5. REVIEW OF THE MASTER PLAN

5.1 Demand Forecast

Target Year of existing Master Plan is 2000. Here, the master plan was reviewed with a long-term perspective for the period up to the year 2005. The review includes "Demand Forecast" and "Review of Facilities Layout Plan".

5.1.1 Delineation of Hinterland

The economic hinterland of New Mangalore Port defined by the government of Karnataka covers the districts of Dakshina Kanara, Kodagu, Hassan, Chikmagalur, Shimoga on the Western Ghats and portions of Uthara kanara in Karnataka state as its primary hinterland.

5.1.2 Origin and Destination of Principal Commodities

New Mangalore Port is basically a bulk commodity port. The main bulk export commodity shipped through the port is iron ore. The share of iron ore cargo handled to total cargo handled in New Mangalore was about 90% in 1987/88 and 71% in 1988/89. Thus it can be said that cargo handling activities at New Mangalore Port are concentrated on iron ore.

(1) Origin of Iron Ore

There are vast resources on iron ore distributed throughout the state, which makes the state number four in the country in terms of the value of iron ore production (1985). Iron ore handled at New Mangalore Port comes from Kudremukh hill located 110km east of Mangalore.

About 6 million tonnes of magnetic ore in Kudremukh are being mined and processed annually, and the Kudremukh iron ore project has a capacity of 7.5 million tonnes of iron ore concentrates per annum.

(2) Destination of Iron Ore

Exports of iron ore in 1988/89 are shown as follows:

Table-5.1.1 Destination of iron ore (1988/89)

(Unit: '000 tonnes)

Countries	Pellet	Concentrate	Total	Share
Japan	–	2,430	2,430	51.3
Hungary	594	–	594	12.5
Turkey	357	–	357	7.5
Yugoslavia	68	241	309	6.5
Australia	72	183	255	5.4
West Germany	176	–	176	3.7
Czechoslovakia	90	59	149	3.2
Bahrain	–	128	128	2.7
U.S.A.	109	–	109	2.3
Other	210	22	232	4.9
Total	1,676	3,063	4,739	100.0

5.1.3 Demand Forecast

(1) Main Cargoes to be Forecasted

Iron ore is the main cargo handled at New Mangalore Port and has a high share of the total amount of cargo handled at New Mangalore Port as mentioned above.

P.O.L. products are imported at present but are expected to be exported in the future because there is a plan to set up an oil refinery near Mangalore. Therefore we independently estimated the demand forecast of crude oil (import cargo) and P.O.L. (products: export cargo).

There is also a plan by Hindustan Petroleum Corporation Limited to develop L.P.G. import and storage facilities at Mangalore. Therefore, we also independently estimated the demand forecast of L.P.G. imports.

Coal is not handled at New Mangalore Port at present. But there is a plan to install a coal based super thermal power plant near Mangalore.

Thus coal is expected to be a major cargo of New Mangalore Port in the near future. Therefore we estimated the demand forecast of coal independently.

(2) Summary of Demand Forecast

Table-5.1.2 and Figure-5.1.1 show projected cargo volumes through New Mangalore Port for the years 1994/95 and 2004/05.

Table-5.1.2 Summary of Demand Forecast

(Unit: Thousand Tonnes)

Items		1988/89 (Actual)	1994/95	2004/05
Export	Iron Ore	5,011	7,500	10,000
	POL(Products)	–	1,570	3,160
	Granite Stone	386	386	386
	Other Cargoes	120	184	274
	Sub Total	5,517	9,640	13,820
	Crude Oil	–	3,000	6,000
Import	POL(Products)	571	–	–
	L.P.G	–	200	500
	Coal	–	450	12,120
	Other Cargoes	996	1,320	2,530
	Sub Total	1,567	4,970	21,150
Total		7,084	14,610	34,970

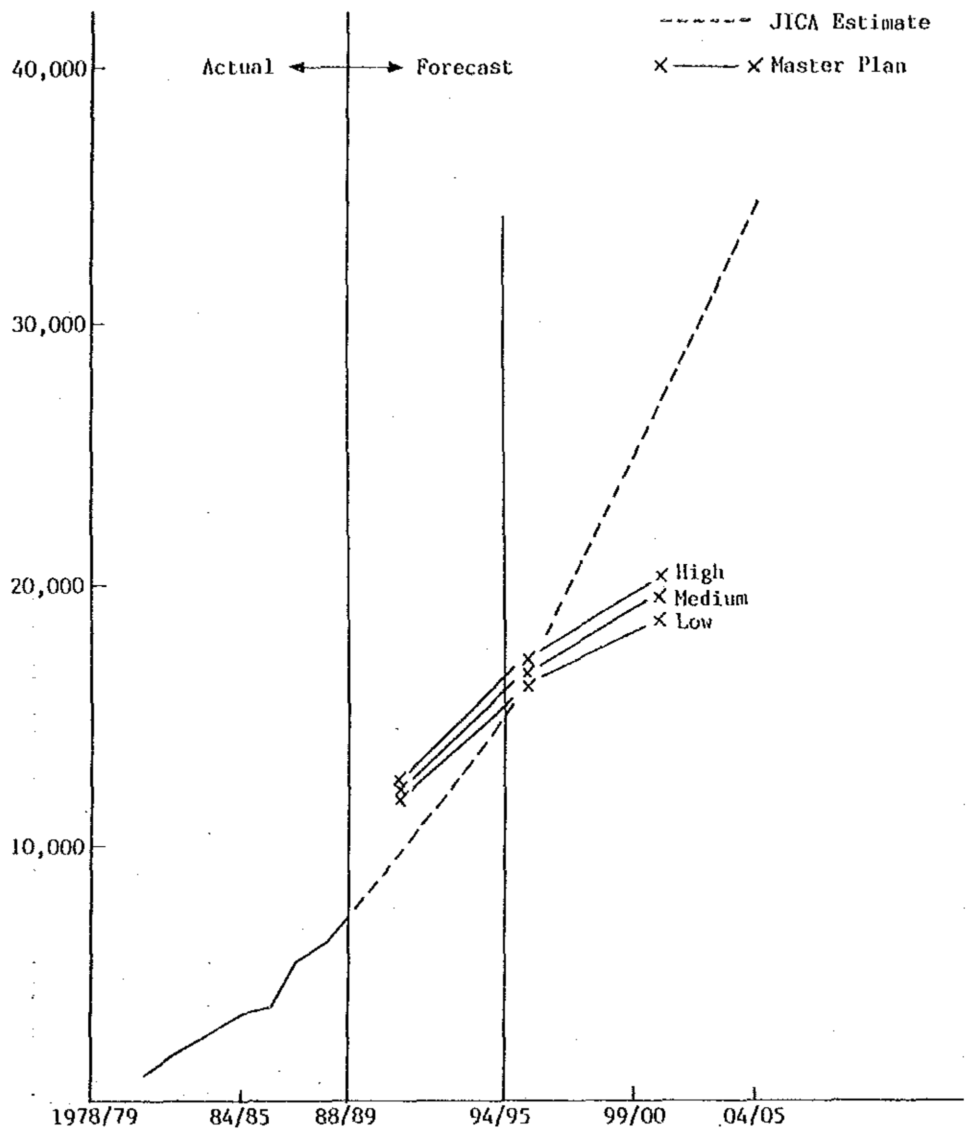


Figure-5.1.1 Demand Forecast

(3) Method of Forecast

i) Export

① Iron Ore

It is assumed that the utilization rate of the present iron ore cargo handling system will reach to almost 100% in 1994/95 from 70% in 1988/89. We estimate 7,500 thousand tonnes of iron ore cargo will be handled in 1994/95.

Due to improvement of the production system of iron ore, the cargo will be handled at a level of 10,000 thousand tonnes after 1995.

Thus we assume that the cargo volume of iron ore will level off up to 2004/05: 10,000 thousand tonnes.

② P.O.L.(Products)

There is a plan to set up an oil refinery near Mangalore by 1994/95, with an installed processing capacity of 3 million tonnes of crude oil in Stage I and 6 million tonnes of crude oil in Stage II. The refinery produces P.O.L. products in which several products will be exported through New Mangalore Port. According to information from Mangalore Refinery and Petrochemicals Ltd., the export volume of P.O.L. products will be 1,570 thousand tonnes in 1994/95 and 3,160 thousand tonnes in 1999/2000. Therefore we have adopted the estimates assuming that the export of P.O.L products in 2004/05 will be on the same level as that in 1999/2000.

ii) Import

① Crude Oil

As mentioned above, the planned oil refinery will need imports of crude oil from Bombay High and Gulf Countries. Mangalore Refinery and Petrochemicals Ltd. estimates the import volumes of crude oil at 3 million tonnes in 1994/95 and 6 million tonnes in 1999/2000. Thus, we have adopted an estimate of 3 million tonnes in 1994/95 and we assume that imports of crude oil in 2004/05 will be on the same level as that in 1999/2000.

② P.O.L (Products:LPG)

Hindustan Petroleum Corporation Limited (HPCL), one of the public sector undertakings of the Government of India, has proposed to develop L.P.G. import and storage facilities at Mangalore in order to meet the projected L.P.G. short fall in the country.

L.P.G. is handled at the oil jetty of New Mangalore Port and transferred to storage tanks by a pipeline about 8km long. The proposed facilities are desinged to handle L.P.G. imports of about 200,000 tonnes/year and go up to 500,000 tonnes/year in the ultimate stage. Therefore, we have adopted the estimate.

③ Coal

There is a plan to install a coal-based super thermal power plant whose capacity is 210MW x 2 for Stage I and 500MW x 4 for Stage II.

According to the National Thermal Power Corporation Ltd. (a government of India enterprise), Stage I shall be commissioned by 1994/95 through New Mangalore Port, but it is not clear when stage II of the project will be commissioned. Recently the Ministry of Energy has informed us of the requirement of coal as finalised for the proposed Thermal Power Station at Mangalore as follows:

1994/95	0.45	million	tonnes
1999/2000	6.24	"	"
2004/05	12.12	"	"

We adopt the above requirement of coal as the estimate of New Mangalore Port cargo handling of coal.

④ Other Cargo

The total amount of other cargo was first estimated through correlation between the Gross National Product (GDP) and cargo volume.

Table-5.1.3 Total Other Cargo Projection

Year	Total Other Cargo (thousand tonnes)
1994/95	2,100
2004/05	3,660

Then, we forecast other export cargo from the time series correlation using a 5-year moving average. The cargo volumes of other export cargoes are as follows:

Table-5.1.4 Other Cargo Projection (Export)

Year	Other Cargo (Export, thousand tonnes)
1994/95	780
2004/05	1,130

According to NMPT information, the amount of granite stone at present being exported may not increase in the future due to the Indian Government's policy and the development of Karwar Port on the west coast. Therefore, we assumed that the export of granite stone through NMP would be the same level with 1988/89 cargo handling volume. Thus exports of granite stone are 386 thousand tonnes in both 1994/95 and 2004/05. The volume of other cargo, excluding granite stone is estimated through the share of other cargo excluding granite stone are same with the share in 1988/89, that is 23.7% in 1994/95 and 2004/05.

The level of other import cargoes was estimated from total other cargo minus other export cargo (Table-5.1.4). The cargo volume of other import cargoes are as follows:

Table-5.1.5 Other Cargo Projection (Import)

Year	Other Cargo (Import, thousand tonnes)
1994/95	1,320
2004/05	2,530

⑤ LNG

According to information from the New Mangalore Port Trust, the Gas Authority of India Limited (GAIL) is examining the possibility of importing Liquified Natural Gas (LNG) and is in the process of preparing a techno-economic feasibility report.

In the information, demand for LNG is predicted as 2.9 million metric tons per year (MMTPA) in 1995 and 4.1 MMTPA in 2000. However we haven't included the LNG prediction in our demand forecast, because the above proposal for importin LNG depends on the results of the techno-economic feasibility report. However we forecast that there is a possibility of handling LNG at New Mangalore Port after 2005 in the very long term.

5.2 Review of Facility Layout

5.2.1 Iron Ore Berth

(1) Present Situation of the Existing Iron Ore Terminal

Approximately 4.3 and 5 million tonnes of iron ore were handled in 1987-88 and 1988-89, respectively, at the berth. This resulted in high occupancy rates at the berth of 76% and 89%, respectively, and long preberthing waiting times of 130.1 and 203.6 hours per ship in 1987-88 and 1988-89, respectively.

(2) Capacity of the Iron Ore Handling Facility

The current and improved (with a minor or major modification) capacity of the system are shown in Table-5.2.1.

Table-5.2.1 Loading Capacity of the Handling System

	Capacity of the System (t/h)	Modification
Present	6,000 / 3,500	None
Minor Modification	7,000 / 3,500	Capacity Upgrading of Out-going Conveyor Cross Conveyor Wharf Conveyor
Major Modification	8,100 / 4,100	Additional Reclaimer for concentrate capacity upgrading of Reclaimer for pallets Out-going Conveyor Cross Conveyor Wharf Conveyor

Concentrate / Pellets

Table-5.2.2 shows the berth occupancy rate when the berth handles iron ore of 7.5 (concentrate : 60%) or 10.0 (concentrate : 40%) M tons.

Table-5.2.2 Berth Occupancy Rate

Annual Throughput of Iron Ore	Max. Ship Size (Ave. Ship Size)	Modification			
		None	Minor		Major
		D=270	D=270	D=290	D=290
7.5 million	60,000 DWT (40,000)	0.81	0.78	0.73	0.68
concentrate = 4.5 (60%)	100,000 (65,000)	0.66	0.63	0.59	0.54
pellets = 3.0 (40%)	130,000 (73,000)	0.64	0.61	0.57	0.52
	150,000 (88,000)	0.60	0.57	0.53	0.48
	170,000 (95,000)	0.59	0.56	0.52	0.47
10.0 million	60,000 (40,000)	1.14	1.12	1.04	0.96
concentrate = 4.0 (40%)	100,000 (65,000)	0.95	0.92	0.86	0.78
pellets = 6.0 (60%)	130,000 (73,000)	0.91	0.89	0.83	0.75
	150,000 (88,000)	0.86	0.84	0.78	0.70
	170,000 (95,000)	0.85	0.82	0.76	0.69

It can be concluded that:

1) in order to handle 7.5 M tons (pellets ratio = 0.4), the berth should be upgraded up to at least 100,000 DWT, and additional working days and at least minor modifications of the equipment will be needed,

2) in order to handle 10.0 M tons, an additional iron ore berth will be required.

(3) Enlargement Scale of the Berth

The berth must be enlarged to accept at least 100,000 DWT vessels, and improvement of the handling equipment must be carried out in order to handle 7,500,000 tonnes per year without congestion and to maintain an appropriate occupancy rate. Moreover, 10,000,000 tonnes cannot be loaded at one berth even if a 100,000 DWT or larger carrier is acceptable.

(4) Vessel Sizes

(Present Stock in the World)

About 70% and 36% iron ore carriers currently operating are large size ships of 100,000 DWT or more and 150,000 DWT or more, respectively. This distribution depends on the area in the world where carriers are operated. More than 50% of carriers operated in Japan, on the Pacific coast of South America and in Other Africa are vessels of 150,000 DWT or more and in West Africa, Asia, Other Europe, USA and other areas, more than 50% of carriers have less than 100,000 DWT.

By studying the year of launch for ore carriers in the world by DWT class, it can be said that many new (built after 1981) vessels can be found in the 40,000 - 60,000 DWT class and the 60,000 - 80,000 DWT class.

(Japanese Ore Carries)

According to the record of ships that docked at the iron ore terminal of New Mangalore, almost all large carriers of iron ore concentrate were Japanese, and the predominant classes of Japanese Iron Ore Carrier are 140,000-150,000DWT, 170,000-180,000DWT and those over 200,000DWT.

(Iron Ore Loading Ports)

Most of the world's main iron ore loading ports have capacities above 100,000 DWT, and the Iron Ore loading ports in India have or plan to have capacities above 100,000 DWT.

(Proposed Oil Handling Facility)

The proposed oil refinery plant would export and import oil products and crude oil, respectively, through the port. The sizes of tankers likely to call at the proposed jetties are 100,000 - 150,000 DWT.

(Vessel Size Alternatives)

100,000 and 150,000 DWT can be set as alternative.

1) 100,000 DWT is a vessel size which is required to handle 7.5 million

tonnes of iron ore annually, as well as the size which other Indian ports can currently accommodate and New Mangalore Port should catch up with, and is the size whose full draught is similar to that of a crude Oil tanker of 100,000 DWT class, one of the alternative sizes for the oil handling plan. Moreover, the maximum size which the present terminal can accept with minor changes in the existing shiploader. There is a jump of full draught from 100,000 DWT to 130,000 DWT and the difference in dredging cost between these two alternatives will be enormous.

2) 150,000 DWT is a vessel size whose full draught is similar to that of a crude oil tanker of 150,000 DWT class, one of the alternative sizes and the largest for the oil handling plant. And one of predominant vessel sizes of Japanese iron ore carriers.

(5) Improvement Scenario

Consequently, improvement of the port's iron ore handling capability will be achieved, according to one of the two following scenarios:

-- Scenario 1

a) Not later than 1994-95, the existing iron ore berth will be upgraded for 100,000 DWT or larger vessels, and

b) the handling equipment will be upgraded with minor modifications, then.

c) not later than 1999-2000, an additional iron ore berth will be constructed at one of the possible sites and proper handling equipment will be installed at the same time.

--Scenario 2

a) Not later than 1994-95, an additional iron ore berth will be constructed at one of the possible sites and proper handling equipment will be installed at the same time.

(Meanwhile, the existing berth and equipment are left unchanged.)

5.2.2 Oil Berth

(Berth Scale)

The scale of the crude oil jetty is decided in accordance with the water depth decided by the scale of the iron ore berth.

Following alternatives for oil jetties are set in accordance with the alternatives for the iron ore berth.

Table-5.2.3 Oil Berth Alternative

Iron Ore Berth Alternative (DWT)	Oil Berth Alternative	
	Crude Oil Jetty (DWT)	Product Jetty (DWT)
100,000	100,000	35,000*
150,000	150,000	35,000*

* 85,000 is possible (for use of crude tanker in case of breakdown of the crude oil jetty)

(Number of Berth)

In 1994/95, crude oil of 3.0 million tonnes and oil products of 1.6 million tonnes as well as 0.2 million tonnes of LPG will be handled, according to the demand forecast.

Tanker sizes can be set as follows

Crude Oil Tanker	Max.	100,000 DWT
	Ave.	83,000 DWT
Oil Products Tanker	Max.	35,000 DWT
	Ave.	28,000 DWT

Then, Berth Occupancy rates by a single jetty for each oil cargo are 0.24 and 0.47 respectively.

Therefore, a single crude jetty and a single products jetty will be required to meet the demand of 1994/95.

Secondly, in 2004/05, the demand for crude oil, oil products and LPG will be 6.0 million tonnes, 3.16 million tonnes and 0.5 million tonnes, respectively. Similarly, the same conditions are applied to calculate the required number of jetties.

On the same conditions, the both occupancy rates are 0.48 and 0.97 respectively.

Therefore, a single crude jetty and a two products jetties will be needed in 2004/05.

(Location)

- Crude Oil Jetty

Besides being located in the basin (inner port area), location in outer port area is possible because, unlike an iron ore jetty, only light gear (pipeline, loading arms etc.) are needed. That is, structure dose not have to be as firm as that for an iron ore berth. Therefore, possible locations of the crude oil jetty are:

1) on the south dike of the lagoon (renovation of the existing oil product jetty and,
2) in the outer port area.

- Oil Products Jetty

Possible locations of the oil products jetty are:
1) on the south shore of the lagoon and,
2) in the outer port area.

5.2.3 Coal Berth

According to the demand forecast, coal handling volume will jump up to 6,240,000 tonnes in 1999/2000 and 12,120,000 tonnes in 2004/05 from 450,000 tonnes in 1994/95 (This amount can be handled at general cargo berth).

Therefore, not later than 1999/2000, a coal terminal should be constructed .

The ship size of coal carriers is assumed to be 50,000 DWT, the same size as that used in the existing master plan. Then, two berths and three unloaders will be required to receive 6,240,000 tonnes per annum and an additional one berth and three unloaders will be needed to handle 12,120,000 tonnes per annum.

The terminal can be located on the west side of the proposed west dock and half of the area currently leased to M/S M.D.L. will be returned to be used for a coal stock yard.

5.2.4 Other Berths

(General Cargo)

Plan for general cargo berths, remain unchanged, from the following reasons.

The projected volumes of both exported and imported other cargo (general cargo) are 2,340,000 (coal included) and 3,190,000 tonnes in 1994/95 and 2004/05, respectively. The present annual handling rate per berth is around 330,000 t/berth (1,502,000 t/4.5 berths; a shallow berth = 0.5 berth). On the other hand, if all berths are completed (2 berths will be completed soon and 4 more berths are proposed in the proposed west dock) to handle 3,190,000 tonnes, the annual handling rate will be reduced to about 304,000 t/berth.

(LNG)

LNG is expected to be handled at New Mangalore Port in the future. The Gas Authority of India Limited has proposed (not been authorized) a LNG terminal at New Mangalore Port. According to the proposal 1) 4.1 Million MT would be accepted per annum, and 2) land of 20 - 30 hectares would be required for the terminal. The southern shore of the south breakwater should be reclaimed as land for the terminal, and the jetty should be constructed inside the breakwater.

5.2.5 Channel and Basin

(1) Depth

The squat and trim of ships should be considered when deciding on depth requirements. The under-keel clearance allowances for the basin and channel are 1.0m and 1.5m, respectively.

(2) Other Dimensions

(Width of Channel)

The width of the channel should be one length of biggest vessels under single lane traffic control. On the other hand, according to "UNCTAD Handbook", the width of a channel composed of a maneuvering lane and bank clearance for both sides is 5 times the beam.

(Stopping Distance)

A straight protected water area of a relevant depth and five times the length of a ship approaching a berth at the port is normally required to ensure the safe maneuvering of the ship.

(Turning Circle)

It is generally accepted that the diameter of the turning circle for vessels aided by tugboats is twice the length of the biggest vessels.

(3) Required Dimensions of Basin and Channel

Table-5.2.4 shows the required dimensions of the basin and channel discussed above for each size of iron ore carrier.

Table-5.2.4 Requirement of Demensions for the Basin and Channel

Iron Ore Carrier Size (DWT)	Length (m)	Beam (m)	Full Draught (m)	Depth		Width of Channel (m)	Diameter for Turning Circle (m)
				Basin (m)	Channel (m)		
100,000	270	42	15.5	-16.5	-17.0	275*	550*
150,000	300	47	17.5	-18.5	-19.0	300	600

* In the case of a 100,000 DWT iron ore carrier, crude oil tanker of 100,000 DWT can enter at high tide. The width and diameter are decided by the length of the tanker.

(4) Layout of the Channel and Basin

As mentioned in 2.4.3, bedrock strata are found in a wide area inside the basin. In order to accept larger ships, the basin and channel must be widened and dredged and it is requested that these facilities be shifted to the south as much as possible so that the volume of expensive rock dredging can be reduced. On the other hand, to ensure safety during the ships' maneuvering, channel and basin must keep a necessary distance from structures and mooring ships.

In the case where the crude oil jetty is located in the outer port area, a deep turning circle could be located outer port area because iron ore carriers which come into the basin in ballast condition does not need a deep turning circle. In this case, deep dredging can be limited to only an area for out-going fully-loaded iron ore carriers so that rock dredging can be reduced. This applies to the Master Plan Alternative.

5.2.6 Breakwaters

Extension of the breakwaters is one of the possible countermeasures against the siltation and littoral sand drift that takes place in areas with a depth of up to -7 m and accumulates compact sand in the channel. Other elements which determine the length and layout of breakwaters are stopping distance and tranquility at the berth.

5.2.7 Layout Plan Alternative

Based on examinations above, the following alternative facility layout plans are drawn (Figure-5.2.1 - 5.2.4).

Case-1 is planned under scenario-1 and other cases are planned under scenario-2.

The layout of the breakwater of case-1 and 2 is different from that of cases-3 and 4 because a future LNG jetty is planned outside of the existing southern breakwater in the latter 2 cases.

The turning circles of cases-3, and 4 are located in the outer port area, where as those of case-1 and 2 are located in the lagoon. Moreover, cases-3 and 4 have deep dredging plans of limited area in the lagoon for outgoing iron ore carriers of 150,000 DWT.

Plans of mooring facilities for each case are as follows:

(1) Case-1

-- Improvement of the Existing Iron Ore Berth to 100,000 DWT Class (short-term)

-- Reconstruction of the Existing Oil Products Jetty to Crude Jetty of 100,000 DWT Class (short-term)

-- Oil Products Jetty of 85,000 DWT Class (short-term)

-- Additional Iron Ore Berth and Oil Products Jetty

-- Construction of Three Coal Berths (long-term)

-- LNG jetty (future)

-- Reclamation of Southern Shore for LNG Terminal (future)

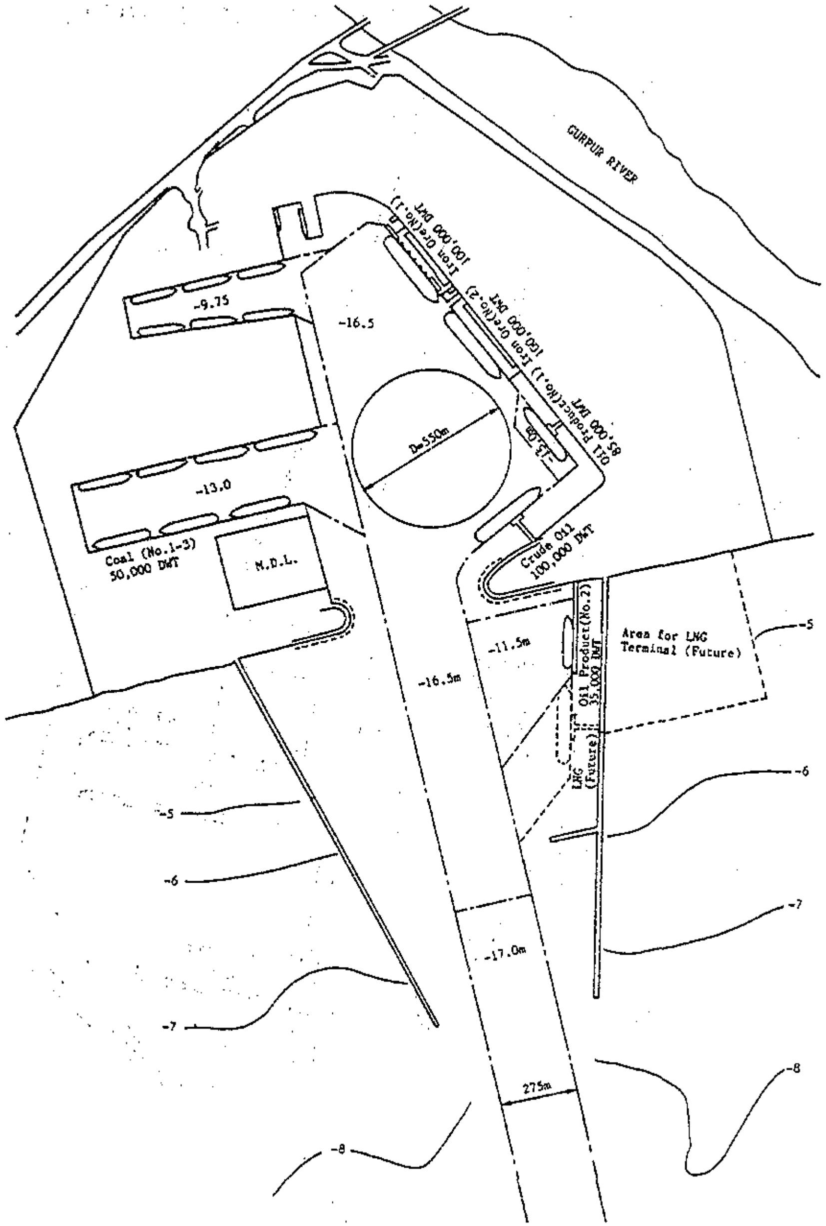


Figure-5.2.1 Master Plan Alternative (Case-1)

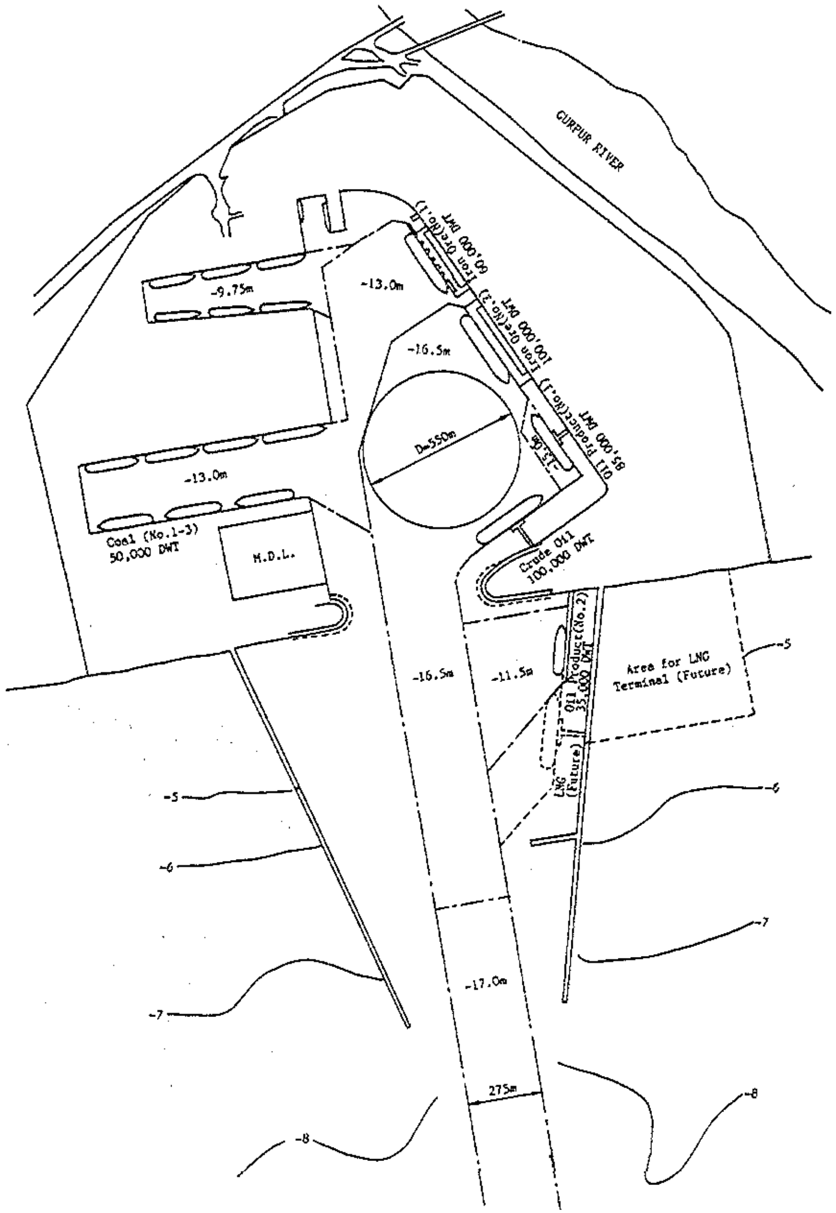


Figure-5.2.2 Master Plan Alternative (Case-2)

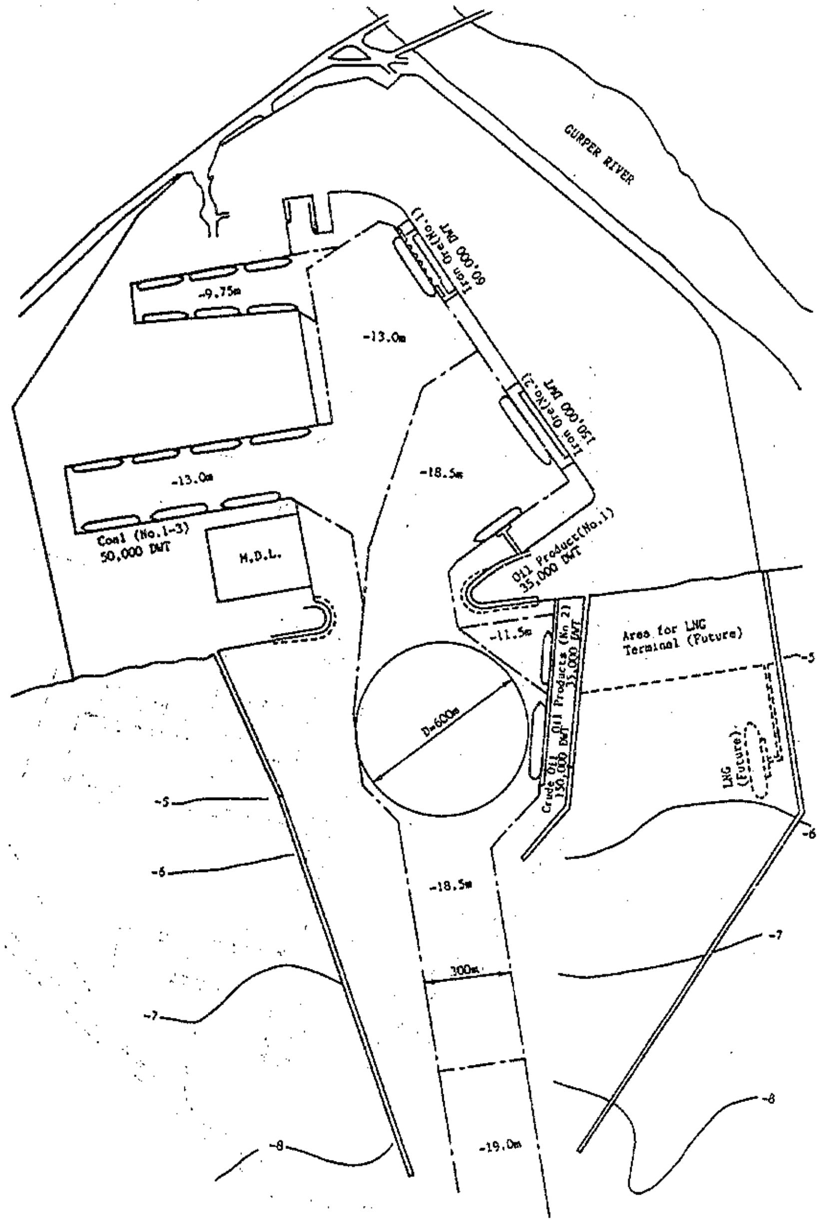


Figure-5.2.3 Master Plan Alternative (Case-3)

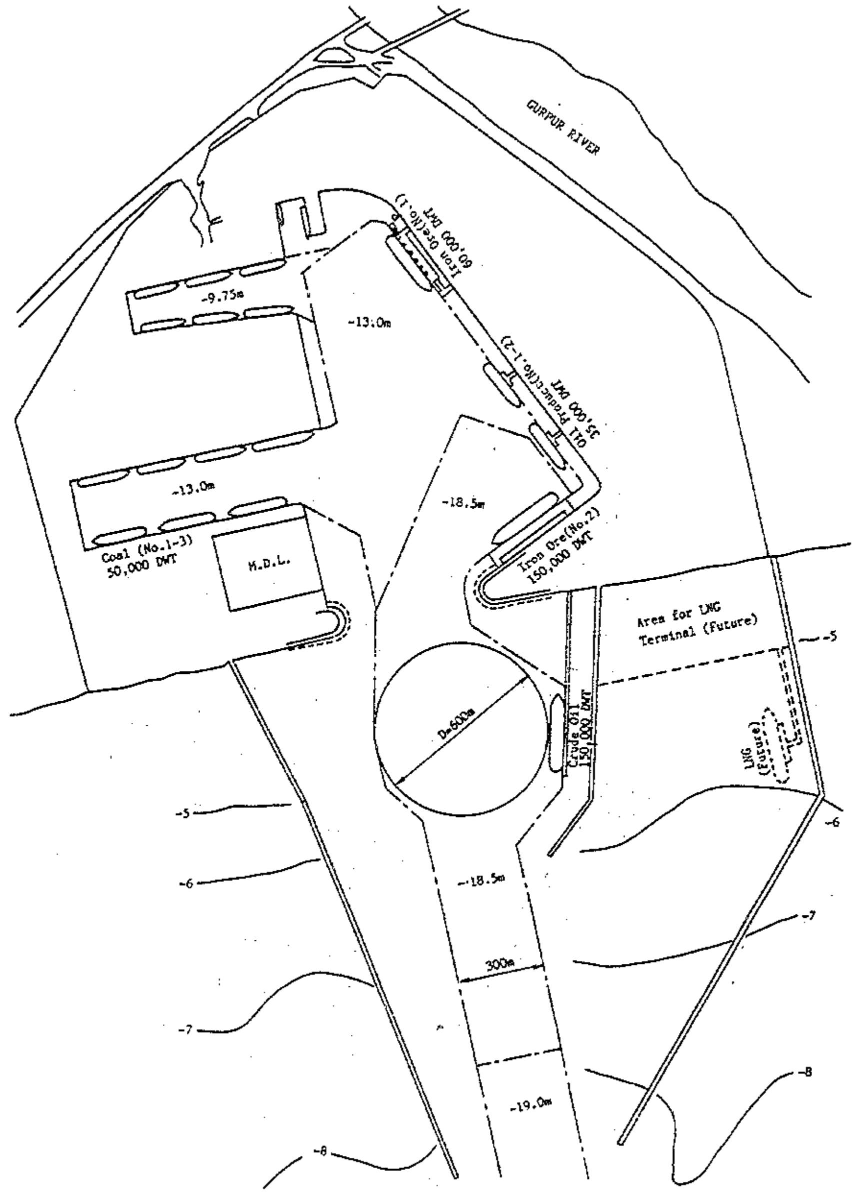


Figure-5.2.4 Master Plan Alternative (Case-4)

(2) Case-2

-- Construction of a New Iron Ore Berth of 100,000 DWT Class (Short-term)

-- Crude Jetty, Oil Products Jetty, Coal Berths (short-term), Additional Oil Products Jetty (long-term) and Facilities Related to LNG (future)

(3) Case-3

-- Construction of New Iron Ore Berth of 150,000 DWT Class (long-term)

-- Construction of Crude Oil Jetty of 150,000 DWT Class in the Outer Port Area (short-term)

-- Additional Oil Products Jetty (long-term)

-- Coal Berths (long-term) and Facilities Related to LNG (future)

(4) Case-4

--Construction of New Iron Ore Berth of 150,000 DWT Class (short-term)

-- Oil Products Jetty (short-term and long-term)

-- Crude Oil (short-term), Coal Berths (long-term) and Facilities Related to LNG (future)

5.2.8 Selection of the Optimum Layout Plan

(1) Methodology

Of the four alternatives shown in the previous section, the optimum layout plan is selected based upon the following point of view:

Costs
Benefit
Flexibility
Future Development (LNG Jetty)

(2) Costs

Costs considered here are capital costs, maintenance costs, administration costs and operation cost.

The cost of other facilities, such as general cargo berths, can be discounted, because these other facilities could be constructed separately from the project discussed in this report.

Table-5.2.5 and 5.2.6 shows the cost of the various alternatives.

Table-5.2.5 Rough Capital Costs

(unit: Crore Rs.)

Case	1	2	3	4
Iron Ore Berth (long-term) (short-term) ('000 DWT)	100+100 (100)	60+100 (60+100)	60+150 (60+150)	60+150 (60+150)
Iron Ore Berth				
Improvement	3.5	-	-	-
Construction	9.7	9.7	13.7	13.7
Crude Oil Jetty	3.7	3.7	10.9	10.9
POL Jetty	9.3	9.3	4.3	8.9
Dredging	66.2	63.9	94.3	73.2
Breakwater	22.0	22.0	45.4	45.4
Total (for short-term plan only)	114.4 (99.6)	108.6 (103.5)	168.6 (164.3)	152.1 (148.9)
Equipment (for short-term plan only)	80.7 (21.6)	78.5 (78.5)	85.2 (85.2)	98.8 (98.8)
Other (for short-term plan only)	7.3 (7.3)	7.3 (7.3)	7.5 (7.5)	7.5 (7.5)
Grand Total (for short-term plan only)	202.4 (128.5)	194.4 (189.3)	261.3 (257.0)	258.4 (255.2)

Table-5.2.6 Increase in Annual Maintenance Dredging Cost

Case	1	2	3	4
Siltation Volume (Mm3)	6.1	6.1	5.1	5.1
Increase in Maintenance Volume (Mm3) *	1.3	1.3	0.6	0.6
Increase in Dredging Cost (Cr. Rs.)	2.0	2.0	0.9	0.9

* Present maintenance dredging volume ≒ 3 Mm^3
Maintenance dredging volume = 0.7 x siltation volume

(3) Benefits

Here, benefits are calculated as the sum of savings in operating time, savings in waiting time and savings in freight cost. These savings can be increased as the size and number of the berths grow. For long-term development, the benefit/cost ratio of each case is shown in Table-5.2.7, which shows that there are no significant differences between the alternatives.

(4) Flexibility

Besides case-1, alternative plans include a great expenditure before 1994/95, when 5.5 million tonnes of iron ore will be exported, which would enable the port to handle over 10 million tonnes of iron ore. Although the projection shows that the volume of iron ore exports will increase to 10 million tonnes, there is some uncertainty regarding this and when such a volume will be reached. Therefore, cases-2, 3 and 4 present the possibility of excess investment. Conversely, case-1 has flexibility regarding demand because in that case the existing iron ore berth would first be upgraded to handle 7.5 million tonnes and the decision to build an additional iron ore berth can be made by considering the demand trend.

Table-5.2.7 Benefit/Cost of Each Long-term Development Alternatives

Discount Rate	0.05	0.07	0.1	0.12	0.15	0.2
Case-1	1.54	1.34	1.11	0.98	0.84	0.66
Case-2	1.62	1.38	1.12	0.98	0.83	0.65
Case-3	1.66	1.40	1.10	0.95	0.79	0.61
Case-4	1.69	1.42	1.12	0.97	0.81	0.62

(5) LNG Terminal

For all cases, LNG terminal can be planned in harmony with the other facilities.

(6) Conclusion

Based on the examination as stated above, case-1 is considered to be the best solution, as shown in Table-5.2.8.

Table-5.2.8 Evaluation of the Alternatives

Case	1	2	3	4
Cost				
Short-term	A	B	C	C
Long-term	B	A	C	C
Benefit	A	A	A	A
Flexibility	A	C	C	C
LNG Terminal	B	B	B	B
Overall Evaluation	A	B	C	C

6. SILTATION

6.1 Breakwater as a Countermeasure

From the analysis of the present situation of siltation, it is thought that the primary mechanism of siltation is deposition of fine materials widely distributed on the bed around the channel. These fine materials consisting of silt and clay are suspended in water column by vigorous wave agitation during the southwest monsoon season. After the suspended materials move into the channel and lagoon, they settle gravitationally due to the decrease of silt carrying capacity of water.

Therefore a primary concept in countermeasures against siltation is to prevent inflow of water containing a lot of sediments into the channel and lagoon. One of the most direct measures to mitigate this inflow is the extension of breakwaters.

It is said that littoral sand drift sometimes takes place in a area of depth up to -7m and compact sand accumulates in the channel. This compact sand requires immediate dredging to clear the navigation channel. The extension of breakwaters is also expected to be effective in mitigation of the inflow of sand drift into the channel.

A long extension of breakwaters would be expensive. The construction of breakwaters for the entire channel may be impossible due to financial constraints.

The amount of sediment transported into the channel from the surrounding area is considered to be the largest in the breaker zone and decrease gradually offshore. Therefore, the role of the breakwater extension on the mitigation of siltation is most effective at the initial stage of the extension and gradually decreases its effectiveness as the breakwater is extended offshore. On the other hand the construction cost per unit length of breakwater extension is smaller in the initial stage and increases gradually as the breakwater is extended into deeper water. From this reason, the sum of the construction cost of breakwater and the cost of maintenance dredging (not the cost per year but the total cost of dredging for several ten years of project life) is expected to be a function of the length of the breakwater extension with the minimum at a certain length of the extension.

6.2 Estimation of the Effect of the Breakwater Extension on Siltation

6.2.1 Model

(1) Concept of Modelling

According to a result of sounding survey carried out in the post-monsoon period, the channel depth in the area more than 2km offshore from the base line is almost the same as the original depth in the surrounding area. This means that the channel is almost completely filled by siltation. On the other hand, in the harbour area, the thickness of siltation decreases from the base line to the head of the harbour with the bottom slope of about 1/2000. This small bottom slope, together with the fact that the large siltation thickness is found in the area in front of the Iron Ore Berth, which is dredged deeply every year, indicates that the mobility of inflowing sediment is very large.

From these evidences, the siltation of the part of the channel surrounded by the breakwaters and in the harbour area is considered to be a result of the movement of very fine sediment as a density current along the channel. The original source of this sediment may be a longshore drift of bottom materials transported into the channel where no breakwater exists. Of course, there may be a part of siltation which is a result of sedimentation of solid materials suspended by wave actions in the monsoon period and then transported into the harbour by advective-diffusive mechanisms.

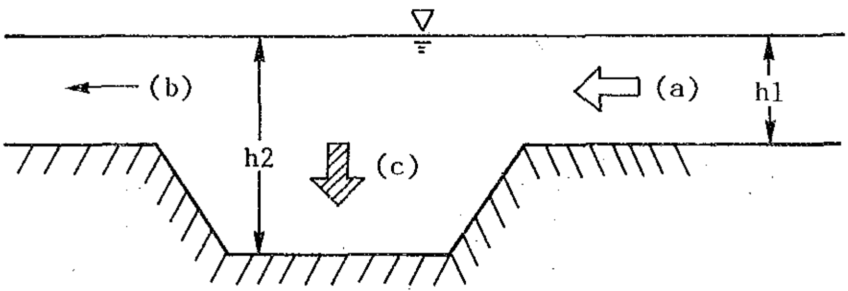
However, according to a result of a numerical simulation using an advective-diffusive model, it was not possible to reproduce the very flat and small slope of the water bottom. Thus, it may be concluded that the influx of solid materials into the harbour was mainly caused by the movement of the sediment as a density current. The material was originally transported into the channel by a longshore drift.

Taking these factors into account, the siltation is estimated by two models. The first is the Swanby model, by which the inflow of solid material into the channel is estimated. The Swanby model was used in the past by CWPRS for the estimation of siltation in New Mangalore Port and another major ports in India.

The second is a sediment transport model, by which the slow movement of solid material along the channel is formulated as a density current. Although there is no literature documenting the application of the latter model to a realistic situation, we believe that this modelling is adequate and necessary from an engineering and practical point of view, taking into account the actual situation of siltation in New Mangalore Port.

(2) The Swanby Model

The Swanby formula is a formula to estimate total sediment load in open sea coasts where both waves and currents exist. The formulat has been applied to estimate siltation volume in major ports including New Mangalore Port by the Central Water & Power Research Station. How to apply the formula to the estimation of siltation volume is as follows.



Section of a Channel

(a) Total sediment load in the upstream side.
(b) Total sediment load in the downstream side.
(c) Deposited sediment into the channel (a)-(b).

(a) is larger than (b) because silt carrying capacity in shallow water is largest than deep water like the channel.

By specifing the conditions of waves and currents in both the uptream side and the channel, total sediment load (a) and (b) are computed through the Swanby formula and accordingly deposited sediment into the channle.

(3) A Model of Sediment Transport in the Channel and Lagoon

A recent conceptual model of cohesive sediment transport has been proposed as shown in Figure-6.2.1. This figure shows that there is a layer of mobile fluid mud with high sediment concentration between water column including suspended sediment and cohesive bed. The sediments deposited in the channel during and just after the monsoon season are thought to have considerable fluidity and to correspond to the layer of mobile fluid mud in

Figure-6.2.1. The water depth detected by echo-sounder corresponds to the depth of lutocline in the figure, and so called nautical depth is thought to be in the layer of stationary mud in the figure.

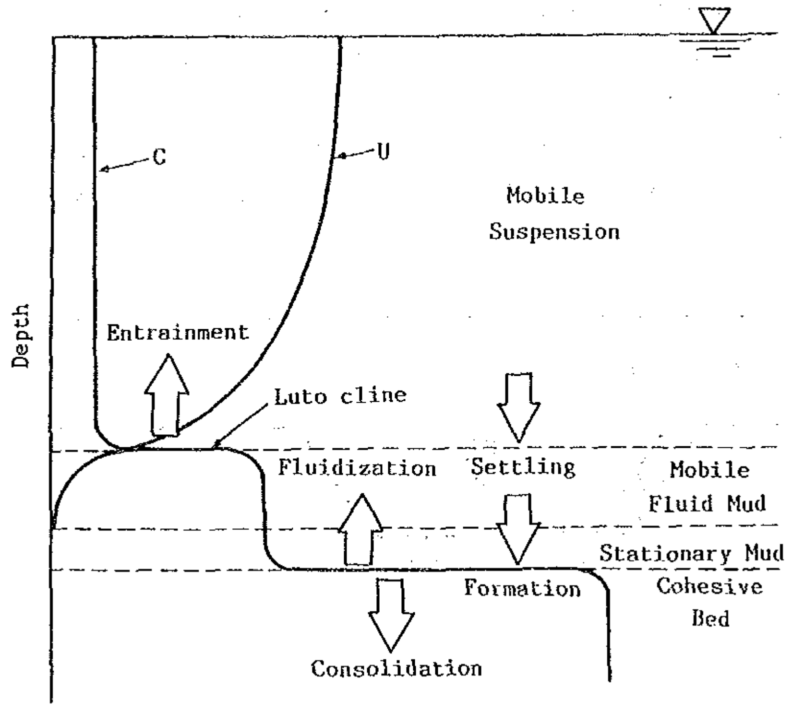


Figure-6.2.1 Idealized Profiles of Instantaneous Vertical Concentration and Velocity
(A.J. Mehta, On estuarine cohesive sediment suspension behaivior, JGR, Vol.94 No.C10, 14303-14314, 1989)

In this report, a one dimensional density current model along the channel has been employed to take into account the effect of the above mobile fluid mud on siltation and this model has been used in combination with the Swanby model. This combination of the two models is necessary not only to represent correctly the movement of sediment in the channel, but also to improve accuracy of the estimation of siltation volume in the channel outside the breakwaters,. because the channel depth changes by the movement of sediment in the channel and this effects again quantity of sediment inflowing into the channel from the surroundings.

(4) Wave Condition

At the time of preparing the designs for New Mangalore Harbor Project, a wave observation was performed from 1968-1969 for a period of about 18 months (Jade Dattatri, Waves off Mangalore Harbour - west coast of India, Journal of the Waterways, Harbours and Coastal Engineering Division, Proceeding of the American Society of Civil Engineers, Vol. 99, No. WW1, Feb. 1973). Table-6.2.1 shows the cumulative distribution of the significant wave height from June to September. The distribution of the significant wave height in Table-6.2.1 has been used as the wave condition in the Swanby model computation.

Table-6.2.1 Cumulative Distribution of the Significant Wave Height from June to September (1968)

month	percentage of time, significant wave height exceeded					
	0.5m	1.0	1.5	2.0	2.5	3.0
June	100	97	55	25	8	1
July	100	73	31	17	3	1
August	100	94	25	3	0	0
September	100	18	0	0	0	0

IMOBCO International Inc., Report of wave & current studies pertinent to an offshore terminal site at Mangalore.

6.2.2 Estimation of the Siltation Volume

(1) Calibration of the Model

Model parameters have been calibrated so that the model described in the previous sub-section faithfully reproduce the present situation of siltation. The result is shown in Table-6.2.2 in which the actual siltation volume is shown for comparison. It can be seen that the model output almost coincides with the actual siltation volume. In this case, the total sediment load inflowing to the channel outside the breakwater has been simulated to be 10.1 million m^3 during 4 months of the monsoon season, and total sediment load outflowing from the channel has been calculated to be 5.4 million m^3 during the same period. Therefore the net inflow volume to the channel is 10.1 - 5.4 = 4.7 million m^3. This value does not coincide with the value 3.3 million m^3 of the simulated siltation volume. This means that the balance 4.7 - 3.3 = 1.4 million m^3 flow offshore along the channel. A large sediment load amounting to 5.4 million m^3 is outflowing from the channel and this outflow arises from the situation that the channel is completely filled up at sometime during the computation. From these simulation results, it appears that the potential power of siltation is very large.

Table-6.2.2 Comparison of Siltation Volume between Model Output and the Actual Siltation

(million m^3)

	Channel (a)	Lagoon (b)	(a) + (b)
Model output	2.26	1.02	3.28
Actual Siltation	2.48	0.95	3.43

(2) Estimation of Siltation Volume for Various Lengths of Breakwater

In order to decide the optimum length of the breakwater, calculation of siltation volume has been performed for cases with various lengths of the breakwater from 500m (corresponds to the present situation) to 2,500m with a pitch of 500m. The results are shown in Table-6.2.3.

In these cases, the outer approach channel has been planned to be -17m deep, 270m wide with a side slope of 1/5, and 7,500m long. This length of the channel is about 2,500m longer than the present channel length. The water volume of the channel outside the breakwaters with a length of 500m is about 12 million cubic meters in the plan, while the value in the present situation is 2.9 million cubic meters.

From Table-6.2.3, we can see that the siltation volume in the case with a length of 500m is 9.3 million m^3 and the siltation volume decreases as the length of the breakwater becomes longer. The amounts of the decrease in siltation volume are 2.2 million m^3 for the first extension of 500m and 1.0 million m^3 for each extension of 500m after that. Thus, the breakwater extension appears to be very effective for the mitigation of siltation.

Table-6.2.3 Estimation of Siltation Volume for Cases with Various Lengths of the Breakwater from 500m to 2,500m

(million m^3)

length of the breakwater	Channel outside the breakwater	Channel inside the B.W. and Lagoon	Total
500 m	7.3	2.0	9.3
1,000 m	5.6	1.5	7.1
1,500 m	4.6	1.5	6.1
2,000 m	3.7	1.4	5.1
2,500 m	2.9	1.2	4.1

7. DREDGING

7.1 Past Records of Dredging

7.1.1 Dredging History

New Mangalore Port is an artificial lagoon harbour. The port was declared Indian ninth major port in May 1974 and was commissioned in May 1975 to cater to the requirements of vessels drawing a draught of -9.15m (First Stage Development)

The total area of the lagoon is 704,900m2 and the channel's width and length are 152m and 3,210m, respectively. The diameter of the turning circle is 366m.

At the end of 1976, the government of India approved a scheme for the development of New Mangalore Port, which was needed to facilitate the export of 7,500,000 tons of Kudremukh Iron Ore Co. concentrates to Iran (Kudremukh Development Scheme). The port was deepened to provide for vessels drawing a draught of 12.5m.

The channel's width and length are 245m and 5,340m, respectively. The diameter of the turning circle is 490m.

A large amount of siltation occurs at New Mangalore Port during the monsoon period from June to September. Therefore, maintenance dredging is necessary to keep the depth required for ships to navigate. However, in view of financial constraints, maintenance dredging in the outer approach channel is being carried out for a width of 152m and depth of 1.0m shallower than the planned level. Dredging in the lagoon is similar.

7.1.2 Dredging Fleet

The dredging work at First-Stage Development was done by Dredging corporation of India (DCI) and Dutch dredging company. Used dredgers were mainly cutter suction dredgers.

The dredging work at Kudremukh Development Scheme was done by DCI. Used dredgers were mainly trailer suction hopper dredgers, and partially cutter suction dredgers.

The maintenance dredging work also has been done by DCI with trailer suction hopper dredgers.

The rock dredging and blasting were done by the joint venture of Indian and Norway companies keeping pace with Kudremukh Development Scheme.

The rock was cleared by underwater drilling and blasting using a jack-up platform (drill rig) and by dredging using a put-on mounted crawler crane.

7.1.3 Past records of Dredging

Past dredging records at first-Stage Development and Kudremukh Development Scheme are as follows.

Table 7.1.1 Dredging Records for first-Stage Development Kudremukh Development Scheme

	Quantity (m3)	Time (Hrs)	Cost (Rs)
First-Stage	13,891,000	58,877	149,280,000
Kudremukh Scheme	9,361,000	64,560	283,460,000

Past dredging records at maintenance dredging are shown in Table-7.1.2.

Table 7.1.2 Dredging Records for Maintenance Dredging

Year	Quantity (m3)	Days	Cost (Rs)	Unit Cost (Rs/m3)	Hire Charge (Rs/day)
1975	3,507,120	70	6,755,000	1.93	93,000
1976	1,690,200	52	5,264,000	3.11	87,000
1977	1,636,150	40	9,914,000	6.06	220,000
1978	1,137,480	34	9,128,000	8.02	220,000
1979	1,765,600	38	10,110,000	5.73	220,000
1980	540,000	13	3,337,000	6.18	220,000
1981	4,549,800	114	38,200,000	8.40	220,000
1982	1,686,900	40	13,463,000	7.98	308,000
1983	3,113,110	64	23,152,000	7.44	308,000
1984	1,851,200	66	24,661,000	13.32	352,500
1985	3,296,890	80	30,248,000	9.17	361,400
1986	1,960,892	100	38,291,500	19.52	330,600
1987	3,092,994	74	36,600,000	11.83	388,000
1988	2,400,000	66	27,871,000	11.61	388,000

Past records of the rock drilling and blasting are shown below.

Volume of rock dredged	:	31,200 m3
No. of holes drilled	:	12,150
Total length of drill holes	:	19,900 m
Quantity of explosives	:	85.58 t
Actual time spent for frilling of 226 settings	:	160 days
Total idle time	:	200 days
Total working/idle time	:	360 days

7.2 Proposed Dredging Plan

7.2.1 Estimation of Volume Dredged

(1) Capital Dredging

The study team carried out a sonic prospecting survey in order to verify the distribution of rock in the lagoon and the channel near the entrance of the lagoon. Previous probing and boring data obtained from the New Mangalore Port Trust (NMPT) were also taken into consideration (see Figure-7.2.1).

The rock mainly consisted of hard granite overlaid with soft weathered rock with the thickness of around 1.5m. Moreover, grit is distributed on the west-south part of the lagoon and is found in a leans-type shape. The thickness is estimated at around 1.5m. The volumes of hardrock, weathered rock and grit are 116,100m3, 20,000m3 and 47,600m3, respectively.

The lagoon is to be dredged up to -16.5m based on the "Layout Plan Alternatives" in chapter 7. The side slopes in the lagoon are to be basically 1:3. The outer approach channel is also to be dredged up to -17.0m. The side slopes in the channel are to be 1:5. The extra depth to be dredged is assumed to be 50cm.

The volumes of soil in the lagoon and the channel are estimated at 3.910,000m3 and 9,330,000m3, respectively.

(2) Maintenance Dredging

The volume to be dredged for annual maintenance should be equal to the annual siltation volume after the completion of this project, which is estimated in Chapter 8. However, in deepening the channel the siltation volume increases heavily. Therefore, the volume to be dredged in the first year after the completion of this project is estimated based on the following assumption in consideration of financial constraint. The volume is estimated at 4,200,000m3.

- The dredging is to be carried out with the channel width of five (5) times of the beam length of the biggest vessel, that is, 215m.

- The dredging is to be carried out with the bottom level of the channel of 0.5m above from the planned depth. In this case, the biggest vessels with full loads have to wait off the coast when tide level is lower than +0.5m.

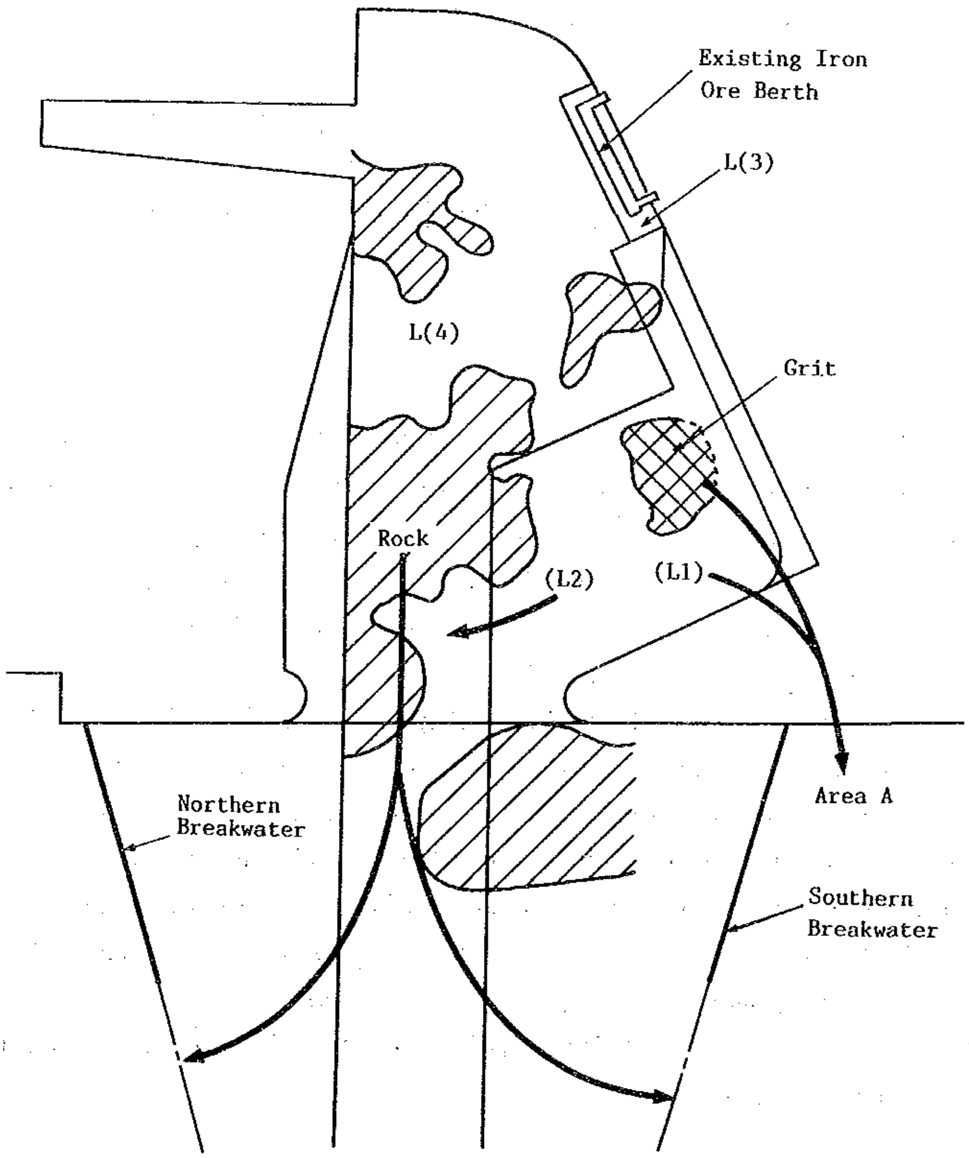


Figure-7.2.1 Rock Distribution Map and Transportation Plan of Dredged Materials

The volume to be dredged from the second year after completion of this project is equal to the annual siltation volume estimated against the restricted capacity of the channel. The volume is 5,270,000m3.

The extra depth to be dredged is assumed to be 50cm.

(3) Summary of Volumes Dredged

Asummary of the volumes dredged for the short-term Plan is shown in Table-7.2.1.

Table 7.2.1 Proposed Quantity Dredged

Hard rock	Area	m2	76,000
	Volume	m3	116,100
Soft Rock	Weathered Rock	m3	20,000
	Grit	m3	47,600
	(Sum)	m3	67,600
Soil	Lagoon	m3	3,910,000
	Channel	m3	9,300,000

7.2.2 Dredging Method

(1) Capital Dredging

A trailer suction hopper dredger may be used in the channel. In the case of slope dredging above the level of -8.0m, a cutter suction dredger is to be used, because a fully loaded trailer suction hopper dredger cannot navigate in this area. The dredged materials are to be dumped with a short floating pipeline in the deeper waters to be rehandled with the trailer suction hopper dredger. All the dredged materials are transported and dumped at the designated offshore disposal area (See Figure-7.2.2).

A cutter suction dredger is to be used in the south-west part of the lagoon. Sandy materials sucked up by a dredging pump are transported to the seashore area located south of the southern breakwater through floating/shore pipelines (See Figure-7.2.1). Erosion caused by sand littoral drift occurs to some extent in this area. Silty materials sucked up by the dredging pump are dumped at the designated deeper area near the dredger through a short floating pipeline to be rehandled with the trailer suction hopper dredger.

A grab dredger is to be used in the area in front of the existing iron ore berth in order to avoid any damage to structure. Dredged material are transported and dumped at the designated offshore disposal area.

The trailer suction hopper dredger is used in other areas. Dredged materials are transported and dumped at the designated offshore disposal area.

(2) Maintenance Dredging

Basically, a trailer suction hopper dredger is to be used in the channel and the lagoon because it is suitable for long-distance dredging and the dredged materials are usually very soft sediment. However, if a dredger encounters some hard compact materials, the plan should consider using a water jet device or a different type of dredger such as a cutter suction dredger. Dredged materials are transported and dumped at the designated offshore disposal area (See Figure-7.2.2).

7.2.3 Rock Dredging and Blasting

(1) Removal of Over-burden Lying over the Rock

Before hard rock blasting, the over-burden is to be removed to the extent that is possible by the cutter suction dredger. Materials sucked up by the dredging pump are dumped at the designated deeper area near the dredger through a short floating pipeline to be rehandled with the trailer suction hopper dredger.

Besides the over-burden, in view of economical considerations, overlaying weathered rock is to be removed by the cutter suction dredger. Materials sucked up by the dredging pump are discharged into the hopper barges alongside the dredger through a short pipeline and dumped at the extended alignment of the breakwater.

A grab dredger can be used instead of the cutter suction dredger for the removal of the over-burden and the weathered rock.

(2) Underwater Drilling

After the removal of the over-burden and weathered rock, rock drilling is to be carried out. A special floating pontoon or a self elevated platform with drilling rigs is to be used for drilling. As it is impossible to remove the over-burden completely, the over-burden drilling technique developed in Sweden or a similar technique is to be adopted as the method of drilling.

The holes are to be drilled at intervals of two (2) meters both longitudinally and transversely. And to ensure rock blasting up to -17.0m from CD, the holes are to be drilled up to -18.5m or more.

(3) Underwater Blasting

Explosives are to be placed into the borehole via the casing tube. When the prescribed number of holes have been charged with explosives, the pontoon or platform is moved 200m or more away from the blasting area. The average fragmentation of the rock after blasting is to be around 20cm.

The total quantity of explosives to be used for blasting is about 250t. A grab dredger is to be used for the dredging of the blasted rock. Dredged materials are transported and dumped at the extended alignment of the breakwaters using hopper barges.

(4) Dredging of Grit

Grit is to be dredged by a cutter suction dredger. Materials sucked up by a dredging pump are transported to the seashore area south of the southern breakwater through floating/shore pipelines.

(5) Considerations

Regarding rock drilling and blasting, the values such as a interval of holes, depth of holes, quantity of explosives and so on as mentioned above are only standard values. And the effect of blasting is affected by a various site conditions. therefore, pilot drilling and blasting should be carried out before the execution of the project. Then, these values should be finally decided upon.

Necessary steps for safety should be taken to prevent accidents and to carry out the blasting smoothly because the blasting is to be carried out for two (2) years in areas congested with vessels.

7.2.4 Location of Offshore Disposal Area

The offshore disposal areas for the capital dredging and maintenance dredging are shown in Figure-7.2.2.

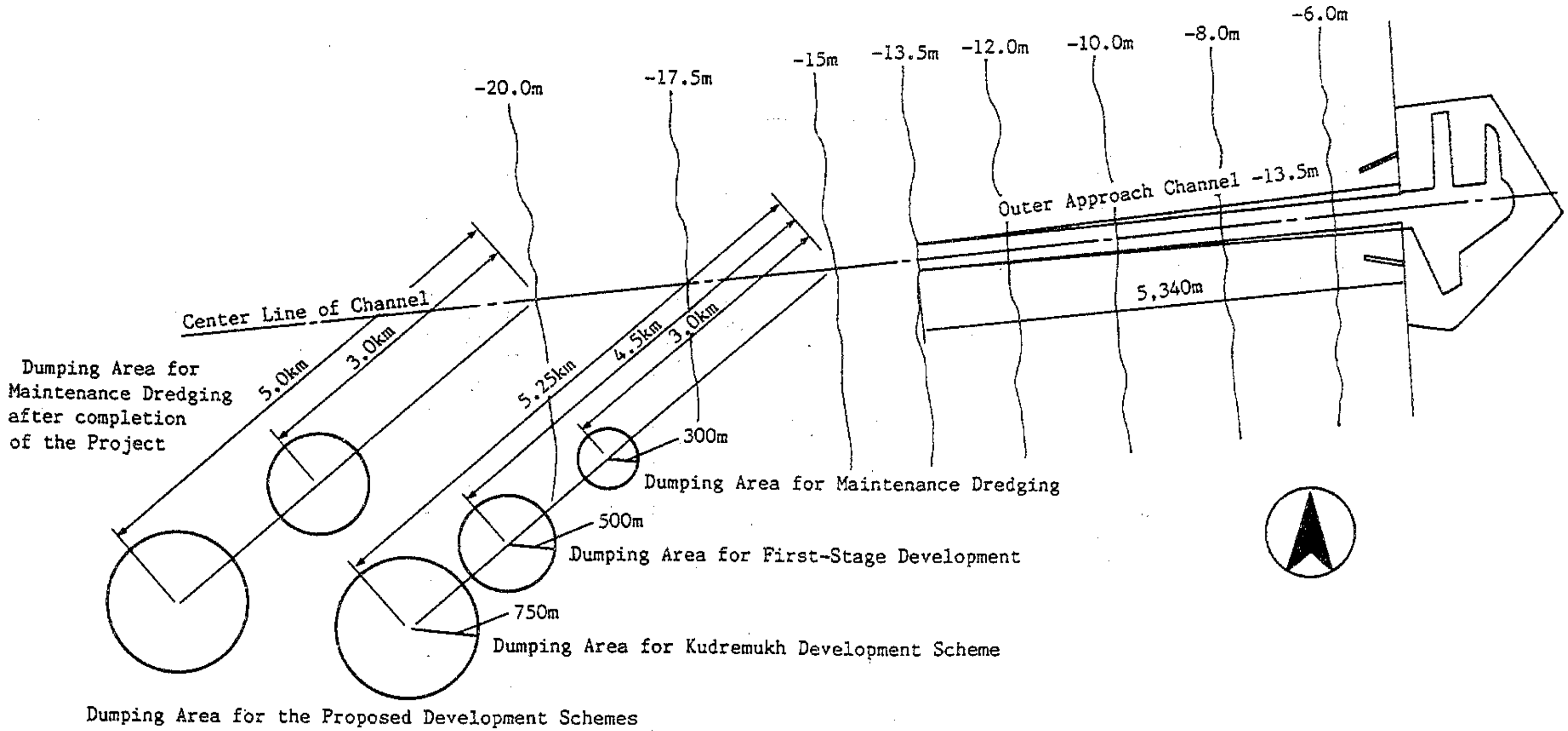


Figure-7.2.2 Location of Proposed Dumpling Areas

8. FORMULATION OF SHORT-TERM PLAN (1995)

8.1 Improvement Plan for the Iron Ore Handling Facilities

8.1.1 Vessels Size

As mentioned in Chapter 5, the maximum vessel size is 100,000 DWT. Sizes of ships calling at the berth will be distributed according to the maximum acceptable size at the berth.

The iron ore has been exported mainly to Japan, Eastern European countries and other destinations. Assuming that the shares of iron ore exports from New Mangalore Port to each of these destinations do not change, iron ore export volume in 1994-95 can be calculated as shown in Table-8.1.1.

Table-8.1.1 Iron Ore Export Volume by Destination (1994-95)

Unit: 1,000ton

Destination	Total	Concentrate	Pellets
Japan	3,400	3,400	0
Eastern Europe	2,600	500	2,000
Others	1,500	600	1,000
Total	7,500	4,500	3,000

Table-8.1.2 shows the distribution of ships for exporting 7,500,000 tonnes of iron ore. The figure for 60,000 DWT (existing) was calculated by using the same percentage as the present distribution.

Table-8.1.2 Ship Size Distribution for Short-term Plan

(No. of ships)

Ship Size (DWT)	Berth Capacity (DWT)	
	60,000 (existing)	100,000 (Improved)
0 - 20,000	10	3
20,000 - 40,000	86	19
40,000 - 60,000	59	44
60,000 - 80,000	39	34
80,000 - 100,000	0	35
AVERAGE SHIP SIZE (DWT)	43,000	65,000

8.1.2 Berth Requirement

As mentioned in Chapter 5, improvement of the existing iron ore berth up to 100,000 DWT capacity will be enough for handling iron ore of 7.5 million tonnes.

So, no other iron ore berth will be required.

In the improvement, to accommodate 100,000 DWT carriers, depth, the position of bitts (position of mooring dolphins) and width and length of the apron, as well as the strength of port structures must be examined.

(Depth)

As mentioned in Chapter 5, the depths at the berth should be -16.5m.

(Position of Bitts)

So, new mooring bitts and dolphins must be located at distances appropriate for the length of the vessel.

(Length/Width of Apron)

In the case of improvement of the existing berth for handling vessels of 100,000 DWT, the apron should be extended by 33m. However, the apron should not be widened because the existing shiploader can be used for 100,000 DWT vessels with minor modifications.

8.2 Plan for the Oil Handling Facilities

8.2.1 Vessel Size

Crude oil would come from the Persian Gulf or Bombay High. According to Oil F/S Report, tankers of 65,000/85,000 and 150,000 DWT would be suitable for crude oil exports from Bombay High and the Persian Gulf, respectively. Moreover, the report adds that 100,000/120,000 DWT would be used for crude oil exports. Therefore, tankers of 65,000, 85,000 and 100,000 DWT are expected to call at the New Mangalore Port.

The existing product jetty currently accommodates tankers of up to 35,000 DWT, as shown in Table-3.1.4. Therefore, we assume that the distribution rates will be the same as at present.

Table-8.2.1 and 8.2.2 show oil tanker size distribution.

Table-8.2.1 Crude Oil Tanker Size Distribution

Crude Tanker Size (DWT)	No. of Ship
65,000 DWT	13
85,000	10
100,000	17
Total	40
Av. Size	83,000 DWT

loading factor = 0.9

Table-8.2.2 Oil Product Tanker Size Distribution

Product Tanker Size (DWT)	Product Jetty 35,000 DWT
0 - 5,000	0
5,000 - 10,000	0
10,000 - 15,000	0
15,000 - 20,000	23
20,000 - 25,000	19
25,000 - 30,000	19
30,000 - 35,000	2
Total	63
Av. Size	28,000 DWT

8.2.2 Berth Requirement

One oil products jetty as well as one crude oil jetty is required to meet the demand of oil products and crude oil transport.

Another oil products jetty planned in the outer port area will be set aside for long-term demand.

Required depths of oil jetties are as follows:

Table-8.2.3 Required Depths for the Oil Jetties

Jetty	Vessels	Full Draught(m)	Depth (m)
Crude Jetty	Crude Tanker (100,000DWT)	16.4m	-16.5m*
Oil Product Jetty	Oil Product Tanker (35,000DWT) Crude Tanker (85,000 DWT)	10.5m 14.0m	-15.0m

* 100,000 DWT tankers can call with 90% of full load.

8.3 Plan for the Other Facilities

8.3.1 General Cargo Berth

The general cargo berths will handle 2,340,000t in 1994/95. There are seven existing or under-construction berths (including one shallow berth). Each berth should handle 360,000t per annum (shallow berth is regarded as 0.5 berth in calculation) in 1994/95 (at present 330,000t/y). Therefore, no additional general cargo berth should be constructed before 1994/95.

8.3.2 Channel

The channel should be widened and deepened as follows to accept iron ore carriers and crude oil tankers of 100,000 DWT.

Width : 275M
Depth : -16.5M (inside the breakwaters)
-17.0M (outside the breakwaters)

The channel has one-tenth slopes on the both sides.

8.3.3 Basin

The basin should be also widened and deepened as follows:

Diameter of Turning Circle : 550 M
Depth : -16.5M

8.3.4 Breakwater

Both breakwaters should be extended in almost the same alignment as that of the existing ones. The length of the breakwater is decided from the point of view of siltation, littoral sand drift, tranquility and stopping distance.

(1) Siltation

There must be a balancing point between the extension and siltation because breakwater extension requires much expenditure in expenditure in exchange for reduction of siltation, that is, reduction of maintenance dredging costs. Therefore, the optimum extension length should be decided by total costs of the extension and maintenance dredging.

Table-8.3.1, showing the total of the two costs, gives the solution: 1,500M (total length).

Table-8.3.1 Total Cost of the B/W Estimation and Maint. Dredging

Length of Breakwater (m)	500	1000	1500	2000	2500
Total Cost (crore Rs.)	129.5	107.0	104.8	105.5	108.5

(2) Littoral Sand Drift

Littoral sand drift takes place in area of depth up to -7m and fills the channel with compact sand in the case of a strong storm. Therefore, breakwater with lengths of at least 1,300m, whose points would reach depth of -7m, will be needed.

(3) Tranquillity

Tranquillity at each berth was calculated by using a numerical simulation model. This calculation results that extension up to 1,500m satisfies necessary tranquillity levels.

Table-8.3.2 Annual Effective Rates of Berths

Berth	Effective Rate (%)
Iron Ore Berth	93 (78)
Crude Oil Jetty	100 (100)
Oil Products Jetty	100 (100)
East Dock	99 (98)

( ) : effective rate during S/W monsoon (June to September)

(4) Stopping Distance

A protected and strait water area five times the length of the largest vessel and deep enough for the vessel is normally needed for stopping distance. As the largest vessel is 100,000 DWT crude oil tanker with 275m length, a stopping distance of more than 1,375m should be prepared.

The necessary length will be protected by a 1,500m- extension of the breakwater.

(5) Conclusion

Consequently, the optimum length of each breakwater should be 1,500m.

8.3.5 Improvement Plan for Aids to Navigation

As the channel will be extended to around 8km to accommodate 100,000 DWT vessels, navigation aids will be required for safety maneuvering in the long waterway.

Table-8.3.3 shows equipment required for navigation aids.

Table-8.3.3 Equipment for Navigation Aids

Type of Aids	No.of Units
1) Rader Beacon (Transponder)	2 (spare 1)
2) Loading Light	2 (spare 1)
3) Day Mark	2
4) Light Buoy	15
a) Lateral Marks	14
- Port hand marks	7
- Starboard hand marks	7
b) Safe Water Marks	1
5) Light Beacon	8
a) Breakwater	2
b) Dolphin	6 (3 X 2)
6) Synchronized Flashing	1

8.4 Short-term Plan

The following facilities are included in the Short-term Plan:

- Improvement of the Existing Iron Ore Berth to 100,000 DWT Class
- Reconstruction of the Existing Oil Product Jetty to a Crude Oil Jetty of 100,000 DWT Class
- Construction of an Oil Products Jetty of 85,000 DWT Class
- Deepening and widening of the Channel
  - Depth : -16.5m (protected area)
  - -17.0m (un-protected area)
  - Width : 275m
- Deepening and Widening of the Basin
  - Depth : -16.5m
  - Turning Basin : Diameter 550m
- Extension of the Southern and Northern Breakwaters up to 1,500m

Figure-8.4.1 depicts the Layout of the Short-term Plan.

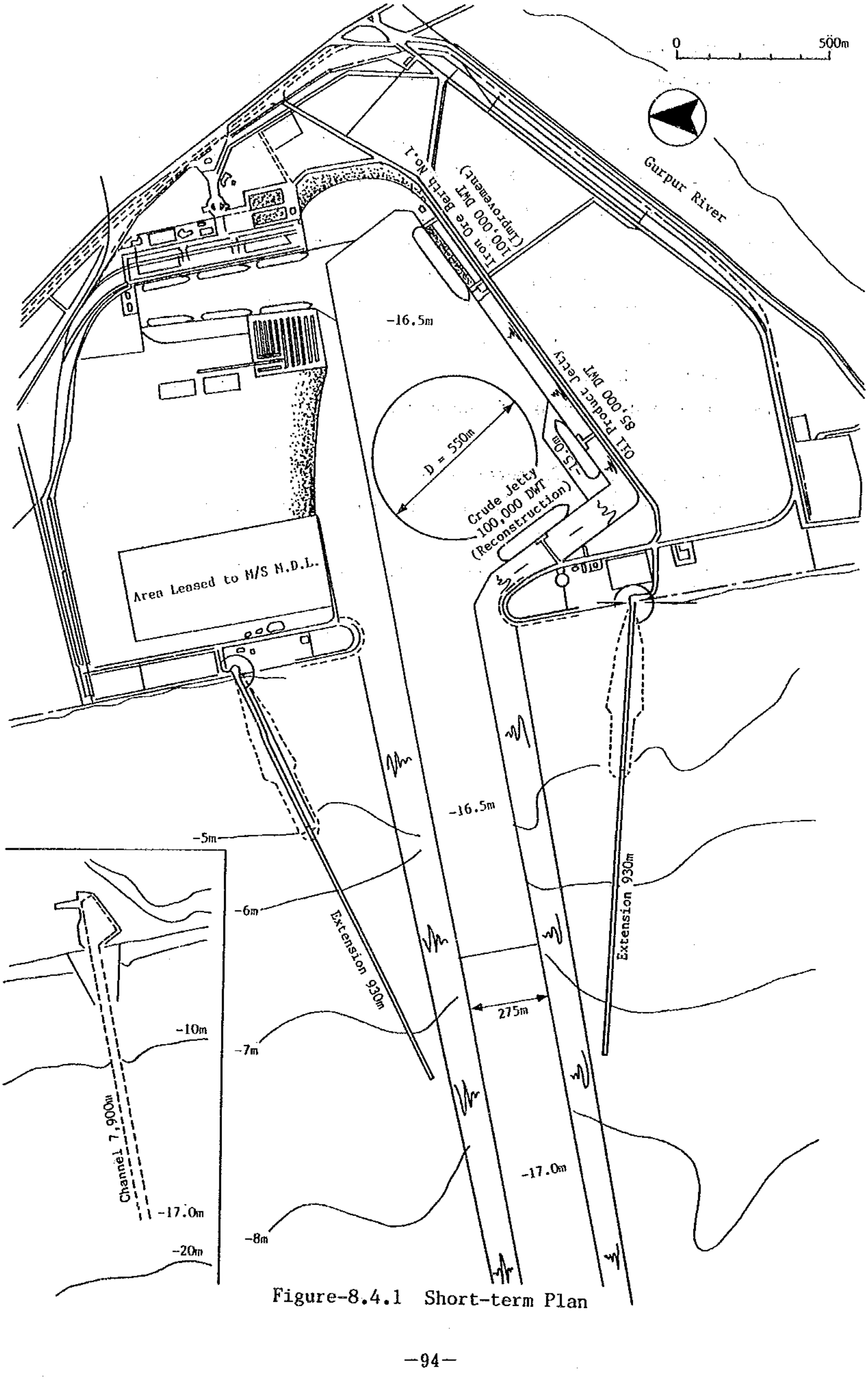


Figure-8.4.1 Short-term Plan

9. PRELIMINARY DESIGN FOR EACH ALTERNATIVE SHORT-TERM PLAN

9.1 The Iron Ore Handling Facility

9.1.1 Improvement Plan of Existing Iron Ore Berth

The present iron ore berth with its associated handling system was originally designed for 60,000 DWT ships to load iron ore concentrate.

The berth shall be improved in order to receive 100,000 DWT class ships.

For dealing with ships bigger than 60,000 DWT, two schemes are considered.

- Warping of the vessel during loading,
- Extending the berth to accommodate the extra distance traveled by the shiploader.

Considering the maneuvering difficulties of vessels for a long term in the future, the second scheme is to be recommended.

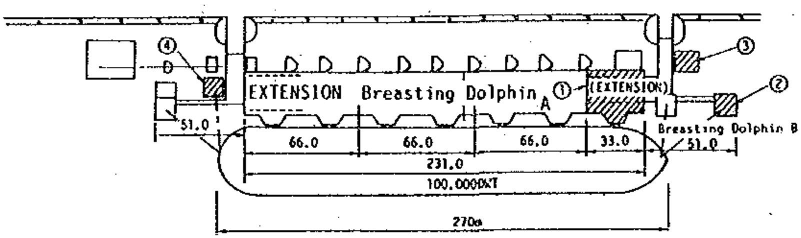


Figure-9.1.1 Augmentation Plan of the Iron Ore Berth

Figure-9.1.1 shows the sketch of the augmentation plan. The scheme mainly consists of the following.

1 Constructing a new breasting dolphin 33m in length
2 Constructing 2 mooring dolphins.
3 Constructing a new drive house for the conveyer
4 Protecting the existing soil level below the berth

9.1.2 Design of Iron Ore Berth Augmentation

The structural type of the facilities to be extended shall be determined considering various factors including natural conditions, construction period and availability of the construction material.

The conditions to be considered include the following:

- Marinal condition
- Meteorological condition
- Soil condition
- Earthquake
- Construction period

Design Details are shown in Figure-9.1.2 - 9.1.4, and the items to be augmanted are shown in Table-9.1.1.

Table-9.1.1 Item to be Augmented for 100,000 DWT

Item	Nos	Piles	Slab	Note
1. Two Mooring Dolphins	2	∅ 1,220 x 32	As per DWG	. All pile length shall be L = 28.0 meters
2. Breasting Dolphin	1	∅ 1,220 x 26	As per DWG	
3. Drive House	1	∅ 1,000 x 4	1.0m "	
4. Walk Way	1	∅ 910 x 8	0.6 "	
5. Sheet Pile	1-Lot	Type IV. = 10m		
6. Rubber Fender	7	suc-2000H		

S=1/2,000

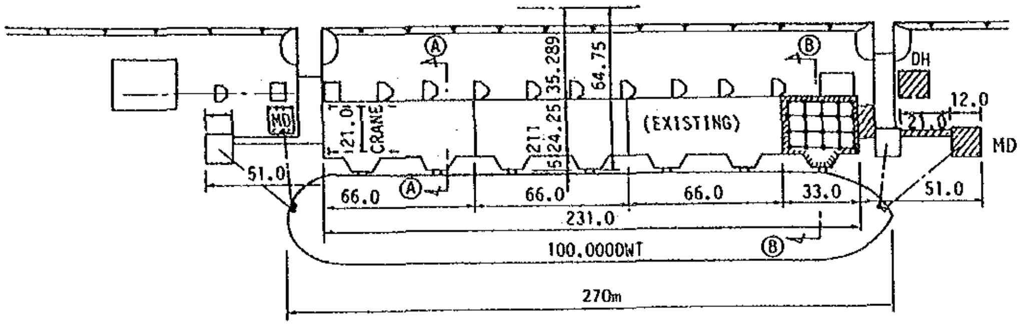


Figure-9.1.2 Lay-out Plan of 100,000 DWT Iron Ore Berth

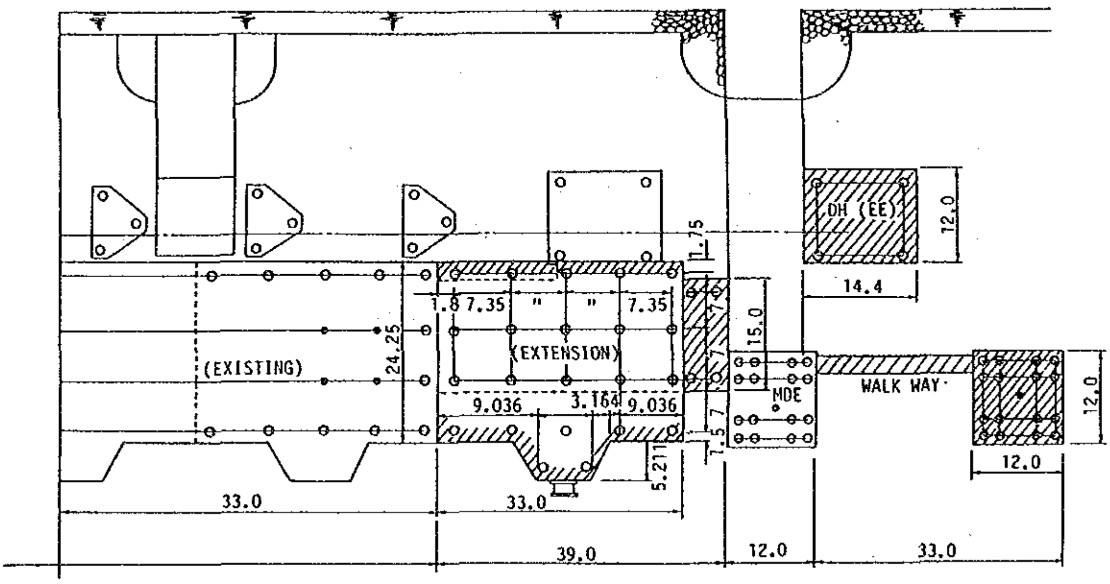


Figure-9.1.3 Detailed Plan of 100,000 DWT Iron Ore Berth

S=1/400

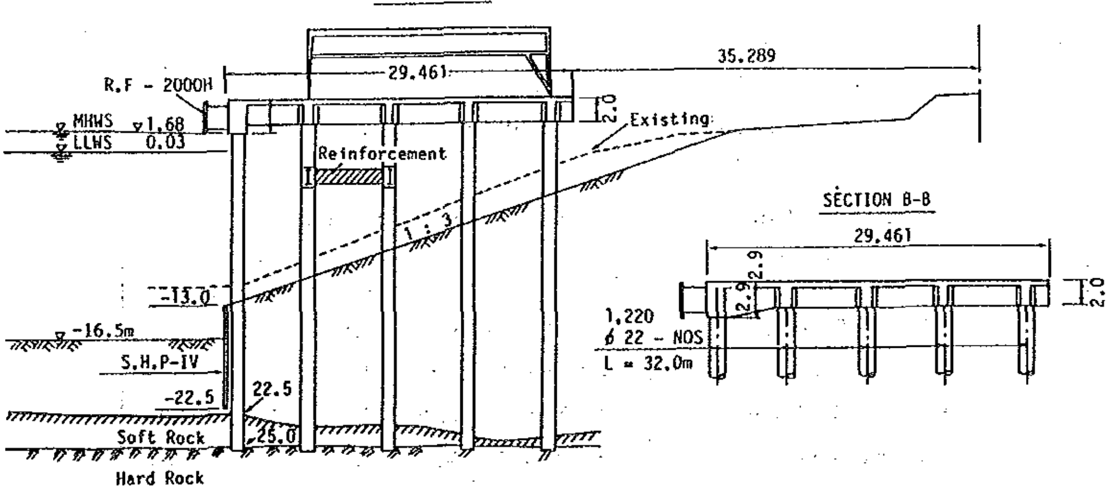


Figure-9.1.4 Typical Section of 100,000 DWT Berth

9.2 The Product and Crude Oil Jetties

9.2.1 Crude Berth

The crude oil berth will be created by extending/strengthening the existing oil jetty of 35,000 DWT capacity.

The maximum extent of improvement of the berth shall be designed to cater for vessels of 100,000 DWT, which is incidentally much bigger than the oil tankers of 35,000 DWT which mainly use the jetty . This will enable the berth also to receive product vessels whenever the main product berth is either over burdened or out of commission. A plan illustrating this proposal is shown in Figure-9.2.1 and the structures are listed up in Table-9.2.1.

Table-9.2.1 List up the Structure

Item	Piles	Slab	Note
1. Two B. Dolphins	ø 1,200 x 50	1.5m thick	
2. Six M. Dolphins	ø 600 x 144	1.0m "	
3. One Platform	ø 800 x 27	0.6m "	
4. One Approach Jetty	ø 800 x 27	As Per DWG	
5. Walk Way	ø 800 x 32	"	
6. Rub. Fenders.	ø 1,300 x 4	– "	

9.2.2 Product Berth

1) New 85,000 DWT

New 85,000 DWT Oil Product Jetty was planned at the southern part of the basin.

The layout of the berth is also shown in the general layout. Facilities enabling them to meet present-day and future requirements of crude/product handling shall be provided.

The structures are listed up in Table-9.2.2.

Table-9.2.2 List up the Sturcture

Item	Piles	Slab	Note
1. Two B. Dolphins	ø 1,200 x 50	1.5m thick	
2. One Platform	ø 800 x 12	0.6m "	
3. Two M. Dolphins	ø 600 x 48	1.0m "	Pile length
4. One Approach Jetty	ø 800 x 27	As Per DWG	to be 33.0m
5. Walk Way	ø 800 x 24	" "	
6. Rub. Fenders.	ø 1,700 x 4	– "	

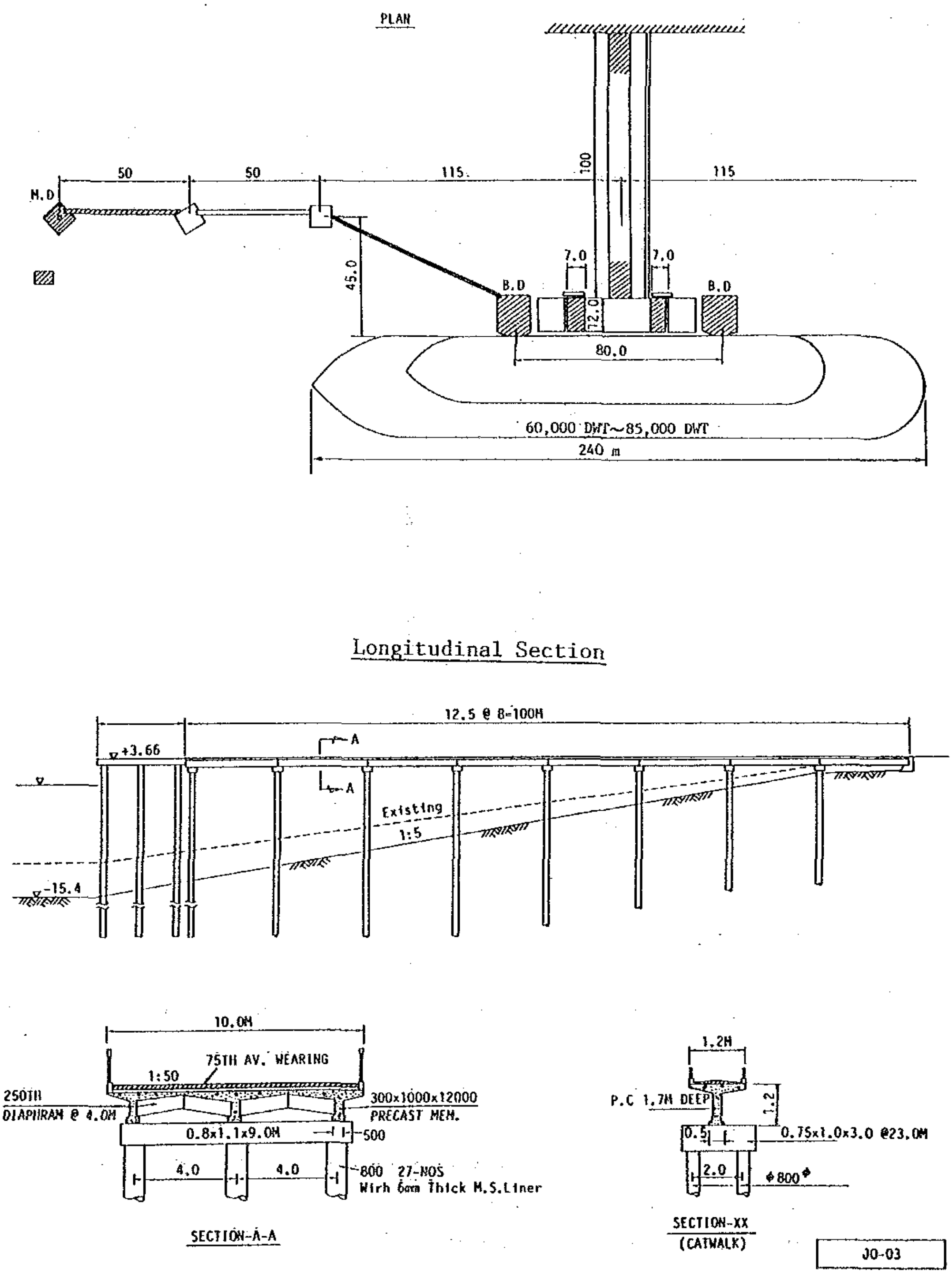


Figure-9.2.1 Upgrading the Existing Oil Berth up to 100,000 DWT Ships

9.3 The Breakwater

9.3.1 General

According to the Master Plan, several layout plans are suggested but they are forcussed in a plan for the breakwater arrangement.

Figure-9.3.1 shows the breakwater arrangement of the inner port type. Both north and south breakwaters are extended 930m in length and at their extremity the water depth becomes -7.5m.

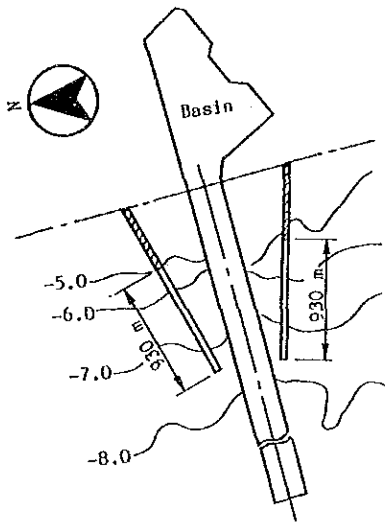


Figure-9.3.1 Breakwater Arrangement (1)

9.3.2 Stability of Breakwaters

Study Cases

The calculation of the circular failure are examined for the following three cases.

a) Breakwater section at -5.5m contour

b) Breakwater section at -8.0m contour

c) Existing south breakwater area where dredging works are expected at the level of -19.0m for outer port plan.

Figure-9.3.2 shows one of the results of circular Failure analysis.

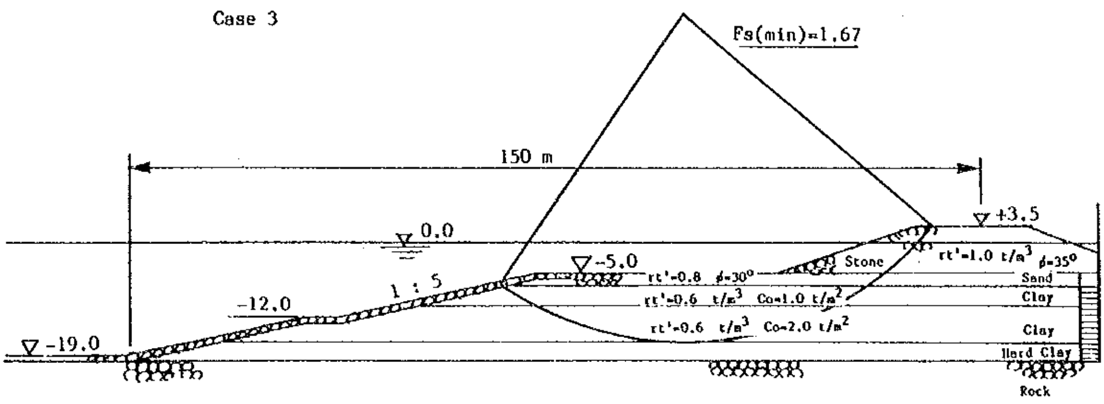
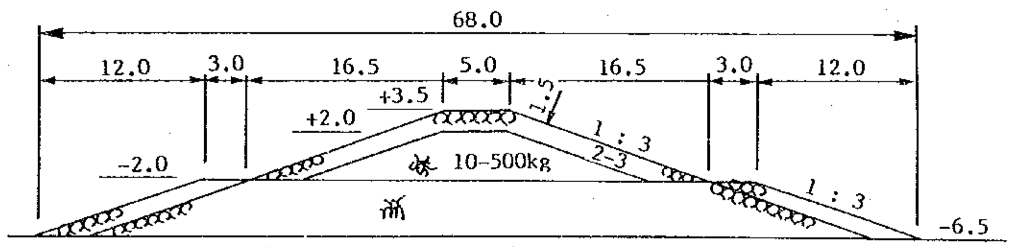


Figure-9.3.2 Circular Failure Analysis at existing breakwater areas

9.3.4 Standard Sections of Breakwaters

Standard Sections of Breakwater are shown Figure-9.3.3.



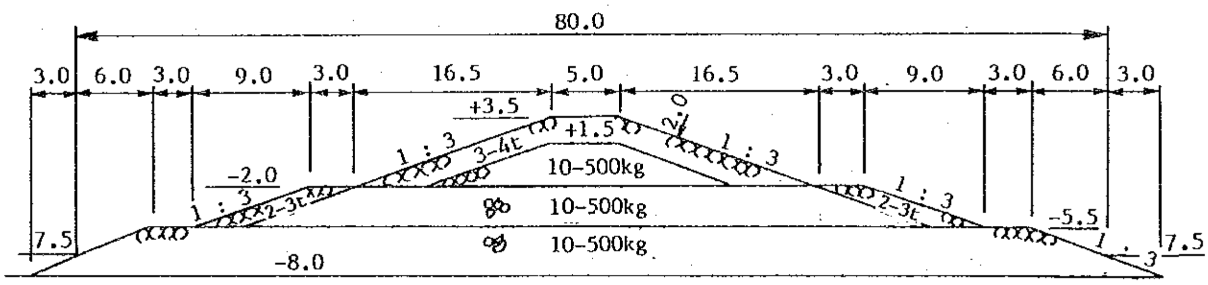


Figure-9.3.3 Standard Section of Breakwater

9.4 The Iron Ore Handling Equipments

9.4.1 Introduction

The handling equipments for the iron ore handling facility to be designed in this report are the shiploader, conveyer, stockpile for concentrate and pellet, shed for concentrate stockpile and reclaimers for concentrate and pellet.

9.4.2 Shiploader

(1) Loading rate

It was concluded in Chapter 5 that capacity upgrading of conveyors and berth upgrading to at least 100,000 DWT class ships is required to handle annual throughput of 7.5 million tons (pellet ratio = 0.4). Therefore, the ore shiploading capacity will be examined as follows:

Table-9.4.1 Shiploading Capacity

System Capacity t/h		Modification
Present	6,000/3,500*	
Future (7.5 Million t)		Capacity Upgrading of Outgoing Conveyor Cross Conveyor Wharf Conveyor

* The shiploading capacity of each Concentrate/Pellet.

(2) Conclusion

The following modifications or additions will be required for the existing shiploader to be able to handle 100,000 DWT class ships:

a) Boom chute modification

b) Extension of travelling rail

c) Replacement of cables for travelling

d) Replacement of cable drums, etc.

9.4.3 Conveyor System

The conveyor capacity must exceed the required shiploading capacity, as shown in Table-9.4.1. The required in capacity and conveyor length extension are shown in Table-9.4.3.

9.4.4 Reclaimer

The existing two bridge girder type reclaimers for concentrate and one boom rotating type reclaimer will be capable for this plan.

9.4.5 Stockpile

It is calculated that the existing stockyard capacity is not enough for both concentrate and pellet to handle the planning annual throughput. Therefore, the extension of the stockyard for both concentrate and pellet is recommended as shown on Table-9.4.2.

Table-9.4.2 Recommended Stockyard Capacity

unit:10,000tons

		1989-90	1994-95
Annual Throughput		500	750
Concentrate	Yard Capacity	2 x 20	2 x 30
	Yard Length (m)	370	555
Pellet	Yard Capacity	15	20
	Yard Length (m)	370	490

9.4.6 Modification Layout

For 100,000 DWT class ship, each piece of shiploading equipment shall be modified as listed in Table-9.4.3, and the layout is shown on Figure-9.4.1.

Table-9.4.3 Modification List

Equipment		Modification
Shiploader		Chute modification
		Cable Drum modification
		Cable for travelling replacement
		Extension of travelling rail
		Boom conveyor speed up
Conveyors	Incoming concent.	Extension Length
	Outgoing concent.	Extension Length and Capacity up
	Cross	Capacity up
	Wharf	Capacity up and Extension Length
	Drive Unit Tower	Shift
	Incoming Pellet	Extension length
	Out going Pellet	Extension Length
Stockyard	Concentrate	Extension Yard and Shed
	Pellet	Extension Yard

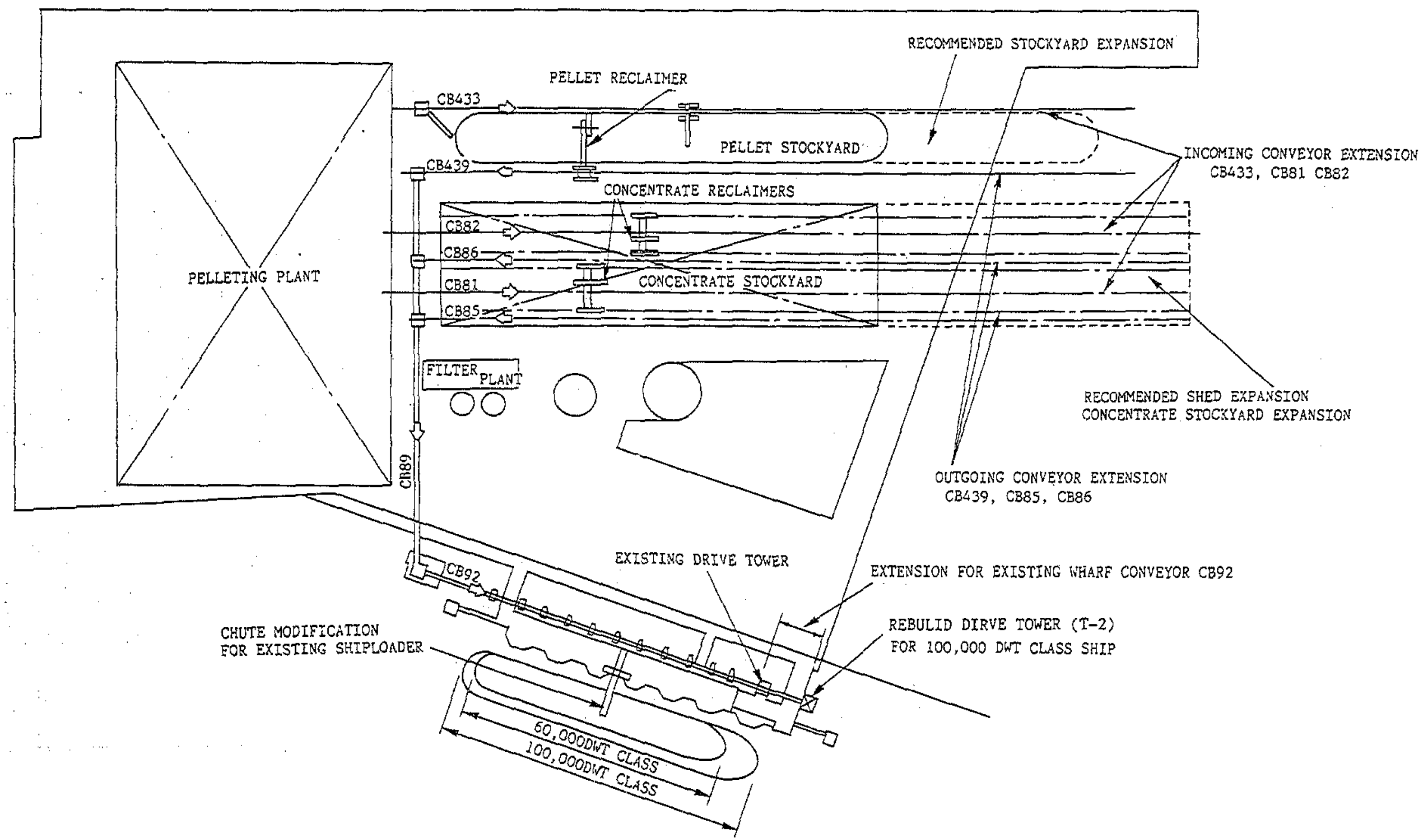


Figure-9.4.1 Modification Plan for Shiploading System

10. IMPLEMENTATION PROGRAMME FOR THE SHORT-TERM PLAN

10.1 Working principles

The following must be taken into account for the implementation programme:

a. The current port operations, including ship maneuvering, cargo handling, etc., should not be interfered with.

b. Capital dredging procedure should be taken in order to delay the time when an annual siltation volume is increased.

c. Efficient and economical method to dredge hard rock.

In order to meet the above demand it is necessary to make appropriate plans for both in the planning phase and design phases.

10.2 Major facilities and construction works

Major facilities and construction works are listed below:

Iron Ore Berth for 100,000DWT (Improvement)	Breasting dolphin A	33.0m x 29.5m x 1span
	Breasting Dolphin B	33.0m x 29.5m x 6span (reinforcement)
	Mooring Dolphin	12.0m x 12.0m x 2units
	Driving House	12.0m x 14.4m(base)
Crude Oil Jetty for 100,000DWT	Breasting Dolphin	15.0m x 14.25mx 2units
	Mooring Dolphin	8.6m x 8.6m x 2units
	Platform	70.0m x 12.0m x 2units
	Approach Jetty	100m x 10m x 1units
Oil Products Jetty for 85,000DWT	Breasting Dolphin	15.0m x 14.25mx 2units
	Mooring Dolphin	8.6m x 8.6m x 6units
	Platform	39m x 12m x 1units
	Approach Jetty	100m x 10m x 1units
Breakwaters	South-breakwaters	930m
	North-breakwaters	930m

10.3 Construction Materials

It is assumed that there will be no shortage in the supply of stones and sand in Mangalore district. Cement, reinforcement-bars and wood are also available locally. It is assumed that large-sized steel pipe piles, sheet piles and large rubber fenders must be imported.

10.4 Outline of Construction

In improving the iron ore berth, the crude and oil products berths works should be carried out offshore by constructing ther concrete decks on the cast-in-situ concrete piles with steel liner pipes.

In the case of the augmentation of the existing iron ore berth, the augmentation works could be carried out independently of the existing berth operation. But some pile-driving works will interrupt normal loading operations.

The total length of time in which loading operations will be suspended will be about three (3) weeks or so, even though adjusting the civil construction and the mechanical erection works or using fully the idle time or night time for works.

Breakwaters are supposed to be the stone-filled type, considering materials' availability, cost, and ease of construction. At first, part of the existing breakwaters is to be raised in dry work to pass the road to the site of breakwaters for extension. We assume the section of the breakwaters above -2.0m shall be constructed in dry work. For construction of the part under -2.0m level, we shall use stone carrier vessels, tug-boats, diver-boats, etc. Careful attention must be paid so that circular slides do not occur in the soft sea bed section.

The methods of dredging and rock blasting is described in "Clause 7.4".

10.5 Construction Schedule

To meet the demand for iron ore in 1994/95, improvement of the Iron ore berth is to be started in 1990/91. Principal construction works are to be carried out based on the following schedule:

Table-10.5.1 Construction Schedule

Item		1990/91	1991/92	1992/93	1993/94	1994/95
Survey/Consultant Work		—	—	—		
Iron Ore Berth	100,000 DWT				—	
Product Oil Berth	85,000 DWT			—		
Crude Oil Berth	100,000 DWT				—	
Southern Breakwater	930 m		—	—	—	
Northern Breakwater	930 m		—	—	—	
Dredging	Channel			—	—	
	Lagoon		—			
Rock Blasting			—	—		
Handling Equipment	Shiploader				—	
	Conveyor				—	
	Stock Shed			—	—	

11. ROUGH COST ESTIMATION FOR THE SHORT-TERM PLAN

11.1 General

In this chapter the approximate construction cost is estimated for the short-term Plan suggested in Chapter 8. The estimates have been prepared based on current market prices and the cost of similar works carried out in recent years at New Mangalore Port and its vicinity. The estimates include a local sales tax, but they don't include an import tax and other taxes related to the project. Large steel pipe piles more than 1.0m in diameter and large rubber fenders cannot be manufactured locally, so they are to be accounted as foreign currency expenditures.

11.2 The Iron Ore Handling Facility

According to the Figures in "Chapter 9" the quantity of each facility is roughly calculated, and using unit prices and costs, the cost of the construction work is determined. The result of the Iron Ore Berth for 100,000 DWT vessels is shown in Table-11.2.1.

Table-11.2.1 Iron Ore Berth for 100,000 DWT Carrier

Description	Q'ty	Unit	Unit cost (Rupees)	Amount (Lakhs)	For. C (Lakhs)	Note
Breasting Dolphin A	6	nos	1,293,500	77.61	72.55	reinforcement only
sheet pile (IV)	833	sheets	8,157	67.95	63.77	
brace(Ibeam)	30	nos	32,200	9.66	8.78	
Breasting Dolphin B	779	sq'm	12,512	97.47	28.58	1nos
pile (1220 ϕ)	26	nos	221,780	57.66	17.18	
deck	779	sq'm	3,570	27.81	-	
rubber fender (2000H)	1	nos	1,200,000	12.00	11.40	
Mooring Dolphin	288	sq'm	29,479	84.9	21.14	2nos
pile (1220 ϕ)	32	nos	224,063	71.70	21.14	
deck	288	sq'm	3,540	10.20	-	
bollard(200t)	2	nos	150,000	3.00	-	
Driving House	162.4	sq'm	10,603	17.22	2.16	1nos
pile (1000 ϕ)	4	nos	174,000	6.96	2.16	
deck	172.8	sq'm	3,540	6.12	-	
house building	162.4	sq'm	2,550	4.14	-	
Walk Way	42	sq'm	12,905	5.42	1.48	21m length x 2m wide
pile (910 ϕ)	3	nos	159,330	4.78	1.48	
deck	42	sq'm	1,520	0.64	-	
Rubber Fender(2000H) replace	6	nos	1,200,000	72.00	68.4	replace
Total				354.62	194.31	

11.3 Oil Handling Facilities

To meet the demand for oil handling cargo volume, one (1) crude oil berth for 100,000 DWT tankers and one (1) oil products berth for 85,000 DWT tankers are to be constructed. According to the Figures in "Chapter 9", the cost can be estimated.

The results are shown in Table-11.3.1 for the oil products berth and in Table-11.3.2 for the crude oil berth. The foreign currency portions for the oil products berth and the crude oil berth are 25.3% and 27.1%, respectively. These costs do not include navigation/berthing aids, fire-fighting facilities, anti-pollution facilities and loading/unloading equipment.

Table-11.3.1 Oil Products Berth for 85,000 DWT Tankers

Description	Q'ty	Unit	Unit cost (Rupees)	Amount (Lakhs)	For. C (Lakhs)	Note
Breasting Dolphin	426	sq'm	37,700	160.6	55.1	2nos
pile (1200 ϕ)	50	nos	197,600	98.8	16.3	
deck	426	sq'm	3,582	15.3		
bollard(150t)	2	nos	125,000	2.5		
rubber fender (1300H)	4	nos	1,020,000	40.8	38.8	
miscellaneous	2%			3.2		
Mooring Dolphin	444	sq'm	59,410	263.8	57.6	6nos
pile (600 ϕ)	144	nos	162,080	233.4	57.6	
deck	444	sq'm	3,650	16.2		
bollard(200t)	6	nos	150,000	9.0		
miscellaneous	2%			5.2		
Platform	468	sq'm	9,145	42.8	9.7	1nos 39.0mx12.0m
pile (800 ϕ)	27	nos	118,340	32.0	9.7	
deck	468	sq'm	2,140	10.0		
miscelaneous	2%			0.8		
Approach Jetty	1,000	sq'm	5,450	54.5	9.8	100m length
pile (800 ϕ)	27	nos	118,340	32.0	9.8	
deck	1,000	sq'm	2,140	21.4		
miscellaneous	2%			1.1		
Walk Way	437	sq'm	10,660	46.6	11.6	364m length
pile (800 ϕ)	32	nos	118,340	37.9	11.6	
deck	437	sq'm	1,780	7.8		
miscellaneous	2%			0.9		
Total				568.3	143.8	

Table-11.3.2 Crude Oil Berth for 100,000 DWT Tankers

Description	Q'ty	Unit	Unit cost (Rupees)	Amount (Lakhs)	For. C (Lakhs)	Note
Breasting Dolphin	426	sq'm	41,033	174.8	58.4	2nos
pile (1200 ϕ)	50	nos	197,600	98.8	16.3	
deck	426	sq'm	3,582	15.3		
bollard(200t)	2	nos	150,000	3.0		
rubber fender (1700H)	4	nos	1,170,000	44.3	42.1	
dismantling work	1			10.0		
miscellaneous	2%			3.4		
Mooring Dolphin	148	sq'm	59,390	87.9	19.2	2nos
pile (600 ϕ)	48	nos	162,080	77.8	19.2	
deck	148	sq'm	3,650	5.4		
bollard(200t)	2	nos	150,000	3.0		
miscellaneous	2%			1.7		
Platform	168	sq'm	10,830	18.2	4.3	1nos
pile (800 ϕ)	12	nos	118,340	14.2	4.3	
deck	168	sq'm	2,140	3.6		
miscellaneous	2%			0.4		
Approach Jetty	1,000	sq'm	5,450	54.5	9.8	100m length
pile (800 ϕ)	27	nos	118,340	32.0	9.8	
deck	1,000	sq'm	2,140	21.4		
miscellaneous	2%			1.1		
Walk Way	312	sq'm	4,936	34.7	8.7	260m length
pile (800 ϕ)	24	nos	118,340	28.4	8.7	
deck	312	sq'm	1,780	5.6		
miscellaneous	2%			0.7		
Total				370.1	100.4	

11.4 Breakwaters

The cost of the Breakwaters is estimated based on the amount of materials and their prices. The results are shown in Table-11.4.1.

Table-11.4.1 Breakwater

Description	Q'ty	Unit	Unit cost (Rupees)	Amount (Lakhs)	For.C (Lakhs)	Note
Raising Existing Breakwater	840	m	9,720	81.6		crown height+3.5
South-Breakwater	930	m	104.600	972.8		"
North-Breakwater	930	m	107,690	1,001.5		"
Total				2,055.9		

11.5 The Navigation channel and the Basin

Unit costs are estimated as follows:

Capital dredging		
Hard rock	:	1,570 (Rs./m3)
Soft rock	:	525 (Rs./m3)
Soil in the Lagoon	:	60 (Rs./m3)
Soil in the channel	:	22 (Rs./m3)
Maintenance dredging		
At present	:	15 (Rs./m3)
In future	:	14 (Rs./m3)

Total cost and the breakdown of capital dredging are shown in Table-11.5.1 with the following notes attached:

Notes

- .The blasting and the dredging of hard and soft rock are to be carried out by foreign contractors.
- .The dredging of soil in the lagoon is to be carried out by both foreign contractors and domestic contractors.
- .The dredging of soil in the channel is to be carried out by domestic contractors.

The total cost and the breakdown of maintenance dredging are shown in Table-11.5.2.

Table-11.5.1 Cost of Capital Dredging

	Quantity (m3)	Unit Cost (Rs./m3)	Total Cost (Rs.)	Foreign Currency (Rs.)	Local Currency		
					Materials/ Equipment (Rs.)	Skilled Labor (Rs.)	Unskilled Labor (Rs.)
Soil (C)	340,000	56	19,100,000	5,973,474	7,139,526	5,987,000	0
Soil (C)	8,990,000	21	190,600,000	57,180,000	76,240,000	57,180,000	0
Sub Total	9,330,000		209,700,000				
Soil (L)	1,000,000	77	77,300,000	59,339,300	16,612,600	1,070,900	277,200
Soil (L)	1,170,000	84	97,800,000	30,689,780	36,345,451	30,764,768	0
Soil (L)	30,000	168	5,100,000	831,300	1,147,500	3,121,200	0
Soil (L)	1,710,000	32	54,400,000	16,320,000	21,760,000	16,320,000	0
Sub Total	3,910,000		234,600,000				
Rock	116,100	1,570	182,300,000	158,820,874	20,746,073	2,733,053	0
Rock (W)	20,000	540	10,800,000	8,905,344	1,755,998	138,658	0
Grit	47,600	520	24,800,000	20,152,245	4,308,993	325,546	13,215
Total			662,200,000	358,212,317	186,056,141	117,641,127	290,415

Table-11.5.2 Cost of Maintenance Dredging

	Quantity (m3)	Unit Cost (Rs./m3)	Total Cost (Rs.)	Foreign Currency (Rs.)	Local Currency		
					Materials/ Equipment (Rs.)	Skilled Labor (Rs.)	Unskilled Labor (Rs.)
			(Maintenance	Dredging (P))			
Soil (C)	2,000,000	14	27,800,000	8,340,000	11,120,000	8,340,000	0
Soil (L)	1,000,000	17	17,200,000	5,160,000	6,880,000	5,160,000	0
Total			45,000,000	13,500,000	18,000,000	13,500,000	0
			(Maintenance	Dredging (B))			
Soil (C)	540,000	35	19,100,000	5,996,806	7,222,390	5,880,804	0
Soil (C)	4,790,000	14	66,600,000	19,980,000	26,640,000	19,980,000	0
Soil (L)	1,500,000	17	25,800,000	7,740,000	10,320,000	7,740,000	0
Total			111,500,000	33,716,806	44,182,390	33,600,804	0
			(Maintenance	Dredging (A1))			
Soil (C)	3,780,000	13	50,700,000	15,210,000	20,280,000	15,210,000	0
Soil (L)	420,000	18	7,400,000	2,220,000	2,960,000	2,220,000	0
Total			58,100,000	17,430,000	23,240,000	17,430,000	0
			(Maintenance	Dredging (A2))			
Soil (C)	4,840,000	13	64,900,000	19,470,000	25,960,000	19,470,000	0
Soil (L)	430,000	18	7,600,000	2,280,000	3,040,000	2,280,000	0
Total			72,500,000	21,750,000	29,000,000	21,750,000	0

11.6 Iron Ore Handling Equipment

The cost of improvements to handling equipment are presented in Table-11.6.1.

Table-11.6.1 Improvement of Handling Facilities

crone.

Shiploader Modification	29
Conveyor	865
Stockpile Shed	985
Total Japanese Yen (Crore Rs.)	1987(21.62)

11.7 Total

Total capital costs for the Short-term Plan are shown in Table-11.7.1 and the annual investment schedule is shown in Table-11.7.2.

Table-11.7.1 Total Construction Cost

Item		Total Cost (Rs.)	Foreign Currency (Rs.)	Local Currency		
				Materials/ Equipment (Rs.)	Skilled Labor (Rs.)	Unskilled Labor (Rs.)
Survey/Consultant		7,380,000	7,380,000	0	0	0
Iron Ore Berth		35,462,000	19,431,000	12,983,000	1,288,000	1,760,000
Product Oil Berth		56,830,000	14,370,000	34,392,000	3,397,000	4,671,000
Crude Oil Berth		37,010,000	10,040,000	21,845,000	2,158,000	2,967,000
Breakwaters	Southern	101,360,000	0	96,333,000	2,513,500	2,513,500
	Northern	104,231,000	0	99,060,000	2,585,500	2,585,500
Dredging	Channel	209,700,000	63,153,500	83,379,500	63,167,000	0
	Lagoon	234,600,000	107,180,400	75,865,500	51,276,900	277,200
	Soft Rock	35,600,000	29,057,600	6,065,000	464,200	13,200
	Hard Rock	182,300,000	158,820,900	20,746,100	2,733,000	0
Contingency	5 %	50,224,000				
T o t a l (A)		1,054,697,000	409,433,400	450,669,100	129,583,100	14,787,400
Handling Equipment	Shiploader	3,338,000	1,266,000	921,000	1,151,000	0
	Conveyor	99,540,000	42,578,000	35,098,000	11,507,000	10,357,000
	Stock Shed	113,348,000	0	73,072,000	16,110,000	24,166,000
Contingency	5 %	10,811,000				
T o t a l (B)		1,281,734,000	453,277,400	559,760,100	158,351,100	49,310,400

Table-11.7.2 Annual Investment Schedule

(Unit: Million Rs.)

Item		1990 / 91		1991 / 92		1992 /93		1993 / 94	
		Foreign	Local	Foreign	Local	Foreign	Local	Foreign	Local
Survey/Consultant		2.06		1.7		3.62			
Iron Ore Berth								19.43	16.03
Product Oil Berth						14.37	42.46		
Crude Oil Berth								10.04	26.97
Breakwaters	Southern				28.40		48.64		24.32
	Northern				29.12		50.08		25.04
Dredging	Channel					21.05	48.85	42.10	97.70
	Lagoon			107.18	127.42				
	Soft Rock			29.06	6.54				
	Hard Rock			52.94	7.83	105.88	15.65		
Navigation Aids								31.80	
Tug Boats								41.43	
Contingency	5 %	0.10		9.54	9.97	7.25	10.28	7.24	9.50
T o t a l (A)		2.16		200.42	209.27	152.17	215.96	152.04	199.56
Handling Equipment	Shiploader							1.27	2.07
	Conveyor							42.58	56.96
	Stock Shed						56.67	0.00	56.67
Contingency	5 %					0.00	2.83	2.19	5.79
T o t a l (B)						152.17	275.47	198.08	321.05

Total (B): Including Handling Equipment

12. ECONOMIC ANALYSIS

12.1 Purpose and Methodology of the Economic Analysis

The purpose of economic analysis is to appraise the economic feasibility of the Short-term Plan of New Mangalore Port.

The economic evaluation of a project should show whether the project is justifiable from the economic point of view by assessing its contribution to the national economy.

Thus, the basic 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 exceed those which could be derived from other investment opportunities in India (the opportunity cost of Capital).

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

12.2 Prerequisites of the Economic Analysis

12.2.1 "With" Case

The major projects of this study are the improvement of the iron ore berth and the oil jetty and extension of the breakwater. We have selected four cases as "With" cases from combinations among the iron ore and oil berths and the breakwater as follows:

Case	Iron Ore Berth	Break Water		Oil Berth	
Case 1	100,000 DWT	North	930 m	Crude Oil	100,000 DWT
		South	930 m	Product Oil	85,000 DWT
	(Improvement of existing berth)				
Case 2	100,000 DWT	North	930 m	Crude Oil	100,000 DWT
		South	930 m	Product Oil	85,000 DWT
	(Breasting Dolphin 231m)				
Case 3	150,000 DWT	North	1,430 m	Crude Oil	150,000 DWT (Outer area)
		South	2,270 m	Product Oil	35,000 DWT
	(Breasting Dolphin 264m)				
Case 4	150,000 DWT	North	1,430 m	Crude Oil	150,000 DWT
		South	2,270 m	Product Oil	35,000 DWT

12.2.2 "Without" Case

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

(1) It is assumed that 7,500 thousand tonnes of iron ore can be handled in 1994/95 by improvement of the present mechanical equipment even at the "without" case.

(2) It is assumed that as for oil berths, one additional small jetty that can accommodate up to 35,000 DWT tankers will be constructed in the "without" case instead of the above "with" case.
The construction cost of two small jetties is estimated as 62.7 million rupees.

12.2.3 Base Year (the starting year of the economic evaluation)

The year of 1990

12.2.4 Project Life

The economic cost/benefit evaluation is carried out starting in 1990/91 and ending 2019/20 (the 30th year from the engineering service starting year, 1990/91)

12.2.5 Foreign Currency Exchange Rate

US $ 1 = Rs 16.75

12.3 Benefit

12.3.1 Benefit Items

As benefits brought about by the improvement of New Mangalore Port, the following items are identified in this report:

1 Savings in ships' staying costs.
2 Savings in freight costs.
3 Savings in time costs.

The following tables show the calculation results of above benefits.

(1) Calcutlation of saving in ship's staying costs

Item	Different of Staying between "With" and "Without" case (days)	Ship cost (US$/ship day)	Share of benefits accruing to India (%)	Exchange Rate (US$1=)	Saving in ships' staying cost (million Rs.)
Iron Ore	261.5	15,230	60	Rs. 16.75	40.0
Oil	497.3	17,530			87.6

(2) Savings on Freight Cost

Freight Cost (US$/ton)		Cargo Volume (1,000 tonnes)				Saving in freight cost (million Rs.)
		Without case		With case		
India-Japan	India-other countries	India-Japan	India-other countries	India-Japan	India-other countries	
Iron Ore		3,000	4,500	3,000	4,500	104.7

Freight Cost (US$/ton)		Cargo Volume (1,000 tonnes)				Saving in freight cost (million Rs.)
		Without case		With case		
Mangalore-Middle East	Mangalore-Bombey	Mangalore-Middle East	Mangalore-Bombey	Mangalore-Middle East	Mangalore-Bombey	
Oil		1,500	1,500	1,500	1,500	127.9

Saving in freight cost shows the total of the result calculated by ship size. We assume that the share of benefits accruing to India is 60% of the above savings on freight cost.

(3) Savings on Time Costs

	Average Parcel Size (Tons/vessel)	Cargo Value (US$/ton)	Interest Rate (%)	Different of Staying time between "With" & "Without" case	Savings in time cost (million Rs.)
Iron Ore	28,000 (Concentrate)	13.0	8	261.5 days	0.3
	28,000 (Pellets)	30.0	8	261.5 days	0.8 (Total) 1.1
P.O.L.	75,000	164.2	8	497.3 days	22.5

12.4 Costs

The costs considered in this section are construction costs of the iron ore and, oil berths, breakwater and iron ore handling equipment, dredging costs, maintenance costs and operating costs.

12.5 Economic Pricing

The purpose of the economic analysis is to see if it represents an efficient allocation of resources. The values of goods quoted at a given market price do not always represent the true value of those goods to the nation. Thus, planners often use "economic pricing" to examine the costs and the benefits of development, to evaluate a project from the economic viewpoint. We use border price to apply the concept of economic pricing.

Border prices are intended to represent the international market value, or world prices, of these goods and services.

(Conversion from Market Price to Border Prices)

Taxes and subsides create a price differential between the domestic market and the international market. For the purpose of analysing benefits and costs within the domestic market, the standard conversion factor is applied in order to convert domestic market prices to border prices.

Thus subtracting the 9% sales tax from material/equipment of domestic currency and using standard conversion factor it is possible to calculate the border prices of the construction costs of a short-term project. The following table shows the border prices of the construction costs and the annual investment schedule in border prices.

(1) Construction Costs (Border Prices)

(Unit: 1,000 Rs.)

Item	Total Cost	Foreign Currency	Domestic Currency			
			Total	Materials Equipment	Skilled Labour	Unskilled Labour
Survey Consultant Work	7,380	7,380	0	0	0	0
Iron Ore Berth	30,881	19,431	11,450	9,452	1,030	968
Production Oil Berth	44,694	14,370	30,324	25,037	2,718	2,569
Crude Oil Berth	29,301	10,040	19,261	15,903	1,726	1,632
Breakwaters (Southern)	73,523	0	73,523	70,130	2,011	1,382
Breakwaters (Northern)	75,606	0	75,606	72,116	2,068	1,422
Dredging(Channel)	174,388	63,154	111,234	60,700	50,534	0
Dredging(Lagoon)	203,584	107,180	96,404	55,230	41,022	152
Dredging (Soft Rock)	33,851	29,058	4,793	4,415	371	7
Dredging (Hard Rock)	176,110	158,821	17,289	15,103	2,186	0
Navigation Aids	31,800	31,800	0	0	0	0
Tug Boat	41,430	41,430	0	0	0	0
Contingency(5%)	46,127	24,133	21,994	16,404	5,183	407
Sub-total	968,675	506,797	461,878	344,490	108,849	8,539
Handling Equipment (Shiploader)	2,857	1,266	1,591	670	921	0
Handling Equipment (Conveyor)	83,031	42,578	40,453	25,551	9,206	5,696
Handling Equipment (Stock Shed)	79,375	0	79,375	53,196	12,888	13,291
Contingency (5%)	8,263	2,192	6,071	3,971	1,151	949
Sub-total	173,526	46,036	127,490	83,388	24,166	19,936
Total	1,142,201	552,833	589,368	427,878	133,015	28,475

(2) Annual Investment Schedule (Border Prices)

(Unit: Million Rs.)

		1990/91		1991/92		1992/93		1993/94	
		Foreign	Domestic	Foreign	Domestic	Foreign	Domestic	Foreign	Domestic
Survey/Consultant Work		2.06		1.7		3.62			
Iron Ore Berth								19.43	11.45
Product Oil Berth						14.37	30.32		
Crude Oil Berth								10.04	19.26
Breakwaters	Southern				20.60		35.28		17.64
	Northern				21.12		36.32		18.16
Dredging	Channel					21.05	37.08	42.10	74.15
	Lagoon			107.18	96.40				
	Soft Rock			29.06	4.79				
	Hard Rock			52.94	5.77	105.88	11.52		
Navigation Aids								31.80	
Tug Boats								41.43	
Contingency	5%	0.10		9.54	7.37	7.25	7.60	7.24	7.02
Total		2.16		200.42	156.05	152.17	158.12	152.04	147.68
Handling Equipment	Shiploader							1.27	1.59
	Conveyor							42.58	40.45
	Stock Shed						39.69	0.00	39.69
Contingency	5%					0.00	1.99	2.19	4.08
Total (including Handling Equip.)		2.16		200.42	156.05	152.17	199.8	198.08	233.49

(3) Maintenance Dredging (Border Prices)

(Unit: 1,000 Rs.)

		Total Cost	Foreign Cost	Domestic Currency			
					Materials Equipment	Skilled Labour	Unskilled Labour
"Without" Case	P	37,404	13,500	23,904	13,104	10,800	0
"With" Case	B	92,763	33,717	59,046	32,165	26,881	0
	A1	48,293	17,430	30,863	16,919	13,944	0
	A2	60,262	21,750	38,512	21,112	17,400	0

P : Present maintenance dredging

B : The year just before starting the capital dredging

A1: The first year after the completion of the proposed project

A2: From the second year after the completion of the proposed project

(4) Annual Maintenance Dredging Costs (Border Prices)

(Unit : Million Rs.)

Year	"With" case	"Without" case	Net maintenance dredging costs
1990/ 91	92.76	37.40	55.36
91/ 92	37.40	37.40	0
92/ 93	37.40	37.40	0
93/ 94	37.40	37.40	0
94/ 95	48.29	37.40	10.89
95/ 96	60.26	37.40	22.86
	≀	≀	≀
2019/2020	60.26	37.40	22.86

12.6 Evaluation

12.6.1 Calculation of the EIRR

The EIRR of the Short-term Plan (Case 1) is calculated as follows:

Case	EIRR (%)
Base Case	22.9
Case A : Increase in Costs by 10%	20.7
Case B : Decrease in Benefits by 10%	20.3
Case C : Increase in Costs by 10% and decrease in benefits by 10%	18.3

12.6.2 Conclusion

The leading view is that a project is feasible if the EIRR exceeds the opportunity cost of capital, which is estimated to be 12% in developing countries according to the IBRD and the ADB.

The Short-term Plan is judged to be feasible from the viewpoint of the national economy based upon the EIRR of the project as well as the uncountable benefits arising from this project.

13. FINANCIAL ANALYSIS

13.1 Purpose of the Analysis

The purpose of the analysis is to examine the viability of the project itself and the financial soundness of the NMPT during the project life.

The viability of the project itself is analyzed using the Financial Internal Rate of Return calculated by means of the Discount Cash Flow Method.

The financial soundness of the NMPT is appraised using the projected financial statements.

13.2 General Prerequisites of the Analysis

(1) Project Life : 30 years

(2) Base Year : 1989/90

(3) Cargo Volume

In 1994/95	"Without case"	"With case"
Iron ore	6,200,000 t	7,500,000 t
Crude oil	1,600,000	3,000,000
P.O.L.	800,000	1,570,000
L.P.G.	0	200,000

(4) Costs/Expenses

1) Investment : Import tax : 90% for foreign procurements
(It is possible for public sector projects to apply a different import tax rate.)

2) Re-investment

Table-13.2.1 Service lives of Port Facilities

Facility	Service life
Wharf & Jetty	50
Breakwater	50
Capital Dredging	100
Tugboat	30
Navigational Aid	8

The expenditures for renewal are considered as re-investments and will be financed by the NMPT's internal resources.

3) Operating and Maintenance Expenses : 1% of hte original constuction costs for the facilities related to the project.
   (Other facilities are set considering the correlation with the annual cargo handling volume of the port.)
4) Depreciation : Straight line method based on their service lives.
   Residual value : a negative investment cost at the end of the project life.

13.3 Viability of the Project Itself

1) The Costs and Benefits

Costs	Benefit
Initial investment cost including re-investment for renewal	Port operating revenue Residual value of the fixed assets at the end of the project life
Operating cash expenses including maintenance dredging cost	

2) Tariff Increase

   Three cases are considered as follows:

   (a) No tariff increase during the Short Term Development Plan period,

   (b) 10% after the implementation of the project (from 1994/95)

   (c) 20% 10 years after the implementation of the project (from 2,000/1)

13.4 Results

Table-13.4.1 Results of FIRR Calculation

Case	FIRR
No tariff increase (Case-a)	8.6%
10% increase from 1994/95 (Case-b)	12.5%
20% increase from 2000/01 (Case-c)	12.3%

Case-b is set as a Base Case in the following examination.

(1) Sensitivity Analysis

Case a: The construction costs increased by 10%

Case b: The benefits decrease by 10%.

Case c: The construction costs increase by 10% and the benefits decrease by 10%.

The results of the sensitivity tests are shown in the following table:

Table-13.4.2 Sensitivity Analysis for FIRR

Case	FIRR(%)
Base Case	12.5
Case a: Increase in Costs by 10%	11.4
Case b: Decrease in Benefits by 10%	11.0
Case c: Increase in Costs by 10% and Decrease in Benefits by 10%	10.0

13.5 Financial Soundness of the NMPT

(1) Indices

① Working Ratio and Operating Raatio for the appraisal of the soundness of contnuing operations

② Return on Net fixed Assets for the assessment of earning power

(2) Scenario

A Fund Raising Plan is set up as follows:

i) Foreign currency

Necessary funds for the project are covered by Government Loans

Interest Rate: 10.5%

Grace Period: 5 years

Repayment Period: 20 years

ii) Local currency

Source: Reserves of the NMPT

Any cash shortage should be covered by short-term loans with an interest rate of 10.5% per annum.

(3) Results

i) Profitability

The results of the rate of return on net fixed assets are listed below:

Table-13.5.1 Result of Rate of Return on Net Fixed Assets

Year	Profitability
1987/88	6.1%
1994/95	15.14
2000/01	16.10
2010/11	19.15
2019/20	23.54

The rate of return on net fixed assets is less than the average interest rate of the total funds until 1994/95, but after 1995/96 the rate of return will exceed the average interest rate.

ii) Operational efficiency

When the calculated operating ration is less than 70-75% and the working ratio is less than 50-60%, the operation of the port is efficient.

The results of the operating ratio and the working ratio are shown in the following tables:

Table-13.5.2 Result of Operating Ratio

Year	Operation Ratio
1987/88	67.1%
1990/91	54.0
1991/92	49.1
1992/93	45.6
1993/94	52.6
1994/95 -	49.2

Table-13.5.3 Result of Working Ratio

Year	Working Ratio
1987/88	58.8&
1990/91	49.0
1991/92	44.9
1992/93	42.0
1993/94	49.5
1994/95 -	43.0

Both the operating ratio and the working ratio remain at favorable levels. The operating ratio is less than 60% from 1990/91 the working ratio constantly maintains a low level, under 60%.

ii) Loan repayment capacity

This indicator shows whether the operating income can cover the repayment of the interest on long-term loans, and must be more than 1.

Table-13.5.4 Result of Debt Service Coverage Ratio

Year	Debt Service Coverage Ratio
1987/88	10.64
1994/95	2.23
2000/01	1.75
2010/11	3.19
2019/20	-

(No long-term loans)

The debt service coverage ratio exceeds 1.0 from the beginning of the project life. There will be no problem with the repayment of the long-term loans using the annual operating revenues.

(4) Conclusions

Judging from the above analysis, this project is financially feasible for the NMPT.

However, it is recommended that the following measures be taken in order to improve the financing during the project life in view of the current political situation, the economy and the cost of the future development of the port.

i) The re-lending rate on the long-term loans from the government to the NMPT should be kept as low as possible.

ii) NMPT should maintain its efforts to secure a sufficient cargo volume and improve cargo handling efficiency from now on.

iii) Tariffs

Since the tariffs at New Mangalore Port such as port dues, berth hire charge, wharfage, etc., were raised in April, 1990, the financial status of the port trust has improved. Financial analysis made in this report shows that the FIRR of the proposed project is calculated to be about 8% under new current tariff conditions. If more FIRR, for instance 12% is required, the tariffs will have to be raised by 10% from fiscal year 1994 when improved facilities are commissioned, or by 20% from fiscal year 1999.

The iron ore berth is being used exclusively by the K.I.O.C.L. in spite of having been constructed as a public berth. Again, the crude oil and oil products jetties will be in a similar situation. As the exclusive users will enjoy the convenience of exclusive use, the possibility of imposing special tariffs or charging the users part of the berth construction costs can be examined.

iv) Financial Aids for Non-profitable Public Facilities

A port works only when several basic facilities, such as breakwaters, channels, basins, wharves, handling equipment, etc., have been prepared. Of these facilities, the breakwater, channel and basin are expensive and at the same time do not generate profit on their own. On the other hand, a great deal of demand for labor during construction of these facilities would be produced, production demands would be stimulated in industries that supply materials and construction equipment, course other forms of demand would be stimulated in the service sector. In other words, the economic effects of the construction of these facilities would spread nation-wide. Therefore, part of the capital for construction/maintenance of the breakwater, channel and basin could be supplied by the national government. Subsidies, low-interest loans, tax exemptions, etc., are possible policies. Moreover, these policies could be also applied to facilities essential to exports, for instance, the iron ore berth in this project.

As a reference financial arrangements for port development in Japan is listed in Appendix 16.4.

14. CONCLUSION OF FEASIBILITY STUDY

The feasibility study of the short-term plan was analysed both economically and financially and evaluated using EIRR and FIRR.

The EIRR is calculated based on cost-benefit analysis from the view point of the national economy. The FIRR is calculated to evaluate the profitability of the short-term plan. The calculation results of EIRR and FIRR are as follows:

Calculation Results of EIRR and FIRR

Item	EIRR	FIRR
Base case	22.9	12.5
Sensitivity analysis		
(A) Increase in costs by 10 %	20.7	11.4
(B) Decrease in benefits by 10 %	20.3	11.0
(C) Increase in costs by 10 % and decrease in benefits by 10 %	18.3	10.0
Calculation of viability of the project	12.0	12.0

The EIRR exceeds 12%, which is the guideline of viability of the project, that is, the opportunity cost of capital in developing countries according to the IBRD and the ADB. As for FIRR, unless there is subsidy from the Government, the FIRR can only exceed 12% which is the guideline of the viability of the project since 12% is the lending rate fixed by the Indian Government, under the conditions of the raising port tariff by 10% in 1994/95%.

The financial analysis also evaluated the financial viability of the operating entity responsible for the short-term plan. From our financial analysis, the NMPT would maintain its financial viability throughout the entire project life including the construction period. It will be able to pay all expenditures and have some surplus even after appropriating funds for the repayment of foreign loans including interest.

Judging from the above, we conclude that the short-term plan with the target year of 1994/95 is feasible both economically and financially.

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