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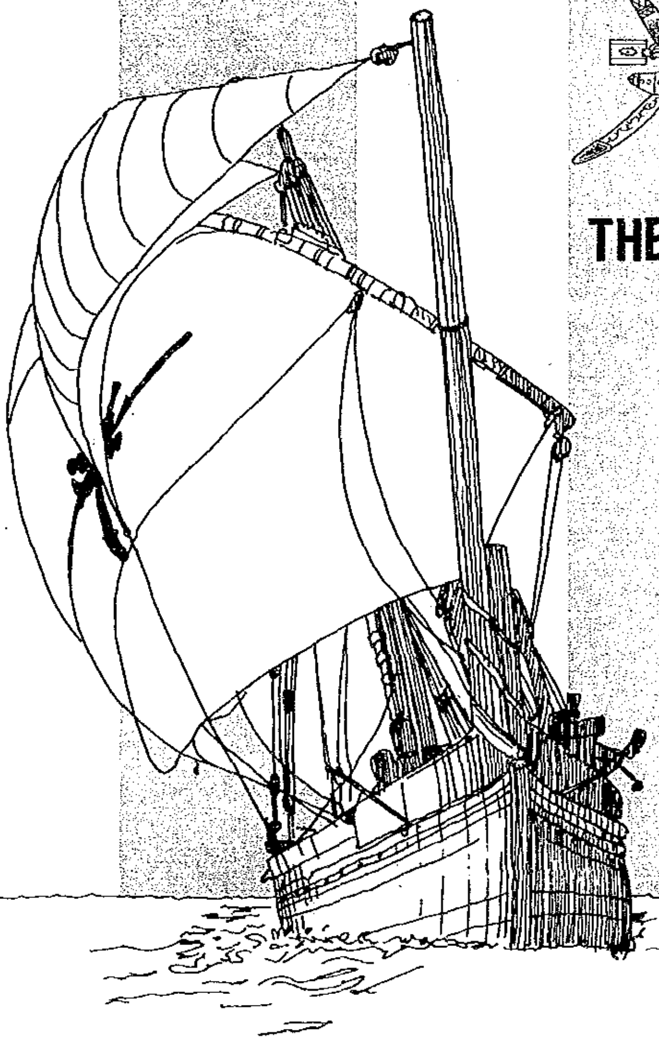
FINAL REPORT

MINA QABOOS DEVELOPMENT PLAN



VOLUME (II)
FOR
THE STUDY
ON
THE PORT DEVELOPMENT
FOR
NORTHERN OMAN

OCTOBER 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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J.I.C.A.

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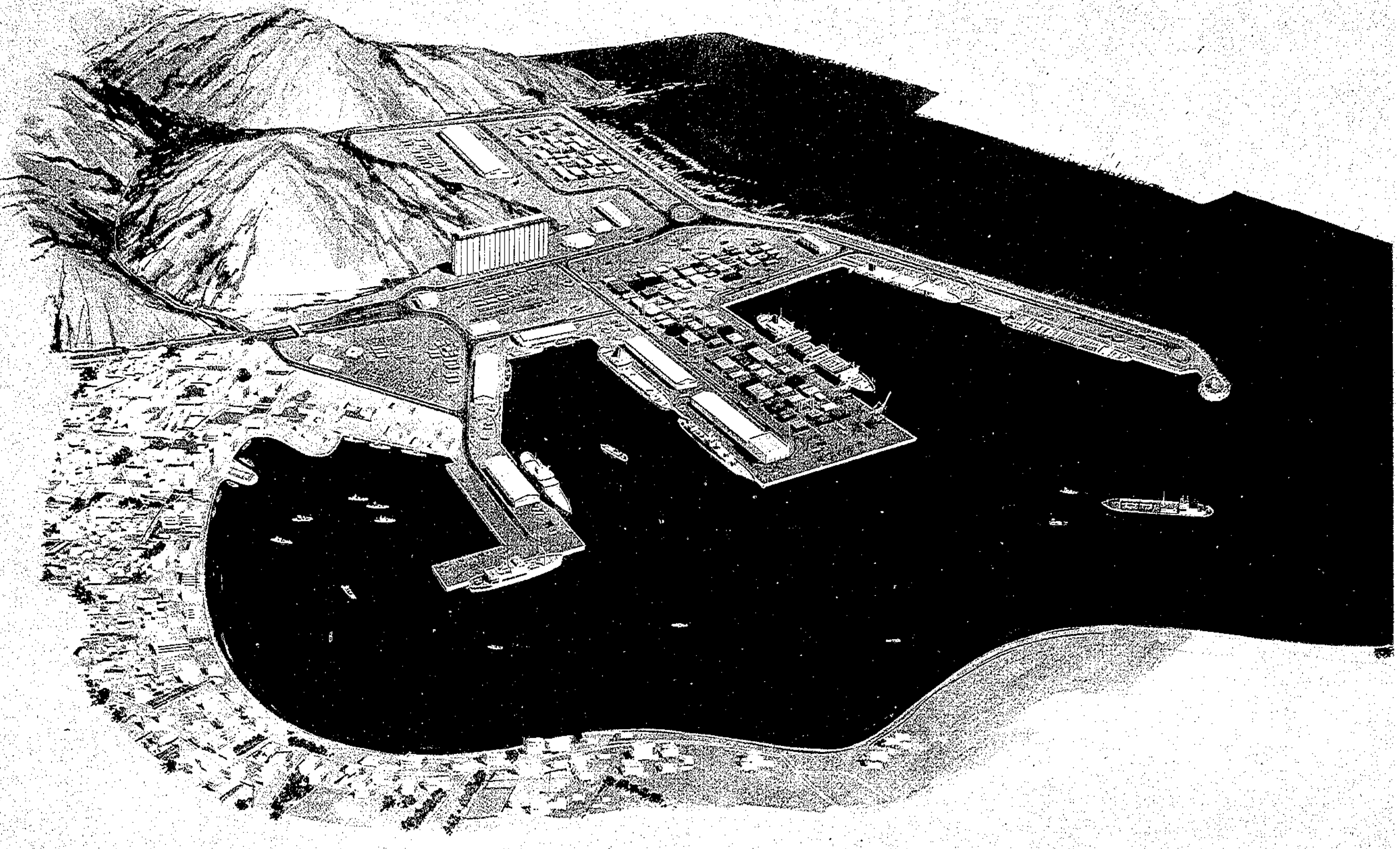

THE STUDY ON THE DEVELOPMENT

FOR NORTHERN OMAN

VOLUME I THE STUDY ON THE DEVELOPMENT FOR NORTHERN OMAN

VOLUME II MINA QABOOS DEVELOPMENT PLAN

VOLUME III NEW PORT DEVELOPMENT PLAN IN SOHAR

SUMMARY

ABBREVIATIONS

CA	Capital Area
CD	Chart Datum
CES	Consulting Engineering Service (India) Private Limited
CFS	Container Freight Station
CMA	Compagnie Maritime d'Affretement
CRT	Cathode Ray Tube
CY	Container Yard
DC	The Development Council
DL	Datum Water Level
DWT	Dead Weight Tonnage
FCL	Full Container Load
FTZ	Free Trade Zone
G.C.	General Cargo
GCC	The Gulf Co-operation Council
GDP	Gross Domestic Product
GDP(R)	GDP for Regression Analysis
GNP	Gross National Product
G.S.	Ground Spot
G/T, GRT	Gross Tonnage
H	Wave Height
Ho	Deep Water Wave Height
H1/3	Significant Wave Height
IBRD	International Bank for Development and Reconstruction
IMO	International Maritime Organization
JAFZ	Jebel Ali Free Zone
JICA	The Japan International Cooperation Agency
J¥	Japanese Yen
L	Wave Length
LAT	Low Astronomical Tide
LCL	Less Than Container Load
LNG	Liquid Natural Gas
L.W.L.	Low Water Level
MAF	Ministry of Agriculture and Fishery
M.H.W.L.	Mean High Water Level
MMSCF	Million Standard Cubic Feet

MMSCFD	Million Standard Cubic Feet per Day
M.L.W.L.	Mean Low Water Level
MOC	The Ministry of Communications
MRO	Million Omani Rial
M.S.L.	Mean Sea Level
MT	Empty Container
MTBE	Methyl Tertial Butyl Ether
MTD	Metric Tonnes per Day
MTPA	Metric Tonnes per Annum
MW	Mega Watt
NYK	Nippon Yusn Kabushikigaisha
OBAF	The Oman Bank for Agriculture and Fisheries
OCDI	The Overseas Coastal Area Development Institute of Japan
ORC	Oman Refinery Company
PAMAP	The Public Authority for Marketing Agricultural Produce
PMB	Port Management Body
PSC	The Port Services Corporation
R.O	Omani Rial
Ro/Ro	Roll on/Roll off
SMDS	Shell Middle Distillate Synthesis
SPT	Standard Penetration Test
TEU	Twenty-foot Equivalent Unit
TRS	Transshipment
UAE	The United Arab Emirates
US$	The United States Dollars
ϕ	Angle of Internal Friction

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RECOMMENDATIONS

Recommendation

(1) The wave conditions have been observed by using marine buoys since 1988. It is desirable to continue this observation because the natural conditions of the Port are important to daily port administration and development.

(2) Due to their lack of length, Berths Nos.1, 1A & 2, Nos.4 & 5, Nos.7 & 8 cannot be considered sets of two independent berths. Therefore, berth allocation should be done carefully in order to maximize the port's capacity. Regarding port capacity, it should be also noted that berth occupancy by non-commercial users is to be expected to some extent even in the future. Port capacity should thus be evaluated considering these factors.

(3) It should be emphasized that the proposed Mina Qaboos development plan is based upon adequate cargo allocation with a new port in the year 2000, and delay in the new port development schedule will bring about a serious shortage of cargo-handling capacity at Mina Qaboos. Hence the development schedule of Mina Qaboos and the new port should be controlled carefully.

(4) In this project, development of multipurpose berth, dredging of water basin and reclamation of Shutaify Bay are very closely related to each other. Therefore, for the efficient use of the multipurpose berth, dredging of the water basin should be implemented at an early stage after completion of the multipurpose berth.

(5) The transfer crane system should be adopted to accommodate the rapidly increasing amount of container traffic in Mina Qaboos. Effective land utilization can be expected only with this system because it enables higher stacking of containers, and a smaller area is needed for containers. The new system requires an appropriate number of tractor-trailer, top lifters and other equipment.

(6) The number of gangs needed for handling conventional cargoes and containers and at CFS is to be increased. At the same time, the productivity of handling cargo is to be improved by mechanization, using

appropriate equipment, training of gang members and recruiting younger labourers.

(7) Computerization should be speeded up to match the new handling system. The new handling system can maintain its function with appropriate support from the integrated computer system. Application of the following systems is indispensable for the introduction of new handling system:

i) Terminal control system
   Marshalling yard control program
   Gate control program
ii) Terminal planning system
   Loading schedule program
   Discharging schedule program
iii) Program for optimum handling equipment procedure
iv) Documentation

(8) Facility design and evaluation are carried out based on the sub-soil surveys and the existing bore hole data. But more sub-soil surveys should be carried out in the implementation stage, because there are many different sub-soil characteristics in each section of the port area.

(9) Construction work such as dredging, erection of container cranes. etc., should be executed without interfering with regular port activities by ensuring coordination among the administration and operation sections and port users in order to maintain smooth port operations.
Alternative space for normal port operations should be provided during the construction period.

CHAPTER 1 CONTAINER SHIPPING IN THE GULF REGION

Chapter 1. CONTAINER SHIPPING IN THE GULF REGION

All the analyses in this chapter are based upon data which have been obtained from the following sources:

(Route of each service and names of individual vessels)

1) Sailing schedules of some shipping lines which the Study Team collected in Oman for this Study. (This information covers six major shipping lines and 50 vessels.)
2) "Container Ships and Services in the World": The Japan Shipping Exchange Inc. 1989 (This report covers full-container ships of more than 3,000 G/T with a capacity of more than 150TEUs deployed by international shipping services. Data on 51 vessels are used for this analysis.)

(Dimensions of Each Ship)

1) "Register of Ships, 1988-89" : Lloyd's London Press Ltd.
2) Reports by The Ports and Harbour Research Institute, Ministry of Transport, Japan

   (It should be noted that not all of the data regarding the above 101 vessels is available from these sources.)

1.1 Traffic Trend

1.1.1 Main Liner Services in the Gulf Region

The main liner services calling at the ports in the Gulf region can be roughly divided into four groups:

(1) US•Europe/Gulf/Far East Services

The traffic flow in this type of service is shown in Fig. 1-1-1.

- Main international services in the Gulf region.
- Some of them serve only between Europe and the Gulf.
- Singapore is always the entrance point for the Far East.
- There are other services between Europe and the Far East which call at Jeddah but not at the Gulf ports.

(2) US•Far East/Gulf Services

The traffic flow is shown in Fig. 1-1-2.

- Some serve only between the Far East and the Gulf, with a few serving between the US and the Gulf only or on the US/Gulf/Far East route.
- Singapore is the entrance point for the Far East in every case.
- Japanese shipping lines are prominent in these services.

(3) Australia•New Zealand/Gulf Services

The traffic flow is shown in Fig. 1-1-3.

- Singapore, Bombay, Karachi and Colombo are included in this route.
- All vessels on this route call at Dubai, Damman (Saudi Arabia) Bahrain and Kuwait.

(4) Feeder Services from the Gulf

Not enough data is available on these services. Therefore, the Study Team has supplemented the data by interviews with some of the shipping lines in Oman.

- Feeder services from the Gulf are mainly from Dubai and most of them are to India (Bombay, Cochin), Pakistan (Karachi) and Sri Lanka (Colombo).
- There are only a few cases where East Africa is served by feeders from the Gulf.
- Mina Qaboos also provides feeder services to India, Karachi and Colombo as well as inter-Gulf ones. Feeder service to East Africa is via Dubai.

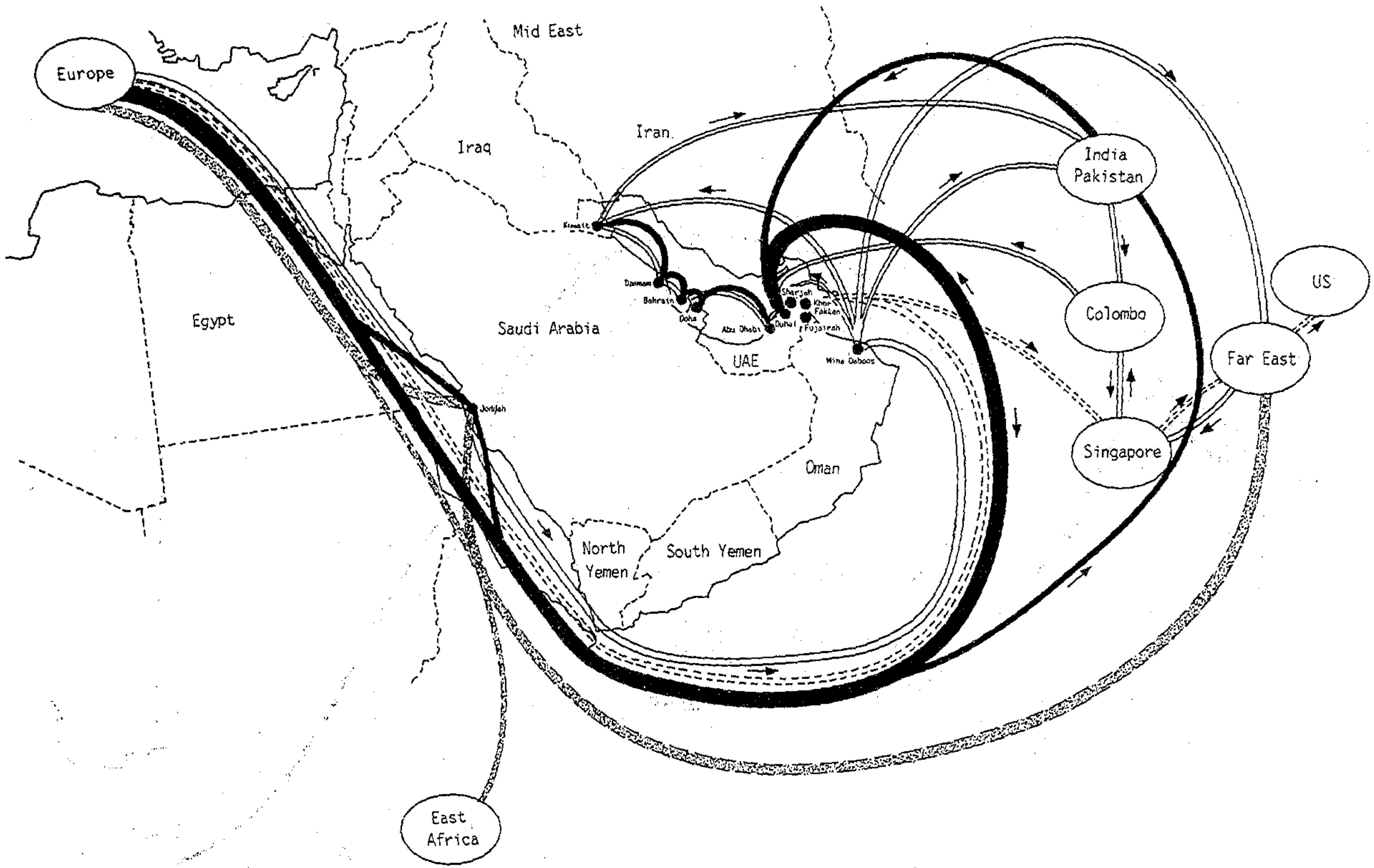


Fig. 1-1-1 US・Europe/Gulf/Far East Route

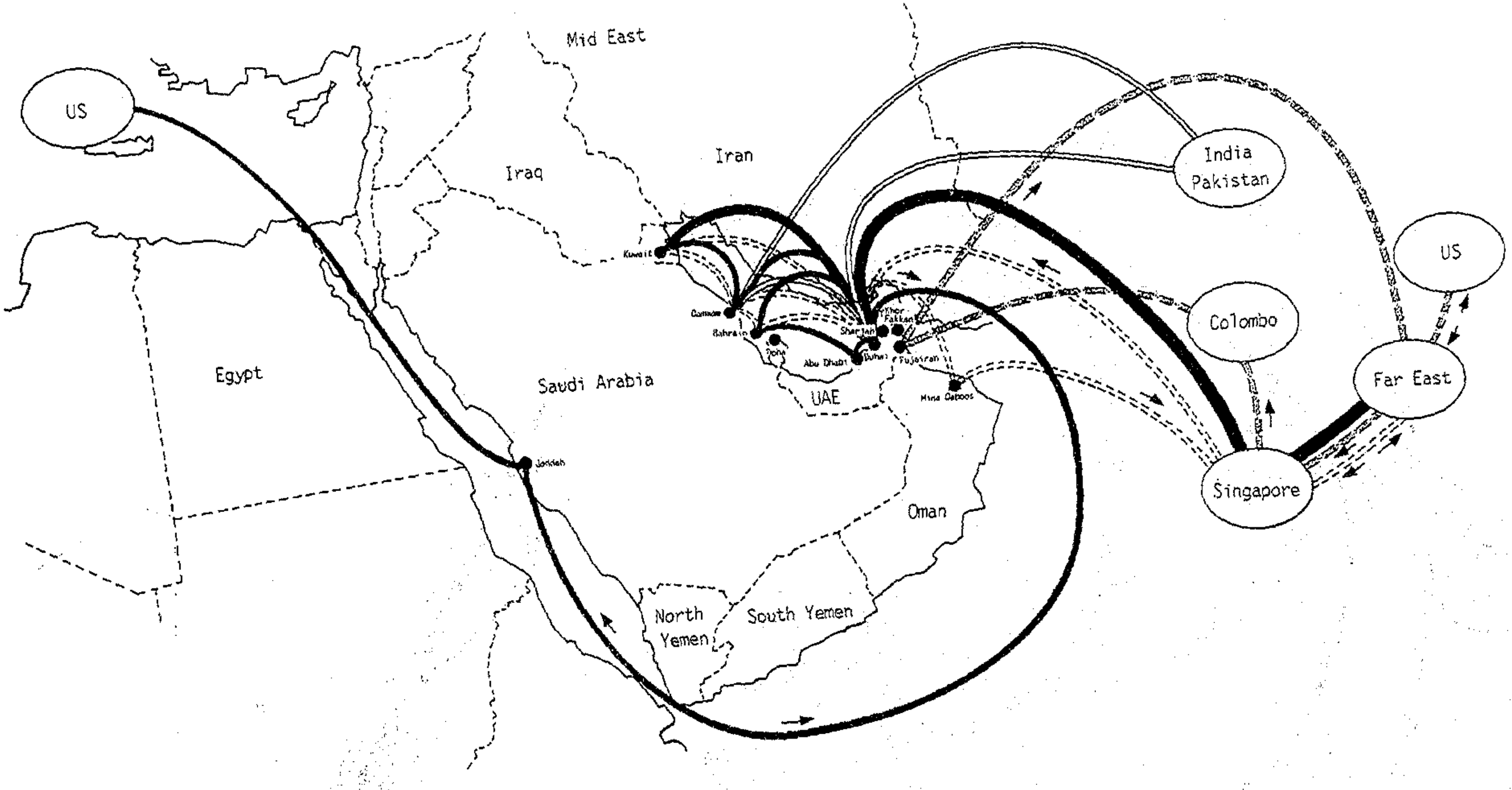


Fig. 1-1-2 US·Far East/Gulf Route

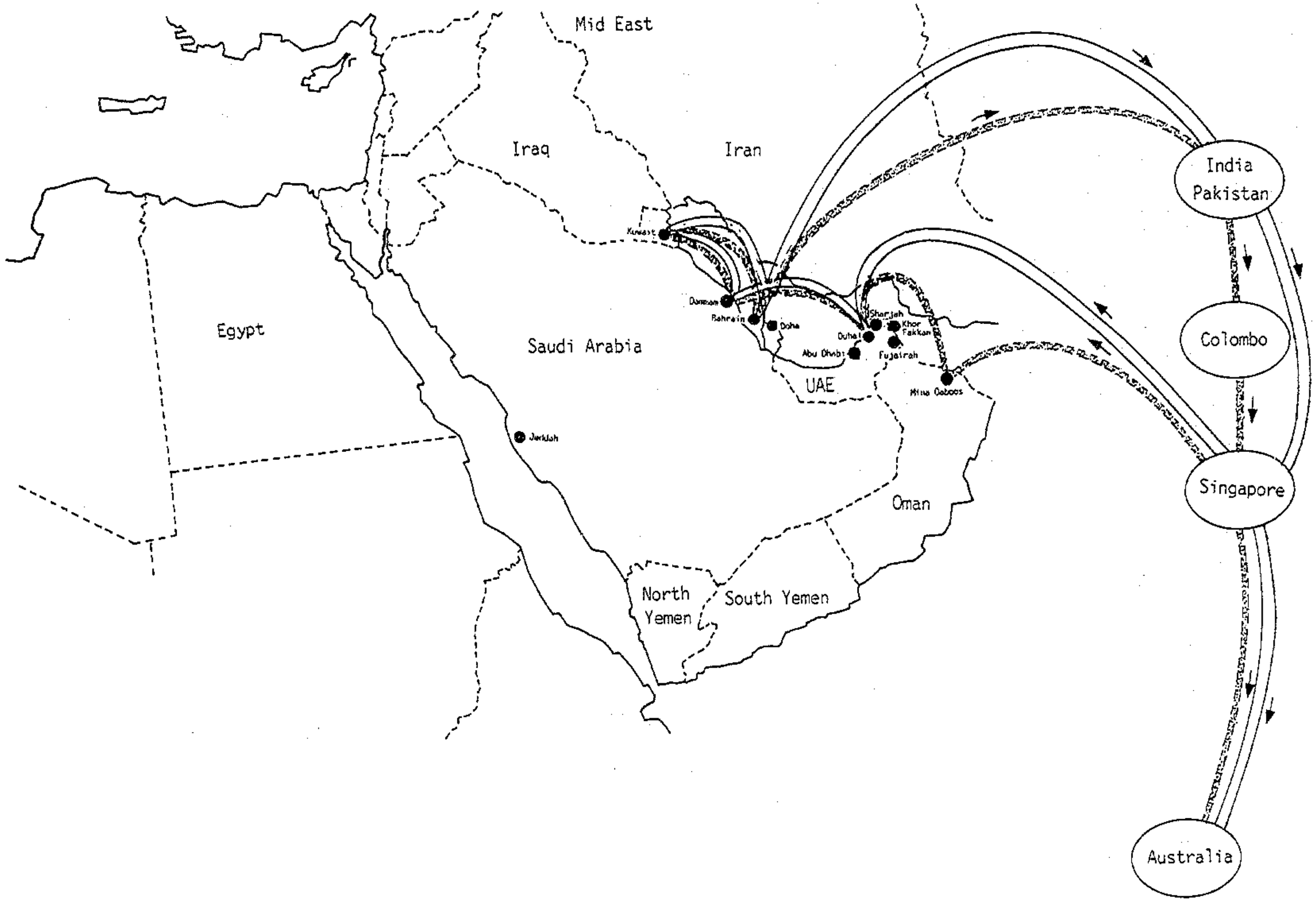


Fig. 1-1-3 Australia・New Zealand/Gulf Route

1.1.2 Characteristics of Traffic

The characteristics of the traffic in the Gulf region are as follows:

- Most of the vessels entering the Gulf region call at Dubai. It is only in exceptional cases that a vessel calls at only one port other than Dubai, such as Mina Qaboos, Fujairah and Khor Fakkan.
  In other words, Dubai overwhelms the other ports as a hub or mother port in the Gulf. The other ports in the UAE and Oman are now becoming mere feeder ports and are patronized only by particular shipping lines as transshipment bases.
- There is a tendency whereby round-the-world services make only one stop in the Gulf. (e.g., Senator Linie at Khor Fakkan)

- Damman, Bahrain and Kuwait are still hub ports, even though in some cases one or two of them are skipped.

- A number of shipping lines have used Dubai as a base for inter-Gulf feeder services that extend to all the other ports in the Gulf. However, there are some cases where Mina Qaboos, Fujairah or Khor Fakkan provide feeder services to other ports, even Dubai.

- Feeder transport from Dubai to Oman is mainly done by feeder ships, but some commodities such as steel, timber, fresh fruit and fresh vegetables enter Oman by land.

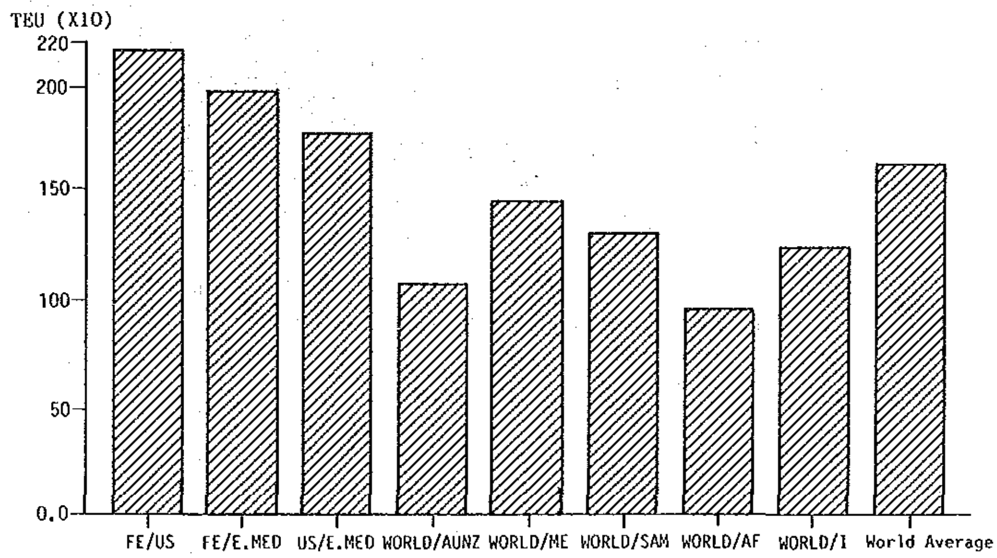
- East Africa is served by feeder services mostly via Jeddah from Europe. As mentioned above, there are not so many feeder services from the Gulf to East Africa.

- Most of the feeder shipments to Iran are at present from Dubai.

1.2 Characteristics of Calling Ships

1.2.1 World-wide Trend and Ships Calling in the Gulf

Fig. 1-2-1 shows the average TEUs of full-container ships deployed on each route.



FE : Far East
US : North America
E.MED: Europe.Mediterranean
AUNZ : Australia・New Zealand
ME : Middle East
SAM : South America
AF : Africa
I : India

Fig. 1-2-1 Full-Container Ships Classified by Route

The average TEUs of vessels deployed on the Middle East route is somewhat smaller than the world average. However, compared with routes such as those to Australia/New Zealand, South America, Africa and India, it can be seen that considerably larger vessels are deployed on this route, while vessels of the largest dimensions are deployed exclusively on routes such as those in the Far East, North America and Europe.

In Figures 1-2-2 to 1-2-4, comparisons are made in terms of DWT, draft and length between the vessels calling at ports in the Gulf and those in the world as a whole.

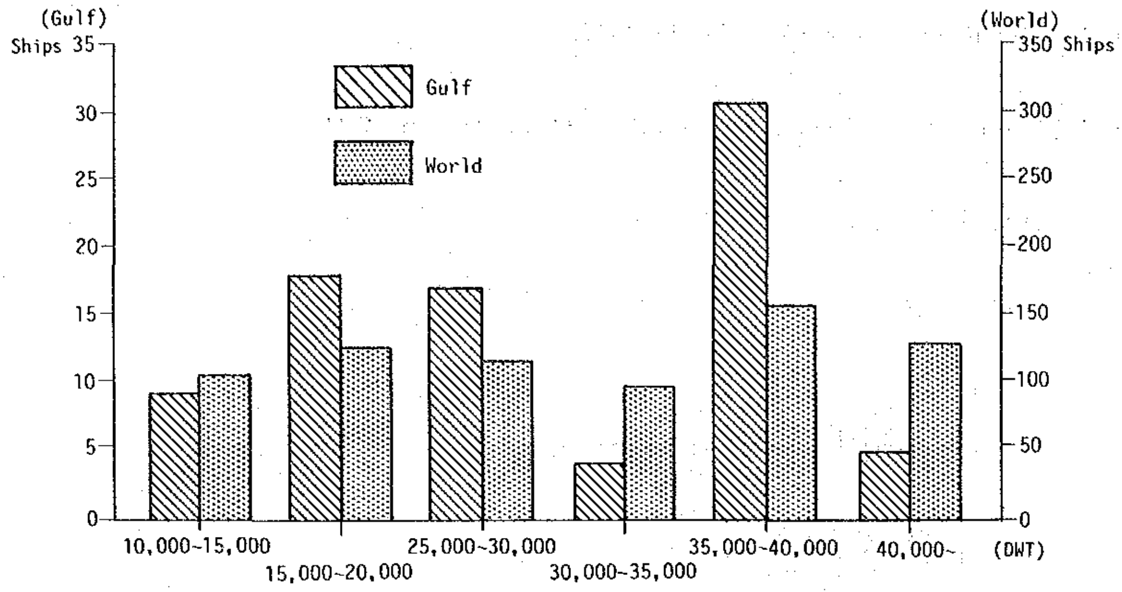


Fig. 1-2-2 Distribution of Ships in the Gulf and in the World as a Whole (by Dead Weight Tons)

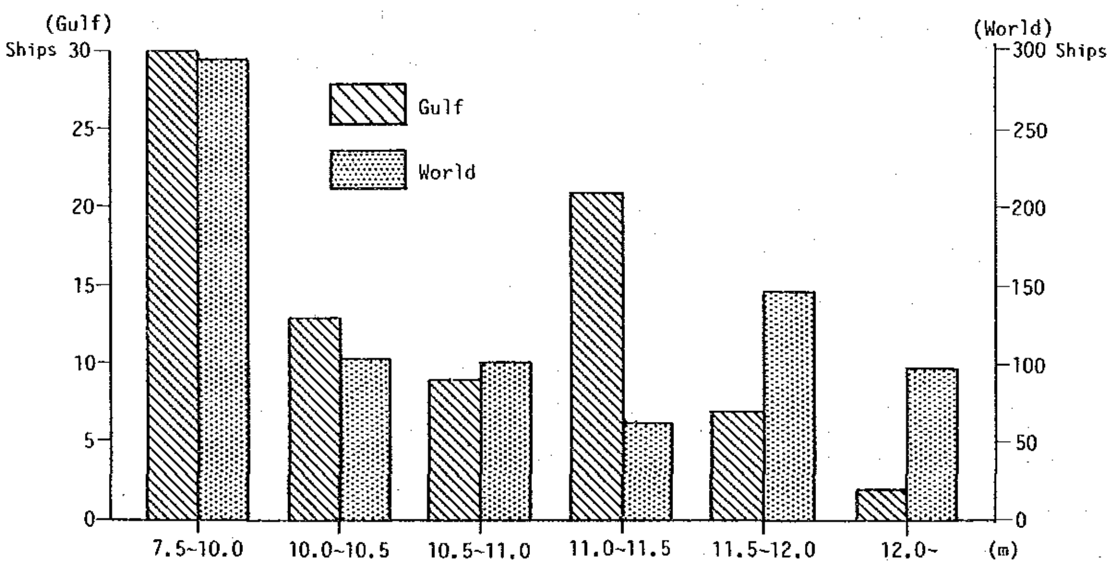


Fig. 1-2-3 Distribution of Ships in the Gulf and in the World as a Whole (by Draft)

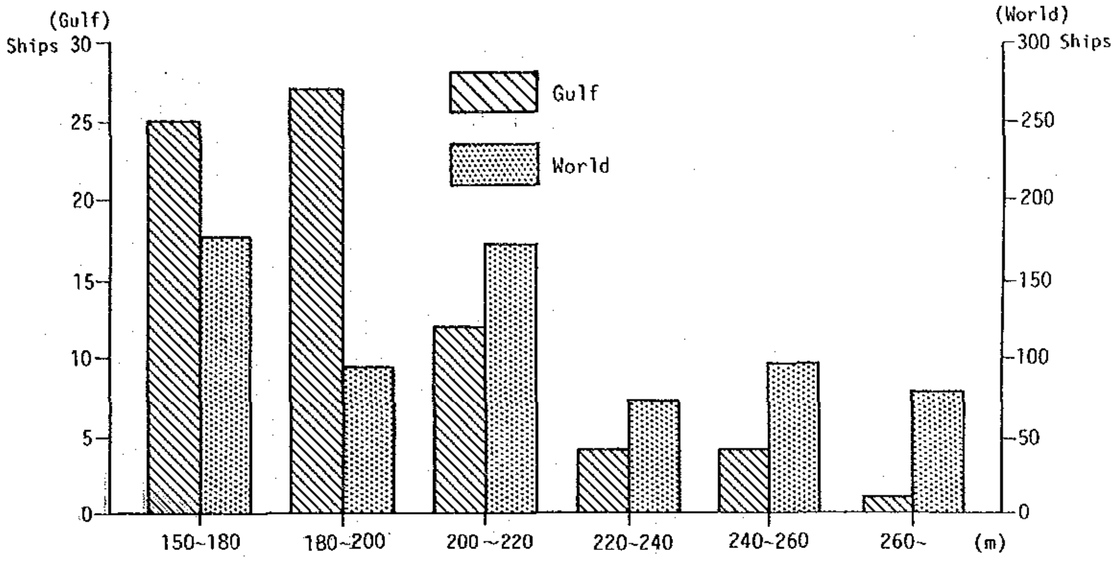


Fig. 1-2-4 Distribution of Ships in the Gulf and in the World as a Whole (by Length)

There is a trend whereby, up to a certain level of ship size, the distribution of the ships calling at Gulf ports is by and large the same as that of the ships in the world as a whole. However, beyond that point, it should be noted that ships of the largest class are not deployed in the Gulf region very often, and that ships of the second-biggest class are principally deployed.

1.2.2 Comparison between Mina Qaboos and Dubai

In Figures 1-2-5 to 1-2-7, comparisons are made in terms of DWT, draft and length between the vessels calling at Mina Qaboos and those at Dubai.

(Dead Weight Tons)

There is not a large difference between the two ports. However, looking at ships of more than 40,000 DWT, the ratio of such ships is larger at Dubai than at Mina Qaboos.

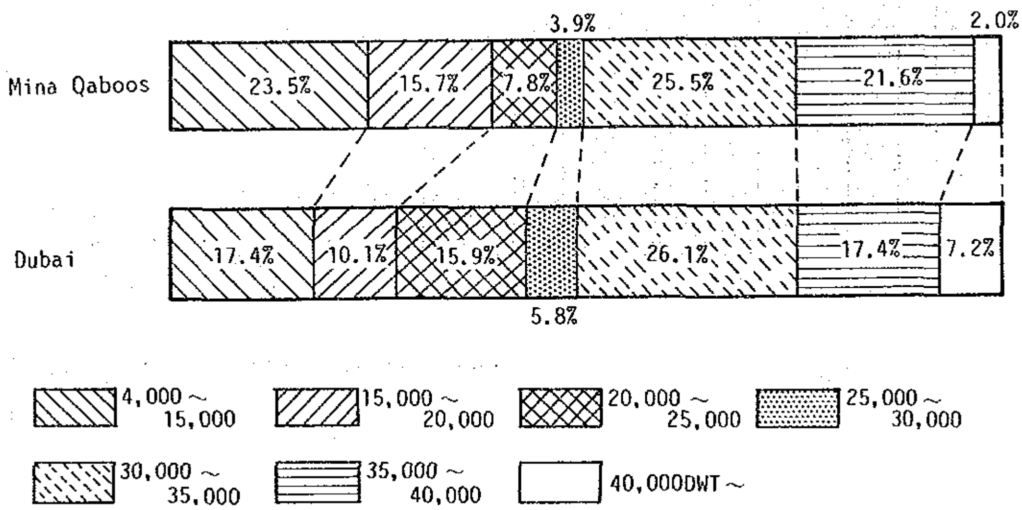


Fig. 1-2-5 Distribution of Ships in Mina Qaboos and Dubai (Dead Weight Tons)

(Draft)

The deepest draft of vessels calling at Mina Qaboos is 12.0m, the same as at Dabai. There is little difference between them in the average draft of vessels of more than 10.0m in draft.

However, as can be seen in Fig. 1-2-6, the distribution is considerably different, particularly with respect to larger ships, that is, the ratio of ships of more than 11.5m in draft at Mina Qaboos is only half of that at Dubai. This shows that Mina Qaboos has a certain limitation with respect to draft. Even at Mina Qaboos, ships of more than 9.5m in draft account for more than 75% of all calling ships.

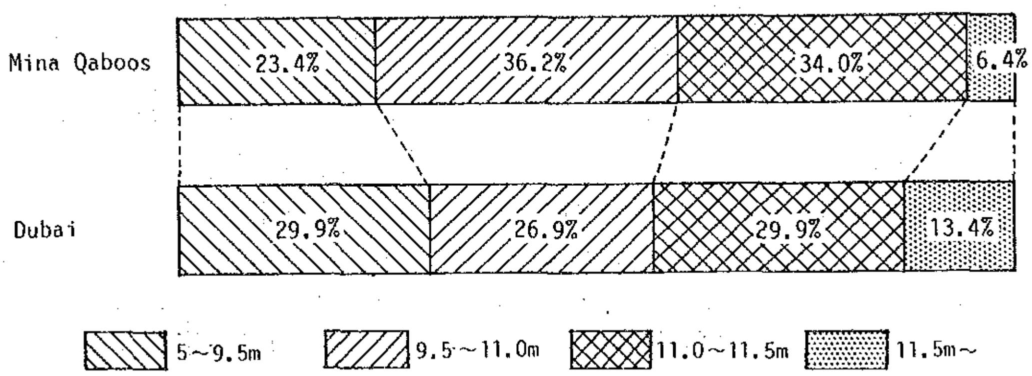


Fig. 1-2-6 Distribution of Ships in Mina Qaboos and Dubai (Draft)

(Length)

The tendency whereby the biggest ships skip Mina Qaboos is most noticable with respect to length. The maximum length of the ships calling at Mina Qaboos is 227.6m, as compared with 264.5m at Dubai.

No ships of more than 230m in length call at Mina Qaboos, while such ships account for more than 10% of those calling at Dubai.

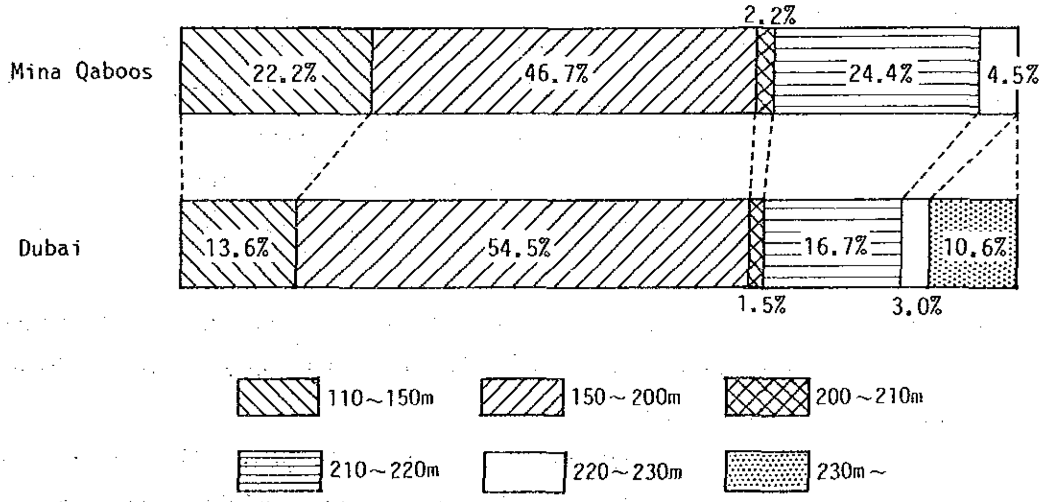


Fig. 1-2-7 Distribution of Ships in Mina Qaboos and Dubai (Length)

1.3 Role of Mina Qaboos

The characteristics of Mina Qaboos can be summarized as follows:

(1) Transshipment base in the Gulf region

Only a few shipping lines have used Mina Qaboos as a transshipment base in the Gulf. In this case, Mina Qaboos is only one stop in the region and provides feeder services not only to the other Gulf countries but also to India, Pakistan and Sri Lanka (Colombo).

(2) Mother port for local cargo

Some mother vessels call at Mina Qaboos to load/unload local Omani cargo. Every vessel in this case calls at Dubai and some of the other major ports in the Gulf. It is important to remark that recently there has been a tendency for Mina Qaboos to be passed over.

(3) Feeder port

Some of the local cargo is delivered to Mina Qaboos by feeder services mainly from Dubai, which, as mentioned above, is used as a transshipment base in the Gulf by a number of shipping lines.

The volume of transshipment cargo, most of which is handled by the French shipping line "CMA", has increased in recent years and accounted for nearly forty percent of the total cargo at Mina Qaboos in 1988. On the other hand, with regard to the local Omani cargo, Mina Qaboos is becoming a mere feeder port and tends to be skipped by mother vessels.

There are some reasons for major shipping lines to skip Mina Qaboos on the main route, even though Oman has an absolute geographical advantage over all other Gulf countries:

- Mina Qaboos faces various problems, such as physical constraints on the dimensions of facilities, low handling productivity and a lack of handling equipment in good condition.
- Dubai has become so established as a Middle East trading center that it is now more convenient for port users to use Dubai as a distribution center in this region.

With regards to constraints on draft and length of the berths, it is apparent that Mina Qaboos is restricted compared with Dubai, as was seen in the last section. This restriction is more obvious in length than in draft, where the problem can be coped with by lading partially or by making Mina Qaboos the last port of call.

In order to make Oman's ports attractive for port users and competitive with Dubai, it is necessary not only to solve the above physical problems but also to properly carry out commercial and financial development plans.

Once these problems are solved, Mina Qaboos will be able to play a more important role as a hub port in the Gulf, possibly with feeder services to Iran and East Africa as well as the Gulf countries, India, Pakistan and Sri Lanka.

CHAPTER 2 NATURAL CONDITIONS

Chapter 2. NATURAL CONDITIONS

2.1 General

2.1.1 Locations

The Sultanate of Oman occupies the south-eastern corner of the Arabian Peninsula and is located between Latitudes 16°40' and 26°20' North and Longitudes 51°50' and 59°40' East.

It has a coastline extending almost 1700km from the Strait of Hormuz in the north to the borders of Peoples Democratic Republic of Yemen (PDRY), overlooking three seas; the Arabian Gulf, the Gulf of Oman and the Arabian Sea.

The Sultanate of Oman borders on Saudi Arabia and the United Arab Emirates (UAE) in the west; on the People's Democratic Republic of Yemen in the south; on the Straits of Hormuz in the north and on the Arabian Sea in the east.

2.1.2 Area

The total area of the Sultanate of Oman is approximately 300,000 sq.km and it is the second-largest country in the Arabian Peninsula.

Total Land Area	sq.km	sq.Miles	%
	300000	120000	100.00
of which*			
Al-Janubiah	100000	40000	33.33
Musandam	2000	800	00.67
Others	198000	79200	66.00
Type of Terrain:			
Mountains (450 M+)	45000	18000	15.00
Costal Plains	9000	3600	3.00
Wadi and Desert Area (450 M-)	246000	98400	82.00

* Al-Janubiah: This area is located at the southern part of Sultanate of Oman.

2.1.3 Topography

The Sultanate is composed of varying topographic areas, consisting of plains, wadis and mountains. The most important area is the plain overlooking the Gulf of Oman and the Arabian Sea with an area of 9000 square km (3% of the total) while mountain ranges occupy about 45,000 square km (15%), the most important of which are 'Hajar', extending in the form of an arch from Ras Mussandam in the North to Ras Al-Hadd and 'Al Qara', in the South western corner of Oman. The remaining area is mainly sand and desert, which occupies 246,000 square km (82% of the total area).

2.1.4 Coastline

The coastline in the Sultanate is divided as shown in Fig. 2-1-1.

(1) Sector II Khawr Kalba to Sawadi

The almost entirely homogeneous Batinah Coast is characterised by an intensely cultivated coastal plain extending inland for up to 10km from either the sea's edge or inland from extensive, sometimes very wide sabkha (unvegetated, low-lying salt flats) areas. The beaches along this coastline are composed primarily of fine-grained, terrigenous sand with shoal areas extending out to 2km offshore. These beaches are almost always backed by a fringe of dunes and dune grass vegetation, with either date plantations or halophyte scrub/sabkha areas inland.

The Batinah Coast begins in Fujarah (UAE) in the north and continues south to the mangrove khawrs at Qurum. Several other khawrs occur along this coast and are its most interesting feature. During periods of goods rainfall these khawrs are important resting-areas for migratory wildfowl, nursery grounds for juvenile coastal fish, and feeding areas for numerous other marine and terrestrial fauna.

Within three of the more permanent khawrs there are extensive stands of the black or dwarf mangrove, Avicennia marina and associated fauna and flora.

Most of the Batinah Coast is densely populated and the local populations are substantially dependent on agriculture and fishing. Fishing contributes a significant portion to local incomes and any disruption of fishing activity during and after an oil pollution incident would adversely affect this entire region.

With the exception of some locally known sabkha areas, vehicle access to all coastal areas of the Batinah is excellent. Roads suitable for heavy vehicle traffic connect coastal villages to the main dual carriageway at regular intervals along the entire coastal plain.

(2) Sector III Capital Area

This sector includes several habitats typical of other areas along the Oman coast. The section between Ras Suwadi and Qurum is a continuation of the typical sand beach environment characteristic of the Batinah Coast, whereas the Damaniyat islands form a unique environmental unit. These islands have well developed coral communities in the shoal areas around them and along some of the northern subtidal cliff faces, and an abundance of reef fish, seabirds, turtles, lizards and halophyte vegetation. They are also an important bird nesting site and possibly one of the largest Hawksbill Turtle nesting sites in the world.

The coastline from Qurum to Ras Abu Daud is composed of both sedimentary and igneous rock cliffs interspersed with numerous bays and coves, including Al Fahal, Muttrah and Muscat Harbours. This section of the coastline also contains the major recreational beaches in the Capital Area including the very popular private and public beaches at Qurum, Ras AL Hamra, Bustan, Bandars Jizzah and Khayran and Khawr Yiti.

Vehicle access to coastal areas along this sector is generally good between Qurum and Bandar Jizzah and extends from Yiti to Asifa via a relatively rough track. There is virtually no vehicle access between Asifa and Quryat.

(3) Sector IV Dagmar to Ras Al Hadd

The coastal area along this sector is composed primarily of undercut sedimentary rock cliffs of varying heights with gravel/boulder and mixed sand/gravel beaches at the mouths of the numerous wadis that cross the coastal plain. There are two major and one minor khawr along this sector as well as the long coarse-grained white sand beach at Ras Al Hadd.

This sector of Oman's coast is very scenic and of significant historical and ecological importance. In addition to the ruins at Qalhat, other historical sites are known at Quryat, Sur, Ras Al Hadd, and Ras Junayz. Sur and its associated villages is the largest and most important population and administrative centre in the region.

There are four major habitat types along this coastline: undercut sedimentary rock cliffs (1-100m. high); khawrs; sand/gravel beaches with wave-cut platform extending offshore; and coarse grained shell beaches. vehicle access to coastal areas in this sector is generally good.

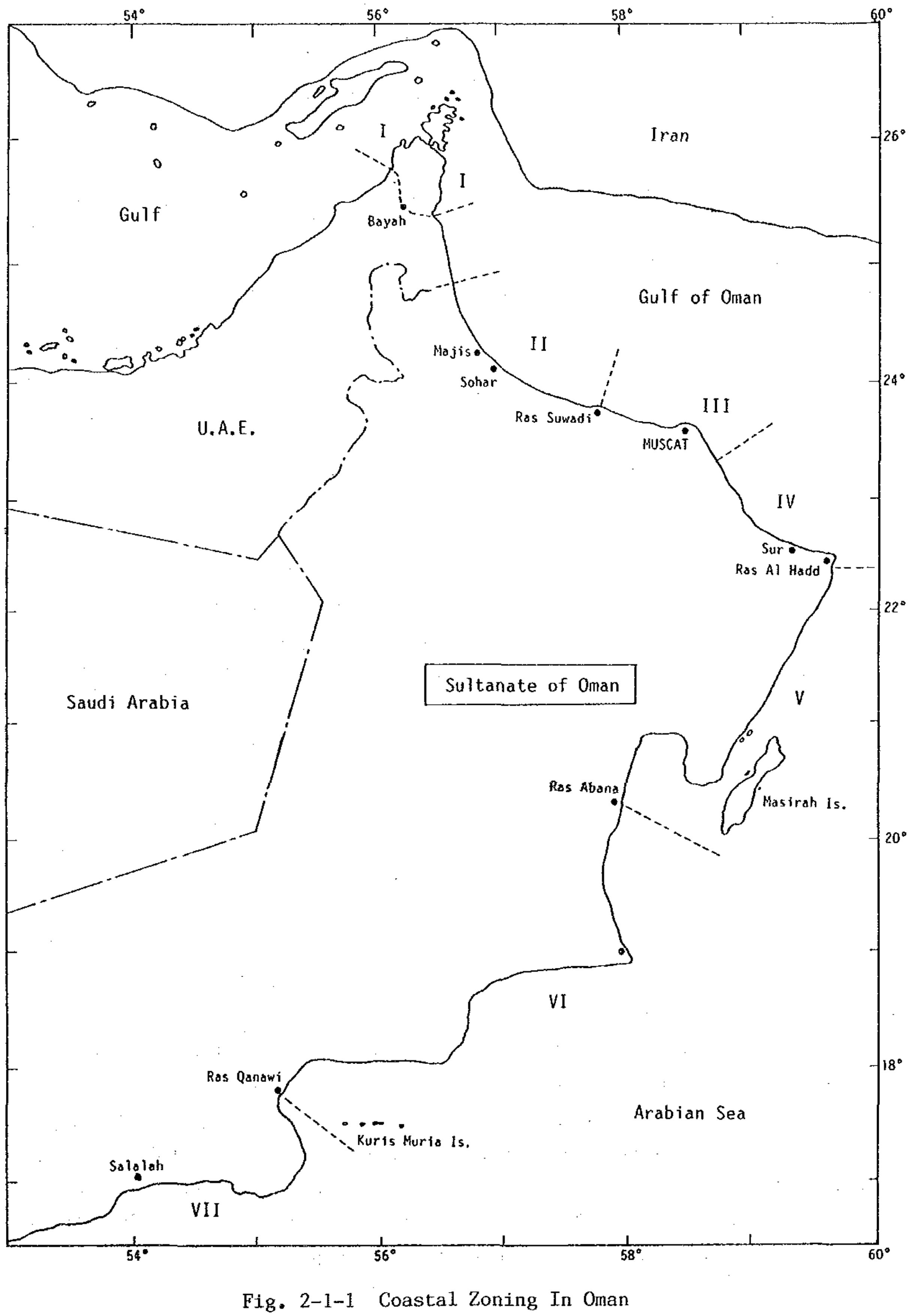


Fig. 2-1-1 Coastal Zoning In Oman

2.2 Geology

2.2.1 Introduction

The available documents related to geological and geotechnical aspects of Oman, a list of which is attached to the last part of this chapter, have been reviewed and analysed.

Following is a summary of the findings:

2.2.2 The Surface Geology of Oman

The geology of Oman has been extensively investigated in recent years and is described in a number of publications (Reference Nos. 1,2, & 3). The principal interest has related to the search for petroleum, and stratigraphic studies have penetrated to considerable depths in many parts of the country (Reference Nos. 4 & 5). Following the upsurge in construction a number of reports have been published on surface geology and aggregate resources in the Middle East, including some by P.G. Fookes (Reference Nos. 6 & 7), which include Northern Oman in their compass. Economic Geology is very actively studied at present and for specific works projects it may be possible to obtain information from the appropriate authority, in particular the Ministry of Petroleum and Minerals, Directorate General for Technical Affairs, and the Ministry of Electricity and Water Public Authority for Water Resources.

A simplified map of the surface geology is shown in Figure 2-2-1. The principal feature in the north is the cresent of Mesozoic limestones which have been intruded by ultrabasic igneous rocks to form the backbone of the Hajar Mountains. These extend from the Musandam Peninsula in the extreme north to the coast east of Muscat and further east to Ras Al Hadd; the highest part, the limestone massif of Jabal Akhadar, lies to the southwest of Muscat.

In the south, the hills surrounding the Salalah Plain are formed of somewhat younger sedementary rocks, and there are some Precambrian outcrops in the extreme south. On the east coast bordering Masirah Bay, the Huqf Group consists of Cambrian sedimentary rocks.

Much of the central area of the country consists of desert gravel plain and sandy desert of recent origins merging westwards into the Rub'al Khali. The Salalah plain in the south is formed of wadi outwash sands and earlier conglomerates. The Batinah plain in the north and the fertile coastal strip also consist of recent alluvial deposits.

The Hajar mountains to the north form a broken and rocky range, broadening from the north to south and comprising Jurassic and Cretaceous limestones and dolomites, and the dark-coloured igneous intrusions of periodites gabbros and basaltic lavas. Much of the rock is fissured and weathered, and jagged peaks are a feature of the scenery. The slopes are covered with screes and loose boulders. Among the more striking features are the wadis, which intersect the foothills, often forming narrow steep-sided channels, gouged out by the flash floods that severe rainstorms bring to the mountains, much of the outwash has been deposited along the channels, and wadi gravels, which are free of salts and often have good natural grading, provide some excellent building aggregates in Oman.

Outwards from both sides of the Hajar mountains, the outwash materials gradually become finer and lighter in colour, running from thick layers of boulders and gravel into the sandy plains of the UAE on the west with some areas of shallow-water evaporate deposition, and into the alluvial maritime Batinah plain to the northeast.

The Jabel Al Qamar and Jebel Qara, which surround the Salalah plain in the south, consist mainly of younger and softer Tertiary limestones and the hills show a somewhat gentler topography than the rugged mountains of the north. Flash flooding following violent rainstorms occasionally occurs and while much of the drainage is to the northwest, there are shallow wadis to the south also and severe flooding has occurred in recent years in Salalah.

Although in the interior of the country there are salt domes and evaporite deposits, and regions of high water table with salt contamination, there is little call for construction in these areas and *sabkha and duricrust do not constitute the severe foundation and material*-contamination problem that they do along the Gulf Coast from the UAE west and northwards.

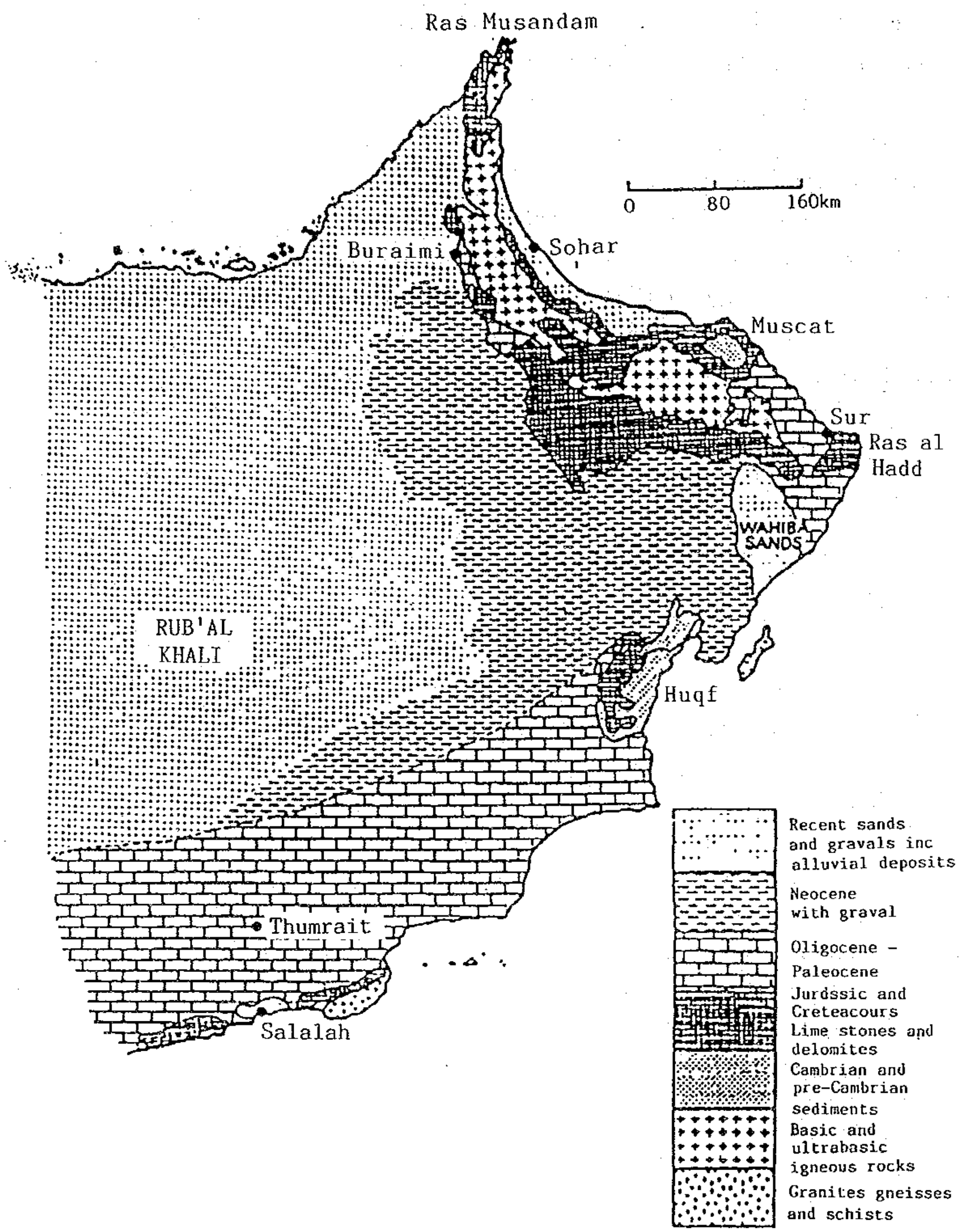


Fig. 2-2-1 Surface Geology of Oman

2.2.3 Characteristics at Mina Qaboos

(1) Geology of the Area

The mountainous terrain surrounding the port area is constituted of very dense ultra basic rock known as peridotite. The rock has been extruded slowly from the earth's mantle by enormous pressures, resulting in shear strain displacements. These displacements have created cleavage planes along which the rock splits quite steadily. Along with the shearing there has also been chemical alteration of the mineral composition. A large percentage of the peridotite has been permeated by the secondary material serpentine. This is a weak material and its presence encourages the rock to split and fragment (Reference No. 8).

(2) Summary of Previous Study

The sub-soil conditions revealed from the previous site investigation work conducted during August 1982 at the location of Berth 1-A at Mina Qaboos, indicate that the stratigraphy of the sea bottom material from the level of -13m from Chart Datum to about the level of -35m is constituted of an intercalation of granular material, non-cemented, poorly cemented and cemented SAND, gravelly SAND, silty SAND or a mixture of these. Some corals and shelly limestones are also noted. In some boreholes, a stabilizing rock stratum is noted and it is believed to be an artificial fill for breakwater.

In general the SPT value is found to vary between N=15 and N=30 below the seabed down to the level of about -16.5m and becoming greater than N=30 with depth.

The strength of these strata varies from medium dense to very dense depending on the degree of cementation.

The location of the boreholes and a summary of the sub-soil findings at the location of Berth 1-A are in Figure 2-2-2 and 2-2-3, respectively.

(3) Sub-Soil Survey

1) General

Within the Scope of the Study on the Port Development for Northern Oman Project, a site investigation was carried out at Mina Qaboos in January 1990. The work was performed upon the request and under the supervision of the JICA STUDY Team.

The purpose of the site investigation work is to assess the sub-soil

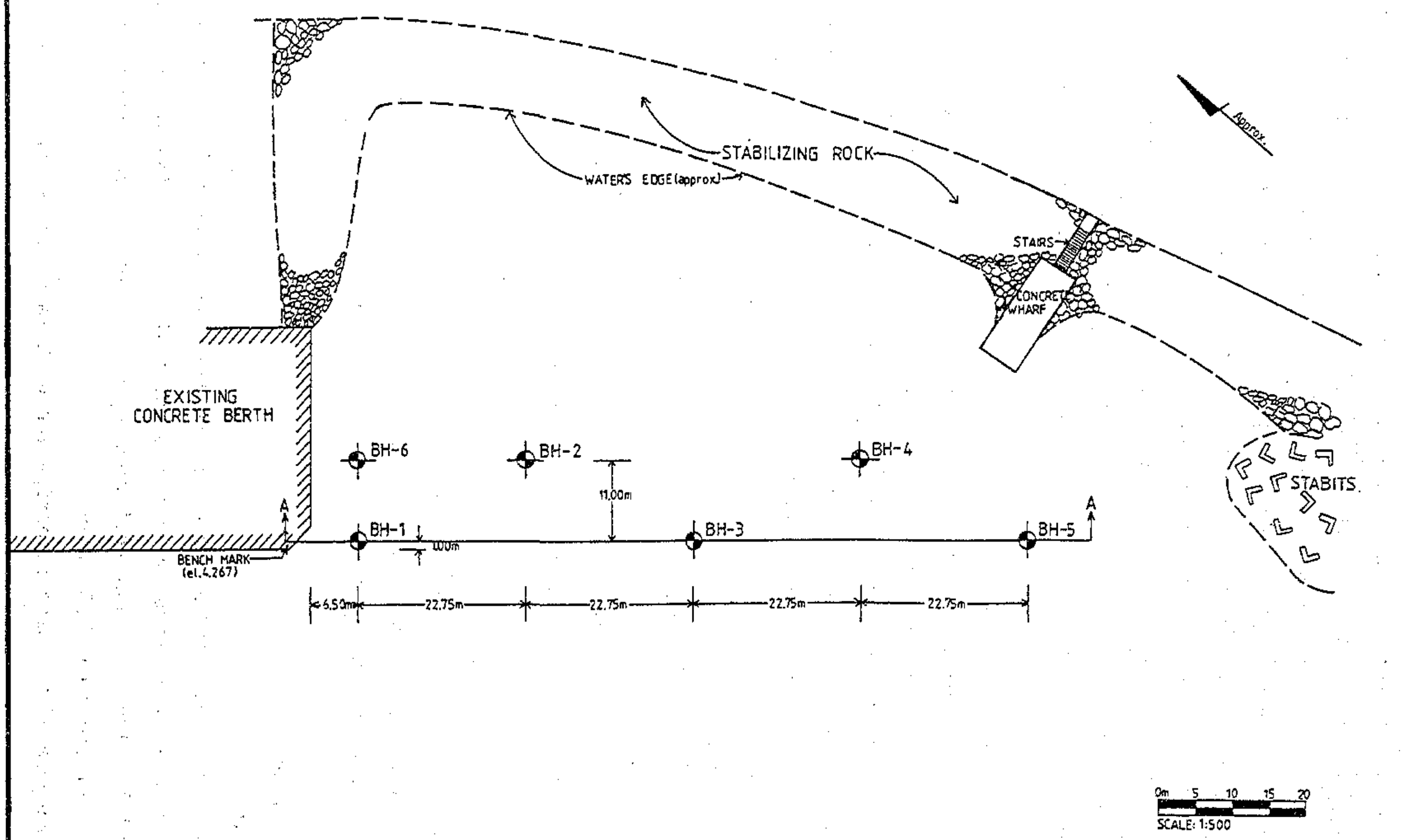
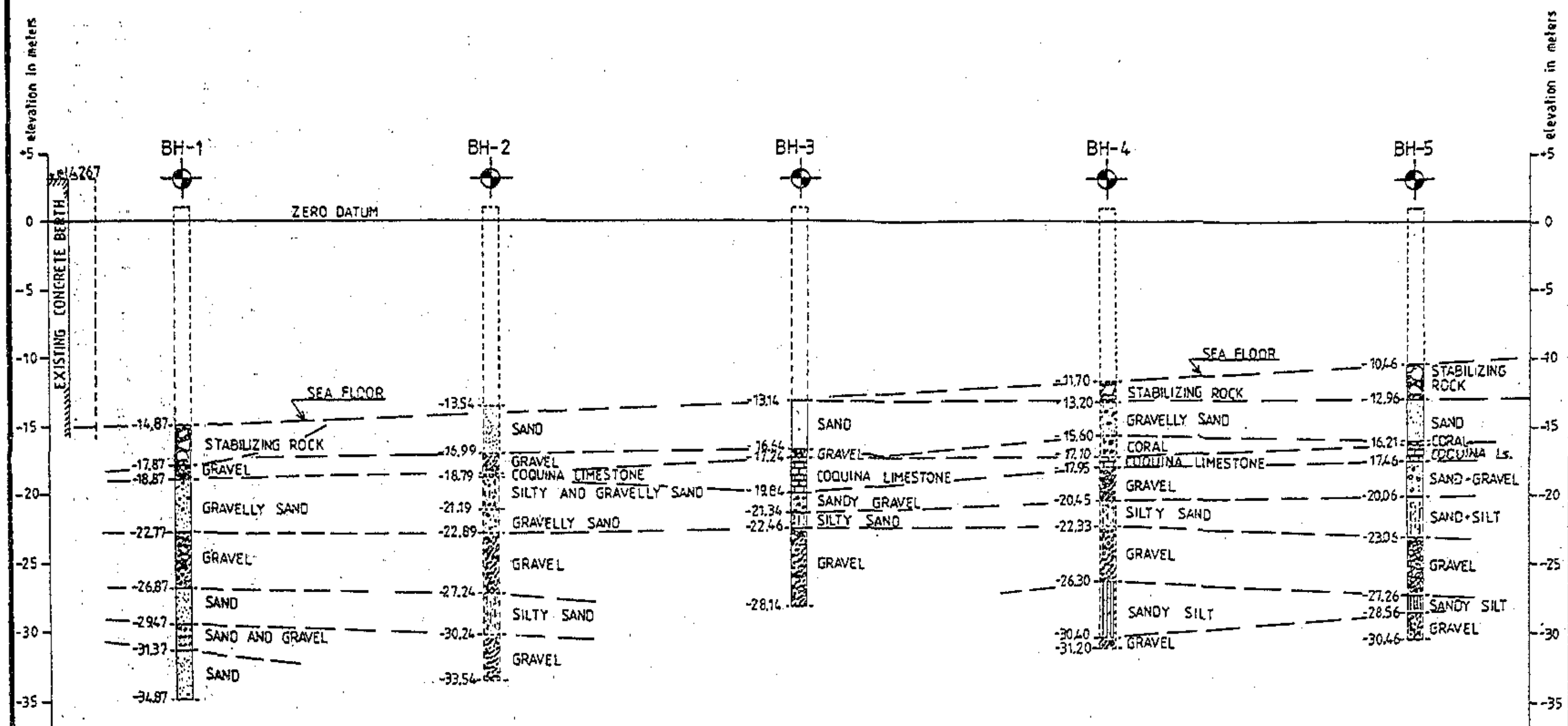


Fig. 2-2-2 Location of Boreholes at Berth 1A --- Mina Qaboos



NOTES

1) Section is drawn through boreholes 1, 3 and 5. Boreholes 2 and 3 are located 11 metres to the north-east of the line of the section.

2) All geological contacts between the boreholes are infered.

3) Vertical scale equals horizontal scale.

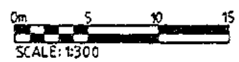


Fig. 2-2-3 Sub-Soil Stratigraphy at Berth 1A --- Mina Qaboos

conditions and to determine the following:

a - the dredgeability of the material at Mina Qaboos

b - The foundation parameters at the proposed new extension of Berth No.12

In order to achieve the above purposes, three boreholes were drilled to the following depths:

B.H. No.1 = 5.45m from seabed
B.H. No.2 = 5.45m " "
B.H. No.3 = 10.50m " "

The locations of the boreholes at Mina Qaboos are shown in Figure 2-2-4.

In-situ standard penetration tests and usual laboratory testing were also carried out.

2) Sob-Soil Conditions

The sub-soil conditions revealed from the drilling of boreholes Nos.1, 2 and 3 at Mina Qaboos are presented in their detailed logs, shown in Figs. 2-2-5, 2-2-6 and 2-2-7 respectively. A summary of the findings including the description and thickness of each stratum and the standard penetration tests performed at different depths is illustrated in Fig. 2-2-8. The results of SPT tests are shown in detail in Table 2-2-1.

Generally the material encountered in boreholes Nos.1 and 2 is similar, contrary to the material found in borehole No.3.

in boreholes Nos.1 and 2, the material is constituted of an intercalation of medium dense and dense granular material of silty fine to coarse SAND with some shells and some corals down to the level of -16.5m from Chart Datum. The SPT value varies in general between N=10 and N=30 and exceeds the value of N=30 in some areas. It is believed that the dense stratum of sandy material is probably due to the presence of shells and dense coral pieces encountered at that depth. Also, we should note the presence of peridotite gravel found in borehole No.2 below the level of -14.6m, which was absent in brehole No.1.

The material found in borehole No.3 down to the level of -9.6m is constituted of a medium dense silty sand gravel with some cobbles (Gravel

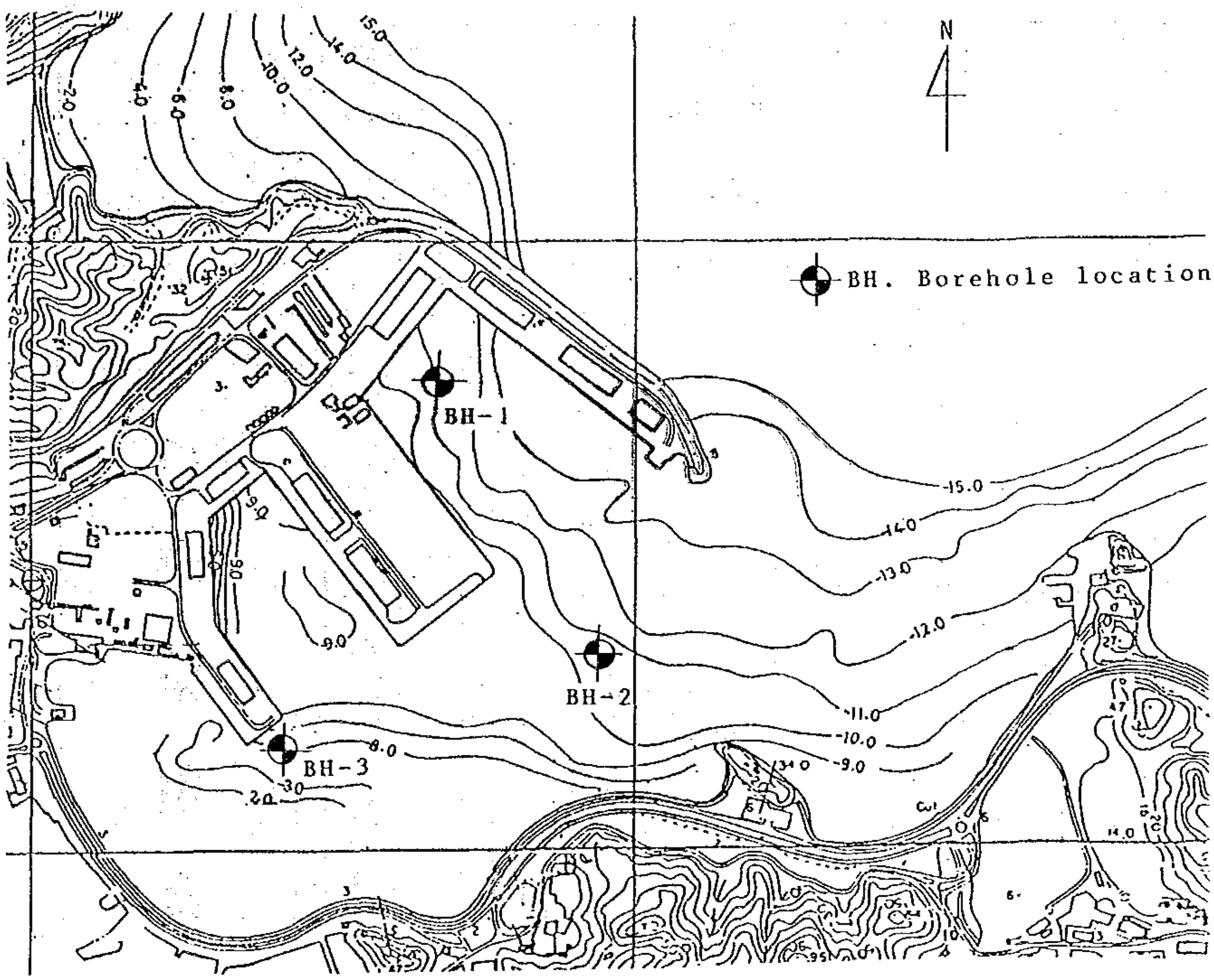


Fig. 2-2-4 The Location of the Boreholes

Client : Minstry of Communication
Consultant: JICA
Project : Port Development - Mina Qaboos

JOB NO: E-505
BH No.: BH-1
Sheet : 1 of 1

Drill Date : 15.1.90 - 17.1.90
Drill Method: Rotary
Drill Fluid : Mud/Water

Rig : 5R60
Casing Dia : H.W.
Casing Depth: 5.00m

Ref. Level : -11.054m CD
G.W.T. : --
Orientaition: Vertical

Depth (m)	Thickness (m)	Visual Description
		Sea Bed
(-11.504)	0.55	Loose, dark grey, silty fine to medium SAND with shell fragments.
(-11.604)	1.05	Loose to medium dense, light brown slightly silty, very shelly medium to coarse SAND.
(-12.654)	0.90	Medium dense, light brown, silty very shelly fine to coarse SAND with coral fragments from 1.70m to 1.90m.
(13.554)	2.95	Medium dense, grey silty very shelly fine to coarse SAND with coral fragments Organic material from 5.42 - 5.45m.
-16.504		End of Hole : -5.45m

Depth of SPT Test	"N" values	Number of Blows 15cm	15cm	15cm
1.0m	11	10	4	7
2.0m	>50	26	34	16 per 5cm
3.0m	13	5	6	7
4.0m	18	6	12	6
5.0m	22	14	14	8

Fig. 2-2-5 Borehole Log of B1 --- Mina Qaboos

Client : Minstry of Communication
Consultant: JICA
Project : Port Development - Mina Qaboos

JOB NO: E-505
BH No.: BH-2
Sheet : 1 of 1

Drill Date : 17. 01. 1990
Drill Method: Rotary
Drill Fluid : Mud/Water

Rig : 5R60
Casing Dia : N.W.
Casing Depth: 5.00m

Ref. Level : -10.146m CD
G.W.T. : --
Orientaition: Vertical

Scale 1:50	Depth (m)	Thickness (m)	Visual Description	Core: Dia (m)	Run (m)	Recov (%)	RQD (%)	STP: "N" values	Number of Blows 15cm	15cm	15cm	Sample: UD	D	Water Return (%)	Depth of SPT Test
	(-10.146)	1.00	Sea Bed Loose to medium dense, grey, slightly silty SAND with some coral fregment.					21	7	11	10				
1.0	(-11.146)	1.00	Medium dense, grey, shelly, medium to coarse SAND with some coral fragments.					26	12	12	14				
2.0	(-12.146)	2.00	Dence to very dense, light brown, silty very shelly, occasionaly gravelly fine to coarse SAND with coral fragments.					51	12	24	27				
3.0								42	16	24	18				
4.0	(-14.416)	0.80	Medium dense, brown, slightlyb silty, shelly fine to midium SAND with coral fragments & some gravels.					33	13	14	19				
5.0	(-14.946)	0.65	Medium dense, dark brown, slightly silty, fine to coarse SAND & fine medium GRAVELS with some shell fragments.					17	11	11	6				
	(-15.596)		End of Hole : -5.45m												

Fig. 2-2-6 Borehole Log of B2

Client : Minstry of Communication
Consultant: JICA
Project : Port Development - Mina Qaboos

JOB NO: E-505
BH No.: BH-3
Sheet : 1 of 3

Drill Date : 14.1.90 - 18.1.90
Drill Method: Rotary
Drill Fluid : Mud/Water

Rig : 5R60
Casing Dia : N.W.
Casing Depth: 10.40 & 14.75m

Ref. Level : -1.963m CD
G.W.T. : --
Orientaition: Vertical

Scale 1:50	Depth (m)	Thickness (m)	Visual Description	Core: Dia (m)	Run (m)	Recov (%)	RQD (%)	STP: "N" values (20 40 60)	Number of Blows (15cm 15cm 15cm)	Sample: UD	D	Water Return (%)	Depth of SPT Test
			Sea Bed										
1.0	(-5.965)	1.00	Loose, to medium dense, brown to dark grey poorly graded sandy, silty, periodititie GRAVELS with cobbles & occasional shell fragments.					22	7 10 12				1.0m
2.0		3.70	Medium dense to very dense, darkish grey sandy, slightly silty peridotite GRAVELS with cobbles.					>50	14 32 18 per 6cm				2.0m
3.0													
4.0	(-9.665)							50	18 20 30				4.0m
5.0		5.05	Very weak to extremely weak, brown to greenish, medium to coarse grained, highly decomposed, peridotite CONGLOMERATE (breccia) with sandy silty matrix, poorly cemented.					>50	24 35 15 per 5cm				5.0m
6.0								>50	17 40 10 per 3cm				6.0m
7.0													
8.0								>50	38 50/14cm				8.0m
9.0	(-14.715)												
10.0	(-15.465)	0.75	Very weak to weak, dark green to brown highly decomposed PERIDOTITE.										

End of Hole : -10.5m

Fig. 2-2-7 Borehole Log of B3

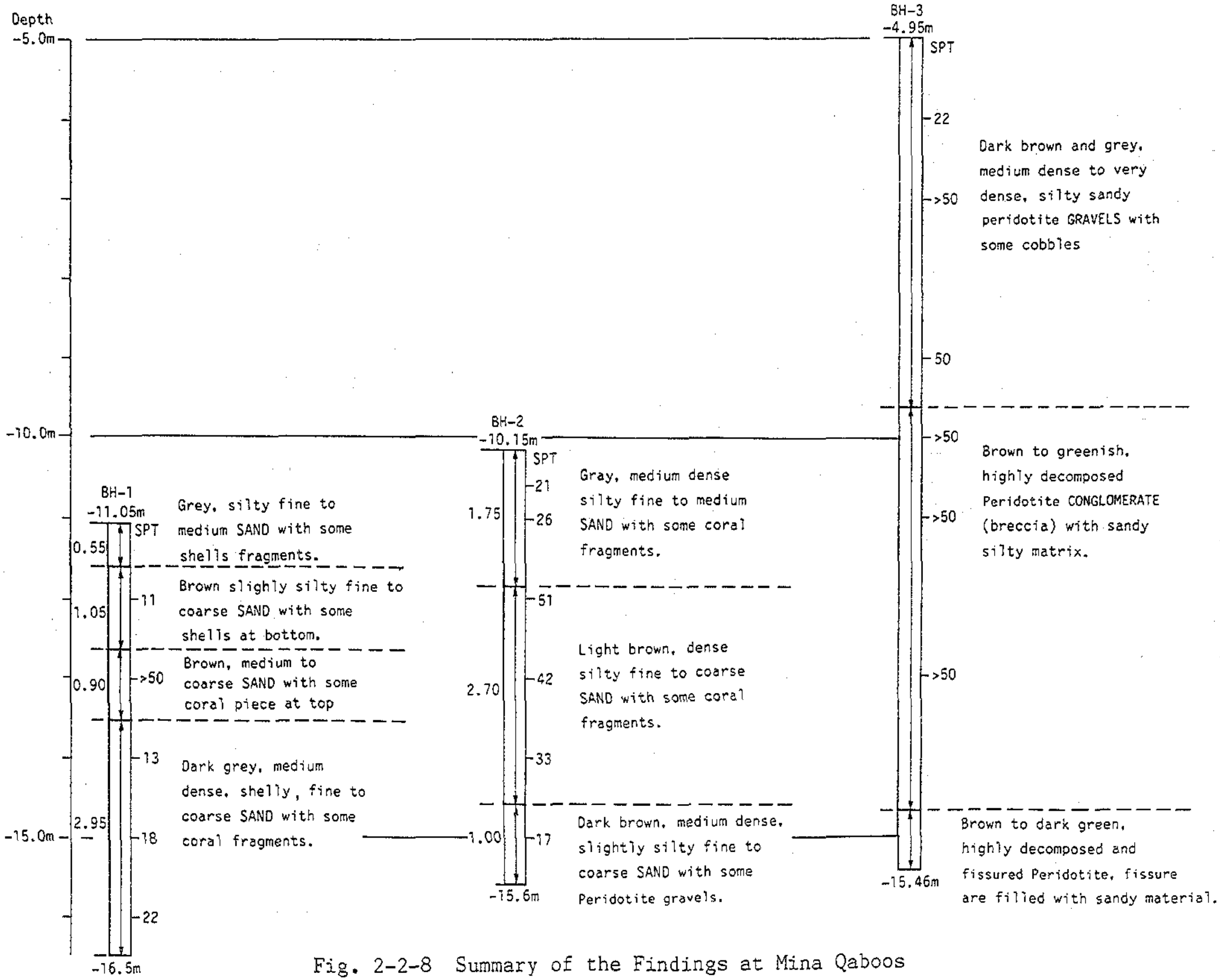


Fig. 2-2-8 Summary of the Findings at Mina Qaboos

and Cobbles are of peridotite type of rock). The above strata is underlain by a highly decomposed Peridotite Conglomerate (Breccia), weakly cemented with a silty sandy matrix and extends to the level of -14.65m from Chart Datum. At the bottom of this stratification a highly fissured and decomposed Peridotite is encountered and fissures are filled with silty sandy material.

The difference in stratigraphy encountered in boreholes Nos.1 and 2 and borehole No.3, could be attributed to the location of these boreholes relative to the shoreline, where a mountainous peridotite rock is exposed. Since borehole No.3 (seabed level at -4.96m) is located closer to the shore line than boreholes Nos.2 (-10.15m) and 1 (-11.05m), it is possible that borehole No.3 is located at the piedmont zone and consequently its material is constituted of the same material of neighbouring exposed rock.

Table 2-2-1 Results of Standard Penetration Tests

B.H.	Depth at start of Test m	Seating Drive Blows for 150mm Penetration	Test Drive: Blows for 300mm Penetration 150mm	Test Drive: Blows for 300mm Penetration 150mm	Test Drive: Penetration after Limiting Blows mm	N Value
1	1.0 m	10	4	7	---	11
	2.0 m	26	34	16	200	>50
	3.0 m	5	6	7	---	13
	4.0 m	6	12	6	---	18
	5.0 m	14	14	8	---	22
2	0.5 m	7	11	10	300	21
	1.1 m	12	12	14	300	26
	2.0 m	12	24	27	300	51
	3.0 m	14	24	18	300	42
	4.0 m	13	14	19	300	33
	5.0 m	11	11	6	300	17
3	1.0 m	7	10	12	300	22
	2.1 m	14	32	18	210	>50
	4.0 m	18	20	30	300	50
	5.0 m	24	35	15	200	>50
	6.0 m	17	40	10	180	>50
	7.65 m	38	50	---	140	>50
	9.00 m	50	---	---	0	>50

Blows was limited to 50 numbers in Split barrel test.

3) Laboratory Testing

The usual laboratory tests have been carried out on 7 selected soil samples and 2 rock samples. Laboratory Tests on Soils included:

Unit Weight   Specific Gravity   Moisture Content

Grain Size Distribution and Attenberg Limits

The results of the laboratory tests are summarized in Table 2-2-2.

Table 2-2-2 The Results of the Laboratory Tests

B.H. No.	Sample Type m	Depth (m)	Natural Moisture Content (%)	Specific Gravity	Grain Size Distribution			
					Clay (%)	Silt (%)	Sand (%)	Gravel (%)
1	SPT	1.0 - 1.45	33	2.67	-	7	72	21
	SPT	3.0 - 3.45	40	2.63	3	10	54	33
2	SPT	0.5 - 0.95	47	2.69	3	10	65	22
	SPT	1.0 - 1.45	65	2.68	-	10	84	6
3	SPT	4.0 - 4.45	18	2.58	-	7	34	59
	SPT	5.0 - 5.35	28	2.45	3	15	32	50
	SPT	7.65- 7.95	28	2.52	3	16	31	50

2.2.4 The Seismicity of the Area

There is a moderate risk of earthquakes in the northeastern part of the country (See Reference 10) bordering on the Gulf of Oman, and a fairly low risk elsewhere. The eastern and western Hajar Mountains, together with the Zagros mountains of southwestern Iran from a great mobile belt, most of the activity being concentrated on the Iranian side, with some tremors in the sea around the Straits of Hormuz, so the Musandam Peninsula is the most susceptible part of Oman. The interior of the Arabian Peninsula is comparatively stable, its rigidity being determined by the Precambrian basement, and the influence of this dominates the seismicity of Oman. The map in Fig. 2-2-9 shows two areas that have been defined following a study of the limited available historical records, instrumental data obtained from the Global Seismology Unit in Edinburgh, and knowledge of tectonics.

In area A, damaging earthquakes (Modified Mercalli intesity VII or greater) may occur within the lifetime of permanent buildings. Area B shown on the map is not itself expected to be subject to damaging earthquakes but would be affected by strong distant earthquakes which could reach intensities of up to V to VI. No special precautions would be required in area B for ordinary structures although there is the possibility of damage to structures with natural periods of vibration greater, for example, than 1 second, from distant earthquakes, and liquefaction could occur in weak soils.

The regulations in current use make no reference to design for earthquakes. The framework and general configuration of most multi-storey buildings may well be found to satisfy such needs. Wide-span buildings may require special attention. Consultants working in the Capital Region indicate however that no special allowance is normally made for earthquakes in the design of major structures.

Area indicated	intensity (Modified Mercalli 1958)
A (Major event)	VII or greater
B (Minor event)	V or VI

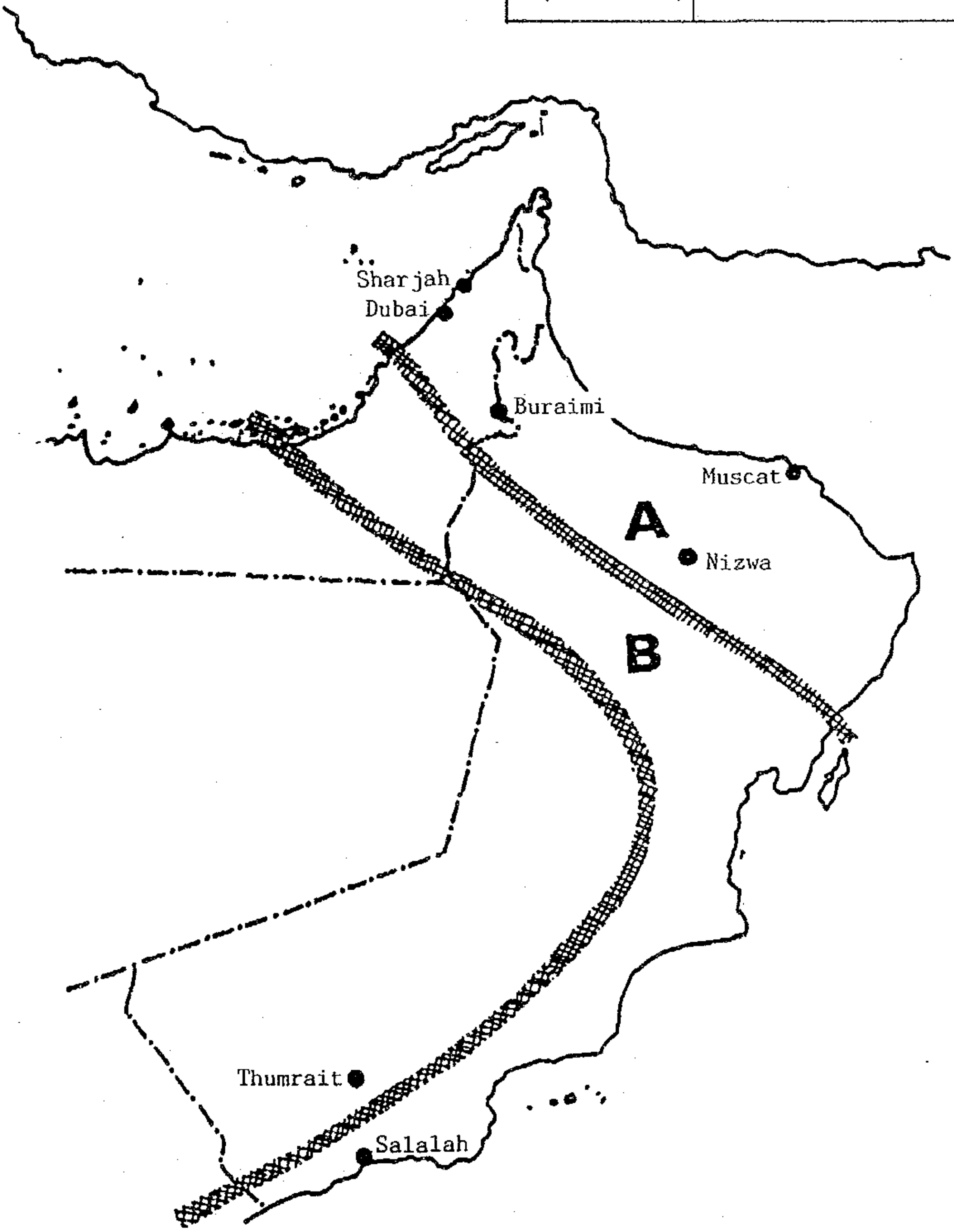


Fig. 2-2-9 Seismicity of the Area

2.3 Meteorology

2.3.1 General Outlook

The climatic year in the Sultanate can be divided into distinct periods, i.e., the winter months from November to April and summer months from June to September. April-May and October-November are considered to be transitional period between winter and summer. Northern Oman is located in sub-tropical zone and southern Oman is tropical zone. The climate of the Sultanate varies with a wide range of topographical features. Therefore, the climate differs from one area to another. It is hot and humid in the coastal areas in summer, hot and dry in the interior with the exception of higher mountains, which maintain a moderate climate throughout the year. The climate of southern Oman is also moderate.

Precipitation is recorded in the Sultanate every month, but basically, most rainfall in central and northern Oman occurs as a result of synoptic situations of cyclonic or frontal types, mainly during the winter months (November-April). In southern Oman, heavy and regular rains fall during the summer months (June-September) because of monsoons.

The orographic effect of northern Oman's mountains and Ras Al Jibal results in the highest average rainfall in the Sultanate falling on the mountains. Such rainfall is the principal source of groundwater for the Batihah, the Musandam and the interior side of the mountains.

2.3.2 Temperature

The monthly average temperature of Seeb varies from 20.8°C to 36.1°C. The maximum temperature varies from 24.7°C to 41.0°C, while the minimum ranges between 17.2°C and 32.0°C. The difference between the maximum and minimum temperatures is 8 to 9°C, which is almost constant through the year.

2.3.3 Precipitation

Generally, the Sultanate has little and irregular rains. Sometimes, however, there is heavy rainfall. In the middle of February 1989, a low pressure area developed over the Arabian Gulf with a trough crossing the northern parts of the Sultanate. Moderate to heavy widespread rain/thoudershowers were recorded at most of the Sultanate. The monthly maximum total rainfall of 235.3mm was recorded at Majis with a daily maximum of 110.3mm, while the monthly maximum total rainfall of 25.6mm at

Seeb with a daily maximum of 12.8mm.

2.3.4 Wind

Wind data at Mina Qaboos has been recorded since January 1988 using marine buoy about 5km north offshore from Mina Qaboos. Wind and wave records are kept at the same time and same place.

Cyclones are not frequent within 160km of the Oman coast and of a total of 87 streams recorded during the period from 1879 to 1944 it appears that only about 16 had any serious effect on the coast. Two cyclones were recorded on the Muscat coast since 1879, both during the month of June, but there is no evidence of a cyclone affecting the muscat coast in the last 40 years.

Tropical storms affected coasts of Oman are refered to the next note. Some tracks of tropical cyclones are shown in Fig. 2-3-1. (Reference No.5) Extreme maximum wind speeds, cyclone conditions are also given in Table 2-3-1. (Reference No.5)

[Note]

Tropical Storms Affected Coasts of Oman

1] August 1983
A deep depression emerged over the North Arabian Sea from Gujarat (India) in the early hours of 9th August 1983 and intensified into a tropical storm (associated winds between 34 and 47 knots) on the same day. It continued moving west-southwest and crossed the eastern coast of Oman just north of Masirah Island at about 2 p.m. (local time) on 10th August. Thereafter it weakened gradually and became a well-marked low-pressure area over the Rub-al-Khali on the following morning. The lowest pressure at Masirah was 984 hPa, when the center of the storm was nearest the island.

2] October 1981
The lowest pressure was 992 hPa, when the storm was nearest the coast.

3] November 1979
When the cyclone was about 110 NM south east of Masirah the lowest pressure estimated was 996 hPa.

4] September 1979
The lowest central pressure of 980 hPa was estimated when the cyclonic storm was approximately 300 NM southeast of Masirah.

5] June 1979
A weak cyclonic storm crossed the coast of Oman near Ras Al Madrakah on 19.6.1979. When the storm was approximately 125 NM south south east of Masirah and 100 NM east of Ras Al Madrakah central estimated pressure was 989 hPa.

6] November 1978
A severe cyclonic storm in the Arabian sea developed off the southwest coast of India during the 5th and 6th of November, 1978.
The storm intensifying rapidly, moved northwest reaching latitude 19.8N and longitude 61.7E, or 180 nautical miles south-east of Masirah Island, at 1120 GMT, 09 November. This position was confirmed by satellite picture which showed a small but well-defined "eye".
The centre moved northward after passing Masirah Island then curved northeast; it became extra-tropical and weakened as it came under the steering influence of a jet stream over the Arabian subcontinent and the Gulf of Oman. The storm continued to weaken and moved eastward to cross the Gujarat coast of India on 12 November. The estimated central pressure was 950 hPa when the storm was nearest to the coast.

7] June 1977

The cyclonic storm developed in an area of convergence in the Eastern Arabian Sea along the southwest coast of India.

The storm, intensifying gradually, moved northward off the coast of India between longitudes 68 and 70E until 10 June at which time a west-northwest movement began and continued, with minor fluctuations, throughout most of the period. Complete data is lacking, however, it appears the storm centre moved westward and then slightly south of west as the core, or "eye", of the cyclone passed along the extreme northern tip of Masirah Island on the morning of the 13th of June. The lowest pressure recorded was 959 hPa.

8] May 1974

During the period 11-20 April 1974 a tropical cyclone developed in the middle of the Indian Ocean and moved northwest before becoming slow-moving and decaying about 200 NM south west of Salalah.

9] May 1963

When the tropical cyclone crossed near Salalah the lowest pressure recorded was 948 hPa.

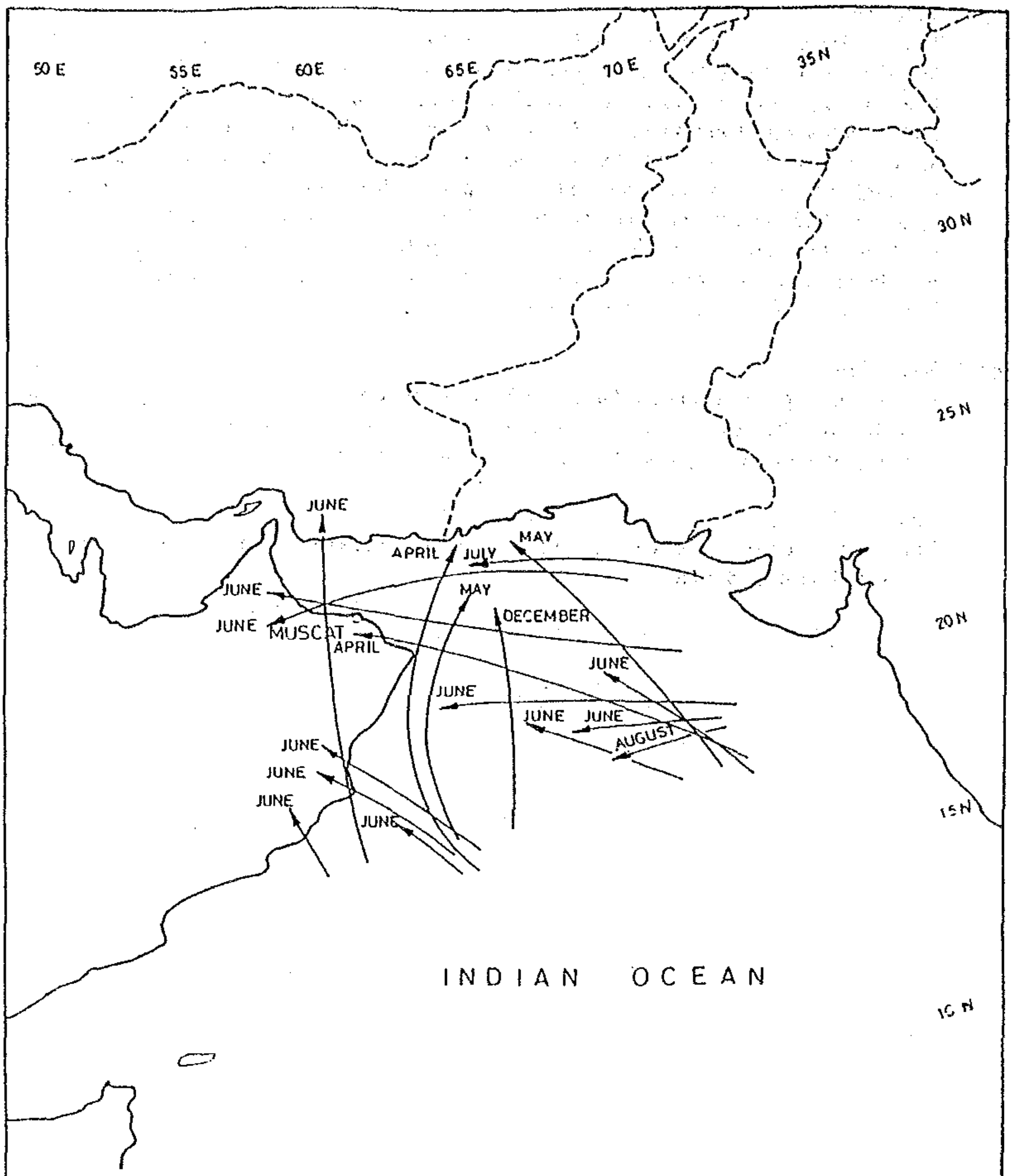


Fig. 2-3-1 *Some Tracks of Tropical Cyclones*

Source : Halcrow Report

Table 2-3-1 Analyses of Existing Wind Data for the Muscat Area

Frequency (%) Distribution of Hourly Mean Wind Speeds (metres/second), Normal Regime

Wind Speed	< 3	3 - 5	5.6 - 7.7	8.2 - 10	10.5 - 12.8	13.4
Frequency	66.3	24.5	7.3	1.7	0.1	<0.1

Extreme Maximum Wind Speeds (meters/second), Normal Regime

Duration	Return Period in Years		
	100	50	10
Gust	30.3	28.8	26.2
1 min.	23.7	22.6	20.6
10 mins.	20.6	19.6	18.0
1 hr.	19.0	18.0	16.5
3 hrs.	17.5	16.5	14.9
6 hrs.	15.9	14.9	13.9
12 hrs.	13.9	13.4	12.4
24 hrs.	12.4	11.8	10.8

Extreme Maximum Wind Speeds (meters/second), Cyclone Conditions

Duration	Return Period 1 in 100 years
Gust	48.9
1 min.	38.1
10 mins.	32.9
1 hr.	30.3
3 hrs.	27.8
6 hrs.	25.2
12 hrs.	32.6
24 hrs.	20.1

2.4 Hydrography

2.4.1 Tides

The predicted tidal levels for Muscat together with Seeb, Wudam, Sohar are as follows:

	Muscat	Seeb	Wudam	Sohar
Highest astronomical Tide	+ 3.1	--	--	--
Mean high water spring	+ 2.7	+ 2.3	+ 2.5	+ 2.3
Mean high water Neap	+ 2.4	+ 2.0	+ 2.4	+ 2.0
Mean sea level	+ 1.9	+ 1.5	+ 1.8	+ 1.5
Mean low water Neap	+ 1.6	+ 1.2	+ 1.5	+ 1.2
Mean low water spring	+ 0.8	+ 0.4	+ 0.8	+ 0.4
Lowest astronomical Tide	0			

The above figures are taken from the Admiralty tide tables for 1988.

The tide is semi-diurnal, i.e., high and low water occur twice daily, but the tides are unequal. The diurnal influence appear to be greatest during times of neap tide, when the tidal range is relatively small. It is apparent that there is little difference in tidal range along the Batinah coast.

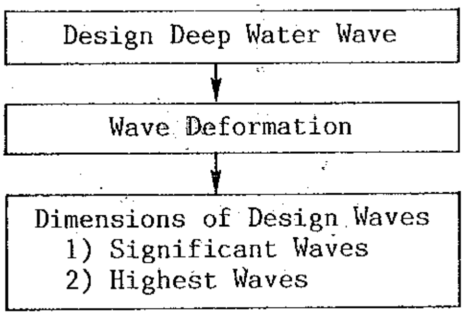
2.4.2 Waves

(1) Cyclone Condition

During 1962-1965, Imcos Marine Liarited measured waves using a pressure recorder situated off the coast at Sail Al-Malch, which is on the northern coast between Muscat and Sur. The average annual wave rose for the period from August 1962 to March 1965 in shown in Fig. 2-4-1. The majority of waves come from the north, with some 16% of the waves higher than 0.6m, and almost equally distributed either sides of north.

The significant wave height is given in Table 2-4-1 for both normal and cyclonic conditions. The deep water wave characteristics in cyclone conditions according to this prediction are adopted for the Muscat area. It is assumed that the Muscat area is hit by cyclones crossing the northern Indian Ocean and moving west (cf Fig. 2-3-1). Consequently, the wave direction is determined to be ENE, which represents the greatest danger to Mina Qaboos.

The wave characteristics at the design depth can be determined by the following procedure:



The dimensions of design waves at the depth of -10m in Shutaify Bay can be estimated based on the hydraulic model tests carried out so far.

Table 2-4-1 Significant Wave Height and Return Period for the Muscat Area (Deep Water)

Item / Wave Condition	Return Period in Years		
	10	50	100
Normal Regime			
Significant Wave Height in Meters.	2.9	3.3	3.6
Wave Period in Seconds	9	10	10
Cyclone			
Significant Wave Height in Meters.			6.4
Wave Period in Seconds			12

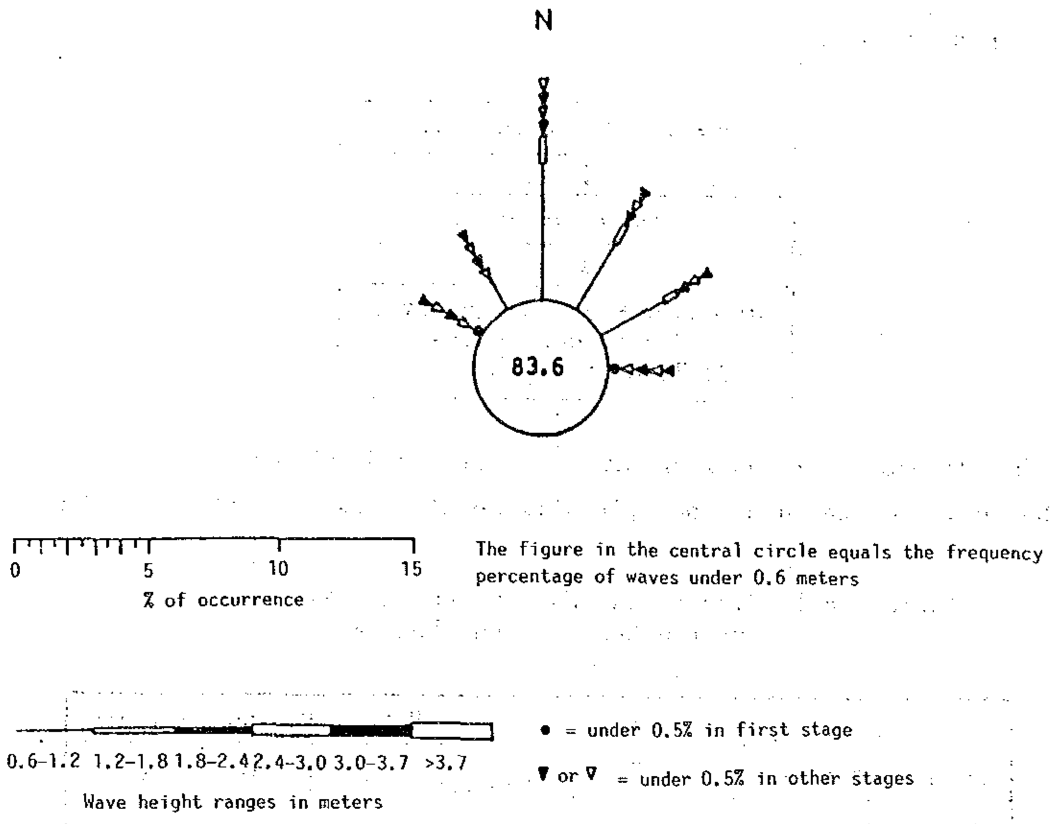


Fig. 2-4-1 Annual Average Wave Rose Offshore at Saih-Ai-Malah
Aug. 1962 - March 1965

i. Design Deep Water Wave

Wave Direction	:	ENE	
Wave Height	:	Ho	= 6.4 m
Wave Period	:	T	= 12.0 sec
Wave Length	:	Lo	= 224.6m
Slope of Sea Bottom	:	tan	= 1/50
H.W.L	:	+ 2.7 m	

ii. Equivalent Deep Water Wave Height (Ho')

Ho' = Ho x K•r = 6.4 x 0.88 = 5.6 m

iii. Design Waves

Design Depth	:	h	= 12.7 m (10 m + 2.7 m)
Significant Wave Height	:	H1/3	= 5.8 m
Maximaum Wave Height	:	Hmax	= 9.5 m

Wave Refrection is shown in Fig. 2-4-2.

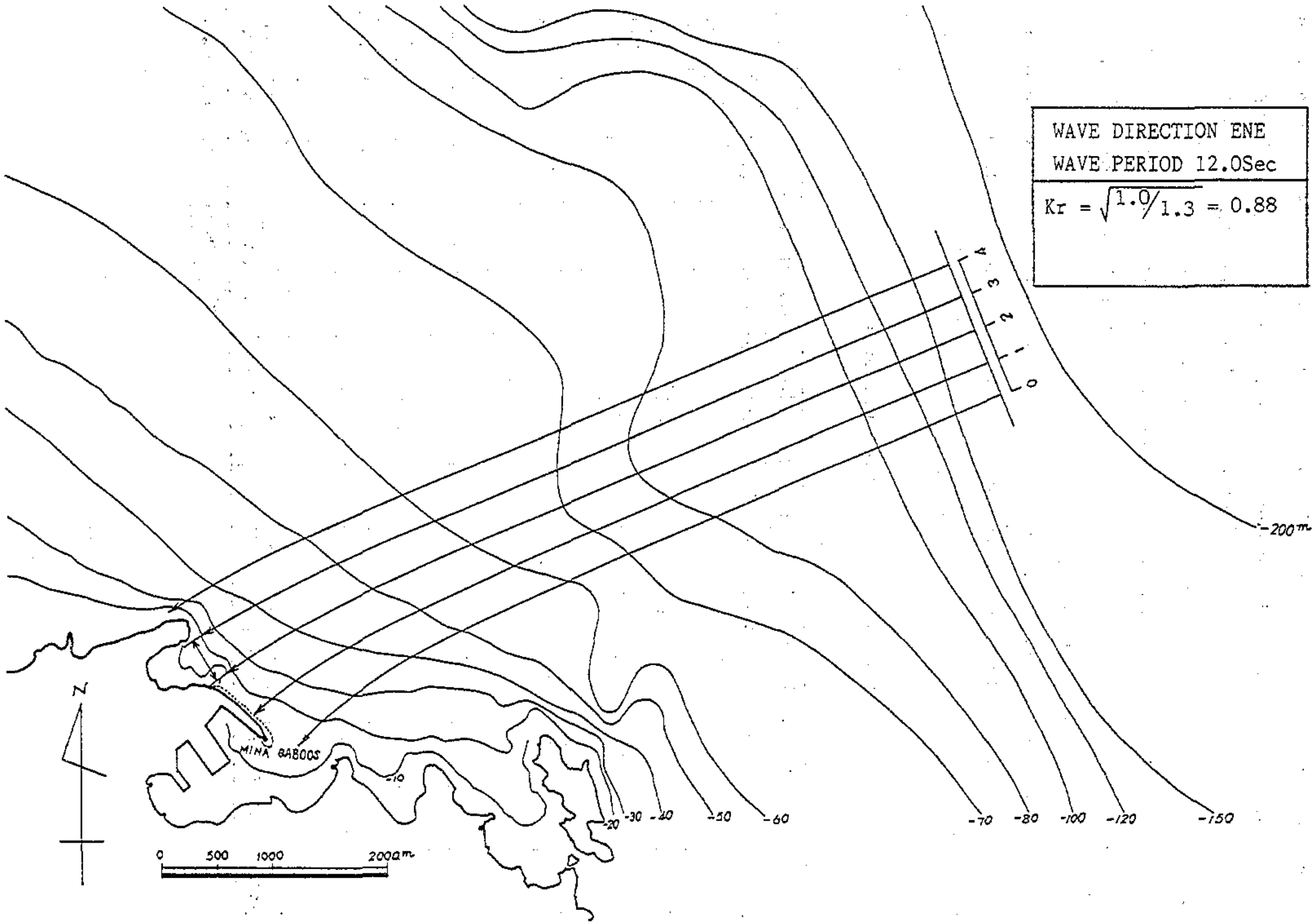


Fig. 2-4-2 Wave Refraction

(2) Normal Conditions

Waves were measured throughout 1988 at a buoy 5km offshore from Mina Qaboos by using a super sonic wave system. Based upon the resulting data, the frequency distribution by wave height and wave period is arranged, as shown in Table 2-4-2 (1). The frequency distribution by wave height and wave direction is also shown in Table in Table 2-4-2 (2). (The wave directions are assumed to be the same as the wind directions)

Wave directions affecting Mina Qaboos are NNW, N, NNE, NE and ENE. Figures 2-4-3 (1) - 2-4-3 (5) denote ratios of wave height within the port area to wave height at port entrance.

The degrees of calmuness in the port area are analysed as shown in Table 2-4-3, and these figures represent the excellent availability of port facilities at Mina Qaboos.

Table 2-4-2 (1) Wave Frequency

Mina Qaboos

T(Sec) / H1/3(m)	≤4.4	4.5~5.4	5.5~6.4	6.5~7.4	7.5~8.4	8.5~9.4	9.5~10.4	10.5~11.4	11.5~12.4	12.5~13.4	13.5~14.4	14.5~15.4	15.5≤	Total (%)
≤ 0.4	223													223 (68.4)
0.5~0.6		10	17	12	7	8	5	5	2	1	2		2	71 (21.8)
0.7~0.8		7	1	1	2									18 (5.5)
0.9~1.0		2	5	1										8 (2.5)
1.1~1.2			3											3 (0.9)
1.3~1.4				1										1 (0.3)
1.5~1.6			1	1										2 (0.6)
1.7 ≤														
Total (%)	223 (68.4)	21 (6.4)	32 (9.8)	16 (4.9)	9 (2.8)	8 (2.5)	5 (1.5)	5 (1.5)	2 (0.6)	1 (0.3)	2 (0.6)		2 (0.6)	326 (100.0)

H1/3 : Daily average wave height
T : Period

Table 2-4-2 (2) Wave Frequency

Mina Qaboos

W.D / H1/3(m)	Calm	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total (%)
≤ 0.4	223																	223 (64.6)
0.5~0.6				2		20	26	6	4					10	16	2	2	88 (25.5)
0.7~0.8		1				1	3	1			1			2	5	3	1	18 (5.2)
0.9~1.0				1			1	1						1	3	1	2	10 (2.9)
1.1~1.2								1							2			3 (0.9)
1.3~1.4								1										1 (0.3)
1.5~1.6														1	1			2 (0.6)
1.7~1.8																		
1.9 ≤																		
Total (%)	223 (64.6)	1 (0.3)		3 (0.9)		21 (6.1)	30 (8.7)	10 (2.8)	4 (2.1)		1 (0.3)			13 (3.8)	27 (7.8)	7 (2.0)	5 (1.4)	345 (100.0)

H1/3 : Daily average wave height
W.D : Wave Direction

Table 2-4-3 Degrees of Calmness at Mina Qaboos

(%)

Point \ Limit of Wave Height	0.5 m	0.7 m	1.0 m
1	100	100	100
2	100	100	100
3	99.7	100	100

Note: The figures were calculated based on the daily average waves heights for 1988.

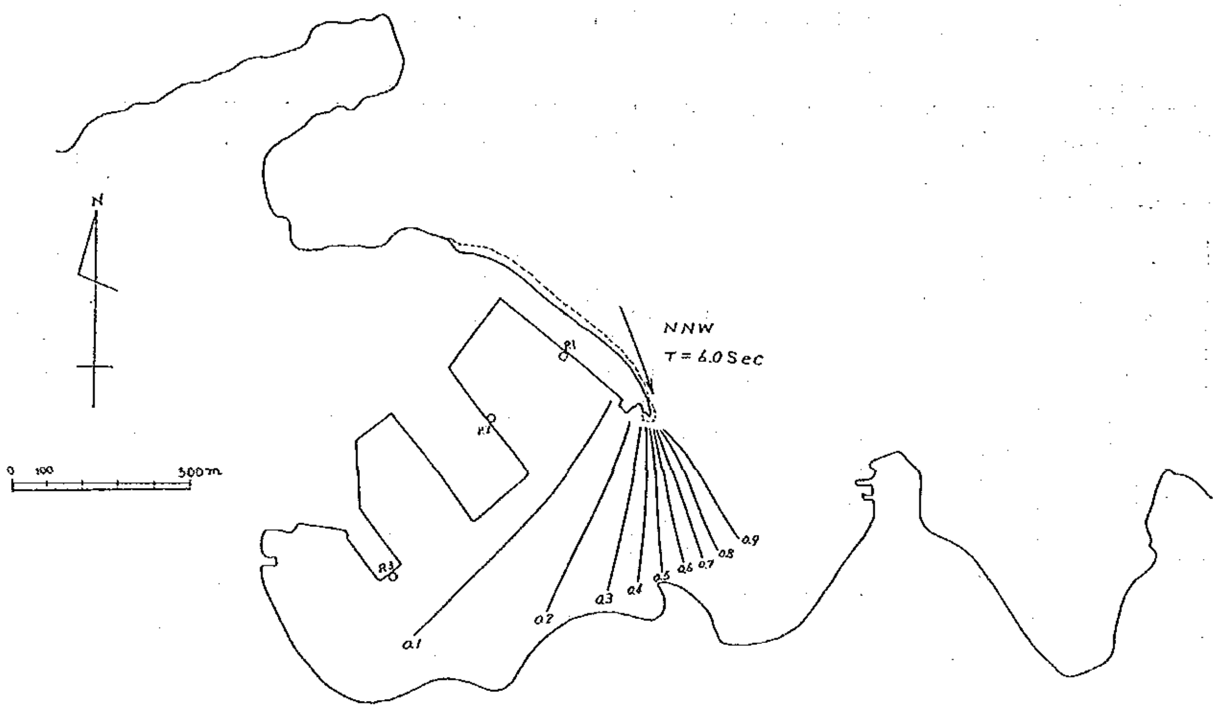


Fig. 2-4-3 (1) Wave Diffraction Diagram

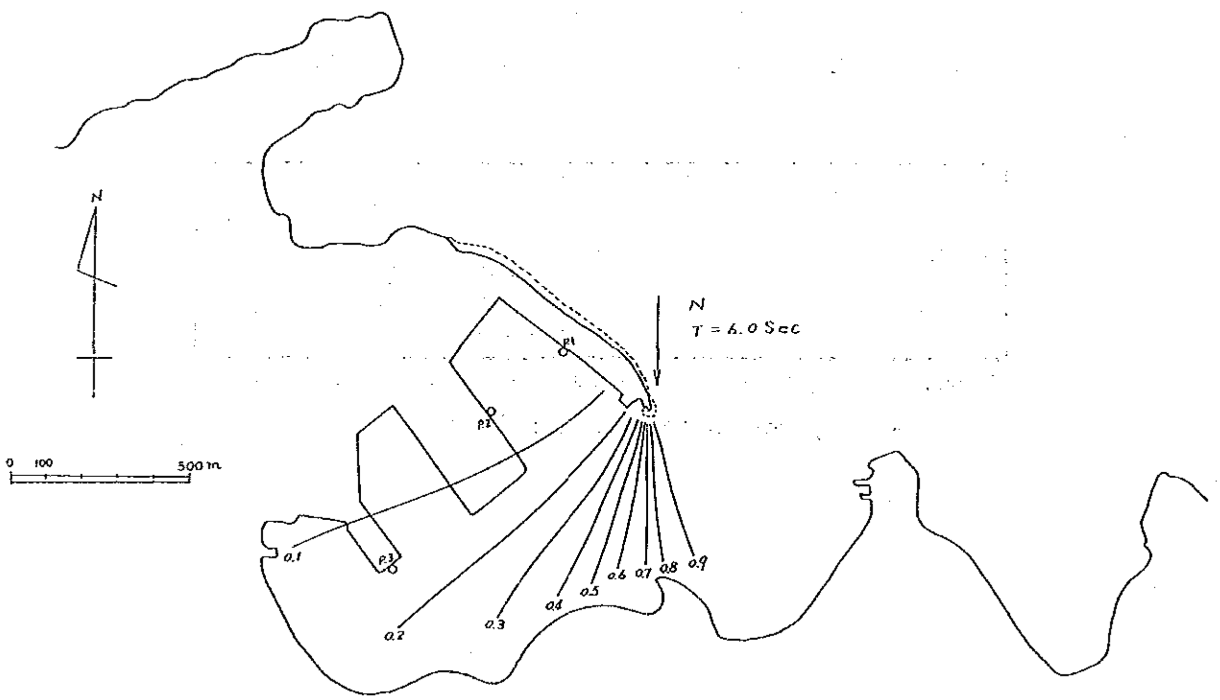


Fig. 2-4-3 (2) Wave Diffraction Diagram

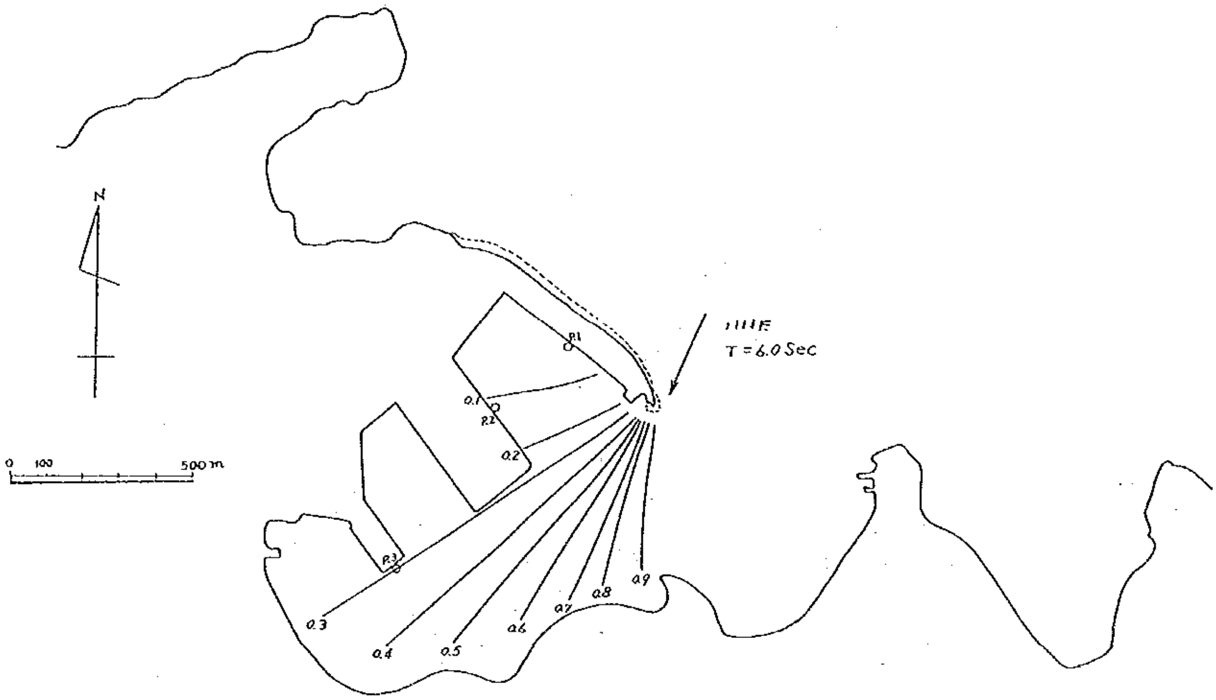


Fig. 2-4-3 (3) Wave Diffraction Diagram

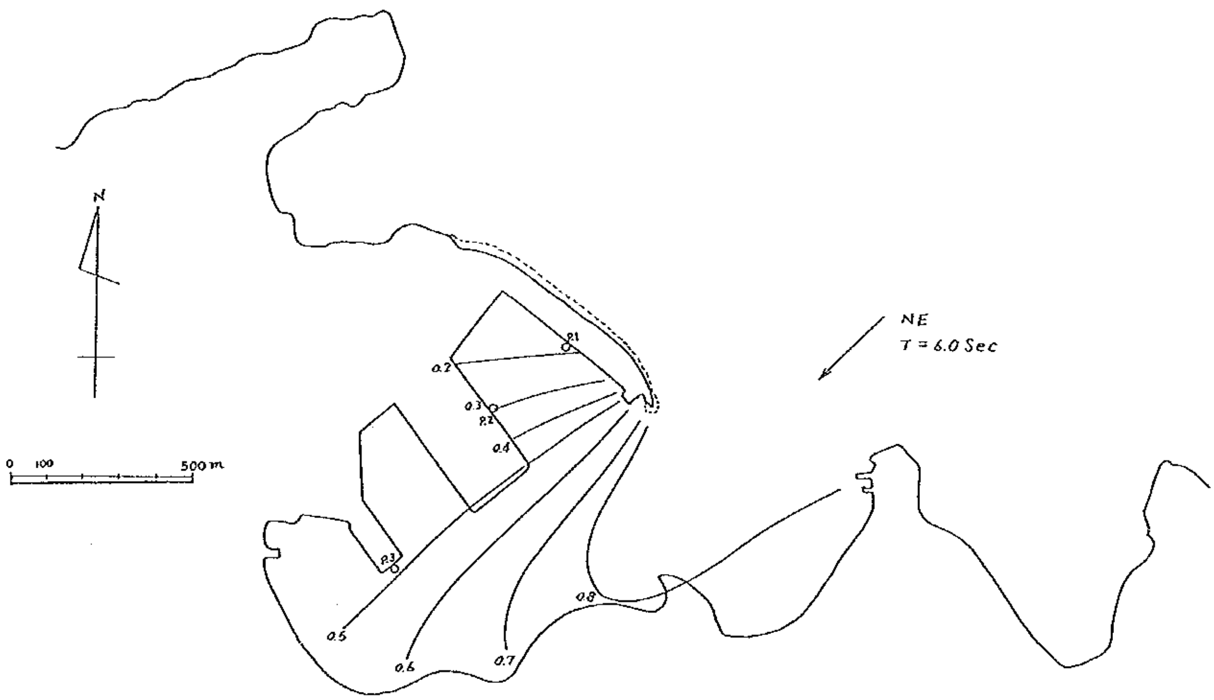


Fig. 2-4-3 (4) Wave Diffraction Diagram

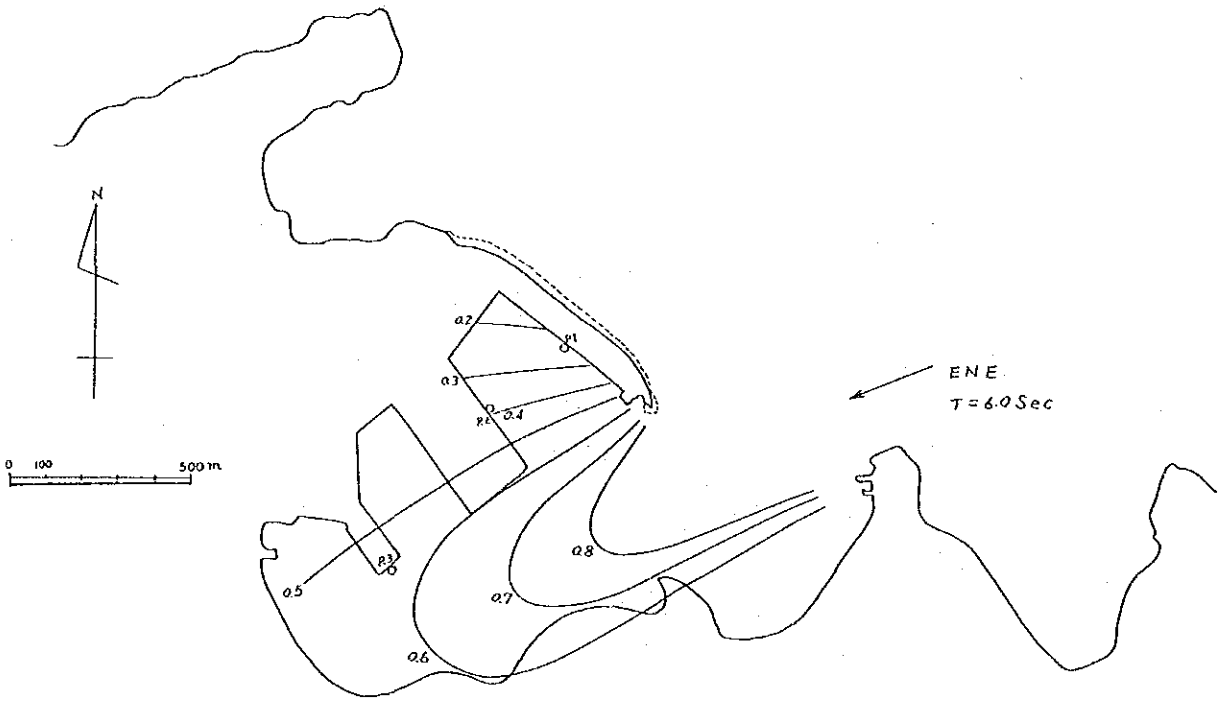


Fig. 2-4-3 (5) Wave Diffraction Diagram

List of References (I)
(Geology)

1. Glennie KW, Beuf MGA, Hughes-Clarke MW, Moody-Stuart M, Pilaar WFH, Reinhardt BM. The geology of the Oman Mountains; Verhandeling van het Koninklijk Nederlands, Geologisch-Mijnbouwkundig Gennootschaap, Deel 31, 1974 (423 pp).

2. Morton DM. The Geology of Oman: Proc 5th World Petr Congr., New York, Section 1, Paper 14, 227-290, 1959.

3. Techopp PH. The General Geology of Oman: Proc 7th World Petr Congr., Mexico, Vol 2, 231-242, 1967.

4. Glennie KW. Outline of the Geology of Oman: Memoire hors-serie Soc Geol France, No. 8, 25-31, 1977.

5. Hawkins TRW, Hindle D, Strugnell R. Outline of Stratigraphy and Structural Framework of Southerm Dhofar (Sultanate of Oman): Geol Mijnbouw, 60 247-256, 1981.

6. Fookes, PG. Natural Construction Materials in the Gulf: Paper to the Dubai International Construction Conference, 1977.

7. Fookes PG and Hgginbottom IE. Some problems of construction aggregates in desert areas with particular reference to the Arabian Peninsula-occurrence and special characteristics, pp 39-67; Investigation procedure and quality control, pp 60-90: Proc Inst Civ Eng, Part 1, 1980, 68, (Feb).

8. Comprehensive Study on Development/Improvement required in Mina Qaboos with Drawings. (Indian Consultants, July 1988).

9. Subsurface exploration for the preposed wharf extension at Mina Qaboos. (Trow OMAN, August 1982),

10. Building Research Establishment; Earthquake risk to buildings in the Middle East, Overseas Building Note No. 190, BRE, Garston, 1982.

List of References (II)

1. Statistical Year Book, (Sultanate of Oman, 1989).

2. Annual Climate Summary, 1988; Department of Meteorology.

3. Willam W. Doyel, James W. Aubel, W. Donald Davison, Jr., Charles G. Graf, James R. Jones, and Keith G. Kennedy. The Hydrology of the Sultanate of Oman. Report: PAWL 83-1, Public Authority for Water Resources, February 1984.

4. Tropical Storms Affected Coasts of Oman, Department of Meteorology, (2 pages)

5. Potential Commercial Port Sites between Muscat and Sur. (Halcrow, September 1984).

6. Admiralty Tide Tables, 1989.

7. Marine Buoy Monthly Climatological Summary 1988. Department of Meterology.

8. Wave Records (Salalah), 1977-1979. Ministry of Communications.

CHAPTER 3 PRESENT CONDITIONS OF MINA QABOOS

Chapter 3. PRESENT CONDITIONS OF MINA QABOOS

3.1 Port Facilities

3.1.1 Breakwater

The approximately 700m breakwater is located at the north end of Mina Qaboos. The breakwater is of basic trapezoidal shape in cross section, with a mound of smaller sized rock (0.1 tons) called the core. 1 - 6 ton graded stone armouring is placed on the slope and on top of this core. On the outside face of the breakwater, which dissipates the energy of the storm waves, the largest primary armour of concrete blocks (15 ton stabit) is placed. There is in situ a concrete buttress wall on the top. This breakwater protects the port areas and shelters the water area from waves (Fig. 3-1-1).

3.1.2 Quaywall

There are long wharves consisting of large berths and dhow & small-craft berths. Precast concrete block work type structures have been adopted, except for No.1A berth, for which a concrete caisson foundation has been adopted. Typical cross sections of the quay walls of Berths Nos.1 - 13 are shown in Fig. 3-1-2. This type of quay wall requires a firm, non-erodable foundation, preferably rock or stiff clay. At Mina Qaboos, a rock blanket over dredged seabed has been adopted to prevent scouring.

3.1.3 Crane Rails

The rails of the quayside container gantry cranes are installed on the No.4 and No.5 berths. The rails are supported on the quay wall on the seaside and on a reinforced concrete beam on the land side. The seaside rail is supported on the existing coping beam of the berths for the whole length, while the land side rail is supported on a new reinforced concrete beam for its full length. Fig. 3-1-3 shows the location of crane rails for gantry cranes.

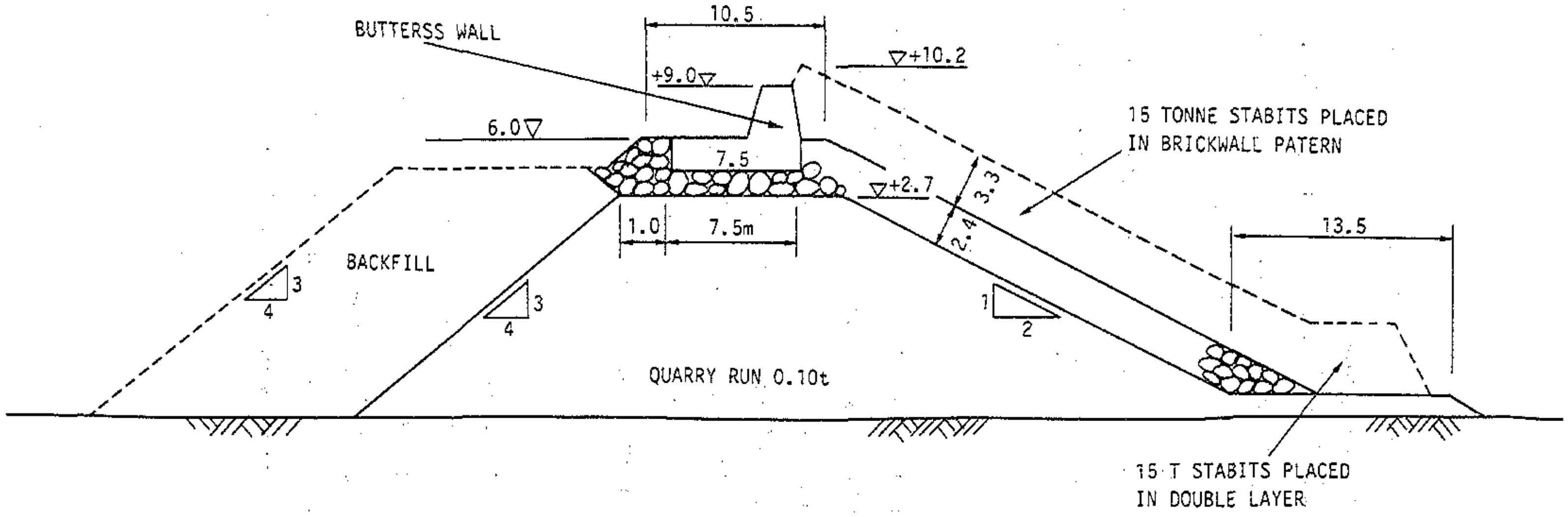


Fig. 3-1-1 Existing Breakwater

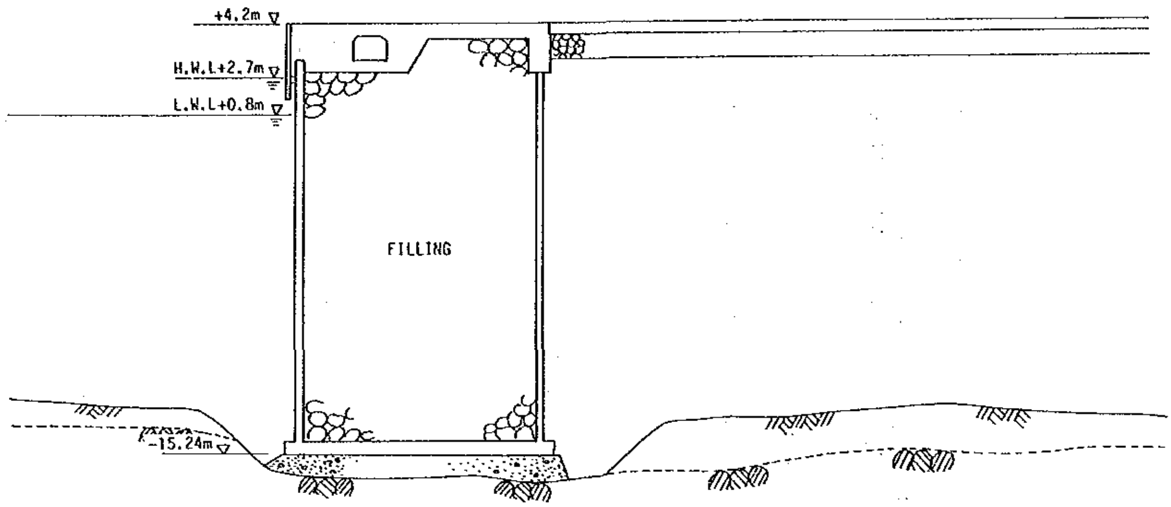


Fig. 3-1-2(1) Existing Quay Wall (Berth No.1A)

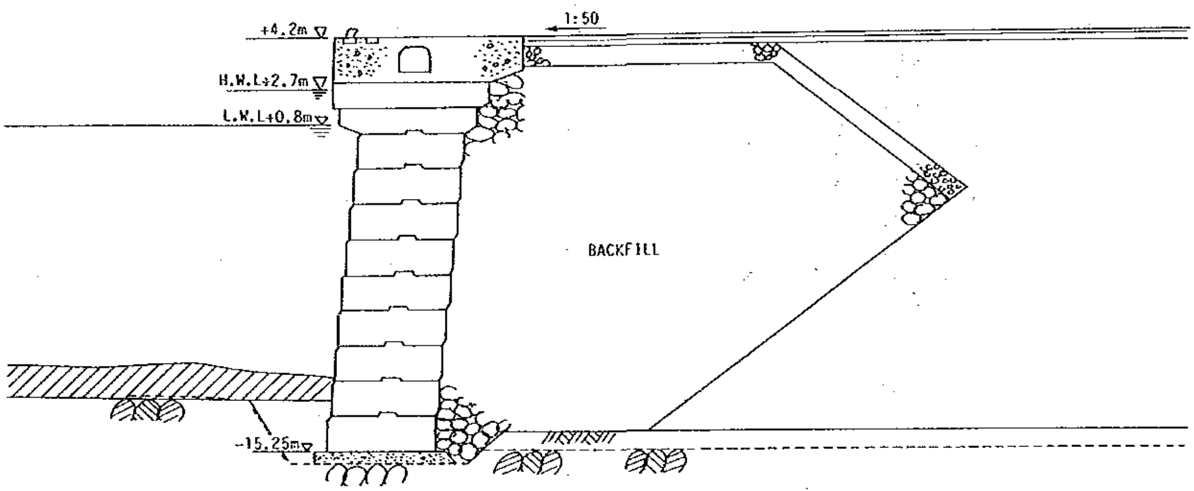


Fig. 3-1-2(2) Existing Quay Wall (Berth No.1, No.2)

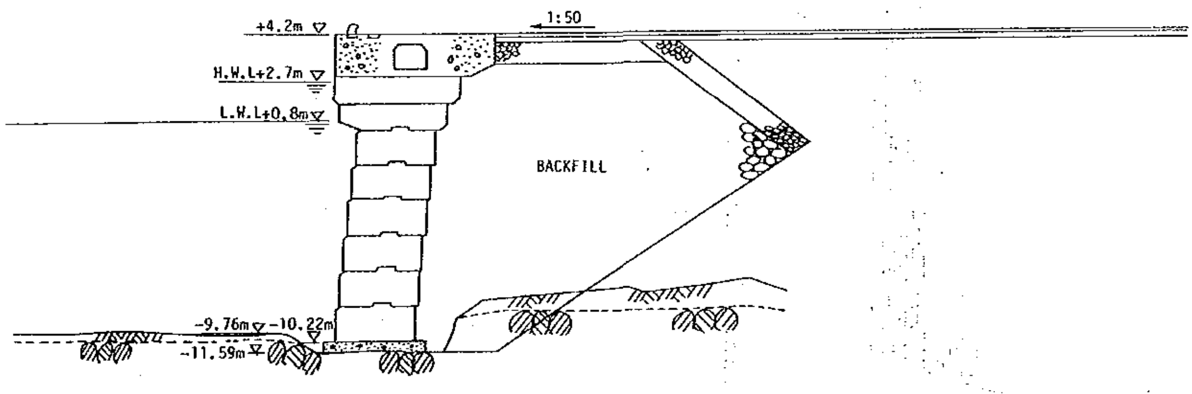


Fig. 3-1-2(3) Existing Quay Wall (Berth No.3-8, No.11)

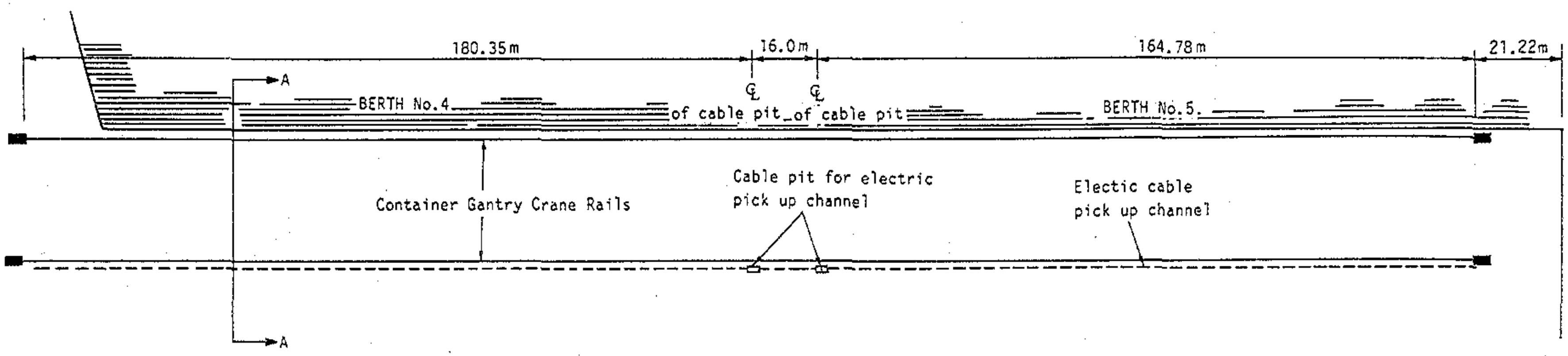


Fig. 3-1-3 Location of Crane Rails

3.1.4 Length of and Draft at Berths

There are 9 deep water berths, 3 coaster berths and 1 berth for launches. Berths Nos.1, 1A and 2, 4 and 5, 7 and 8 are "in line," therefore larger vessels can occupy part of the next berth when necessary. Berths Nos.6 & 11 & 12 are used for His Majesty's vessels. Berths Nos.10 & 13 are for government, Royal Oman Navy and Royal Oman Police Vessels.

The officially calling vessels are mainly accommodated at No.7 & 8 berths, with a high berth occupancy ratio.

The layout of the port is presented in Fig. 3-1-4.

The length of each berth and draft available at Low Astronomical Tide (LAT) are given in Table 3-1-1 below:

Table 3-1-1 Length of and Draft at Berths

Berth No.	Length (m)	Available Depth below CD (m)	Declared Draft (m)	Remarks
1A	91.5	13.0	10.4	Ro/Ro, Convention
1	183	13.0	10.4	Ro/Ro, Convention
2	183	13.0	10.4	Ro/Ro, Convention
3	228	11.0	9.8	Bulk Grain, Rice
4	183	9.5	9.1	Container
5	183	9.5	9.1	Container
6	198	9.5	9.1	Royal Support Yacht, Convention
7	183	9.5	9.1	Convention, Naval Vessel
8	183	9.5	9.1	Convention, Bitumen
9	122	5.0	4.0	Port Service
10	183	5.0	4.0	Naval, Police Vessel
11	183	9.5	4.0	His Majesty's Vessel
12	76	3.5	3.0	His Majesty's Vessel
13	152	2.5	2.2	Coast Guard Launch

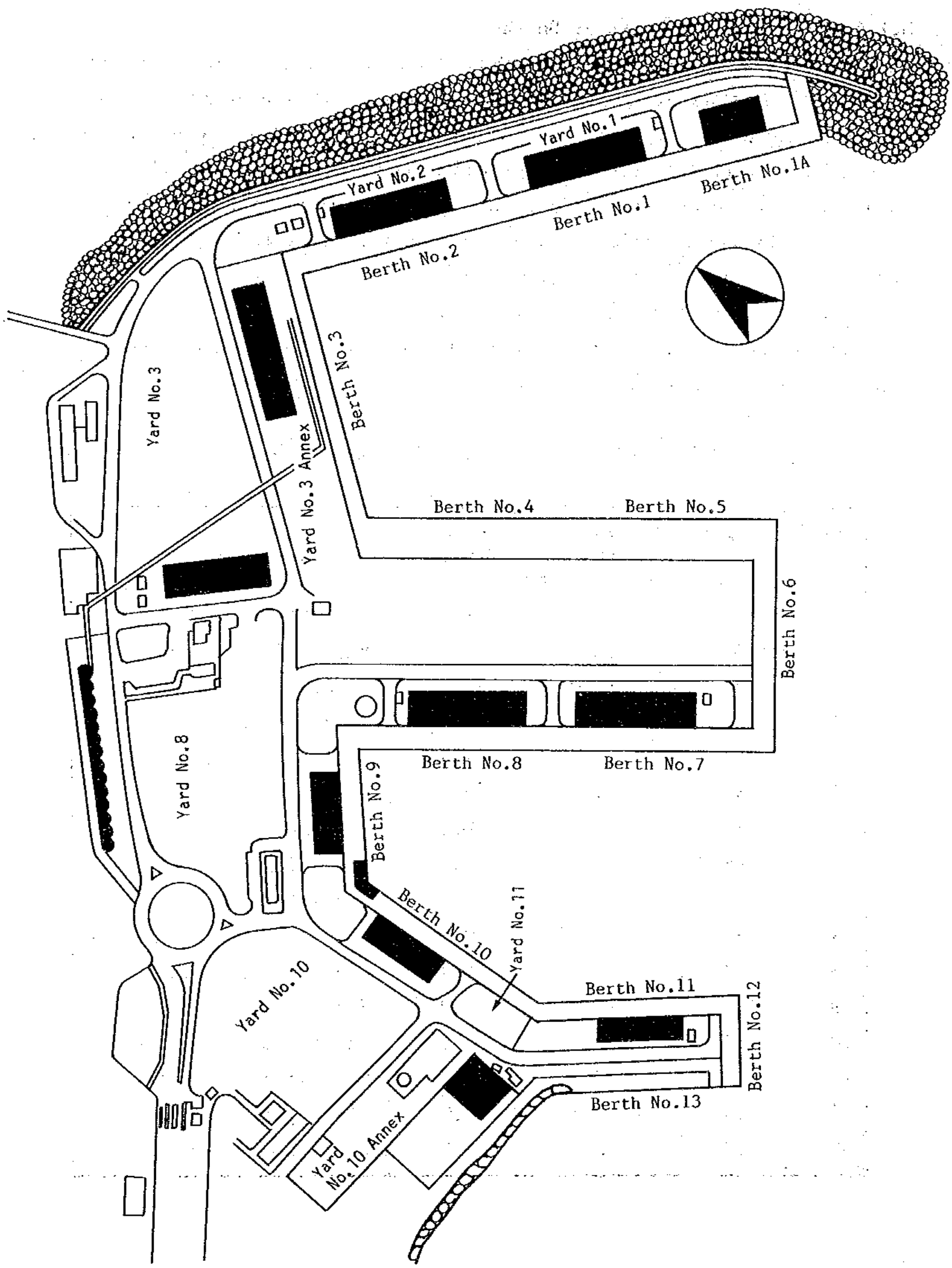


Fig. 3-1-4 Layout of Mina Qaboos

3.1.5 Transit Shed and Open Storage Yard

The following transit sheds and open storage yards are available and utilized for the storage of cargoes. Those dimensions are shown in Table 3-1-2.

Table 3-1-2(a) Dimensions of Transit Shed

No.	Dimension	Area	Cargo by traffic mode
No. 1A	55 X 30.5m	1,678 m^2	Conventional
No. 1	110 X 30.5m	3,355 m^2	Conventional
No. 2	110 X 30.5m	3,355 m^2	Conventional
No. 3	131 X 30.5m	3,996 m^2	Conventional
No. 4	95 X 30.5m	2,898 m^2	Container (CFS)
No. 7	110 X 30.5m	3,355 m^2	Conventional
No. 8	110 X 30.5m	3,355 m^2	Conventional
No. 9	76 X 24.0m	1,824 m^2	Container (CFS)
No.10	76 X 24.0m	1,824 m^2	Government use
No.11	76 X 24.0m	1,824 m^2	His Majesty's use
	Total	27,462 m^2	

- Covered storage for conventional cargo: 19,094 m^2
- Covered storage for LCL cargo (CFS): 4,722 m^2
- Covered storage for government use : 3,648 m^2

Table 3-1-2(b) Dimensions of Open Storage Yard

No.	Area	Cargo by traffic mode
No. 1A	2,200 m^2	Conventional
No. 1	2,000 m^2	Conventional
No. 2	2,020 m^2	Conventional
No. 3	28,430 m^2	Conventional/Container
No. 3A	7,180 m^2	Container
No. 4/5	36,900 m^2	Container
No. 8	18,030 m^2	Container
No. 9	1,225 m^2	Conventional
No.10	20,000 m^2	Conventional/Container/Ro/Ro
No.10A	5,250 m^2	Ro/Ro
No.11	2,100 m^2	Container
Total:	125,335 m^2	

- Storage yard for conventional cargo: 39,910 m^2
- Storage yard for containers: 87,425 m^2

Note: Open yard allocation by commodity is illustrated in Fig. 3-1-5.

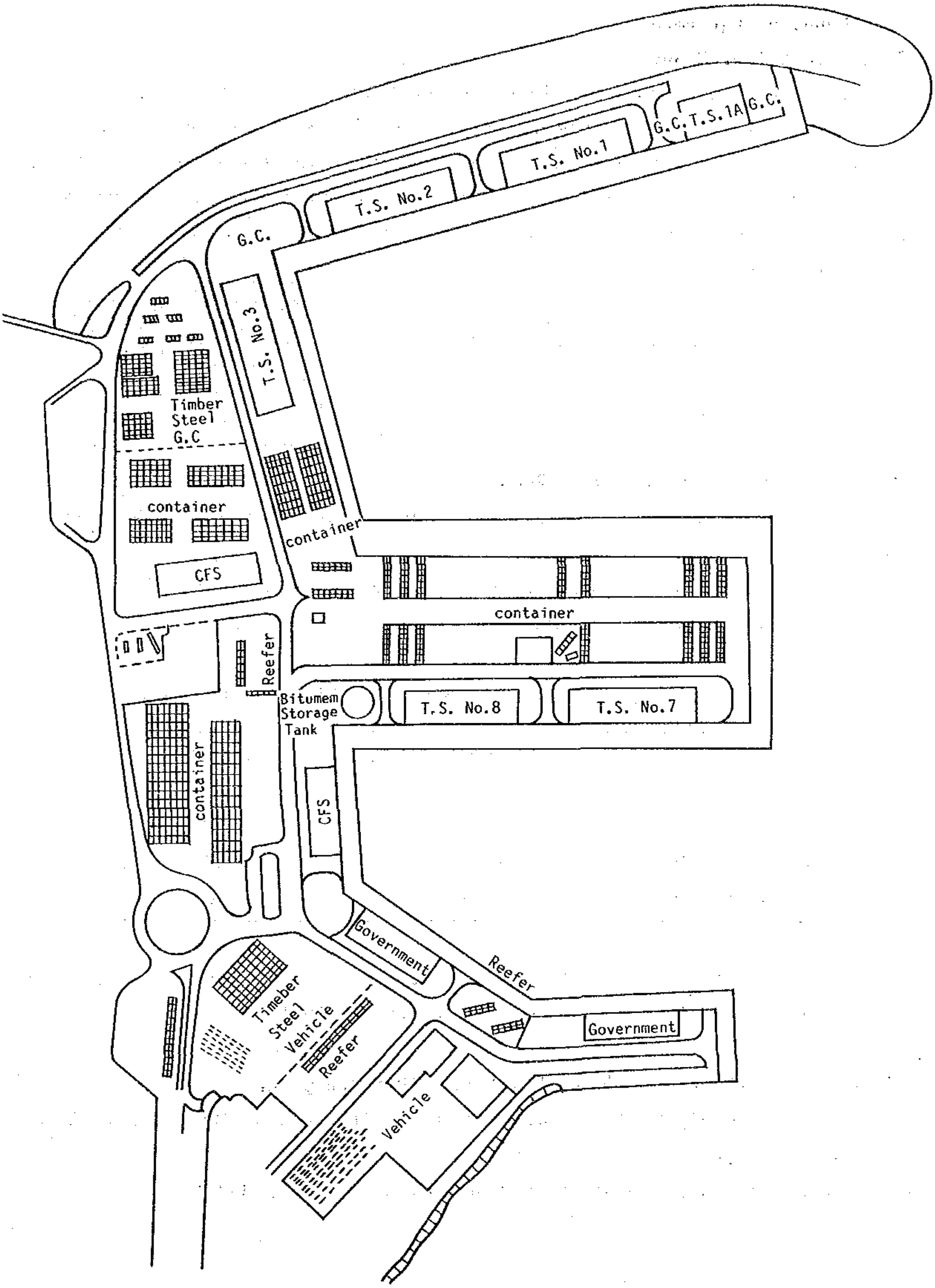


Fig. 3-1-5 Open Yard Allocation

3.2 Handling Equipment

3.2.1 Container Crane

Two container cranes are installed on No.4 and 5 berths respectively. These two cranes are at present kept in good operating conditions as a result of good maintenance work by engineering department staff members. Because of this good maintenance, working and maintenance documents show that there are not many cases in which cranes are off work due to major accidents involving the machine.

The average rate of unloading/loading work at each container crane is 25 to 30 containers per hour. But at Mina Qaboos the average unloading/loading rate is lower. It seems that each container crane handles 17 to 20 containers per hour.

3.2.2 Pneumatic Unloader and Chain Conveyer

A pneumatic unloader and a chain conveyer are provided at No.3 berth by Flour Mill Co. Ltd..

According to actual daily reports of the Flour Mill Co. site office, transport tonnages are as follows:

Table 3-2-1 Actual Carrying Capacity of Flour Mill Conveyers

Date	Transport tonnage per 24h	Average (t/h)
Nov. 19/89	4,980	207
Nov. 30/89	5,500	230
Nov. 04/89	3,652	170

This system has improved its carrying capacity from 230 t/h to 250 t/h by replacing the electric motors and reducers in 1984.

3.2.3 Forklift Trucks (Heavy Type) and Other Equipment

There are eight (8) forklift trucks with a capacity over 25,000kg weight at the port.

Other handling equipment is described in Appendix 3-2-1.

3.3 Cargo Movement

Table 3-3-1 shows the cargo volume handled at Mina Qaboos between 1978 and 1988. As compared with imports which have declined since 1986, when oil prices fell, transshipments have been on the rise for the last few years. The port owes the constant increase in the total volume of cargo to this upsurge of transshipment.

Table 3-3-2 shows the import cargo volume by commodity. Cement, which had been the largest import, has fallen sharply since Oman started operating its own cement factories in Rusayl and Salalah. Since the 1986 crisis, most cargoes have been decreased but above all a down trend of in imports of construction materials (steel, timber, other building materials, heavy duty trucks and so forth) is remarkable.

Import cargo volume by handling mode is shown in Table 3-3-3. Although less than 15% of rice is containerized, the containerization ratio of all containerizable imports is quite high: 76% in 1987 and 73% in 1988 (containerizable cargo is defined as all non-bulk cargo exclusive of vehicles, livestock timber and steel).

Tables 3-3-4 and 3-3-5 provide the information about export cargo. Major export commodities handled at Mina Qaboos are copper, fish, scrap and provisions but the quantity of exports is quite small compared with imports. The ratio of containerized export cargo has reached more than 90%, utilizing a lot of empty containers which have brought import cargoes.

Tables 3-3-6, 3-3-7, and 3-3-8 show the container traffic of imports, exports and transshipments, respectively. The proportion of 20ft. containers and 40ft. containers is nearly fifty-fifty in terms of TEU (this means that the ratio is about 2:1 in terms of boxes).

In Mina Qaboos, there are four different types of container cargo movement, namely, the movement of import containers, export containers (loaded), export containers (empty) and transshipment containers. There are various kinds of combinations of container shipments in Mina Qaboos, as shown in Fig. 3-3-1, and among these, five combinations dominate. From this figure, it is understood that in most cases, transshipment cargoes are transported with other kinds of containers, except for 3.2% of all combinations.

The number of containers discharged/loaded for each ship call is shown in Fig. 3-3-2, and some specific features are revealed here. Reflecting the total throughput for each type of container, the number of transshipment container handled is by far the largest, with more than 1000 TEUs at one ship call. In contrast, the number of export containers (loaded) handled is very small and concentrated in a range of less than 20 TEUs at one ship call. Import containers and export containers (empty) show almost the same characteristics. This information is very helpful in planning the locations an areas of container stocking yards.

Fig. 3-3-3(a) - (e) show the characteristics of cargo storage for principal conventional cargoes such as steel, timber, vehicle, rice and general cargoes. These characteristics were analyzed based on three months' data given by PSC, namely October, November and December of 1988 (See Appendix 3-3-1). In Fig. 3-3-3, only the results for October are shown. Table 3-3-9 shows the calculated dwelling time for the principal conventional cargoes. This result shows that dwelling times are around one week for principal conventional cargoes and two weeks for general cargoes.

Table 3-3-1 Cargo Volume Handled at Mina Qaboos

(Unit: '000 tonnes, TEUs)

Year	Cargo Volume (Import)	Cargo Volume (Export)	Cargo Volume (Ex+Im)	Cargo Volume (Tranship)	Cargo Volume (Total)	(Container) TEU
1978	782.2	10.1	792.3	0.0	792.3	
1979	697.7	19.6	717.3	11.8	729.1	
1980	781.9	23.7	805.6	2.2	807.8	
1981	1,088.6	21.6	1,110.2	0.1	1,110.3	
1982	1,352.2	31.8	1,384.0	12.2	1,396.2	14,965
1983	1,318.2	38.8	1,357.0	31.6	1,388.6	44,112
1984	1,195.0	51.1	1,246.1	90.7	1,336.8	65,901
1985	1,207.1	62.0	1,269.1	192.7	1,461.8	90,175
1986	930.4	50.0	980.4	287.4	1,267.8	111,596
1987	777.5	57.7	835.2	713.4	1,548.6	110,635
1988	950.9	67.3	1,018.2	603.7	1,621.9	139,256

Source: PSC

Table 3-3-2 Import Cargo Volume at Mina Qaboos by Commodity

(Unit: '000 tonnes)

Year	Rice	Wheat & Flour	Other Grain	Sugar	Chilled & Frozen Foodstuffs	Other Food-Stuffs	Timber & Plywood	Steel & Pipe
1978	20.5	39.1		10.1	13.5	53.2	42.7	31.6
1979	25.3	62.5		6.1	17.7	47.8	36.5	54.0
1980	20.4	68.7		2.2	24.4	63.6	56.0	51.9
1981	17.7	87.3		4.8	19.3	60.5	67.2	99.7
1982	25.8	80.3		4.3	23.8	69.3	107.3	136.6
1983	48.7	98.8		6.0	29.7	91.5	121.7	140.1
1984	55.7	117.2		19.4	42.6	99.4	130.8	167.6
1985	61.8	100.9		7.5	49.0	86.5	134.3	155.0
1986	60.1	156.4		17.1	48.8	64.5	82.7	63.5
1987	60.5	150.5		16.0	39.4	72.3	60.7	34.2
1988	82.3	105.8	29.7	22.7	44.9	81.8	70.9	149.0

Source: PSC

(Unit: '000 tonnes)

Year	Cement-bagged	Cement-bulk	Other Building Materials	Vehicles	Livestock	General Cargo	Total
1978	382.0	28.7	6.5	26.4	0.6	127.3	782.2
1979	232.6	38.6	7.6	40.6	0.3	128.1	697.7
1980	145.8	118.1	6.1	60.5	0.4	163.8	781.9
1981	300.8	128.0	8.0	69.9	0.4	225.0	1,088.6
1982	261.5	271.1	13.5	88.6	3.1	267.0	1,352.2
1983	96.2	242.9	30.0	94.0	8.1	310.5	1,318.2
1984	43.9	0.0	39.0	98.2	7.0	374.2	1,195.0
1985	34.4	0.0	36.7	83.1	6.5	451.8	1,207.5
1986	25.3	0.0	24.2	27.6	8.2	352.0	930.4
1987	10.4	0.0	22.0	19.1	10.4	282.0	777.5
1988	10.2	0.0	19.5	32.6	14.3	287.2	950.9

Source: PSC

Table 3-3-3 Import Cargo Volume at Mina Qaboos by Handling Mode

(Unit: '000 tonnes)

Year	Bulk Grain	Bulk Cement	Other Bulk	Ro/Ro Live stock	Timber & Plywood	Steel & Pipes	Break bulk Cargo	Container	Total
1981	87.2	128.0	0.0	70.3	67.2	99.7	480.7	155.5	1,088.6
1982	80.2	271.1	13.7	91.7	107.3	136.6	431.7	220.0	1,352.2
1983	98.7	242.9	21.4	102.1	121.7	140.1	269.1	322.1	1,318.2
1984	110.2	0.0	27.6	105.2	130.8	167.6	241.4	412.3	1,195.0
1985	100.8	0.0	40.1	89.6	134.3	155.0	216.7	471.0	1,207.5
1986	156.3	0.0	17.8	35.8	82.7	63.5	157.7	416.6	930.4
1987	150.3	0.0	31.0	29.5	60.7	34.2	111.5	360.3	777.5
1988	135.4	0.0	18.8	46.9	70.9	149.0	144.4	385.9	950.9

Source: PSC

Table 3-3-4 Export Cargo Volume at Mina Qaboos by Commodity

(Unit: '000 tonnes)

Year	1986	1987	1988
Copper	15.5	14.2	11.6
Fish	10.8	11.6	10.5
Scrap	4.2	11.7	3.2
Provisions	0.9	2.2	10.3
Vehicles	4.8	5.8	2.8
Dates	0.2	0.1	0.0
Other Cargo	13.6	12.1	28.9
Total	50.0	57.7	67.3

Source: PSC

Table 3-3-5 Export Cargo Volume at Mina Qaboos by Handling Mode

(Unit: '000 tonnes)

Year	Container	Break Bulk	Bulk	Total
1981	2.8	18.8	0.0	21.6
1982	6.3	25.5	0.0	31.8
1983	12.3	26.5	0.0	38.8
1984	34.5	10.7	5.9	51.1
1985	32.3	28.6	1.1	62.0
1986	43.5	1.6	4.9	50.0
1987	50.5	7.2	0.0	57.7
1988	60.2	7.0	0.1	67.3

Source : PSC

Table 3-3-6 Import Container at Mina Qaboos

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total ① (TEU)	Boxes of 20ft. ②	Boxes of 40ft.	② / ① %	Boxes of Container
1981	14,925								
1982	21,379	98.0%	446	2.0%	21,825	15,169	3,328	69.50%	18,497
1983	31,412	97.7%	727	2.3%	32,139	19,609	6,265	61.01%	25,874
1984	40,044	98.4%	646	1.6%	40,690	22,874	8,908	56.22%	31,782
1985	47,146	97.6%	1,154	2.4%	48,300	25,518	11,391	52.83%	36,909
1986	39,422	97.2%	1,116	2.8%	40,538	20,996	9,771	51.79%	30,767
1987	30,619	96.9%	972	3.1%	31,591	17,393	7,099	55.06%	24,492
1988	32,701	96.8%	1,091	3.2%	33,792	17,494	8,149	51.77%	25,643

Source: PSC

Table 3-3-7 Export Container at Mina Qaboos

Year	With Cargo (TEU)	%	Empty (TEU)	%	Total ① (TEU)	Boxes of 20ft. ②	Boxes of 40ft.	② / ① %	Boxes of Container
1981	305								
1982	772	3.7%	20,307	96.3%	21,079	14,665	3,207	69.57%	17,872
1983	1,342	4.4%	28,917	95.6%	30,259	19,427	5,416	64.20%	24,843
1984	2,409	6.1%	36,824	93.9%	39,233	22,075	8,579	56.27%	30,654
1985	2,833	6.0%	44,487	94.0%	47,320	25,254	11,033	53.37%	36,287
1986	4,115	9.8%	37,947	90.2%	42,062	21,650	10,206	51.47%	31,856
1987	4,939	16.1%	25,782	83.9%	30,721	16,847	6,937	54.84%	23,361
1988	5,610	16.2%	28,978	83.8%	34,588	18,134	8,227	52.43%	26,361

Source: PSC

Table 3-3-8 Transshipment Container at Mina Qaboos

Year	With Cargo (TEU)	%	Loaded (TEU)	%	Total ① (TEU)	Boxes of 20ft. ②	Boxes of 40ft.	② / ① %	Boxes of Container
1981	20	50.0%	20	50.0%	40	24	8	60.00%	32
1982	604	50.0%	604	50.0%	1,208	964	122	79.80%	1,086
1983	1,752	50.0%	1,751	50.0%	3,503	1,777	863	50.73%	2,640
1984	5,145	50.2%	5,107	49.8%	10,252	5,716	2,268	55.75%	7,984
1985	8,008	50.1%	7,968	49.9%	15,976	12,086	1,945	75.65%	14,031
1986	14,318	51.1%	13,717	48.9%	28,035	21,109	3,463	75.30%	24,572
1987	38,613	50.2%	38,331	49.8%	76,944	43,386	16,779	56.39%	60,165
1988	39,801	50.1%	39,701	49.9%	79,502	45,355	17,073	57.05%	62,428

Source: PSC

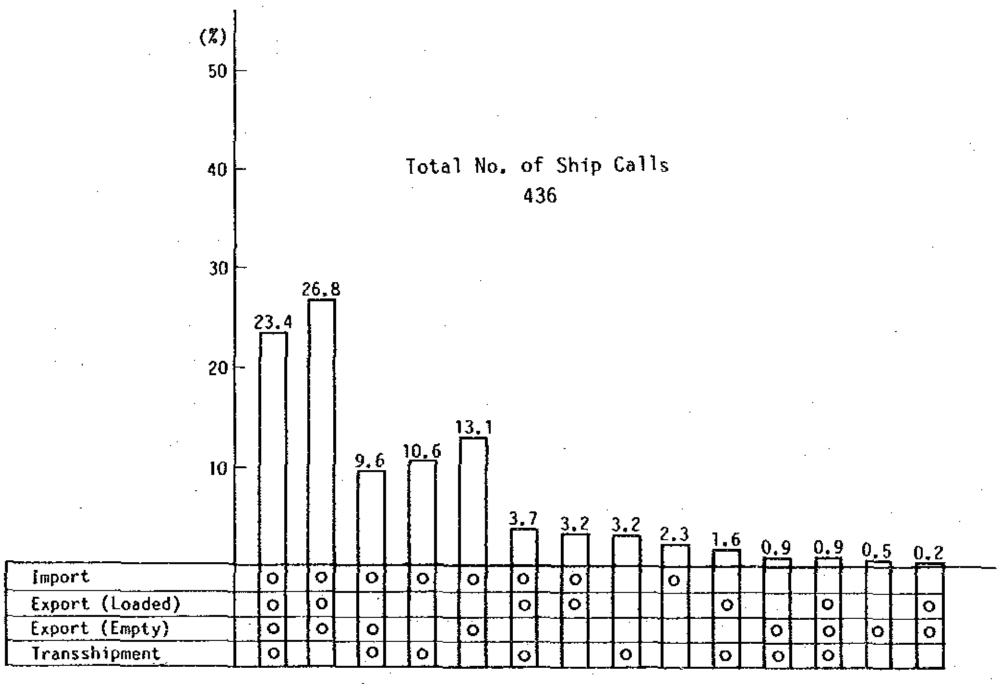
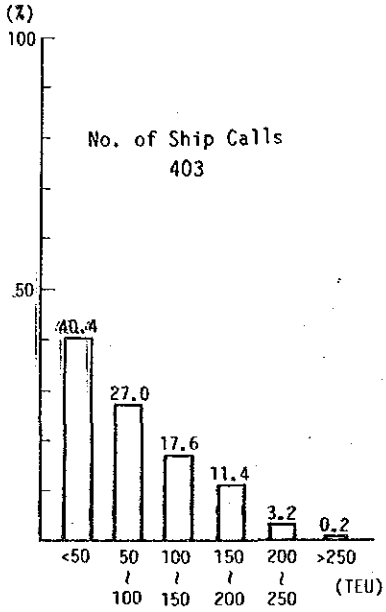
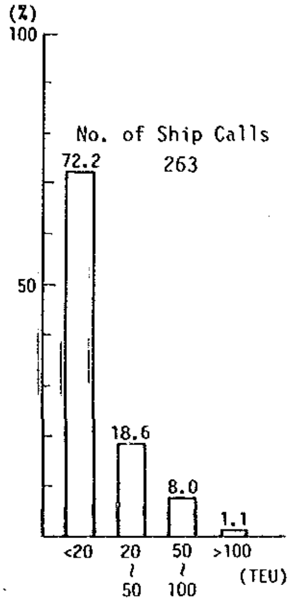


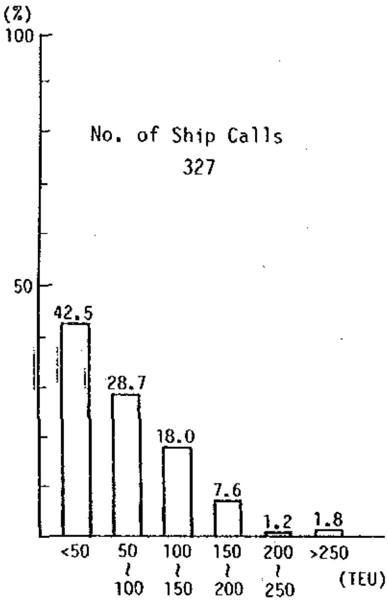
Fig. 3-3-1 Combination of Container Movements for Each Ship Call (1987)
(Source: PSC data)



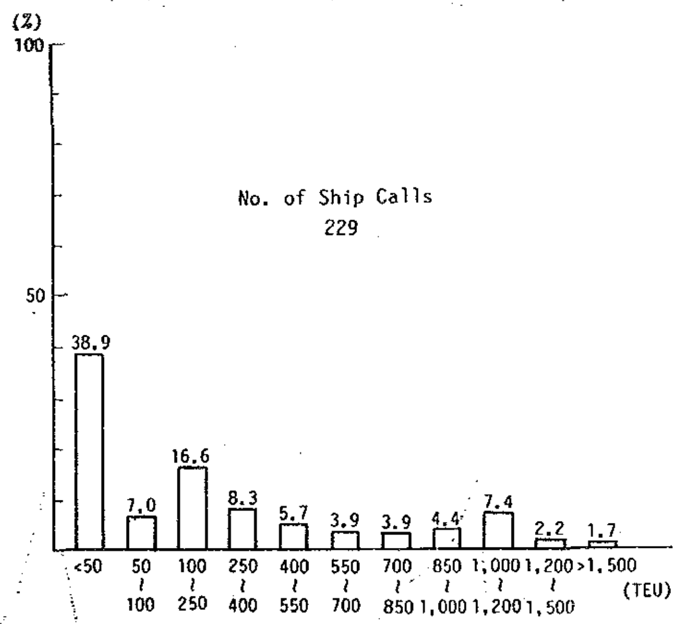
(a) Import Containers



(b) Export Containers (Loaded)



(c) Export Containers (Empty)



(d) Transshipment Containers

Fig. 3-3-2 Number of Containers per One Dischange/Loading (1987)
(Source: PSC data)

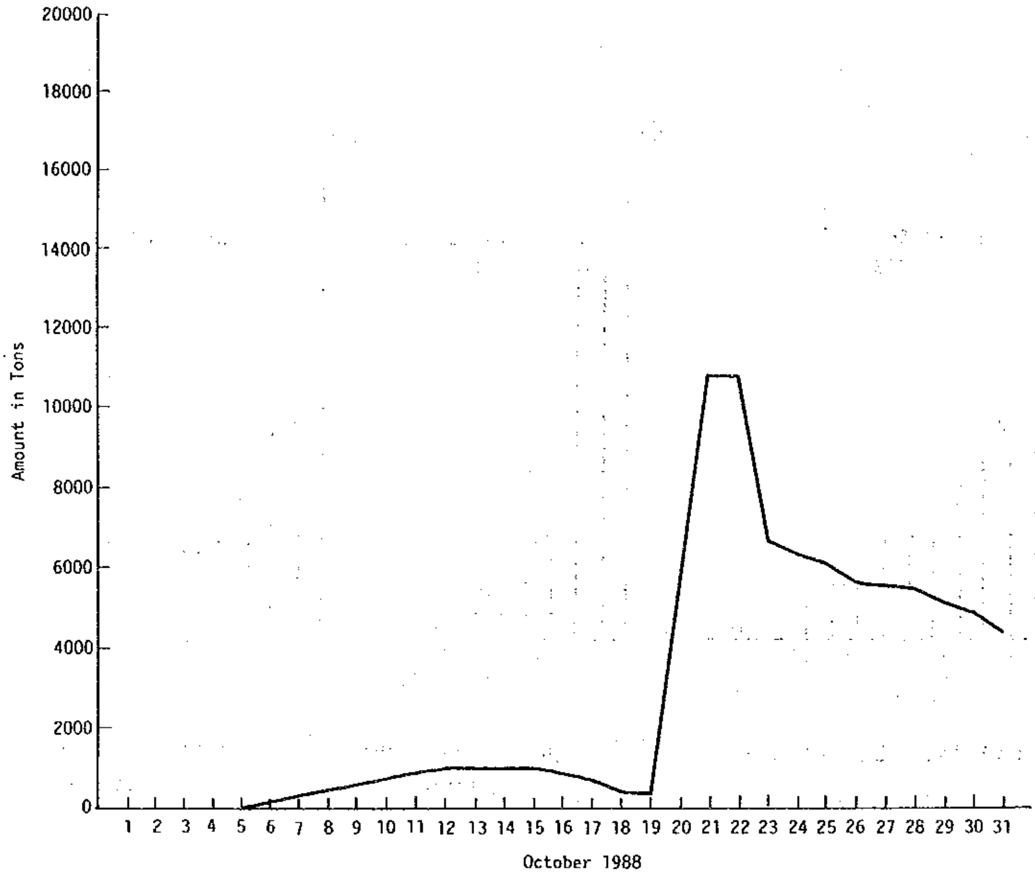


Fig. 3-3-3(a) Change in Amount of Cargo (Steel/Pipes)

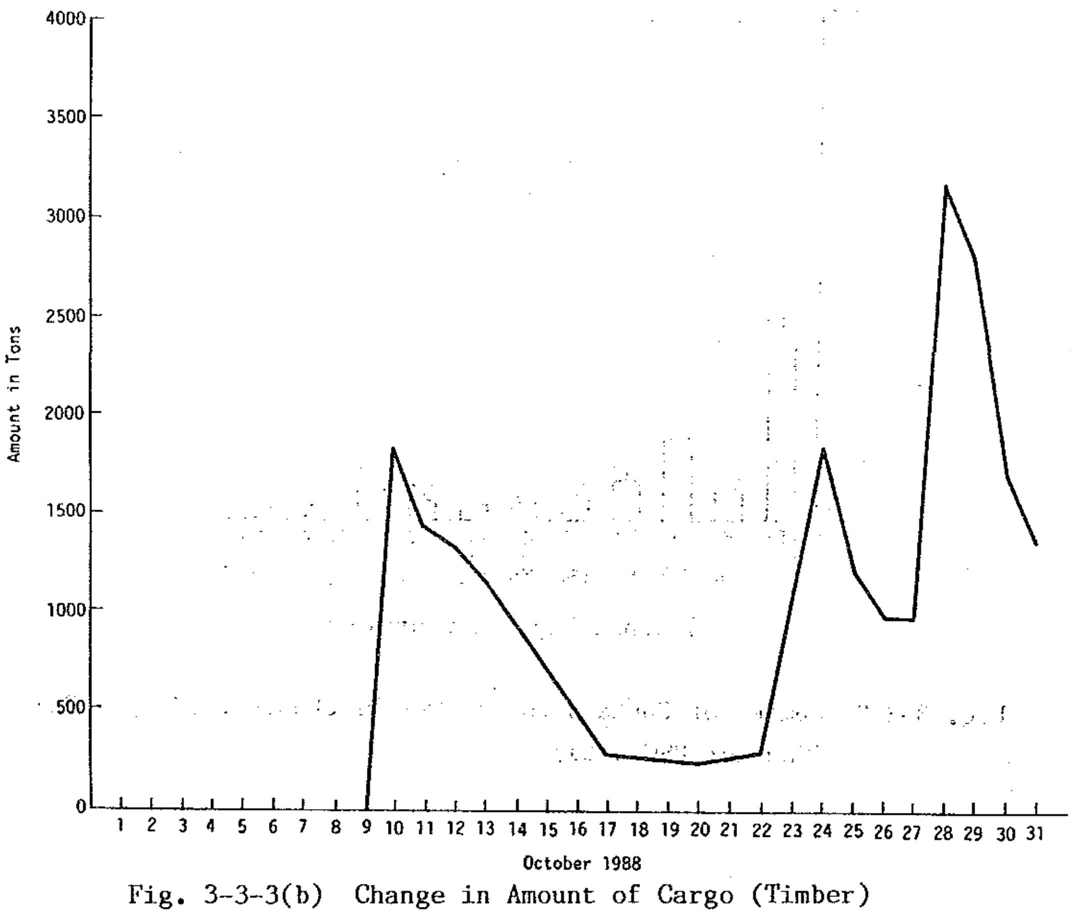


Fig. 3-3-3(b) Change in Amount of Cargo (Timber)

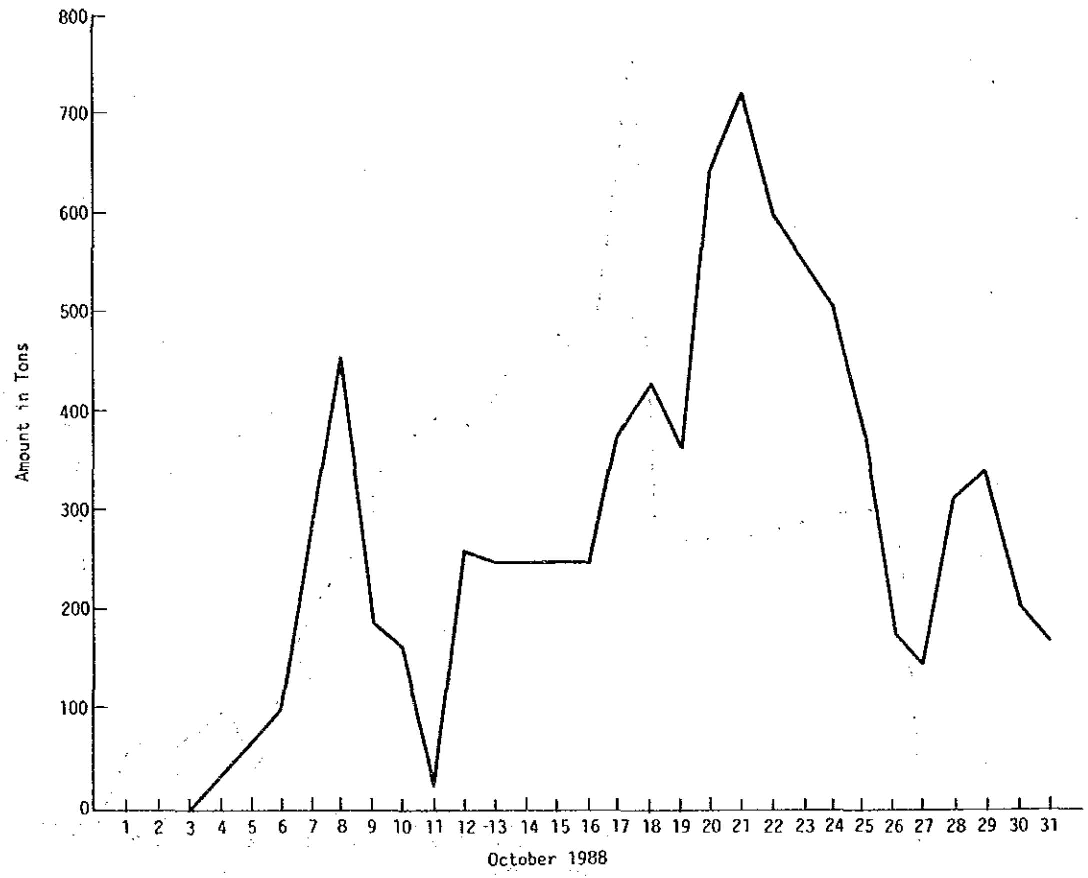


Fig. 3-3-3(c) Change in Amount of Cargo (Vehicles)

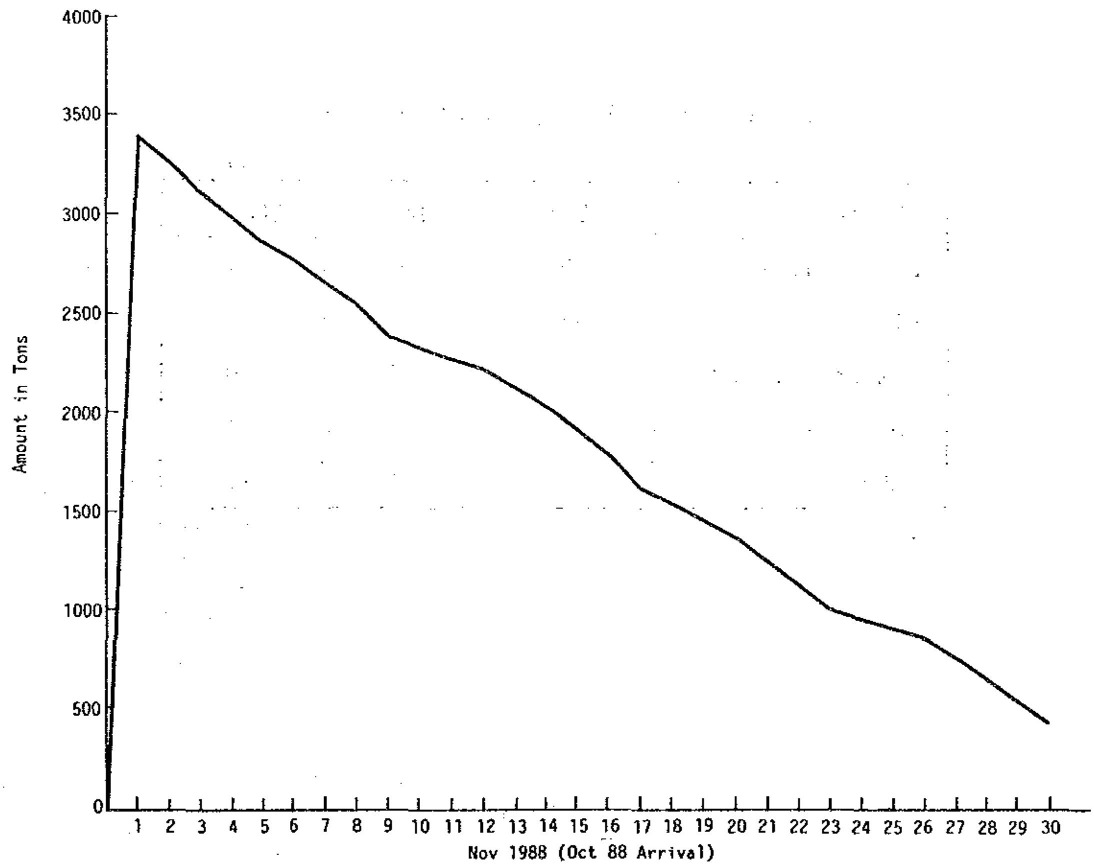


Fig. 3-3-3(d) Change in Amount of Cargo (Rice)

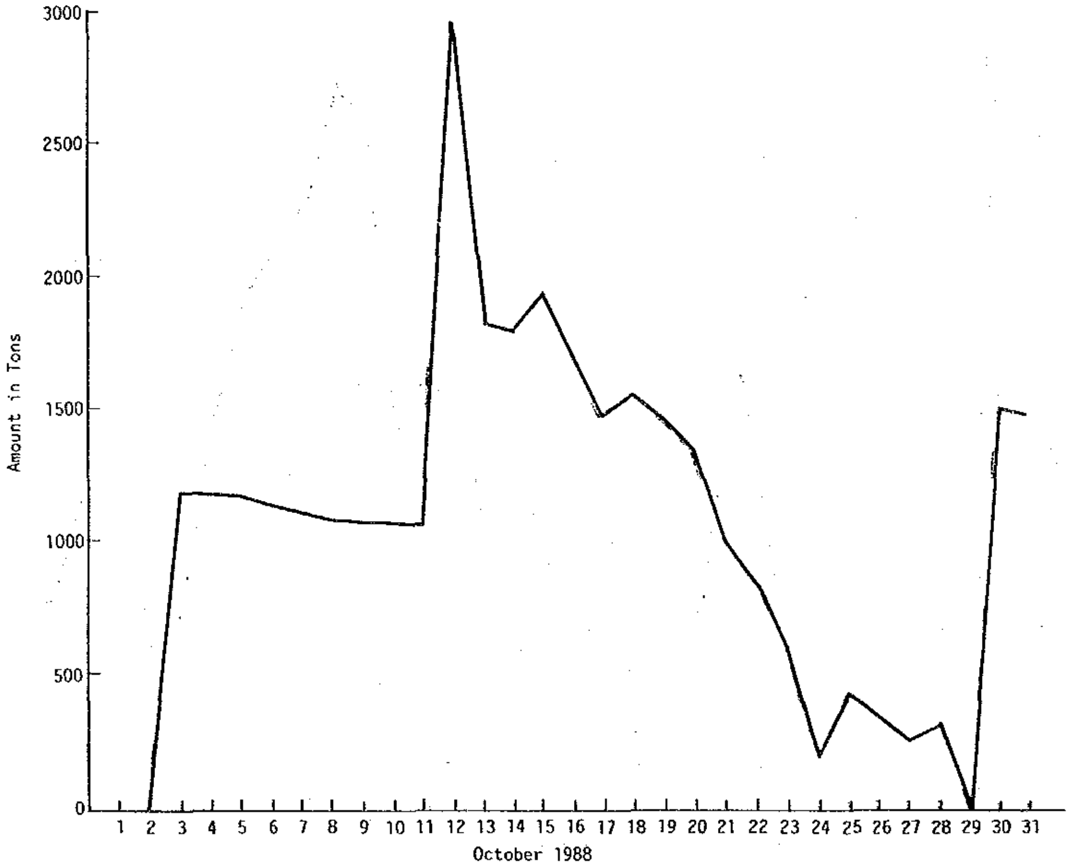


Fig. 3-3-3(e) Change in Amount of Cargo (General Cargo)

Table 3-3-9 Average Dwelling Time

(Days)

Commodity	OCT 88	NOV 88	DEC 88
Steel/Pipes	8	6	7
Rice	48	7	
Timber/Plywood	8	7	9
Vehicles	5	5	6
Others	14	12	12

3.4 Calling Ships

The total number of ships calling at Mina Qaboos amounted to 1,056 in 1988. Among these, the number of container ships was by far the largest, about 40% of all calling ships. Other types of ships calling often were conventional ships, Ro/Ro ships and livestock ships. Details of the characteristics of calling ships are shown in Table 3-4-1. Maximum arrival drafts and tonnages (GRT) are shown in Table 3-4-2. This table shows most of the largest ships for each ship type exceeded 10 meters in arrival draft. In Mina Qaboos, declared draft is at most 10.4 meters, even for Berths Nos.1, 1A and 2, due to the limited depth of the approach channel. In the case of container berths, Berths Nos.4 and 5, the declared draft is only 9.1 meters. This situation means many ships have been utilizing Mina Qaboos with the aid of tides. Table 3-4-3 show the dimensions of container ships calling at Mina Qaboos. It is obvious most of these ships cannot call at Mina Qaboos with its maximum draft under usual conditions. Hence some of them call utilizing tides and some of them use Mina Qaboos as the last port on their itinerary.

Fig. 3-4-1 (a) - (d) show the distributions of ships arrivals by gross tonnage for principal ships, that is conventional ships, full container ships, grain carrier ships and Ro/Ro ships, respectively (See Appendix 3-4-1). Concerning conventional ships, more than 40% of such ships are concentrated in a small size range of less than 2,000 GRT, with large ships of more than 20,000 GRT accounting for only 5% of all ships. The distribution of container ships depicts one conspicuous feature, that is the existence of two different size groups, one being the group of less than 10,000 GRT and the other comprising ships of more than 18,000 GRT. This can be interpreted as meaning the small-ships group represents feeder ships and the large-ship group represents main line ships. Most grain carriers transport wheat from Australia. Among these, large ships call at Mina Qaboos half loaded due to the limited depth at Berth No.3. Concerning Ro/Ro ships, no draft limits are expected, due to its structural characteristics. Even for maximum-sized ship of 53,578 GRT, the draft is only 8.1 meters. For Ro/Ro ships, their overall length is a more important factor regarding the use of berths. Twelve calls were made by such ships with lengths of more than 200 meters.

Table 3-4-1 Number of Calling Ships (1988)

Ship Type Size	Berth Numbers 1	2	2A	2B	3	4	5	6	7	7A	7B	8	8A	8B	10	11	Total
11	6	5	1	1	12	16	2	1	9	1		12	1	2	3		72
12	4	3			2			2	7	1		6	2			1	28
13	5	14			11		1	3	16	2		17					69
14	10	26			1			5	3								45
21						1											1
22		1				39	21					1					62
23	1	2				102	43	1									149
24	1					129	62										192
31	1	3			3	5											12
32		1			2	2	4		1			1					11
33	2	1				10	3	1									17
34	1	4				6	2										13
41																	0
42		1			1				2	1		1	1				7
43		1			4							1					6
44					4												4
51																	0
52																	0
53					2												2
54																	0
61																	0
62	3				1		2	2	2								10
63	1	2							3			1					7
64																	0
71																	0
72	7	2				1		2									12
73	71	4				2	5	11	1								94
74	39	1				2	3	3									48
81																	0
82	1						1										2
83	7																7
84	13						1										14
91	5				15		1	7	10		4	34	3	1	7		87
92	5	1			2		1	7	8	1		9			3	10	47
93	6							15	1			2				3	27
94	2						2	5	2								11
Total	191	72	1	1	60	315	154	65	65	6	4	85	7	3	13	14	1056

Source: PSC

Table 3-4-2 Min/Max Draft/Gross Tonnage of Calling Ships (1988)

Ship Type Size	Draft		Tonnage	
	Minimum	Maximum	Minimum	Maximum
11	0.9	6.1	147	996
12	3.0	6.9	1000	4633
13	5.0	10.4	5084	12750
14	5.6	10.2	15041	28005
21	3.4	3.4	984	984
22	4.0	7.3	1223	4999
23	5.2	8.8	5332	13107
24	4.2	10.6	15122	33761
31	1.8	1.8	258	795
32	3.1	7.4	1000	4633
33	6.0	9.2	5575	11941
34	6.8	10.3	15122	33761
41				
42	4.3	7.2	1223	4548
43	8.2	10.1	7083	14440
44	9.6	9.8	16023	18622
51				
52	5.3	9.2	8844	9315
53				
54				
61				
62	3.9	8.2	1599	4412
63	6.0	10.3	5266	14418
64				
71				
72	4.3	8.1	1000	4046
73	7.0	9.3	7050	14660
74	7.2	10.0	15673	53578
81				
82	6.0	6.0	3369	3761
83	7.0	8.2	8269	12079
84	7.2	10.7	16222	34082
91	2.0	3.8	147	750
92	4.5	8.1	1200	4609
93	6.0	8.5	5000	12359
94	6.3	10.3	16000	30645

Ship Code	Ship Type GRT
11	Conventional < 1000
12	Conventional 1000 - 5000
13	Conventional 5000 - 15000
14	Conventional > 15000
21	Full Container < 1000
22	Full Container 1000 - 5000
23	Full Container 5000 - 15000
24	Full Container > 15000
31	Semi Container < 1000
32	Semi Container 1000 - 5000
33	Semi Container 5000 - 15000
34	Semi Container > 15000
41	Grain Carrier < 1000
42	Grain Carrier 1000 - 5000
43	Grain Carrier 5000 - 15000
44	Grain Carrier > 15000
51	Dry Bulk Carreir < 1000
52	Dry Bulk Carrier 1000 - 5000
53	Dry Bulk Carrier 5000 - 15000
54	Dry Bulk Carrier > 15000
61	Liquid Carrier < 1000
62	Liquid Carrier 1000 - 5000
63	Liquid Carrier 5000 - 15000
64	Liquid Carrier > 15000
71	Ro-Ro Ship < 1000
72	Ro-Ro Ship 1000 - 5000
73	Ro-Ro Ship 5000 - 15000
74	Ro-Ro Ship > 15000
81	Livestock Carrier < 1000
82	Livestock Carrier 1000 - 5000
83	Livestock Carrier 5000 - 15000
84	Livestock Carrier > 15000
91	Visit/Other Ship < 1000
92	Visit/Other Ship 1000 - 5000
93	Visit/Other Ship 5000 - 15000
94	Visit/Other Ship > 15000

Source: PSC

Table 3-4-3 Container Vessels Calling at Mina Qaboos

Name of Owner	Maximum LOA (m)	Maximum Arrival Draft (m)
CMA	188	10.7
Norasia Line	180	10.0
Bule Star Line	188	10.5
Mitsui O S K Line	212	10.0
Nippon Yusen Kaisha (Far East)	215	8.8
Nippon Yusen Kaisha (Aus/NZ)	151	8.0
Lloyd Triestino	150	8.5
Seacrest Shipping	115	6.0
P & OCL	215	10.5
CMB	209	10.5
NCHP	205	10.5
Jugolinija	146	9.0
Maersk Line	241	11.0
Maersk Line (Feeder Vessels)	128.5	6.8
Maersk Line (Feeder Vessels)	137.1	6.4
Showa	216	
Ellerman	216	
Ceylon Shipping Corporation	129	7.5
DSR	150	7.0
Nedlloyd	230	10.5
Happag Lloyd	226	10.5
UASC	211	10.8
Y.S. Line (Last Port)	227	9.0
K Line (Last Port)	227	9.0
Sealand	151	7.8
OOCL	221	9.3
APL	202	9.5
Merzario	192	7.4

Note: LOA stands for Overall Length
Source: PSC

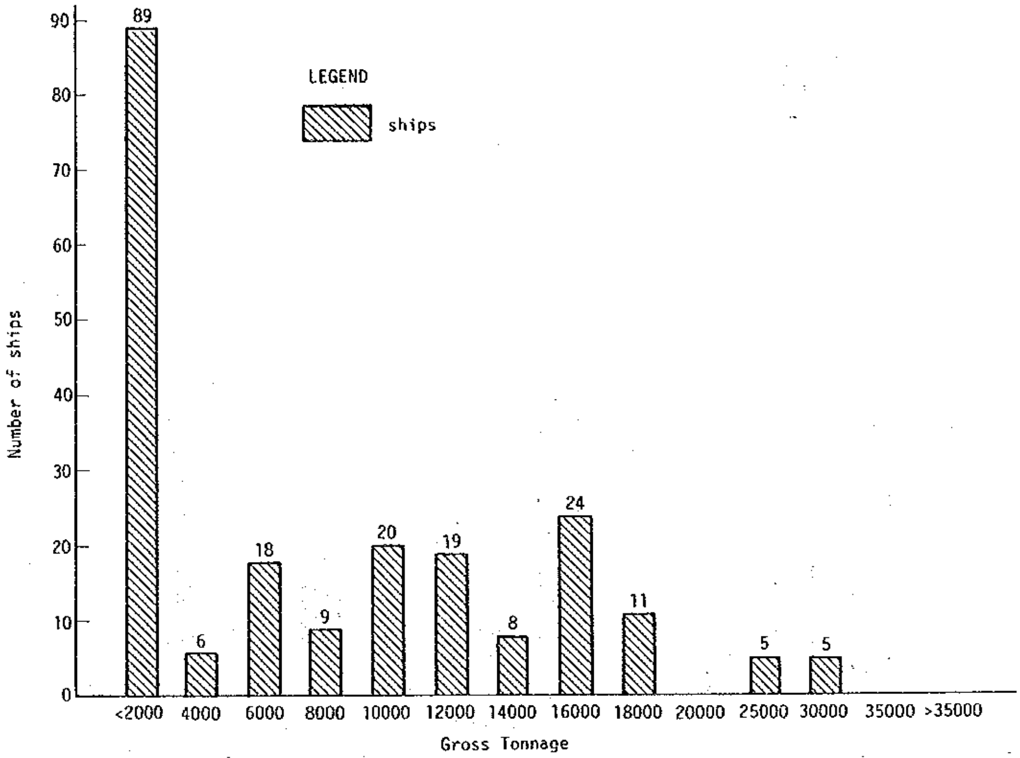


Fig. 3-4-1(a) Distribution of Ship Arraivals by Gross Tonnage
(Conventional Ships
Year 1988)

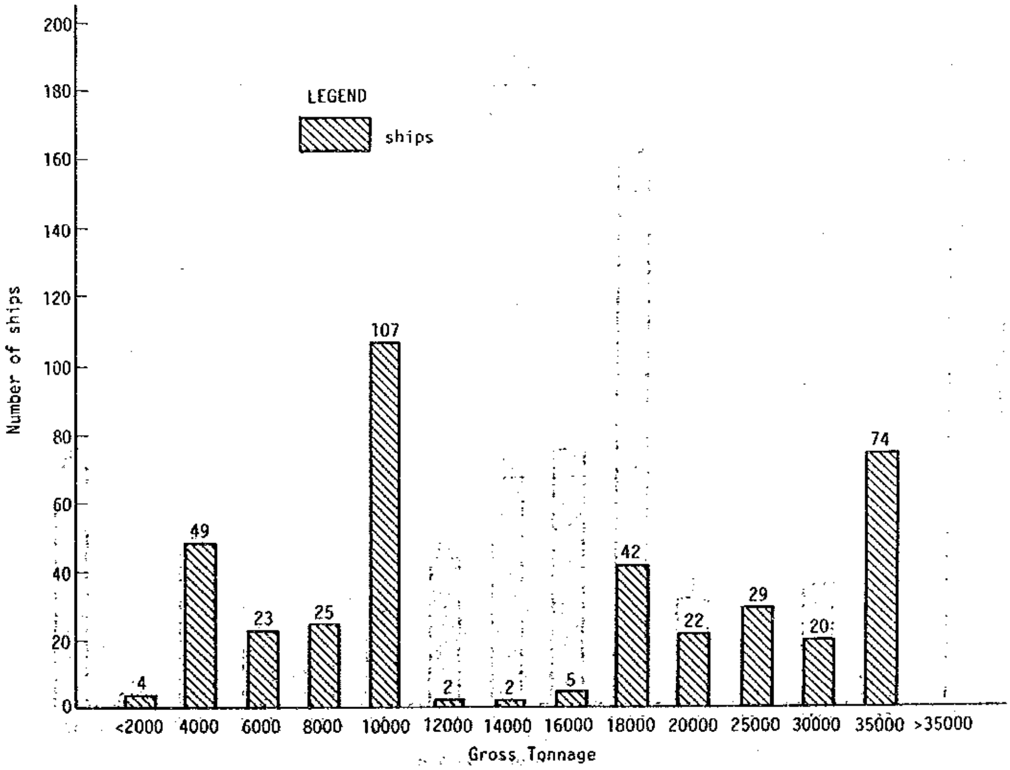


Fig. 3-4-1(b) Distribution of Ship Arraivals by Gross Tonnage
(Full Container Ships
Year 1988)

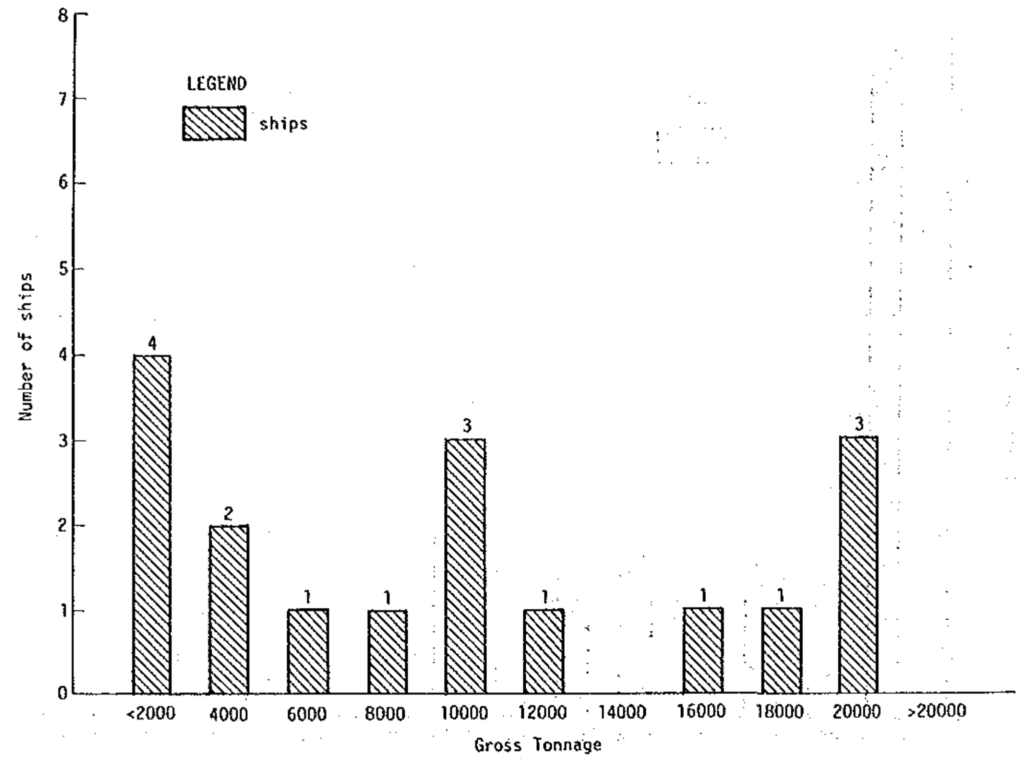


Fig. 3-4-1(c) Distribution of Ship Arraivals by Gross Tonnage
(Grain Carrier Ships
Year 1988)

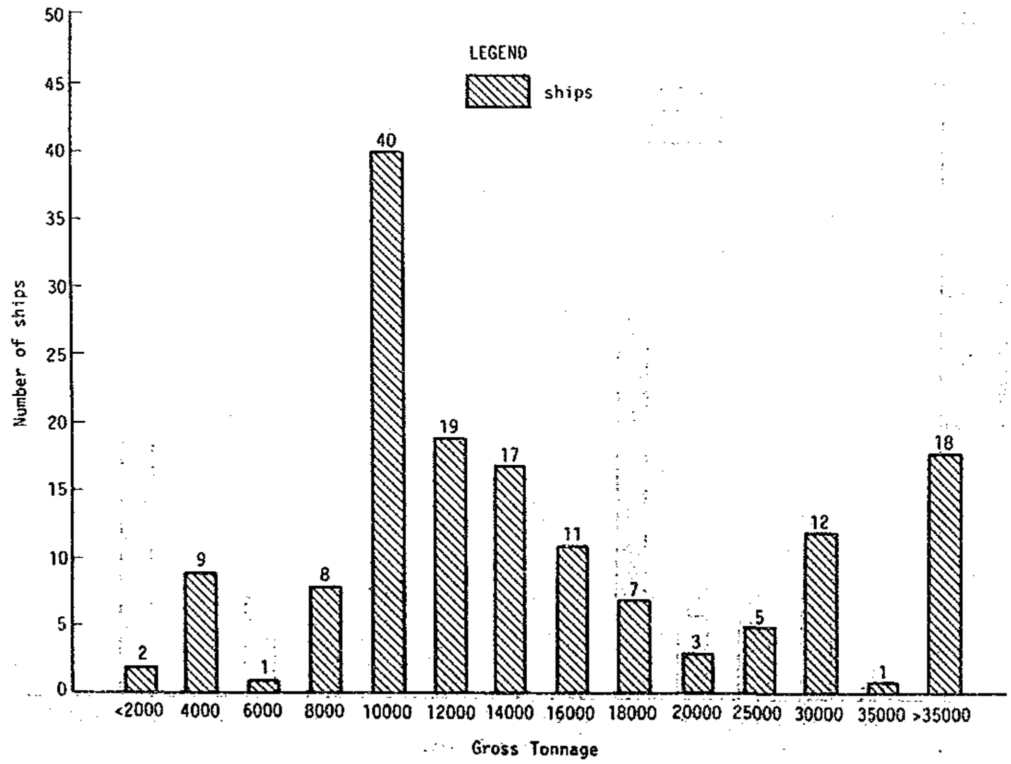


Fig. 3-4-1(d) Distribution of Ship Arraivals by Gross Tonnage
(Ro/Ro Ships
Year 1988)

3.5 Cargo Operation

3.5.1 Storage Facility and Cargo Throughput

The import/export cargo handled at Mina Qaboos in 1988 can be calculated according to delivery/storage mode as follows:

- Total Import Throughput 950,900 tons
  - Container Cargo = 385,900 tons
  - Conventional Cargo = 565,000tons
    - Direct Delivery Cargo : 220,830 tons
    - Covered Storage Cargo : 62,925 tons
    - Open Storage Cargo : 281,245 tons

- Total Export Throughput 67,300 tons
  - Container Cargo : 60,200 tons
  - Break Bulk : 7,000 tons
  - Bulk : 100 tons

The area inside the port is currently allocated according to storage mode as follows. (calculation results):

Cargo mode	Throughput (Import)	Area allocated
Container cargo	385,900 tons	87,425 m^2
Open storage cargo	281,245 tons	39,910 m^2
Covered storage cargo	62,925 tons	19,072 m^2

Note: Transit shed Nos.4 & 9 are mainly utilized for CFS and excluded from the covered storage area for conventional cargo.

3.5.2 Productivity of Cargo Handling

3.5.2.1 Conventional Cargo

The productivity of cargo handling discharge was calculated for major commodities transported by several typical vessels. The results are as follows:

(a) Steel in bars and pipes

Maximum : 26.8 tons/G/Hr.
Minimum : 17.0 tons/G/Hr.
Average : 23.2 tons/G/Hr. (out of 5 specific vessels)

(b) Timber (In bundles, poles, crates etc.)

Maximum : 49.3 tons/G/Hr. (poles)
Minimum : 12.0 tons/G/Hr.
Average : 23.9 tons/G/Hr. (out of 7 specific vessels)

(c) Rice (in bags)

Maximum : 13.4 tons/G/Hr.
Minimum : 10.6 tons/G/Hr.
Average : 12.2 tons/G/Hr. (out of 4 specific vessels)

(d) Reefer cargo

Maximum : 7.5 tons/G/Hr.
Minimum : 4.2 tons/G/Hr.
Average : 6.1 tons/G/Hr. (out of 5 specific vessels)

(e) General cargo (mixed, such as cement, timber, pipes, drums Cables, etc.)

Maximum : 30.2 tons/G/Hr.
Minimum : 9.4 tons/G/Hr.
Average : 18.9 tons/G/Hr. (out of 15 specific vessels)

The productivity for loading is generally less than that of discharging, approximately 80% or less.

3.5.2.2 Container Cargo

We picked 24 vessels at random and calculated the productivity of container per crane per hour. The results are shown in Table 3-5-1:

Table 3-5-1 Productivity of Container Cargo

Ship Name	Discahrging 20ft	Discahrging 40ft	Hours (3)	Rate (1)	Loading 20ft	Loading 40ft	Hours (4)	Rate (2)	Ratio (2)/(1)	(1)x(3)	(2)x(4)
Apap Plan	241	65	12.75	24.0	0	0	1	0.0	0.00	306	0
	241	130	12.75	29.1	0	0	1	0.0	0.00	371	0
Maersk	88	66	7.25	21.2	0	0	1	0.0	0.00	154	0
Fieno	88	132	7.25	30.3	0	0	1	0.0	0.00	220	0
Ville de	347	126	22	21.5	427	135	26	21.6	1.01	473	562
Vesta	347	252	22	27.2	427	270	26	26.8	0.98	599	697
Buzet	6	28	1.75	19.4	23	24	2.5	18.8	0.97	34	47
	6	56	1.75	35.4	23	48	2.5	28.4	0.80	62	71
Este	0	0	1	0.0	10	50	4.75	12.6	–	0	60
Clipper	0	0	1	0.0	10	100	4.75	23.2	–	0	110
Norasia	56	22	3	26.0	62	24	3	28.7	1.10	78	86
Arabia	56	44	3	33.3	62	48	3	36.7	1.10	100	110
Orient	174	30	9.25	22.1	0	0	1	0.0	0.00	204	0
Triumph	174	60	9.25	25.3	0	0	1	0.0	0.00	234	0
Ville de	272	175	22	20.3	197	98	14.75	20.0	0.98	447	295
Jupitor	272	350	22	28.3	197	196	14.75	26.6	0.94	622	393
Ville de	308	129	17.5	25.0	285	85	22.5	16.4	0.66	437	370
Omam	308	258	17.5	32.3	285	170	22.5	20.2	0.63	566	455
Kapetan	150	27	8.5	20.8	0	0	1	0.0	0.00	177	0
Pavrovic	150	54	8.5	24.0	0	0	1	0.0	0.00	204	0
Tokyo	154	50	15	13.6	197	98	14.75	20.0	1.47	204	295
Bridge	154	100	15	16.9	197	196	14.75	26.6	1.57	254	393
Ville de	118	120	11.5	20.7	222	111	17.1	19.5	0.94	238	333
Vega	118	240	11.5	31.1	222	222	17.1	26.0	0.83	358	444
Secret	0	0	1	0.0	42	17	2.25	26.2	–	0	59
Pioneer	0	0	1	0.0	42	34	2.25	33.8	–	0	76
Japan Sea	94	27	5	24.2	264	71	19	17.6	0.73	121	335
	94	54	5	29.6	264	142	19	21.4	0.72	148	406
Al Ihsaa	89	43	8	16.5	143	48	12.75	15.0	0.91	132	191
	89	86	8	21.9	143	96	12.75	18.7	0.86	175	239
Ville de	147	64	10.5	20.1	214	100	23.5	13.4	0.66	211	314
Oman	147	128	10.5	26.2	214	200	23.5	17.6	0.67	275	414
Al Mirqab	138	61	11.5	17.3	0	0	1	0.0	0.00	199	0
	138	122	11.5	22.6	0	0	1	0.0	0.00	260	0
Dubai	160	38	12.5	15.8	10	50	4.75	12.6	0.80	198	60
	160	76	12.5	18.9	10	100	4.75	23.2	1.23	236	110
Nashuri	89	2	6.75	13.5	62	24	3	28.7	2.13	91	86
	89	4	6.75	13.8	62	48	3	36.7	2.66	93	110
Aries	80	8	4	22.0	23	10	1.75	18.9	0.86	88	33
	80	16	4	24.0	23	20	1.75	24.6	1.02	96	43
AlWajba	122	56	6.5	27.4	0	0	1	0.0	0.00	178	0
	122	112	6.5	36.0	197	0	1	197.0	5.47	234	197
Orient	205	83	11.5	25.0	0	0	1	0.0	0.00	288	0
Express	205	166	11.5	32.3	0	0	1	0.0	0.00	371	0
Vill de	156	153	19	16.3	321	261	44.5	13.1	0.80	309	582
Venus	156	306	19	24.3	197	522	44.5	16.2	0.66	462	719
Mandana	142	23	6	27.5	222	111	17.1	19.5	0.71	165	333
	142	46	6	31.3	222	222	17.1	26.0	0.83	188	444
Sum	3336	1396	233.75		2760.5	1317	240.95			4732	4041
										6128	5431

Note: Upper cell in each line shows number in boxes and lower cell in TEUs.

Average rate of discharging: 4732/233.75 = 20.2
6128/233.75 = 26.2

Average rate of loading: 4041/240.95 = 16.8
5431/240.95 = 22.5

From the calculation we obtained the following results:

a) Rates of discharging : Maximum: 27.5 Box/Hr/Crane
Minimum: 13.5 Box/Hr/Crane
Average: 20.2 Box/Hr/Crane

b) Rates of loading : Maximum: 28.7 Box/Hr/Crane
Minimum: 12.6 Box/Hr/Crane
Average: 16.8 Box/Hr/Crane

c) The loading rates are generally lower than those for discharging. The difference is approximately 17%.

3.5.3 Labour Force and Work Hours

The labour force, their constitution and work hours were indicated by the PSC and were noted as follows:

(1) Gangs for Handling General Cargo

i) Number of gangs:

Gangs for day shift: 7 gangs

Gangs for night shift: 5 gangs

ii) Work hours:

day shift : 0700 - 1500

night shift: 1500 - 2300

iii) Constitution of gangs

Foreman: 1 person

Tindale: 2 persons

Labourers on ship : 8 persons

Labourers on shore: 4 persons

In addition to the gangs, one supervisor is stationed on each vessel.

(2) Gangs for Handling Containers

i) Number of gangs

1) Sea side for loading/discharging

1st shift: 1 gang

2nd shift: 1 gang

3rd shift: 1 gang

2) Land side for CFS

1 gang is deployed for the day shift

ii) Work hours

1) Sea side operation

Round the clock service is provided for the sea side.

2) Land side operation

1st shift: 0600 - 1400

2nd shift: 1400 - 2200

3rd shift: 2200 - 0600

3) CY operation (Delivery/Receiving)

1st shift: 0700 - 1500

2nd shift: 1500 - 2300

4) CFS operations

Day shift only: 0700 - 1500

As well, ship side gangs can be deployed for CFS operations if the CFS operation is very busy and also if there are no vessels at the berth.

iii) Constitution of gangs

1) Sea side (shipside) gangs

Foreman: 1 person

Winchman: 2 persons

Labourers: 13 persons

In case of 2 cranes being in service, the gang is divided into 2 groups for operations with each crane.

2) CFS gang

Foreman: 1 person

Tally clerk: 2 persons

Marker boy: 1 person

Labourers: 8 persons

Forklift drivers: 3 persons

In addition to the above, one supervisor conducts the CFS operation.

3.5.4 Dwelling Time of Cargo

In order to estimate the appropriate land area, an investigation into the dwelling time of cargo and the peak factor of operation is essential. Dwelling time of container was analyzed by the PSC's staff for a total of 41,282 units and the results were submitted to the Study Team. An investigation of the dwelling time for general cargo is proceeding at this moment and will be obtained later.

The summary of dwelling times is as follows:

Summary of Dwelling Times

Import FCL Container	20 Ft.	9.42 days
	40 Ft.	7.76 days
Import LCL Container	20 Ft.	2.74 days
	40 Ft.	3.13 days
Import TRS Container	20 Ft.	7.86 days
	40 Ft.	8.92 days
Export MT from FCL	20 Ft.	11.51 days
	40 Ft.	10.99 days
Export MT from LCL	20 Ft.	13.44 days
	40 FT.	13.40 days

Note: MT = empty container

3.5.5 Shore Side Operations

We investigated the shore side operations by processing the records of daily container movements.

The records show the number of containers daily delivered, received, grounded and shifted to the CFS. The records we used were those of July 1988.

The results obtained is as follows:

i) Total number of containers delivered: 1813 Boxes (58 Boxes/day)
ii) Total number of containers received: 1858 Boxes (60 Boxes/day)
iii) Total number of containers grounded: 234 Boxes (8 Boxes/day)
iv) Total number of unloaded LCL containers: 143 Boxes (5 Boxes/day)
v) Ratio of LCL containers: 6.5% (import)
vi) Ratio of FCL containers grounded: 11% (import)
vii) Daily handling rate at shore side: 144 Boxes/day
(grounded and CFS containers were counted twice)

3.5.6 FCL Grounded Containers

From the container movement report, we found that many FCL container are treated as grounded container. This means FCL containers are unloaded within the port area. The unloading area is not pre determined and so we found the operation being carried out here and there. The service is provided to consignee who don't have proper premises, but this interfered with the rotation of containers and effective land use. The grounding service makes FCL containers' dwelling time longer to some extent and occupies some area with on-tier stacking. Because some consignees use containers as a substitute for warehouses and keep them in the port area with cargo in one-tier stacking for some time, they can stay at the port for a long time. The PSC cannot shift them into one place and stack them in tiers.

3.5.7 Present Situation of Computer-Based Container Terminal Operations

3.5.7.1 Existing System

At Mina Qaboos, the development program for a computer-based container terminal operations has been divided into the following four stages and continuously developed step by step:

Stage I : Vessel Operations (Discharging/Loading)
Stage II : Full Container Movement
Stage III : Empty Container Movement
Stage IV : Shipping Operation

At present, Stages I and II have been already introduced to daily terminal operations and Stage III and IV, of which necessary programs have been already developed, are in the proposal stage.

The outline of the processing system of Stage I and Stage II is summarized as follows:

(1) Manifest

A manifest is submitted to the Cargo Documents Office (CDO) by a shipping agent prior to the vessel's arrival. Prior to data input at CDO, the Rotation Number of the vessel in question is determined by the Harbour Master, and an Index Number is given according to the number of B/Ls by the CDO. Based upon these two keywords, data processing is carried out on screen. The CDO inputs such items as Container Agent Code, Consignee Name, Vessel Name, B/L Number, Container Number, ISO Code, Deiscription of Goods and so on.

(2) Stowage Plan

The Stowage Plan of the vessel together with the Dangerous Cargo List and Reefer Container List is submitted to the Control Centre, where the Discharging List (Expected) is printed out. The Head Planner manually arranges a sequencing schedule of each container for dischaging and sequence numbers are input in order to print out Discharge Working Lists.

(3) Discharging Working List/Tally Sheet

These Lists are distributed to the ship's supervisor and the berth supervisor, and also to tally clerks who use these as tally books.

(4) Discharging

During the discharging operations, Tally Clerks inspect the condition and record the seal number of each container, and triplicate Container Inspection Reports, which indicate the damage to the box itself as well as container No., ISO Code and Seal Number. The Original Report is delivered to the agent and teh inspection details and teh result of tallying are input.

(5) Discharge List (Actual)/Discrepancy List

After completion of discharging, the Discharge List (Actual) and Discrepancy List are printed out. The Actual Discharge List is sent to the Agent and the Discrepancy List to the CDO of the Finance Department. Such reports as the Ship's Supervisor Report, Stevedoring Report and Service Render Report, which are prepared manually, are sent to the Account Section in order to collect the relevant charges.

(6) Stacking and Movement

The stacking method of containers is different in the cases of LCL, Transshipment (TR) and Local containers respectively. LCLs are stacked in blocks and wait for the arrangement of CFS operations. TRs are segregated by port, weight, size, IMO and type. Regarding Local containers, there are three ways of handling i.e. FCL Delivery, Direct Delivery and Grounding. Grounding containers are unstuffed inside the port area by the consignee with their labourers and equipment. When each container is stacked, a Stacking Slip is made out and based upon this Slip, the location of each container is input. Tracking of containers is done by Stacking Slip from the berth to the Marshaling Yard. FCLs are moved before delivery for the purpose of Quarantine and Customs Inspections. In order to track such movement, Container Movement Slip is made out to identify the present location of the container inside the port.

From the view point of flow of the containers and the activity in the yard we noted as follows: Containers discharged from a vessel are stored in the marshalling yard according to the instructions of the yard clerk who is in charge of recording and reporting container locations regularly to a yard planner in the terminal office. On the basis of the yard clerk's report, the yard planner to the computer inputs the container location with their specifications to the computer and prepares a yard map and data base for stored containers.

The yard map and data base are available when a consignee comes to receive his container, a gate clerk can give the specific container location to drivers of yard top lifters and issue a gate pass.

After the issuance of a gate pass, the location of the container is automatically deleted from the file.

(7) CCRO

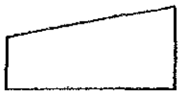
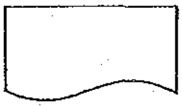
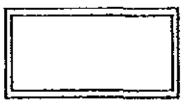
After completion of the necessary inspections and payment to the authorities concerned, Delivery Order together with Customs certificate are submitted to the CDO. The CDO prints out Cargo Charges and Removal Order (CCRO), which is endorsed by the Cashier after payment of standard delivery charges, grounding charges if any and certificate charges for the CCRO itself as well as demurrage. Then the CCRO is presented at the Control Centre, where Gate Pass-cum-Delivery Orders are issued in triplicate. The Order distributed to the consignee is used as a Gate Pass when the container is returned empty to the gate.

(8) Loading

Exporters obtain an Export Shipping Notes from the CDO. A duly completed Export Shipping Note with endorsements from the Agent and custom is presented to the CDO for registration prior to cargo delivery inside the port.

The Note and the Gate Pass are submitted at the gate for Full Container Export.

Fig. 3-5-1(a)-(c) shows the outline of the information flow under the present system. The symbols used in this flow chart for the operating activities are as follows:

Symbol	Description
	Data Input
	Data Output
	Documents from outside/manually made
	Actual Work Discharging/Loading/Stacking etc.
———→	Information Flow through CPU
- - - - →	Information Flow manual Method
	Collàtion/checking of information

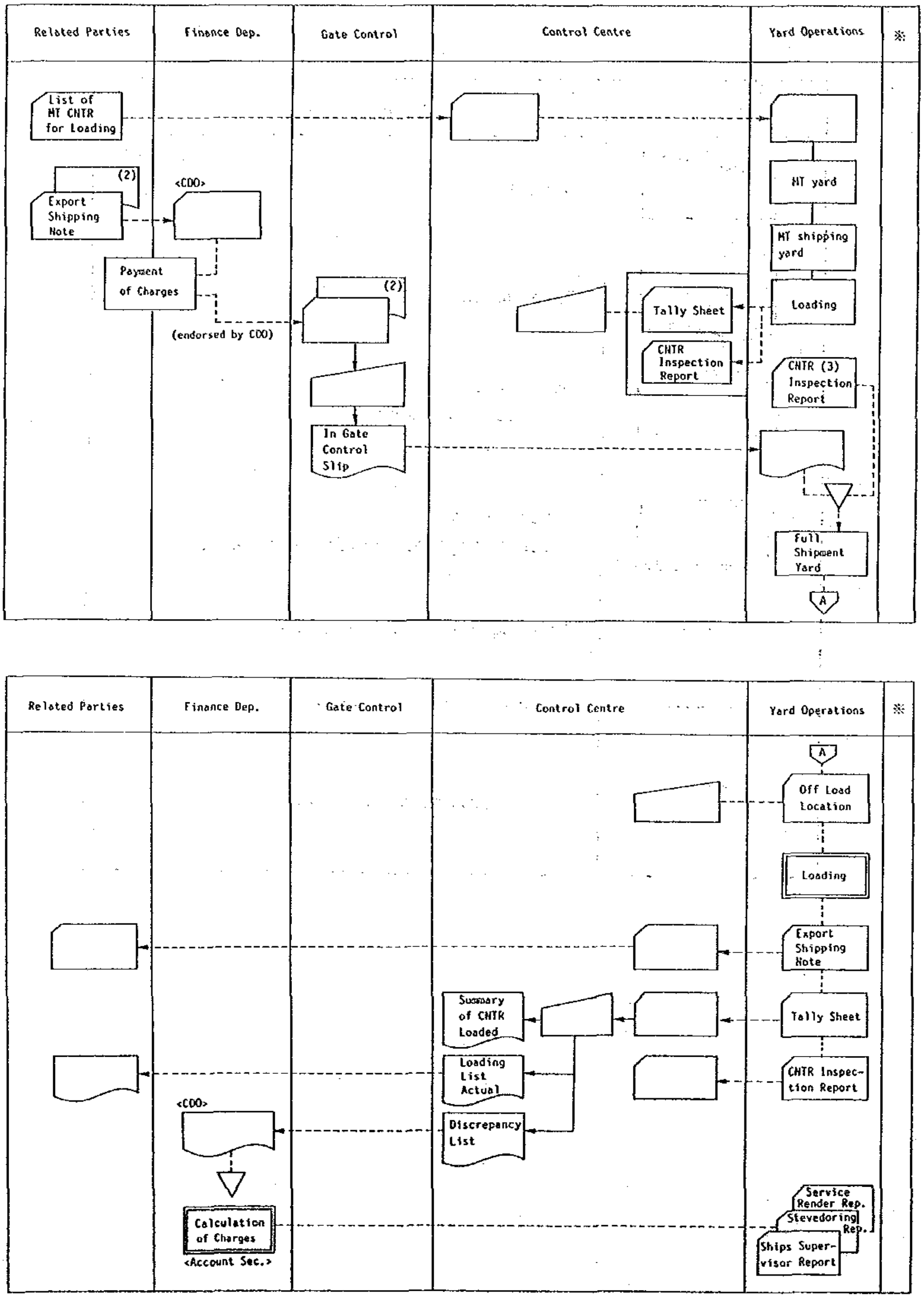
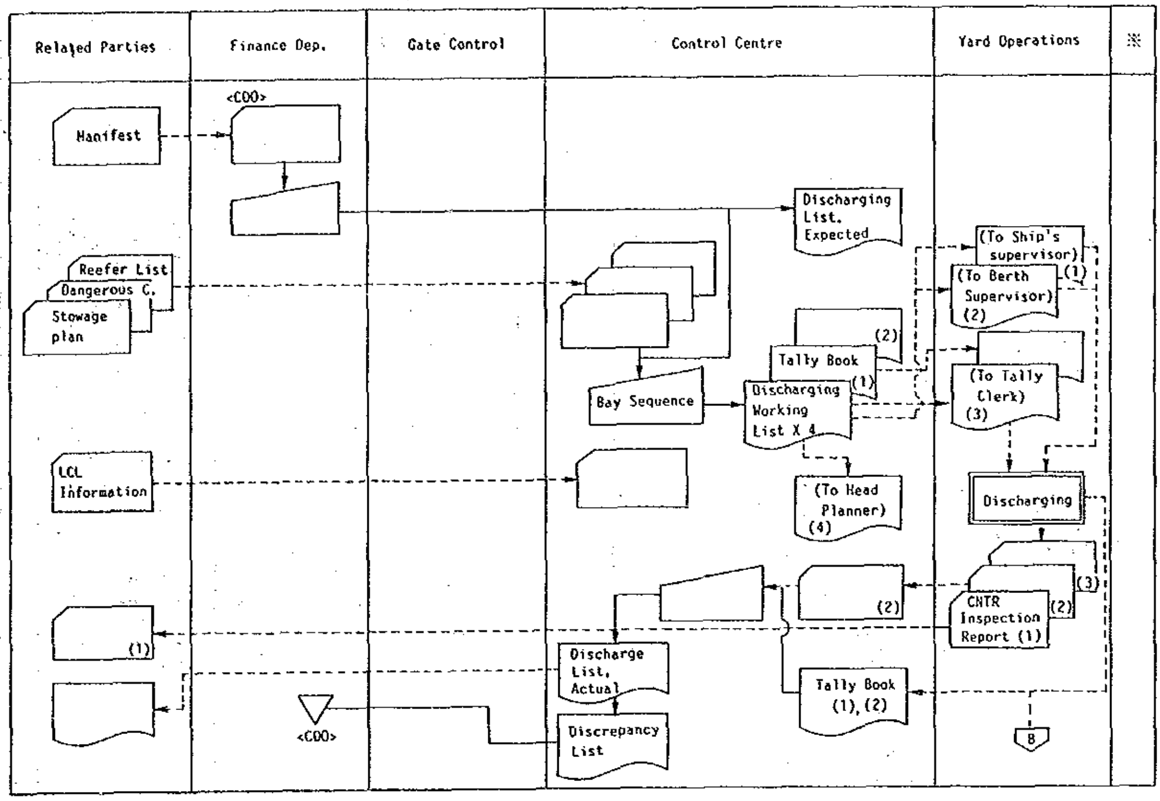


Fig. 3-5-1(a) Stage I Vessel Operations (Loading)



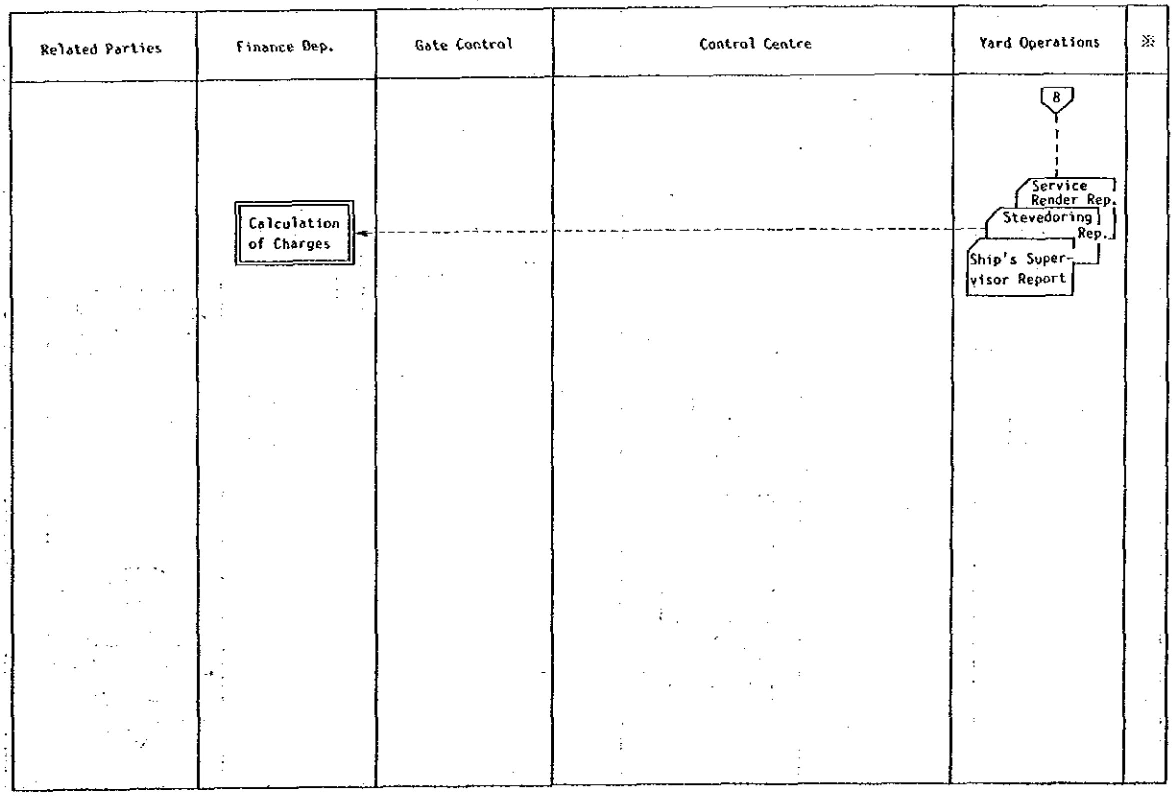
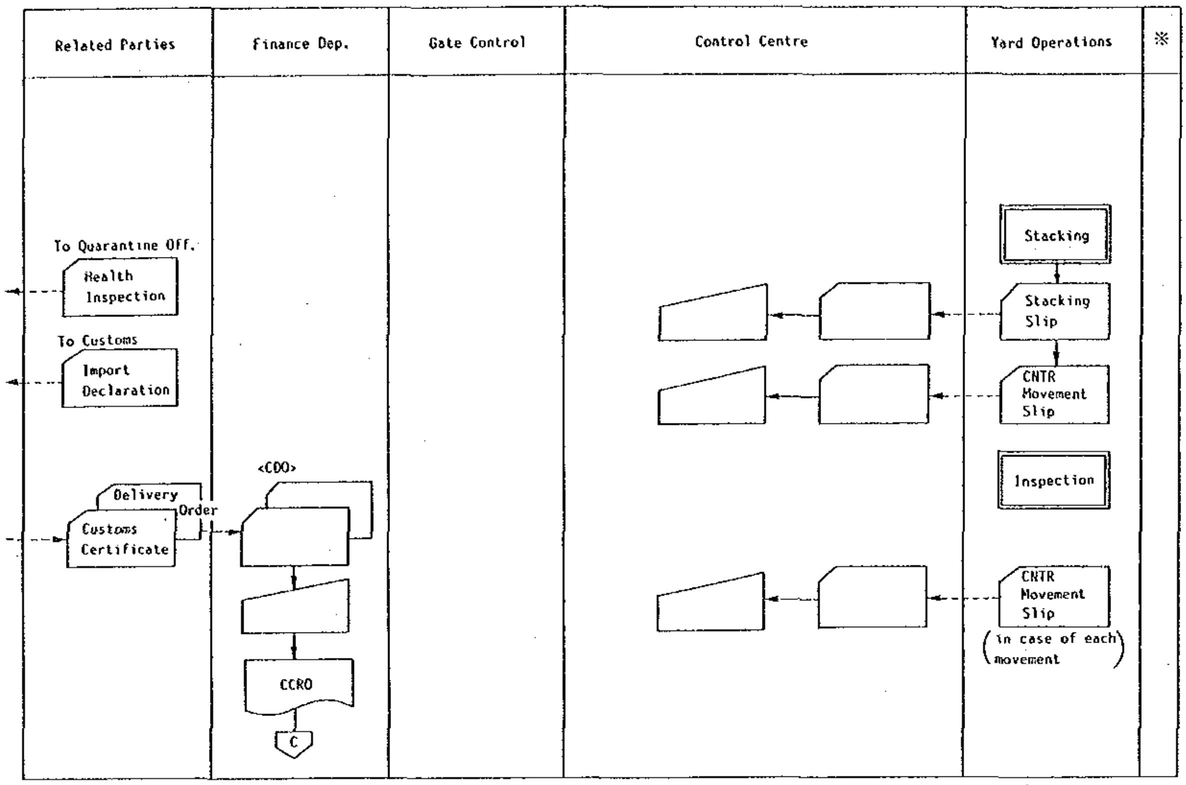


Fig. 3-5-1(b) Stage I Vessel Operations (Discharging)



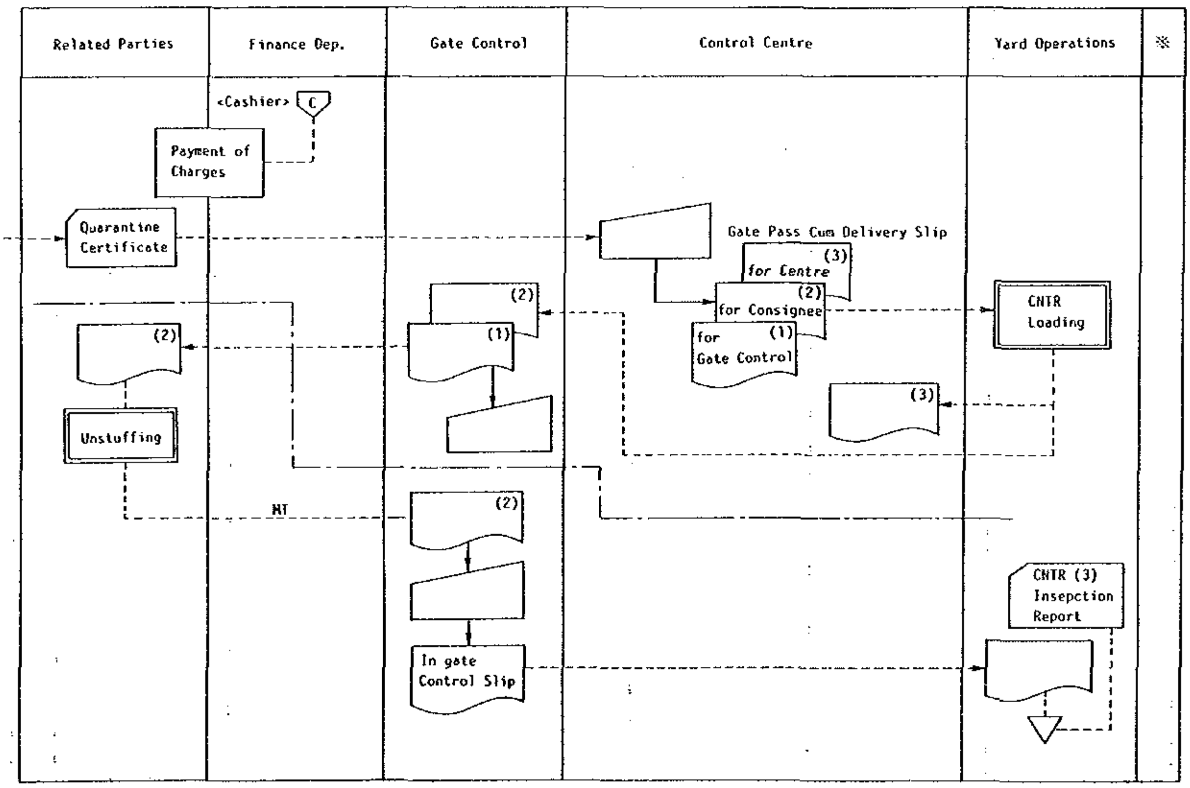


Fig. 3-5-1(c) Stage II Full Container Movement

CHAPTER 4 CURRENT MAJOR PROBLEMS IN MINA QABOOS

Chapter 4 CURRENT MAJOR PROBLEMS IN MINA QABOOS

4.1 General

As a gateway port of the Sultanate of Oman, Mina Qaboos has been playing an important role since 1974. Especially since 1982, Mina Qaboos has served as a container transshipment base to connect European countries with Asian countries due to its geographically favorable location. However, Mina Qaboos faces various kinds of problems, such as physical constraints on the dimensions of its facilities, low cargo handling productivity, and a lack of good cargo handling equipment in good condition.

By carrying out an investigation over two months, several major problems of Mina Qaboos have been identified based upon a series of discussions and analyses of relevant port data. In this chapter, these problems are discussed in detail.

4.2 Limited Land Area

In Mina Qaboos, the land area is extremely limited. Originally this port was developed as conventional type port, so the layout of its facilities and the site are not adequately designed for handling a considerable number of containers. Because of increasing demand for container use, Mina Qaboos has been changing its operations forwards container handling step by step, leaving already occupied areas as it is. Hence, container related areas are dispersed over the whole port area together with conventional cargo areas. For container cargo handling especially, dispersed land use should be avoided. Some countermeasures are necessary to ensure efficient use of the port's land area.

4.3 Dimensions of Berthing Facilities

Insufficient available depth is one of the most serious problems Mina Qaboos faces. As already mentioned, the declared depth for Berths Nos. 1, 1A and 2, which have been mainly used by large conventional ships, RO/RO ships and livestock ships, is 10.4 meters, and the depth for container berths, Berth No.4 and 5, is only 9.1 meters. Although maneuvering conditions in Mina Qaboos are excellent due to its calm wave and wind conditions, calling ships with arrival drafts of more than 10 meters and 9 *meters for Berths No.1, 1A, 2 and No.4, 5 respectively,* should be considered as having limited maneuverability to some extent.

According to the statistics of calling ships in 1988, about 30 calls of conventional, RO/RO and livestock ships are with its draft more than 10 meters and about 110 calls of container ships are with more than 9 meters drafts. These ships seem to wait and use tides to call at Mina Qaboos or at least required extremely careful maneuvering in the port. This fact must have a negative impact on Mina Qaboos, which has been experiencing severe competition from neighboring ports, especially in terms of container services. Hence countermeasures should be given to priority.

4.4 Berth Use Allocation

Because of its status in this country, Mina Qaboos has been expected to exercise various kinds of functions not only as a gateway for foreign trade but also as a base port for many different kinds of vessels and even as a marketplace for citizens. Table 4-1 shows the characteristics of berth use by ship type. In this figure, ship types are categorized into 9 types and type 90 (other ships), includes fishing trawlers, Navy vessels, the Royal yacht and other small craft. Table 4-2 shows working time ratio using the same categories as Table 4-1.

5. These figures describe clearly the current berth use allocation at Mina Qaboos. Concerning principal cargoes such as general cargoes, container cargoes, grains, vehicles and livestock, basic berth allocation based upon priority uses of these principal cargoes are organized. Namely, berths Nos. 1, 1A, and 2 are used primarily for general cargoes, vehicles and livestock; Berth No.3 for Grains; Berth No.4 and 5 almost exclusively for container cargoes; Berths No.7 and 8 for general cargoes, and so on. However, it is also true that the share of berth occupancy for type 90 ships is very significant. Hence, it is very important to find some countermeasures for this situation in order to improve the port capacity of Mina Qaboos together with other measure to respond to the increasing level of demand for the port's services.

Table 4-4-1 Berth Occupancy (1988)

(%)

Ship* Type	Berth Numbers 1	2	2A	2B	3	4	5	6	7	7A	7B	8	8A	8B	10	11
Whole	55.6	60.9	0.7	0.3	68.3	69.7	32.1	62.0	58.8	6.2	9.2	74.8	6.2	2.7	7.9	40.7
10	22.3	51.1	0.7	0.3	26.8	8.7	2.1	9.7	37.1	3.5		27.9	2.1	1.6	0.3	0.8
20	0.5	0.5				53.4	25.7	0.1				0.5				
30	2.8	5.5			3.6	7.3	0.9	0.1				0.1				
40		1.9			20.1				3.7	1.7		1.9	1.9			
50					2.1											
60	0.6	0.2			0.1		0.4	0.3	0.7		0.2					
70	11.8	1.6				0.3	0.4	1.9	0.2							
80	4.2						0.3									
90	14.4	0.1			15.6		2.4	49.7	16.9	1.1	9.2	44.3	2.2	1.1	7.6	39.9

* Ship type : 10 Conventional, 20 Full Container, 30 Semi Container, 40 Grain Carrier, 50 Dry Bulk Carrier, 60 Liquid Carrier, 70 RO/RO Ship, 80 Livestock Carrier, 90 Visit/Other Ship

Table 4-4-2 Working Time Ratio by Berth (1988)

Ship** Type	Berth Numbers 1	2	2A	2B	3	4	5	6	7	7A	7B	8	8A	8B	10	11
Whole	17.4	36.2	0.4	0.2	16.3	26.4	17.8	6.4	20.1	2.8	0.0	15.5	1.9	0.8	0.0	0.3
10	8.5	30.0	0.4	0.2	9.7	0.2	1.4	5.5	18.1	2.0		12.2	1.0	1.0	0.0	0.3
20	0.3	0.2				24.4	15.6	0.1				0.4				
30	1.0	2.0			0.8	1.6	0.5	0.1	0.1			0.1				
40		3.1			5.8				1.8	0.8		2.8	1.0			
50					0.0											
60	0.0	0.0			0.0		0.0	0.0	0.0			0.0				
70	5.4	1.0				0.2	0.4	0.5	0.0							
80	2.2															
90	0.0	0.0			0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

** See Table 4-4-1

4.5 Land Use Allocation

4.5.1 General Cargo

The area allocated for general cargo is some 4 ha for open storage yard and 1.9 ha for covered storage. Of the 4 ha for the open storage yard, 1.2 ha is a small area, that is to say beside the transit sheds 2000 m^2 or less. The remaining 2.8ha, is actually used as open storage area and is equivalent to the area required by the present level of cargo throughput. The open storage yard consists mainly of yards Nos. 3 & 10. Yard No. 10 is located apart from the other berths, which results in increased cargo traffic within the port area.

On the other hand, the covered storage area of some 1.9 ha should be much larger than that required by the present cargo volume as well as that in future. Therefore, certain measures should including re-allocation of land between the open storage yard and the covered storage area be taken in order to accomodate the increased future cargo traffic volume.

4.5.2 Containers

The area allocated for container stacking consists of 4 areas (8.7 ha). The area required by container traffic in 1988 is estimated to be 10 ha. The present container handling system in the yard, a forklift truck system, requires a large vacant space for passage & maneuvering area between stacking bays, although a bay, consisting of 2 rows, required a width of only 16 - 18 feet. Furthermore, the passage must be some 50 feet wide for one passage of 40 feet container movement. These makes land utilization less efficient and this lack of stacking area increases the intrusion into the open storage yard of general cargo, resulting in disordered stacking in whatever places are available. The lack of stacking area for increased container traffic is very apparent, consequently fundamental measures, including a change in handling system, expansion of new land and so on are crucial.

4.6. Productivity of Cargo Handling

4.6.1 General Cargo

The productivity of cargo handling including major commodities at Mina Qaboos has been found to be generally less than that normally expected.

For example:

Productivity at Mina Qaboos (data based on certain ships calling in 1988 & 1989)		Productivity normally expected
Steel	23.3 ton/G/H	30 - 50 ton/G/H
Timber	23.9 ton/G/H	30 - 50 ton/G/H
Rice (in bags)	12.2 ton/G/H	30 - 40 ton/G/H
General cargo	18.9 ton/G/H	25 - 30 ton/G/H

From the above figures and the increase in cargo volume in future, productivity should be improved significantly. The number of gangs should also be increased. Detailed analyses in this point, taking into account seasonal factors and other aspects, will be described in Chapter 7.7

4.6.2 Container Cargo

1) Shipside Operation

The rate of container handling varies according to the vessel, yard congestion, readiness of the back-up system and other factors. The average rate of 20.2 box/H/crane for discharge and 16.8 box/H/crane for loading is however, rather small than the potential of gantry crane and the record achieved in UAE ports. In our interviews with shipping agents it was said to be from 30 up to 40 in UAE ports such as Port Rashid and Fujairah. It is not known whether the figures for UAE ports were calculated using net hours or gross hours.

As for productivity at Mina Qaboos, it should be increased to at least 25 Box/H/crane or more in terms of gross hours. The fact that the figures achieved at Mina Qaboos are rather small in terms of crane potential might be attributable to a wide range of management problems. The difference of loading and discharging is, however, attributable to the improper back up system, i.e., insufficient number of forklift trucks, improper stacking and so on.

2) Land Side Operation

The present container stacking system has a major demerit for import cargoes, especially in terms of deliveries to consignees. The system causes a lot of inefficient handling. When a given container under over-stacked containers has to be delivered quickly, the overstacked containers must be removed and stacked in an other place temporarily, then later put back in their original place. Replacement of containers in the same place is necessary, because the computer program used to manage container storage is based on their remaining in one location. This greatly increases the frequency of container handling, as shown in the following table:

Stacking height	Handling frequency/number of container delivered (without replacing)	(with replacing)
1 tier	1.0	1.0
2 tiers	1.5	2.0
3 tiers	2.0	3.0

Thus, the present system increases container handling frequency up to 3 times in terms of the number of containers delivered. Numbers of container daily handled were 60 boxes/day for receiving, 59 boxes/day for delivery, 8 boxes/day for grounding and 5 boxes/day for CFS. Applying the handling frequency ratio, that is, 3 times, the maximum number of boxes that can be handled is calculated to be 289. Assuming that the land side operation continues for 12 hours and the container handling ration is 10 - 15 boxes/hour, 2 - 3 top lifters are required for the land side operation. Although the number of top lifters provided for the land side operation is said to be 2, according to our interview with the PSC officials, only 1 unit is actually available.

4.6.3 Required Quantity of Container Equipment

Assuming that a gantry crane handles some 65,000 TEU per anumm, the number of major container handling equipment units both at ship side and shore side for a gantry crane is normally described as follows:

	Top lifter	Straddle carrier	Rubber tyred g.c.
Ship side	2	3 - 4	1
Shore side	1 - 2	2	1
Maintenance	1	2	
Sum	4 - 5	7 - 8	2

Tractor trailers are deployed in combination with top lifters and the rubber-tyred transfer crane at shipside.

Tractor - T	4	4
Maintenance	1	1
Sum	5	5

Applying the above figures to the present situation of Mina Qaboos, required machineries are as follows:

	Required	Present
Annual throughput	147,882 TEU	147,882 TEU
Gantry crane	2 units	2 units
Top lifter at sea side	6 - 8 units	4 units
Forklift at sea side		1 units
Top lifter at shore side	2 units	2 units
Maintenance	2 - 3 units	2 units
Sum	10 - 13 units	9 units

The number of back up machines seems to be nearly sufficient, however, it is actually insufficient because of a lack of good assistance by tractor-trailers and a streamlined traffic system due to the deployment of top lifters.

From the above, the number of top lifters and heavy forklift trucks provided for the operation at the moment is marginal or obviously insufficient, taking into consideration downtime and/or maintenance time.

4.7 Equipment Utilization

The operating hours of the forklift trucks are shown in Table 4-7-1.

Table 4-7-1 Equipment Utilisation in Three Months

(August 1989)

Srl. No.	Day/s Stopped	Hours worked in August	Srl. No.	Day/s Stopped	Hours worked in August
Forklifts					
15	4	31	51	2	100
16	6	32	52	2	58
17	4	61	53	2	19
18	3	22	54	4	19
19	8	26	55	1	33
20	9	58	*57	5	202
21	2	26	*58	Awtg.spares	---
22	2	36	*59	13	167
23	1	16	*60	5	230
24	1	19	61	1	176
25	2	64	62	4	155

(September 1989)

Srl. No.	Day/s Stopped	Hours worked in September	Srl. No.	Day/s Stopped	Hours worked in September
Forklifts					
15	–	43	51	3	147
16	3	35	52	3	74
17	2	39	53	1	34
18	1	14	54	1	26
19	–	05	55	1	18
20	1	53	*57	3	238
21	7	27	*58	Awtg.spares	---
22	7	23	*59	16 (A/S)	110
23	4	10	*60	2	241
24	4	11	61	26	28
25	1	61	62	3	210

(October 1989)

Srl. No.	Day/s Stopped	Hours worked in October	Srl. No.	Day/s Stopped	Hours worked in October
Forklifts					
15	9	17	51	9	87
16	–	16	52	20	21
17	1	16	53	4	24
18	2	18	54	–	24
19	1	29	55	2	37
20	2	57	*57	2	213
21	–	18	*58	Awtg.spares	---
22	1	24	*59	Awtg.spares	---
23	3	16	*60	6	209
24	2	17	61	2	179
25	–	44	62	3	142
26	15	23	64	3	163

* Over 25,000 kg heavy capacity forklift
Source: PSC

These heavy capacity forklift trucks of Srl. Nos. 57, 58, 59 & 60 have more non-working days than small forklifts Srl. No. 15 to 25.

The main reasons of the above mentioned are

1) Long carrying distance and nearly full loads,
2) Insufficient road paving conditions,
3) Resulting damage to drive shaft on wheel axle,
4) The PSC's & dealers' storehouses do not keep large & expensive spare parts, and
5) Lengthy insurance procedures.

As a result, these forklift cannot work properly and maintenance staff member could not repair them effectively.

4.8 Computer System

Present problems of computer system in relation to the yard activity is noted as follows. In this section problems stipulated are rather in the yard activity which can be improve with the aids of computer system than computer system itself.

4.8.1 Instruction System for Container Location

Discharging of containers from a vessel is carried out according to a discharging sequence checklist which is prepared manually by the head planner. Copies of this plan printed out are delivered to key personnel of the operation: that is to say the ship supervisor, the yard supervisor the tally clerks of the PSC and chief officer of the vessel.

The location of the container in the marshaling yard, however, is not scheduled beforehand. It is determined by the yard supervisor in the course of operation. The yard supervisor is responsible for determining the locations of discharged containers according to vacant slots he finds in the marshaling yard and instructs the drivers of top lifters via a yard clerk.

Picking up a container underneath a gantry crane, the top lifter proceeds to the place instructed. At the same time, the yard clerk proceeds to the place and confirms whether the location of the container is correct or not.

If the container is in the correct position, he records and reports the locations at times convenient to the yard planner.