2.6 Existing Major Port Facilities

This section deals with an outline of the existing port facilities at Imam Khomeini Port. The first facilities were initiated in 1931 (1310) simultaneous with the construction of Nowshahr and improvement of Khoramshahr Ports. Modernization of the port facilities was started by construction of four berths, No.7 ~ No.10, in 1971 (1350) and all the Berths upto No. 34 were completed to meet the third stage schedule of Imam Khomeini Port master plan (MP-74).

At present, both ports of Imam Khomeini and Shahid Rajaee are the largest cargo handling ports in Iran. Cargo volume handled by Imam Khomeini Port is ten million tons. Total cargo volume of these two ports cover nearly 90% of the whole cargo served by the six major ports.

A new era of world port activities started from early 1970's by means of multi-purpose services. In order to stimulate industrial activities, coastal development was widely understood by the policy makers. In this sense, Imam Khomeini, and Rajaee Ports, located on the south of Iran, play a great role in the international trades of Iran.

The recent concept of port development is to harmonize port activities with such various supporting services as commercial activities, as well as financial and industrial developments. However, the largest impact was given by an introduction of container. This concept is going to provide the port users with quick and safe delivery, without which the modern industry can not survive.

Operational system of a container port, such as equipment, documentation and physical layout is different from that of a conventional one. Many ports in the world have been modified or completely redeveloped to meet the containerization. They set forth mechanical handling system in a wide cargo handling yard.

A container terminal actually requires a wide open space. An average land depth of a conventional berth is about 150 meters, while the container berth requires at least three times wider space. Accordingly the initial investment required for containerization is also three times more. However, the outcome of a container berth is three times more than a conventional one.

A port designated to conventional cargoes, normally has finger piers of marginal wharves with a narrow back-up space. Imam Khomeini Port is a typical conventional port because of its physical arrangement. A good answer should be given to the question that, whether to modify the existing facilities or to build a new terminal. One of the purposes of this study is to prepare basic data to answer this question.

Thus, this section provides necessary data about the existing port facilities for the planning of the best scheme with respect to rehabilitation, up grading and new development. Data will also be a basis for estimation of up-grading efforts and the cost required for the port facilities.

2.6.1 General Information

Imam Khomeini Port, the most prominent port, which is located near the northern end of the Persian Gulf. It is the largest national port with respect to the scale of facilities and cargo traffics. It currently handles more than 50% of the total national maritime traffics.

Rajaee port is the second important one, however, its recorded traffic is two third of that in Imam Khomeini port.

Imam Khomeini port has various advantages as follows:

(1) Well protected by the existing channel banks against waves.

(2) Wide and deep basin for vessel maneuvering and anchorage. However, routine maintenance dredging work should be carried out.

(3) Wide open space in and around the port including a free port zone to be utilized by industrial activities. Business activities might be accelerated in future by foreign investors

(4) Well prepared on-land access to the major cities, however, some rehabilitation should be carried out on them.

The port has railway connections to Ahvas city and highway network to the other parts of country. It is easy to reach the international airports of Abadan and Ahvaz by two hours driving.

Every year more than 500 vessels berth at the port. The port has a berthing space of approximately 7,000 meters long. The maximum water depth is DL-13.0M.

There are two types of berth namely, exclusive use and general use. The former consist of the grain jetty and ore loading jetty (floating crane), and the latter is for the major activities of general cargo handling including containerised cargoes, bulk cargoes etc.

The main general cargo berths are divided into two parts, namely finger piers and 26 marginal wharves.

Both transit sheds and warehouses are provided along the marginal wharves. The most recent development is construction of warehouse and open storage yard behind the berth No.21 and at further north.

There are one container berth with two gantry wharf cranes. A CFS is currently under construction behind existing Berth No. 12.

The final objective of this report is to prepare both a Master Plan for the year 2010 and a Short Term Development Plan for the year 2000 for each of Imam Khomeini Port.

The scale of port facilities should be determined generally based on the traffic demands. If the demands exceed the handling capacity of the existing facilities, modification or a new facility development may be required. If the future cargo growth rate is constant, say 5%, the cargo traffic in years 2000 and 2010 will increase by approximately 50% and 150% respectively.

Then, the first question will arise:
"How much extra traffic can the existing facilities handle if necessary rehabilitation and up-grading are given to them?"

An answer to this question should also indicate the timing of a new development and its required capacity.

The second question will be:
"What functions should be allocated to the existing facilities and a new development?"

In order to give exact answers exactly to these questions, an evaluation of the capacities of the existing facilities is a must. The capacities can be estimated only when the following basic figures are known.

(1) Physical space

(2) Structural durability and its shelf life

(3) Access to the hinterland

Thus, this section aims to provide necessary data to evaluate the status of existing facilities in Imam Khomeini port. To carry out the evaluation, both current utilization and structural conditions of the facilities are investigated.

Since most of the waterfront structures are an open structure which consists of concrete deck supported by piles, visual inspection over the entire structures is carried out. The investigation covers the following areas:

(1) Marginal wharves, existing Berth No.7 ~ No.8.

(2) Marginal wharves, existing Berth No.11 ~ No.34.

(3) Outline inspection on the rest of marginal wharves at Barge Harbor, both Eastern and Western Jetties and Grain Jetty.

Due to lack of necessary information so far, an additional site investigation are carried out by detailed visual inspection together with quality tests including concrete core sampling, crushing test, chemical test and electric potential test. Refer to section

2.8 for more information.

2.6.2 Possible Port Boundary

MP-74 mentions the "Port Limits" and "Property survey" as follows:

Although there is no official designation of the port limits but they are normally considered to be parts of Khor Musa, extending approximately 4km on either sides of the junction of the Eastern and Western Jetties and the lower 3km of Khor Zahid.

A detailed survey was performed in 1352/53 on the port property and immediately adjacent areas. Maps on scale 1:1,000 were prepared giving location and elevation of all significant port features.

For the time being, any major obstruction for the port expansion unlikely exists along both the Dorag Channel and Zangi Channel.

A land allocation map proposed by PM-74 divides the total area of approximately 309km^2 into five categories as follows.

Port areas
* Area-1, for near future port development approximately 20km^2

* Area reserved for future port development and related industry, approximately 42km^2.

Industrial areas
* Land reserved for National Petrochemical Company, approximately 80km^2

* Land for industrial development requiring deep water, approximately 17km^2

* Land for industrial park, approximately 150km^2

2.6.3 Existing Land Use

This section deals with the existing land use together with waterfront facilities. Most of data were provided by PSO.

(1) Present Land Use Beyond PSO Area

There is no other land except for low marsh and wet-land on the both banks of Musa Channel beyond the area for existing port facilities.

On the eastward upstream, there are three factories on the reclaimed land. Razi Petrochemical is located adjacent to the port eastern boundary, with 730m three-berth jetty which has about 9.1m alongside and has modern mechanical means for receiving various chemicals. I.J.P.C. which is recently restored from the damage is located next to Razi Petrochemical.

Bandar Mahshahr crude oil terminal, Iran's principal petroleum product shipping facility is located about 8km upstream of the port. Tankers up to 780 feet (240m) long, drafting up to 11.6m can use the port.

(2) Present Land Use in PSO Area

Total port area is about 1,200ha or 12km^2 which can be divided into two groups namely the developed zone and the future zone. The former consists of the general cargo handling area in 276ha and the direct back-up area in 167ha. The latter includes the indirect back-up area in 339ha and the empty area in 418ha without any specification. Details of the existing land use is shown in Table 8.2.4.1

All marginal wharves in general use have the land depth of 520m including the concrete deck apron of wharf and occupy 75% of the total available waterfront line faced to the channels. Remaining 25% of coastal line provides port with various services, initiated in early 1930s. The former maintains rather systematic arrangement comparing the latter which consists of pier type structures.

(3) Existing Waterfront Use

As discussed previously, total waterfront line belonging to PSO is approximately 11.5 Km.

- Northern waterfront (Zangi Channel) ---- 5.0km
- Western waterfront (Dorag Channel) --- 3.7km
- Southern waterfront (Musa Channel) ---- 2.8km

Both western and southern waterfronts are fully utilized by berthing facilities. Total length of the existing berths is about 7.0km which exceeds total waterfronts facing to Both Dorag and Musa Channels, since there are many jetty type berthing facilities in the old port area. Table 2.6.1.1 indicates major characteristics of the existing berthing facilities.

There are 34 berths including the grain jetty and one dolphin but excluding two incomplete berths at No.9 and No.10. 28 berths out of the total 34 are now ready for PSO operations. Currently PSO is not using six berths for commercial purposes, as follows.

- Three berths (NO.32 ~ No.34) are being used by the Air Force.

- Three berths of Western Jetty (No.4 to No.6) are under the structural renovation, (Nov. 1994)

Other than these cargo oriented facilities, there are three service facilities, namely the barge harbor, the ship repair system and service boat jetty. The barge harbor has marginal wharves of DL -4.0 m for 820 m long. It consists of an U-shaped basin penetrating into the land.

Table 2.6.3.1 Existing Cargo Berth: Imam Khomeini Port

Category in Use	Existing Berth No.	No.	Berth (m)	Length (m)	Depth. (m) DL
1. Bulk					
1.1.Grain Terminal	-----	1	180x1+90	270	-12.5
1.2.Ore Dolphin 1.3.Eastern Jetty	-----	1	180x1	180	-13.0
1.4.Western Jetty	No.1~No.3	3	174x3	522	- 9.0
	No.4~No.6	3	180x3	540	-10.0
Total (1)		8	1,422+90	1,512	-----
2. General Cargo					
2.1.Marginal Wharf 2.2.Marginal Wharf	7~10	2(4)	180x2+411	771	-10.0
	12~15	4	180x2+16 240x2+16	872	-12.5
2.3.Marginal Wharf	16~20	5	180x5+11	911	-11.0
2.4.Marginal Wharf	21~26	6	180x6+14	1,094	-11.0
2.5.Marginal Wharf	27~34	8	180x8+18	1,458	-10.0
Subtotal	11~15	25(27)	4,620+486	5,106	---
2.6.Container	No.11	1	180x1	180	-12.5
Total (2)		26(28)	4,800+486	5,286	
Grand Total (1+2)		34(36)	6,222+576	6,798	

Notes: 1. Berth lengths are taken from the New General Layout in March 1991.
2. Datum of berth depth is Cesco Datum, DL.
3. Figure in parenthesis shows an actual berth number excluding two incomplete berths at No.9 and No.10.

2.6.4 Common Facilities

(1) Management and Administration Area

The required facilities for port management and administration are under construction near the existing port entrance. According to the New General layout issued on March 1991, the inventory of major facilities are as follows:

1) Administration building
2) Customs building (under construction)
3) Canteen
4) Guest house
5) Radio communication center

6) Forwarding agent offices
7) Garage and service station
8) Car parking
9) Quarantine station and medical station
10)Others

It is reported that PSO has a plan for development of the various facilities shown above. Thus the existing administration building will be renovated in future. The customs building is being almost completed.

From this area, two main access roads lead vehicles to the port area, namely the access to the old port area and the access to the newly constructed area after 1972.

Other than these facilities, following systems are or will be constructed at the specified location out of the administration area.

1) Area canteens
2) Fire stations
3) Seamen's club complex
4) Workshop areas
5) Gas stations (private sector)
6) Others

Recommended location of these facilities in MP-74 were partly modified during the detailed design stage.

(2) Residential Area

The existing residential areas are located just behind the existing administration building and between the southern end of old sidings and the ore yard. It is reported that PSO intends to construct it's new residential quarter in Sar Bandar (Imam Khomeini City) about 13km to the north. This new area will accommodate houses of 400 PSO families.

(3) Utilities

This subsection is prepared mainly based on the data in MP-74 with some modifications by the latest information provided by PSO.

Water Supply System

Water is supplied by the Khuzestan Water and Power Organization through 106cm (42") dia main from the Karun river to the existing Petrochemical factory east of the port. From this main a 20cm dia line branches to the port. The water is supplied to the existing two 600m^3 water reservoirs, where pumps and pressure tanks for the distribution are installed. The distribution network, which belongs to the Organization was old and in bad condition in the past.

The capacity of the main (42") is 54,000 m^3 per day. This could be doubled by introducing a booster station halfway between the intake and the petrochemical plant.

MP-74 strongly recommended that a reconditioning of the old water pipes was necessary, in order to maintain water pressure at the required level.

All berths are supplied with two portable water outlets from a 100mm distribution line located in a pipe trench at front of the berths. The ship connections are 63.5mm diameter hose connections.

Power Supply System

The port power supply system consists of a main and a back-up system including emergency generators. Originally, the power station was made for the port power consumption, but now it serves standby purposes only since the reliable hydro-electric power was brought to the port.

Power is also supplied by the Khuzestan Water and Power Organization. The power supply line to the port branches off from a ring supply net covering Ahwaz, Abadan and Omidieh.

The power was supplied at 11kv through overhead wires placed along the Sar Banadar road. The power line was, however, designed for 132kv. When needed the power could be supplied at this voltage and a transformer station would be established northeast of the port. From here the power would be supplied through underground cables to the main distribution station of the port.

The distribution station was located in the power station of the port. The power station had 2x525, 2x250 and 1x120KVA generators plus a portable 1x160KVA one, and 2-1,000 KVA transformers for transforming the generated power from 11,000V to 440V. However all these generators are currently out of use by mechanical damage.

MP-74 prepares its recommendation on the power supply system to be employed in the port, as follows.

- Additional substations would be required for each section of the port area.

- Three power outlets should be provided at each berth for stevedoring equipment. Outlets should be 5 KW 380/220V/50 cycles.

Sewerage Treatment System

In 1974, raw sewage was discharged into Musa Channel. MP-74 recommended to provide the port area with a sewerage treatment plant with a daily capacity of 2000 m^3 sufficient for a population of 10,000.

Upto now there is no progress. All the raw waste water are discharging into primitive septic tanks.

Storm Water Drainage
Rainfall intensity is moderate. MP-74 has recommended that a Surface drainage system should be provided within the port areas, to collect all surface water to the main drains, then discharge into the nearest channel. PSO is performing the constructing of drainage based on the general layout.

Disposal of Oily Waste, Bilge Water and Solid Waste
PSO has responsibility to maintain the seawater out of wastes, especially oil spill. Taking environmental problems into consideration, new regulations are subject to completion for their purpose. This includes various rules as follows.

- To form an organization for protection of seawater from pollution.

- Preservation of seawater from pollution.

- Control and convention on the oil pollution.

- Collection of the wastes from the surface of water.

- Equipment required for wastes collection.

- Prior cautions to the captain and his crew.

- Communication under the emergency cases.

- To indicate the basic sources of pollutants.

MP-74 has recommended as follows:

a) Consideration should be given to a collection barge system at each berth for bilge water and oily wastes, which should be taken to a separation and filtration plant prior to discharge of the treated water into the sea.

b) All refuse from and within the port area and from ships alongside should be collected and destroyed. For this purpose collection bins, two per berth and one for each building, should be provided. Collection of bins should be on a daily basis and they should be taken to an incinerator where the refuse is burnt.

Bunker Fuel Supply System
At present there are no bunker oil facilities in the port but the National Iranian Oil Company is preparing to establish a tank farm and a distribution network with supply points for gas, oil, diesel oil, and marine fuel oil to each of the cargo berths of the port.

2.6.5 Grain Terminal

Between subsections 2.6.6 and 2.6.14, an outline description will be provided about the existing waterfront facilities. At present the new port area, Berths No.11~ No.34

with 520m depth of land is principally developed. On-land facilities including the secondary open storage yards and road access behind the first 520m are under preparation stage.

Discussion about the waterfront facilities will start from those located at the eastern end of the port area then towards the west.

The highest installation in the port presently is the control tower of grain silo.

(1) General Description

The grain terminal locates at the eastern end of the port area. The distance between the boundary fence to neighboring petrochemical factory and the axis of terminal is about 200m. The existing jetty of 270 m long has detached from the seawall and projected up to the faceline of the Eastern Jetty. The mainland access to the terminal is maintained by both an access road and railway sidings. Construction of the terminal was started in 1974 and completed in 1977.

Additional works in the silo, civil works, electrical works and equipment started in 1980. The terminal has a storage capacity of 70,000 tons of grain. Presently the main cargo is imported wheat.

The silo including its mechanical facilities was seriously damaged by fire in July, 1994. Required structural repair works and replacement of damaged equipment currently are undertaking by PSO. It is reported these works will complete by the middle of 1995.

(2) Facilities

The water front structure is a single jetty with a dredged basin on each faceline, one for grain imports and the other for loading of products. The jetty on the West side has a basin of about 80m wide and serves bulk carriers up to 45,000 DWT. The basin on the East side with 80m width and could serve 18,000 DWT vessels, however not loading at present due to shallow water by sedimentation and few demand.

(3) Basic Structural Type

For the construction of a 70,000 ton capacity grain elevator, land reclamation work was carried out at the beginning. Selected Earth was dumped on the marsh at that time.

The jetty consist of the concrete deck supported by R.C. piles. The length of jetty is about 270 m and width of the deck is 24m. There are many damages visible on the corner of the concrete deck. The connection part between the pile and deck beam is also damaged. PSO currently provides these damage with urgent repair works. Damage of under surface structure of deck is also visible.

It is recommended that the urgent repair works should be also conducted at the damaged part of submerged piles before happening of heavy damage and accident. Grain dust problem should also be solved in order to maintain the port environmental better conditions.

According to PSO information, the existing water depth is rather shallow water of DL-7m comparing to the design depth of water of DL-15.0m. Thus urgent maintenance dredging is requires also.

2.6.6 Barge Harbor

(1) General Description

The barge harbor is located at the space between the grain silo area and the ship repair facility. The western boundary faces to the railway siding and the ore handling yard. Total land area for the harbor is about 80,000 m^2. On-land access both railway and road are available.

The construction of the barge harbor amounted to 27 million US$ was started in 1974. Inner harbor has a quaywall of 820m long. The harbor was initially developed to serve LASH traffic and lighterage.

(2) Facilities

The waterfront structure is a typical marginal wharf retained by bulkhead wall. The service craft facilities are being provided with quay length of 200m, and coastal harbor is developed with a quay length of 270 m. The design water is DL-4.0m.

(3) Basic structural Type

All the waterfront facilities are built by typical open structures consisting of reinforced concrete deck supported by PC piles. According to the visual inspection undertaken by the Study Team, all the structures are so healthy.

However the existing water depth of basin is about DL±0, due to heavy sedimentation and insufficient maintenance dredging.

2.6.7 Ship Repair and Service Boat Jetty

(1) General Description

The existing ship repair yard is located between the Barge Harbor and the Eastern Jetty. On-land access road links to the same access for the grain terminal. It is assumed that the construction of the ship repair yard started before 1970s.

(2) Facilities

Ship repair yard consists of a repairshop and two slipways on the reclaimed land.

A pier was build for assembly and mooring.
Total land area for this is about 25,000 m^2 .

The pier consists of steel framed structures supported by H-shaped steel pile. There is no data about the soundness of these piles. The crown height of pier is DL+7.35 m. Boarding to small service boat is so difficult due to the height difference.

According to the hydrographic survey by the Study Team, the depth of water is Dl-4.0m at the deepest point while the design depth is DL-7.5m.

2.6.8 Floating Crane (Ore Dolphin)

(1) General Description

The existing ore dolphin is located at V-notch basin between the approaching trestles of the Eastern and Western Jetties. This unloading pier connects by a trestle to the existing ore storage yard immediately behind the ship repair yard. A separate access road with railway sidings is available.
The western limit of storage yard directly faces to the existing residential area for the railways.

The construction of this facility amounting to 27 million US$ was carried in 1974 and 1975.

(2) Facilities

An ore unloading pier and single-spout loading tower lies between Berths No.3 and 4. It is fed from the 7,800m^2 storage yard. Stockpiling and reclaiming are conducting by the clam shell bucket on an overhead gantry. Ore can be received either by truck or by rail.

(3) Basic Structural Type

Marine structure consists of a loading platform and mooring dolphins. The platform is supported by piles and is connected to the land by a bridge. The structure can originally accommodate vessels of 16,000 DWT.

The platform is provided with a loading tower which is connected by an overhead belt conveyor to the ore yard. The design capacity of the loading installation originally is 350 tons per hour. The design depth DL-13.0m is maintained.

2.6.9 Eastern Jetty, Existing Berth No.1~No3

The Eastern Jetty is the first waterfront structure in Imam Khomeini port. It has played its great role since the beginning.

(1) Location and Access

Both the Eastern and Western Jetties are located at the center of the old port area which was built in 1931 and 1941. The starting point of the approaching trestle to the berth is on the axis of old railway siding.
On-land access consists of roads and the railway. This access seems to be congested due to the existence of various facilities and railway crossing.

The first berth (Berth No.3 at present) was built in 1931, then the second berth No.2 was built in 1939 for giving service to the Ocean-going vessels. The first rehabilitation of Berth No.1 was conducted by structural overhaul and redecking in 1973. Berths No.2 and No.3 were also improved so far.

It is reported that the entire superstructure of the jetty will be rehabilitated again after the current overhaul on the Western Jetty.

(2) Facilities

The jetty is connected to the mother land by two trestles, main and supplemental trestles. The length of these trestles are approx. 250 m and 150 m respectively.

The existing berths consist of a 522m long pier with DL-9.0m water depth. The jetty is an open structure about 28 m wide, timber-decked, on steel piles.

(3) Basic Structural Type

All the jetties and trestles are typical open structures timber-decked on the H-Shaped steel piles. Seawall at the landslide end of trestle is a steel sheet pile structure.

This jetty is on duty to carry three railway tracks and other loads. Truck loads are locomotives with four 15-ton axles 1.6 m apart or wagons with 40 tons bogies on two axles 1.6 m apart. This loading condition was restricted to one ton/m^2 in the past.

The principal problem on the structures is possible deterioration on steel piles caused by corrosion. According to MP-74, it is reported that the maintenance and working condition of the cathodic protection system of the jetties was questionable. Because of corrosion and lack of maintenance, the estimated shelf life of these jetties in 1974 was about 12 to 15 years.

Since then, it is past 20 years. PSO reported to the Study Team that pile inspection was carried out recently. However no data is available for the time being. It is strongly recommended that PSO conducts necessary action based on such data to prevent the jetty from the structural failures.
If the quality of visual inspection is insufficient due to low visibility by mudwater, strength of piles can be tested by lateral force.

2.6.10 Western Jetty, Existing Berths No.4~No.6

The Western Jetty is similar to the Eastern one in respect to its historical background and structural type. Both jetties are located in symmetrical alignment against the central axis of two trestles.

(1) General Description

The landward end of approaching trestle starts at the same point as that of the eastern one. The existing on-land access to the Eastern Jetty can also be applied to the Western one.

The jetty was constructed in 1941 following the construction of the Eastern one. The jetty was prepared initially for ocean-going vessels. PSO is currently conducting large scale overhaul of the superstructures. It is reported that PSO performed the first major repair work of the jetty in 1978.

(2) Facilities

The jetty is connected to the mother land by two main and supplemental trestles. Length of each trestle is about 250m.

Three existing berths consisting of each 180 m long with DL-10m water depth can accommodate vessels up to 15,000 DWT. The jetty is an open structure about 28 m wide and 540 m long. The jetty carries three railway tracks. Track loads are locomotives with four 15 ton axles 1.6 m apart or wagons with 40 ton bogies. This loading condition was restricted to one ton m^2 in the past

Decking was edge bearing laminated wood before overhauling and loads were 2 tons/m^2 uniform, or 3 ton mobile cranes or forklifts, tractors and 5 ton trailers or trucks with 8 tons on a rear axle or 14 tons tandem.

A belt conveyor is extended from a pair of movable receiving hoppers on Berth No.6 to three steel storage tanks and a large gabled storage building of the Iranian Aluminum Company (IRAL Co.). The facility was designed to off-load self unloading vessels of up to 500 tph. Approximately 120,000 tons per year are handled at this facility. Dust collection was built into the system, and the receiving hoppers roll aside to permit regular use of the berth.

For the discharge of bulk grain, the jetty has mobile pneumatic grain loaders. It is reported that each with nominal capacity of 70 tons per hour, and working capacity of approximately 30 tons per hour. They are generally used at Berth No.5 for transferring of grain from the ships to railway wagons.

(3) Basic Structural Type

Similar to the Eastern Jetty, all the berths and approaching trestles are typical open

structures consisting timber-decked on the H-shaped steel piles. The connection beam on pile tops are also provided.
Seawall surrounding the trestle is a typical bulk head wall consisting of steel sheet pile.

PSO is currently conducting the repair works of superstructures above the low water level. New deck consists of reinforced concrete slabs supported renewed steel fram. However, technical doubt on the H-piles is remaining. Consideration similar to the Eastern Jetty should be taken into account.

2.6.11 Four Berth Extension, Berth No.7 ~ No.10

This section deals with the first parallel jetties built in early 1970. Type of these berths are a transitional one between the detached jetty and the marginal wharf.

(1) General Description

Berth No.7 ~ No.10 are located on the immediately west of the Western Jetty. The main access to these berths is an inner access connected directly to the existing gate. Railway siding is also provided through the old one.

Berth No.10 is located at the meeting point of both Musa Channel and Dorag Channel. All the waterfront structures upto this point belong to the planned facilities before the new facility arrangement based on MP-74.

In 1971 the construction of four berths extension was commenced. Construction efforts continued even during the preparation of MP-74. Unfortunately the western two berths (Berths No.9 and No.10) were not completed except the concrete pile driving.

(2) Facilities

These berths consist of a detached pier constructed parallel to the seawall. The pier and seawall are connected by the short span bridges.
Scale of the existing transit sheds and open storages are as follows:

a. Transit sheds -------- 3 units, each 40m x 90m

b. Open storage --------- 56,000m^2
750mX75m

At the eastern end of Berth No.7, there is a RO/RO facility but not in use.

(3) Basic Structural Type

This detached pier was supposed to be a total length of 771m consisting of two berths of each 180m and two berths of each 240m and water depth of DL-12.5m. Only the first two berths were completed.

The wharf structure consist of the reinforced concrete deck and R.C. concrete piles. The width of deck is about 28m. The deck is connected to land by 30m long access bridges, one of which is a bridge combined road and railway. The berth No.10 was originally planned as the marginal wharf which should have been fully connected to the land.

The structures are designed for a uniform distributed load of 4 tons per m^2 or a concentrated load placed at random of 25 tons.

According to the visual inspection, both the upper deck structure and concrete piles are rather normal conditions except minor damage. This deck is constructed up to Berth No.8 and all the rest of works included in the plan have not been executed except the pile driving of 600 numbers.

Reinforcements at this end are exposed to air without any protection. Driven piles were not provided by any support on their tops. According to the electric potential tests, they are under the serious corrosive condition.

According to the hydrographic survey data, present water depth is DL-8.5m which is 1.5m shallower than the design depth. This may attribute to sedimentation due to the shadow effect of the Western Jetty.

2.6.12 Ten Berth Extension, Existing Berth No.11~No.20

These extension was made by a completely modern idea proposed in MP-74. Although one berth out of ten were initially oriented as container wharves, other four berths are structurally arranged to be container wharves in the future. It is also noted that a structural standardization was taken into consideration.

(1) Location and Access

Berth No.11 ~ No.20 were constructed along the estuary to Dorag Channel and are located at the eastern half of the marginal wharf area.

There are three access roads namely:

a. Inner Access No.3 (IA-3)
   Direct access to the container yard.
b. Two branches from the Inner Access No.4 (IA-4) Eastern one approaches to the middle of the berths, while the western one connects to the Berth No.20 at its western end.

The detailed design and construction supervision were carried out by Iran-Kampsax after 1972. The construction works were commenced in 1974 by DHH, Damez, Hamoun and Nadish. Construction of both roads including utilities and transit sheds were started in 1978 and 1988 respectively.

Total construction costs were 139 million US$.

(2) Facilities

Total length of the quay is 1,963m which originally consists of two parts in respect to the type of cargo to be handled.

<u>The First Part: Eastern Part, Berth No.11~No.15</u>

- Total quay length	1,152m
- Special berth	one unit
- Container berth	one unit
- General cargo berth	three units

Initial design water depth for these are DL-11.0m, however they structurally are capable to DL-12.5m.

There is a large scale open storage yard of 520,000m^2. Behind the yard, a container freight station (C.F.S) is going to build. Along the faceline, rails for the wharf crane are installed. There are two gantry cranes for container cargo handling.

<u>The Second Part: Western part Berth No.16~No.20</u>

- Total quay length 911m
- General cargo berth five units

Design depth for these are DL-11.0m.

Land use behind the quay apron is an ordinary arrangement for general cargo berth, Average land depth is about 425m which is divided into three parallel zones as follows:

- First Zone : Quay apron and transit sheds or open storage yerds.
- Second Zone : Open storage yard
- Third Zone : Mixed use of the warehouse and open storage yard.

Present condition of these architectural works is as follows:

Table 2.6.12.1 Present Condition of Transit Shed and Warehouse of Berth No.16~No.20

Berth No.	Type	Condition	Major Cargo, etc.
16	T	Operation	General cargoes
16	W	"	"
17	T	"	"
18	T	"	General cargoes and bulk
18	W	"	General cargoes
19	T	"	"
20	W	Working (gate)	
	4T/3W		

T: Transit shed, W: Warehouse

(3) Basic Structural Type

Waterfront Structure

Quay structure consists of reinforced concrete deck cast in situ and/or precast deck supported by prestressed concrete piles. Width of this dock for the first part is 55 meters to allow the design depth of DL-12.5m, while the second part is 50 meters for DL-11.0m. Standard deck length is 60 meters except both the corner point and bending point. Since the apron width is 25m, the seaward wall foundation of transit sheds rest on the middle of deck.

Architectural Works

The size and structure of all the transit sheds and warehouses is standardized in 60m x 90m (9,000m^2). The main frame consists of steel skeletons. The wall is made of the precast concrete planks. All the wall and columns are rest on the foundation piles. There are four transit sheds and three warehouses.

Storage Yard

All the existing land were created by means of lands reclamation with selected materials.

There are two types of pavement, namely asphalt pavement and concrete pavement. The former is mainly used for the floor of the closed storage, maintenance shop etc., where a hard loading condition or chemical action is anticipated. Asphalt pavement is commonly used for the port inner access and open storage yard where smooth vehicular traffic is required. The deck apron is covered by asphalt for protection

Results of Visual Inspection

In 1991, Tehran Berkeley of engineering company issued an observational report about the damage of concrete front wall.

In addition to this, visual inspection on the lower deck surface and pile caps were carried out by an engineering company, Rod Bid, employed by the Study Team.

Summary of findings are reported in section 2.8.

Rod Bid made an extensive survey on the structural damage mainly to the concrete works. The survey concentrates to the existing condition of lower surface of decks and concrete piles, since no inspection has been conducted to these most vulnerable parts before. Then, a plenty of damage were found through all the marginal wharves. It is recommended to undertake an urgent repair on these.

2.6.13 Fourteen Berth Extension, Existing Berth No.21~No.34

Construction of Fourteen Berth Extension was started following the Ten Berth. All the berths were initially originated as general cargo wharves. It is noted that the standardization of architectural work and berths were also taken into consideration. This group of berths are located at the northern end of marginal wharves at present.

(1) Location and Access

Berths No.21~No.34 were also constructed along the Dorag Channel. The quay faceline changes its direction again after the eastern six berths.

There are three access roads namely.

a. Inner Access No.3 (IA-3)
   Parallel access to this area.
b. Three branches from the Inner Access No.4 (IA-4).

Each branch access covers four berths.

The detailed design and construction supervision were carried out also by Iran-Kampsax after 1974. The construction works required for waterfront structures were commenced in 1974 by Sherkat J.V. Construction of storage yard pavement and transit shed were started in 1974 and 1978 respectively. The required costs amounted to 225 million US$

Among these works, completion of the pavement, utilities and building works were delayed. Five warehouses out of fourteen storages were under construction in the beginning of 1994.

(2) Facilities

Basic dimensions of the berth are as follows:

- Total quay length	2,552m
- Total berth length	2,520m (180mx14units)
- Container berth	none,so far
- General cargo berth	14 units

Initial design depth are DL-11.0m for six southern berths and DL-10.0m for the rest. However the eight northern berths structurally are capable to DL-11.0m.

There are fourteen standardized buildings, nine transit sheds and five warehouses. The present condition of them is shown in Table 2.6.3.

Table 2.6.13.1 Present Condition of transit shed and warehouses of Berths No.21~No.34

Berth No.	Type	Condition	Major Cargo, etc.
21	T	*	Sodium
22	T	*	Rice
23	T	*	NA
23	W	Working (wall)	-
24	T	*	NA
25	T	*	NA
25	W	Working (gate)	-
28	T	*	NA
28	W	Working (wall)	-
29	T	Working (gate)	-
30	T	Working (wall)	-
30	W	"	-
31	T	"	-
32	W	"	- (Air Force area)
	9T/5W		

T: Transit shed, W: Warehouse

(3) Basic Structural Type

Waterfront Structure

Quay structure consists of reinforced concrete deck cast in situ and/or precast deck supported by prestressed concrete piles.

Width of the unit deck is 50m. Since the apron width is 25m, foundation for seaward wall of transit sheds rest on the middle of the deck.

Land use behind the quay apron is of ordinary arrangement. Average land depth is about 425m and is divided into three parallel zones as follows:

- First zone : Quay apron and transit sheds or open storage yards.

- Second Zone : Open storage yard

- Third zone : Used Commonly between the warehouses and open storage yard.

Storage Yard

Similar arrangement is adopted as for the Ten Berth Extension. According to the PSO information, all the existing land was created by means of land reclamation with selected materials. There are two types of pavement, namely asphalt pavement and concrete pavement.

Results of Visual Inspection

Similar to Ten Berth Extension area, there are a plenty of structural damage. Urgent repair works should be provided.

2.7 Review of Existing Structures

This subsection deals with structural review on the existing waterfront structures. The basis of analysis consist of design records, which are provided by PSO and visual inspection of existing wharf together with concrete core tests.

2.7.1 Necessity of Structural Review

Waterfront facilities including wharves jetties and piers are always under severe environmental conditions, namely chemical affection, wave force, current force, live loads including cranes on the deck and vessel impacts. Thus design and their construction are conducted under the special cautions. Accordingly more careful watching and repairing of damaged parts are provided also. For the marine structures, more efforts on the protective maintenance should be made before the collective maintenance.

Most of damages of waterfront facilities happen on the piles and under-surface of deck element. Thus repair works on them are so expensive, time-consuming and disturb the use of facility. One of reasons for these damages might be an over-loading on the structures. This may happen when an introduction of heavy equipment which was not expected during the design stage. In this respect, more exact functions should be allocated to the waterfront structures. Function allocation, modernization and required design for their structural upgrading in order to meet new func- tions for Imam Khomeini port will be studied in Chapter 6 and Chapter 7.

There are four basic questions in order to cope with the above aspects.

(1) Are the existing wharf structurally durable enough for the present utilization?

(2) What kind of rehabilitation works should be provided to the existing structures?

(3) What kind of routine repair works should be given to the existing structures regardless of their usage?

(4) What kind of structural strengthening should be made for upgrading the existing structures in order to meet the new functions?

The latter two questions will be answered in Chapter 8 of Preliminary Design. Thus this subsection concentrates on preparation of basic data for the first two questions.

"Protective maintenance" means maintenance works advance to possible damage while the collective maintenance are those works to be provided after happening of damages.

Definition of "rehabilitation works", "routine repair" and "upgrading" will be provided in Chapter 12.

2.7.2 Scope of Visual Observation of Existing Structures

In July 1994, visual observation including several quality testing of the existing wharves was carried out by ROD-BIT Engineering Co. of Iranian Consultant under supervision of the Study Team.

All the data obtained are complied in a main report with appendix drawings, namely "Field Report FR. No.5, Structural Survey at Imam Khomeini Port". This report contains not only the results obtained through visual observation of concrete structures but also those of the Electric Potential Test, concrete crushing tests and chemical content tests in and our of the site.

Deterioration state of the reinforced concrete structures are statistically evaluated and the intrusion of aggressive agents such as chloride and sulphate into the concrete are investigated by determination of concentration Cl & SO_4 ions in 5 centimeter slices taken from concrete core samples of slabs.

(1) Introduction

There are a total of 34 berths at the port which can be divided into six groups as follows (Fig. 2.7.2.1):

Group 1: Berths No.1 through 6 on the Eastern Jetty and Western Jetty are classified in this group. These jetties are constructed from wooden deck, supported by steel H-shaped piles and are currently under large scale rehabilitation works by PSO. These works include an entire replacement of superstructure above the low water by new steel frames and new concrete deck construction of reinforced concrete. This group was however excluded from the investigation.
Group 2: Berth No. 7 to berth No. 10 (Marginal wharves)
Group 3: Berth No. 11 to berth No. 15 (Marginal wharves)
Group 4: Berth No. 16 to berth No. 20 (Marginal wharves)
Group 5: Berth No. 21 to berth No. 26 (Marginal wharves)
Group 6: Berth No. 27 to berth No. 34 (Marginal wharves)

Structural survey is carried out on berths Group 2 through 6. Location of wharfs for the detailed visual observation is fixed by the Study Team after a quick review of the existing situation. Preliminary Visual Observation (PVO) was directly performed by the Study Team. In order to prepare more comprehensive data the survey report also contains PVO records. Technical specification for this survey is attached in Appendix.

In order to have a reference for the easy location of structures to be studied the respected number of each fender is marked by red colour. The last fender of western block of berth No. 34 is fender No. 1 and the first fender of eastern block of berth No. 7 is fender No. 333. Table 2.7.2.1 shows fender numbers of each berth.

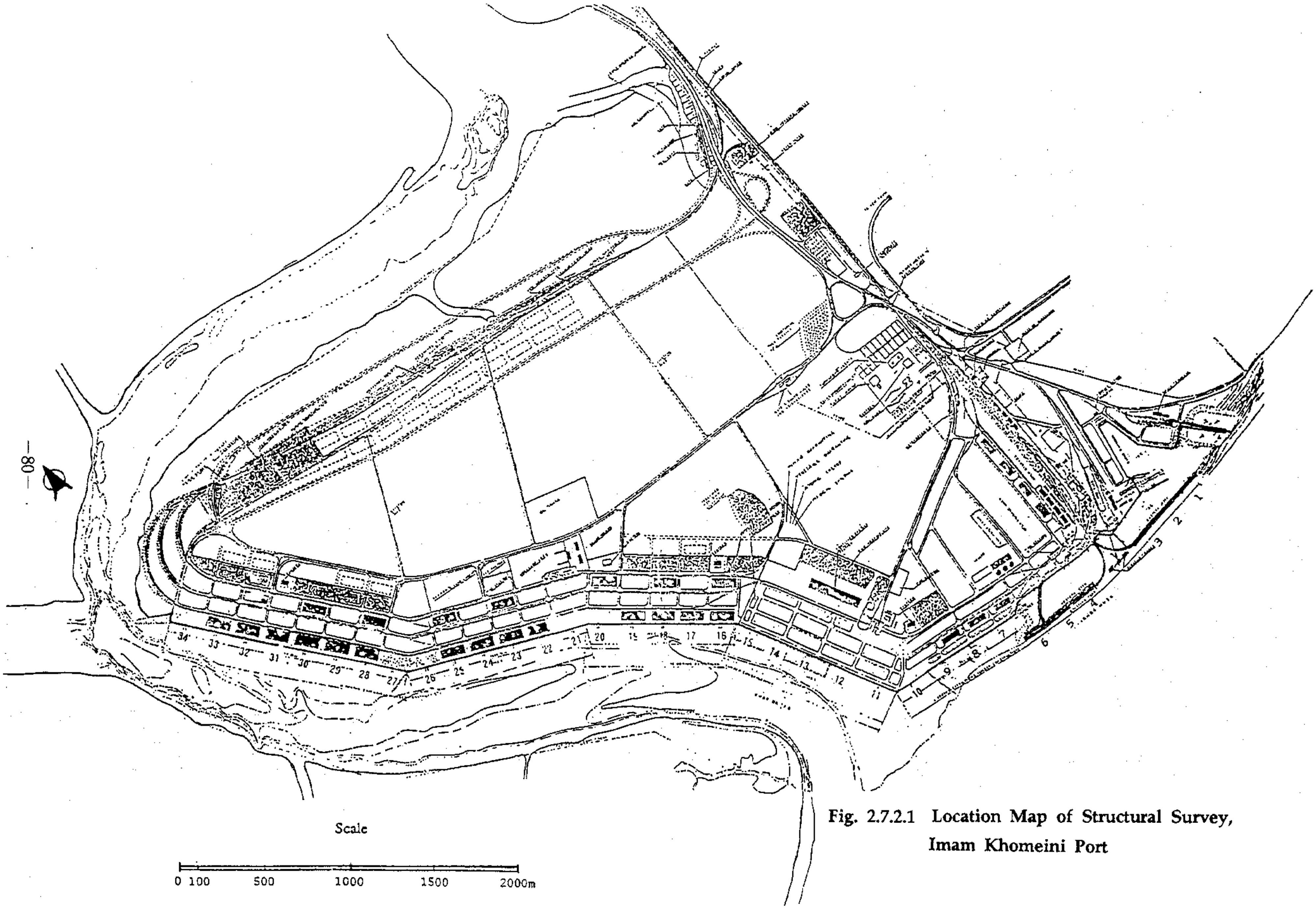


Fig. 2.7.2.1 Location Map of Structural Survey, Imam Khomeini Port

Table 2.7.2.1 Fender Numbers Appropriated to Each Berth

Fender No.	Berth No.	Group
From Fender No. 1 to Fender No. 13	34	6
From Fender No. 14 to Fender No. 25	33	6
From Fender No. 26 to Fender No. 37	32	6
From Fender No. 38 to Fender No. 49	31	6
From Fender No. 50 to Fender No. 61	30	6
From Fender No. 62 to Fender No. 73	29	6
From Fender No. 74 to Fender No. 85	28	6
From Fender No. 86 to Fender No. 97	27	6
From Fender No. 98 to Fender No. 111	26	5
From Fender No. 112 to Fender No. 123	25	5
From Fender No. 124 to Fender No. 135	24	5
From Fender No. 136 to Fender No. 147	23	5
From Fender No. 148 to Fender No. 159	22	5
From Fender No. 160 to Fender No. 170	21	5
From Fender No. 171 to Fender No. 183	20	4
From Fender No. 184 to Fender No. 195	19	4
From Fender No. 196 to Fender No. 207	18	4
From Fender No. 208 to Fender No. 219	17	4
From Fender No. 220 to Fender No. 230	16	4
From Fender No. 231 to Fender No. 246	15	3
From Fender No. 247 to Fender No. 260	14	3
From Fender No. 261 to Fender No. 273	13	3
From Fender No. 274 to Fender No. 290	12	3
From Fender No. 291 to Fender No. 304	11	3
No Fender at present	10	2
No Fender at present	9	2
From Fender No. 305 to Fender No. 320	8	2
From Fender No. 321 to Fender No. 333	7	2

(2) Scope of Works

The structural survey consist of six work components as follows:

- Preliminary Visual Observation (PVO):

  The existing condition of piles, pile caps, beams, capping beams and slabs of 12 blocks of 12 berths (one block per berth) are investigated and deterioration state of concrete structures are classified in accordance with Damage Grade scale as indicated in Table 2.7.6.1 Selected berths for the observation are shown in Table 2.7.2.2.

- Detailed Visual Observation (DVO):

  The existing condition of piles, pile caps, beams, capping beams and slabs of 22 blocks of 11 berths (two blocks per berth) are investigated and deterioration state of concrete structures are classified in accordance with Table 2.7.6.1. Selected berths for DVO are also shown in Table 2.7.2.2.

- Concrete Core Sampling (CCS):

  In order to check the compressive strength and chemical contents of concrete themselves, a total of 15 core samples of the slabs were taken. Table 2.7.2.3 shows the locations of concrete core samplings.

- Laboratory Tests:

  The compressive strength of core samples taken from slabs are determined by crushing test. Chemical analyses such as chloride & sulphate tests as well as PH values are carried out on slices cut out of core samples each 5 cm in thickness.

- Electric Potential Test (EPT):

  Preliminary evaluation of the possible corrosion in the reinforcement of slabs and piles of selected berths are accomplished by Electric Potential measurements. Table 2.7.2.4 shows the locations of EPT's carried out.

- Schmidt Hammer Test:

  Approximate compressive strength of concrete structures at the site are evaluated by Schmidt Hammer test. Selected berth numbers for the test are No.11, No.15 No.25 and No.34. Concrete piles at the previous Four Berth Extension area are also tested.

Table 2.7.2.2 Selected Berths for Visual Observation

o: (DVO)
×: (PVO)

Berth No.	Block		
	West	Middle	East
7			×
11	o	o	
12		×	
14	o		o
15		×	o
16		o	o
17	o	o	
18			×
19	×		
20			×
21	×		
22		o	o
23	×		
24		o	o
25			×
26		×	
27	×		
28			×
30	×	×	
31	×	×	
32	×	×	
33	×	×	
34		×	×

Table 2.7.2.3 Location of Concrete Core Samples (CCS)

Sample No.	Berth No.	Fender No.	Distance from the Edge of Curtain Wall
S1	18	Between 207 & 208	2 m
S2	18	Between 207 & 208	5 m
S3	18	Between 207 & 208	46 m
S4	15	Middle of Fender 233	2 m
S5	15	Middle of Fender 233	5 m
S6	15	Middle of Fender 233	51 m
S7	25	Between 123 & 124	2 m
S8	25	Between 123 & 124	5 m
S9	25	Between 123 & 124	41 m
S10	29	Between 73 & 74	2 m
S11	29	Between 73 & 274	5 m
S12	29	Between 73 & 274	41 m
S13	11	Between 300 & 301	2 m
S14	11	Between 300 & 301	22.5 m
S15	11	Between 300 & 301	27 m

Table 2.7.2.4 Location of Electric Potential Tests (EPT)

Berth No.	No. of Tests	Location	Remarks
7	5	Slabs	
8	9	Piles	
Grain Jetty	5	Piles	Before repair works
Grain Jetty	5	Piles	After repair works
18	2	Slabs	
15	2	Slabs	
25	2	Slabs	
29	3	Slabs	
11	1	Slabs	

2.7.3 Outline of Survey Results

(1) Evaluation of concrete structures deterioration

Deterioration of concrete generally are wide spread in 15-20 years old concrete structures in the Persian Gulf region, perhaps this is due to the environmental conditions prevailing in this area. Soil, seawater and atmosphere contain large amount of chlorine and sulfur compounds. Temperature varies from 30°C to 50°C during summer with more than 25°C variation on the same day. The mean relative humidity is usually above 40% with frequent maximum value of 95%. The atmosphere is also contaminated with high concentration of salt particles and sulfur dioxide. Highly aggressive environment of this region causes the deterioration of the structures within a short period of their design life.

The causes of concrete deterioration at Imam Khomeini Port are corrosion of reinforcing steel, sulphate and chloride radicals attack and salt weathering of reinforced concrete. Among these, reinforcement corrosion is the most serious concrete durability diminishing problem. Ingress of chloride initiate corrosion of reinforcing steel, and the corrosion products formed on the steel are more voluminous than the steel which has been lost, therefore longitudinal cracks appear on concrete covers which, in many cases, result in the spalling of concrete cover.

Spalling of concrete covers have mainly been encountered in the pile caps, beams and capping beams. No major concrete deterioration has so far been observed in the slabs & piles.

(2) Summary of existing situation

Existing condition of structures are summarised as shown below together with other typical findings.

<u>General conditions</u>

1) Prestressed concrete piles have minor damage.
2) Concrete cappings for single pile have ordinary damage.
3) Concrete capping beams have extensive damage.
4) Precast concrete deck elements show also extensive damage.
5) Concrete in situ between the deck elements indicate severe damage where the damaged deck element is nearby.
6) Concrete in situ is generally good.
7) Pavement and upper slab on the deck are also damaged.

<u>Other typical findings</u>

1) Rate of damage is proportionally increase by use of it. The largest damage was found at the container berth, Berth No. 11 and No. 12.
2) Time difference in construction timing has minor effect to damage.
3) Berths No. 32 to 34, which were utilized by other government agency (military use), show another severe damage instead of minor cargo handling recorded in the

past.
4) Chemical test of concrete cores together with the electric potential tests indicate that reinforcement which is embedded in concrete are under the severe corrosive condition.
5) Concrete covering to reinforcement is 4 cm or less which is absolutely shortage against the normal criteria for marine concrete.

(3) Conclusion of structural survey

Conclusion of the structural survey at Imam Khomeini port can be summarized as follows. It is recommended however to carry out further investigation to obtain more exact conclusion.

- Spalling of concrete cover are the major type of deterioration on concrete structures at Imam Khomeini port. Generally it seems that the concrete cover on the reinforcement bars are not thick enough to protect the bars from influence of chemical attacks, therefore concrete cover have been worn out at many cases.

- Concrete slabs are sound almost at all berths. Bottom surface of slabs are not subjected to tidal action and at the top are protected by asphalt pavement.

- The majority of beams are deteriorated at their pre-cast elements.

- There are some cracks on pile caps and beams but it seems that the cracks are not due to settlement of piles. Perhaps applying of heavy loads on the deck and low thickness of concrete cover are the main reasons.

- There is no evidence showing large impact forces to create severe structural damages.

- Concrete of the curtain walls at the sea side were damaged approximately at 70% of the berths. Although rubber fenders are provided but it seems that damages are partly due to direct vessel contacts.

- There is no evidence indicating that age of structures is main factor on the damages. However the loading conditions may affect the grade of damages.

- Compressive strength of concrete by crushing tests is rather low and may be one of the main factor of damage.

- Chemical analyses of concrete core samples show that the concentration of chloride ions are two times more than the allowable amount. These chemicals intrude deep in concrete however its intensity gradually decreases by a half in the depth of 10 cm.

- Electric potential tests show that the most of structures are worse than allowable level (-0.35 V) indicating corrosive or heavy corrosive condition.

Table 2.7.3.1 Summary of Damaged Structures, Berth No. 11~34

Block	Description	Total No.	Total No. of sides	Damage Grade					
					1	2	3	4	5
Berth 11-34	Pile (No.)	3,718	-	3,591	7	66	54	-	-
	Pile (index)	-	-	96.6%	0.2%	1.8%	1.4%	-	-
	Pile cap (No.)	2,886	11,544	10,330	0	140	370	629	75
	Pile cap (index)	-	-	89.5%	0%	1.2%	3.2%	5.4%	0.7%
	Beam (No.)	6,169	-	5,108	1	75	312	649	24
	Beam (index)	-	-	82.7%	0.1%	1.2%	5.1%	10.5%	0.4%
	Cap beam (No.)	448	-	312	0	10	26	30	70
	Cap beam (index)	-	-	69.6%	0%	2.1%	5.8%	6.9%	15.6%
	Slab (No.)	3,048	-	3,042	0	1	2	3	-
	Slab (index)	-	-	99.7%	0%	0.1%	0.1%	0.1%	-

2.7.4 Quantitative Evaluation

All existing wharves along the Dorag Channel, Berth No. 11 to Berth No. 34, have been investigated. Scope of observation are as follows.

(1) Pile above MSL 3,718 piles

(2) Pile cap,

Single pile caps (2,886 caps) and Dual pile connecting beams (448 beams)

(3) Beam, 6,165 beams

Combined beam between precast concrete and concrete cast in situ

(4) Slab, precast deck element 3,048 elements

Table 2.7.3.1 shows the summary of observation. Table 2.7.4.1 shows the Damage Grade (D.G) by which all the observed elements were classified for further evaluation. Fig. 2.7.4.1, 2.7.4.2 and 2.7.4.3 show more details.
Damage grade 3 is the critical one beyond which damage becomes severe ones requiring for rehabilitation works.

Damage grades 1 to 3 ------ minor damage
Damage grades 4 and 5 ---- severe damage.

The major findings per each structural element are given below.

Piles

Piles have no severe damage at present. This might attribute to the quality of piles and careful handling of them during pile driving. The rate of minor repair is only 3.4%.

Pile Cap for single pile

Rates of minor and severe occurrence are 4.4 % and 6.1 % respectively. These consist of concrete cast in situ and typically damaged at the corner of members.

Beams

Rates of minor and severe damage occurrence are 1.3 % and 16.0 % respectively. These figures are the second worst next to the pile cap beams. Beam consists of concrete cast in situ and side faces of which are covered by two precast deck elements. Fig. 2.7.4 shows this with explanation. It is to be noted that only certain precast deck element shows like this. In many case, healthy deck element can be seen along the damaged one. This may attribute to following two reasons.

1) Only the part of element units has less quality of concrete than specified value.
2) Present covering concrete could not protect well the reinforcement.

Dual Pile Connecting Beams

This beam consists of reinforced concrete, which is cast in situ. It connects with two piles in order to support large loading such as container gantry crane and/or transit shed. This member has the worst damage condition than any other members. The rate of minor damage is 8.1 % and severe one raises to 23.3 %. Damage of this element is typically observed under the container gantry crane foundations.

There are generally two types of damages, namely quality damage and stress damage. In the latter case, direction of cracks should be located normally to the main stress. However, the shape of existing cracks shows that the main reason of damage should be due to the quality itself. There is no stress cracks. This part should firstly be selected for the urgent rehabilitation.

Slab

Condition of slab consisting of precast element is rather good. This may justify the adoption of precast element during the detailed design in 1974.

Table 2.7.4.1 Damage Grade (D.G)

D.G	Present Status and Possible Countermeasures
0	- No damage at preset - No problem should occur if present use continues
1	- No damage at present except minor hair crack and scratching - No problem should occur if present use continues - No repair work should be required
2	- There are crack but no structural damages - No problem should occur if present use continues. Monitoring should be made periodically. Maintenance work would be required in future.
3	- There are crack and a few damages. Structural strength begins to reduce - Little problems might occur if present use continues but repair works should be required. Monitoring of damaged parts should be conducted every two years. Repair records should be filed.
4	- There are heaving of concrete covers & some are partially fallen. There are R-bar exposures. Structural strength has already reduced but it is not critical. - Careful use of deck should be introduced on the damaged parts. However present use can be continued after required repair works are conducted. - Repair works should be conducted within a year in order to prevent main structure from severe damage. Repair records should be filed. If no repair work is provided, loading condition on deck should be restricted, however this is not a recommendable method. If repair works are not performed, damaged grade will advance to 5 within few years. Monitoring of damaged parts (or repaired parts) should be accomplished every year.
5	- Advanced damage of Grade 4. There are heavy structural damage that reached deep bar of the concrete members. R-bar are rusting & partly cut down. Damage will expand rapidly due to heaving of reinforcement. Concrete covers over R-bars will be easily fallen. - Urgent repair works of concrete should be accomplished as soon as possible. - Even after rehabilitation, loads on damaged deck may be restricted. If enough repair works are made for reinforcement, loading condition can be the same as before. Repair works both for reinforcement & concrete should be urgently performed in order to prevent failure of main structure. Repair record should be filed.

Source, JICA Study Team

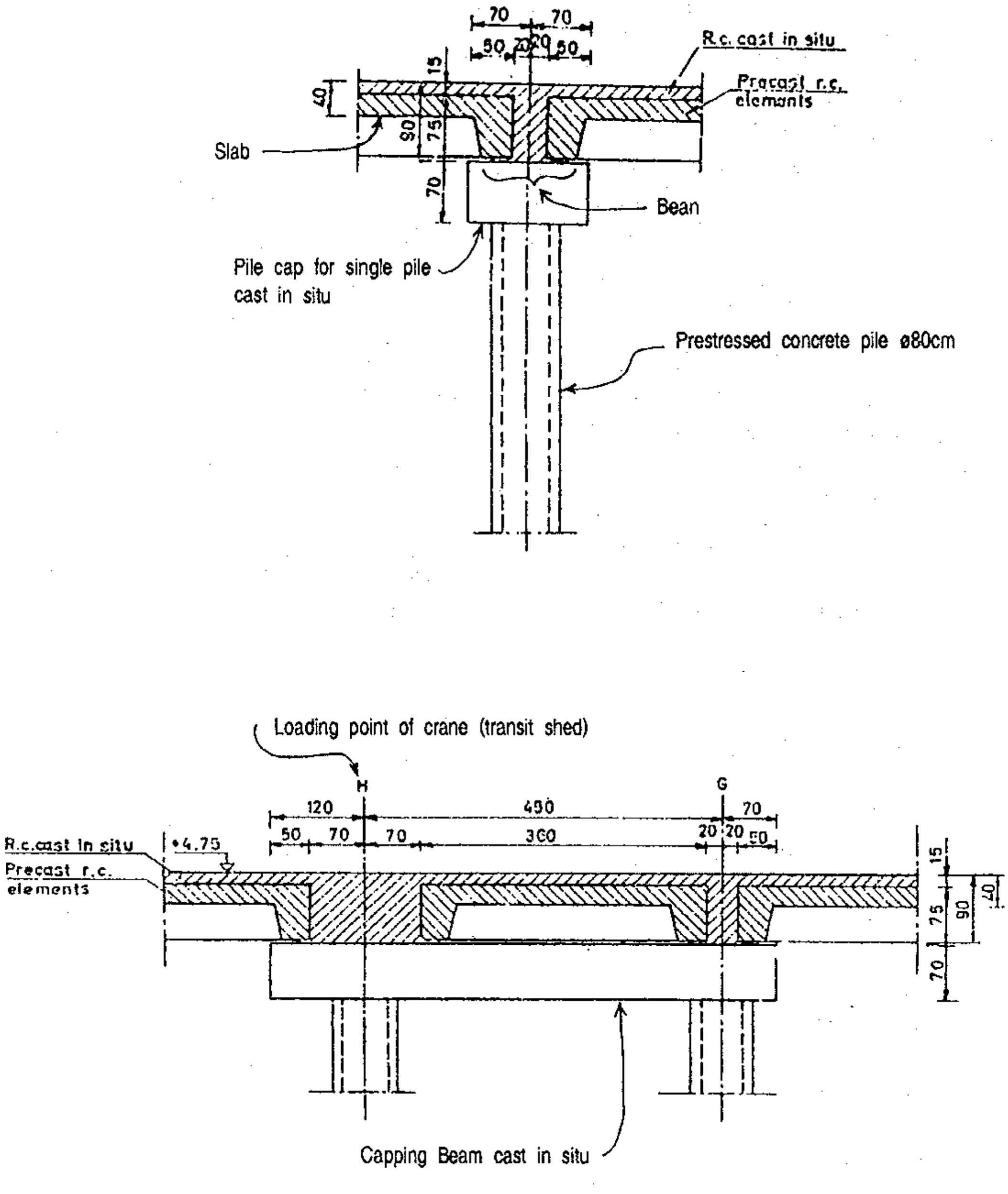


Fig. 2.7.4.1 Existing Wharf Deck Elements (1/2)

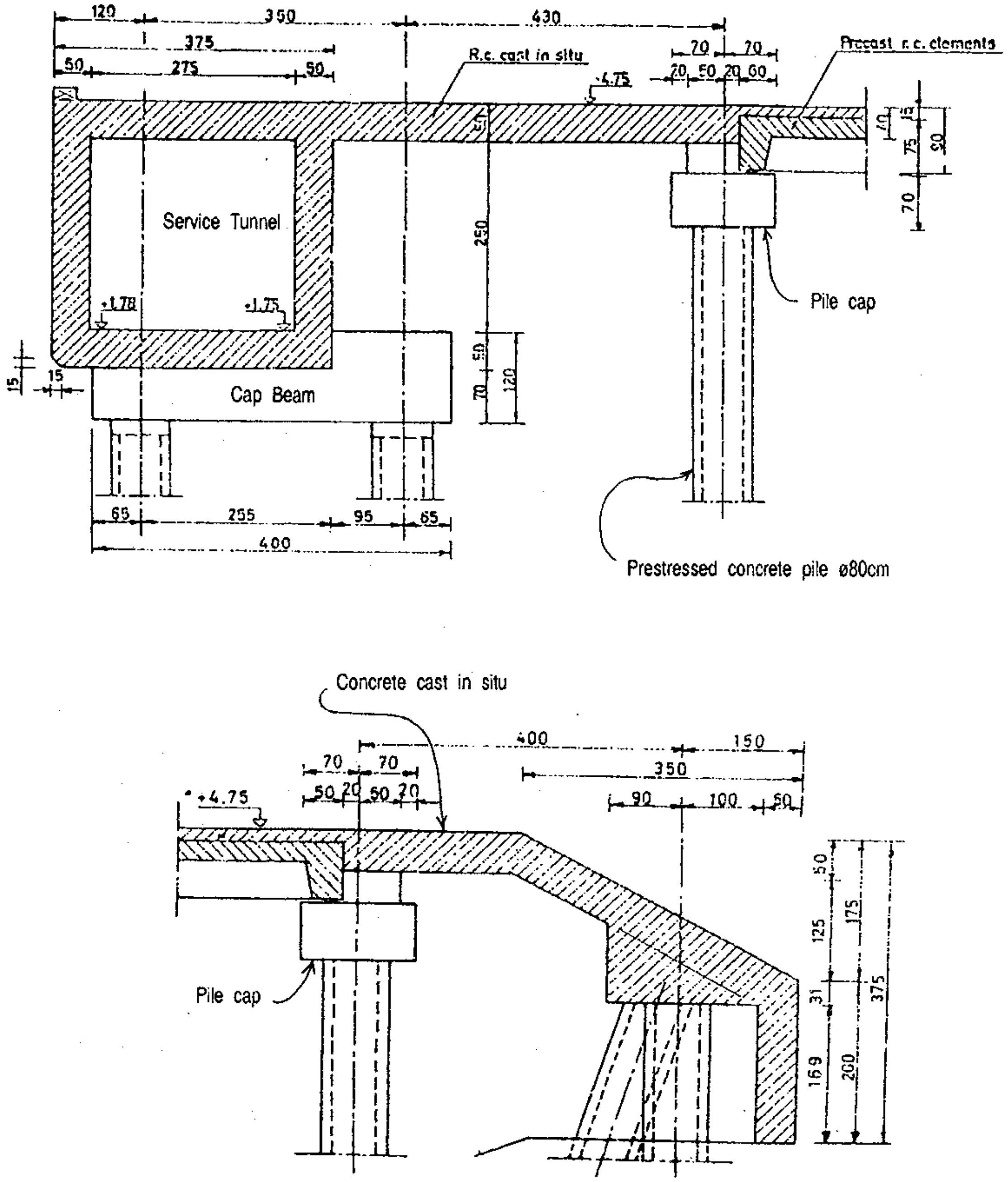
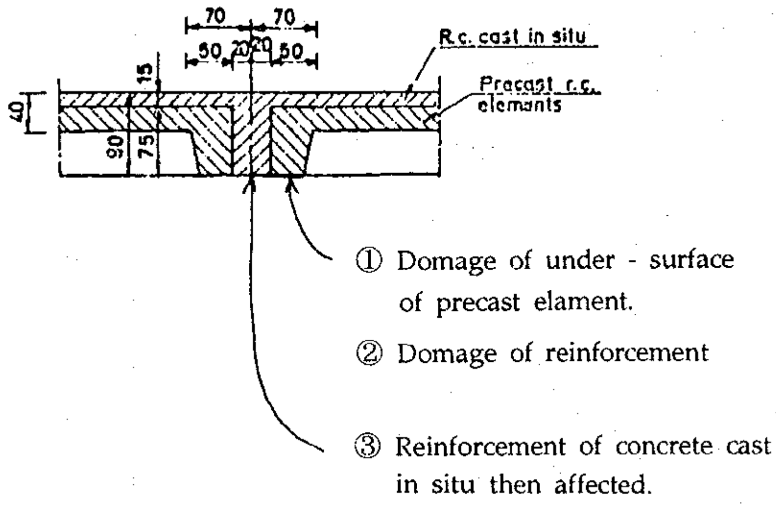


Fig. 2.7.4.2 Existing Wharf Deck Elements (2/2)



Note. Only part of precast element shows this.

Fig. 2.7.4.3 Typical Beam Damage

2.7.5 Evaluation of Damage by Actual Utilization

Fig. 2.7.5 shows the rate of damage occurrence based on the visual observation by the Study Team. The rate of damage occurrence is for those worse than Damage Grade 3. For the evaluation, the worst three structural members are selected, namely, cap beams, deck beams and pile caps. According to the previous study report of these berth construction, the time of construction was recorded as follows.

Ten Berth Extension	1976 to 1979 plus
Fourteen Berth Extension	1976 to 1980 plus

Difference on the completion time between both extensions is just minor thus it may not affect damage. Currently, transit sheds and warehouses in the northward of after Berth No. 24 are under construction. It is assumed that the berths which are located in the southward Berth No. 23 are actually utilized for cargo handling and storage.

(1) Dual Pile Connecting Beams (Cap beams)

This member has the most serious damage as shown in Table 2.7.5.1.

1) Damage of cap beams of present container berths (Berth No. 11 to 15) have widely happened and severe. (more than 40 % occurrence)
2) Berth No. 34 has the highest damage occurrence, more than 90 %
3) Berths No.17, 20, 22, 32, and 33 were damaged more than 5%.

These may indicate that heavy live loads on the deck also affect on the pile connecting beams.

There are two type of loads, namely live loads and dead loads. The former is the movable ones including cargo handling cranes and cargoes. The latter includes weight of fixed facility such as concrete deck and transit shed.

(2) Beams (Combined deck beam between the precast concrete and cast in situ concrete)

This member has the second worse damage.

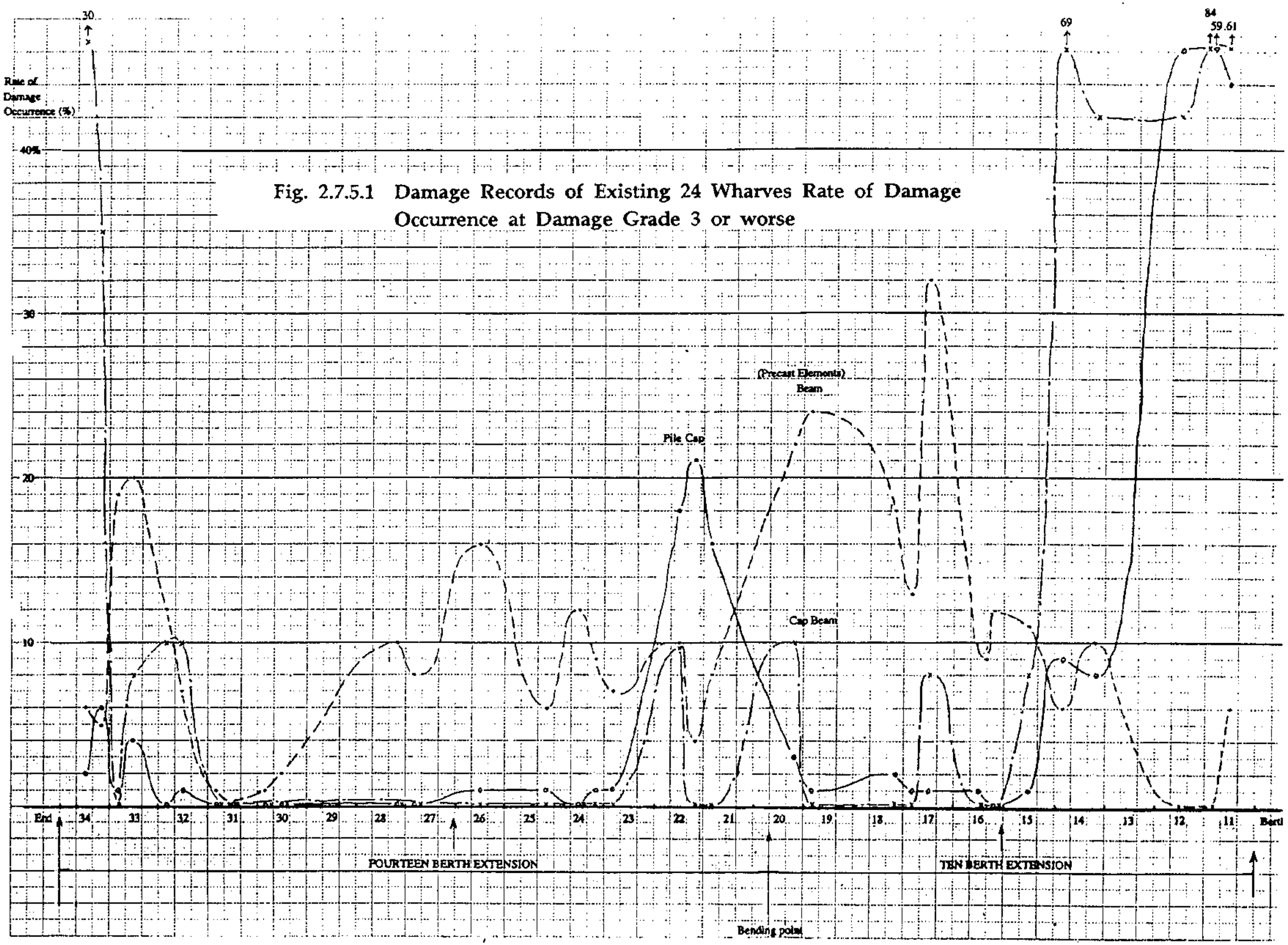
1) Beams of the northern five berths of previous Ten Berth Extension have seriously damaged, about 20 % damage occurrence. Southern five berths generally are more healthy than those of half northern in respect of beams.
2) Average damage occurrence in the previous Fourteen Berth Extension is about 10 %. Berth No. 33 has about 20 % damage occurrence.
3) It should be noted that there isn't any damaged structure except beams between Berth No. 23 and No. 31.
This may imply that main reason of beam damage is not by the loads but the quality of materials.

(3) Pile Cap (Single pile cap)

Pile cap is relatively healthy condition in comparison with the above two worsts.

1) There are two damage peaks, namely Berth No. 11 and 12 of Ten Berth Extension and Berth No. 21 and 22 of Fourteen Berth Extension.
2) Berth No. 14 and No. 15 have pile cap damage by 9 % occurrence.
3) At the western end damage at Berth No. 33 and No. 34 is increasing to 6 % occurrence.

Fig. 2.7.5.1 Damage Records of Existing 24 Wharves Rate of Damage Occurrence at Damage Grade 3 or worse



2.7.6 Evaluation by the Concrete Strength

In order to evaluate the existing concrete strength, two type of tests were carried out namely, the compressive strength test of core samples at the laboratory and preliminary strength measured by Schmidt hammer tests at site. For the former test, 15 core samples, three cores each five selected berths, were taken as shown in Table 2.7.1.3 For the latter, 15 tests at the piles of previous Four Berth Extension area and 44 tests at the structures of selected four berths.

Average strength by the core tests and Schmidt hammer test are 263 kg/cm^2 and 450 kg/cm^2 respectively. Table 2.7.6.1 and Table 2.7.6.2 indicate these test results. The core test results are more reliable.

Strength by core tests should be targets for evaluation than those of schmidt hammer tests. 263 kg/cm^2 is almost the allowable limit. Average strength of marine concrete should be 300 kg/cm^2 or more.

Table 2.7.6.1 Concrete Compressive Strength by Core Test

Sample No.	Berth No.	Compressive strength kg/cm^2	Member
S1	18	171 (T), 231 (B)	Service tunnel
S2	18	229	Front slab
S3	18	-	Rear slab
S4	15	380 (T), 198 (B)	Service tunnel
S5	15	-	Front slab
S6	15	-	Rear slab
S7	25	202	Service tunnel
S8	25	224	Front slab
S9	25	327	Beam
S10	29	222 (T), 364 (B)	Service tunnel
S11	29	236	Front slab
S12	29	-	Beam
S13	11	-	Service tunnel
S14	11	375	Beam
S15	11	-	Beam
Average		263	

Note: (T) Top of sample, (B): Bottom of sample

Table 2.7.6.2 Schmidt Hammer Test Results

Location	Compressive Strength Kg/cm²					Average kg/cm²
Pile of Berth No. 9	415 *400 *562	500 600 480	500 515 *562	448 545 500	500 *380 430	494
Berth No. 15	460 430	*395 480	*500 *395	430 480	460 *515	457
Berth No. 11	*590 460	*410 445	*430 430	430 *515	480 410	443
Berth No. 25	*530 515	480 460	515 *565	*410 *380	445 460	429
Berth No. 34	*360 380 345	410 500 *515	445 *<100 410	380 480 *515	460	424
Average						450

Note: For obtaining an average value, the lowest two and highest two are excluded (*).

2.7.7 Electric Potential Test

Preliminary evaluation of the possible corrosion in the reinforcement of slabs and piles of selected berths are accomplished by Electric Potential measurements. Table 2.7.7.1 shows the test results.

According to the past experience the electric potential relates to tendency of corrosion for reinforcement as follows.

Electric potential,

more than -0.300 volt .... No corrosion
-0.300 volt to -0.350 volt .... Doubtful zone
less than -0.350 volt .... Corrosive zone

As shown in the table, an average value is -0.487 volt which unfortunately belongs to the corrosive condition. The most corrosive value has been seen at the concrete pile at the grain jetty before the repair works. The next worst is observed at Berth No. 11, the container wharf. The best condition was found at Berth No. 29 however its value was -0.387 volt which is still among the corrosive condition.

The measured value at the concrete piles at the grain jetty after the repair works is -0.458 and improved by 25% than those before the works.

Table 2.7.7.1 Electric Potential Test Results

Location	Test Results in Volts					Average
Slabs of Berth No. 7	-0.4411	-0.4257	-0.4631	-0.4362	-0.4316	-0.440
Piles of Berth No. 8	-0.4617 -0.4150	-0.5343 -0.5122	-0.6059 -0.4713	-0.4162 -0.4417	-0.4612	-0.480
Grain Jetty Before Repair	-0.6128	-0.5949	-0.6715	-0.6813	-0.5849	-0.629
Grain Jetty After Repair	-0.4130	-0.3691	-0.5182	-0.4961	-0.4932	-0.458
Berth No.18	-0.3929	-0.4136				-0.403
Berth No.15	-0.4611	-0.5241				-0.493
Berth No.25	-0.5172	-0.4918				-0.505
Berth No.29	-0.3814	-0.3917				-0.387
Berth No.11	-0.5916					-0.592
Average						-0.487

2.7.8 Chemical Contents

Table 2.7.8.1 shows the summary of chemical content tests together with PH tests on seven core samples. Penetration of chloride and sulphate into the concrete and PH values have been measured. The laboratory tests were carried out on 5 cm slices (in a bottom to top direction). A value under the column of "2.5 cm" indicates a test result at the first section of 5 cm slices. Major findings are as follow.

(1) Chemical contents are decreasing by depth. Significant changes are seen in chloride.

(2) PH value constantly keep a high figure.

(3) Chloride at "2.5 cm" section is 0.32% which can be seen when concrete is mixed with seawater. The value at "7.5 cm" section is 0.15% which is a limit figure to protect reinforcement from the corrosive condition.

Table 2.7.8.1 Chemical Content Test Results

Sample No.	Berth No.	Chloride (%) cm			Sulphate (%) cm			PH cm		
		2.5	7.5	12.5	2.5	7.5	12.5	2.5	7.5	12.5
S1	18	0.56	0.28	0.18	1.60	1.38	1.63	11.95	11.80	11.85
S2	18		-			-			-	
S3	18		-			-			-	
S4	15		-			-			-	
S5	15		-			-			-	
S6	15	0.08	0.11	0.09	1.03	0.71	0.55	12.10	12.00	11.95
S7	25	0.37	0.09	0.09	0.50	0.75	0.89	11.95	11.95	11.85
S8	25	0.32	0.08	0.06	0.82	0.59	0.77	12.20	12.25	12.30
S9	25	0.54	0.37	0.28	1.35	1.18	0.65	11.75	11.80	11.75
S10	29		-			-			-	
S11	29		-			-			-	
S12	29	0.16	0.07	0.01	1.04	0.82	0.67	11.80	11.70	11.95
S13	11		-			-			-	
S14	11	0.21	0.14	0.15	1.52	1.12	1.05	11.95	12.10	11.95
S15	11		-			-			-	
Average		0.32	0.15	0.12	1.12	0.94	0.89	11.96	11.94	11.94

Chapter 3

Demand Forecast

Chapter 3 Demand Forecast

3.1 Commodity-wise Cargo Traffic Demand for the Port

In Chapter 3.5 of Volume I, cargo traffic demand at each study port was forecasted. Based on these results, commodity-wise cargo traffic demand at each study port was then forecasted.
Hereinafter, cargo traffic demand at Imam Khomeini port will be discussed for the Master Plan Study.

3.1.1 Past and Current Cargo Handling Volume in Imam Khomeini Port

Present economic activities in connection with port activities in a recent six-year period are shown in Table 3.1.1.1, Table 3.1.1.2 and Table 3.1.1.3. Figure 3.1.1.1, Figure 3.1.1.2 and Figure 3.1.1.3 show handled cargo volume by commodity type.

From 1988/89 to 1989/90, the handled cargo volume surged due to the end of the war. Then from 1989/90 to 1993/94 (with the exception of 1992/93, have been stagnant due to import controll of the government), the handled cargo volume grew steadily every year. This trend toward steady growth is seen not only at Imam Khomeini port but at all Iranian ports.

In particular, 1992/93, at which time the share of exports began to significantly climb, can be regarded as a transition year. The socio-economic structure of Iran seems to have clearly undergone changes since 1992/93 as a result of the economic policy.

Table 3.1.1.1 Total Cargo Volume at Imam Khomeini Port

Unloaded & Loaded (Import & Export) Unit: 1,000 tons

COMMODITY	1988/89		1989/90		1990/91		1991/92		1992/93		1993/94	
	tons	ratio	tons	ratio	tons	ratio	tons	ratio	tons	ratio	tons	ratio
DRY BULK	837	45.7%	2,185	38.8%	1,817	28.9%	2,044	22.8%	2,230	25.0%	2,071	20.6%
Barley	0	0.0%	176	3.1%	159	2.5%	106	1.2%	37	0.4%	208	2.1%
Wheat	551	30.1%	1,521	27.0%	1,171	18.6%	1,043	11.6%	1,460	16.4%	1,341	13.3%
Corn	163	8.9%	212	3.8%	242	3.8%	551	6.1%	700	7.8%	468	4.7%
Sulphur	123	6.7%	276	4.9%	245	3.9%	344	3.8%	0	0.0%	0	0.0%
Const. Material	0	0.0%	0	0.0%	0	0.0%	0	0.0%	33	0.4%	54	0.5%
Salt	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
LIQUID BULK	21	1.1%	36	0.6%	0	0.0%	0	0.0%	47	0.5%	69	0.7%
Molasses	0	0.0%	0	0.0%	0	0.0%	0	0.0%	43	0.5%	69	0.7%
Petroleum Products	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Vegetable Oil	21	1.1%	36	0.6%	0	0.0%	0	0.0%	4	0.0%	0	0.0%
Liquid Gas	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
BAGGED CARGO	462	25.2%	971	17.2%	654	10.4%	488	5.4%	2,605	29.2%	2,661	26.5%
Fertilizers	320	17.5%	634	11.3%	212	3.4%	119	1.3%	274	3.1%	279	2.8%
Chemical Material	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1,676	18.8%	1,702	16.9%
Sugar	35	1.9%	82	1.5%	110	1.7%	123	1.4%	233	2.6%	89	0.9%
Rice	107	5.8%	253	4.5%	225	3.6%	148	1.6%	195	2.2%	303	3.0%
Soy Bean	0	0.0%	2	0.0%	107	1.7%	98	1.1%	227	2.5%	288	2.9%
CONTAINER												
Others	15	0.8%	27	0.5%	62	1.0%	72	0.8%	73	0.8%	38	0.4%
REFRIGERATED GOODS												
Meat	15	0.8%	43	0.8%	18	0.3%	62	0.7%	64	0.7%	66	0.7%
STEEL MATERIAL												
Metallic Product	287	15.7%	689	12.2%	2,654	42.2%	4,076	45.4%	3,017	33.8%	3,679	36.6%
MINERAL	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Coal	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Copper	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
GENERAL CARGO	193	10.5%	1,680	29.8%	1,088	17.3%	2,240	24.9%	888	10.0%	1,463	14.6%
Dried Fruits & Nuts	0	0.0%	0	0.0%	1	0.0%	1	0.0%	20	0.2%	3	0.0%
Others	193	10.5%	1,680	29.8%	1,087	17.3%	2,239	24.9%	868	9.7%	1,460	14.5%
T O T A L	1,830		5,631		6,293		8,982		8,924		10,047	

Note: Classification of commodity-wise cargo is based on PSO data.
There are some differences between above cargo volume and records of calling vessels.
Material of metallic product, Iron Powder and Aluminum Powder etc, are included under Metallic Product in the records of calling vessels.
Source: Ports & Shipping Organization

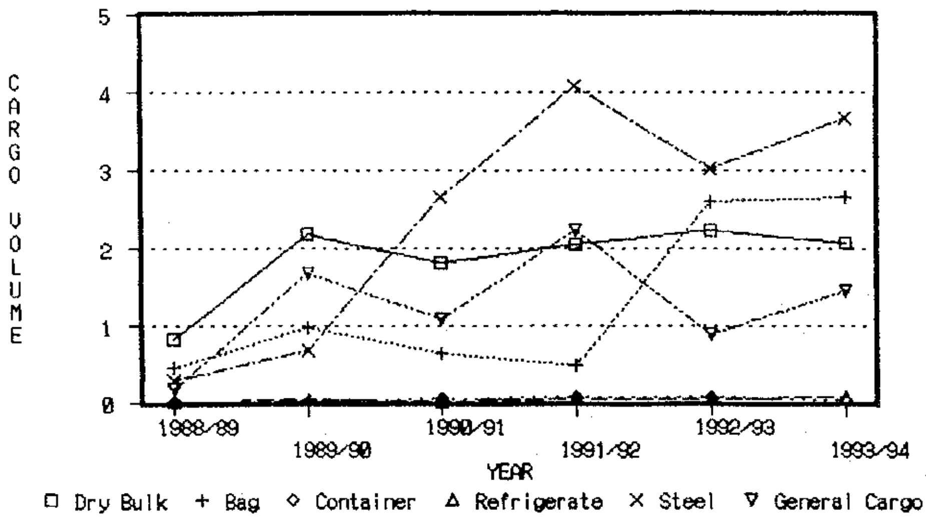


Figure 3.1.1.1 Total Cargo Traffic Movement at Imam Khomeini Port
(unit: million tons)

Table 3.1.1.2 Import Cargo Volume at Imam Khomeini Port

Bander Imam Khomeini — Unit: 1,000 tons

COMMODITY	1988/89		1989/90		1990/91		1991/92		1992/93		1993/94	
	tons	ratio	tons	ratio	tons	ratio	tons	ratio	tons	ratio	tons	ratio
DRY BULK	714		1,909		1,572		1,700		2,197		2,017	
Barley	0	0.0%	176	3.4%	159	2.7%	106	1.3%	37	0.5%	208	2.9%
Wheat	551	32.6%	1,521	29.5%	1,171	20.0%	1,043	13.2%	1,460	19.8%	1,341	18.5%
Corn	163	9.7%	212	4.1%	242	4.1%	551	6.9%	700	9.5%	468	6.4%
LIQUID BULK	21		36		0		0		4		0	
Petroleum Products	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Vegetable Oil	21	1.2%	36	0.7%	0	0.0%	0	0.0%	4	0.1%	0	0.0%
BAGGED CARGO	462		971		654		488		1,608		1,356	
Fertilizers	320	19.0%	634	12.3%	212	3.6%	119	1.5%	274	3.7%	279	3.8%
Chemical Material	0	0.0%	0	0.0%	0	0.0%	0	0.0%	679	9.2%	397	5.5%
Suger	35	2.1%	82	1.6%	110	1.9%	123	1.6%	233	3.2%	89	1.2%
Rice	107	6.3%	253	4.9%	225	3.8%	148	1.9%	195	2.6%	303	4.2%
Soy Bean	0	0.0%	2	0.0%	107	1.8%	98	1.2%	227	3.1%	288	4.0%
CONTAINER												
Others	0	0.0%	24	0.5%	52	0.9%	50	0.6%	70	1.0%	29	0.4%
REFRIGERATED GOODS												
Meat	15	0.9%	43	0.8%	18	0.3%	62	0.8%	64	0.9%	66	0.9%
STEEL MATERIAL												
Metallic Product	287	17.0%	689	13.4%	2,654	45.2%	4,076	51.4%	2,568	34.9%	2,674	36.8%
MINERAL												
Coal	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
GENERAL CARGO												
Others	189	11.2%	1,489	28.9%	916	15.6%	1,554	19.6%	857	11.6%	1,117	15.4%
TOTAL	1,688	100.0%	5,161	100.0%	5,866	100.0%	7,930	100.0%	7,368	100.0%	7,259	100.0%

Source: Ports & Shipping Organization

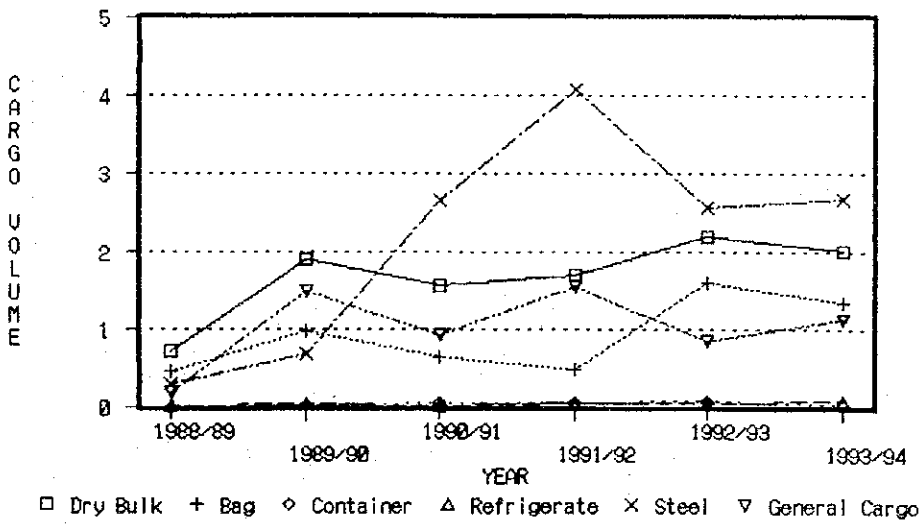


Figure 3.1.1.2 Import Cargo Traffic Movement at Imam Khomeini Port (unit: million tons)

Table 3.1.1.3 Export Cargo Volume at Imam Khomeini Port

Bander Imam Khomeini — Unit: 1,000 tons

COMMODITY	1988/89		1989/90		1990/91		1991/92		1992/93		1993/94	
	tons	ratio	tons	ratio	tons	ratio	tons	ratio	tons	ratio	tons	ratio
DRY BULK	123		276		245		344		33		54	
Sulphur	123	96.9%	276	58.7%	245	57.4%	344	32.7%	0	0.0%	0	0.0%
Const. Material	0	0.0%	0	0.0%	0	0.0%	0	0.0%	33	2.1%	54	1.9%
Salt	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
LIQUID BULK	0		0		0		0		43		69	
Molasses	0	0.0%	0	0.0%	0	0.0%	0	0.0%	43	2.8%	69	2.5%
Petroleum Product	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Liquid Gas	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
BAGGED CARGO	0		0		0		0		997		1,305	
Chemical Material	0	0.0%	0	0.0%	0	0.0%	0	0.0%	997	64.1%	1,305	46.8%
Rice	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
CONTAINER												
Others	0	0.0%	3	0.6%	10	2.3%	22	2.1%	3	0.2%	9	0.3%
REFRIGERATED GOODS												
Meat	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
STEEL MATERIAL												
Metallic Product	0	0.0%	0	0.0%	0	0.0%	0	0.0%	449	28.9%	1,005	36.0%
MINERAL												
Copper	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
GENERAL CARGO	4		191		172		686		31		346	
Dried Fruits & nuts	0	0.0%	0	0.0%	1	0.2%	1	0.1%	20	1.3%	3	0.1%
Others	4	3.1%	191	40.6%	171	40.0%	685	65.1%	11	0.7%	343	12.3%
TOTAL	127	100.0%	470	100.0%	427	100.0%	1,052	100.0%	1,556	100.0%	2,788	100.0%

Source: Ports & Shipping Organization

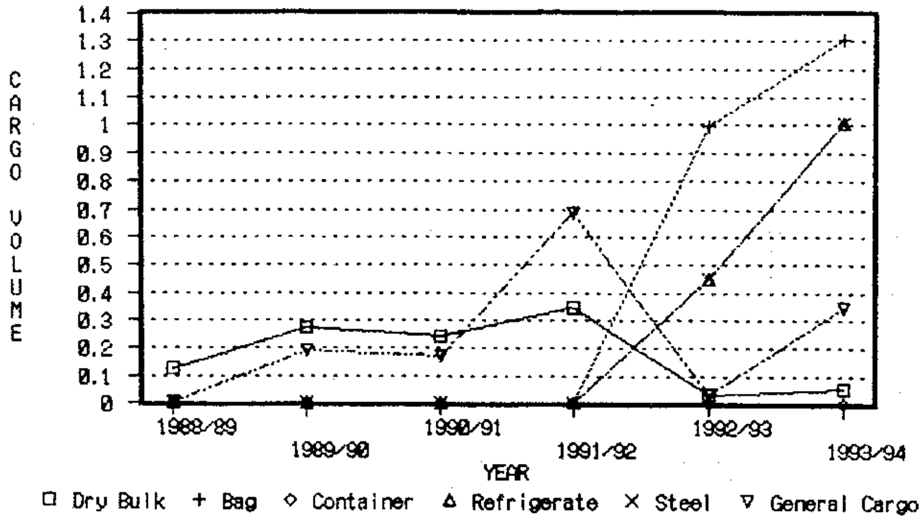


Figure 3.1.1.3 Export Cargo Traffic Movement at Imam Khomeini Port (unit: million tons)

3.1.2 Forecast Cargo Handling Volume in Imam Khomeini Port

Forecasted Commodity-wise cargo handling volume in the target years 2000/01 and 2010/11 is shown in the Table 3.1.2.1.

Table 3.1.2.1 Forecasted Cargo Handling Volume

(Unit: 1,000 tons)

Commodity	1993/94	2000/01	2010/11
Dry Bulk Cargo	2,071	3,711	4,505
Liquid Bulk	69	174	197
Bagged Cargo	2,661	3,375	5,405
Container Cargo	38	914	8,167
Refrigerated Cargo	66	219	410
Steel Product	3,679	4,434	6,650
Mineral (bulk)	0	99	133
General Cargo	1,463	2,762	4,473
Sub-Total	10,047	15,688	29,940
Transit Cargo	0	545	1,235
TOTAL	10,047	16,233	31,175

Note: 2000/01 & 2010/11 forecasted by the Study Team

Annual growth ratio of each commodity from 1993/94 to 2000/01 and from 2000/01 to 2010/11 is as follows.

Table 3.1.2.2 Annual Growth Rate

Commodity	1993/94 to 2000/01	2000/01 to 2010/11
Dry Bulk Cargo	8.7%	2.0%
Liquid Bulk	14.1%	1.2%
Bagged Cargo	3.5%	4.8%
Container Cargo	57.5%	24.5%
Refrigerated Cargo	18.7%	6.5%
Steel Product	2.7%	4.1%
Mineral (bulk)	120.0%	3.0%
General Cargo	9.5%	4.9%
TOTAL	6.6%	6.7%

Table 3.1.2.3 indicates the forecasted volume of import, export and total cargo by commodity. The change of export cargo shows a tendency to increase. The shares of export cargo in weight are estimated as 27.7%, 31.1% and 36.1% in 1993/94, 2000/01 and 2010/11 respectively.

Forecasted total cargo volume, import cargo volume and export cargo volume from present to the target years are also shown in Figure 3.1.2.1, 3.1.2.2 and 3.1.2.3 respectively.

Table 3.1.2.3 Forecasted Import & Export Cargo Handling Volume

Unit: 1,000 tons

COMMODITY	*1993/94(Actual Data)			**2000/01			**2010/11		
	Imp.	Exp.	Total	Imp.	Exp.	Total	Imp.	Exp.	Total
Dry Bulk	2,017	54	2,071	3,531	180	3,711	4,342	163	4,505
Liquid Bulk	0	69	69	47	127	174	55	142	197
Bagged Cargo	1,356	1,305	2,661	1,501	1,874	3,375	1,780	3,625	5,405
Container	29	9	38	793	121	914	4,786	3,381	8,167
Refrigerated Cargo	66	0	66	219	0	219	410	0	410
Steel Product	2,674	1,005	3,679	2,986	1,448	4,434	4,810	1,840	6,650
Mineral	0	0	0	99	0	99	133	0	133
General Cargo	1,117	346	1,463	1,640	1,122	2,762	2,807	1,666	4,473
Sub Total	7,259	2,788	10,047	10,816	4,872	15,688	19,123	10,817	29,940
Land Bridge Cargo	0	0	0	235	310	545	540	695	1,235
Total	7,259	2,788	10,047	11,051	5,182	16,233	19,663	11,512	31,175
Ratio of Imp/Exp	72.3%	27.7%		68.1%	31.9%		63.1%	36.9%	

Note: Forecasted cargo volume does not include transit cargo volume
*Source: *1993/94(Actual Data) ---- PSO Data*
***2000/01 & 2010/11 ------- Forecasted by the Study Team*

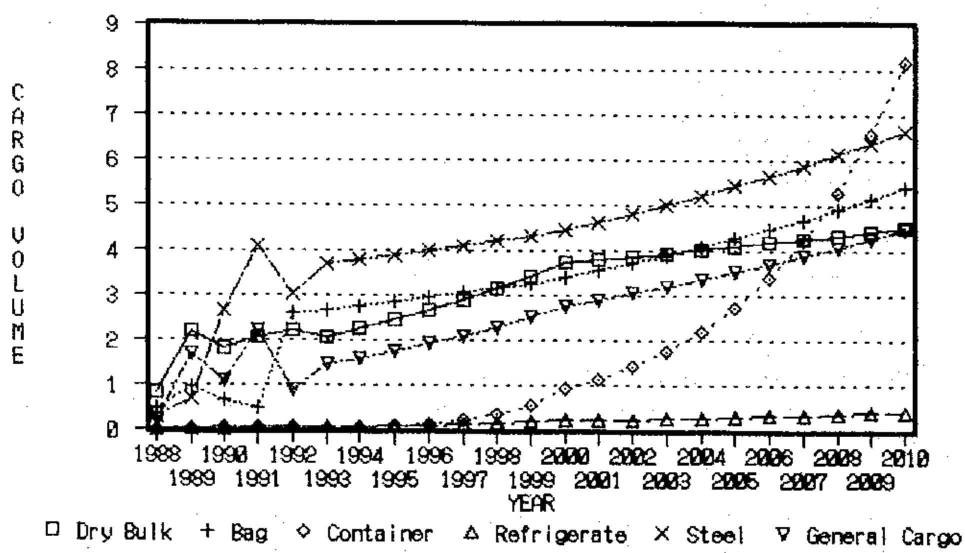


Figure 3.1.2.1 Forecast Total Cargo Traffic Movement
(unit: million tons)

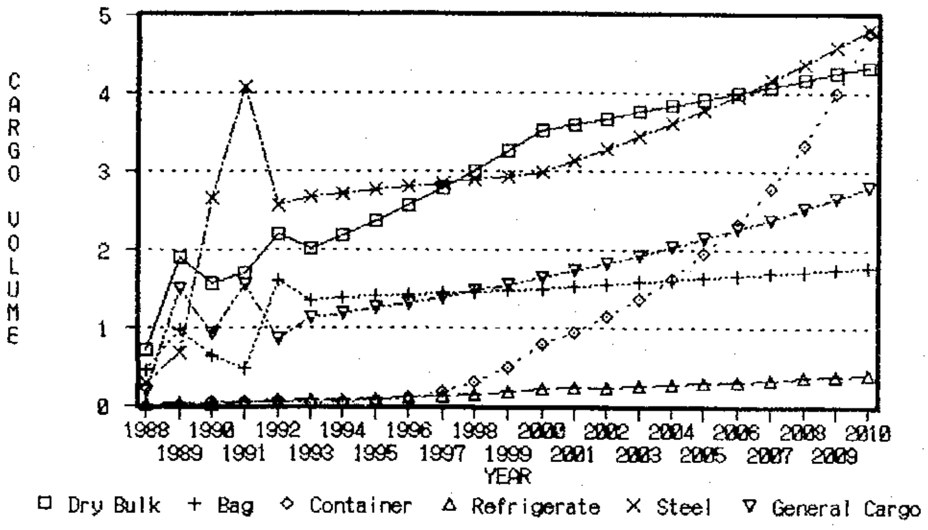


Figure 3.1.2.2 Forecast Import Cargo Traffic Movement

(unit: million tons)

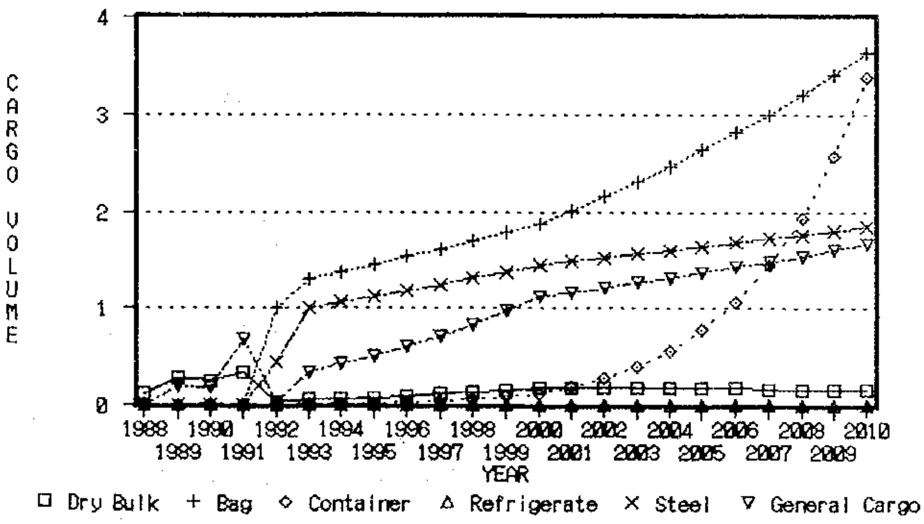


Figure 3.1.2.3 Forecast Export Cargo Traffic Movement

(unit: million tons)

3.2 O/D Analysis of Future Cargo Traffic

3.2.1 Share of Cargo Volume in Each Port by Analysis of Transport Cost

To obtain the cargo volume share of each port in the Persian Gulf, The transport network of each port's hinterland is analyzed.
Flowchart of the analysis is as follows :

Calculation of Transportation Cost and Time Port--Hinterland (A,B:port)
↓
Convert Time into Cost Calculation of Total Cost from Port to Hinterland (At,Bt)
↓
Reciprocal Number and Ratio (1/At:1/Bt)
↓
Share of each Port (A% B%)

Figure 3.2.1.1 The Procedure of The Cargo Volume Share Analysis

3.2.2 Method of analysis

(1) condition

Transport method and cost from Persian Gulf port to hinterland are as follows.

Case 1: Normal condition
Case 2: Transportation cost by ship is reduced
Case 3: Railway from Abbas to Tehran is not completed

Truck:	30.0 Rls/t/km	V=50km/h	conversion 2,000Rls/US$
Rail:	14.5 Rls/t/km	V=50km/h	conversion 2,000Rls/US$

Convert transportation time into cost
Rate: 20 %/year
Mean value of cargo: 1,000US$/t

1,000US$x0.2/365days/24h=0.0228US$/t/h

(2) Hinterland

Ports and their hinterland are shown in Table 3.2.2.1 and Figure 3.2.2.1.

Table 3.2.2.1 Ports and their Hinterlands

Hinterland (Province)	Core City	Port
Tehran, Zanjan, Semnan, Gilan Mazandaran, East Azarbayejan West Azarbayejan	Tehran	Khomeini port Rajaee port
Esfahan	Esfahan	Khomeini port Rajaee port
Khuzestan, Kohgiluye & Boyer-Ahmad, Chaharmahal & Bakhtiyari	Ahvaz	Khomeini port Rajaee port Bushehr port
Markazi, Bakhtaran, Kordestan Hamadan, Lorestan, Ilam	Arak	Khomeini port Rajaee port
Fars, Bushehr	Shiraz	Khomeini port Rajaee port Bushehr port
Yazd	Yazd	Khomeini port Rajaee port Bushehr port
Kerman, Sistan & Baluche tan Hormozgan	Kerman	Rajaee port Bushehr port Behesti port
Khorasan	Mashhad	Khomeini port Rajaee port Behesti port

Transport cost and time are calculated on the basis of the distance between the port and the core city of its hinterland. Transport time is converted to cost using the conversion factor (0.0228US$/t/h).

Each share of port is obtained based on the population of its hinterland and transportation cost.

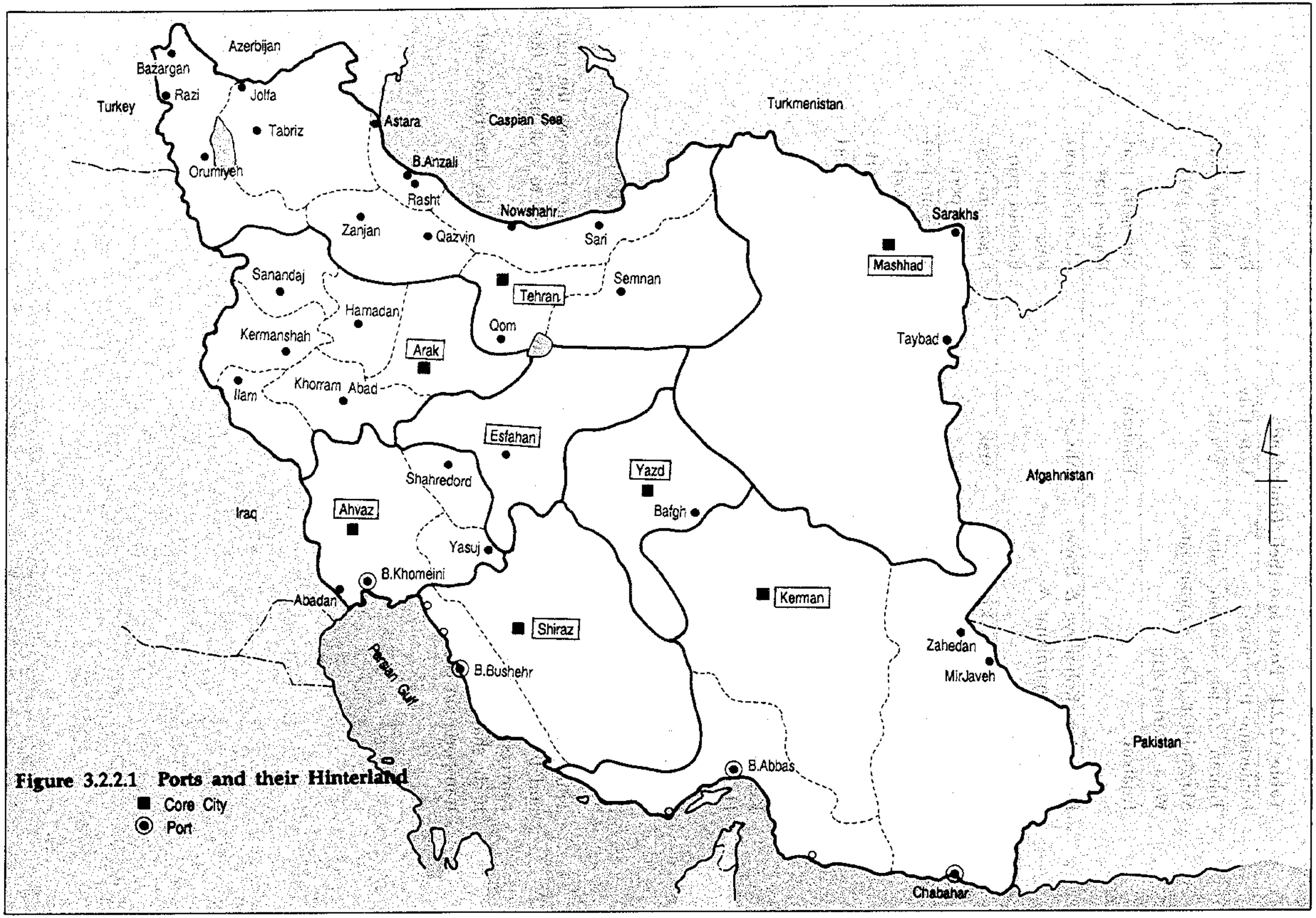


Figure 3.2.2.1 Ports and their Hinterland

Table 3.2.2.2 Calculation of Transportation Cost

Abbas-Khomeini-Tehran

Mode	US$	Hour	US$	Hour	Conversion US$
Ship+Truck(Kt)	5	36	15	21	21.30
Ship+Railway(Kr)	5	36	7	23	13.35

Abbas-Tehran

Mode	US$	Hour	US$	Hour	Conversion US$
Ship+Truck(At)	0	0	20	27	20.62
Ship+Railway(Ar)	0	0	11	37	11.84

Table 3.2.2.3 Calculation of 1/Kt:1/kr:1/At:1/Ar

Port---------- Hinterland	Mode		%	%
Khomeini---- Tehran	1/Kt	0.047	18	-
		0.075	29	48
Abbas------ Tehran	1/At	0.049	19	-
	1/Ar	0.084	33	52

Table 3.2.2.4 Share of Cargo Volume at Each Port(%)

Case 1

Hinterland	Khomeini	Rajaee	Busher	Behesti
Tehran	48	52	0	0
Esfahan	38	62	0	0
Ahvaz	60	23	17	0
Arak	49	51	0	0
Shiraz	25	38	36	0
Yazd	23	47	30	0
Kerman	0	63	0	37
Mashhad	47	28	0	26

Case 1 Khomeini port

(Population of Tehran Area)x0.48
(Population of Esfahan Area)x0.38

(Population of Mashhad Area)x0.38

Total Population of Hinterland
= Share of Cargo Volume(45%)

Case 1 Rajaee port

(Population of Tehran Area)x0.52
(Population of Esfahan Area)x0.62

(Population of Mashhad Area)x0.28

Total Population of Hinterland
= Share of Cargo Volume(46%)

Table 3.2.2.5 Share of Cargo Volume in Each Port(%)

	Khomeini	Rajaee	Busher	Behesti
Case 1	45	46	4	6
Case 2	48	42	4	6
Case 3	61	30	4	6
1993	53	41	3	3
2010	49	43	4	2

(3) Result

Transportation cost(US$5) by ship from Abbas port to Imam Khomeini port has a great influence on the use of Imam Khomeini port. In case 2, in which the transport cost per ton is reduced to US$2.5, shares of Imam Khomeini port and Abbas port are reversed.

Table 3.2.2.6 Share of Cargo Volume at Imam Khomeini Port & Abbas Port

	Khomeini	Abbas
Case 1	45%	46%
Case 2	48%	42%

Case 3 assumes that railway from Abbas port to Tehran is not completed. In this case the share of Imam Khomeini port is 61% and Abbas port is 30%. In 1993 the share of Imam Khomeini port is 53% and Abbas is 41%

Table 3.2.2.7 Comparison of Share of Cargo Volume

	Khomeini	Abbas
Case 3	61%	30%
1993	53%	41%

The share of Imam Khomeini port in 1993 is smaller than that yielded by the study teams' analysis. This means that Imam Khomeini port has some problems with cargo transportation.

3.3 Shipload and Number of Ship Call

3.3.1 Present Condition of Vessel-size and Vessel-calling

(1) Calling Vessels

The number of calling vessels at Imam Khomeini port from 1990/91 to 1992/93 is as follows:

Table 3.3.1.1 Total Calling Vessel at Imam Khomeini Port

(unit: number of ship)

Year	1990/91	1991/92	1992/93
Vessel	332	452	507

Source: PSO

(2) Average Vessel-size and Average Unloaded Cargo Volume

Table 3.3.1.2 indicates number of calling vessels, average dead weight ton (DWT), average import cargo volume and loading rate (L.R) by commodity-wise cargo from 1990/91 to 1992/93 at Imam Khomeini port.

(3) Calling Vessels and Vessel-size (DWT) by Commodity-wise Cargo

The yearly transition and trend of calling vessel-size (DWT) by each commodity-wise unloaded cargo from 1990/91 to 1992/93 at Imam Khomeini port are as follows.

Table 3.3.1.2 Average Vessel-size & Imported Cargo at Imam Khomeini Port

Unit:tons

	1990				1991				1992				1990-91-92		
	Ship	Av.DWT	Av.Cargo	L.R	Ship	Av.DWT	Av.Cargo	L.R	Ship	Av.DWT	Av.Cargo	L.R	Av.DWT	Av.Cargo	L.R
Dry Bulk															
Barley	4	39,286	25,968	66.1%	6	40,701	32,954	81.0%	0	-	-	-	40,135	30,160	75.1%
Corn	10	40,755	31,300	76.8%	12	34,555	31,417	90.9%	15	37,672	34,259	90.9%	37,494	32,538	86.8%
Fertilizer	9	35,349	30,772	87.1%	5	31,304	26,908	86.0%	5	34,253	32,442	94.7%	33,996	30,195	88.8%
Wheat	28	42,079	38,695	92.0%	31	42,236	40,042	94.8%	33	45,336	40,637	89.6%	43,300	39,845	92.0%
Total	51				54				53						
Average		40,413	34,849	86.2%		39,346	36,122	91.8%		42,121	38,059	90.4%	40,621	36,361	89.5%
Bag Cargo															
Rice	11	30,668	21,253	69.3%	8	29,676	23,747	80.0%	14	22,809	15,747	69.0%	27,093	19,522	72.1%
Soya Bean	2	35,839	26,249	73.2%	4	27,996	23,715	84.7%	10	26,085	19,725	75.6%	27,782	21,538	77.5%
Sugar	9	25,139	14,224	56.6%	9	17,721	14,062	79.4%	15	16,043	14,706	91.7%	18,981	14,399	75.9%
Chemical Material	17	22,024	18,392	83.5%	14	22,581	5,643	25.0%	27	17,283	13,721	79.4%	19,951	13,140	65.9%
Cement	0	-	-	-	8	***	***	***	18	***	***	***	***	***	***
Total	39				43				84						
Average		25,889	18,640	72.0%		23,572	14,011	59.4%		19,507	15,284	78.4%	22,059	15,743	71.4%
Container	7	17,694	5,487	31.0%	4	23,720	9,582	40.4%	10	18,474	3,641	19.7%	19,213	5,388	28.0%
Refrigerated															
Meat	2	15,216	4,478	29.4%	16	20,679	6,314	30.5%	15	15,216	4,839	31.8%	17,865	5,532	31.0%
Cheese	6	49,547	9,612	19.4%	4	12,142	8,289	68.3%	5	***	9,985	***	34,585	9,383	27.1%
Butter	4	26,659	5,553	20.8%	0	-	-	-	0	-	-	-	26,659	5,553	20.8%
Total	12				20				20						
Average		36,196	7,403	20.5%		18,972	6,709	35.4%		15,216	4,839	31.8%	22,171	6,289	28.4%
Steel															
Iron Product	78	28,653	18,346	64.0%	113	24,580	17,073	69.5%	88	27,386	16,730	61.1%	26,604	17,321	65.1%
Iron Ingot	6	17,715	9,999	56.4%	4	32,361	20,510	63.4%	4	31,189	20,882	67.0%	25,749	16,112	62.6%
Cast Iron	0	-	-	-	3	***	***	***	4	***	***	***	***	***	***
Total	84				120				96						
Average		27,872	17,750	63.7%		24,846	17,191	69.2%		27,551	16,911	61.4%	26,563	17,263	65.0%
Mineral															
Alminium Powder	4	48,062	34,000	70.7%	4	***	33,872	***	6	23,272	18,626	80.0%	33,188	24,776	74.7%
Iron Ore	11	58,630	39,433	67.3%	0	-	-	-	0	-	-	-	58,630	39,433	67.3%
Iron Powder	0	-	-	-	33	37,532	35,840	95.5%	25	42,487	41,573	97.8%	39,668	38,311	96.6%
Ore Powder	2	38,450	35,518	92.4%	2	36,909	35,797	97.0%	2	40,422	40,090	99.2%	38,594	37,135	96.2%
Phosphat Powder	5	35,790	33,525	93.7%	8	46,165	38,925	84.3%	11	43,254	39,193	90.6%	42,669	37,923	88.9%
Total	22				47				44						
Average		49,683	36,747	74.0%		39,109	36,412	93.1%		39,965	37,781	94.5%	41,589	37,032	89.0%
General Cargo															
Miscellane.	89	17,178	8,022	46.7%	115	16,654	4,727	28.4%	149	17,487	4,015	23.0%	17,138	5,257	30.7%

Note: All data is based on import cargo.

**** Lack of sufficient information*

Source: Ports & Shipping Organization

1) Dry Bulk Cargo

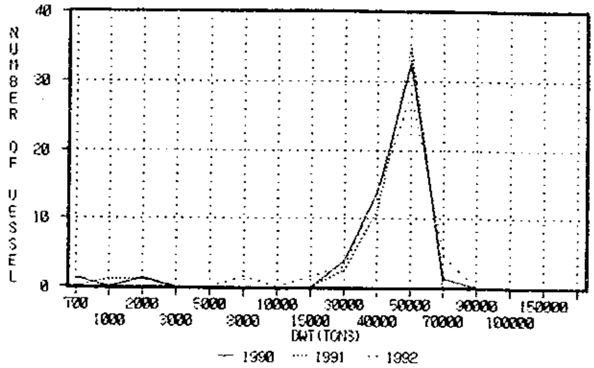
According to Table 3.3.1.3 and Figure 3.3.1.1, there was no distinct trend in the size of vessels from 1990 to 1992. The average vessel size was 40,000-50,000 DWT.

Table 3.3.1.3
Distribution of Calling Vessels

DRY BULK

Vessel Size (DWT)	1990	1991	1992
700	1	0	0
1,000	0	1	0
2,000	1	1	0
3,000	0	0	0
5,000	0	0	0
8,000	0	0	2
10,000	0	0	0
15,000	0	0	2
30,000	4	2	3
40,000	14	11	14
50,000	33	35	28
70,000	1	0	5
90,000	0	0	0
100,000	0	0	0
150,000	0	0	0
Over 150000	0	0	0
Total	54	51	53

Figure 3.3.1.1
Yearly Transition of Calling Vessel



2) Bagged Cargo

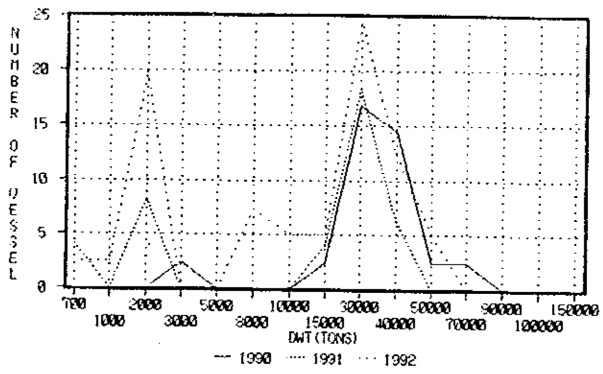
According to Table 3.3.1.4 and Figure 3.3.1.2, 1,000-2,000 DWT and 15,000-30,000 DWT vessels increased in number with the increasing cargo volume from 1990 to 1992. The average vessel size was 15,000-30,000 DWT.

Table 3.3.1.4
Distribution of Calling Vessel

BAG CARGO

Vessel Size (DWT)	1990	1991	1992
700	0	4	2
1,000	0	0	2
2,000	0	8	20
3,000	2	0	0
5,000	0	0	0
8,000	0	0	7
10,000	0	0	5
15,000	2	4	5
30,000	17	18	25
40,000	14	6	12
50,000	2	0	5
70,000	2	0	0
90,000	0	0	0
100,000	0	0	0
150,000	0	0	0
Total	41	41	84

Figure 3.3.1.2
Yearly Transition of Calling Vessel



3) Container Cargo

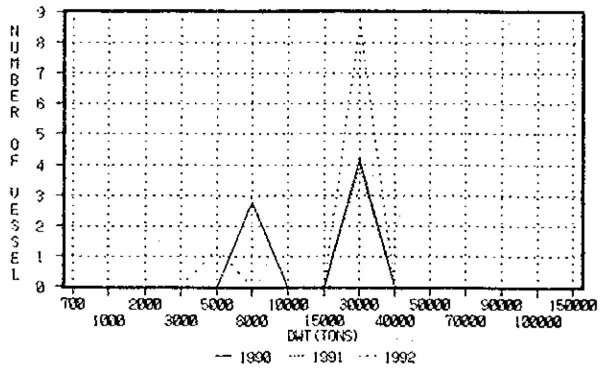
According to Table 3.3.1.5 and Figure 3.3.1.3, Container cargo volume remained low but the number of calling vessels increased. The average vessel size was 15,000-30,000 DWT.

Table 3.3.1.5
Distribution of Calling Vessel

FULL CONTAINER

Vessel Size (DWT)	1990	1991	1992
700	0	0	0
1,000	0	0	0
2,000	0	0	0
3,000	0	0	0
5,000	0	0	1
8,000	3	0	0
10,000	0	0	0
15,000	0	0	0
30,000	4	4	9
40,000	0	0	0
50,000	0	0	0
70,000	0	0	0
90,000	0	0	0
100,000	0	0	0
150,000	0	0	0
Total	7	4	10

Figure 3.3.1.3
Yearly Transition of Calling Vessel



4) Refrigerated Cargo

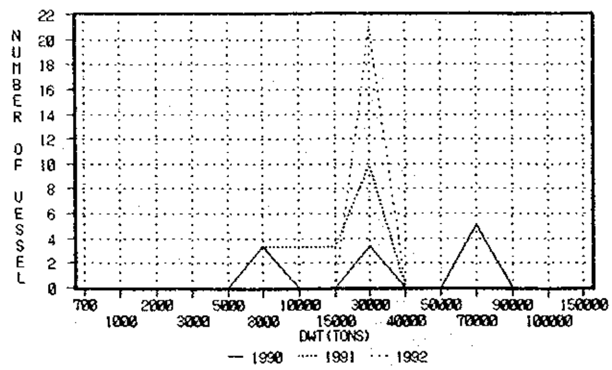
According to Table 3.3.1.6 and Figure 3.3.1.4, in 1990 and 1991, various sized vessels entered the port. In 1992, the size of all calling vessels was within 15,000 to 30,000 DWT.

Table 3.3.1.6
Distribution of Calling Vessel

REFRIGERATED

Vessel Size (DWT)	1990	1991	1992
700	0	0	0
1,000	0	0	0
2,000	0	0	0
3,000	0	0	0
5,000	0	0	0
8,000	3	3	0
10,000	0	3	0
15,000	0	3	0
30,000	3	10	21
40,000	0	0	0
50,000	0	0	0
70,000	5	0	0
90,000	0	0	0
100,000	0	0	0
150,000	0	0	0
Total	12	20	21

Figure 3.3.1.4
Yearly Transition of Calling Vessel



5) Steel Product

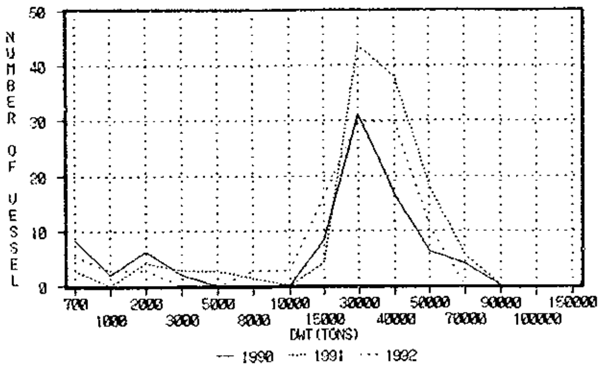
According to Table 3.3.1.7 and Figure 3.3.1.5, the size of calling vessels tended to increase from 1990 to 1991.

Table 3.3.1.7
Distribution of Calling Vessel

STEEL

Vessel Size (DWT)	1990	1991	1992
700	8	3	5
1,000	2	0	3
2,000	6	4	3
3,000	2	3	0
5,000	0	3	0
8,000	0	1	3
10,000	0	0	3
15,000	8	4	16
30,000	31	44	30
40,000	17	38	30
50,000	6	18	11
70,000	4	6	0
90,000	0	0	0
100,000	0	0	0
150,000	0	0	0
Total	85	124	103

Figure 3.3.1.5
Yearly Transition of Calling Vessel



6) Mineral(bulk)

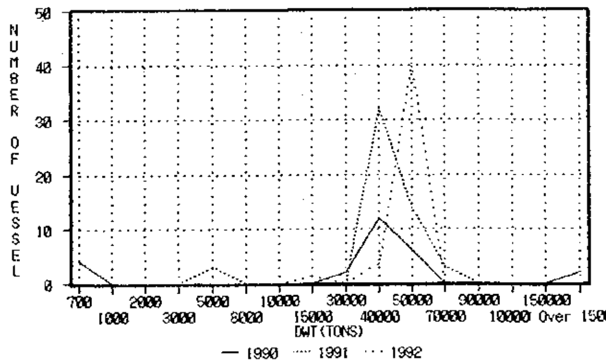
According to Table 3.3.1.8 and Figure 3.3.1.6, the size of calling vessels tended to increase from 1990 to 1992. Present average vessel size is 40,000-50,000 DWT.

Table 3.3.1.8
Distribution of Calling Vessel

MINERAL

Vessel Size (DWT)	1990	1991	1992
700	4	0	0
1,000	0	0	0
2,000	0	0	0
3,000	0	0	0
5,000	0	3	0
8,000	0	0	0
10,000	0	0	0
15,000	0	0	1
30,000	2	0	0
40,000	12	32	4
50,000	6	14	40
70,000	0	3	0
90,000	0	0	0
100,000	0	0	0
150,000	0	0	0
Over 150000	2	0	0
Total	26	52	45

Figure 3.3.1.6
Yearly Transition of Calling Vessel



7) General Cargo

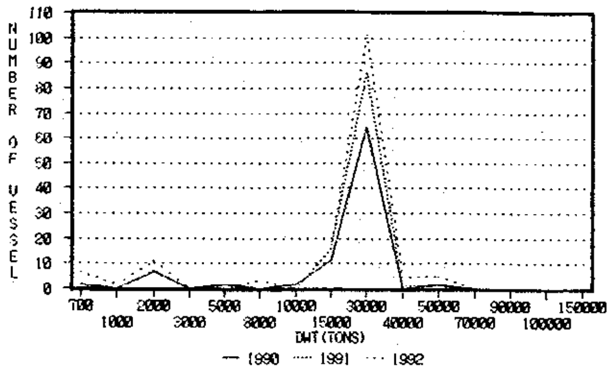
According to Table 3.3.1.9 and Figure 3.3.1.7, there was no distinct trend in the size of vessels from 1990 to 1992. The average vessel size was 15,000-30,000 DWT.

Table 3.3.1.9
Distribution of Calling Vessel

MISSCELLANEOUS

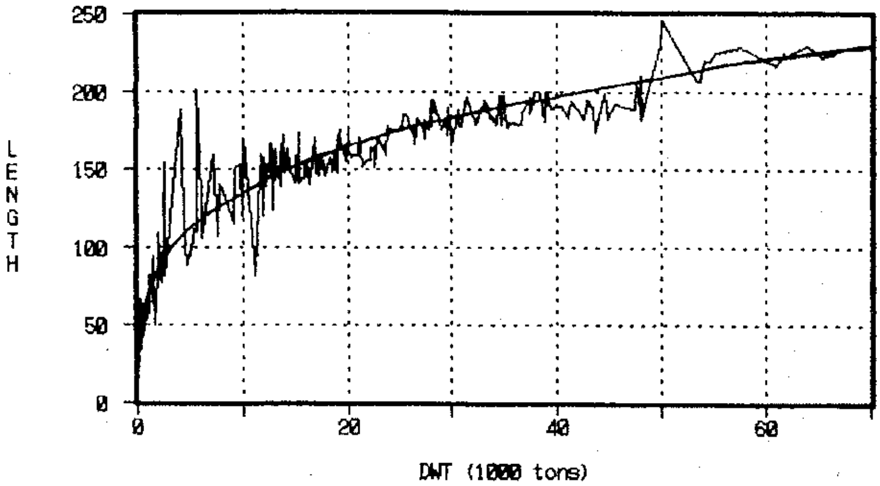
Vessel Size (DWT)	1990	1991	1992
700	2	1	6
1,000	0	0	2
2,000	6	7	11
3,000	0	0	0
5,000	2	1	0
8,000	0	0	3
10,000	2	0	0
15,000	11	16	16
30,000	65	86	101
40,000	0	1	5
50,000	2	1	5
70,000	0	0	0
90,000	0	0	0
100,000	0	0	0
150,000	0	0	0
Total	89	115	149

Figure 3.3.1.7
Yearly Transition of Calling Vessel



(4) Correlation with Vessel length and DWT

Figure 3.3.1.8 shows the correlation with vessel length and DWT of calling vessels at Imam Khomeini port from 1990 to 1992. The average length of calling vessels is as shown in Table 3.3.1.10.



Source: Calling Vessel Records (1990 - 1992) at Imam Khomeini Port

Figure 3.3.1.8 Correlation with Vessel Length and DWT

Table 3.3.1.10 DWT and Vessel Length

DWT (tons)	Length (m)
10,000	133
15,000	152
20,000	164
30,000	180
40,000	195
50,000	215
60,000	221
70,000	235

Note: Vessel Length obtained from Figure 3.3.1-4

3.3.2 Forecast of Vessel-size and Vessel-calling

The method of forecast of vessel-size and vessel-calling is shown in Figure 3.3.2.1.

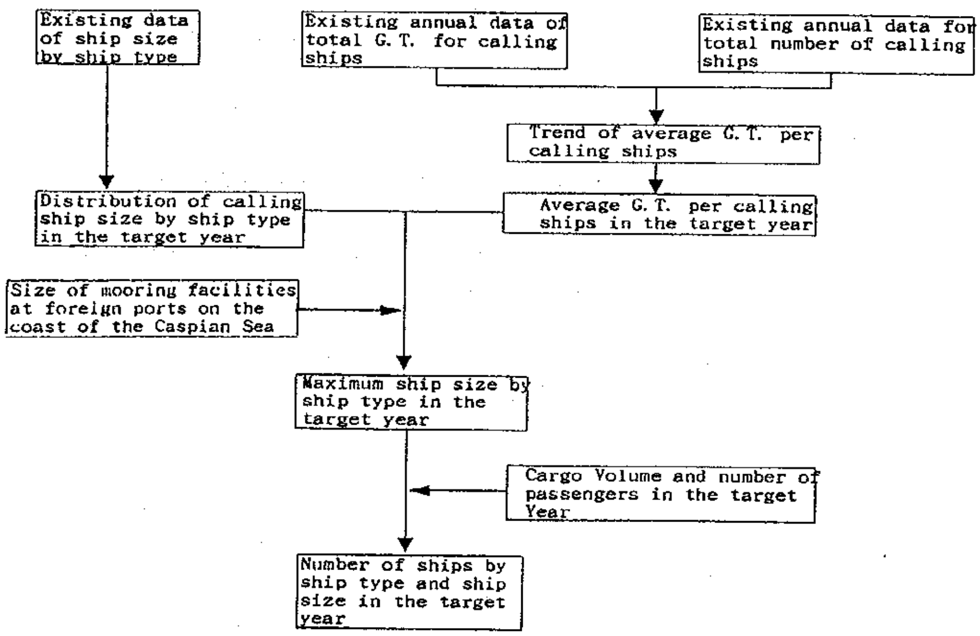


Figure 3.3.2.1 Flow Chart of Forecast for Ship Type and Number of Ship Call in Future

(1) Forecast of Vessel-size in Target Years

In the preceding chapter 3.3.1-(3), the present average vessel-size was determined by commodity-wise cargo. Hereinafter, future average vessel-size in target years at Imam Khomeini port will be forecasted by considering the following factors.

1) Yearly transition and trend of present vessel-size
2) Increase of commodity-wise cargo handling volume in the target years
3) Vessel-size trends in international marine transportation, especially container ship

After considering above mentioned factors, future average vessel-size in the target years is given in Table 3.3.2.1.

Table 3.3.2.1 Future Average Vessel-size (unit: DWT)

Ship Type	2000/01	2010/11
Bulk Ship (Bulk Cargo and Mineral)	45,000	50,000
Container ship	24,000	30,000
Mix type ship		
Bagged & Refrigerated cargo	26,000	30,000
Steel Product	28,000	30,000
General Cargo	23,000	30,000

Note: Vessel-size in 2010/11 is forecasted by the Study Team.
It is assumed that vessel-size will increase with a fixed rate from present vessel-size (Table 3.3.1.2) to forecasted vessel-size in 2010/11.

(2) Forecast of Vessel Calling

The average cargo loading ratio (cargo volume per vessel divided by vessel DWT) from 1990 to 1992 has already been examined as shown in Table 3.3.1.2 in Subsection 3.3.1.2. Hereby, average loading ratio by each commodity-wise cargo in target years will be examined as shown in the Table 3.3.2.2.

Table 3.3.2.2 Cargo Loading Ratio

Commodity	Loading Ratio (in 2000 & 2010)
(1) Dry Bulk Cargo	90%
(2) Bagged Cargo	75%
(3) Container Cargo	31%
(4) Refrigerated Cargo	30%
(5) Steel Product	65%
(6) Mineral (bulk)	89%
(7) General Cargo	30%

Hereinafter, the number and distribution of calling vessel-size by each commodity will be calculated by adding the difference of average DWT in target years and present average DWT from 1990 to 1992 to the DWT of each vessel which is based on actual data obtained from PSO. Then, forecasted cargo volume of each commodity is divided by the average vessel size and loading factor. Cargo handling volume in the target year was forecasted in the preceding Subsection 3.1.2.

The result of aforesaid study is as follows.

1) Dry Bulk Cargo

Table 3.3.2.3 Distribution of Calling Vessel for Dry Bulk Cargo

(unit: number of ship)

DRY BULK DWT	IMP. 1992/93	IMP.&EXP.2000 3711000/(45000*0.900)	IMP.&EXP.2010 4505000/(50000*0.900)
0 ~ 700	0	0	0
700 ~ 1000	0	0	0
1000 ~ 2000	0	0	0
2000 ~ 3000	0	0	0
3000 ~ 5000	0	0	0
5000 ~ 8000	2	0	0
8000 ~ 10000	0	0	0
10000 ~ 15000	2	0	0
15000 ~ 30000	3	2	2
30000 ~ 40000	14	16	2
40000 ~ 50000	28	69	30
50000 ~ 70000	5	5	65
70000 ~ 90000	0	0	2
90000 ~ 100000	0	0	0
100000 ~ 150000	0	0	0
Total	53	92	100

2) Bagged Cargo

Table 3.3.2.4 Distribution of Calling Vessel for Bagged Cargo

(unit: number of ship)

BAGGED CARGO DWT	IMP. 1992/93	IMP.&EXP.2000 3375000/(26000*0.75)	IMP.&EXP.2010 5405000/(30000*0.75)
0 ~ 700	2	0	0
700 ~ 1000	2	0	0
1000 ~ 2000	20	0	0
2000 ~ 3000	0	0	0
3000 ~ 5000	0	6	0
5000 ~ 8000	7	20	0
8000 ~ 10000	5	0	32
10000 ~ 15000	5	9	8
15000 ~ 30000	25	68	87
30000 ~ 40000	12	57	47
40000 ~ 50000	5	9	51
50000 ~ 70000	0	6	16
70000 ~ 90000	0	0	0
90000 ~ 100000	0	0	0
100000 ~ 150000	0	0	0
Total	84	173	240

3) Container Cargo

Table 3.3.2.5 Distribution of Calling Vessel for Container Cargo

(unit: number of ship)

FULL CONTAINER

DWT	IMP. 1992/93	IMP.&EXP.2000 1459000/(24000*0.31)	IMP.&EXP.2010 9402000/(30000*0.31)
0 ~ 700	0	0	0
700 ~ 1000	0	0	0
1000 ~ 2000	0	0	0
2000 ~ 3000	0	0	0
3000 ~ 5000	1	0	0
5000 ~ 8000	0	0	0
8000 ~ 10000	0	13	0
10000 ~ 15000	0	13	67
15000 ~ 30000	9	170	337
30000 ~ 40000	0	0	607
40000 ~ 50000	0	0	0
50000 ~ 70000	0	0	0
70000 ~ 90000	0	0	0
90000 ~ 100000	0	0	0
100000 ~ 150000	0	0	0
Total	10	196	1,011

4) Refrigerated Cargo

Table 3.3.2.6 Distribution of Calling Vessel for Refrigerated Cargo

(unit: number of ship)

REFREGERATED

DWT	IMP. 1992/93	IMP.&EXP.2000 219000/(26000*0.30)	IMP.&EXP.2010 410000/(30000*0.30)
0 ~ 700	0	0	0
700 ~ 1000	0	0	0
1000 ~ 2000	0	0	0
2000 ~ 3000	0	0	0
3000 ~ 5000	0	0	0
5000 ~ 8000	0	0	0
8000 ~ 10000	0	4	0
10000 ~ 15000	0	4	6
15000 ~ 30000	21	16	31
30000 ~ 40000	0	0	0
40000 ~ 50000	0	0	0
50000 ~ 70000	0	0	0
70000 ~ 90000	0	5	9
90000 ~ 100000	0	0	0
100000 ~ 150000	0	0	0
Total	21	28	46

5) Steel Product

Table 3.3.2.7 Distribution of Calling Vessel for Steel Product

(unit: number of ship)

STEEL

DWT	IMP. 1992/93	IMP.&EXP.2000 3284000/(28000*0.650)	IMP.&EXP.2010 5500000/(30000*0.650)
0 ~ 700	5	0	0
700 ~ 1000	3	0	0
1000 ~ 2000	3	0	0
2000 ~ 3000	0	0	0
3000 ~ 5000	0	5	0
5000 ~ 8000	3	2	7
8000 ~ 10000	3	0	2
10000 ~ 15000	16	14	5
15000 ~ 30000	30	93	141
30000 ~ 40000	30	40	74
40000 ~ 50000	11	19	35
50000 ~ 70000	0	8	17
70000 ~ 90000	0	0	0
90000 ~ 100000	0	0	0
100000 ~ 150000	0	0	0
Total	103	180	282

6) Mineral (bulk)

Table 3.3.2.8 Distribution of Calling Vessel for Mineral (bulk)

(unit: number of ship)

MINERAL

DWT	IMP. 1992/93	IMP.&EXP.2000 1249000/(45000*0.89)	IMP.&EXP.2010 1283000/(50000*0.89)
0 ~ 700	0	0	0
700 ~ 1000	0	0	0
1000 ~ 2000	0	0	0
2000 ~ 3000	0	0	0
3000 ~ 5000	0	0	0
5000 ~ 8000	0	0	0
8000 ~ 10000	0	0	0
10000 ~ 15000	1	0	0
15000 ~ 30000	0	0	0
30000 ~ 40000	4	10	0
40000 ~ 50000	40	18	13
50000 ~ 70000	0	2	15
70000 ~ 90000	0	0	0
90000 ~ 100000	0	0	0
100000 ~ 150000	0	0	0
Total	45	31	29

7) General Cargo

Table 3.3.2.9 Distribution of Calling Vessel for General Cargo

(unit: number of ship)

MISSCELLANEOUS

DWT	IMP. 1992/93	IMP.&EXP.2000 2762000/(23000*0.40)	IMP.&EXP.2010 4473000/(30000*0.40)
0 ~ 700	6	0	0
700 ~ 1000	2	0	0
1000 ~ 2000	11	0	0
2000 ~ 3000	0	0	0
3000 ~ 5000	0	0	0
5000 ~ 8000	3	14	0
8000 ~ 10000	0	0	0
10000 ~ 15000	16	3	17
15000 ~ 30000	101	260	203
30000 ~ 40000	5	12	134
40000 ~ 50000	5	8	9
50000 ~ 70000	0	3	10
70000 ~ 90000	0	0	0
90000 ~ 100000	0	0	0
100000 ~ 150000	0	0	0
Total	149	300	373

From above mentioned result, total calling vessels by each vessel-size is forecasted as in following Table 3.3.2.10 and Figure 3.3.2.2.

Table 3.3.2.10 Distribution of Calling Vessel

SHIP SIZE DWT(tons)	1992/93 (No.)	2000/01 (No.)	2010/11 (No.)
0 ~ 700	13	0	0
700 ~ 1000	10	0	0
1000 ~ 2000	33	0	0
2000 ~ 3000	0	0	0
3000 ~ 5000	4	10	0
5000 ~ 8000	13	35	7
8000 ~ 10000	8	17	34
10000 ~ 15000	41	42	103
15000 ~ 30000	195	609	801
30000 ~ 40000	62	135	864
40000 ~ 50000	118	123	137
50000 ~ 70000	10	24	123
70000 ~ 90000	0	5	10
90000 ~ 100000	0	0	0
100000 ~ 150000	0	0	0
TOTAL	507	1,001	2,080

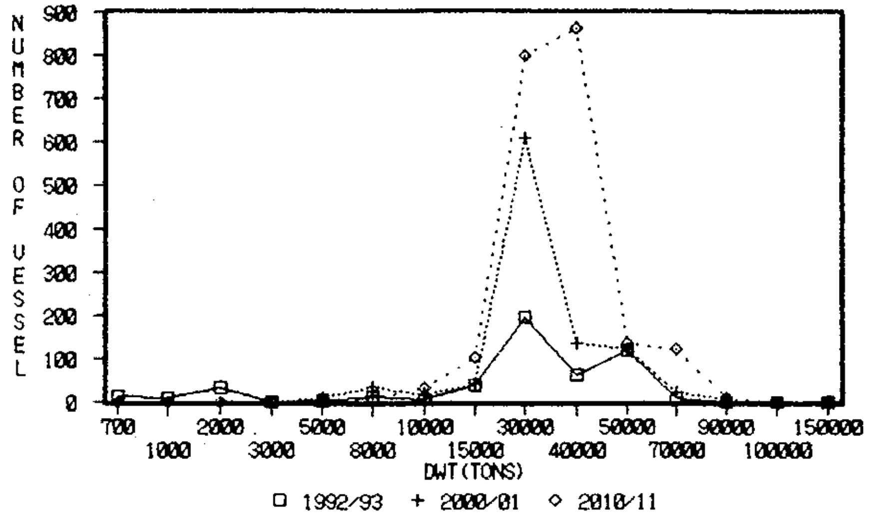


Figure 3.3.2.2 Transition of Calling Vessel

Chapter 4

Functional Allotment and Capacity Evaluation of the Port Activities

Chapter 4 Functional Allotment and Capacity Evaluation of the Port Activities

4.1 Functional Allotment of Port Activities

4.1.1 Basic Concept of Port Function

The previous port master plan of Imam Khomeini port was formulated in 1974 by the PSO as mentioned before. The objectives of that master plan were almost same as those of today, port expansion for to handle the increasing general cargo and steel cargo. However, there is no international container terminal plan. Forecast cargo volume was 15,950 thousand tons, port facilities length was about 6,875m.

Considering actual port activities, Imam Khomeini port should be the center of foreign trade. Future cargo share of each port in the Persian Gulf is forecast based on cargo flow analysis and transportation cost. (Details are shown in section 3.2 of Chapter 3)

Table 4.1.1.1 Share of Cargo Volume among Four Ports (2010)

Port	1993	2010 By Micro Forecast	Case1 By Cost Analysis	Case 2 By Cost Analysis	Case 3 By Cost Analysis
Khomeini	53%	50%	45%	48%	61%
Abbas	41%	44%	45%	42%	30%
Bushehr	3%	4%	4%	4%	4%
Chabahar	3%	2%	6%	6%	6%

Note: Import/Export cargo volume is equal to 100% with four ports at The Persian Gulf ports in Iran

Case1; Cost is $5.0 per ton between Abbas and Imam Khomeini with sea lane.

Case2; Cost is $2.5 per ton between Abbas and Imam Khomeini with sea lane.

Case3; Cost is $5.0, railway will not connect from Abbas to existing railway.

Based on the above, it is clear that Imam Khomeini port and Abbas port will be the major ports in Iran.

Considering the increasing cargo volume and enlarging vessel size, (see Chapter 3) the basic concepts of port function of Imam Khomeini port are proposed as follows.

Foreign trade

(1) To increase the port capacity, existing port facilities should be upgraded. In particular, grain bulk jetty, container berth and general cargo berth should be improved by maintaining the berth length and depth.

(2) To handle the increasing import/export cargo volume, new development[1] should be implemented. In particular, steel and general export cargo berth should be expanded.

(3) To facilitate cargo handling of land bridge cargo, service time should be as short as possible.

Cargo handling

(1) For frozen cargo, some facilities should be improved.

(2) A part of bagged cargo commodity should change to bulk cargo for example fertilizer.

(3) Iron ore cargo should be handled at steel company's private berth. However, unloading of alumina powder will continue to be done at existing site.

(4) A part of chemical fertilizer of bagged cargo should be handled at chemical company's berth.

Industrial and commercial activities

(1) For industrial and commercial activities, IKPAO should prepare land and necessary utilities.

Transportation and cargo distribution

(1) Access road should connect to express way.

(2) A domestic line in the Persian Gulf should be established to connect each port.

(3) Transportation system for the cargo must be smooth and effective.

(4) Sheds and warehouses should be upgraded to avoid time consuming direct delivery operation.

Others

(1) The volume of iron ore from Abbas port will be 5 million tons per year and, will be handled at the steel company's private berth.

(2) Additional working boats should be supplied immediately.

(3) Port utilities to support port activities should be improved sufficiently.

Note: (1) Existing harbor area is on the east side of Khor Dorag. One of candidates areas for this is on the west side of Khor Dorag.

(4) To handle some cargo from/to Chemical company and petroleum company when capacity at their private berths exceeded.

(5) To maintain the adequate depth of the channel and basins, dredger should be procured.

4.1.2 Port Function Allocation

(1) Cargo handling

Existing facilities and cargo handling activities are described in Section 2.3 of Chapter 2. Figure 4.1.2.1 shows cargo volume and commodities by each berth in 1992. Existing facilities and activities will be retained as much as possible if the port capacity can be increased.

1) Grain silo Jetty

Dry bulk cargo is one of the major cargo in Imam Khomeini port. Existing berth is not good for grain unloading because of its proximity to the steel company and ore yard. Dust may mix into the grain. If the grain silo cannot be relocated, port must take appropriate measures to prevent dust dispersal.

2) Old Western and Eastern Jetty

Existing facilities are very old and cargo handling efficiency here is substandard. However, it is easy to secure the required depth for large vessels at this site. It is proposed that many old buildings behind these jetties be removed and that land for cargo handling activities be secured through reclamation.

3) Berth No.7-No.10 berth

Eastward two berths No.7 and 8 currently provide port service, since the remainings are not completed yet.
Apron and sorting yard is very narrow and water depth in front of the said two berths is very shallow (-8m to -9m). If these berths will continue to be used by vessels, it will constitute inefficient usage of the already limited waterfront line. Thus these areas should be rearranged to achieve more port capacity.

4) Berth No.11-No.15

International container berth should be developed. The length and depth of berth can easily be secured in this site. Excess cargo from the grain jetty can be handled at one berth.

Note: Depth of water is below the Cases Chart Datum, which is 2.6m below the mean Sea Level.

5) No.16-No.20

There are many quay cranes. However, the shed and warehouse were built in the back of apron and there is no sorting yard for the heavy and bulky cargoes.

6) Berth No.21-No.25

The depth in front of berth is currently -9m to -10m. The structural maximum depth of water is -11m, thus large vessels than 20,000 DWT cannot be accommodated here. Existing unit berth length is only 180m which is not enough to future requirement.

7) Berth No.26-No.33

The depth (structurally -11m) and length (180m) are insufficient for vessels in future. The number of existing berths should be reduced to achieve a standard berth length of 220 meters.

4.1.3 Functional Separation

(1) Waterfront facilities

In front of the berth, it is necessary to secure a sufficient berthing basin and turning basin. Size of a turning basin, 1.0 x L - 3.0 x L (L = Vessels length) are standard.

(2) Land use

Behind the waterfront, there is a apron. The apron is the quay surface between the front line of the berth and the transit shed or sorting yard where cargoes and vehicles used for cargo handling are placed temporarily. The width of the apron must be adequate to ensure safe and smooth cargo handling. Apron's width should be 25 meters wide.

Area for transit sheds and sorting yard usually is located right behind the aprons. Warehouses and open storage yard are used for the storage of cargoes.

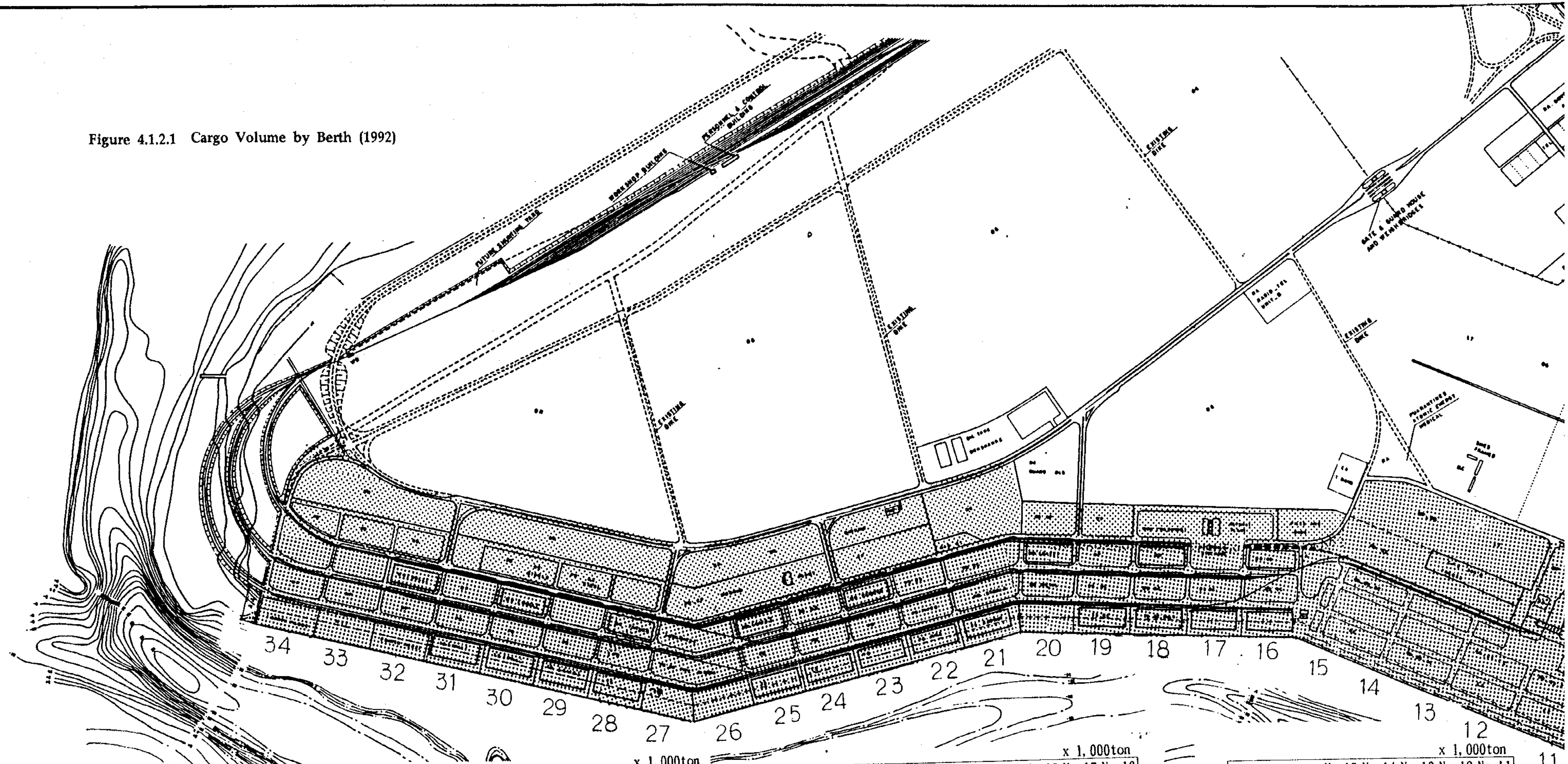
These areas are used for collection, distribution, sorting, marshalling, inspecting and primary storage of cargo.

(3) Cargo handling method by cargo volume

Excess Grain cargo after the exclusive grain jetty operation should be handled at the by pneumatic crane. Grain cargo handled at the marginal wharf should be stored in sheds behind the apron rather than direct delivery to increase port capacity.

About 41% of the General cargo volume will be containerized in 2010/11.

Figure 4.1.2.1 Cargo Volume by Berth (1992)



x 1,000ton

Commodity	No. 30	No. 29	No. 28	No. 27	No. 26	No. 25	No. 24	No. 23
Meat	11		11	37	8	9		
Soya	25		3	5	26	76	33	13
Rice				6	13	42	10	31
Corn	52				30	31		51
Sugar			13		5	14	12	86
Cement	8						3	5
Miscellaneous	5	7		5	39	17	17	
Metal		10				21	2	59
Others		16	11	52			16	
Export								
Metal	55				23			30
Miscellaneous							5	

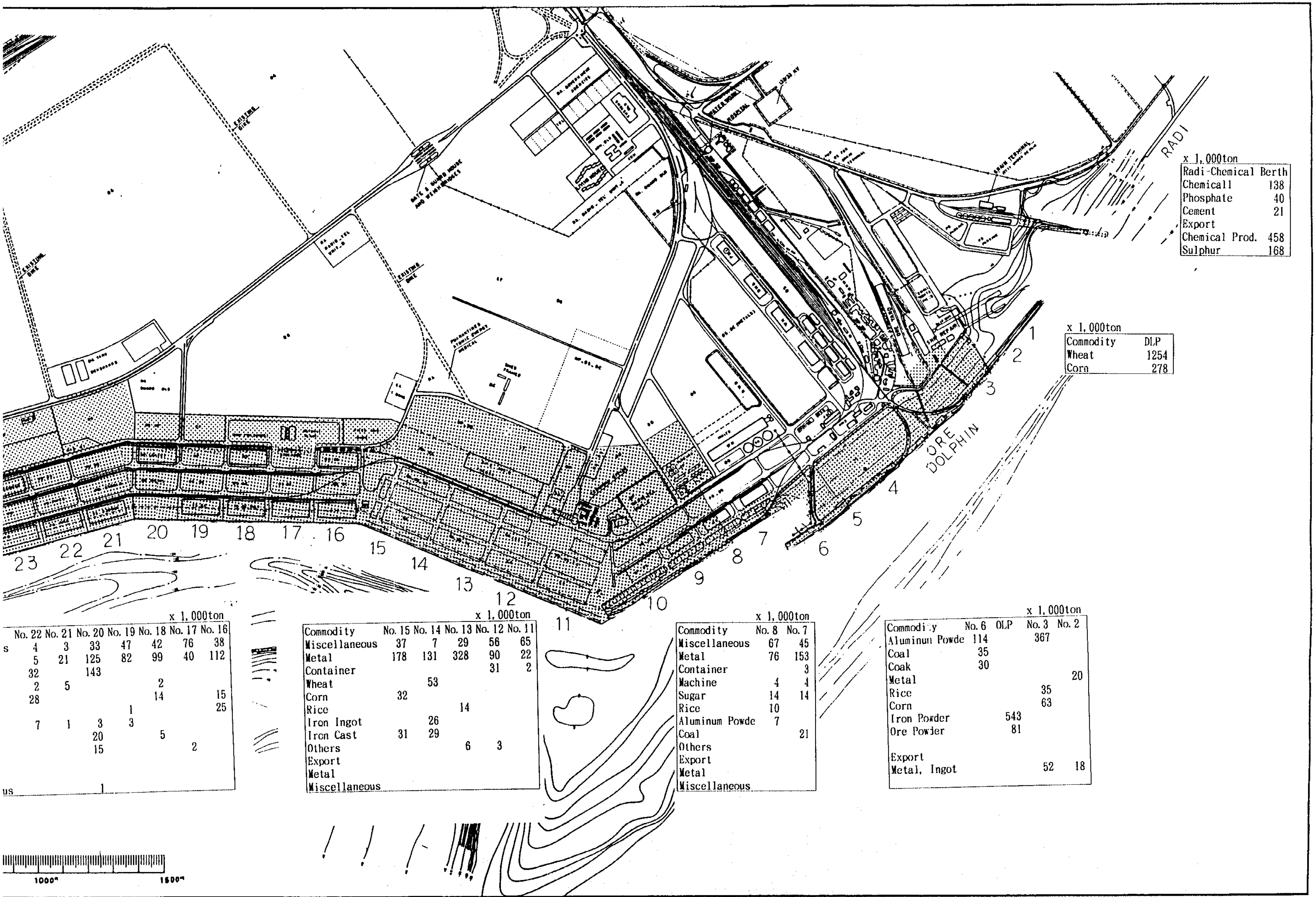
x 1,000ton

Commodity	No. 22	No. 21	No. 20	No. 19	No. 18	No. 17	No. 16
Miscellaneous	4	3	33	47	42	76	38
Metal	5	21	125	82	99	40	112
Fertilizer	32		143				
Chemical	2	5			2		
Sugar	28				14		15
Rice				1			25
Cement	7	1	3	3			
Iron Cast			20		5		
Others			15			2	
Export							
Metal							
Miscellaneous			1				

x 1,000ton

Commodity	No. 15	No. 14	No. 13	No. 12	No. 11
Miscellaneous	37	7	29	56	65
Metal	178	131	328	90	22
Container				31	2
Wheat		53			
Corn	32				
Rice			14		
Iron Ingot		26			
Iron Cast	31	29			
Others			6	3	
Export					
Metal					
Miscellaneous					

Imam Khomeini Port
Iran Ports Master Plan
Cargo Volume By Berth (1992)
Date SEPTEMBER 1994



x 1,000ton

Radi-Chemical Berth	
Chemicall	138
Phosphate	40
Cement	21
Export	
Chemical Prod.	458
Sulphur	168

x 1,000ton

Commodity	DLP
Wheat	1254
Corn	278

x 1,000ton

	No. 22	No. 21	No. 20	No. 19	No. 18	No. 17	No. 16
s	4	3	33	47	42	76	38
	5	21	125	82	99	40	112
	32		143				
	2	5			2		
	28				14		15
				1			25
	7	1	3	3			
			20		5		
			15			2	
us			1				

x 1,000ton

Commodity	No. 15	No. 14	No. 13	No. 12	No. 11
Miscellaneous	37	7	29	56	65
Metal	178	131	328	90	22
Container				31	2
Wheat		53			
Corn	32				
Rice			14		
Iron Ingot		26			
Iron Cast	31	29			
Others			6	3	
Export					
Metal					
Miscellaneous					

x 1,000ton

Commodity	No. 8	No. 7
Miscellaneous	67	45
Metal	76	153
Container		3
Machine	4	4
Sugar	14	14
Rice	10	
Aluminum Powde	7	
Coal		21
Others		
Export		
Metal		
Miscellaneous		

x 1,000ton

Commodity	No. 6	OLP	No. 3	No. 2
Aluminun Powde	114		367	
Coal	35			
Coak	30			
Metal				20
Rice			35	
Corn			63	
Iron Powder		543		
Ore Powder		81		
Export				
Metal, Ingot			52	18

(4) Transportation area

Marshalling and depositing yard for container, container freight station, counting and weighing area will be proposed. Parking areas for trucks and marshalling yard for railway will also be proposed.

4.2 Basic Concept for Capacity Evaluation

4.2.1 Basic Method of Capacity Calculation

Berth productivity depends on various aspects including commodities to be handled, size and type of ship to be berthed, cargo handling system to be applied, cargo handling equipment to be used and working conditions.
All of the above items should be decided before calculation of the berth productivity. The berth productivity at this stage will be calculated basically on the existing conditions except for the cargo handling equipment.
However, working hours and days must be adjusted partially from the present conditions.
The reasons are as follows:

(1) According to the site interview, the working days per year are 363 days and the working hours per day are 24 hours.

(2) It is not supposed that their numerical values are expressed as actual working days and hours but they are expressed as workable days and hours due to the small cargo volume compared with the labor population and the existing equipment.

(3) When cargo volume to be handled increases, it is very difficult to keep the above values.

(4) Considering the berth occupancy, working days per year are limited.

(5) Cargo handling equipment at the exclusive berth can not work full days through the year due to maintenance and repairs.

(6) There are some nun-workable days due to bad weather

(7) Working conditions shall be improved to keep good labor and health.

The cargo handling system for bulk grain at the general cargo berth will be changed from direct delivery by truck to provisional storage behind the berth, so that unloading capacity can be increased.
For cargo handling equipment, it is considered that the required numbers of equipment and facilities should be fully arranged and maintained in good condition.

4.2.2 Major Elements for Evaluation

(1) Handling Capacity per gang per net working hour

1) The type of crane that its capacity is expressed by the capacity per hour
This is calculated by the following formula

$$Qa = Qn \times Eu$$

Qa : Actual handling capacity (t/h)
Qn : Nominal or design capacity per hour (t/h)
Eu : Handling efficiency

Handling efficiency (Eu) will be quoted from the result of actual handling throughput by the existing equipment.

2) The type of crane that his capacity is expressed by the lifting capacity
This is calculated by the following formula

$$Qa = Ta \times 60 / Cy$$

Ta : Actual lifting weight (t)
Cy : Average cycle time (minutes)

Actual lifting weight (Ta) is calculated by the following formula

$$Ta = Np \times W$$

Np : Number of packages at one lifting
W : Unit weight of package (t)

Average cycle time will be quoted from the result of site investigation

(2) Number of gangs per ship (Ng)

1) Exclusive berth with the fixed handling equipment

Number of gangs at the exclusive berth is equal to the number of handling equipment.

2) Non-exclusive

Number of gangs at the non-exclusive berth is decided normally by the ship size (number of hatches of the ship) to berth.

(3) Berth productivity(Bp) per net working hour

This is calculated by the following formula

$$Bp = Qa \times Ng \quad t/h$$

(4) Berth productivity per year

This is calculated by the following formula

$$By = Bp\ t/h \times Dy \times Bo \times Hs \times E\ w$$

By : Berth productivity per year or Berth capacity per year (t/y)
Dy : Working days per year (day/year)
Bo : Berth occupancy
Hs : Working hours per day (hours/day)
Ew : Working time efficiency
Bp : Berth productivity

1) Working days per year (Dy)

This value will be decided by the two elements.
One is the number of un-workable days, e.g. holidays which are decided by P.S.O. policy. Another one is the number of days required for corrective maintenance and preventive maintenance of equipment.

2) Berth occupancy (Bo)

This is the balance of merits and losses of ship charterage due to berth waiting

3) Working hours per day (Hs)

This is decided by the PSO policy and working circumstances.

4) Working time efficiency (Ew)

The following factors and elements will be included in this item
* Required preparation and setting time before and after the operation
* During the operation, slight interruption due to change of hatches, working method, some trouble of the operation and equipment, and others

4.3 Commodity-wise Standard for Evaluation of Current Cargo Handling Capacity

This section deals with the basic criteria by which the existing port capacity will be evaluated.

4.3.1 Wharf and Jetty

As discussed in section 2.8, the existing marginal wharfs have structural damages which are observed at the pile caps, pile connecting beams and beams. It is strongly recommended to conduct the urgent rehabilitation before the happening of decisive structural failures. More detailed discussion for both design and costing will be carried out in both sections 8.11 and 12.9.

Design loads of present marginal wharf is 4 t/m^2, which is relatively large figure comparing to the ordinary standards. However this criteria makes the existing waterfront facility of heavy duty oriented and durable one. As far as the current utilization is continue, there is no serious problem in respect of both cargo handling operation and vessel berthing.

However, large concentrated loads like a container wharf crane should be supported after structural strengthening, if the existing structure was not designed for such load.

The structural design depth of wharf is only DL-11.O m except the first five berths of the previous Ten Berth Extension area the depth of which are DL-12.5 m. On the other hand, the existing two old jetties of about 60 years old should be utilized carefully since there is not enough evidence that they have adequate structural strength. It is reported by PSO that the existing steel piles are sound enough according to PSO investigation. However no evidence on this is provided by PSO for the time being. Loads restriction and pile strengthening should be introduced on these jetties.

In case of introduction of larger vessel than those expected in the original design, a parallel pier along the existing faceline will be provided in order to maintain a deep water. When it is necessary, new fender system will also be provided.

4.3.2 Transit Shed and Storage Facility

Capacity of storage facilities is calculated by the following formula.

Mb = (Ab x Rt x w x r) / p

where Mb : Capacity of storage facilities (ton/year)
Ab : Area of storage facility (m^2)
Rt : Turnover ratio (times/year)
w : Volume of cargo per unit area (ton/m^2)
r : Utilization ratio
p : Peak ratio

Following parameters based on actual data in Japanese ports are used for evaluation of capacity.

- For transit shed and sorting yard
  - Peak ratio : 1.3
  - Turnover ratio : 24 times/year
  - Volume of cargo per unit area:
    - 3.5 ton/m^2 for dry bulk cargo
    - 2.5 ton/m^2 for bagged cargo
    - 2.5 ton/m^2 for metallic cargo
    - 2.0 tom/m^2 for general cargo
    - 2.0 ton/m^2 for refrigerated cargo
  - Utilization ratio : 0.7

- For warehouse and open yard
  - Peak ratio : 1.0
  - Turnover ratio : 12 times/year
  - Volume of cargo per unit area:

3.5 ton/m^2 for dry bulk cargo
2.5 ton/m^2 for bagged cargo
2.5 ton/m^2 for metallic cargo
2.0 tom/m^2 for general cargo
2.0 ton/m^2 for refrigerated cargo

Utilization ratio : 0.7

4.3.3 Channel and Basin

The approach to the port is made through a 93 km bar channel, the width of it is 220 meters minimum and 60 degrees maximum bends.

From buoy No.9/14 to No.23/30 is narrow channel less than 250 meters width and extends 21 km. And the depth of the bar channel is maintained 12.2 meters. In future the depth of channel should be maintained as this level for vessels.

Using tidal range about 2.5 meters, 50,000 DWT vessels regularly cross the bar.

4.3.4 Access Transport Facility to/from the Port

(1) Access Road to/from Khomeini port

Table 4.3.4.1 Distance between Cities and Khomeini Port by Road

Route	Distance	Remark
Khomeini---Abadan	100km	Two lane Main road
Khomeini---Khorramshahr	120km	Two lane Main road
Khomeini---Ahvaz	156km	Two lane Main road
Khomeini---Mahshahr	22km	Two lane Main road

(2) Access Railway to/from Khomeini port

There is a railway stretching 928km from Khomeini port to Tehran. The present network comprises a single track line (Ahwaz-Tehran) and a double track line (Khomeini port-Ahvaz).

Table 4.3.4.2 Main Railway Section around Khomeini Port

Main Section	Distance	Operation year
Khomeini--Ahvaz	131km	1938
Khomeini--Arak	650km	1938
Khoramshahr--Ahvaz	121km	1942

(3) Access Airway to from Khomeini port

There are three airports near Khomeini port. Ahwaz and Abadan airport are domestic airports, while Mahshahr airport is a private airport of NIOC.

4.3.5 Total Available Port Space

From the above mentioned, the land of apron, yard, shed and warehouse and road which used by cargo handling should be secured about the 300 m width area behind quay front line.

Behind the container cargo terminal, some buildings obstruct to extension for deposit yard. Western and Eastern Jetties have only apron area, cargo commodity-wise is limited with cargo handling.

About 7 square kilometers is available in Imam Khomeini port for direct port activities. Among the total area of 12 square kilometers. However Waterfront line is currently limited at Khor Musa and Khor Dorag.