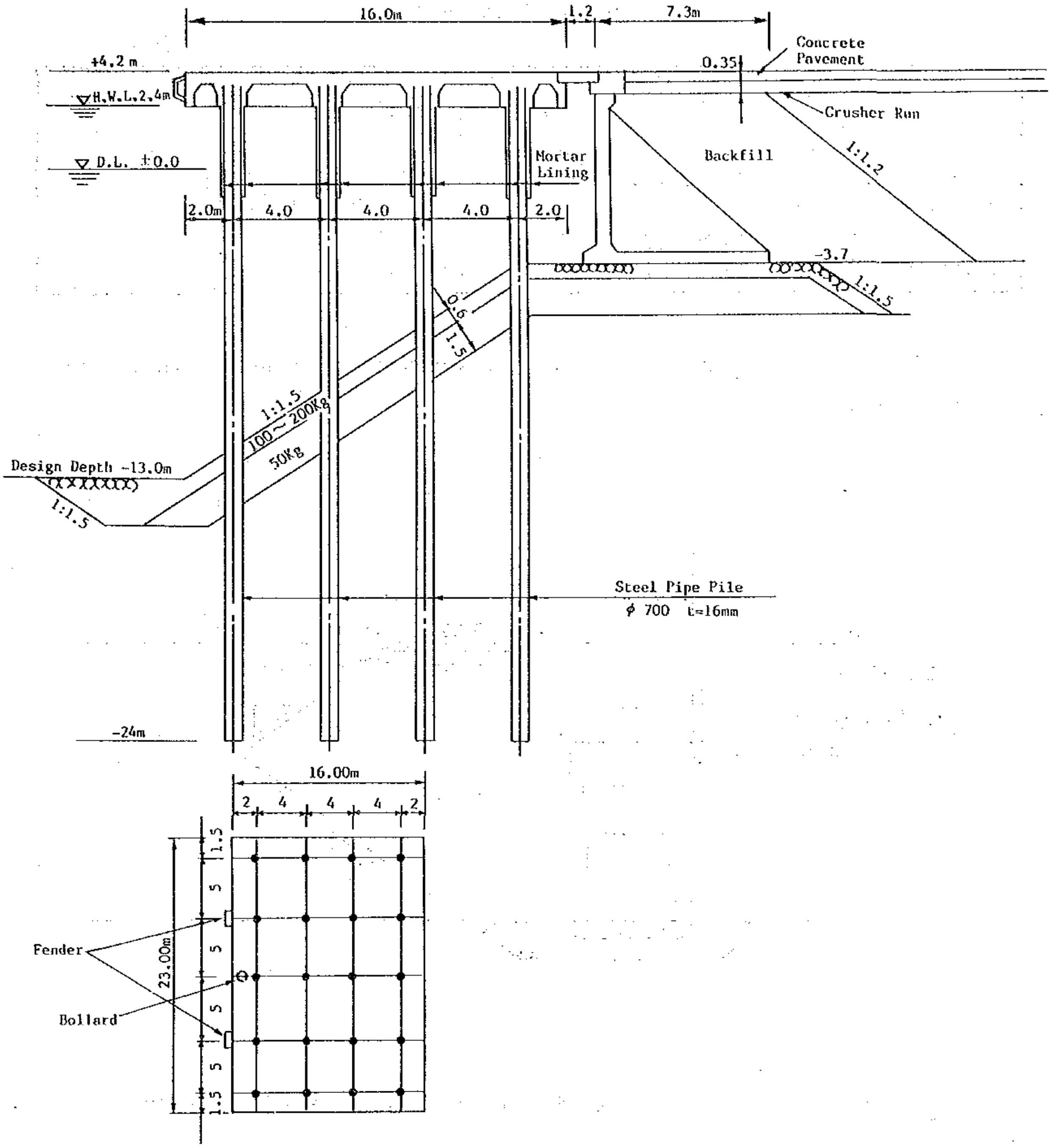


Fig. 6-1-8 Proposed Cross Section of the Berth (-13m) (Alternative)

Table 6-1-5 Fishing Port

Item / Quay	Structural Type	Depth(m)	Apron Width(m)
Loading and Preparation Quay	Concrete Block Type	-5.5	10
Lying Quay (1)	Open Type	-5.5	11
Lying Quay (2)	Open Type	-5.5	11

The standard cross-sections of the various quaies are shown in Fig. 6-1-9 - 11.

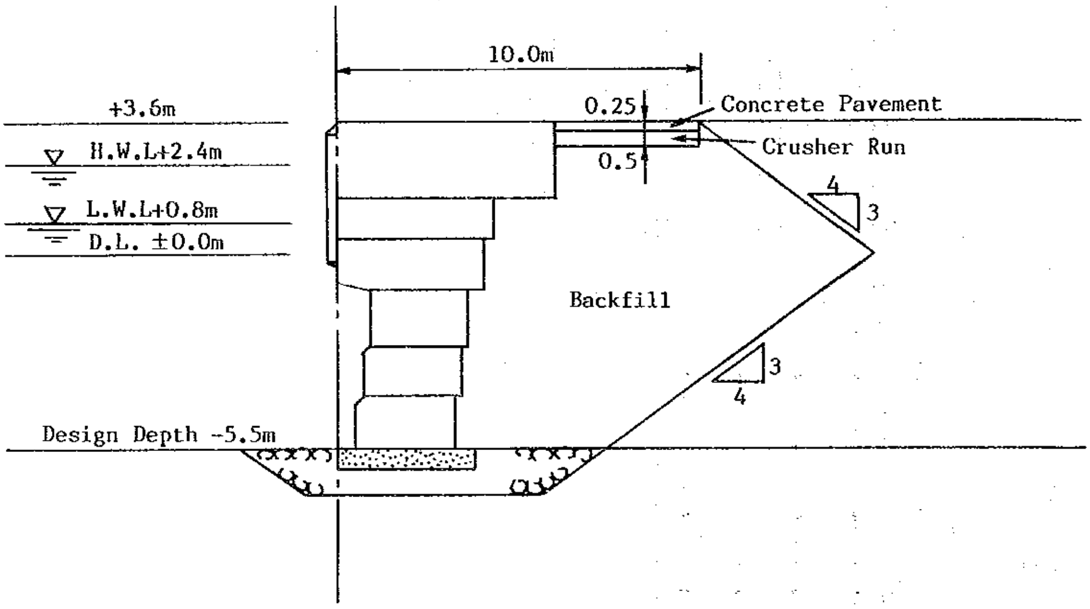


Fig. 6-1-9 Standard Cross Section of the Loading and Preparation Quay

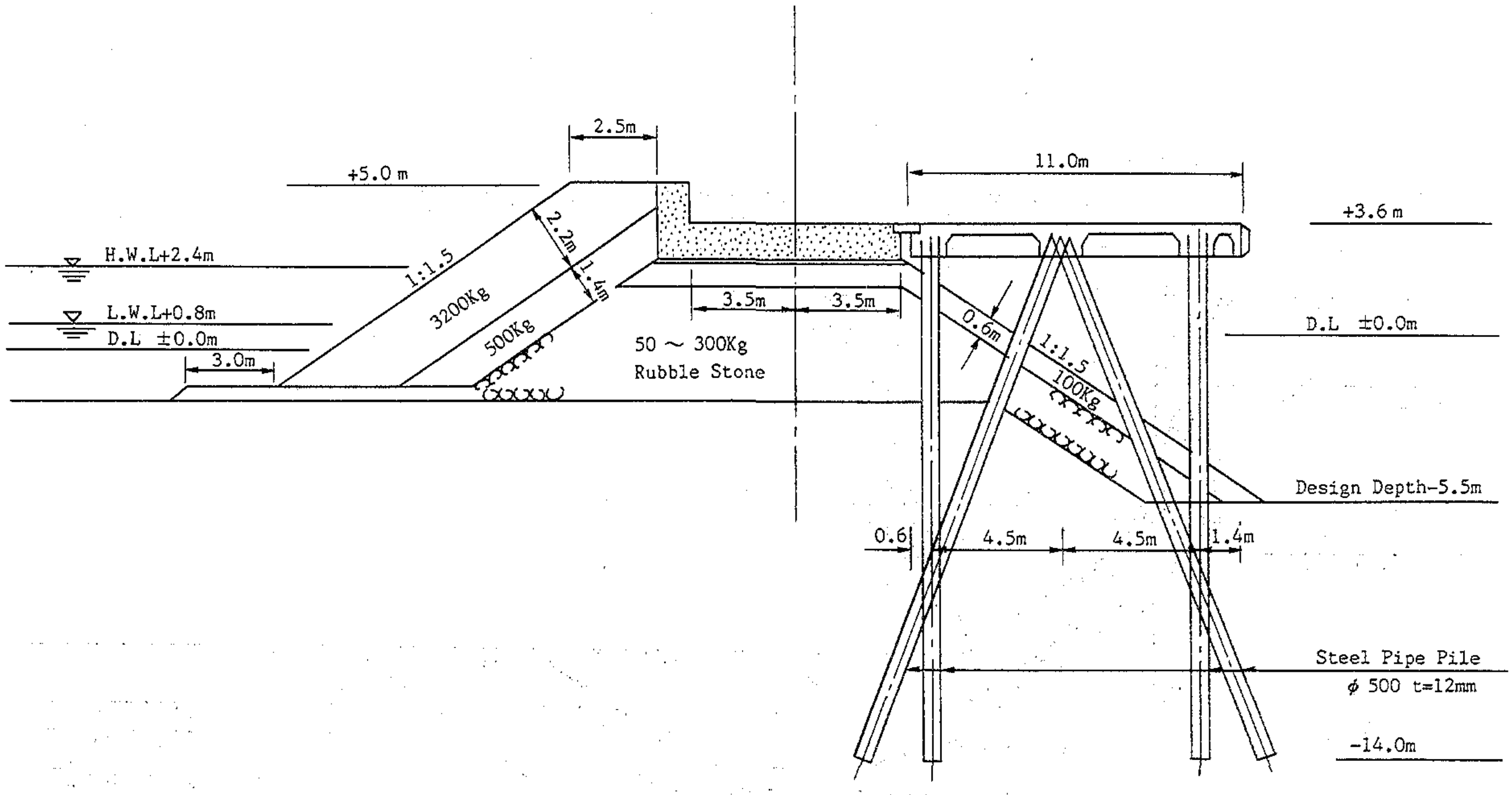


Fig. 6-1-10 Standard Cross Section of the Lying Quay (1)

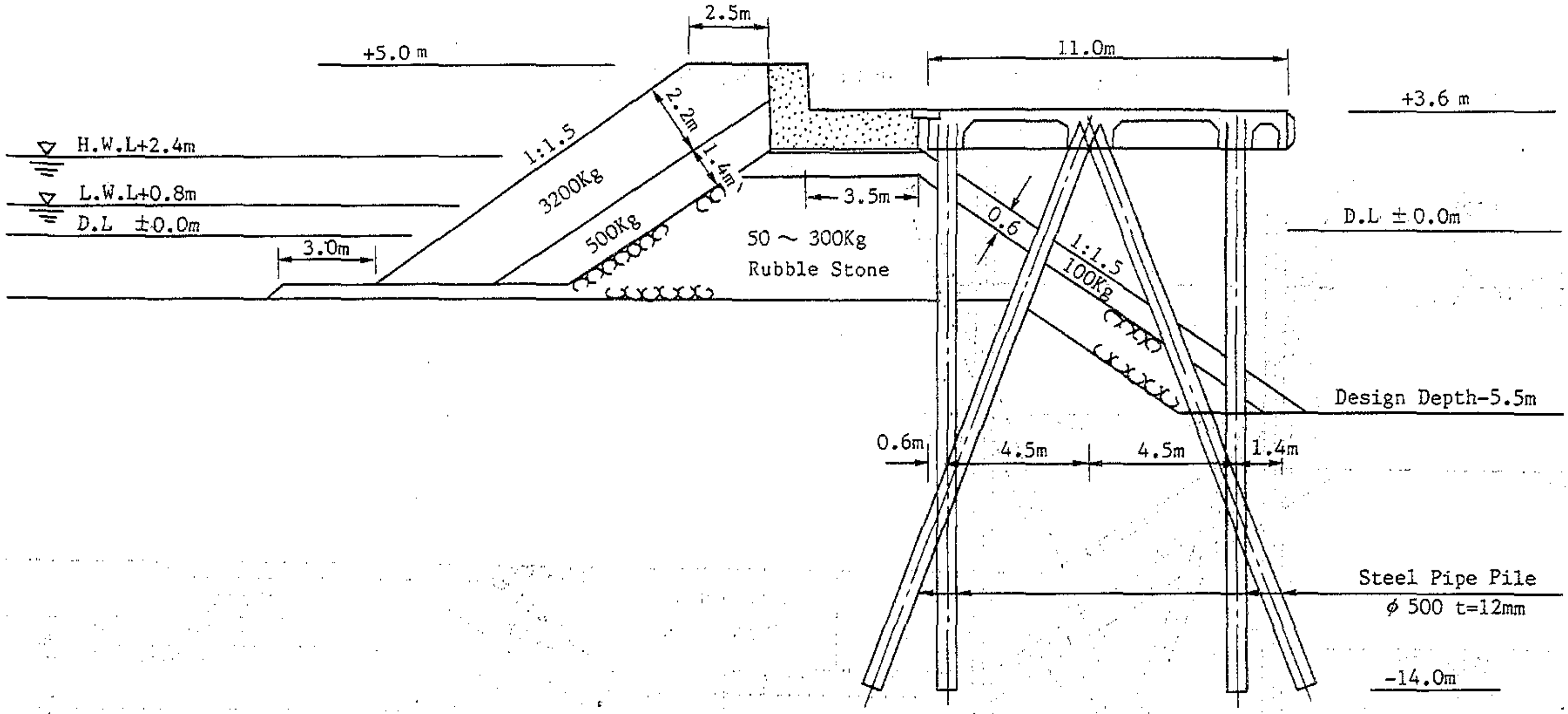


Fig. 6-1-11 Standard Cross Section of the Lying Quay (2)

6.1.3 Other Facilities

(1) Revetment

At the end of the channel, a revetment is planned. This revetment will absorb the invading wave energy and also protect the channel from slope failure.

The revetment will be armored with around 1000Kg stones and will be efficient to protect the surface from wave attacks uo to an estimated 1.4m height. (Fig.6-1-12)

The wave overtopping quantity can be estimated by the data obtained from the hydraulic model experiments carried out thus far.

H.W.L	+ 2.4 m
H1/3	1.4 m
Design depth (14 + 2.4)	16.4 m
Crown level of revetment	+ 3.2 m

q: Overtopping quantity ($m^3/m/sec$)*

q = 0.02

Above overtopping quantity is allowed for the port area according to the following standard.

Table 6-1-6 Overtopping Quantity Standards

Area	Overtopping Quantity ($m^3/m/sec$)
Densely inhabited district	0.01
Important Area	0.02
Others	0.02 - 0.06

* Yoshimi GODA, Yasuharu KISHIRA and Yutaka KAMIYAMA: "Laboratory Investigation on the Overtopping Rate of Seawalls by Irregular Waves", Reft of PHRI, Vol 14.

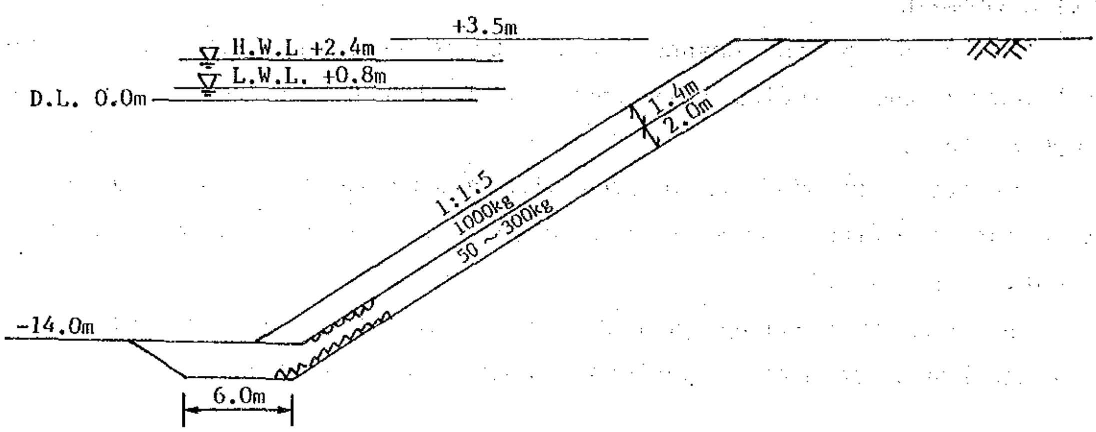


Fig. 6-1-12 Standard Cross Sectionof the Pavement

(2) Slipway

A slipway is planned in the inner port area. This slipway is needed to accommodate for repairs of ships up to 300 GWT. Dimensions of the respective parts are determined as follows:

i) The crown height of the front wall should be lower than L.W.L by the maximum draft of ships using the slipway (4.0m).

ii) The crown height of the ship storing yard is designed as the same height as the adjacent fishery port area. Anticipated wave heights in this front water area are very small, so there is no need to consider runup waves.

iii) A shingle slipway gradient would be preferable. But in this case, because of the limited land available, two slopes are adopted, that is, a fore slope of 1:3 and a rear slope of 1:8.

iv) The foundations, using 30 - 50kg cobblestones, are designed to have sufficient bearing capacity and to withstand scouring by waves.

The standard cross section of the slipway is shown in Fig. 6-1-13.

(3) Pavement and Transfer Crane Tracks

Considering construction and maintenance costs, all the pavement work will be bituminous except for the transfer crane tracks, and the standard cross-section will be as per the required strength owing to the cargo handling vehicles and equipment.

-- Transfer crane Track

Container yard for the transfer crane

-- Pavement

Container yards, open storage yards, in-port roads, parking areas, others

The cross-sections of the pavements and transfer crane tracks are shown in Fig. 6-1-14, 6-1-15.

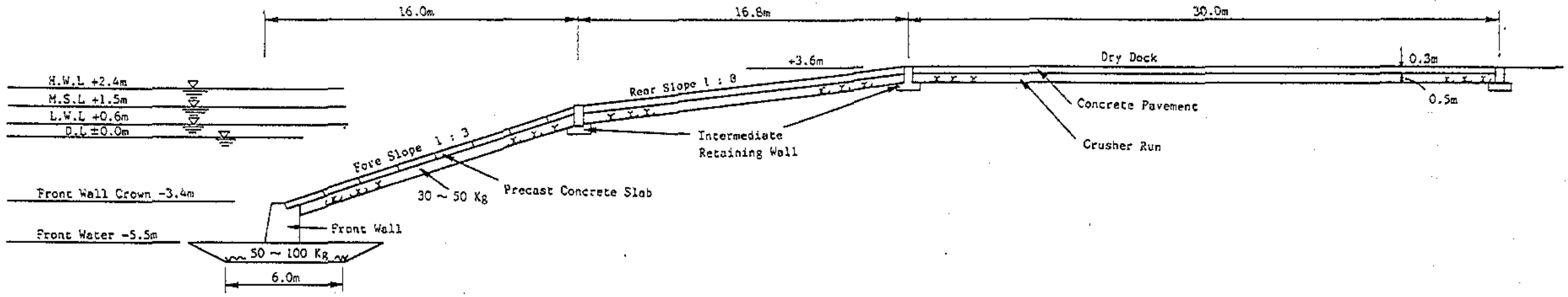


Fig. 6-1-13 Standard Cross Section of the Slipway

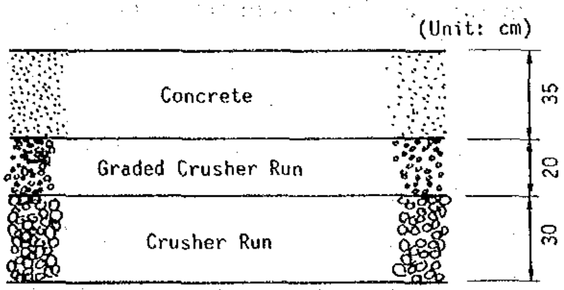


Fig. 6-1-14 Standard Cross Section of Transfer Crane Track

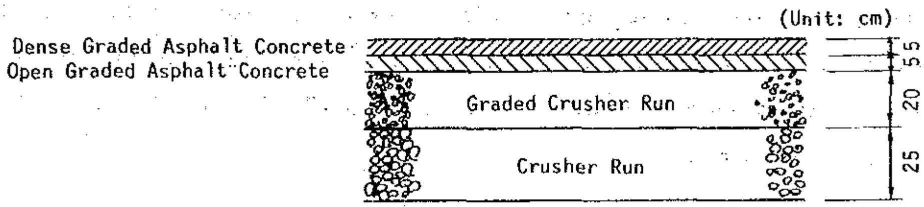


Fig. 6-1-15 Standard Cross Section of Pavement

6.2 Implementation Schedule of Port Construction

6.2.1 General

The construction quantities for each facility in this project up to the beginning of the year 2,000 are shown in Table 6-2-1 and Fig.6-2-1, and the main construction materials which have been estimated based upon the foregoing preliminary design are listed in Table 6-2-2.

Since the meteorological and marine conditions at the site are gentle and the hinterland of the site has no noteworthy obstructions to construction, the project should be smoothly implemented.

To complete the project within four years, the implementation of construction and the supply of construction equipment and materials should be carefully planned.

Construction equipment, particularly construction craft, are difficult to obtain in the Sultanate of Oman, and so they will be procured outside the country. An economic construction plan shall be developed, making full use of local equipment.

Table 6-2-1 Construction Quantities

Description	Unit	Quantities
Dredging / Land Excavation		
Channel	m^3	1,586,000
Basin (A)	m^3	6,434,000
(B)	m^3	3,842,000
Land Excavation	m^3	596,000
Quay		
-14^m	m	580
-13^m	m	540
-5.5^m (A)	m	340
-5.5^m (B)	m	156
Breakwater		
East	m	600
South	m	1,060
West	m	1,035
East Inner	m	200
Yard Pavement		
Container Yard	m^2	148,000
Open Yard	m^2	100,000
Road	m	3,500
Buildings	m^2	12,950
Cargo Handling Equipment and Tug-Boat	NO	61

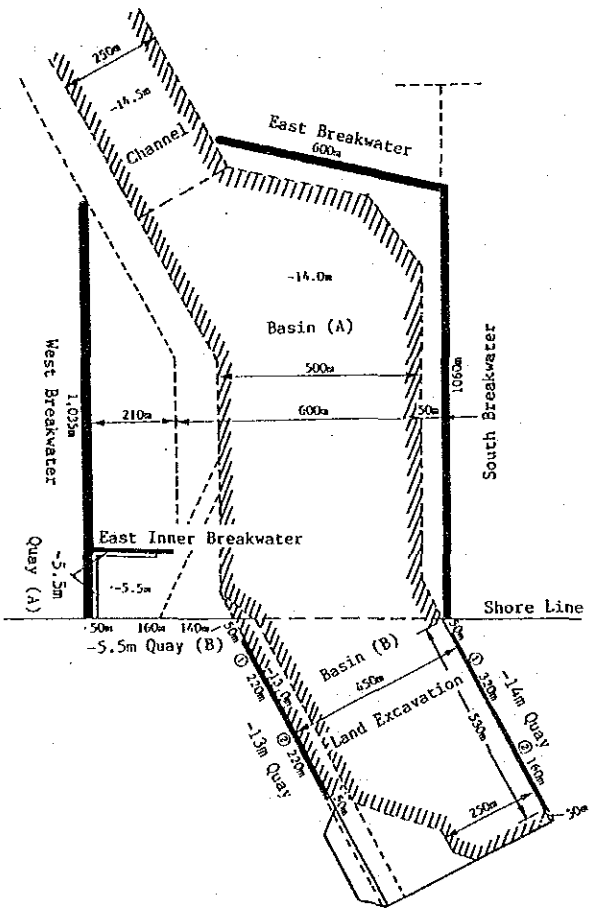


Fig. 6-2-1 Port Facilities

Table 6-2-2 Main Materials

Material	Unit	Breakwaters	Quay	Yard/Build	Total
Concrete Block (16^{TON} - 8^{TON})	No	14,020	-	-	14,020
Concrete Block (26^{TON})	No	-	7,493	-	7,493
Rubble Stone	m^3	342,000	27,970	-	369,970
Armoured Stone	m^3	261,000	-	-	261,000
Concrete	m^3	31,348	34,000	113,500	178,848
Steel Bar	Ton	-	1,149	780	1,929
Steel Pipe	Ton	-	745	-	745

6.2.2 Preliminary Study on Construction Procedure

After completion of the detailed design in 1994/1995, the construction of the port facilities is to start in 1996 and be completed by the end of 1999.

The construction method of major works is briefly described below;

(1) Dredging and Land Excavation

The required dredging and excavation volume is estimated to be 1,586,000m^3 in the Channel, 6,434,000 m^3 in Basin (A), 3,842,000m^3 in Basin (B) and 596,000m^3 inland.

From the borehole data (Refer to Fig.6-1-3), the types of soils in the dredging area are judged to be as follows:

In the Channel and Basin (A) areas..............N = 30

In Basin (B) and the Land Excavation areas.......N = 50

* N means N-value (Standard Penetration Test)

Dredging work will be conducted by 8,000 P.S. pump dredger and the dredged material will be dumped in the hinterland and landscaped.

The required period is about 3.5 years.

In order to start the construction of the Quay (-14m), (-13m) in the early stage, dredging work in the area of the quays should be carried out at the beginning of the dredging procedure.

Because the dredger has a draft of nearly 4m, a 100m channel should first be dredged through the Basin (A) from the point where the seabed is 5m below sea level towards the existing shore line. After completion of the channel, dredging should be conducted in the Basin (B) area.

As a matter of course, the land excavation should be done before the above dredging works.

The dredging work in the Channel and Basin (A) areas should be completed by the end of 1999.

(2) Quay (-14m) and (-13m)

On completion of the dredging work in Basin (B), installation of base rubble stone, in-situ concrete and concrete blocks (1.5m x 1.5m x 5.0m, about 26 ton/unit) should begin.

Since 9 or 10 concrete blocks will be placed on the in-situ concrete, the bases should be tightly placed on the dredged seabed.

After that, backfill, placing of coping concrete and apron pavement should be carried out.

Lastly, as regards to the -14m Berth, a concrete beam will be constructed as the base of the container crane site.

Given a construction period of about two years and four months, construction materials should be procured and concrete blocks should be manufactured in advance. For storage of these materials, stock yards of an estimated size of 4,000m^2 for each quay will be needed.

(3) Breakwater

Since the required volumes of rubble stone and armoured stone are almost equal for the 600m long East Breakwater, the 1,065m long South Breakwater and the 1,030m long West Breakwater, the construction work is divided into three sections. Construction of the South and West Breakwaters will be carries out from the land, and the East Breakwater will be constructed in the sea using the existing jetty nearby.

An existing quarry located about 30km from the construction site will be utilized for the project. The various sizes of rock and rubble are as follows:

Description	Size	Volume
Rubble stone	50kg to 300 kg	342,000m^3
Armoured stone	500kg, 1,000kg, 3,200kg	261,000m^3

These, sorted into the above-mentioned sizes and stockpiled at the quarry site, will be directly hauled to each section and dumped by dump trucks and barges.

Another possible method is to procure a large volume of rock materials in advance and to stockpile them at the construction site. Since such a method would involve much time and work for the second delivery from the stockyard to the construction site, it has not been adopted.

To secure rock rubble at the start of construction work is indispensable in order that a supply of rock rubble during the construction period can be realized smoothly.

On the other hand, the required number of concrete blocks (16 ton, 12.5 ton, 8 ton) are estimated to be 4,600 to 4,800 for each section and a total area of about 4,000m^2 will be required for manufacturing and temporarily stockpiling them.

(4) Harbour for Small Craft

The dredging work (-5.5m) of the basin for small crafts and the construction work of the East Inner Breakwater (200m) should be completed at an early stage, in parallel with the foundation work for the West Breakwater. The Basin can be used as a basin for construction craft.

6.2.3 Construction Equipment and Construction Crafts

The main construction equipment and craft are shown in Table 6-2-3.

Table 6-2-3 Main Construction Craft and Equipment

NO	Description	Capacity	Unit	Quantity
1	Pump Dredger	D-8000 P.S.	No.	1
2	Self Anchor Barge	35^{Ton} 600 P.S.	No.	1
3	Flat Barge	300^{Ton}	No.	6
4	Barge	250m^3	No.	4
5	Tug Boat	D-1000 P.S.	No.	1
6	Tug Boat	D-350 P.S.	No.	2
7	Pile Driving Barge	D 30 P.S.	No.	1
8	Concrete Pumping Car	45m^3/HR	No.	2

6.2.4 Construction Schedule

When considering the construction schedule, working days and working capacity for the above-mentioned method have been set as follows:

(1) Assessment of Working Days

The annual working days for the onshore and offshore work at the site have been estimated based on the following considerations: All the datas relevant to construction planning have been collected from nearby stations; wind records have been gathered from the meteorological observatory at Majis and wave records from Marine Buoy Climatological Summary, M.O.C.

An average wind speed of 10m/sec and significant wave height of 1.0m have been assessed as critical for the carrying out of offshore work;

As for holidays, 52 non-working Fridays and 10 public holidays, a total of 62 non-operational days have been considered, but in the case of offshore work the number of non-working days has been reduced to 40 days annually. The working days used for construction planning are shown below.

Table 6-2-4 Estimated Annual Works

Description	Onshore Work (days)	Offshore Work (days)
Windy Days (non-working)	18	15
*Rough Sea Days (non-working)	-	(9)
Holiday (non-working)	62	40
Total of Non-working Days	80	55
Annual Working Days	285	344
Monthly Average Working Days	24	28

* Rough Sea Days are included in Windy Days.

(2) Working Capacity

The working capacities of the major works which will be used most frequently in the Project have been compiled as follows:

Table 6-2-5 Working Capacity

Dredging (pump dredger 8,000 P.S.)	N=30	15,000m^3/day
(operating hours : 17 HRS)	N=50	7,900m^3/day
Pile-driving		4 piles/day
Disposal of rubble and armoured stone for breakwaters		1,000m^3/day
Installation of concrete block for the quays		20 units/day

(3) Construction Schedule

The construction schedule of the project is shown in Table 6-2-6.

Table 6-2-6 Construction Schedule

No.	Item	Unit	Q'ty	1996	1997	1998	1999
1.	Dredging						
	(1) Channel	m3	1,586,000				
	(2) Basin (A)/(B)	m3	10,276,000				
	(3) Land Excavation	m3	596,000				
2.	Quay						
	(1) - 14m Quay	m	580				
	(2) - 13m Quay	m	540				
3.	Breakwater						
	(1) East Breakwater	m	600				
	(2) South Breakwater	m	1,060				
	(3) West Breakwater	m	1,035				
4.	Small Craft Harbour						
	(1) East Inner Breakwater	m	200				
	(2) - 5.5 m Quay (A)	m	340				
	(3) - 5.5 m Quay (B)	m	156				
5.	Yard Pavement						
	(1) Container Yard	m2	148,000				
	(2) Open Yard	m2	100,000				
	(3) Tracks for Transfer Crane	m	4,000				
6.	Road	m	3,500				
7.	Buildings and Facilities						
	(1) Office/ C.F.S. etc	m2	12,950				
	(2) Other Facelities	L.S	1				
8.	Cargo Handling Equipment	L.S	1				
9.	Others						
	(1) Navigation Aids	L.S	1				
	(2) Slipway, etc	L.S	1				

6.3 Cost Estimation

6.3.1 General

The cost of the project has been estimated based upon the preliminary design, construction method and schedule.

The basic concept of cost estimation is briefly described below:

(1) Unit Rate for Labourers and Materials

These rates have been estimated using the average values obtained from various sources in Oman. If the rates were unavailable, they were estimated by comparison with other rates in Oman.

(2) Operating Cost of Equipment or Craft

(a) The cost of equipment or craft that are to be delivered from abroad has been calculated based on the standards used in Japan for calculating rental cost - that is the depreciation cost/maintenance cost per working day and operating hour.

(b) The cost of domestic equipment has been calculated from interviews with various sources. Wherever possible, these rates have been cross-checked.

(3) Unit Price

Unit price for each type of work, such as dredging, construction of breakwaters and quays, etc., are calculated as the sum of labour, fuel, materials, rental and other costs, and were checked by comparison with the corresponding unit prices in Oman and Japan.

6.3.2 Conditions for Cost Estimation

The main conditions for the cost estimation are as follows:

(1) Construction costs have been estimated using the prices and rates obtaining in December 1989 in principle.

(2) The inflation factor has been excluded from the estimation.

(3) The exchange rates of the U.S.$ against the Omani Rial (R.O.) and Japanese Yen (J¥) are as follows:

1U.S.$ = 0.385 R.O.
1U.S.$ = 144 J¥

(4) Rents or compensation for land and fishing activities have been excluded from the estimation.

(5) In general, the costs of the foreign portion of the operation include the following:

i) Materials, equipment, machinery and craft not produced in Oman.
ii) Materials available in Oman but which have been imported.
iii) Cost of foreign labourers.

Based on the above criteria, the foreign portion comprises:

- Skilled crew and common crew
- Rental cost of pump dredger and its attachments, pile-driving barge, and other craft.
- Mobilization/demobilization charge of the above craft and the cargo handling equipment.
- Steel pipe piles and steel bars
- Rubber fender, bits, crane rails and their attachments
- Container cranes, transfer cranes, tractor trailers, tugboats, etc.
- Consultation and technical cooperation fee
- Customs duties

(6) The constructions costs of water and electric supply, drainage and communication facilities are excluded.

(7) Customs duties on imported materials are fixed at 5% of their cost. For construction equipment and craft mobilized outside Oman, customs duties are excluded from the cost estimation.

(8) Indirect costs and administration costs are fixed at 20% of the direct cost.

(9) Physical contingencies are as follows:
- 0% Cargo-handling equipment
- 5% Dredging costs, costs of roads and land
- 10% Construction costs of breakwaters, quays and buildings

(10) The consultation and technical cooperation fee is 5%

Items of (7)(8)(9) and (10) are not included in direct cost.

6.3.3 Estimation Procedure

The estimation procedure has been carried out on the above conditions and the resulting unit prices and rates are as follows:

i) The unit prices for main materials:

. Concrete	15 R.O./m^3
. Steel pipe pile	214 R.O./t
. Steel bar	152 R.O./t
. Armoured Stone (1,000 kg)	2.6 R.O./m^3

ii) The day work for main labourers per day:
- . Skilled workers 10 R.O.
- . Unskilled workers 4-8 R.O.

iii) The prices per unit quantities of main items:

. Dredging	1.13 R.O./m^3
. Pavement	4.5 - 10.0 R.O./m^2
. Building	90 R.O./m^2

6.3.4 Result of Estimation

A summary of the estimation results is presented in Table 6-3-1 and the result for each item is presented in Table 6-3-2.

Table 6-3-1 Summary of Construction Costs

Unit: 1,000 R.O.

No.	Item	Construction Cost		
		Foreign Portion	Local Portion	Total
1	Dredging	10,558	3,441	13,999
2	Quay	678	8,642	9,320
3	Breakwater	13	9,995	10,008
4	Small Craft Harbour	191	1,263	1,454
5	Yard Pavement	-	1,986	1,986
6	Road	-	301	301
7	Buildings and Facilities	513	1,102	1,615
8	Cargo Handling Equipment	12,581	6	12,587
9	Others	32	50	82
10	Direct Cost	24,566	26,786	51,352
11	Indirect Cost	11,657	5,328	16,985
12	Grand Total	36,223	32,114	68,337

On the basis of the construction schedule drawn up in Table 6-2-6, the yearly disbursement schedule has been estimated as shown in Table 6-3-3.

Table 6-3-2 Construction Cost for Each Item

No.	Item	Unit	Q'ty	Unit Cost(R.O.)			Amount (1,000 R.O.)		
				Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion	Total
1.	Dredging								
	(1) Channel	m3	1,586,000	0.89	0.24	1.13	1,412	380	1,792
	(2) Basin	m3	10,276,000	0.89	0.24	1.13	9,146	2,465	11,611
	(3) Land Excavation	m3	596,000	-	1.00	1.00	-	596	569
	Sub-Total						10,588	3,441	13,999
2.	Quay								
	(1) - 14m Quay	m	580	587.93	7,894.82	8,483.00	341	4,579	4,920
	(2) - 13m Quay	m	540	624.07	7,524.07	8,148.00	337	4,063	4,400
	Sub-total						678	8,642	9,320
3.	Breakwater								
	(1) East Breakwater	m	600	-	6,553.00	6,553.00	-	3,920	3,920
	(2) South Breakwater	m	1,060	-	2,916.00	2,916.00	-	3,091	3,091
	(3) West Breakwater	m	1,035	12.56	2,883.44	2,896.00	13	2,984	2,997
	Sub-total						13	9,995	10,008
4.	Small Craft Harbour								
	(1) East Inner Breakwater	m	200	60.00	1,106.00	1,166.00	12	221	233
	(2) - 5.5 m Quay (A)	m	340	520.59	2,091.00	2,612.00	177	711	888
	(3) - 5.5 m Quay (B)	m	156	12.86	2,123.18	2,136.00	2	331	333
	Sub-Total						191	1,263	1,454
5.	Yard Pavement								
	(1) Container Yard	m2	148,000	-	10.00	10.00	-	1,480	1,480
	(2) Open Yard	m2	100,000	-	4.50	4.50	-	450	450
	(3) Tracks for Transfer Crane	m	4,000	-	14.00	14.00	-	56	56
	Sub-Total						-	1,986	1,986
6.	Road	m	3,500	-	86.00	86.00	-	301	301
7.	Buildings and Facilities								
	(1) Office/ C.F.S. etc	m2	12,950	4.86	85.10	89.96	63	1,102	1,165
	(2) Other Facelities	L.S	1				450	-	450
	Sub-Total						513	1,102	1,615
8.	Cargo Handling Equipment	L.S	1				12,581	6	12,587
9.	Others								
	(1) Navigation Aids	L.S	1				32	-	32
	(2) Slipway, etc	L.S	1				-	50	50
	Sub-Total						32	50	82
10.	Direct Cost						24,566	26,786	51,352
11.	Indirect Cost								
	(1) I.C/Administration						7,324	2,946	10,270
	(2) Consultation/ Technical Cooperation						2,570	-	2,570
	(3) Contingencies						615	2,382	2,997
	(4) Custom Duties						698	-	698
	(5) Mobilization						450	-	450
	Sub-Total						11,657	5,328	16,985
12.	Grand Total						36,223	32,114	68,337

Table 6-3-3 Yearly Disbursement Schedule

Unit: 1,000 R.O.

No.	Item	Construction Cost			1994		1995		1996		1997		1998		1999	
		Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion	Foreign Portion	Local Portion	Foreign Portion	Local Portion	Foreign Portion	Local Portion	Foreign Portion	Local Portion	Foreign Portion	Local Portion
1.	Dredging	10,558	3,441	13,999	-	-	-	-	1,614	1,031	3,228	870	3,228	870	2,488	670
2.	Quay	678	8,642	9,320	-	-	-	-	-	-	101	1,330	302	3,988	275	3,324
3.	Breakwater	13	9,995	10,008	-	-	-	-	-	2,217	-	3,155	-	3,155	13	1,468
4.	Small Craft Harbour	191	1,263	1,454	-	-	-	-	12	221	-	-	179	1,042	-	-
5.	Yard Pavement	-	1,986	1,986	-	-	-	-	-	-	-	-	-	123	-	1,863
6.	Road	-	301	301	-	-	-	-	-	301	-	-	-	-	-	-
7.	Buildings and Facilities	513	1,102	1,615	-	-	-	-	-	-	-	-	32	551	481	551
8.	Cargo Handling Equipment	12,581	6	12,587	-	-	-	-	-	-	-	-	-	-	12,581	6
9.	Others	32	50	82	-	-	-	-	-	-	-	-	-	-	32	50
10.	Direct Cost	24,566	26,786	51,352	-	-	-	-	1,626	3,770	3,329	5,355	3,741	9,729	15,870	7,932
11.	Indirect Cost	11,657	5,328	16,985	500	-	500	-	2,627	1,331	2,385	1,331	2,481	1,331	3,164	1,335
12.	Grand Total	36,223	32,114	68,337	500	-	500	-	4,253	5,101	5,714	6,686	6,222	11,060	19,034	9,267

6.4 Construction Cost for the Master Plan

The cost of construction up to year 2,000 has been estimated, as mentioned in Chapter 7.3. The remaining quantities and construction costs for the Master Plan are shown in Table 6-4-1.

Table 6-4-1 Construction Cost for the Master Plan

No.	Item	Unit	Q'ty	Unit Cost(R.O.)			Amount (1,000 R.O.)		
				F.P	L.P	Total	F.P	L.P	Total
1.	Dredging								
	(1) Channel	m3	86,000	0.89	0.24	1.13	76	21	97
	(2) Basin	m3	4,633,000	0.89	0.24	1.13	4,123	1,112	5,235
	(3) Land Excavation	m3	1,710,000	-	1.00	1.00	-	1,710	1,710
	Sub-Total						4,199	2,843	7,042
2.	Quay								
	(1) - 14m Quay	m	480	587.93	7,894.42	8,482.75	282	3,789	4,071
	(2) - 13m Quay	m	745	624.07	7,524.07	8,148.14	465	5,605	6,070
	Sub-total						747	9,394	10,141
3.	Small Craft Harbour								
	(1) South Inner Breakwater	m	150	-	1,106.00	1,106.00	-	166	166
	(2) - 5.5 m Quay (B)	m	154	12.86	2,123.18	2,136.04	2	327	329
	Sub-Total						2	493	495
4.	Yard Pavement								
	(1) Container Yard	m2	282,980	-	10.00	10.00	-	2,830	2,830
	(2) Open Yard	m2	96,500	-	4.50	4.50	-	434	434
	(3) Tracks for Transfer Crane	m	6,500	-	14.00	14.00	-	91	91
	Sub-Total							3,355	3,355
5.	Road	m	5,230	-	86.00	86.00	-	450	450
6.	Buildings and Facilities								
	(1) Tramsot Sjed etc	m2	4,650	4.86	85.10	89.96	22	396	418
	(2) Other Facelities	L.S	1	-	-	-	370	-	370
	Sub-Total						392	396	788
7.	Cargo Handling Equipment	L.S	1	-	6	-	11,119	6	11,257
8.	Others								
	(1) Slipway, etc	L.S	1	-	-	-	-	50	50
	Sub-Total							50	·82
9.	Direct Cost						16,459	16,987	33,446
10.	Indirect Cost								
	(1) I.C/Administration						4,820	1,868	6,688
	(2) Consultation/ Technical Cooperation						1,700	-	1,700
	(3) Contingencies						910	1,360	2,270
	(4) Custom Duties						57	-	57
	(5) Mobilization						450	-	450
	Sub-Total						7,937	3,228	11,165
11.	Grand Total						24,306	20,215	44,611

F.P.= Foreign Portion
L.P.= Local Portion

CHAPTER 7 ECONOMIC ANALYSIS

Chapter 7 ECONOMIC ANALYSIS

7.1 Purpose and Methodology of the Economic Analysis

7.1.1 Purpose

The purpose of the economic analysis is to appraise the economic feasibility of the Short-term Development Plan for the New Port from the viewpoint of the national economy.

Therefore, the purpose of this chapter is to investigate the economic benefits as well as the economic costs which will arise from the project and to evaluate whether the net benefits of this project exceed those which could be obtained from other investment opportunities (the opportunity cost of capital) in the Sultanate of Oman.

7.1.2 Methodology

The economic internal rate of return (EIRR) based upon cost-benefit analysis is used in order to appraise the feasibility of the project. In estimating the costs and benefits of the project, "economic pricing" is applied. Economic pricing here means the appraisal of costs and benefits in terms of international prices (border prices).

Fig. 7-1-1 shows the flow chart of the economic analysis procedure.

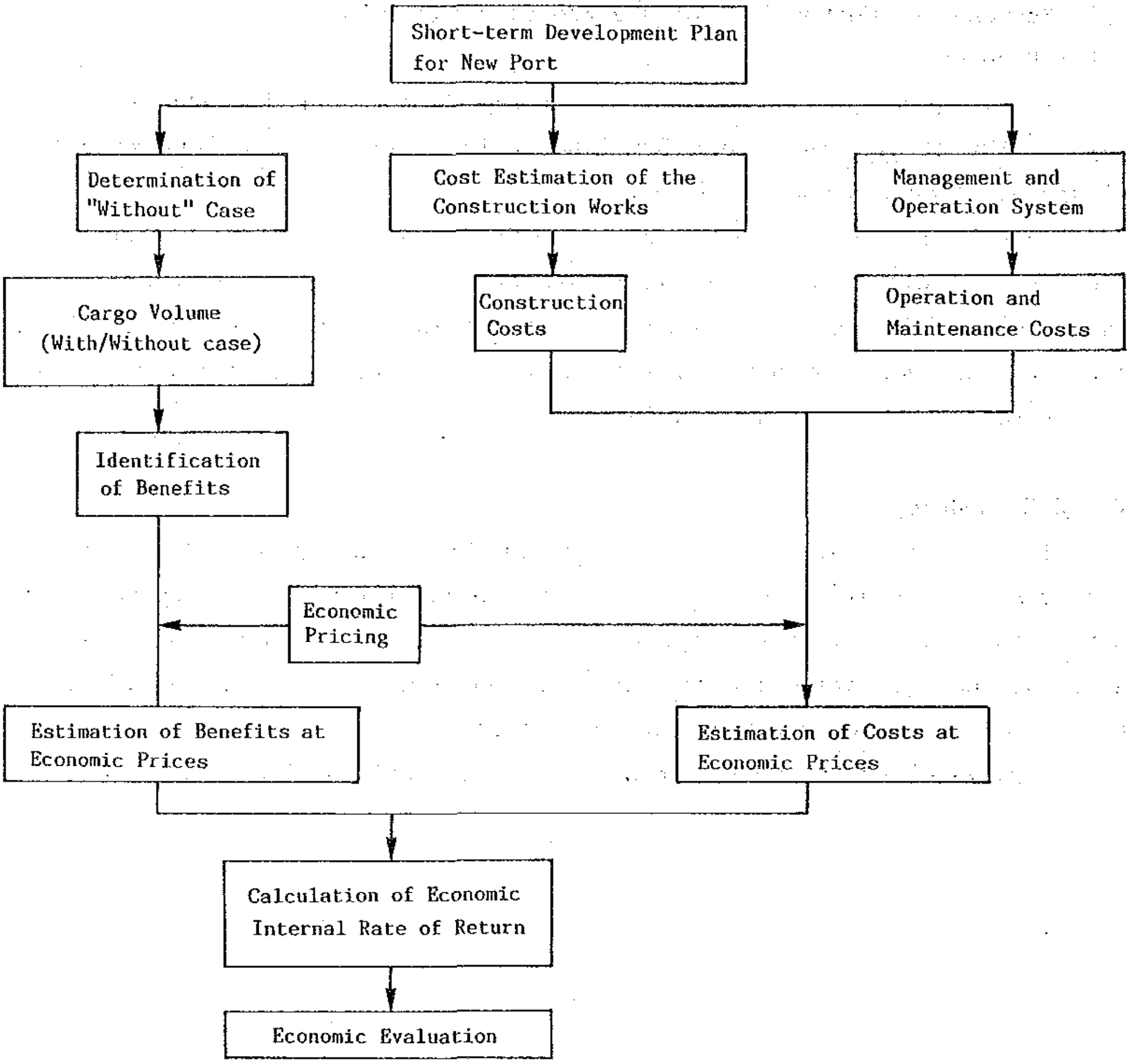


Fig. 7-1-1 Flow Chart of the Economic Analysis Procedure

7.2 Prerequisites of the Economic Analysis

7.2.1 Base Year

The "base year" here means the starting year of the economic analysis. Taking into consideration the construction schedule in Chapter 6, 1994 is set as the base year for this Study.

7.2.2 Project Life

Taking into consideration the depreciation period of the main facilities mentioned in Chapter 8 and the construction period of six years (including D/D), the period of calculation (project life) in the economic analysis is assumed to be thirty-six years from the beginning of construction (i.e., from 1994 to 2029).

7.2.3 Foreign Exchange Rate

The exchange rate adopted for this analysis is 1US$=0.385RO, that is, the same rate as used in the cost estimation.

7.2.4 "Without" Case

A cost-benefit analysis is conducted on the difference between the "With" and "Without" investment cases. In other words, incremental benefits and costs arising from the proposed investment are compared and it is examined whether or not the net benefits generated by the project exceed the opportunity cost of capital in the Sultanate of Oman. Therefore, determining the "Without" case is one of the key points of the economic analysis.

In this Study, the following conditions are adopted as the "Without" case after various possibilities are discussed:

1) No investment is made for the new port.
2) The development plan of Mina Qaboos that is proposed in our Study is implemented.
3) The distribution of ships and the working efficiency of cargo handling is the same as that assumed in the above plan.

7.2.5 Cargo Throughput

(1) "With" Case

The cargo volume under the "With" case is forecast in Chapter 3. Since the Short-term Development Plan for the New Port is in presponse to the cargo throughput in 2005 and 2004 for container cargo and the other cargo, respectively, with the optimum berth occupancy at that period, the cargo volume used for the economic analysis is assumed not to increase after 2005 for containers and after 2004 for the other cargo. The increase of the cargo volume after these periods is to be coped with by the following stages of the development plan for the new port.

(2) "Without" Case

1) Container Cargo

In the Mina Qaboos Development Plan, ships' waiting time is set within about three hours. As mentioned in this report, container ships should not be made to wait longer because of the fierce competition with the neighbouring major ports in the UAE. Hence, waiting time set for the Mina Qaboos Development Plan is considered to be the limit for container ships and the container cargo volume handled at Mina Qaboos under the "Without" case is the same as that under the "With" case.

The ratio of transshipment and local(import/export) cargoes is also assumed to be the same as the "With" case. That is, Mina Qaboos handles transshipments of 144,960 TEUs and local cargo of 101,098 TEUs in 2000.

In other words, the opportunity for handling container cargo of 102,354 TEUs, which is the balance from the cargo volume in the demand forecast in 2000, would be lost for Oman, and of these containers the local cargo of 42,054 TEUs is assumed to deviate to the Dubai ports and to enter Oman from there by land. (This lost cargo volume of containers would increase to 199,187 TEUs in 2005)

2) Other Cargo

All the other cargo except containers is assumed to be handled at Mina Qaboos. According to the results of a queuing simulation, the average waiting time in 2004 under the "Without" case is 17.4 hours per ship, which does not exceed the limit for waiting time calculated in comparison with the cost of the alternative transport mode, i.e., land transport in Oman's case.

Tables 7-2-1 and 7-2-2 show the cargo volume in 2000 and in 2005 under the "With" case and the "Without" case, respectively. As for the other cargo except containers, the cargo volume in 2005 is assumed to be the same as that in 2004.

Table 7-2-1 Cargo Volume under "With" Case and "Without" Case in 2000

(Unit : '000 tons, TEUs)

Cargo Type	"With" Case		"Without" Case	
	Mina Qaboos	New Port	Mina Qaboos	Land Transport
Steel	220.2	141.2	361.4	0
Timber	70.0	54.0	124.0	0
Bulk Grain	250.3	0.0	250.3	0
Vehicle	86.6	0.0	86.6	0
Livestock	20.8	0.0	20.8	0
General Cargo	171.7	141.4	313.1	0
Container (Local Cargo)	101,098	42,054	101,098	42,054
Container (Transshipment)	144,960	60,300	114,960	0
Total	819.6(ton) 246,058(TEU)	336.6(ton) 102,354(TEU)	1,156.2(ton) 246,058(TEU)	0(ton) 42,054(TEU)

Table 7-2-2 Cargo Volume under "With" Case and "Without" Case in 2005

(Unit : '000 tons, TEUs)

Cargo Type	"With" Case		"Without" Case	
	Mina Qaboos	New Port	Mina Qaboos	Land Transport
Steel	220.2	233.0	453.2	0
Timber	70.0	64.8	134.8	0
Bulk Grain	299.7	0.0	299.7	0
Vehicle	86.6	16.8	103.4	0
Livestock	20.8	3.4	24.2	0
General Cargo	171.7	188.7	360.4	0
Container (Local Cargo)	101,098	78,486	101,098	78,486
Container (Transshipment)	144,960	120,701	144,960	0
	869.0(ton) 246,058 (TEU)	506.7(ton) 199,187(TEU)	1,375.7(ton) 246,058(TEU)	0(ton) 78,486(TEU)

7.3 Economic Pricing

7.3.1 Methodology

The purpose of the economic analysis is to examine the value of a project, that is to see if it represents an efficient allocation of resources in the national economy. The values of goods quoted at a market price do not always represent the true value of those goods from the viewpoint of the national economy. The local currency portion of the goods and materials at a market price often includes customs duties. The labour cost at market prices is often influenced by a minimum wage system. Therefore, "economic pricing" should be conducted for the economic analysis.

There are several ways for "economic pricing" to be conducted. In this Study, the prices of domestic goods and services are revised to border prices in an effort to determine a more rational valuation. In general, these border prices are intended to represent the international market value, or the world prices, of these goods and services.

The market prices are changed to border prices by various conversion factors such as "Standard Conversion Factor", "Conversion Factor for Consumption" and so forth.

7.3.2 Exclusion of Transfer Items

Import duties, other taxes and subsidies are merely transfer items which do not actually reflect any consumption of national resources. Therefore, these transfer items should be excluded in the calculation of the costs and benefits of the project for the economic analysis.

7.3.3 Method of Applying Conversion Factors

In general, all the costs and benefits are divided into labour, traded goods, non-traded goods and transfer items. Labour is further divided into skilled labour and unskilled labour. In Oman's case, the factor of foreign labour should be taken into account.

Traded goods are expressed at CIF (cost, insurance and freight) prices for imports and at FOB (free on board) prices for exports. Theoretically speaking, non-traded goods should be divided repeatedly into labour, traded goods, non-traded goods and transfer items, which are the items required for the production of non-traded goods. However, because of the absence of an I/O table in Oman, it is impossible to take these steps in this Study. Hence the local currency portion after deducting labour costs and transfer items is considered as non-traded goods, the economic price of which is calculated by multiplying the Standard Conversion Factor (SCF).

The economic cost of skilled labour is obtained by multiplying its market price by the Conversion Factor for Consumption (CFC) and the economic cost of unskilled labour is calculated by multiplying its market price by a ratio of the shadow wage rate and the CFC.

(1) Standard Conversion Factor (SCF)

Import duties and subsidies cause a price differential between the domestic market and the international market. The Standard Conversion Factor (SCF) is used to determine the economic prices of certain non-traded goods and services which cannot be directly valued at border prices.

SCF is expressed by the following equation:

$$SCF = \frac{I + E}{(I + D_I) + (E + D_E)}$$

Where, I : Total Amount of Imports
E : Total Amount of Exports
D_I: Total Amount of Import Duties
D_E: Total Amount of Export Subsidies

There is no data available about export subsidies in Oman and only import duties are taken into account.

In this Study, the SCF in 1988, 0.971 is adopted.

(2) Conversion Factor for Consumption (CFC)

The CFC is used for converting the prices of consumer goods from domestic market prices to border prices. This is particularly required in converting domestic labour costs to the corresponding border prices. The CFC is usually calculated in the same manner asthe SCF, replacing total imports and total exports by imports and exports of consumer goods only.

In this Study, the CFC in 1988, 0.974 is adopted.

(3) Shadow Wage Rate

For economic analysis, labour costs should be measured in terms of their opportunity costs, that is, the value of lost marginal production which the employment of the labourers for a given project would create for other purposes.

1) Conversion Factor for Skilled Labour

The cost of skilled labour is calculated based on actual market wages, assuming that the market mechanism is functioning properly. However, since these are domestic costs, they should be converted to border prices by multiplying the local wage by the CFC.

Conversion Factor for Skilled Labour	≒	Nominal Wage Rate	X CFC = 1 X 0.974 = 0.974

2) Conversion Factor for Unskilled Labour

Generally speaking, the market wages for unskilled labour should not be used in calculating the economic value of the unskilled labour, since these wages are usually far above the opportunity cost of the labour because of a minimum wage system and other regulations.

On the other hand, it is practically impossible to figure out the opportunity cost of unskilled labour in Oman.

When a project is conducted, the inflow of unskilled labour to the project is mainly from the agricultural sector which is relatively elastic in its use of labour. Therefore, in a simplified manner it is often assumed that the economic cost of unskilled labour is equal to the per capita income of the agricultural sector.

In the absence of a census of the labour force by sector in Oman, per capita income of agricultural sector is also an item for which no firm figures are available. However, the "Statistical Year Book" published by the Development Council presents an average monthly salary for non-Omani workers in farms that can be considered as a proper indicator of the marginal productivity of the agricultural sector.

Therefore, in this Study, this figure in 1988 (55 Reals Omani per month) is used as the opportunity cost of unskilled labour.

The conversion factor for unskilled labour is calculated as follows:

$$\boxed{\text{Conversion Factor for Unskilled Labour}} = \frac{\boxed{\text{Opportunity Cost}}}{\boxed{\text{Nominal Wage}}} \times \text{CFC}$$

$$= \frac{55\ \text{RO/month}}{120\ \text{RO/month}} \times 0.974 = 0.446$$

3) Conversion Factor for Foreign Labour

Specific consideration should be given to foreign labour, whether it is skilled or unskilled. Since foreign workers have a strong tendency to remit most of their earnings to their own homes, the economic cost of foreign labour should be treated just like that of imported goods and services.

Therefore, in this Study it is assumed that the conversion factor for foreign labour is 1.00.