IV. Scale and layout of the commercial port facilities

IV. Scale and Layout of the Commercial Port Facilities

IV-1. Principles

Based on the concept of the layout employed for the various functions of the New Ocean Terminal described under Chapter III, layout of the commercial port facilities (container berths, break bulk cargo berths, grain berths, petroleum oil berths and small craft basins) was determined on the basis of the principles given below.

1) For efficiency in the use of wharfs, mooring facilities are to be of the marginal type.
2) For the economy in the dredging of channels in the harbour, deep water facilities are to be placed near the harbour entrance and relatively shallow water facilities at the inner part.
3) In view of the divisional development, those facilities necessary for the initial stage are not to be dispersed.
4) Berths for crude oil and petroleum products are to be placed near the harbour entrance for safety reasons.
5) Some of the commercial facilities are to be placed in the industrial port area so that industrial goods for distribution may be handled.
6) Two basins for small craft such as tugboats and harbour launches are to be provided, one in the commercial port area and the other in the industrial port area.

IV-2. Number of berths

In Table IV-1, the estimated amount of cargo traffic and the number and length of the berths required in the existing Port of Lagos and the New Ocean Terminal in the year 2000 are shown by type of commercial cargoes. The figures in this table were produced on the basis of the results of the Phase-I Report and "A Review of the Containerization Rate".* Accordingly, we shall refrain from giving a detailed explanation of the basis for the estimates of the cargo traffic and the number of required berths.

According to Table IV-1, the cargo traffic per berth length is approximately 200,000 tons/year for break bulk cargo and 500,000 tons/year for containerized cargo. The figure of 500,000 ton/year is quite low in comparison with the figures in Japan, but the results came from the consideration on the fact that a feature of the Nigerian import-export trade structure is that the quantity of general cargo exported is particularly low, comparing to the imported goods, unlike the case of Japan where there is a comparatively greater balance of imports and exports in the movement of cargo.

The grain wharf's capacity of 1,400–1,500 thousand tons per annual handling capacity per berth is sufficient. As for the petroleum wharf, a yearly capacity of 2 million tons per berth is feasible, taking into consideration the capabilities of a 10,000 D.W.T. class tanker's pumps. It would be sufficient there were to be 3 berths for petroleum oil that will be handled in the future at the New Ocean Terminal.

In conclusion, as of the year 2000, the New Ocean Terminal will need 33 break bulk berths, 27 containerized berths, 1 grain berth and 3 petroleum oil berths for a total of 64 berths.

Table IV-1 Commercial Cargo Traffic and Berthing Facilities at Lagos Ports Complex in the year 2000

Ports	Cargo Traffic and Dimension of Berthing Facilities	General Cargo			Grain	Petroleum Oil	Total
		Break Bulk	Containerized	Sub Total			
Lagos Ports Complex (Existing Lagos Port and New Ocean Terminal)	Cargo Traffic (1,000 ton)	11,186	16,814	28,000	1,042	9,400	38,442
	Number of Berths	54*	35	89	1	5	95
	Total Length of Berths (m)	13,705**	10,100	23,805	300	980	25,085
Existing Lagos Port (including the Third Apapa Extension)	Cargo Traffic (1,000 ton)	4,580	3,400	7,980	–	4,000	11,980
	Number of Berths	21*	8	29	–	2	31
	Total Length of Berths (m)	7,600**	2,000	9,600	–	425	10,025
New Ocean Terminal	Cargo Traffic (1,000 ton)	6,606	13,414	20,020	1,042	5,400	26,462
	Number of Berths	33	27	60	1	3	64
	Total Length of Berths (m)	6,105	8,100	14,205	300	555	15,060

* excluding 2,700 m of berths of two lighterage terminals
** including 2,700 m of berths of two lighterage terminals

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* A review of the containerization rate

The New Ocean Terminal Project, Lagos

November 20, 1978

1. A review was made, based on the result of discussion between the Japanese Study Team and the Nigerian Ports Authority held on July 26, 1978, on the rate of containerization.

The result of the review is as follows.

2. We reexamined the import cargoes handles at the Apapa wharf during the past two years and as a result reached the conclusion that about 65 per cent of the general cargoes except cement would be containerizable.

Based on this rate of containerization, Table IV-2 shows the result of forecasts of containerized cargo in the respective target years.

Similarly, Table IV-3 and IV-4 show forecasts of the total cargo traffic through Lagos Ports Complex and development scale of the New Ocean Terminal respectively.

3. According to the result of our review the following number of berths must be built at the New Ocean Terminal by the year 2000.

Container/ro-ro berths : 27

Conventional general cargo berths : 33

Table IV-2 Forecasts of Containerized Cargo

Unit: thousand metric ton

Year	General Cargo			Containerized Cargo			Remarks
	Outward	Inward	Total	Outward	Inward	Total	
1975-76	385	2,557 (1,140)	2,942 (1,140)	–	241	241	Rate of containerizable cargo about 65%
1984-85	979	6,718 (1,203)	7,697 (1,203)	195	3,493	3,688	Rate of containerization 80%
1989-90	1,463	10,456 (1,381)	11,915 (1,381)	293	5,913	6,206	" 87%
1999-2000	3,080	24,920	28,000	616	16,198	16,814	" 100%

Note: Figures in brakets show the volume of imported cement and are not included in general cargo.

Table IV-3 Forecasts of the Total Cargo Traffic Through Lagos Ports Complex

Unit: thousand metric ton

Year	By Outward and Inward	General Cargo				Grain	Petroleum Oil	Others	Total Throughput
		Break Bulk	Containerized	Cement	Sub Total				
1975~76	Outward	385	–	–	385	81	90	26	582
	Inward	2,316	241	1,140	3,697	380	2,313	70	6,460
	Total	2,701	241	1,140	4,082	461	2,404	96	7,042
1984~85	Outward	784	195	–	979	–	–	–	979
	Inward	3,225	3,493	1,203	7,921	664	4,400	–	12,985
	Total	4,009	3,688	1,203	8,900	664	4,400	–	13,964
1989~90	Outward	1,170	293	–	1,463	–	–	–	1,463
	Inward	4,453	5,913	1,381	11,837	784	6,100	–	18,721
	Towal	5,713	6,206	1,381	13,300	784	6,100	–	20,184
1999~2000	Outward	2,467	616	–	3,080	–	–	–	3,080
	Inward	8,722	16,198	–	24,920	1,042	9,400	–	35,362
	Total	11,186	16,814	–	28,000	1,042	9,400	–	38,442

Notes: 1. Figures in1975-76 show actual results.
2. Grain includes offal.
3. Others mean dry bulk cargoes.

Table IV-4 Development Scale of the New Ocean Terminal

Unit: berth

Facilities	Existing Berths	Number of Berths to be Built at the New Terminal		
		1984–85	1989–90	1999–2000
General Cargo Wharf	21	–	6	33
Container/Roro Wharf	8	1	6	27
Special Wharf for Wheat Grains	0	1	1	1
Wharf for Dry Bulk (cement) Cargo	2*	–	–	–
Petroleum Wharf	2	1	1	3
Total	33	3	14	64

* No. 1 berth at Apapa and No. 1 berth at Tin Can Island Port (to be converted to general cargo berths in 1999/2000)

IV-3. Scale and layout of the commercial port facilities

IV-3-1. Container wharf

(1) Projected ship size

In deciding the scale of wharf, it is first necessary to establish the size of container ships berthing the wharf. Before estimating the characteristics of container ships in future, we will discuss simply the history of the development of container ships. While containers have been used from a very long time back to transport goods on land, the containerization on the ocean liner began in the middle of 1960's. Most of the container ships of that period were the conventional type freighters converted to load containers. They were so-called semi-container ships which could carry both the break bulk cargoes and the containers.

The ships were generally in 15,000 GT range with a speed of 16 knots. They may be called first generation container ships. Following them, full container ships came to be built in the late 1960's. These ships, which were 15,000 GT, class vessels cruised at approximately 20 knots and carried 700–800 containers, may be called second generation container ships. In the beginning of the 1970's the overseas container ship transport system was fully established around the world, and high speed giant containerships came into utilization. These 50,000 GT ships can carry 1,500 to 2,000 containers while maintaining speeds over 25 knots. They may be called the third generation container ships. The container ships going between the developed and developing countries might be said to be in the 2nd generation stage at present.

It is necessary to take into consideration numerous elements in order to forecast the future of container ships which will go in and out of the New Ocean Terminal; and this is not easy. We have to consider that since the oil crisis, the fuel-economizing type of container ships have begun to be built after the third generation container ships. So we believe that there is little possibility that larger ships than 50,000 GT class container ships will become into operation on the Nigerian lines in future, and that, accordingly, it is sufficient if the plan for the New Ocean Terminal covers 50,000 GT ships, 260–270 meters in length, with 11–12 meters loaded draft.

(2) Scale and layout of the container wharf

The berths, which are to handle the projected 50,000 GT ships, require a length of 300 meters and a water depth of 12 meters. Generally, in the case of the marginal type of wharf as in the New Ocean Terminal which calls for large number of berths to be lined up end to end, even if the maximum size of ship turns out to be larger than forecasted, it is normal procedure for large ships to dock at these berths by mixing them with ships smaller than the maximum projected size of ships. Accordingly, there will be relatively little pressure to redo the planned length of the berths.

However, once the structure has been built it is generally difficult to increase the water depth alongside the wharfs from the original depth.

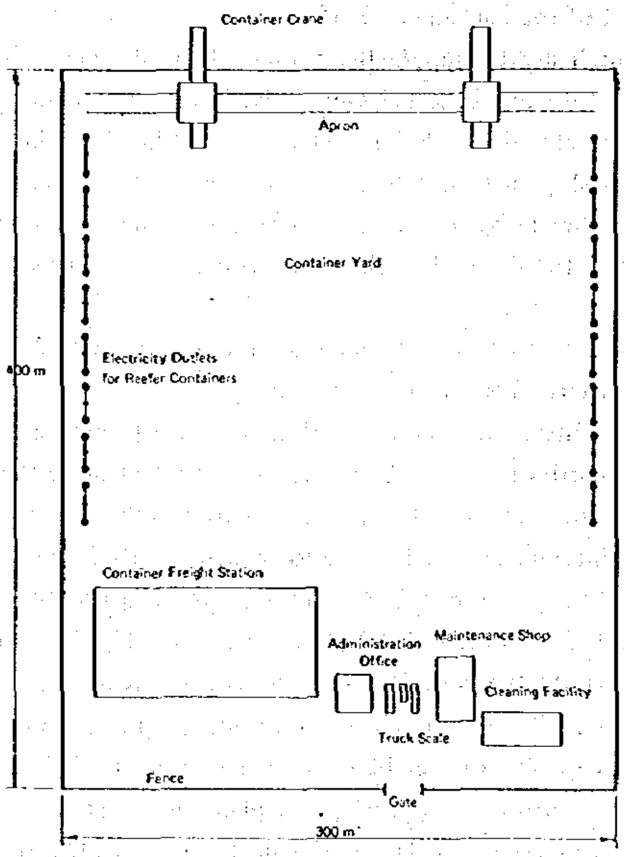
Taking these conditions into consideration, we have proposed a berth structure which will allow the structural depth of berth to be increased one meter more than the standard depth of 12 meters to meet the future increase of ship's size coming to the New Ocean Terminal.

The width of container terminal is a factor which greatly influences the handling capacity of the terminal. Generally, it is standard for a terminal built for 50,000 GT class container ships to have a width of 300–350 meters and thus an area of 105,000m² (berth frontage of 300m x 350m terminal width). At the New Ocean Terminal, it was planned to increase the width by 50 meters to 400 meters for the speedy clearance of imported cargoes in future. Since it is relatively easy to expand the capacity of freight stations and other facilities as needed to cope with the enlarging of ship size in future, it is enough to plan for the area standard facilities as would be appropriate for a 300 meter berth. Table IV-5 shows the basic facilities of the container terminal at the New Ocean Terminal and Figure IV-1 their layout.

Table IV-5 Scale of Main Facilities for the Container Terminal

Facilities	Scale
Mooring Wharf	Length 300 m Depth -12.0 m (-13.0 m)
Depth of Terminal	400 m
Total Terminal Area	120,000 m²
Container Crane	2 unit
Container Freight Station	6,000 m²

Fig. IV-1 Layout of the Container Terminal Facilities



IV-3-2. Break bulk wharf

(1) Projected ship size

As for the size of ocean going freighters, the 10,000–15,000 D.W.T. ship has been generally settled upon as the most economical; this has not changed for several decades, considering from an international perspective on the routes, the amount of cargo, and various other factors.

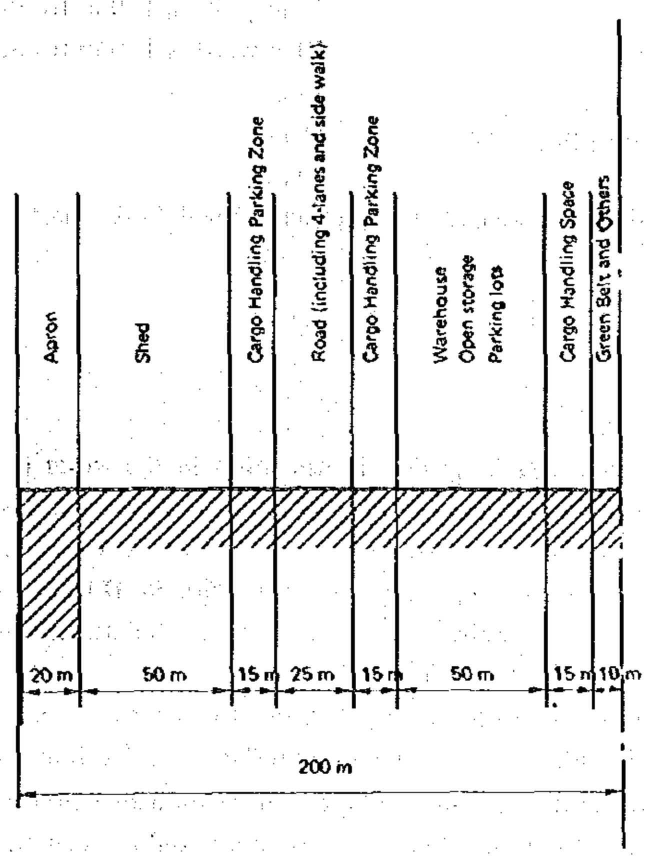
This is because there have been no fundamental changes in the overseas transport of break bulk cargoes and this trend can not be expected to change greatly in future. The average size of bulk carriers which come to Apapa Wharf and Tin Can Port as present are 10,000 D.W.T. It may be said that the ships assigned to the Port of Lagos are of appropriate size for tackling the present day movement of cargo.

The New Ocean Terminal will be constructed step by step by the year 2000 as the target. It is unthinkable that during this interval the break bulk carriers will suddenly increase in size. Accordingly, regarding the break bulk carriers for the New Ocean Terminal we have planned for ships one rank larger than those now entering the Port of Lagos, the 15,000 D.W.T. class ships.

(2) Scale and layout of the break bulk wharf

The standard specifications for the 15,000 D.W.T. class freighter are: overall length 165

Fig. IV-2 Cross Section of the Break Bulk Cargo Terminal Facilities



meters, beam 21.6 meters, loaded draft 9.5 meters. Therefore, the berth length is planned to be 185 meters and the water depth alongside wharfs is planned to be 10 meters including some allowance against the trimming and other phenomena.

The space required by the wharf was planned to satisfy the various conditions listed below. The result was that a width of 200 meters, excluding the rear access roads to the site.

1) Within the terminal area, the layout includes the apron, transit shed, warehouse, stockyard, service roads and other facilities needed for freight handling, sorting and storage, the green areas, etc.
2) The cargo handling will be carried out by ships' derricks. Cranes are not planned to install on the apron of the wharf.
3) The scale of the transit shed is planned so as to be able to store at least the total amount of the transit cargo on an arriving ship.
4) As a general rule there will be one transit shed building per berth.
5) The warehouse, stockyard and green belt will be laid-out to the rear of the transit shed in accordance with necessity.
6) Roads and cargo handling parking zones are laid out between the transit sheds and warehouses, stockyards, etc.

Based on the above objectives, the specifications for the wharf facilities are planned as follows:

apron width	20 m
transit shed	50 m width x 150 m frontage
warehouse	50 m width x 150 m frontage
road	25 m
cargo handling parking zone	15 m
greenbelt	10 m

Fig. IV-2 shows a standard cross section of break bulk wharf.

IV-3-3 Grain wharf

(1) Projected ship size

While the largest grain carriers in operation in the world today are in the 65,000 D.W.T. class, 10,000 D.W.T. class grain carriers are still in common use. As for the New Ocean Terminal, it is appropriate for the plan for the year 2000 to take a long term look and consider 60,000 D.W.T. class grain carriers. The specifications of a 60,000 D.W.T. class grain carrier are as follows:

Overall length; 200–250 m, beam; 30–35 m, loaded draft; 12–13 m.

(2) Scale and layout of the grain wharf

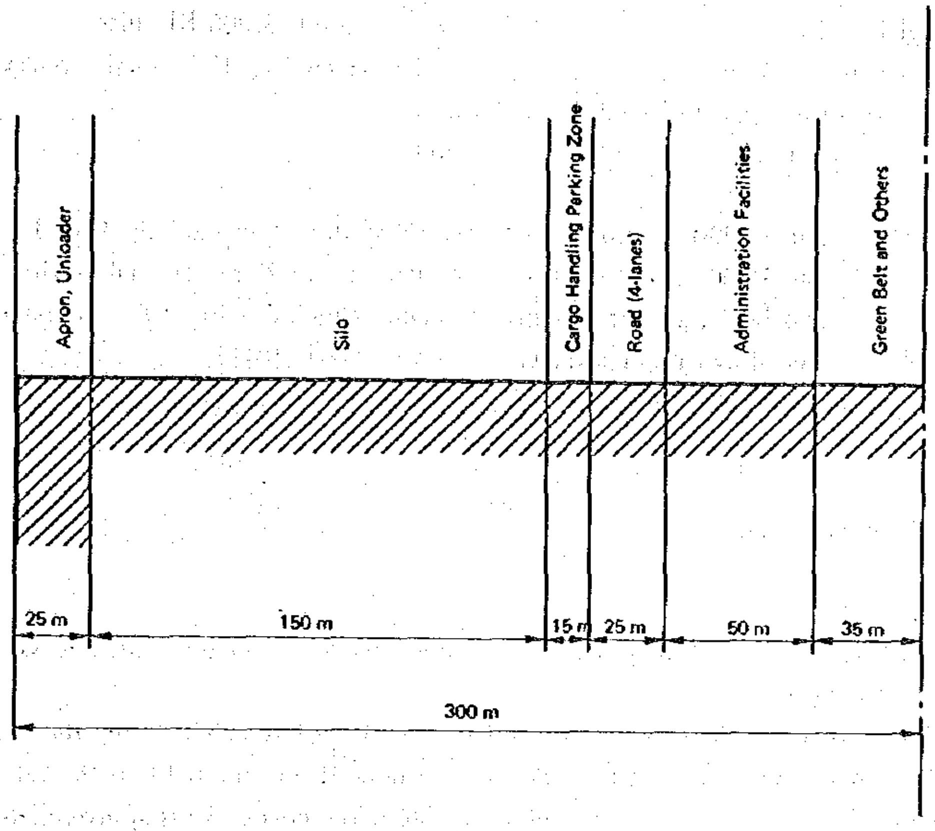
In order to be able to accept the ships described above, it becomes necessary to have a berth scale providing for a length of 300 meters and the water depth of 14 meters.

In order to handle the amount of grains to be unloaded annually at the New Ocean Terminal (1,042,000 tons in the year 2000), two pneumatic unloaders with a capacity of 400 tons/hr. are needed.

The required capacity of grain silos varies depending upon the turn-over rate of grain. But looking at the standard figures of the grain wharf of a similar scale to the New Ocean Terminal's, 1.5 times of the maximum load capacity of the projected grain carrier is sufficient for the silo capacity. Accordingly, a silo with a 100,000 ton storage capacity is planned for the New Ocean Terminal. Because it is posssible in future that as the capabilities of the pneumatic unloaders are increased, a greater quantity of grain can be handled. It is desirable to plan beforehand for the wharf to have adequate space for green belts, administration facilities, etc. for future use. The grain wharf is planned to have a frontage of 300 meters and a width of 300 meters for a total of 90,000m^2.

Fig. IV-3 shows a cross section of the New Ocean Terminal's grain wharf facilities.

Fig. IV-3 Cross Section of the Grain Terminal Facilities



IV-3-4 Petroleum wharf

(1) Projected ship size

It is anticipated that the petroleum products to be unloaded at the New Ocean Terminal will be shipped in from the port of Warri and Port Harcourt. As both of these ports are river ports, 15,000 D.W.T. class tankers will be used because of the limitation of the water way to these ports.

(2) Scale and layout of the petroleum wharf

Taking into consideration the safety of the petroleum wharf, as mentioned in IV-1 "Principles", the dolphins are laid near the harbour entrance and the petroleum is planned to be transferred into the tanks through pipelines. As the ships are expected to be in the 15,000 D.W.T. class, dolphins will be needed for three berths in order to discharge the expected 5 million tons per year. It is planned for each berth to be 185 meters in total length and have the water depth of 10 meters.

The dolphins are planned to be located near the base of the west break water at a distance 50 meters out, bearing in mind the gradient of the side-slope. Thus, ships may tie-up to one side. The oil tanks are to be situated in the land to the rear together with a power station. The per annum quantity of petroleum products to be handled at the New Ocean Terminal is 5.4 million tons. In order to cope with this, the scale of the distribution infrastructure was settled upon as follows:

Main tanks	24	20,000 Kl units
Service tanks	8	3,000–5,000 Kl units
Tank yard	64 ha	(including 13 ha service tankyard)
Land area for supporting facilities	26 ha	
Total	90 ha	

Notes – The 20,000 Kl tanks have diameters of 46 meters and heights of 14 meters.
– The 3,000–5,000 Kl tanks have diameters of 28 meters and heights of 8 meters.
– The land area for supporting facilities includes space for the parking of lorries, unloading equipment, etc.

A 40 hectares site for power station is added to the 90 hectares of petroleum distribution infrastructure, for a total of 130 hectares, which is laid out to the rear of the grain berth.

IV-3-5 Small craft basins

(1) Small craft basins

The larger the scale of the port, the more a variety of service boats are necessary for smooth operation of the port.

Table IV-6 shows the cargo traffic and the number of vessels entering the port at the New Ocean Terminal and Port of Kobe and Port of Kashima. It is estimated that the total cargo traffic through the New Ocean Terminal including the industrial port cargo is approximately 69 million tons per year, and that 6,000 – 7,000 ships call at the port during the same period. Looking at the character of the New Ocean Terminal, it can be said that the New Ocean Terminal has both the characteristics of Port of Kobe which is a commercial port and Port of Kashima which is an industrial port with the cargo traffic in the commercial port being approximately one half that of port of Kobe (Port of Kobe handled 54 million tons in 1977, and the New Ocean Terminal 26 million tons), and the industrial port cargo traffic was roughly equal to that of Kashima (Port of Kashima handled 43 million tons in 1977* and the New Ocean Terminal 42 million tons). And, looking at the number of vessels entering the harbour (overseas vessels), the New Ocean Terminals 6,000 arrivals are half of Kobe's and 6 times that of Kashima's.

In Port of Kobe and Kashima, other domestic shipping traffic (500 tons and up) entering the ports is 60,000 – 70,000 and 4,000 – 5,000 vessels respectively; combining the overseas and domestic traffic for an aggregate count, the number of ships entering the New Ocean Terminal is slightly greater than for Kashima. Considering points such as the above ones as well as Nigeria's particular situation, the type and number of service boats needed for the New Ocean Terminal was decided upon as shown in Table IV-7, and their placement and assignment as shown in Table IV-8.

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* Today Port of Kashima is still under development. Its 1990 cargo traffic target is approximately 100 million tons.

Table IV-6 Cargo Traffic Volume and Number of Vessels Called at Selected Ports

Unit: 1000 ton

		Port of Kobe (in 1977)	Port of Kashima (in 1977)	New Ocean Terminal (in 2,000)
Cargo Traffic	Foreign Trade	54,039	28,246	44,607
	Domestic Trade	62,951	14,852	24,250
	Total	116,990	43,098	68,857
Number of Vessels * Called at the Ports	Foreign Trade Vessels	11,639	1,039	5,000~6,000
	Domestic Trade Vessels	67,284	4,244	1,000
	Total	78,923	5,283	6,000~7,000

Source: Japanese Port Statistics, Ministry of Transport
Note: * Vessels of 500 DWT and over

Table IV-7 Service Boats at Selected Ports

Kind of Service Boats	Port of Kobe (in 1977)	Port of Kashima (in 1977)	New Ocean Terminal (in 2,000)
Customs Inspection Boats	8	1	2
Quarantine Inspection Boats	7	1	2
Immigration Control Boats	3	–	–
General Transportation Service Boats	96	6	5
Tug Boats	35	10	12
Patrol Boats	10	1	2
Supervisory Boats	4	–	2
Fire Boats	5	3	4
Harbor Police Boats	9	1	1
Oil Skimmer	6		2
Water Surface Cleaners	5		2
Water Boats	5		3
Other Miscellaneous Service Boats	–	2	2
Total*	193	25	39

*Excluding workvessels in service temporary

Table IV-8 Number of Service Boats at the New Ocean Terminal

Kind of Service Boats	Assignment	Standard Size of Boats (LmxBmxdm)	Total Number of Boats	Mooring Basin	
				Basin-1	Basin-2
Customs Inspection Boats	Customs	20GT (15.3x3.6x0.6)	2	2	–
Quarantine Inspection Boats	Quarantine	20GT (15.3x3.6x0.6)	2	2	–
General Transportation Service Boats	Private Companies and NPA	20GT (15.3x3.6x0.6)	5	2	3
Tug boats	NPA	280GT (32.8x9.5x3.3)	4	2	2
Tug boats	NPA	30GT (28.4x8.6x2.6)	8	4	4
Patrol Boats	Navy	20GT (15.0x2.0x1.3)	2	2	–
Supervisory Boats	NPA	20GT (15.3x3.6x0.6)	2	2	–
Fire Boats	NPA	100GT (25.0x6.0x2.4)	2	1	1
Fire Boats	NPA	10GT (13.0x3.1x1.1)	2	1	1
Harbor Police Boat	Police	20GT (15.3x2.0x1.3)	1	1	–
Oil Skimmer	NPA	50GT (20.0x5.0x2.0)	1	1	–
Oil Skimmer	Private Companies	50GT (20.0x5.0x2.0)	1	–	1
Water Surface Cleaner	NPA	20GT (15.5x5.0x1.1)	2	1	1
Water Boats	NPA	100GT (26.0x6.0x1.5)	2	1	1
Water Boats	NPA	25GT (15.1x4.2x0.7)	1	1	–
Other Miscellaneous Service Boats	Private Companies	20GT (15.3x3.6x0.6)	2	1	1
Total			39	24	15

(2) Scale and layout of the small craft basins

Among the service boats listed in Table IV-8, the tugboats have the deepest draft.

Accordingly, the berth's depth of 3.5 meters is planned to fit the tugboat's draft. The small craft basin should be as calm a place as possible and should be positioned in a location near the center of the harbour.

In the New Ocean Terminal, two small craft basins are planned. One of them is positioned in the commercial port (Basin-1, A and B), and another in the industrial port (Basin-2).

Basins 1 and 2 are planned so that the boats will be moored alongside the berths. In this case, berth lengthof 1.2 x the boats length (or 1.2 L) is sufficient.

Accordingly

- The total length of basin-1's berth required is 1.2 x 17.8 m (median boat legth) x 24 boats = 513 meters.
- The total length of Basin-2's berth required is 1.2 x 22.7 m (median boat length) x 15 boats = 408 meters.

As it is rare in reality to have all the service boats berthed alongside at once, it is sufficient for the berths in Basin-1 to have a length of 500 meters and in Basin-2 a length of 400 meters.

Berthing area of 1,000 – 1,500m² per boat in the basins is standard. Accordingly it would be sufficient for Basin-1 to have an area of 30,000 – 40,000m² and Basin-2 15,000 – 25,000m².

For the small craft basin, an apron of 25 meters and a supportive facilities area with a 40–70 meter width are planned. Fig. IV-4 and Fig. IV-5 show a basic layout of Basins-1 and 2.

Finally, the commercial port facilities required by the New Ocean Terminal are collected and shown in Table IV-9.

Table IV-9 Number and Size of Berthing Facilities for Commercial Cargoes at the New Ocean Terminal in the year 2000

Cargo Traffic, Dimension of Vessels and Berths	General Cargo Berths		Grain Berth	Petroleum Oil Berths	Small Craft Berths	Total
	Break Bulk	Containerized				
Cargo Traffic (1,000 ton/yr.)	6,606	13,414	1,042	5,400	–	26,462
Maximum Size of Vessels (DWT)	15,000	50,000 G.T.	60,000	15,000	280 G.T.	–
Structural Depth of Berths (m)	-10	-12(-13*)	-14	-10	-3.5	–
Length of Each Berth (m)	185	300	300	185	–	–
Total Number of Berths	33	27	1	3	–	64
Total Length of Berths (m)	6,105	8,100	300	555	1,100	16,160
Total Width of Wharf (m)	200	400	300	–	25	–

* At present, the depth of 12 meters is sufficient for most of the modern container ships, but to meet the further increase of ship's size in future an allowance of one metre is taken into consideration for design purposes.

Fig. IV-4 Plan of Basin-1 (A, B)

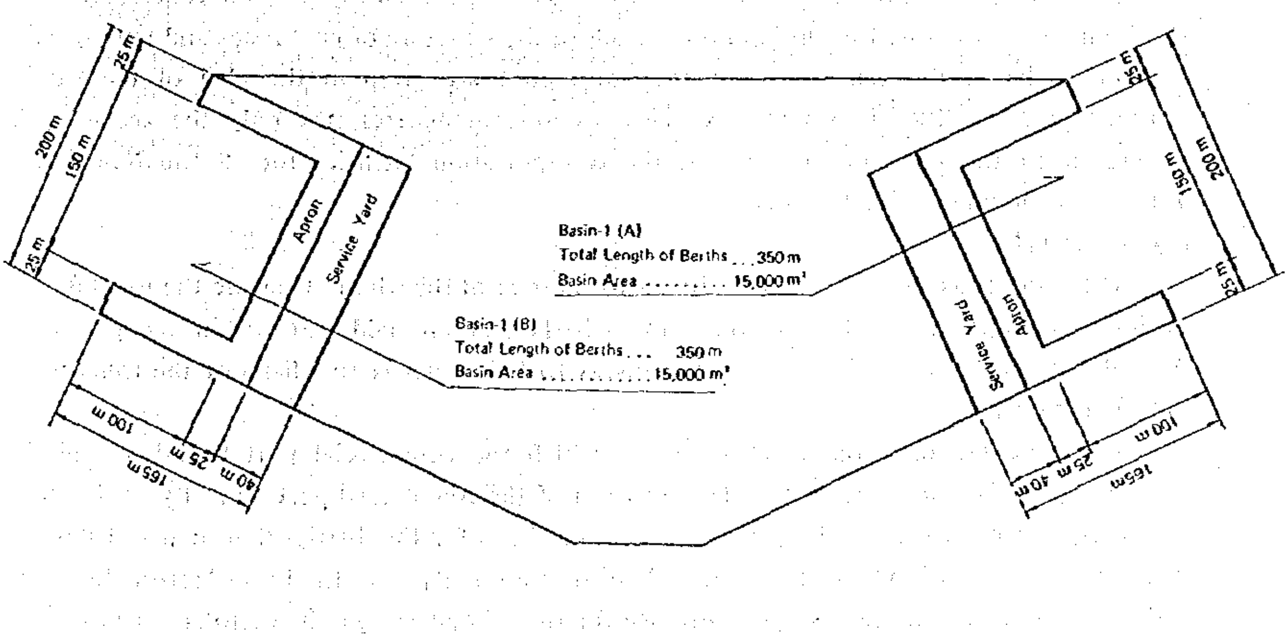
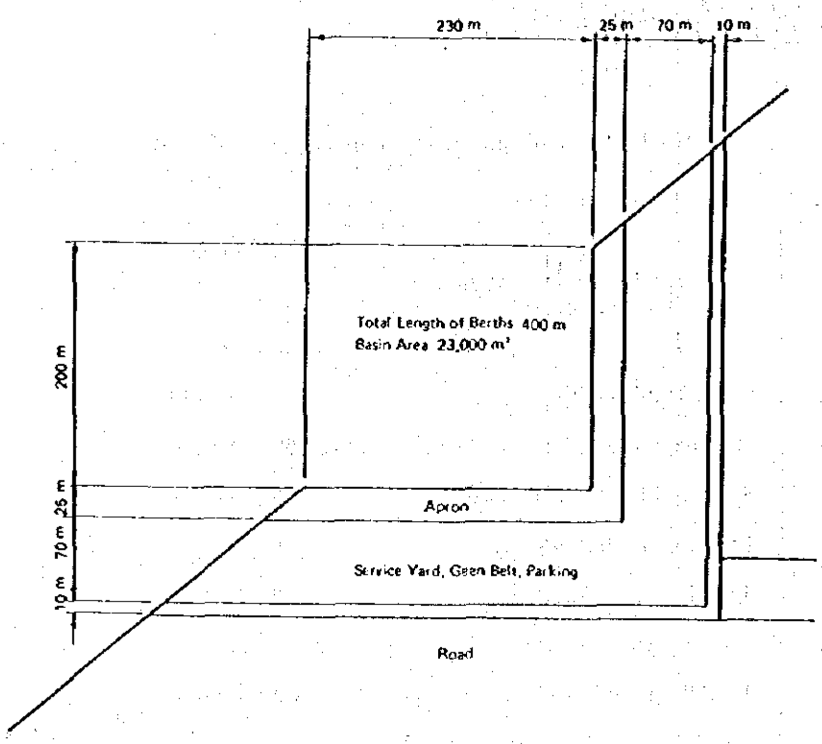


Fig. IV-5 Plan of Basin-2



IV-4 Layout of related facilities

IV-4-1 Transportation facilities

The basic concept on the planning of port roads and port railways and the general layout of the facilities are discussed in this section. Details of the structure of port roads and railways (the number of lanes, the gauge, size of the yard, etc.) are given in the plan of the arterial transportation facilities in Chapter X. This section summarizes not only the access roads connected to the commercial port but the transportation facilities for all the New Ocean Terminal, including the industrial port.

(1) Port roads

The port raods generally come right up to the rear of the wharf. They are the roads for the purpose of cargo traffic to and from the wharfs and are laid out within the port area. Accordingly, the port raods mean such roads as to link a wharf to wharfs or the trunk roads outside the port.

The New Ocean Terminal is a port in which the commercial port functions and the industrial port functions are united. The function of the commercial port is mostly the handling of imported general cargoes, but there are some facilities for the distribution of petroleum and grain. Because the New Ocean Terminal is planned to primarily serve the Lagos Metropolitan area and Lagos State the mean transport distance for these imported goods, petroleum and grain is relatively short, within a 100 kilometers from the terminal. Accordingly, there is almost to merit in transporting these cargoes by railway. That job should be left completely to trucks, tank lorries, etc.

In regard to the industrial port's function, it is not our intent that the industrial estates to be located at the New Ocean Terminal will be scaled up to handle the entire future demand for various products in the nation far into the future. Rather, we think that the industrial complex should be constrained within the scale we have suggested, and additional industrial estate locations should be dispersed and placed in other provinces. Therefore, the mean transport distance for the industrial products, similarly to the commercial port cargo, will not be very far. At its furthest, the port will cover the western half of the republic. Yet, among the cargoes generated by the industries (refer to Chapter V) that will be located in the New Ocean Terminal there are some, like iron and steel products, which may be thought that rail transportation would be advantageous, because of its amount of lot.

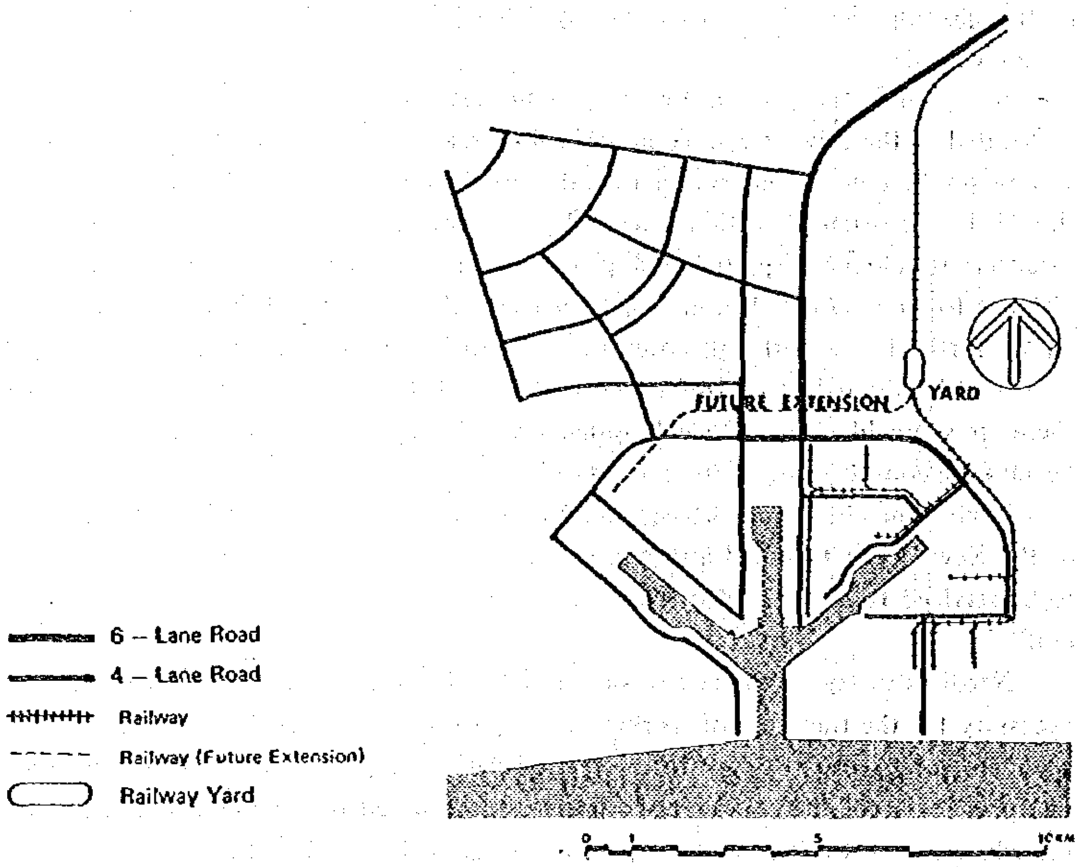
Taking the above stated basic structure of the flow of goods originating from the existence of the New Ocean Terminal into consideration, it is appropriate to plan for the commercial port to be serviced 100% by road transportation and the industrial port by a combination of road and rail.

Needless to say, the port roads are not for the trucking of port related cargo only, but are necessary for the transport of workers in the port. For this reason, it is necessary to construct an adequate access road network to the rear of the wharfs, and in and out of the industrial estage. The port roads for the commercial wharfs are positioned running parallel and just to the rear of the wharfs. A network consists of port roads and a ring road to tie them which directly receive traffic to and from the port related business areas discussed in IV-4-2. Port roads for the industrial zone will be laid out between various industries and be connected with an outer ring road.

(2) Port railway

The basic ways of thinking about the ground transportation facilities have already been brought up in section (1). The port railway should be planned to handle exclusively cargoes relating to manufacturing industries, with industrial sidings provided for the respective plants if necessary, and a marshalling yard should be arranged between he joint of these sidings and the main line toward the inland. The yard should function as a freight station of the entire New Ocean Terminal. Fig. IV-6 shows the basic layout of the transportation facilities.

Fig. IV-6 Basic Layout of the Transportation Facilities



IV-4-2 Port related business areas

Needless to say, the port activities do not simply consist of the wharfs, channels and other basic facilities but of various related business activities which support port activities as well. It is only by these business activities that the port can fully function.

Table IV-10 lists the various port related business activities necessary for supporting the activities of the New Ocean Terminal. Actual activity level of these various businesses is determined by the quantity of commercial cargo. In order to make these activities possible, a site appropriate for the scale of the activities is needed.

Table IV-11 shows the relationship between the port area of major Japanese ports and the amount of cargo traffic. The port area consists of wharfs and port roads, and includes the sites of business related with the port. And this area is usually administrated by single port authority. As the conditions in Japan and Nigeria differ greatly, these values can not be directly applied to the New Ocean Terminal plan, but they can be used as references for comparison with the commercial cargo traffic. The port area per million tons of cargo traffic in the major 5 Japanese ports varies in wide range but the mean area is 19 ha/million tons. The New Ocean Terminal cargo traffic being 26 milliontons, applying the Japanese mean value we have 500 hectares (26 million tons x 19 ha/million tons). In order to have room to spare at the New Ocean Terminal,

Table IV-10 Port Related Business

A. Shipping Business Shipping carrier Ship leasing Shipping agency Plying boat service Excursion boat service	E. Cargo handling service jobs ● Tally service Appraisal and inspection Guard Clearance service Packing ● Fumigation
B. Service businesses for ships Piloting Line handling ● Tugboat service Ship overhauling ● Oil bunkerage Fresh water supply ● Ship chandler	F. Container related work Container van repair Inland transportation of the maritime container vans
C. Intra-port transportation work ● Stevedoring Lighterage conveyance ● Longshore cargo handling	G. Port related land transport business Rail transport (Port Railway) Trucking Taxi
D. Warehousing	H. Port-related construction business
	I. Port-dependent enterprise Bank Non-life insurance Trading company Wholesaler Port-dependent production industry Port-dependent construction industry

Table IV-11 Port Area of Major Japanese Ports

Ports	Port Area (ha)	Cargo Traffic (1,000 ton)	Port Area/Cargo Traffic (ha/Million ton)
Tokyo	234	49,886	4.7
Nagoya	3,786	98,935	38.3
Osaka	1,396	78,819	17.7
Kobe	1,436	135,868	10.6
Hakata	458	15,232	30.1
Total	7,310	378,740	19.4

Source: Port Area Survey, Ministry of Transport, Japanese Government we have multiplied this value by 1.5, giving a needed area of 750 hectares. Because this value includes the area for wharf and port road, deducting these two areas from the total will give the area for the use of port related business.

To wit: 750 ha – (446 ha wharf area +75 ha port road area) = 229 ha. Therefore, using this figure as the standard for the New Ocean Terminal, a 150 meter wide port related business area is situated to the rear of the wharf. As the total length of the wharf is 15 km, the area for the use of port related business is 150m x 150,000m, for a total of 225 hectares.

The above mentioned concerns the layout of port related business comprised primarily of private enterprise operations, but there are other important jobs for the support of port activities, the port related public service functions.

Table IV-12 lists the ordinary types of basic public institutions, ships crew welfare facilities and recreation facilities necessary for port operations. These facilities we are taking up here, are minimal requirements for the New Ocean Terminal to function properly as a port. These facilities will often be located together. And, considering the convenience of ordinary users, it would be desirable to layout the facilities in the same area. These facilities should be situated in the center of the commercial port facilities in order to plan for the smooth execution of channel administration, customs work, anti-disaster activities, etc.

Table IV-12 Public Service Facilities for Port Activities

Administrative & Public Offices	Other Public Service Facilities
Nigerian Port Authority	Clinic, Hospital
Coast Guard	Recreation Center
Port Administration Office	Lodging Facility
Customs	Public Hall
Quarantine	Park
Immigration Control Office	Play Ground
Harbor Police	Exhibition Hall
Fire Department	
Meteorological Observatory	
Navigation Control Office	
Pilotage Office	
Other Federal Office Branch	

V. Concept for industrial development

V. Concept for Industrial Development

The New Ocean Terminal is designed as a port with both the functions of commercial and insutrial port, and in the light of the urgent request, the construction of commercial port facilities will be inevitably preferential. However, as mentioned before, if commercial port functions with a considrable scale are developed in a place with extensive neighboring land and large volume of consumption in the hinter-land, the place becomes very attractive for industrial production. In this context, he concept for industrial development mentioned here aims at planning beforehand to allow the sufficient use of the potential of the New Ocean Terminal as an industrial infrastructure to meet the industrialization of Nigeria, with a view to preparing advantageous conditions for concrete industrialization in future. Therefore, the concept for industrial development described in this chapter lays emphasis on planning with sufficient space to meet industrial development, with a view to pursuing larger possibility in the long run, rathre than on its realization in the short-term. Based on this standpoint, this chapter clarifies the significance and role of the construction of the industrial base. For this purpose following items are studied;

1) Present situation of Nigerian industries
2) The industries to be located in the industrial base
3) Their scales
4) Planning elements (required land area, water, electric power, employees, generated cargo volume and sharing of the volume among transport mode)
5) The layout of the plants of respective industries.

V-1 Significance of industrial development

V-1-1 Present situation of manufacturing industries and industrial policies

(1) Present situation and problems of manufacturing industries

As for the position of manufacturing industries in Nigerian economy, they account for only 4.7% of GNP in 1975 as shown in Table V-1. In the world, advanced industrial countries show about 20 to 30% as a share of manufacturing industries, and in comparison with these countries, Nigeria is still at a low level. And yet, the growth of manufacturig industries of Nigeria in production is remarkable, marking about 8.5 times in the period from 1960 to 1975. Inspite of such remarkable growth, the share of manufacturing industries in GNP fell to about 5% in and after 1971, with 9.5% of 1970 as a peak, because of the rapid increase of income from petroleum. The production of crude oil increased from 54 million tons in 1970 double to 112.4 million tons in 1974, as shown in Fig. V-1, and of the tonnage, 96.2 million tons corresponding to 86% were exported, and the national income relating to petroleum amounts to 95% of the national revenue.

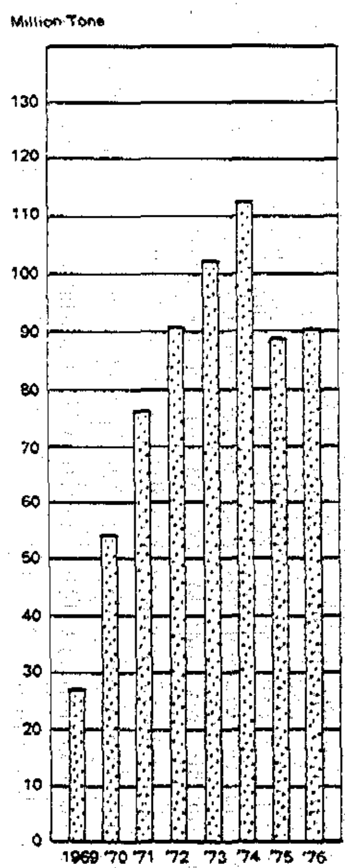
With regard to the general situation of Nigerian manufacturing industries with 10 or more employees, there were 1,036 establishments, 175,287 employees, N1,470,220,000 production and 46.3% rate of added value in 1974, as shown in Table V-2. By state, the share of Lagos State

Table V-1 Contribution of Manufacturing Industries to Gross National Product

Year	Total GNP (million ₦)	Value of Manufacturing and Craft (million ₦)	% of manufacturing and Craft in GNP (%)
1960	2,244.6	80.6	3.6
1961	2,373.4	88.2	3.7
1962	2,630.8	93.4	3.6
1963	2,806.4	151.8	5.8
1964	2,914.0	157.8	5.6
1965	3,080.6	164.8	5.6
1966	3,210.0	192.2	6.2
1967	3,051.8	196.0	6.1
1968	3,140.8	231.2	7.6
1969	3,278.2	270.4	8.6
1970	3,485.8	311.0	9.5
1971	9,442.1	475.1	5.0
1972	11,177.9	460.3	4.1
1973	11,993.1	570.1	4.8
1974	13,135.5	626.5	4.8
1975	14,410.7	683.9	4.7

Sources: (1) F.O.S. Annual Abstracts of Statistics, Lagos, Nigeria.
(2) Federal Ministry of Information, Second National Development Plan 1970-74, Lagos Nigeria, 1970.
(3) Central Planning Office, Third National Development Plan, 1975-80, F.M.E.D.R., Lagos Nigeria, 1975.

Fig. V-1 History of Crude Oil Production



is the largest in the number of establishments, employees and value of products, accounting for 31%, 49% and 66% respectively. The number of employees per establishment was 266, and the value of products was ₦2,979,000, respectively exceeding 169 and ₦1,425,000, averages of the nation. It can be said that most of the large factories are in Lagos State.

The industrial structure of Nigeria in 1974 in reference to employees, values of products, and rates of added value, by industrial type is as shown in Table V-3, and has the following features.

1) The first feature is the large share of light industries such as foods and textiles. The value of products covering meat products to textiles shown in Table V-3 accounts for 43.6% of the whole, and the number of employees accounts for 39.6%. These industries satisfy the most fundamental needs of human beings, food and clothing, and their large share shows that the country is in the initial stage of industrialization.

2) The second feature is the small share of machinery and metal industries. Table V-3 indicates that the value of products covering basic metal industry to motor vehicles accounts for only 20.0% of the whole. This share is not quite low as a level of a developing country but it mainly comprises metal furniture and fixtures, structural metal products, fabricated metal products, etc. Engineering industries, including agricultural machines and instruments, construction machines, household electrical apparatus, electrical instruments, household machinery such as motor vehicles,and other equipment requiring the high level of technology account for only several percent.

3) The third feature is the small share of industrial materials and intermediate products requiring sophisticated technologies. For example, the production of iron and steel is not yet made, and as for chemical industry, the value of products of basic industrial chemicals is only 0.3% of the whole. On the other hand, chemical products for consumers such as cosmetics, soap

Table V-2 General Conditions of Nigerian Industries in the year 1974

States	No. of Establishments	No. of Employees	Value of Products (million ₦)	Rate of Value Added (%)
Lagos	324	86,135	965,267	46.0
Western	176	13,027	53,640	53.6
Mid-Western	59	13,436	49,815	43.0
Rivers	15	2,213	15,371	57.5
East Central	151	7,379	70,847	66.5
South Eastern	56	9,240	14,293	76.8
North Eastern	18	1,703	8,584	18.1
Benue Plateau	60	3,974	56,434	34.8
Kano	86	12,626	105,468	38.5
North Central	50	20,920	113,806	42.3
Kwara	25	3,364	27,821	46.8
North Western	31	3,025	7,225	51.4
* Total	1,036	175,287	1,470,222	46.3

Source: Economic Indicator Vol. 12, F.O.S., Lagos
Note: * Summation of each state is not equal to the total because of statistical treatments

Table V-3. Industrial Structure in Nigeria and Lagos State in the year 1974

I.S.I.C. Code	Nigeria					Lagos State					Index of Specialized Structure (B%/A%)	
	Employees		Value of Products		Rate of Value Added (%)	Employees		Value of Products		Rate of Value Added (%)	by Employees	by Value of Products
	(person)	(%)	(1,000 N)	(%)		(person)	(%)	(1,000 N)	(%)			
Meat Products	1,670	1.0	12,921	0.9	48.4	1,097	1.3	10,997	1.1	49.7	1.34	1.30
Fruit Canning and Preserving	362	0.2	720	0.0	42.2	—	—	—	—		—	—
Dairy Products, Vegetable Oil, and Grain Mill Products	10,529	6.0	131,857	9.0	31.8	2,934	3.4	93,760	9.7	26.3	0.57	1.08
Bakery Products	4,924	2.8	47,484	3.2	65.3	2,372	2.8	18,173	1.9	44.8	0.98	0.58
Sugar, Sugar Confectioney, Miscellaneous Food Products and Animal Feeds	4,683	2.7	64,361	4.4	37.9	2,285	2.7	47,643	4.9	42.6	0.99	1.13
Spirit Distillery and Beer	3,533	2.0	109,967	7.5	72.7	3,215	3.7	105,728	11.0	72.5	1.85	1.46
Soft Drinks and Tobacco	4,820	2.7	66,311	4.5	75.2	3,691	4.3	53,673	5.6	75.3	1.56	1.23
Textiles	38,924	22.2	206,668	14.1	43.4	14,368	16.7	91,451	9.5	44.0	0.75	0.67
Made-up Textile Goods	4,425	2.5	28,017	1.9	33.3	2,629	3.1	23,252	2.4	30.5	1.21	1.26
Knitted Goods, Cordages, Rope and Twine	4,790	2.7	35,967	2.4	39.8	2,949	3.4	28,257	2.9	40.4	1.25	1.20
Wearing Apparel	911	0.5	2,895	0.2	28.6	459	0.5	2,062	0.2	24.6	1.03	1.08
Canning	1,194	0.7	12,342	0.8	42.5	—	—	—	—		—	—
Travel Goods	744	0.4	3,557	0.2	27.6	485	0.6	2,954	0.3	26.7	1.33	1.26
Leather Footwear	4,191	2.4	23,465	1.6	53.5	3,620	4.2	21,765	2.3	55.8	1.76	1.41
Saw Milling	9,613	5.5	24,435	1.7	49.4	191	0.2	137	0.0	64.2	0.04	0.01
Other Wood and Cork Products	50	0.0	149	0.0	96.0	—	—	—	—		—	—
Wooden Furniture and Fixture	5,406	3.1	15,122	1.0	44.3	1,988	2.3	5,544	0.6	37.2	0.75	0.56
Containers, Boxes of Paper and Paper Board	1,852	1.1	25,734	1.8	37.5	1,842	2.1	25,449	2.6	37.4	2.02	1.51
Paper and other Paper Products	1,373	0.8	18,961	1.3	31.0	1,316	1.5	17,548	1.8	31.7	1.95	1.41
Printing	9,147	5.2	42,709	2.9	50.5	4,708	5.5	28,087	2.9	54.1	1.05	1.00
Basic Industrial Chemicals and Paints	1,339	0.8	18,381	1.3	50.5	1,351	1.6	18,197	1.9	51.3	2.05	1.51
Drugs and Medicines	1,888	1.1	13,788	0.9	43.3	1,335	1.5	11,723	1.2	45.0	1.44	1.30
Soap, Perfumes, Cosmetics and other Cleaning Preparations	6,756	3.9	98,268	6.7	46.0	5,191	6.0	70,278	7.3	48.4	1.56	1.09
Other Chemical Products, Product of Petroleum and Coal, Tyres Tubes and other Rubber Products	13,412	7.7	71,580	4.9	55.5	2,843	3.3	38,501	4.0	57.8	0.43	0.82
Plastic Products	3,523	2.0	22,142	1.5	25.3	2,714	3.2	18,230	1.9	25.8	1.57	1.25
Potery and Glass Products	747	0.4	4,811	0.3	40.4	484	0.6	3,573	0.4	44.9	1.32	1.13
Bricks, Tiles and Concrete Products	5,503	3.1	27,899	1.9	55.6	2,223	2.6	13,294	1.4	55.3	0.82	0.73
Cement	2,796	1.6	40,174	2.7	70.5	—	—	—	—		—	—
Basic Metal Industry, Cultery, Handtools and General Hardware	2,463	1.4	56,673	3.9	32.7	1,350	1.6	10,683	1.1	38.1	1.12	0.29
Metal Furniture and Fixtures	3,589	2.0	30,223	2.1	41.6	2,034	2.4	17,272	1.8	47.5	1.15	0.87
Structual Metal Products	5,854	3.3	60,517	4.1	48.1	4,761	5.5	53,055	5.5	34.9	1.66	1.34
Fabricated Metal Products	6,284	3.6	63,703	4.3	30.9	4,914	5.7	53,011	5.5	29.2	1.59	1.27
Electrical Industrial Machinery and Apparatus	697	0.4	8,168	0.6	43.5	660	0.8	8,141	0.8	43.7	1.93	1.52
Household Electrical Apparatus and other Electricals Supplied	1,692	1.0	11,660	0.8	27.0	1,644	1.9	11,627	1.2	27.1	1.98	1.52
Radio, Television, Communication Equipment and Apparatus	1,080	0.6	13,916	0.9	49.0	1,080	1.3	13,916	1.4	49.0	2.04	1.52
Ship Building and Repairing, and Motor Vehicles	2,518	1.4	48,069	3.3	42.6	1,631	1.9	41,450	4.3	38.5	1.32	1.31
Miscellaneous Products	2,005	1.1	6,608	0.4	54.3	1,771	2.1	5,838	0.6	54.2	1.80	1.35
Total	175,287	100.0	1,470,222	100.0	47.1	86,135	100.0	965,267	100.0	46.0	1.00	1.00

Source: Economic Indicator Vol. 12, F.O.S., Lagos and cleaning preparations amount to 6.7%. It can be said that there is a structural unbalance between the production of materials or intermediate products and the production of consumer goods.

Such structural features of Nigerian manufacturing industries apply also to Lagos State which accounts for 66% in the national value of products. In reference to the indices of specialized structure to the nation* by industrial type shown in Table V-3, the features of Lagos State are as follows.

1) Those industries of which the component ratios of Lagos State exceed those of the nation are meat products, spirit distillery and beer, leather footwear, paper products such as corrugated cardboard, paints, drugs and medicines, pottery and glass products, structural metal products, fabricated metal products, machinery, etc.
2) On the contrary, main industries of which the component ratios of Lagos State are lower than those of the nation are fruit canning, bakery products, textiles, canning, saw milling and wood products, cement, bricks, etc.
3) As seen above, it can be said that much industries generally called "urban industries" gather in Lagos State, than "industries based on local resources". However, as obvious from the indices of specialized structure shown in Table V-3, Lagos State is not much different from the nation in the light of industrial structure.

The share of Nigerian manufacturing industries in GNP is small, and the industrial structure is mainly based on light industries. The manufacturing industries requiring the high level of technology are still at an infant stage in Nigeria. In relation to these features, the following problems can be indicated.

* This index shows the specialized industries in a region to the national average. And it is usually calculated on the value of product or the number of employees.
The following is its formula.

$$\text{Index of specialized structure } (i, j) = \left(\frac{\text{i industry in j region}}{\text{total industries in j region}} \Big/ \frac{\text{i industry in Nigeria}}{\text{total industries in Nigeria}} \right)$$

1) In a state in which the share of manufacturing industries is small in G.N.P. and the major portion is occupied with petroleum, it can be said that there is no problem on the national economy as far as petroleum resources exist. However, the proven reserve of crude oil in Nigeria is about 12,242 million barrels in 1976 according to the report in World Oil, and if the present production of about 700 million barrels is continued in future, the reserve will be exhausted in less than 18 years. And this will pose a very large problem on the foundation of the nation as to what industries should support Nigerian economy.
2) The development of manufacturing industries can solve such a problem, but in the present situation, much cannot be expected from such a scheme. As shown in Table V-4, most industrial raw materials are substantially imported. That is to say, Nigeria is mainly engaged in the processing of consumer goods. In this context, the present situation does not allow much runabouts of industrial production nor the strong linkage between industries. And the increase of industrial production must be essentially limited.

Table V-4 Average Coefficients of Imports for Industrial Products and Raw Materials in the year 1971 and 1972

		Imported Raw Materials/Total Raw Materials				
		~ 20%	20 ~ 40%	40 ~ 60%	60 ~ 80%	80 ~ 100%
Imported Products/ Output	~ 10%	Fruit Canning and Preserving Vegetable Oil Milling Bakery Products Sugar Factory Tobacco Leather Footwear Sawmilling Paper and Other Paper Products Soaps, Perfumes, Cosmetics and other Cleaning Preparations Plastic Products Cement Spirit Distillery	Meat Products Basic Metal Cutlery, Hand Tools and General Hardware Metal Furniture and Fixtures	Household Electrical Apparatus	Glass Products	Basic Industrial Chemicals
	10 ~ 20%	Sugar and Chocolate Confectionery Other Rubber Products	Tanning Wooden Furniture and Fixtures Printing Paints Bricks and Tiles Ship Building	Dairy Products Beer Brewing Soft Drinks Tyres and Tubes Other Concrete Products	Miscellaneous Food Preparation	Agricultural Machinery
	20 ~ 30%			Drugs and Medicines Radio and T.V Communication Equipment	Other Chemical Products	
	30 ~ 40%		Spinning Weaving and Finishing Textiles	Wearing Apparel Paper Containers, Paper Boxes and Paper Board Fertilisers and Pesticides Other Electrical Supplies	Structural Metal Products Miscellaneous Products	Manufacture of Carpets and Rugs Pottery Products
	40 ~ 50%	Motor Body Building	Animal Feeds	Travel Goods Products of Petroleum and Coal	Make up Textile Goods (except Wearing Apparel)	Fabricatd Metal Products
	60 ~ 70%					Grain Mill Products Knitted Goods
	80% ~				Other Machinery and Equipments	

Source: Third National Development Plan 1975~80 Vol. 1

It can be considered to produce wide range of import substitution goods to increase industrial production, however, they will also face the difficulty mentioned above.

(2) Direction of industrial policies

As mentioned in the previous paragraph, a present problem of Nigerian manufacturing industries is that the strength of the link between various industries is too fragile to support the Nigerian economy in future instead of petroleum.

In order to build up future national economy, the Third National Development Plan (1975 to 1980) sets the promotion of agriculture and manufacturing industries as the principle of industrial policies, by making effort to break from the monocultural structure based on petroleum.

The industrialization policies of Nigeria pursued so far have emphasized to foster import substitution industries. Accordingly, industrialization has been promoted mainly in the light industries, and as a result, textile industry becomes the largest industry in Nigeria.

Regarded that the light industries have grown to supersede the imports as much as intended, the Third National Development Plan suggests to produce indigenously the goods conventionally imported, such as machines and metal products which require relatively the high level of technology, and it also plans to introduce positively basic industries. Following are their major projects in the Third National Development Plan.

1) Iron and steel

Blast furnace type of iron works of 1,500,000 tons per year and direct reduction type of iron works of 1,000,000 tons per year (500,000 tons x 2), total 2,500,000 tons per year are planned. The blast furnace iron works is scheduled to be constructed in Ajaokuta, Kwara State with the assistance of USSR, and equipments have been partially ordered. The grade of iron ore in Nigeria is as low as about 50%, being almost same as that of USSR. The Soviet Union has made up for the low-grade iron ore with their advanced techniques of sintering, etc., and in this project it is intended to utilize the resource of Nigeria with the technology of USSR. And Nigerian coal is said not to be suitable for carbonization (coke) for iron manufacture.

Direct reduction type of iron works is planned in Warri, Bendel State and Port Harcourt, Rivers State. The Warri plant is under construction, but the plant construction in Port Harcourt is postponed indefinitely, being suspended substantially. The direct reduction type of iron works has the advantages that a plant smaller than blast furnace type in scale can be established, the construction period can be short, the equipment investment can be small, and that natural gas of Nigeria can be used instead of coke as the reducer.

2) Petroleum refining

As for petroleum refining for domestic demand, the existing petroleum refinery of 60,000 B.P.S.D. in Port Harcourt is scheduled to be extended to 75,000 B.P.S.D., and new refineries of 100,000 B.P.S.D. and 70,000 B.P.S.D. are planned to be constructed in Warri and Kaduna. The total capacity will be 245,000 B.P.S.D. Warri petroleum refinery started operation already, and Kaduna refinery is scheduled to be completed in 1981, the extension of Port Harcourt refinery being not yet started. For export, two petroleum refineries of 300,000 B.P.S.D. each are planned, but not yet embodied.

3) Petrochemicals

A plant for producing 40,000 tons/year each of caustic soda, vinyl chloride monomer, vinyl chloride and polyethylene based on 100,000 tons/year of ethylene is planned to be constructed in or around Port Harcourt. It was planned to start operation already in 1978, but is still being studied.

4) Chemical fertilizer

Production of 450,000 tons/year of ammonia and 260,000 tons/year of urea is planned to promote agriculture, to utilize natural gas and to meet prospective demand for export. It was planned to use also tail gas, starting operation in 1977 at the place adjacent to the above petrochemicals plant. But it is not yet realized.

5) Commercial vehicle assembly

For the target production scale of 18,000 units per year of 2-ton or larger trucks, Leyland's factory started operation in Ibadan, Oyo State, and in addition, Steyer, Fiat and Benz are licensed to construct their factories.

6) Others

For cement, extensions of production capacity are planned from 150,000 tons/year to 500,000 tons/year for Ukpilla, from 150,000 tons/year to 400,000 tons/year for Sokoto, and from 100,000 tons/year to 400,000 tons/year for Calabar. In addition, new factories of 600,000 tons/year each are planned to be constructed in Ashaka, Yandey and Shagamu. The extension of Calabar factory and the new construction of Shagamu and another factory are under way.

For pulp and paper making, the existing Jabba factory is being extended to produce 60,000 tons/year, and new factories with a final scale of 100,000 tons/year each are being constructed in Iwopin and Calabar.

Thus, in the Third National Development Plan, the transformation toward heavy and chemical industries is positively promoted to consolidate the foundation as well as to innovate the structure of Nigerian manufacturing industries, and this doubtlessly further accelerates the indigenous production of industrial raw materials and products.

V-1-2 Significance of the industrial development

The Phase-I Report proposed the construction of an industrial base at the New Ocean Terminal with such heavy industries as iron and steel and petrochemicals, which are expected in the Third National Development Plan to contribute to the consolidation of the industrial foundation of Nigeria, and to the structural innovation of Nigerian manufacturing industries. This proposal meets and promotes the industrial policies of Nigeria. Nevertheless a part of the Nigerian Government and the Lagos State Government has an opinion that it would not match with the industrial location policies of Nigeria.

The industrial location policies to aim at the balanced development of the country are based on dispersal of industries and proper regional arrangement. The opinions are heard that the construction of the New Ocean Terminal in Lagos State will cause the further concentration of population and industries toward the Lagos metropolitan area, and this is a problem in the light of not only industrial location policies but also urban development.

With regard to the positioning of the development of the industrial base at the New Ocean Terminal, the Japanese study team already gave opinions in the Phase-I Report. Main points are as follows.

1) First, the industrial base at the New Ocean Terminal contributes to the sound development of Lagos metropolitan area. The gravitation of population and industries toward the Lagos metropolitan area is considerable, but the problems of traffic congestion and aggravation of urban environment can be attributed mainly to the lack of urban facilities due to the drastic progress of gravitation.

With regard to traffic congestion, as indicated in the survey made by the Japanese study team in December, 1978, a considerable quantity of cars are used for business communication, and it will be solved to some extent if telephone situation is improved.

The sound development of Lagos metropolitan area means that it will play the role of promoting the development of Nigeria as a whole by proper arrangement of population and industries and compound accumulation of urban functions in the light of national economy. This is particularly important in a developing country.

The proper arrangement of population and industries is to systematically control the increase of population and industries of Lagos metropolitan area within the range of regional environmental capacity, without undermining the potential activity of Lagos city. It is said that the population of Lagos State in the year 2000 is estimated by the Lagos State to be 12.6 million with increase of 8,880,000 from the present 3,720,000. The number of employees at that time is estimated to be 4,540,000, increasing from the present 1.2 million. Thus, unless a large employment opportunity is created, grave influence may be exerted on the metropolitan public peace and order.

The industrial base at the New Ocean Terminal is a nucleus of the construction of a New City, and provides employment opportunities to meet the population increase of Lagos metropolitan area, contributing to economic activity by the stable supply of industrial raw materials, commodities, etc., thereby promoting the balanced and sound development of Lagos metropolitan area. For this reason, the desirable location is as near to the metropolis as possible, considering the characteristics of the project, and in this sense, the place selected by our study team can be said to be the most suitable.

2) Second, the industrial development at the New Ocean Terminal is based on the concept for industrialization in the Third National Development Plan. The common recognition of the Japanese study team and the Third National Development Plan is that the introduction and development of manufacturing industries relating to basic resources such as materials and intermediate products are indispensable for the consolidation of foundation and structural innovation of Nigerian manufacturing industries, and that these industries should be internationally competitive with export in mind in order to support Nigerian economy in future.

The locations of the manufacturing industries relating to basic resources can be classified into two types. They are locations based on resources and market. Locations based on resources refer to the situation in which factories are located near the places where raw materials or resources are deposited. In Nigera, iron and steel plant in Ajaokuta, petroleum refineries in Warri and Port Harcourt, and pulp and paper making factories belong to this type. Locations based on market refer to the situation in which factories are located near the markets of the products. The optimum location refers, in the light of economic theory, to a place where the total transportation cost of raw materials and the products becomes minimum. Of the manufacturing industries relating to basic resources, the raw materials of iron and steel are bulky, and therefore cost can be easily reduced by means of mass transportation, whereas products are not bulky, the reduction of transportation cost is relatively small.

As for petroleum refining and petrochemicals, both the raw materials and products are bulky, but since the handling lots of the products such as gasoline and resins are small, the reduction of the transportation cost is smaller than that of raw materials. Thus, because of the larger possibility of cost reduction with raw material transportation, it is better to locate factories nearer to markets than to raw material deposits. The optimum solution is to locate factories near both raw material deposits and markets.

The industrial base at the New Ocean Terminal can be said to be an optimum solution in the light of economic theory. With regard to the proximity to markets at first, it is planned ideally in the Lagos metropolitan area. The second point of proximity to raw materia deposits is achieved by the formation of industrial complex. Naphtha can be transported by piping to adjacent petrochemicals plant and chemical fertilizer plant, and fuel oil can be supplied to petrochemicals plant and iron and steel plant, to allow drastic reduction of transportation cost. The iron and steel plant and petroleum refining plant in the New Ocean Terminal cannot be said to be really close to raw material deposits for them. However, the mass transportation of those materials through the port with large ships will provide almost the same effect as obtained by the locations near to the resources.

The construction of the industrial base,with such excellent economic rationality will be sure to reinforce the international competitive power of manufacturing industries and to contribute to the development of Nigerian economy. A large amount of expenses, however, will be required as the initial investment for the construction of the port and industrial base. Therefore, it will be better to develop it together with commercial port functions in view of the economy of investment.

The above are our opinions for the industrial development at the New Ocean Terminal. Our conception is never in opposition to the industrialization policies, industrial location policies and regional policies of Nigeria, but is the result of a study based on the thought underlying those policies. And yet, the construction of the industrial base is still in the stage of idea proposed by our study team, and may lack reality compared with the commercial port construction which is urgently required for the time being. In future, a further discussion will have to be made on the appropriate stage of the development.

V-2 Type and scale of industries

The Phase-I Report proposed the following industries to be located at the New Ocean Terminal, based on the concept as mentioned in the previous section.

Iron and steel:	3,000,000 tons/year as crude steel
Petroleum refining:	300,000 barrels/day
Petrochemicals:	400,000 tons/year as ethylene basis
Chemical fertilizer:	500,000 tons/year

Shipbuilding and repair: 200,000 gross tons/year
Automobile assembly: 100,000 units/shift/year
Flour mill and related foods: 500,000 tons/year
Power generation: 1,000,000 KW
Other related industries

In addition to these industries, edible oil (vegetable oil) plant is newly proposed by the following consideration.

1) The demand of edible oil is expected to increase corresponding to the population increase and the modernization of eating habits resulted from a higher income level in future.

2) Edible oil, made from imported raw materials (for example, soybean), is a product of seaboard industry requiring water front.

The above production scales, of iron and steel plant, petroleum refining plant, automobile assembly plant and power station were of estimates as the initial stage. In this study, however, scales at the final stage will be estimated to prepare the Master Plan.

(1) Iron and steel

The consumption of iron and steel in Nigeria (crude steel base) was 1,380,000 tons in 1976, but it is small compared with the level of economic activity. This is due to the characteristics of economic and industrial structures and the immaturity in the iron and steel industry. The demand for iron and steel is higher in the countries where iron and steel production has been made since longer time ago. In Nigeria, the demand for iron and steel is surmised to be matured, once the iron and steel plants being constructed in Ajaokuta and Warri start operations.

According to the estimates by the Central Planning Office of Nigeria, the potential demand for iron and steel in Nigeria was about 50kg per capita, 3,200,000 tons/year in 1972 to 73, considering the level of economic activity. On the other hand, the total production capacity of iron and steel plants being constructed or planned based on the Third National Development Plan is 2,500,000 tons/year as mentioned in V-1, and when all the potential demand is actualized, they are in a position to supply about 80% domestically for the time being.

With the progress of industrialization of Nigeria, and with the start of iron and steel production, the demand for iron and steel is surmised to increase rapidly in future. The iron works of the New Ocean Terminal is a new project after Ajaokuta and Warri, to cope with the future increase of demand, The Phase-I Report set the production scale at the initial stage at 3 million tons/year. This scale reflects the prospect of the Nigerian Government, and is based on the assumption that production of approximately 3 million tons will be required in addition to 2.5 million tons/year by Ajaokuta, etc. in 1984 to 85. In this study, the production scale of the final stage is set at 6 million tons/year, based on the following considerations.

1) The domestic demand in the year 2000 will be about 7 million tons even if the consumption of crude steel per capita is estimated to be as small as about 50 kg. It will require 1.5 million tons in addition to 5.5 million tons covered by the Third National Development Plan (2.5 million tons) and the initial stage of the New Ocean Terminal (3 million tons). For reference, the average consumption (production) of crude steel per capita in developing countries investigated in 1976 by the United Nations Industrial Development Organization is estimated to be 115 kg in the year 2000 as shown in Table V-5.

Table V-5 Projection for Products of Crude Steel by UNIDO

Unit: million ton

	1975	1976	1985	2000
Scale of Production	646.3	683.5	1,050	1,750
Prospects of Developing Nations				
Scale of Production	62.5	66.5	151	530
Share in the World (%)	9.7	9.7	14	30
Products per Capita (kg per capita)	22.5	23.5	45	115
Rate of Domestic Products on National Consumption (%)	57.8	* 58.8	72	100

Note: * Appearence consumption is supposed.
Source: UNIDO "Basic Projection 1985–2000"

2) The ironworks at the New Ocean Terminal will make iron by blast furnace as in the case of Ajaokuta. In the light of scale merit, the optimum production capacity per a unit of blast furnace is about 3 million to 4 million tons. Therefore, for the initial stage one unit of blast furnace is sufficient, but since only one unit of blast furnace is not sufficient in the light of stability of operation, two or more units of blast furnace are usually used in one plant.

3) Considering the scale merit and operation stability, a plant with 6 million ton capacity covered by two units of 3 million ton blast furnace is planned for the iron and steel plant at the New Ocean Terminal. As a result, the iron and steel production of Nigeria in the year 2000 will be 8.5 million tons including the production of Ajaokuta, etc., exceeding the demand by about 1.5 million tons, which is planned to be exported.

4) The iron and steel production for export is surmised to be made mainly at the New Ocean Terminal to enjoy the scale merit and advantage of port and transport conditions, for international competitive power. It is estimated that the export from the New Ocean Terminal will amount to about 30% of production at the final stage.

(2) petroleum refining, petrochemicals, and chemical fertilizer (industrial complex)

The Phase-I Report estimated the production scale of 300,000 B.P.S.D. for petroleum refining, 400,000 tons/year in terms of ethylene for petrochemicals and 500,000 tons/year for chemical fertilizer. The New Ocean Terminal is planned to employ a pattern of the industrial complex where the raw material, naphtha is supplied to the petrochemical plant and the chemical fertilizer plant from the petroleum refining plant. The production scale of petroleum refining in the Phase-I Report is for the initial stage, and 300,000 B.P.S.D. is proper as a unit of refinery in the light of scale merit. The production scale in the final stage is however set as 400,000 barrels, based on the following consideration.

1) Petroleum refining is the nucleus of industrial complex, and the output of naphtha from 300,000 B.P.S.D. is 1,555,000 tons at a general yield of 11%.

2) On the other hand, naphtha required for the petrochemicals (400,000 tons/year) amounts to 1,550,000 tons, being well balanced with 300,000 B.P.S.D. However, about 200,000 tons of naphtha required for the chemical fertilizer (500,000 tons/year) cannot be supplied by 300,000 B.P.S.D.

3) To cover naphtha supply including that for chemical fertilizers by 300,000 barrel plant, the yield of naphtha can be increased to more than 11%. But, since the outputs of gasoline, kerosene, etc. which have high values added are decreased by that, this method is not economical.

4) For these reasons, as the final scale of petroleum refining, one topper is added in the light of economy of the industrial complex formation to increase the production scale to 400,000 B.P.S.D.

For export, 40% and 50% of the outputs of petroleum refining and petrochemicals respectively are planned. In the Third National Development Plan, the industries of which 40% or more of the outputs are for export are planned to be positively promoted as major export industries, and it is considered that the necessity of export is more important in future. Since the petroleum refining plant of the New Ocean Terminal supplied naphtha to the petrochemicals plant and the chemical fertilizer plant, and since it can be expected to function as an export centre of petroleum products using the favorable port conditions with deep water berths, 40% of the output can be expected to be exported. The petrochemicals plant, too, has excellent international competitiveness, in the light of the scale merit, cost reduction by the formation of industrial complex and advantageious port conditions of the New Ocean Terminal. As a result, 50% of production can be expected to be exported.

(3) Shipbuilding and repair

The scale of shipbuilding and repair is set at 200,000 gross tons. This plant is intended to cover the repairs of large ships visiting the New Ocean Terminal, for the time being. If a dock of 200,000 gross tons is prepared, not only large vessels but also medium and small ones can be repaired and built on flexible operations.

(4) Automobile assembly

The Phase-I Report assumed a production scale of 100,000 units/shift/year, as an assembly of automobiles by knockdown for the time being. In Nigeria, there is already one factory manufacturing trucks in Ibadan, and the plans of additional three factories are licensed. As for passenger cars, two factories of Volkswagen and Peugeot are operated in Lagos and Kaduna. The demand for passenger cars in Nigeria grows rapidly, and recently reaches about 100,000 units per year. In future, due to the improvement of income standard, and the progress of road improvement and the expansion of inter-regional economic activity, the demand is surmised to increase at a rapid pace. Automobile industry is expected to be one of the major industries in future Nigeria, and large factories are supposed to be developed, pursuing the merit of mass production. For this reason, the Phase-I Report estimated a production scale of 100,000 units/shift/year. For the time being, assembly will be done totally with knockdown, and in future, engines, parts, etc. will be produced indigenously (as for trucks, castings for engines are being produced indigenously). Improvement in international competitiveness will allow export, and a production scale of 200,000 units by 2 shifts per year is aimed at the final stage.

(5) Flour mill and food processing

As for the production scale of flour mill, the Phase-I Report estimated imports of 1,042,000 tons based on the domestic supply and demand forecast for wheat in the year 2000, and supposes to cover the flour milliong of 500,000 tons at the New Ocean Terminal. As regards food processing, a factory to produce bread, biscuit and confectionery using flour as the raw material is planned to be constructed behind the flour mill.

(6) Edible oil

Edible oil production is newly proposed in this study, and the final scale is supposed to be 250,000 tons/year in terms of processing of raw materials. Edible oil production belongs to capital intensive industries, and is concerned with scale merit. In Japan, a daily processing volume of raw materials to establish one unit factory is 1,000 tons or more, and a similar scale is employed also for the New Ocean Terminal.

The reason for proposing edible oil production as the new industry is that the conventional supply sources such as palm oil will be insufficient for the demand for fat intake due to the increase of population and the improvement of eating habit, and that the imports of fat sources are surmised to increase. The sorts of oil we think are corn oil, soybean oil, etc. Of these, soybean oil is not well known in Nigeria. But it can be said that there is a large potential demand for it in future, considering the geographical advantage of Nigeria not so far from Brazil, one of the largest soybean supplying countries in the world. Other encouraging factors are: that the present refining technique enables to obtain superior edible oil without limiting to specific raw materials, that the oil cake as a by-product can be used as livestock feed or fertilizer, and so on.

(7) Electric power generation

The Phase-I Report supposed a scale of one million KW as thermal electric power generation for industrial use. This case is set on the electric power demand of the industries at the New Ocean Terminal and partially on the demand of Lagos metropolitan area.

The demand for electric power for all the plants at the New Ocean Terminal will reach approximately 800,000 KW.

Among the industries, the three major industries which require large amount of power; iron and steel (450,000 KW), petroleum refining (62,000 KW) and petrochemicals (175,000 KW), usually have an independent power plant for economy and stable power supply. In this case, 300,000 KW of iron and steel, 32,000 KW of petroleum refining and 75,000 KW of petrochemicals, total 407,000 KW are planned to be supplied by the independent power plant, in addition to the power supplied by the electric power station.

Therefore, 393,000 KW (subtracting the above figure from 800,000 KW) is supplied to the industries by the electric power station. As a result, 607,000 KW can be supplied to the commercial port, New City and the Lagos Metropolitan area by the station. For this reason, the station of one million KW is planned to be the final scale.

As for the other related industries, which cover various manufacturing industries, construction industry, transportation industry and service industry, their production scales are not planned here because of the small scale of each industry, and of the difficulty in estimates.

V-3. Allocation of land, employees and industrial water

Industries to be located in the industrial area at the New Ocean Terminal and their scales are as discussed in the previous section. Here are planned planning elements such as land, employees, industrial water, etc. corresponding to the final production scales, based on the following consideration.

(1) Land

As for the industrial area, Nigeria has little experience of locating industries as considered at the New Ocean Terminal, and only limited data are available. Therefore, planning examples and model factories in Japan as well as standards applicable internationally were introduced in planning.

A factory usually requires various spaces such as land for roads, parking space, office and other management facilities and open space to improve working conditions, in addition to the land for production facilities. Furthermore some factories, depending on production conditions, may require land for storing raw materials or products, port, railway and measures against pollution. Therefore, to plan an industrial area, all the land for respective facilities must be counted for each industry.

(2) Employees

The number of employees of the industries is estimated based on the experience in Japan. However, since it was found that at least two or three times as many as Japanese workers are generally required per production unit in Nigeria, the employees are assumed in view of such a Nigerian condition. In this case, since most of the industries located at the New Ocean Terminal are so-called capital intensive industries, the local difference in number of required workers is not so large, compared with labor intensive industries. In addition, the labor productivity is expected to rise in future. Considering these, the 1.2 ~ 1.5 times larger number of employees compared to the planning examples or model factories in Japan are taken for the industries to be located at the New Ocean Terminal.

(3) Water

As for the water requirement, it is very little affected by regional conditions, compared with employees, and the values of Japanese cases are applied to the industries located at the New Ocean Terminal. Differences in termperature between Japan and Nigeria are surmised to affect particularly the amount of cooling water, but considering this influence eliminated technically, no additional quantity is taken into account.

Based on the above considerations, the scales of major elements for the industries located at the New Ocean Terminal are as shown in Table V-6.

1) Iron and steel

The land area required for an integrated iron and steel works with an output of 6 million ton crude steel per year is 7 million m^2 in total.

The number of employees is 10,000 which includes 5,000 for related industries of the integrated iron and steel works. Industrial water requirement is 2,300,000 m^3/day of fresh water with 2,070,000 m^3/day recycled and the remaining 230,000 m^3/day newly supplied, and 2,150,000 m^3/day of sea water.

2) Petroleum refining

Table V-6 Development Scale of Industries in the New Ocean Terminal

Type of Industries	Production Scale	Plant Area (1,000 m^2)	Employment (person)	Fresh Water (1,000 m^3/d)			Sea Water (1,000 m^3/d)
				Total	Recycled	Supplied	
Iron and Steel	Crude Steel 6 million tons/year	7,000	*10,000	2,300.0	2,070.0	230.0	2,150.0
Petroleum Refining	400,000 barrels/day	3,000	1,200	190.0	152.0	38.0	650.0
Petrochemicals	400,000 tons/year (ethylene basis)	2,100	2,350	750.0	690.0	60.0	1,000.0
Chemical Fertilizer	500,000 tons/year	150	200	110.0	100.0	10.0	400.0
Automobile Assembly	200,000 vehicles/year (Two shifts)	1,200	5,000	5.0		5.0	
Shipbuilding and repair	200,000 G.T. dock	450	1,000	1.2		1.2	1.5
Flour Mill and Food Processing	500,000 tons/year	150 **(80)	1,800 **(200)	3.0 **(0.2)		3.0 **(0.2)	
Edible Oil	250,000 tons/year	50	200	12.0	4.8	7.2	
Power Station	One million KW	400	250	3.0		3.0	3,630.0
Sub Total		14,500	22,000	3,374.2	3,016.8	357.4	7,831.5
Other Related Industries		3,800	8,000	40.0		40.0	
Public Space including roads and railways, etc.		5,500					
Total		23,800	30,000	3,414.2	3,016.8	397.4	7,831.5

Notes: * including the employees of related industries ** shows flour mill, which are included in the uppers.

The land area required for refining 400,000 barrels of petroleum is 3 million m^2 in total.

The number of employees is 1,200. Industrial water requirement is 190,000 m^3/day of fresh water with 152,000 m^3/day recycled and the remaining 38,000 m^3/day newly supplied, and 650,000 m^3/day of sea water.

3) Petrochemicals

The land area required for an output 400,000 ton petrochemicals per year (ethylene equivalent) is 2,100,000 m^2 in total.

The number of employees is 2,350. Industrial water requirement is 750,000 m^3/day of fresh water with 690,000 m^3/day recycled and the remaining 60,000 m^3/day newly supplied, and one million m^3/day of sea water.

4) Chemical fertilizer

The land area required for a plant with an output of 500,000 ton chemical fertilizers per year is 150,000 m^2 in total.

The number of employees is 200. Industrial water requirement is 110,000 m^3/day of fresh water with 100,000 m^3/day recycled and the remaining 10,000 m^3/day newly supplied, and 400,000 m^3/day of sea water.

5) Automobile assembly

The land area required for a factory with an assembling capacity of 200,000 units per year in 2 shifts is 1,200,000 m^2 in total.

The number of employees is 5,000. Industrial water requirement is 5,000 m^3/day, all to be newly supplied.

6) Shipbuilding and repair

The land area required for a dock with 200,000 GT capacity for shipbuilding and repair is 450,000 m^2 in total.

The number of employees is 1,000. Industrial water requirement is 1,200 m^3/day of fresh water, all to be newly supplied, and 1,500 m^3/day of sea water.

7) Flour mill and food processing

The land area required for a factory with a milling capacity of 500,000 tons per year (based on wheat processing) is 80,000 m^2.

The number of employees is 200. Industrial water requirement is 200 m^3/day of fresh water, all to be newly supplied. Behind the flour mill, flour processing plant is planned to be constructed. The land area for the plant for bread, biscuit and confectionery is 70,000 m^2. The number of employees is 1,600. Industrual water requirement is 2,800 m^3/day of fresh water. The total land area required is 150,000 m^2, and the number of employees is 1,800, industrial water requirement is 3,000 m^3/day.

8) Edible oil

The land area required for a factory with an output of 250,000 ton edible oil (based on soybean processing) is 50,000 m^2 in total.

The number of employees is 200. Industrial water requirement is 12,000 m^3/day with 4,800 m^3/day recycled and the remaining 7,200 m^3/day newly supplied.

9) Electric power station

The land area required for a power station with a maximum output of one million KW is 400,000 m^2 in total.

The number of employees is 250. Industrial water requirement is 3,000 m^3/day of fresh water, all to be newly supplied, and 3,630,000 m^3/day of sea water.

10) Other related industries

Other related industries include not only manufacturing industries but the industries which are closely relating to the commercial port and are expected to develop in the hinterland of the port. To be concrete, in addition to manufacturing industries, they include wholesale trade, service industry, construction industry, transportation industry, retail trade, etc.

Take a case in Japan for instance, in Mizushima industrial area where almost same types of industries as at the New Ocean Terminal are located, the plant land area for major industries such as iron and steel, petroleum products, chemical industry, transportation machinery and food processing is approximately 23 million m^2, while the area for other manufacturing industries is 2.4 million m^2. The latter is about 10% of the former.

As a case of related industries behind a commercial port, Chiba Central Port provides a land area of about one million m^2 for related industries such as construction industry, excluding petroleum distribution base, warehousing, truck terminal, etc.

Therefore, assuming that a land area corresponding to 10% of the land for major industries (1,450,000 m^2) is used for related manufacturing industries in reference to the case of Mizushima and assuming that one million m^2 is used for another related industries in reference to the case of Chiba Central Port, the total area of related industries is estimated to be 2,450,000 m^2. However, it must be noted that Mizushima is functionally specialized as an industrial base and that Chiba Central Port, as a commercial port. On the other hand, the New Ocean Terminal is a large port complex with the functions of both commercial port and industrial port, and has the Lagos metropolitan area in the hinterland. In this situation, the demand for land can be estimated to be larger than the cases of Mizushima and Chiba Central Port. For this reason, a large area of more than about 1.5 times of 2,450,000 m^2, viz. 3,800,000 m^2 is supposed.

Since some of industries included in the port related industries require a considerable space for storing materials and equipments, the number of employees per land unit must be small. Therefore, assuming approx. 20 employees/ha., the number of employees is estimated to be 8,000.

The water requirement of related industries is classified into two categories. One is the water requirement for the manufacturing industries, and another is for non-manufacturing industries. The former is estimated on the basis of the standard water requirement per plant land area, and the latter, per employee. 100 m^3/ha/day and 1 m^3/employee/day are applied as the respective standard water requirements mentioned above in reference to various cases of Japanese industrial complex.

As a result, the total water requirement of port related industries is calculated to be 40,000 m^3/day with some allowance.

To totalize the above, the entire New Ocean Terminal industrial base requires a plant area of 18,300,000 m^2 and with about 30% of the plant area as additional land for roads, railway and other public facilities, the total development area of 23,800,000 m^2, fresh water of 3,414,000 m^3/day, with 3,017,000 m^3/day recycled and the remaining 397,000 m^3/day newly supplied and sea water of 7,832,000 m^3/day.

V-4. Amount of raw materials and products

Incoming volumes of industrial raw materials and the outgoing volumes of products correspond to the production scales of manufacturing industries. Here we estimate cargo volumes by mode.

The production scales of manufacturing industries were already set in the previous section, and the generated volumes of raw materials, fuel and products can be calculated as follows.

1) Iron and steel

The productive capacity of the steel mill is 6 million tons of crude steel per year, and products in steel amount to 5,400,000 tons. Raw materials required for this output are 8,430,000 tons of iron ore containing about 65% of iron, 3,330,000 tons of coal for carbonization, and 1,140,000 tons of limestone. In addition, 458,000 tons of fuel oil as main fuel is consumed. The total incoming volume reaches 13,358,000 tons.

2) Petroleum refining

The productive capacity is 400,000 B.P.S.D. with 330 working days per year, 18,850,000 tons of crude oil are processed. The products amount to 17,900,000 tons, excluding 950,000 tons consumed in the refinery itself.

3) Petrochemicals

The productive capacity is 400,000 tons in terms of ethylene, with 330 working days per year. 1,550,000 tons of raw material naphtha, 150,000 tons of crude salt, and 364,000 tons of fuel oil, total 2,064,000 tons of cargoes are carried in, and amount to 1,930,000 tons.

4) Chemical fertilizer

An annual output of fertilizer factory is 500,000 tons, and naphtha as raw material amounts to 200,000 tons.

5) Automobile assembly

The productive capacity is 200,000 units per year in 2 shifts, and in terms of tonnage, parts amount to 250,000 tons, products to 195,000 tons.

6) Shipbuilding and repair

The productive dock capacity of shipbuilding and repair is 200,000 GT, and considering that the repair section accounts for a relatively higher percentage, the incoming volume of steel is 100,000 tons per year.

7) Flour mill

The flour milling capacity is 500,000 tons/year in terms of processed wheat grains, and products are 390,000 tons of flour and 110,000 tons of bran at a yield of 0.78.

8) Edible oil

The productive capacity of edible oil is 250,000 tons/year in terms of processed soybeans, and products are 44,000 tons of soybean oil, and 191,000 tons of oil cake at a yield of about 0.176.

9) Electric power station

The power station generates power by oil burning, having a maximum output of one million KW, and at an operating ratio of 80%, 1,400,000 tons of fuel oil are required.

10) Independent power plant

An independent power plant of total 407,000 KW is jointly used by an iron and steel plant for 300,000 KW, petrochemicals plant for 75,000 KW and petroleum refining plant for 32,000 KW, to secure stable power supply and attain cost reduction. The fuel oil required for it amounts to 686,000 tons/year.

11) Other related industries

Since the other related industries are not divided into respective items, the generated cargo volumes are calculated, using the standard physical units of Japan. With 5,000 tons of cargoes carried in 4,000 tons of cargoes products are generated per hectare, the incoming cargo volume and outgoing cargo volume for 380 ha land are 1,900,000 tons and 1,520,000 tons respectively.

Summing up all the volumes, the total incoming cargo amounts to 39,558,000 tons/year, and the total outgoing cargo to 28,180,000 tons/year as shown in Table V-7. The generated cargo volumes by transport modes are calculated, based on the following considerations (see Table V-7 and Fig. V-2).

(1) Incoming cargoes

1) Of the industrial raw materials carried in, all the naphtha supplied from the petroleum refining plant to the petrochemicals and chemical fertilizer plants is planned to be transported by pipeline.
2) Of the incoming cargoes, all the fuel oil for the power station is supposed to be transported by ships from outside such as Rivers State, since the power station is planned independently of the industrial base. All the fuel oil for the iron and steel plant, petrochemicals plant and the independent power plant may be supplied from the petroleum refining plant of the New Ocean Terminal. But in the light of dispersing the operational risk, it is supposed that 20% should be carried in by ship from outside, and that the remaining 80% should be transported by pipeline from the petroleum refining plant in the base.
3) All the raw materials for the shipbuilding and repair plant are supposed to be supplied from the iron and steel plant in the base.
4) The iron ore, coal and limestone as raw materials for the iron and steel works can be supplied locally. However, the iron ore in Nigeria is of rather low grade, containing as little as about 50% of iron. Generally in the world, the integrated iron and steel works with high efficiency require a grade of about 65%, and therefore not advisable it is to use the iron ore in Nigeria in the planned plant at the New Ocean Terminal. As the coal for carbonization, coking coal is required, it is also difficult to use the coal of Nigeria. Although integrated iron and steel works in Ajaokuta is being constructed with the assistance of USSR to utilize the iron ore and coal deposited in Nigeria, it is planned for the New Ocean Terminal that iron ore is to be imported from Brazil, etc. and that coal and limestone are to be imported from African countries nearby or from South America, etc.
5) Crude oil for petroleum refining is supposed to be mainly procured in the east of Nigeria such as Rivers State, and if necessary, crude oil with different compositions can be imported from Latin America, the North Sea, etc. Anyway, all the crude oil is supposed to be transported by ship.
6) All the crude salt for petrochemicals must be imported. Wheat soybeans, the raw materials for other related industries and automobile parts are supposed to be

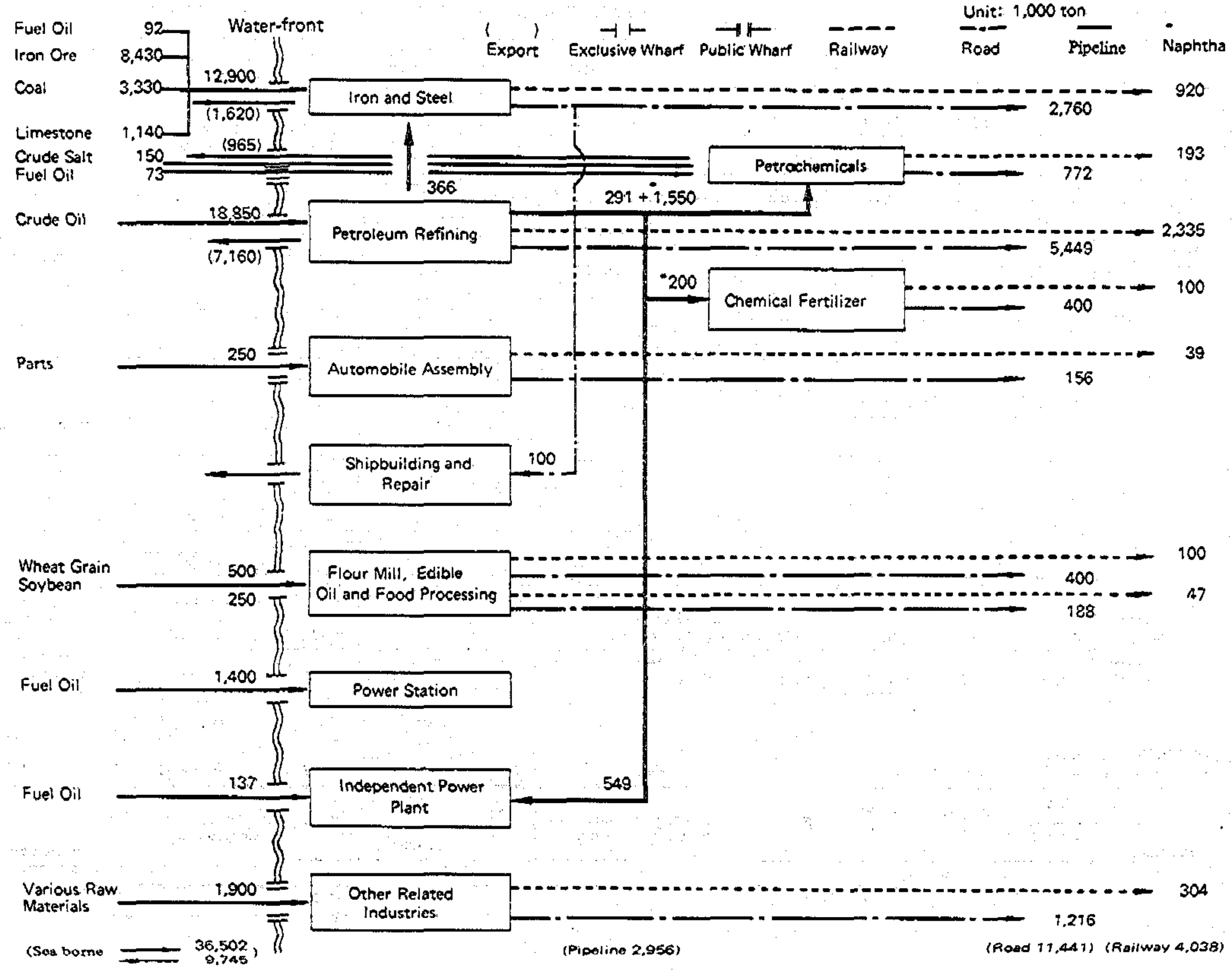
Table V-7 Industrial Goods Traffic at the New Ocean Terminal

Unit: 1000 ton

Type of Industries (Production Scales per year)	Raw Materials (Input)					Products (Output)					Remarks
	Type of Raw Materials	Volume				Type of Products	Volume				
		Total	Sea-borne (public wharf)	by Railway	by Road (by Pipe-line)		Total	Sea-borne	by Railway	by Road (by Pipe-line)	
Iron and Steel	Iron Ore	8,430	8,430			Steel	5,400	1,620	920	2,760 *100	30% for export for shipbuilding
(Crude Steel 6 million tons)	Coal Limestone Fuel Oil	3,330 1,140 458	3,330 1,140 (92)		(366)						
Petroleum Refining (400,000 barrels/day)	Crude Oil	18,850	18,850			Petroleum Products	17,900	7,160	2,335	5,449 (2,956)	40% for export
Petrochemicals (400,000 tons ethylene basis)	Naphtha	1,550			(1,550)	Derived Chemical products	1,930	965	193	772	50% for export
	Crude Salt Fuel Oil	150 364	150 (73)		(291)						
Chemical Fertilizer (500,000 tons)	Naphtha	200			(200)	Fertilizer	500		100	400	
Automibile Assembly (200,000 vehicles/ two-shift)	Parts	250	(250)			Motor Vehicle	195		39	156	
Shipbuilding and repair (200,000 G.T. dock)	Steel	100			*100						
Flour Mill and Food Processing (500,000 tons)	Wheat Grains	500	500			Flour Bran	390 100		78 22	312 88	
Edible Oil (250,000 tons)	Soy Beans	250	250			Soybean Oil Oil cake	44 191		 47	44 144	
Power Station (One million KW)	Fuel Oil	1,400	(1,400)								
Independent Power Station (407,000 KW)	Fuel Oil	686	(137)		*(549)						Iron and Steel 300,000 KW Petroleum refining 32,000 KW Petrochemicals 75,000 KW
Sub Total		37,658	32,650 (1,952)	–	100 (2,956)	Sub Total	26,660	9,745	3,734	10,225 (2,956)	
Other Related Industries	Various Raw Materials	1,900	(1,900)	–		Various Products	1,520		304	1,216	
Total		39,558	32,650 (3,852) Sea Borne Total 36,502	–	100 (2,956)	Total	28,180	9,745	4,038	11,441 (2,956)	

Notes: It is assumed that the seaborne fuel oils are landed through the public wharf (included in the commercial port cargo as 5.4 million tons' petroleum products)
* Transported within the N.O.T.

Fig. V-2 Industrial Cargo Flows at the New Ocean Terminal



mainly imported. All of these are supposed to be transported by ship.

Automobile parts and raw materials for other related industries are planned to be imported through the public wharfs.

For this reason, the port facilities for these industries are not considered in the industrial port plan. The fuel oil not supplied from the petroleum refining plant is also planned to be handled at public wharfs.

(2) Outgoing cargoes

Generated outgoing cargo volumes by transport mode relate to markets of products, transport distances, transport lots, conditions of transportation infrastructure and regional conditions. Therefore, for accurate forecast, highly accurate data of these conditions is inevitable. However, the actual transport conditions of Nigeria are not sufficiently studied. Thus, outgoing cargoes are supposed based on the following assumptions.

1) All the exports are supposed to be transported by ship. Cargo volumes for export are, as mentioned in V-2, 30% of steel products (1,620,000 tons), 40% of petroleum refined (7,160,000 tons), and 50% of petrochemicals (965,000 tons), total 9,745,000 tons.

2) The products consumed within the industrial complex of the New Ocean Terminal is 2,956,000 tons of naphtha and fuel oil transported from the petroleum refining plant by pipeline, as mentioned in the paragraph of incoming cargoes.

3) All the other cargoes are supposed to be transported on land. The sharing ratios of railways to roads are supposed to be 25:75 for iron and steel, 30:70 for petrochemicals, 0:100 for edible oil, and 20:80 for all the others. Although the markets and destinations areas of individual products can be classified into the Lagos metropolitan area and the other area, this cannot be a decisive factor for sharing ratios by transport mode. Therefore, the sharing ratios were set mainly based on the volumes of products of individual industries. With regard to the annual outgoing volume of less than one million tons, most are supposed to be destined for the Lagos metropolitan area, and the main transport mode is considered to be road, giving 80% as their sharing ratio. In the case of iron and steel products and petroleum products with annual outgoing volume of more than one million tons, a little larger dependency on railways is supposed, giving 25% for steel and 30% for petroleum products.

Based on the above considerations, the generated cargo volumes by transport mode are obtained as shown in Table V-7. Of the total incoming cargo volume of 39,558,000 tons, sea-borne volume is 36,502,000 tons, of which the cargoes landed through exclusive wharfs amount to 32,650,000 tons or 89.4%, and those landed through public wharfs, to 3,852,000 tons or 10.6%. No cargoes are carried in by railway, and 100,000 tons or 0.3% (all are steel for shipbuilding and repair) by roads. Pipeline cargoes amount to 2,956,000 tons or 8.1%. Marine transport and pipeline transport as a whole account for 97.5%.

Of the total outgoing cargo volume of 28,180,000 tons, sea-borne cargoes amount to 9,745,000 tons or 34.6%, all for export, railway cargoes, to 4,038,000 tons or 14.3%, road cargoes, to 11,441,000 tons or 40.6%, and pipeline cargoes, to 2,956,000 tons or 10.5%.

Details are shown in Fig. V-2.

(3) Outgoing railway cargo volumes by region

In relation to the planning, the outgoing railway cargo volumes by region are estimated. The major factors for the estimate are the volume of demand for products in to each destination, transport distances between origin and destination, the present situation of railway facilities and the future improvement plans.

The most important factor is the transport distance. According to the report "A Techno-Economic Feasibility for Standard Gauge" of Nigerian Ministry of Transport, railways are more advantageous for the transport distances of 362 km or more in transport cost comparison to trucks. Since the western states of Lagos, Oyo, Ondo and Ogun are located within 360 km from the New Ocean Terminal, it is considered that there is very little transportation by railway to these states.

The next factor is the relation between local demand and supply. For example, in the case of petroleum products, there are refineries of 100,000 B.P.S.D. in Warri, 70,000 B.P.S.D. in Kaduna, 75,000 B.P.S.D. in Port Harcourt. Also with regard to iron and steel, iron works of 1.5 million tons in Ajaokuta and one million tons in Warri and Port Harcoat are scheduled to be operated. Therefore, it is necessary to suppose the distribution areas of the petroleum products and steel produced at the New Ocean Terminal, considering the location of other refineries and iron works.

The individual outgoing railway cargo volumes by region are supposed based on the following considerations.

1) Steel

The railway transport volume of steel is 920,000 tons per year, of which 200,000 tons are supposed to be sent to Niger, Federal Capital and Kwara located at about 500 km from the New Ocean Terminal, and 720,000 tons, Kaduna, Sokoto and Kano farther away. The reasons for this supposition are that Kaduna, etc. have larger demand for steel and the transport distances to Kaduna, etc. are long enough to rely on railway. it is considered that the other supplied from the iron works in Ajaokuta and Warri, and no steel is supposed to be sent there from the New Ocean Terminal by railway.

2) petroleum products

The railway transport volume of petroleum products is 2,335,000 tons/year, of which 1,353,000 tons are supposed to be sent to Niger and other states, 982,000 tons to Kaduna, etc. (groupings of states are the same as those in the case of steel). The reasons for this supposition are that a lot of transportation is large and therefore the petroleum products can enjoy the merit of railway transport even in short distances, and that there are larger demands for petroleum products in Kaduna, etc. than that in Niger, etc. However, the demands in Kaduna, etc. will be covered mostly by the supply from Kaduna refinery which is scheduled to produce 70,000 B.P.S.D. It is considered that the other areas fall under the distribution areas of the refineries in Warri, Port Harcourt, etc., and no petroleum products are supposed to be sent there from the New Ocean Terminal by railway.

3) Other products

Petrochemicals, chemical fertilizers, automobiles, wheat flour, oil cake and products of other related industrials, too, are partially shipped by rail. But their total volume carried by rail is as small as 783,000 tons per year, and supposed to be destined for such states as Kaduna and the states in the east. As the railway project connecting Lagos with Ajaokura will reportedly realized after the year 2000, all the freight will be transported via Kaduna for some years to come.

V-5 Layout of industries

The plants of the industrial base at the New Ocean Terminal are arranged based on the following principles.

1) Security of effective industrial activities
2) Formation of industrial complex
3) Harmony with external environment
4) Effective development of industrial infrastructure

Since industrial production is very economic behavior, the security of the effective industrial activities is a minimum requirement of industrial base. Therefore, an industry which requires mass transport of raw materials or products by ship and much sea water must be arranged in a place of water-front.

Formation of an industrial complex is an intended target. The interdependence on raw materials and energy among different industries gathered at a place provides the advantages of cost reduction.

The harmony of plant location with external environment must be taken into consideration since an industrial base is one element to form a regional society. Therefore, a plant which use much fuel oil, etc. to emit soot or dust must be arranged in a place causing no unfavorable influence on the lee. Furthermore, a plant which drains a large quantity of used sea water must be arranged in a place facing open sea with favorable water draining condition.

The plant location must be harmonized with the layout of industrial port facilities. Generally, a water depth alongside wharfs should be larger at the harbour entrance than at the inside. Therefore, a plant which requires a larger depth for transport by large ships must be arranged at or near the harbour entrance, and a plant which requires a small water depth can be arranged at the inside of the harbour. And consistent development of the industrial base with the port facilities is required. It is also essential to consider the reasonable land use of the entire New Ocean Terminal including the New City and the land for commercial port facilities.

The above mentioned principles for plant layout comprise six layout factors, viz. water front and depth, combinations among different industries, intake and drainage of sea water, wind directions, operation stages of industries, and effective land use of the entire New Ocean Terminal. Based on the relation between these layout factors and the industries shown in Table V-8, the industrial layout at the New Ocean Terminal is planned as shown in Fig. V-3.

First of all, in relation to the land use as a whole, the industrial plants excluding a power station are arranged restrictively in the east and northeast area of the New Ocean Terminal.

In the east area, four types of industries, iron and steel, petroleum refining, petrochemicals and chemical fertilizer are arranged in addition to the shipbuilding and repair plant. The first reason for arranging these four types of industries in the same area is the combination among

Fig. V-3 Layout of Industries

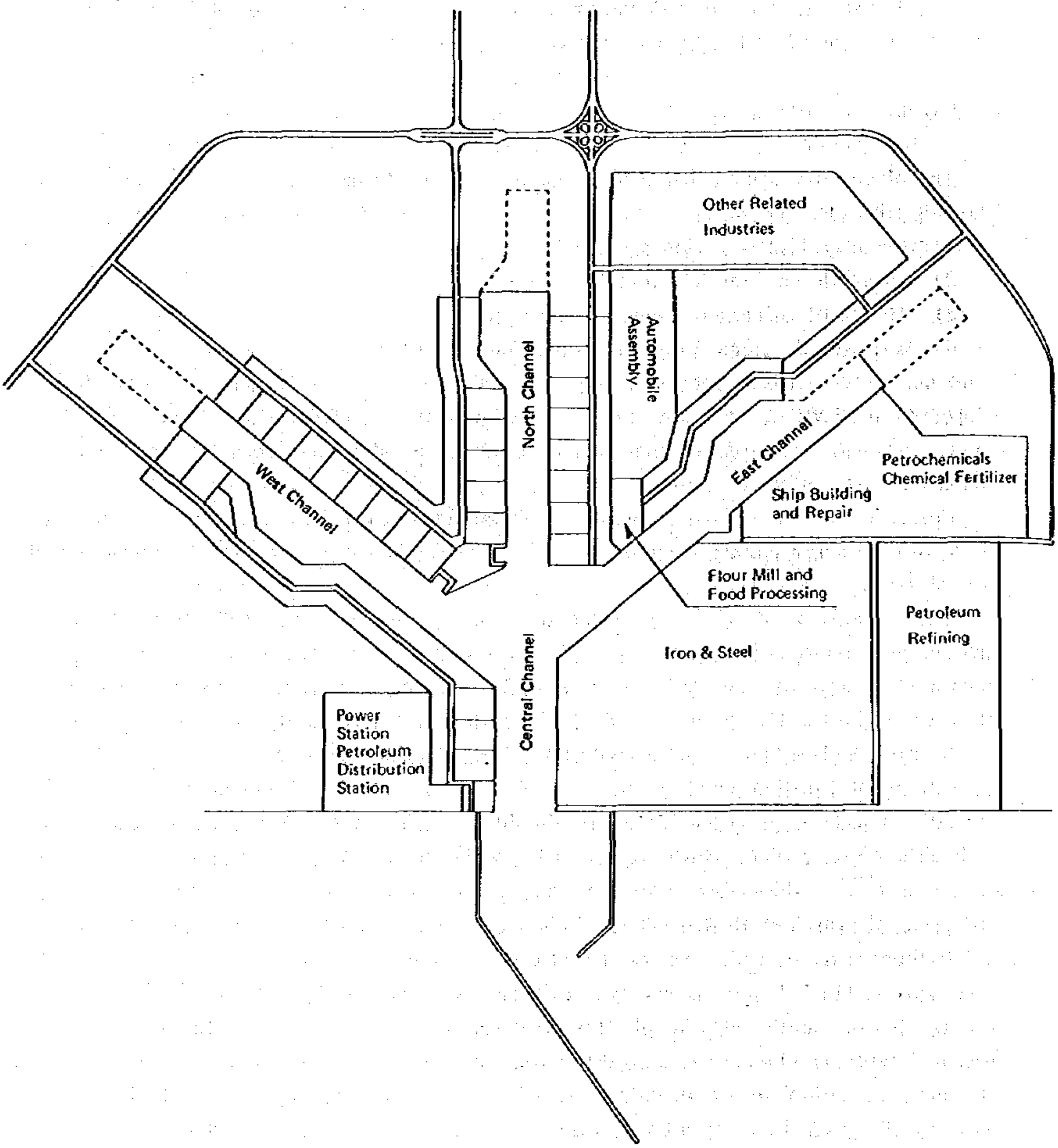


Table V-8 Factors of Industrial Layout and Location

Type of Industries	Factors of Layout						Zone of Location
	Water-Front and Depth	Combination of Industries	Intake and Drainage of Sea water	* Direction of Wind	Stage of Operation	Rational Land Use	
Iron and Steel	X	X	X	X	X		East
Petroleum Refining	X	X	X	X	X		East
Petrochemicals		X	X	X	X		East
Chemical Fertilizer		X		X	X		East
Autmobile Assembly					X	X	Northeast
Shipbuilding and repair	X				X		East
Flour Mill and Food Processing	X				X		Northeast
Edible Oil	X				X		Northeast
Power Station	X		X		X	X	West
Other Related Industries					X	X	Northeast

Note: * The direction of wind is the layout factor to avoid air pollution.

them. Naphtha produced by the petroleum refining plant is a raw material for the petrochemicals plant and the chemical fertilizer plant, and fuel oil is for the iron and steel plant and the petrochemicals plant (including independent power plant). With regard to the naphtha and fuel oil, if the four types of industries are located adjacent to one another in the same area, they can be supplied easily and economically by pipeline from the petroleum refining plant. Therefore, in the east area, a complex by pipeline connection is formed to obtain large reduction of cost such as transport expenses to enable the base to attain higher international competitiveness.

The second reason is the conservation of environment. These four plants consume relatively large quantities of fuel, including the independent power plant. Therefore, in the area where southwest wind prevails, it is appropriate not to locate them on the windward side of the New City.

The other reasons for arranging the respective plants in the east area are as follows. The iron and steel plant requires the largest water depth alongside wharfs among the plants located, and also requires much sea water. Therefore, it is arranged to face the Central Channel, in a place which allows easy approach to the open sea. The petroleum refining plant, too, is arranged similarly in a place facing the open sea, adjacent to the iron and steel plant, considering the water depth and the intake and drainage of sea water. The petrochemicals plant which receives naphtha as a raw material from the petroleum refining plant is arranged in a position neighboring to the petroleum refining plant and facing the East Channel. Although it is desirable to position the petrochemicals plant in a place allowing easy approach to the open sea since it requires much sea water. Emphasis is, however, laid on the combination with the petroleum refining plant and the utilization of water front rather than the access to the open sea in this plan. The chemical fertilizer plant is arranged adjacent to the petroleum refining plant, to receive naphtha as a raw material from the petroleum refining plant. The shipbuilding and repair plant is arranged to face the East Channel due to the necessity of water-front and adjacent to the iron and steel plant, considering the convenience of transport of steel goods.

The plants arranged in the northeast area are the automobile assembly plant, the flour mill, the food processing plant, the edible oil plant and plants of other related industries. Of these plants or facilities, the flour mill and the edible oil plant require water-front and are arranged along the East Channel. The automobile assembly plant, the food processing plant, and plants or facilities of other related industries do not always require water-front. The food processing plant is arranged behind the flour mill, considering the supply of raw material, and the automobile plant and plants or facilities of other related industries are arranged behind the public wharf of the East Channel.

VI. Scale and layout of the industrial port facilities

VI. Scale and Layout of the Industrial Port Facilities

VI-1 Principles

Based on the concept of layout employed for the various functions of the New Ocean Terminal under Chapter III and the concept of industrial development under Chapter V, the layout of the industrial port facilities (wharfs to handle exclusively the goods of various enterprises such as petroleum, iron and steel, grain and petrochemical products) has been determined as shown below.

1) As a rule, each plant area is to be provided with a necessary water-front for the handling of raw materials and products. And, the berth for the discharge of crude oil and that for shipment of petroleum products are to be located near the harbour entrance.

2) In order to reduce the amount of dredging, large scale deep water facilities are to be located near the harbour entrance.

3) It is planned for some commercial port facilities to be located in the industrial port area in order to make it easy to handle industry-related general cargoes.

4) One of the service boat basins is to be located near the centre of the industrial port area for smooth port services.

VI-2 Number of berths and scale of facilities

Table VI-1 shows the industrial cargoes, the maximum size of ships, water depth of and length of each berth, the number of berths necessary and the total length of the berths. These figures are calculated on the basis of the study on the industry location planning in Chapter V. An explanation for each industrial wharf is given below.

Table VI-1 Number and Size of Berthing Facilities for Industrial Cargoes at the New Ocean Terminal in the year 2000

Cargo Traffic, Dimension of Vessels and Berthing Facilities	Iron and Steel Berths				Petroleum Oil Berths		Petrochemical Berths		Ship-building & repair Berths	Grain Berths	Total
	Iron Ore	Coal	Lime-stone	Iron & Steel Products	Crude Oil	Refined Oil Products	Crude Salt	Petro-chemical Products	Steel & Equip-ment	Grain	
Cargo Traffic (1,000 ton/yr.)	8,430	3,330	1,140	1,620	18,850	7,160	150	965	*	750	42,395
Maximum Size of Vessels (DWT)	150,000	120,000	50,000	15,000	100,000	50,000	15,000	15,000	15,000	60,000	–
Structural Depth of Berths (m)	-18	-17	-13	-10	-16	-13	-10	-10	-10	-14	–
Length of Each Berth (m)	350	310	270	185	400	270	185	185	185	300	–
Total Number of Berths	2	1	1	9	2	1	1	5	3	1	26
Total Length of Berths (m)	700	310	270	1,665	800	270	185	925	555	300	5,980

* The ship building berths are planned mainly for repairs and fittings, but used occasionally to unload materials for ship repairs, etc.

VI-2-1 Iron and steel wharf

An integrated steel manufacturing plant of a size producing 6 million tons/year of crude steel requires 8.43 million tons of iron ore, 3.33 million tons of coal and 1.14 million tons of limestone. Part of these raw materials may be procured in Nigeria, but in this plan Nigeria completely depends upon raw materials from abroad. There is a substantial need to make a comparative study about whether domestic raw materials or foreign ones are more economical for industries at the stage of construction.

As the iron ore is supposed to be imported from Brazil, the distance being relatively close, it may be assumed that it would be sufficient for the largest iron ore carrier to be in the 150,000 D.W.T. class.*

The standard specifications for a 150,000 D.W.T. iron ore carrier are: total length 300 – 320 m, width 43 – 44m, loaded draft 16 – 17 m. Therefore, it would be sufficient for the berth measurements to be: length 350 m, water depth 18 m. The cargo handling capacity per berth is determined depending upon the capacity of ore unloaders, the size of the open storage yard to the rear, etc.; but a berth of the size with an 18 meter water depth normally can handle approximately 5 million tons/year. Accordingly, with the New Ocean Terminal handling 8.43 million tons/year of iron ore, it would be sufficient to plan 2 berths for the iron ore wharf. (the total length of wharf is 700 m)

As the coal and limestone are supposed to be imported from neighboring African countries, the United Kingdom, the United States and other countries, the wharfs have been planned for coal carriers of 120,000 D.W.T. class and limestone carriers of 50,000 D.W.T. class. Looking only at the cost of the maritime transport of these raw materials, a larger ship to bring them in would be more economical, but as the ship size increases the cost of constructing the harbour facilities, such as channels and quays, grows greater. For instance, it is necessary to enlarge the capacity of the storage yard to fit the quantity of raw materials brought in all at once. And, the scale of the shipping port facilities of importing countries are not always fit to a large-size ship. Because of these and other drawbacks, we have selected a ship of a size somewhat larger than the median sized vessel presently in service for the planning purposes. The standard specifications for the 120,000 D.W.T. class and 50,000 D.W.T. class bulk carriers are respectively: length 260 – 270 m, beam 40 – 42 m, loaded draft 15 – 16 m, and length 222m, beam 31.4 m, loaded draft 11.7 m.

Accordingly, as for the berth measurements, it is appropriate for the coal berth to have a length of 310 m/berth and a water depth of 17 m, and for the limestone berth to have a length of 270 m/berth and a water depth of 13 m. One berth for each type of cargoes would be sufficient for handling estimated 3.33 million tons/year of coal, and 1.14 million tons/year of limestone.

The plan assumes that 70% of the steel products manufactured at the steel mill are for domestic demand, and 30% for export to nearby African countries and elsewhere. Steel products, in a word, comprise a wide variety of items such as ingots and plate steel, etc. At the master plan stage there is no need for a detailed study on the composition of demand for these products by

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*The Phase-I Report assumed a 200,000 D.W.T. class ship, but there are very few ships of this size. Since they are not ordinarily encountered, a 150,000 D.W.T. class ships are projected for planning purposes.

export destination. Here, using 15,000 D.W.T. class break-bulk carriers for planning purposes, and assuming a cargo handling capacity of 200,000 tons/year/berth, 9 berths with a total length of 1,665 meters are planned. The berth measurements, made to correspond to the specifications of a 15,000 D.W.T. class freighter (total length 160 m, beam 20 m, loaded draft 9.1 m), are to be 185 meters long with a water depth of 10 meters.

VI-2-2 Petroleum wharf

This wharf handles crude oil, naphtha, and other refined petroleum products.

The amount of crude oil needed by a refinery possessing a 400,000 barrels/day capacity (refer to Chapter V) is 18,850 thousand tons/year. There are various opinions on where this crude oil will be shipped from, but here we have assumed that the major part will come from the Eastern part of Nigeria, and some crude oil with a different composition will be imported from abroad (Central and South America, the North Sea, etc.)

Accordingly, considering the maritime shipping distances involved, it is not appropriate to consider the use of 300,000 D.W.T. class tankers. Rather, it would be more profitable to use medium size tankers for economical construction of the port's facilities. For this reason, it is assumed that at the maximum, 100,000 D.W.T. class tankers will unload crude oil at the wharf.

The standard specifications for a 100,000 D.W.T. class tanker is: total length 285 m, beam 41.2 m, loaded draft 15 m. The corresponding berth needs to have measurements of 400 m in length and 16 m in water depth. The berth's unloading capacity depends mainly upon the capacity of the tanker's pumps. The capacity of a 100,000 D.W.T. class tanker's pumps can generally handle 8 – 10 thousand tons per hour. Thus, to obtain the yearly handling capacity per crude oil berth, if the mechanical efficiency, number of workdays, etc. are taken account of, the following results:

Yearly handling capacity = (pump capacity) x (mechanical efficiency) x (workdays per year) x (work hrs./day) or, 8,000 tons/hr. x 0.6 x 220 days x 15 hours/day = 15.84 million tons.

Therefore, to handle 18.85 million tons/year, 2 berths are necessary.

As stated in Chapter V, 40% of the naphtha and other petroleum products refined in the refinery are for export. So, it becomes necessary to ship 7.16 million tons of petroleum products per year. In deciding the size of tanker for these products, it is necessary to consider, the distance and the economy of the loading and unloading ports, etc. Because it is difficult to forecast the above conditions with any certainty, the trends in petroleum product tankers in the world today are used as a basis for judging what is proper. The plan assumes the use of a 50,000 D.W.T. class tanker. In this case, because the ship's specifications are: over-all length 230 m, beam 32 m, loaded draft 11.8 m, the necessary measurements for the corresponding berth are: length 270 m, water depth 13 m. As in the case of crude oil, the berth capacity depends upon the capacity of loading pumps. It is standard in the case of a 50,000 D.W.T. class tanker for the pumps capacity to be for 5,000 – 7,000 tons/hr. Accrodingly a berth's capacity for loading petroleum products is:

Yearly handling capacity = (pump capacity) x (mechanical efficiency)
x (workdays per year) x (work hrs/day)
or

5,000 tons/hr x 0.6 x 220 days/yr. x 15 hrs/days = 9.9 million tons Therefore the 7.16 million tons of petroleum can be handled annually by one berth.

VI-2-3 Petrochemical products wharf

As stated in Chapter V, it is estimated that the petrochemical industry at the New Ocean Terminal will have a productive scale of 400,000 tons on ethylene basis per year in future. The 1.55 million tons/year of napththa needed may be obtained from the adjoining petroleum refinery, but the crude salt must be imported from abroad. The amount of crude salt required per year of 150,000 tons is small, but it is necessary to have one berth prepared for crude salt. Since the quantity to be handled is small ships no larger than 15,000 D.W.T. are assumed sufficient. The berth with a length of 185 meters and a water depth of 10 meters is standard.

The aggregate quantity of petrochemical products comes to a yearly production of 1.98 million tons. Assuming that 50% is to be exported and 50% for meeting the domestic demand, 965,000 tons/year is exported. There being many types of cargo in petrochemical products such as liquids, solids, powders, these products take on a character of midway between break bulk and bulk cargo. Accordingly, here, thinking of the berth's handling capacity in terms of break bulk wharf, 200,000 tons/year per berth can be considered as standard. In this case, the largest size ship assumed would appropriately be of the 15,000 D.W.T. class similarly to a break bulk carrier and it would be proper for the berth length to be planned to be 185 meters and the water depth 10 meters. Accordingly for handling 965,000 tons/year of these products 5 berths with a total combined length of 5 x 185 = 925 m become necessary. Also, even in the case of a need to handle a petrochemical product such as chemical fertilizer, the above 5 berths, each with a planned capacity of 200,000 ton/year, have some excess capacity to be satisfactorily coped with.

VI-2-4 Shipbuilding and repair wharf

Here it is assumed that, as already stated in Chapter V, large scale new ship building is not planned. Rather the primary function of this shipbuilding industry is to make repairs to ships using the port and additionally, to build small and medium size ships. Accordingly most of the needed water-front will be used as moorings for repairs and out fittings, but it is necessary to consider a berth to be used for unloading materials needed for ship repairs, etc. Even if the ships projected to use the out fitting berth are of large size, as they will be empty, a large water depth alongside is not necessary. If the water depth is 10 meters, it will be capable of mooring 250,000 D.W.T. class vessels. At the New Ocean Terminal, 3 berths with a water depth of 10 m and a length of 185 m each, are planned for the ship repair/out fitting and material unloading wharf.

VI-2-5 Grain wharf

The grain wharf as a commercial port facility has the function of discharging imported wheat and other grains to the processing plants in the Lagos area. But the grain wharf as an industrial port facility has the function of handling grains to be used for the processing of feeds, food products, etc. by the processing plants to the immediate rear of the wharf. Chapter V brings up the scale of this activity. Namely, combining the milled flour and the processed goods, an industry with a yearly output of 500,000 tons is planned. Assuming that these 500,000 tons of grain are imported from the Americas, the projected maximum size ship is 60,000 D.W.T. and the port facilities should be accordingly designed. Therefore, it is necessary to make the size of the berth 300 meters long with a water depth of 14 meters. Giving the berth 2,400 ton/hour pneumatic unloaders and assuming a mechanical efficiency of 0.6 and unloading hours of 15 hrs/day, and including an additional 250,000 tons/year of edible oils, one berth is capable of handling the postulated 750,000 tons of grains per year.

VI-3 Layout of the industrial port facilities

Based upon the principles for the layout of industrial port facilities discussed in VI-1 and their scales stated in VI-2, the following type of layout was decided upon:

1) The raw material berths of steel mill wharfs are situated as to run along the east bank of the Central Channel and the iron and steel product berths are laid out along the East Channel.
2) The crude oil and processed petroleum product berths, as stated before, are positioned on the inside of the East Breakwater. A piepline is laid out between the crude oil berth and the refinery skirting the steel mill site. It is planned to carry the crude oil to the petroleum refinery to the rear of the steel mill together with carrying processed petroleum products coming from the refinery to the berths.
3) Because the petrochemical product wharf is of a shallow depth, it is situated to the inside of the ship repair berth on the south bank of the East Channel.
4) As for the grain wharf, one berth is situated at the north side of the East Channel.
5) Taking into consideration the convenience of unloading needed materials, the ship repair berth is positioned to the inside to the east of the small craft basin-2.

VII. Layout of breakwaters

VII. Layout of Breakwaters.

VII-1. Maritime conditions for the layout of breakwater

As regards the maritime conditions, especially wave conditions, of the proposed site for the New Ocean Terminal, no data which could be used for layout and design of breakwaters were available as no wave observations had been made. Accordingly, wave observations were made, though for a short period of two and half months from July to September, 1979, by installing a hydraulic wave gauge at a point of −16m in depth off the proposed site. At the same time, meteorological data on wind direction and velocity, temperatures and humidity were collected at Igando, the proposed site for the New Ocean Terminal.

On the other hand, wave observations were made and the data were processed at a point of −55m in depth off Forcados, 5° 23'N and 5° 00'E, about 200km southeast of the proposed construction site, for the construction of an ocean oil terminal.

As regards the meteorological and maritime conditions of the Nigerian coast, they are extremely stable under the control of monsoons except for thunder storms which occur frequently between the dry and wet seasons resulting in localized heavy rain and strong wind. Since these thunder storms do not last long, it is inconceivable that they cause abnormally high waves locally. Therefore, even the wave data collected at a point 200km from the proposed site for the New Ocean Terminal may be used for design and layout of breakwaters.

Accordingly, general characteristics of maritime and meteorological conditions of the Nigerian coast will be outlined forst, followed by those of the proposed site for the construction of the New Ocean Terminal based on the observation data. At the same time, discussion will be made as to whether the wave data from the point more than 200km away from 5° 23'N and 5°00'E can be used for the New Ocean Terminal plan.

Nigeria is situated near the toropical low air pressure belt called as the Doldrum Belt. During the dry season (November-April) the belt lies approximately on the Nigerian coastal line or a little further to the south. It moves to north, toward the wet season (May-October), reaching the vicinity of Sahara, the northern limit, at the ended of June.

Monsoon winds blow constantly into the low pressure belt from both sides. Accordingly, during the dry season when the low pressure belt lies near the Nigerian coast, strong northeasterly winds blow in the area north of the coastal line which occupies most of Nigeria. However, the winds become weaker in the area near the coastal line and then land and sea breeze prevails everyday, as the centre of the low pressure belt lies in the coastal area. In contrast, during the wet season when the low pressure belt lies north, strong southwesterly winds blow through the entire country. Fig. VII-1 (a) and (b) show the wind direction and the position of the low pressure belt during the dry and wet seasons respectively.

Thunder storms occur all the year round in Nigeria and are most frequent and violent at the beginning and the end of the wet season. They move east to west at a speed of 10-13m/s, accompanied by gusts, and then die down rapidly. They are frequent in the coastal area, particularly on the southeast coast.

Details of the thunder storms such as the scale, central air pressure and route are not known

Fig. VII-1 (a) Pressure and Winds in January

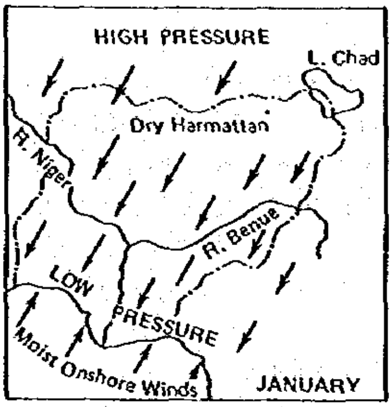
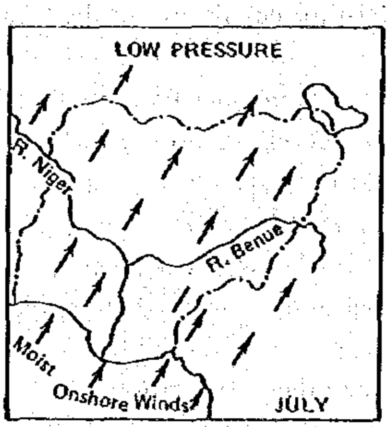


Fig. VII-1 (b) Pressure and Winds in July



due to insufficient observation data. According to the wind record obtained at Ikeja Observation Post, about 30km inland from the coast north of Lagos, the maximum wind velocity recorded in 17 years was 32m/sec. and the 10minute average velocity comes down to about 70%. It seems, therefore, that the wind velocity is not so strong. Furthermore, judging from the facts that the damages due to thunder storms have been caused by accompanying inundation due to heavy rain and that the houses near the coast have not been damaged by wind waves generated by thunder storms, it may be assumed that waves generated by thunder storms are not large enough to be taken into consideration in the New Ocean Terminal plan.

Observations of maritime and meteorological conditions were carried out at the proposed site for the New Ocean Terminal for two and half months from the middle of July to the end of September, 1979. As regards maritime conditions, wave profiles for ten minutes at every two hours were recorded by a hydraulic wave gauge installed at the point of -16m deep about 2km off Igando and the visual observation of wave direction were also carried out.

As regards meteorological conditions, wind speed and direction were recorded continuously by an anemoneter installed at the top of a pole of 10m long erected at the Igando beach and temperatures, humidity and rainfall were also observed at Igando Village.

Fig. VII-2 shows the frequency distribution of wind direction during the two and half months from July 18 to September 29. The figure shows that SSW-WSW winds account for more than 60% of the total in every month, reaching as much as 84% in August. It also shows that while winds of 0–4.9 m/sec are evenly distributed between SE and NNE, though frequency is low, those of more than 5.0 m/sec are concentrated between SSW and WSW, especially in SW direction. This corresponds to the fact that strong monsoon winds of SW direction prevail in the rainy season of July–September as shown by Fig. VII-1 (b). On the other hand, winds of 0–4.9 m/sec seem to be daily land and sea breese. Those of N direction are frequent around 9 o'clock in the morning. Furthermore, those of 0–4.9 m/sec which appear in a wide-ranging direction seem to be induced by the shift from land to sea breeze.

Fig. VII-3 shows the variation of daily mean significant wave height, wave period and daily hours dominated by winds of more than 5 m/sec and those of more than 10 m/sec. As it shows,

Fig. VII-2 Frequency Distribution of Wind Direction at the Coast of Igando in July to September in 1979.

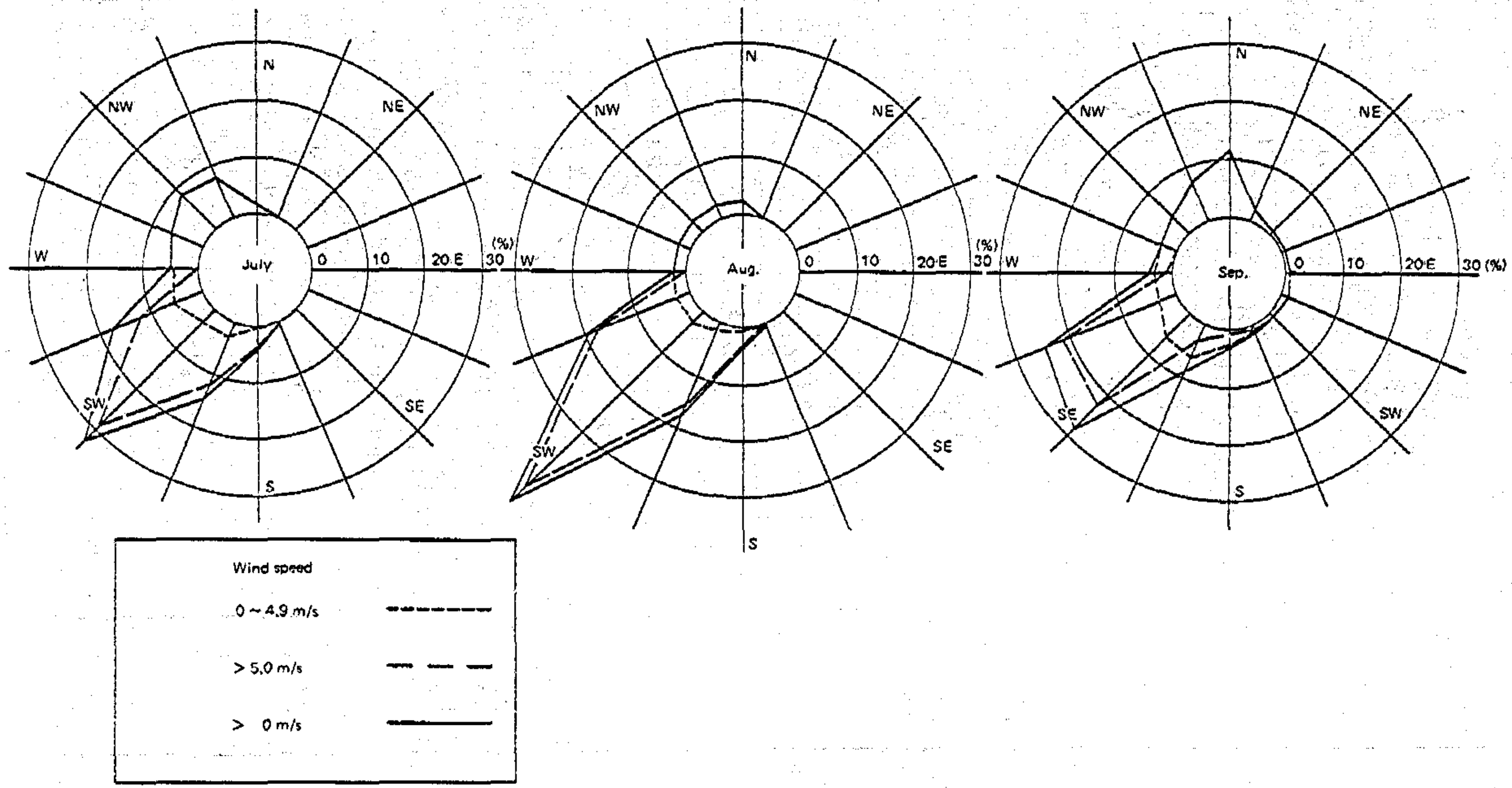
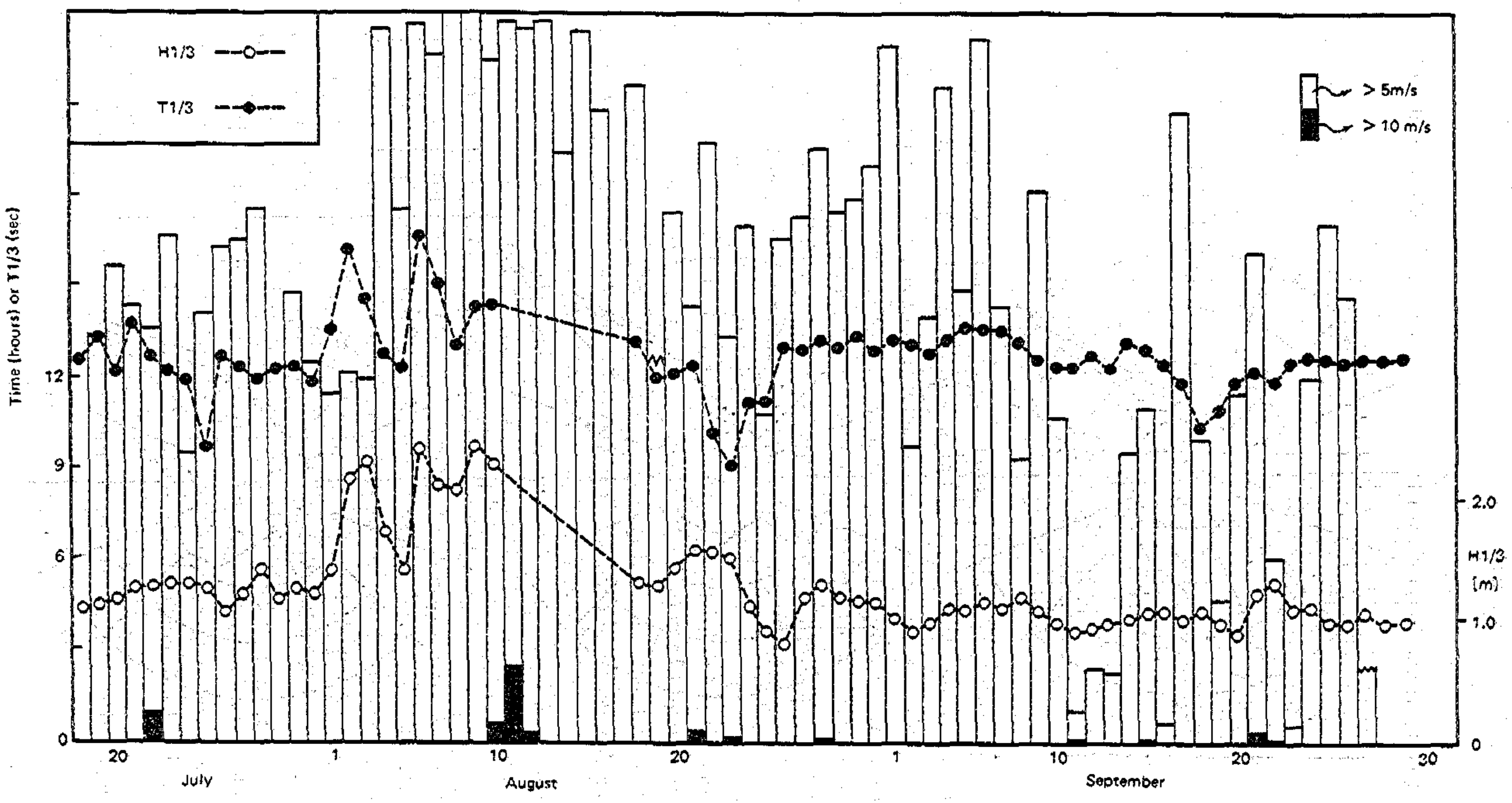


Fig. VII-3 Total Wind Duration and Mean Significant Wave Height and Period



mean significant wave height except for the period of August 1 to 10 when waves are high is 1.1m with mean significant wave period of about 12 sec. The mean significant wave has a small steepness of 0.0049. This means that such waves are swells.

In the period from August 1 to 10 when daily mean significant wave height was more than 2.0m, mean significant wave height and period reaches 2.3m and 15 sec. respectively, larger in height and longer in period compared with those of less than 2.0m in height. However, the wave has the small steepness of 0.0057 and is also considered as swell.

Judging from the small wave steepness of normal large waves, those waves seem to be swells which were generated in the wind area due to a depression at a considerable distnace and reached the Nigerian coast undergoing angular spreading, frequency spreading or reduction in energy. Accordingly, in order to estimate the waves on the Nigerian coast, it is necessary to ascertain from the weather map where waves are generating, in the South Atlantic i.e., where a strong depression lies in the South Atlantic. It means that it is impossible to estimate the waves on the Nigerian coast from the meteorological data covering the coastal area of Nigeria alone. This can be judged from the fact that there is no significant correlation between winds of more than 5 m/sec and wave height and that the duration of high waves lasts 3 days or longer.

Fig. VII-4 shows the variation in significant wave height ($H_{1/3}$) and period ($T_{1/3}$) during the days of high waves from August 1 to 10, based on the wave record collected for 10 minutes at every 2 hours.

According to the figure, waves which were around 1.3m in $H^1/_3$ in the morning of August 1, began to rise in the afternoon, and reached 2m in $H_{1/3}$ around 6 A.M. on August 2. After reaching 3.1m at 10 A.M. on August 3, they began to gradually recede, registering $H_{1/3} < 2.0$m on the morning of August 4.

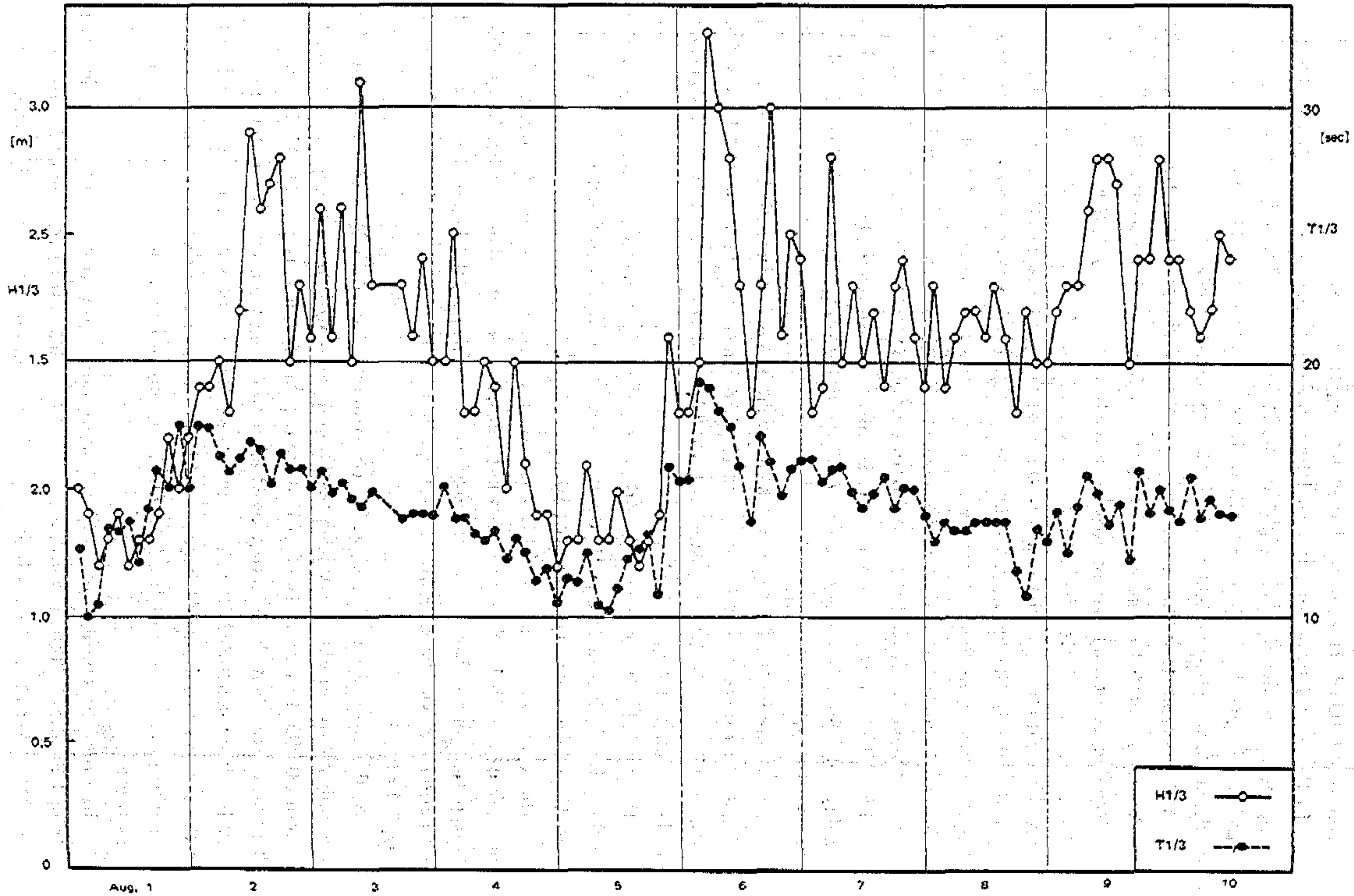
$H_{1/3} = 1.4$m for most of the 5th; but wave height began to rise rapidly from the midnight reaching $H_{1/3} = 3.3$ m at 6 A.M. the next day. Thereafter daily mean significant wave height of more than 2.0m continued until the 10th.

However, due to no available data for the period from the afternoon of the 10th to the morning of the 18th of August, it is not known as to how the wave height receded. Significant wave period also follows the changes of wave height, i.e., the larger the wave height the shorter the period and vice versa. However, waveperiod is long and $T_{1/3} > 15$ sec. at high waves, reaching $T_{1/3} = 19$ sec. in some cases.

As described above, waves at the construction site of the New Ocean Terminal from July to September have an extremely long period compared with wave height and has a small steepness of about 0.005. In view of the fact that wind wave steepness is about 0.04, it can be assumed that these waves reached the Nigerian coast after travelling from somewhere far in the Atlantic where they had been generated. It follows that the difference of wave characteristics is not vary greatly in the entire coastal area of Nigeria and it may be assumed that wave data obtained at a distance from the proposed site of the New Ocean Terminal can be used as wave data for the new port construction.

In order to confirm the above assumption, comparison is to be made with wave data obtained at about 200km, south-east (5° 23'N and 5° 00'E) far from the proposed site for the New Ocean Terminal. Fig. VII-5 shows changes in monthly mean significant wave height. The

Fig. VII-4 Variation of Significant Wave Heights and Periods during Rough Sea



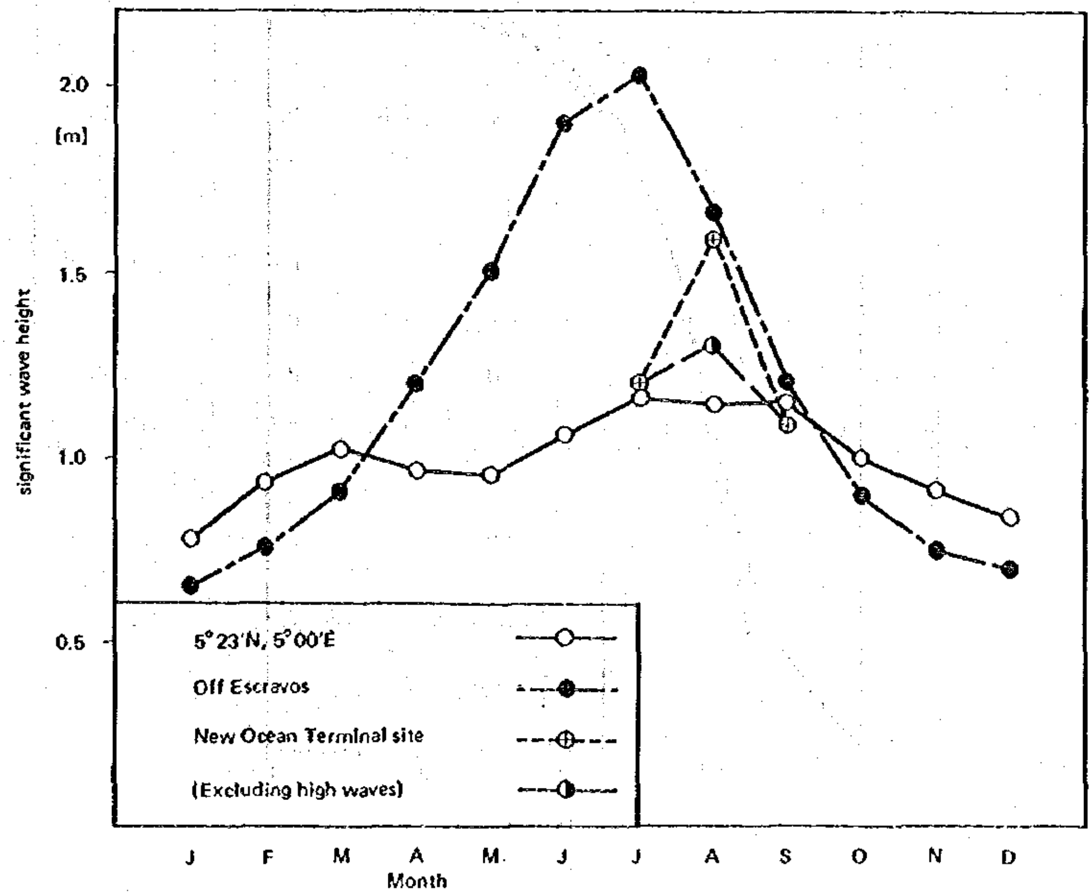
solid line shows monthly mean significant wave height estimated from the monthly wave frequency table obtained at 5° 23'N and 5° 00'E at a depth of -55m and the dash-dot line shows wave height observed at a depth of −15m in the Estuary of Escravos, about 40km northwest from the point of 5° 23'N and 5° 00'E. Though wave height at the proposed site for the New Ocean Terminal is given by a dotted line, the data cover half month in July 18 to 31, 21 days in August except the days of no available record and full month in September.

Though high waves arrived during the 10-days period from August 1 to 10, there is no problem; if such high waves arrive in August of normal year, but if they were peculiar to 1979, it is necessary to exclude them from consideration. Since no judgement can be made as to whether they can be excluded, they are included for Fig. VII-5.

The figure shows that wave height at the Estuary of Escravos is low at 0.7m during the dry season and extremely high at nearly 2m during the rainy season compared with that at 5° 23'N and 5° 00'E. This may have been due to the meteorological conditions of that particular year when wave observation at the Estuary of Escravos was carried out for only one year. Though wave observation at the Estuary of Escravos was carried out at a depth of −15, changes in wave height due to shoaling does not have to be considered in this comparison since there is hardly any shaling effect at this depth.

At 5° 23'N and 5° 00'E wave tends to be high during the wet season. But the difference of wave height between the dry and the wet season is small at about 40cm and does not extend up to 1.3m such as shown by the data at the Estuary of Escravos.

Fig. VII-5 Monthly Variation of Mean Significant Waves



On the other hand, observation data the New Ocean Terminal show that the mean significant wave height in August was roughly the same as the wave height at the the Estuary of Escravos; but the wave height in July and September was close to that at 5° 23'N and 5° 00'E. However, if the duration of high waves ($H_{1/3} > 2m$) in August is excluded, wave height falls to $H_{1/3}$ = 1.29m and becomes close to that at 5° 23'N and 5° 00'E as shown by the broken line.

Fig. VII-6 shows the comparison between the wave data at the proposed site for the New Ocean Terminal and those at 5° 23'N and 5° 00'E in respect to the probability on nonexceedance during the period from July to September. They show a dood agreement in distribution except in the area of small wave height.

It may be assumed. therefore, that there is no major difference between the wave data already collected at 5° 23'N and 5° 00'E and those obtained this time at the proposed site of the New Ocean Terminal. Judging from the facts that the wave data obtained for the New Ocean Terminal cover a short period of two and half months and that the waves arriving at the coast of Nigeria differ between the dry and wet seasons, the data of such a short period cannot be expanded to the wave frequency distribution of a year. Accordingly, the observation data obtained at 5° 23'N and 5° 00'E are to be used for the determination of the calmness in the new Lagos Port as they are similar to those obtained at 5° 23' N and 5° 00'E.

Fig. VII-6 Comparison of Wave Non-Exceeding Probability between Wave Data at (5°23'N, 5°00'E) and the New Ocean Terminal Site

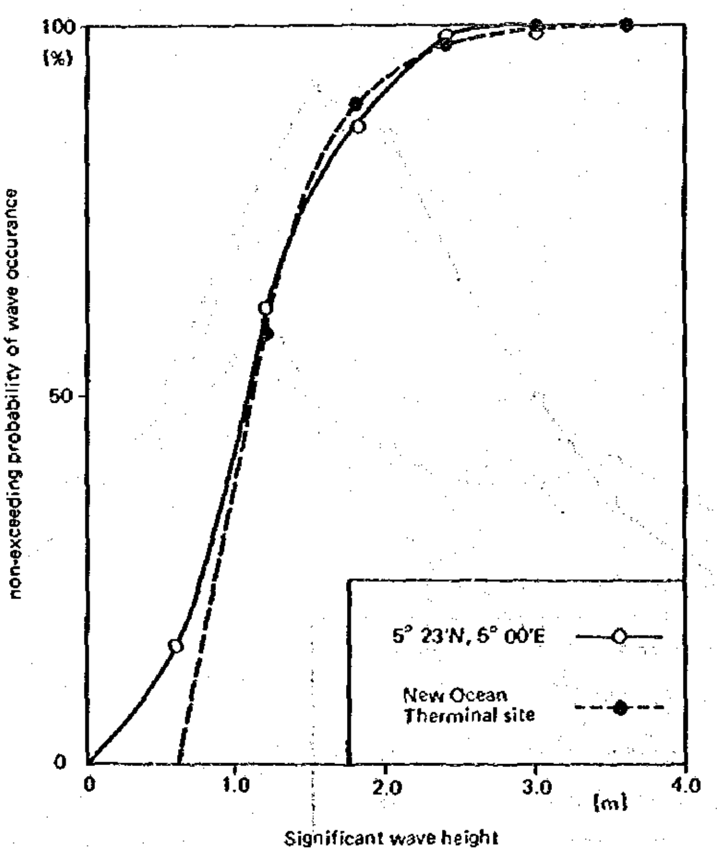


Table VII-1 shows the frequencies of wave heights in the respective eight directions, indicated by percent. The frequencies are calculated by using the observed wave data at a point lat. 5° 23'N. and long. 5° 00'E with −55m water depth. At −55m water depth, the waves with periods of 8.5 sec coming from southwest by refraction, and even the waves with a period of 18 sec or less are not affected involve refraction of about 10° at the largest. Therefore, all the wave directions can be considered almost as those of deepwater waves.

According to Table VII-1, the waves of south to west directions share almost 84%. Judging from this, if the breakwaters are extended in the direction to sufficiently shelter the waves of south to west directions in terms of deepwater wave directions, the inside of the port is surmised to be sufficiently kept calm.

Table VII-2 shows the frequencies of wave heights to the respective period ranges observed at the same point as that of Table VII-1. According to this table, almost 73% of waves occur during the periods of 9 to 15 sec, and the most frequently occurring period of waves is almost 12 sec.

Table VII-1 Average Frequency of Occurrence of Wave Height-Direction Groups at 5°23' North, 5°00' East at Approximately 50 m Depth

Direction	Significant Wave Height (m)							Total
	0-0.6	0.6-1.2	1.2-1.8	1.8-2.4	2.4-3.0	3.0-3.6	3.6 plus	
N	1.1	0.8	0.2	0.0	0.0	0.0	0.0	2.1
NE	1.3	0.7	0.0	0.1	0.0	0.0	0.0	2.1
E	1.9	0.6	0.1	0.0	0.0	0.0	0.0	2.6
SE	2.5	2.4	0.7	0.2	0.1	0.0	0.0	5.9
S	6.3	9.9	3.6	1.1	0.3	0.1	0.0	21.3
SW	7.9	22.6	11.2	4.6	0.9	0.3	0.1	47.6
W	3.0	7.2	3.2	1.2	0.3	0.1	0.0	15.0
NW	1.8	1.1	0.4	0.1	0.0	0.0	0.0	3.4
Total	25.8	45.3	19.4	7.3	1.6	0.5	0.1	100.00

Table VII-2 Average Annual Frequency Distribution of Significant Wave Period at 5°23' North, 5°00' East at Approximately 50 m Depth

Period (sec)	Significant Wave Height ($H_{1/3}$) (m)							Total
	0-0.6	0.6-1.2	1.2-1.8	1.8-2.4	2.4-3.0	3.0-3.6	3.6 plus	
0-3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
3-5	0.8	0.5	0.0	0.0	0.0	0.0	0.0	1.3
5-7	1.8	2.3	0.2	0.0	0.0	0.0	0.0	4.3
7-9	3.2	4.5	1.4	0.3	0.0	0.0	0.0	9.4
9-11	7.2	12.2	4.9	1.5	0.3	0.1	0.0	26.2
11-13	6.2	11.8	7.0	3.0	0.8	0.3	0.1	29.2
13-15	3.9	7.7	3.9	1.9	0.4	0.1	0.0	17.9
15-17	1.8	5.0	1.6	0.5	0.0	0.0	0.0	8.9
17-19	0.5	1.4	0.6	0.1	0.0	0.0	0.0	2.6
Total	25.8	45.3	19.4	7.3	1.6	0.5	0.1	100.00

Source: A.H. Glenn and Associate: Meteorological-Oceanographic factors affecting design and planning of petroleum operations in Nigerian oil company offshore leases.

VII-2 Scale and layout of breakwaters

If breakwaters are arranged in the direction to sufficiently shelter the waves of south to west directions as described in VII-1, the calmness in the port is surmised to be sufficiently kept. Since the waves with the most frequent occurrence have periods of 11 to 13 sec, the typical period of 12 sec was selected to calculate the water directions at −20m or less water depths for the wave directions of south, southwest and west. The calculation results are as shown in Table VII-3. Waves of south direction progress without changing their direction, and the waves of southwest and west directions change their directions by refraction toward south direction normal to coast line, but they do not coincide with the waves of south direction. Table VII-3 shows the variation of predominant wave direction of irregular waves with directional spectrum. The predominant wave direction means the direction of the wave with the highest energy.

It is the most effective to extend the main breakwater, viz. the west breakwater toward east to perfectly shelter the waves of south direction, but the breakwater in this direction causes incoming ships to receive waves perpendicularly to the broadside, undersirably for the navigation of the ships. Therefore, the extending direction of the breakwater is turned toward south, to facilitate the navigation of incoming boats. and at the same time, an auxiliary breakwater at the outside of the port is extended toward south, to inhibit the advance of waves into the port. How far the west breakwater should be extended toward south depends on submarine topography

Fig. VII-7 Alignment of Breakwaters and Sounding Chart

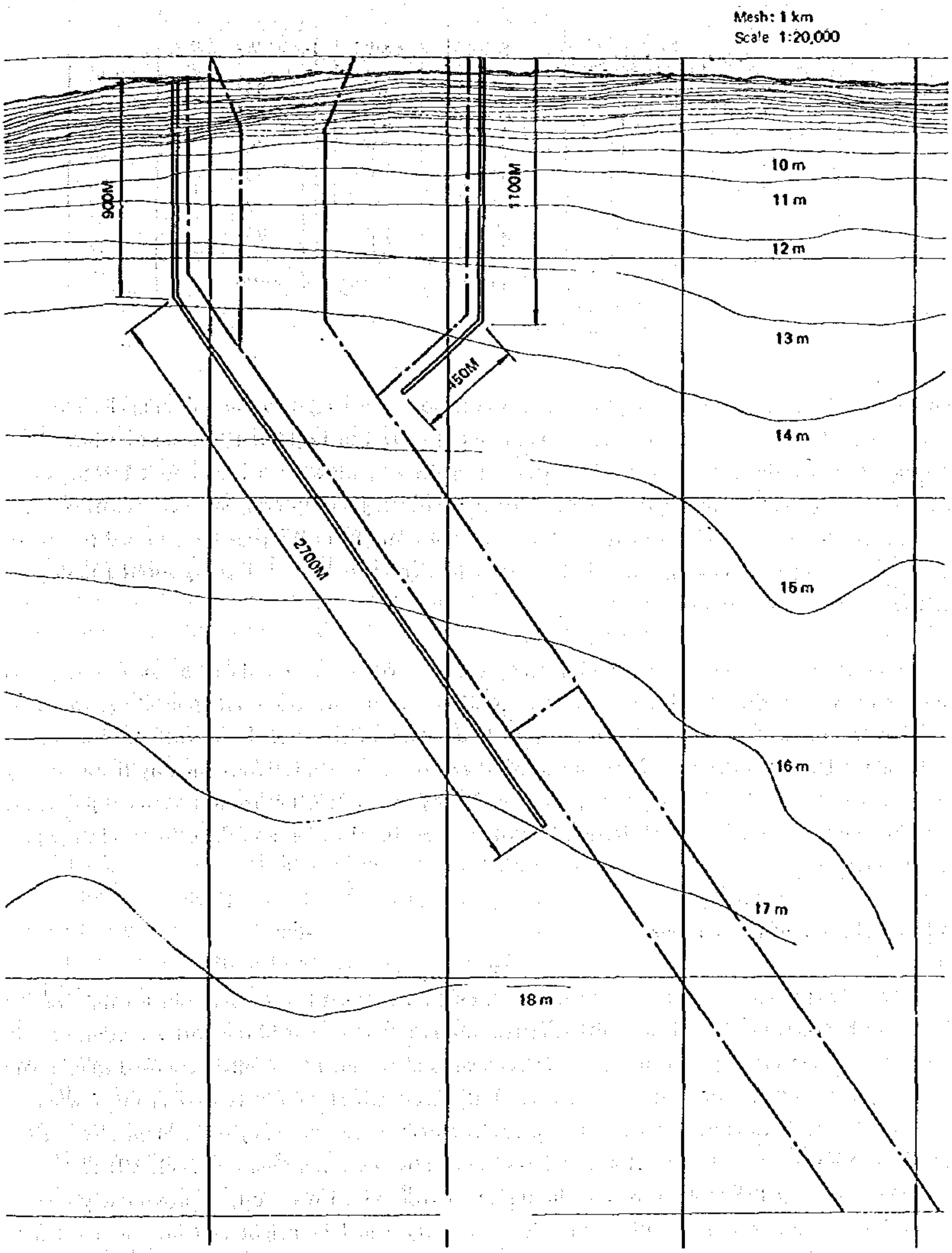


Table VII-3 Variation of Wave Direction at Different Sea Depth

Wave Dir. / h (meter)	S	SW	W
20	0°	26°	35°
18	0°	24°	32°
16	0°	23°	30°
14	0°	22°	29°
12	0°	20°	27°
10	0°	18°	25°

* Wave directions are shown by the angles to south direction
h : water depth

(dredged volume of waterway) and calmness in the port. Looking into the sounding chart around the construction site of the New Ocean Terminal as shown in Fig. VII-1, the contour lines swell to the offing on the east site. So, the water depth there is more shallow by about 1 m than that of the west. To reduce the dredging volume of the waterway, considering such change of contour lines, it is surmised the best to extend the west breakwater from the coastline in the direction of south by 900m, and to extend the breakwater further from that point, turning about 150 degrees in the east direction from north.

The calmness in the port is determined by the relativity of west and east breakwaters, and in the coast where the deepwater waves of south to west directions are prevailing, the west breakwater must be extended sufficiently long. The interval of both the breakwaters is determined by the functions of the port, and the entrance width is determined by the necessary waterway width. If the west breakwater is extended by about 2,700 m from the curved point, the east breakwater comes in the sheltering area of the west breakwater, and the calmness in the port can be secured.

VII-3 Calmness of the harbour

In order to examine as to whether sufficient calmness is kept of the harbour for the size and layout of breakwaters described in VII-2, distribution of wave height in the port was computed in respect to waves for every 16 bearings between SE and W and the results were used to estimate the frequency distribution of wave height at the west wharf of the central channel where a container berth is expected to be constructed. The occurance frequency of incident wave height to the port is shown on Table VII-4, which is obtained by the amendment of Table VII-1.

As shown by the table, waves in the direction from SE to W occupy approximately 85% of the total and the waves of other directions are very small in height and low in frequency. Accordingly, examination of the calmness in the port in respect to the waves in SE to W directions seems to be sufficient for our purpose here.

Table VII-4 Average Frequency of Occurance of Wave Height-Direction

Direction	Significant Wave Height (m)							Total
	0-0.6	0.6-1.2	1.2-1.8	1.8-2.4	2.4-3.0	3.0-3.6	3.6 plus	
SE	1.3	1.2	0.4	0.1	0.1	0.0	0.0	3.1
SSE	2.2	3.1	1.1	0.3	0.1	0.0	0.0	6.8
S	3.2	5.0	1.8	0.6	0.2	0.1	0.0	10.9
SSW	3.5	8.0	3.7	1.4	0.3	0.1	0.0	17.0
SW	4.0	11.3	5.6	2.3	0.5	0.2	0.1	24.0
WSW	2.7	7.0	3.6	1.5	0.3	0.1	0.0	15.2
W	1.5	3.6	1.6	0.6	0.2	0.1	0.0	7.6
Total	18.4	39.2	19.2	6.8	1.7	0.6	0.1	84.6

Since the influence of incident wave period on the distribution of wave height of the harbour is insignificant, the most frequent period of 12 sec is adopted in the computation. For computation of wave height in the port in respect to irregular waves, the program developed by the Port and Harbour Research Institute, Ministry of Transport, Japan was used.

Since the waves arriving at the proposed site of the New Ocean·Terminal are swells with small steepness as described in VII-1, the form of the directional distribution function of irregular waves was determined in considering the small wave steepness. Furthermore, since the irregular waves more concentrate their direction to the predominant direction, which is defined as the direction of most wave energy transmission, decreases, the increase in directional concentration was taken into consideration in selecting input conditions of computation.

The reflection coefficient of the wharf is assumed to be constant at 0.9 in assumption that wharfs in the port are all upright. As regards breakwater, the reflection coefficient of 0.9 is used for computation as the total length of rubble mound breakwaters is not so long.

Figs. VII-8 (a)-(d) are diffraction diagrams for wave directions of SSE, S, SSW and SW respectively. The values of the contour curves are the ratios of wave height in the port to incident waves. Since the computation is for irregular waves, the wave height ratios were computed as those of significant wave height.

As can be seen from these figures, wave height in the port decreases as the wave direction shifts from SSE to SW. This is because the sheltering effect of the west breakwater increases as the wave direction shifts toward SW. In the front of the wharf west of the central channel, the diffraction coefficient Kd decreases from approximately 0.25 in the wave direction of SSE to Kd = 0.10 in S and to Kd = 0.04 in SW. The diffraction coefficient falls to 1/6 with the change in wave direction from SSE to SW. Though it is not presented in a graph here, it further falls to Kd = 0.02 in W, but increases to Kd = 0.4 at SE. An increase in wave height at SSE along the west breakwater is not due to an increase in diffracted waves, but due to the reflection of waves by the breakwater.

Fig. VII-9 shows the occurance frequency distribution of wave height at the front of the wharf west of the central channel derived by the diffraction diagram in the wave direction SW

Fig. VII-8(a) Diffraction Diagram of Irregular Waves in the Direction of SSE

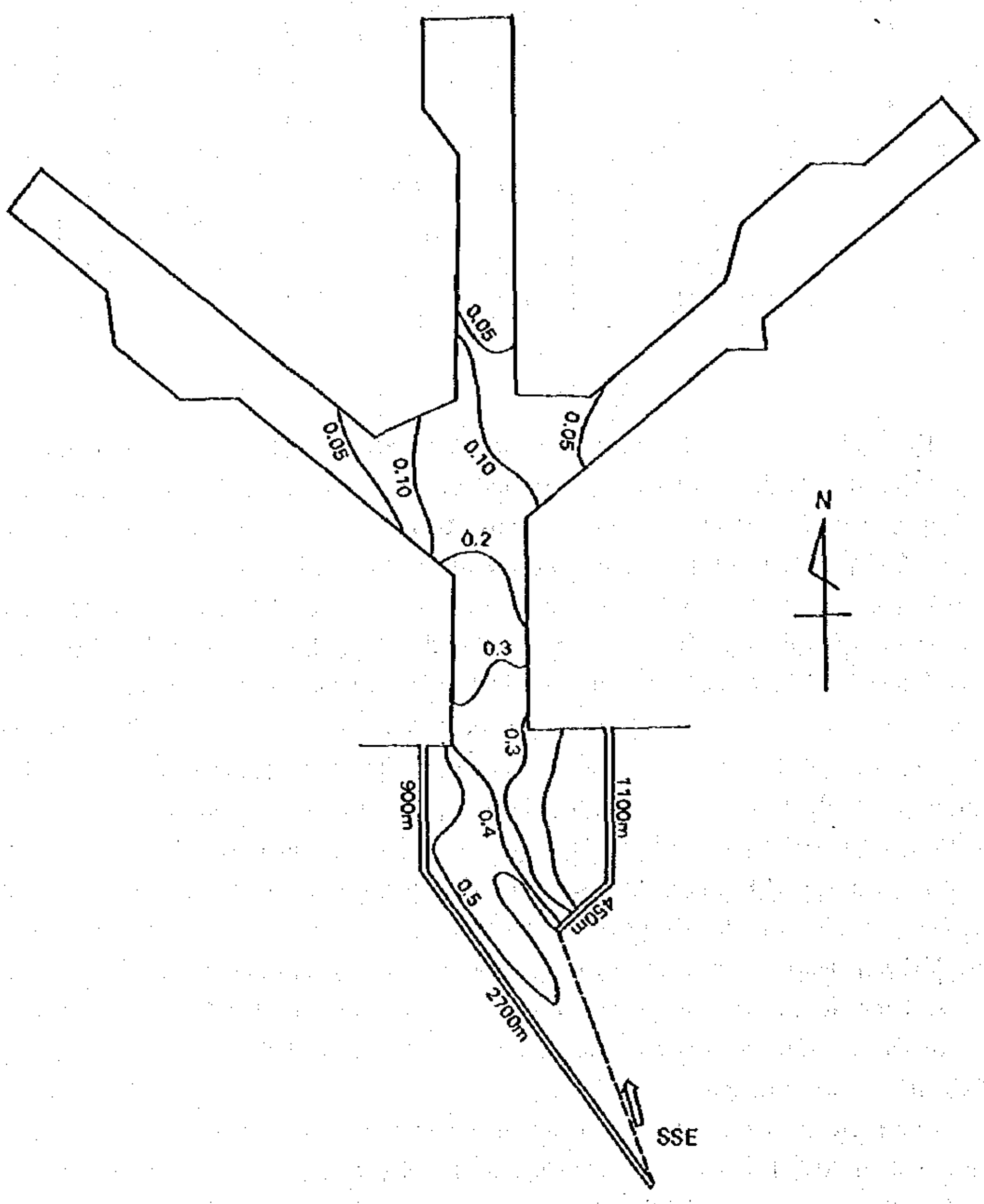


Fig. VII-8(b) Diffraction Diagram of Irregular Wave in the Direction of S

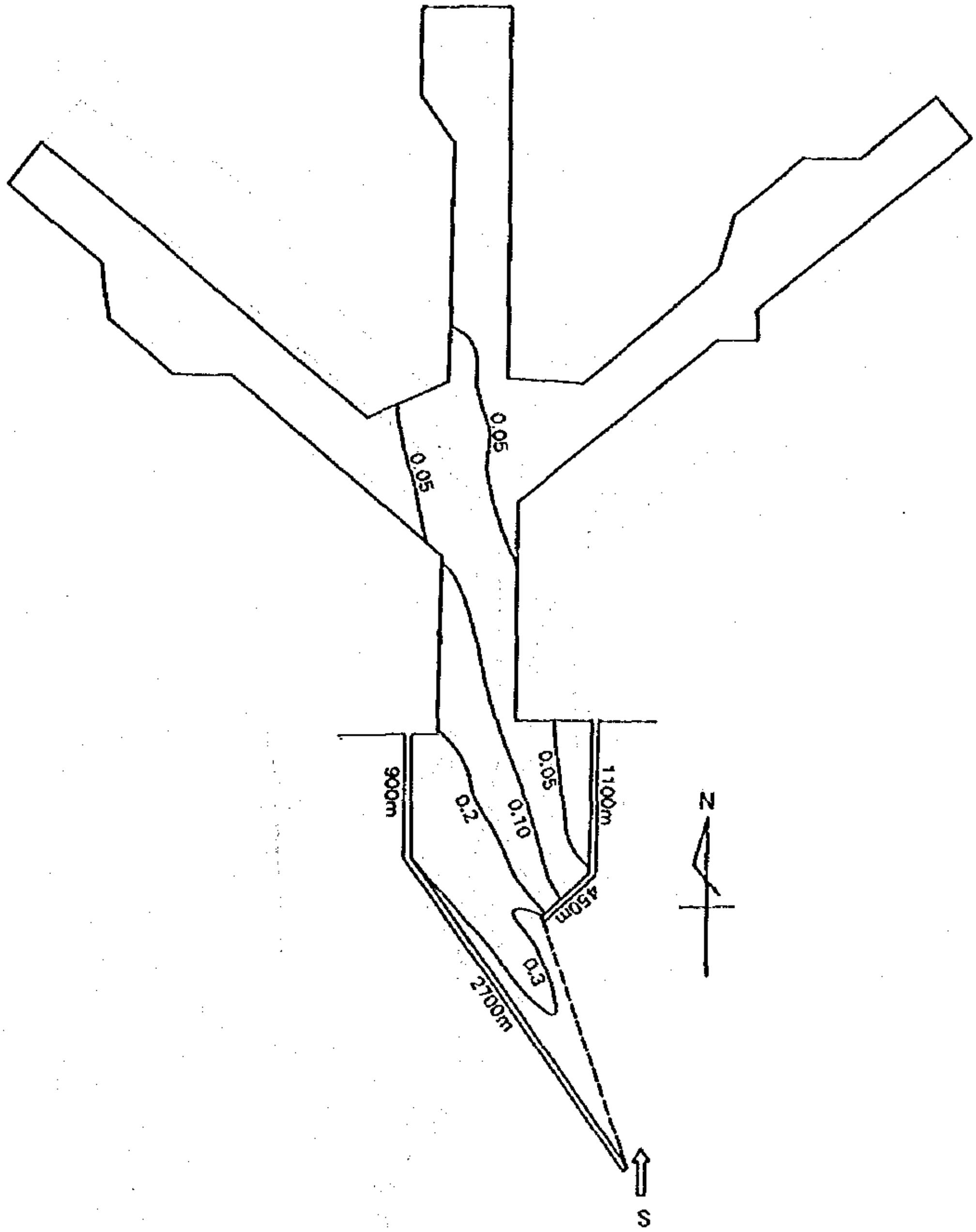


Fig. VII-8(c) Diffraction Diagram of Irregular Wave in the Direction of SSW

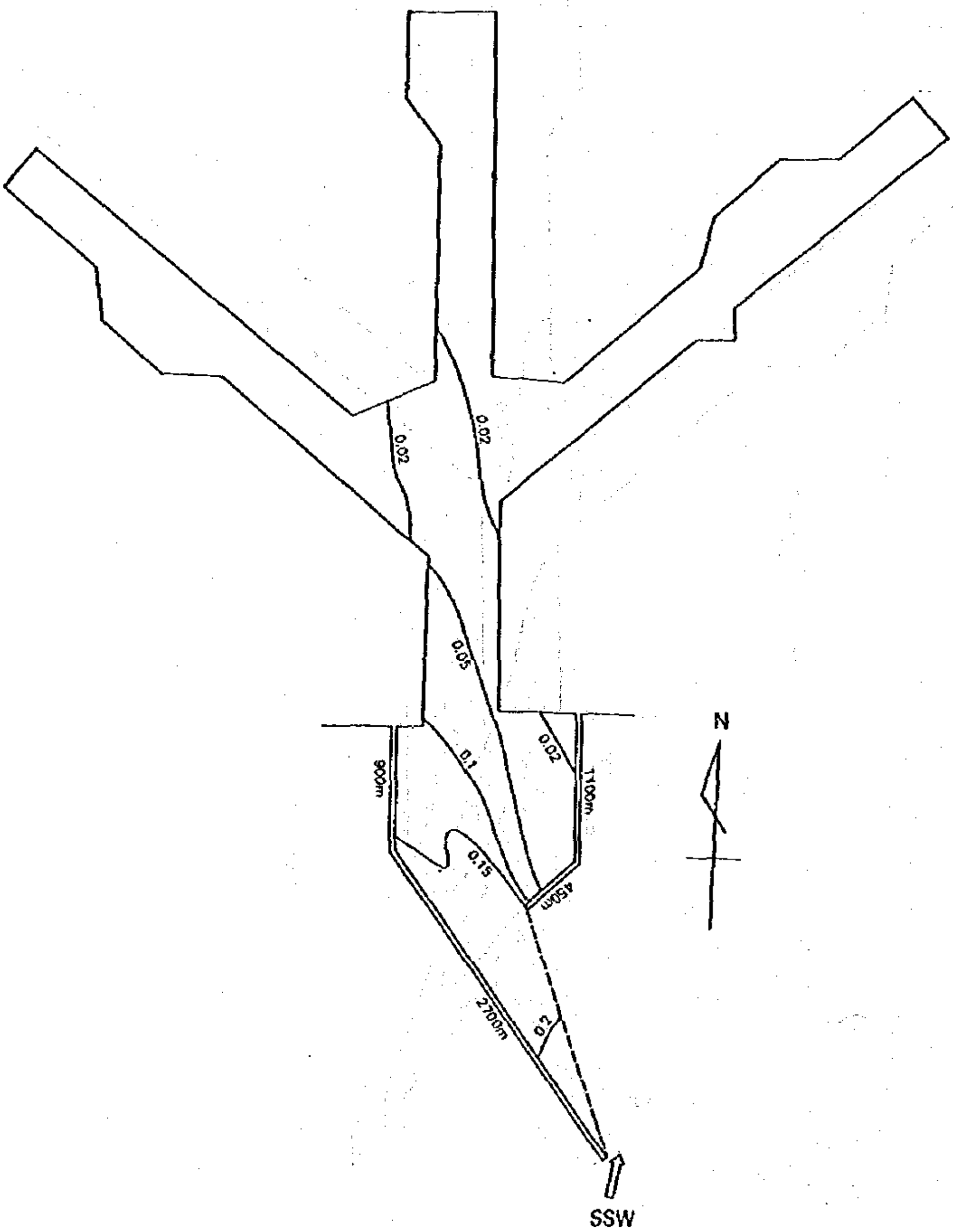


Fig. VII-8(d) Diffraction Diagram of Irregular Wave in the Direction of SW

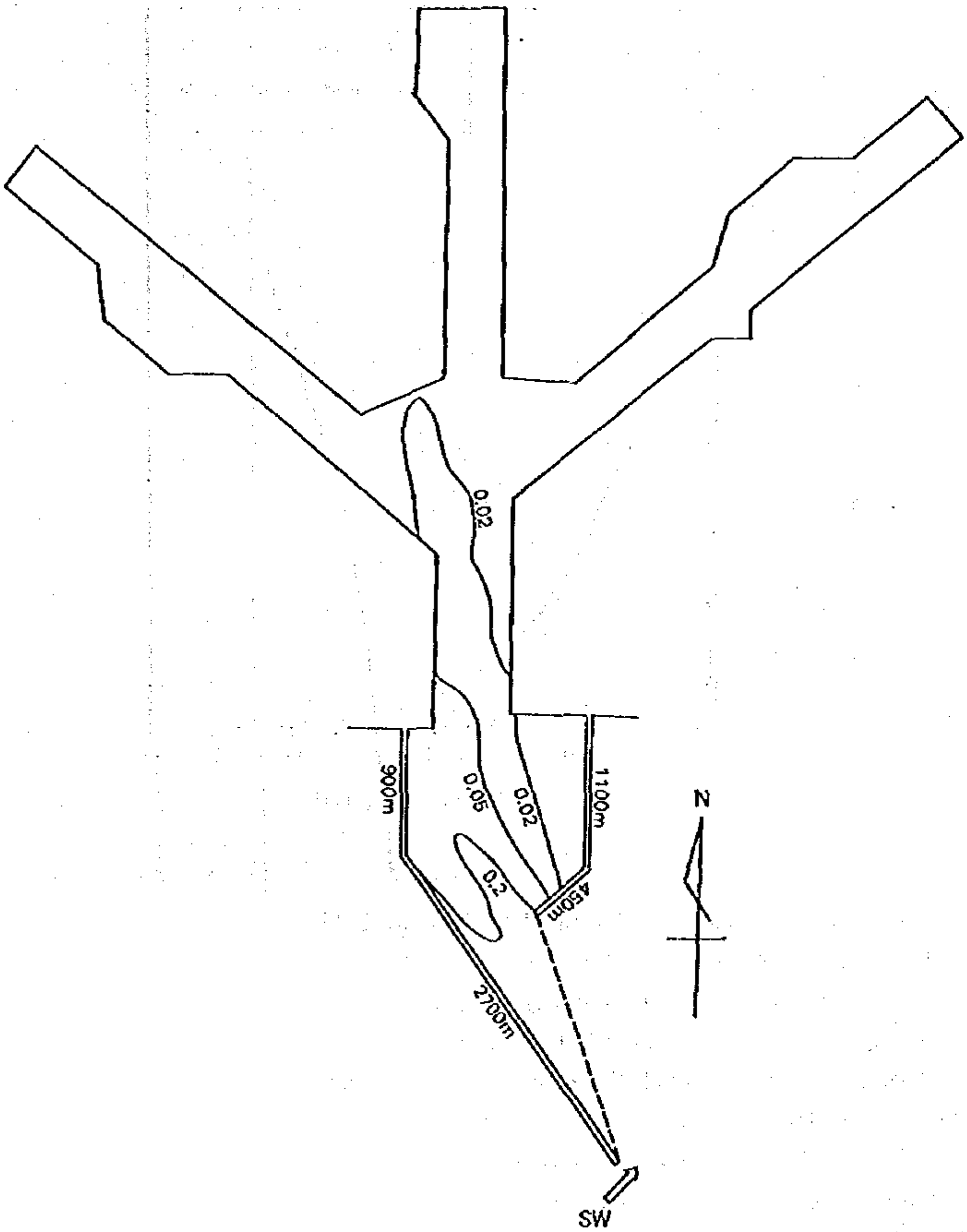
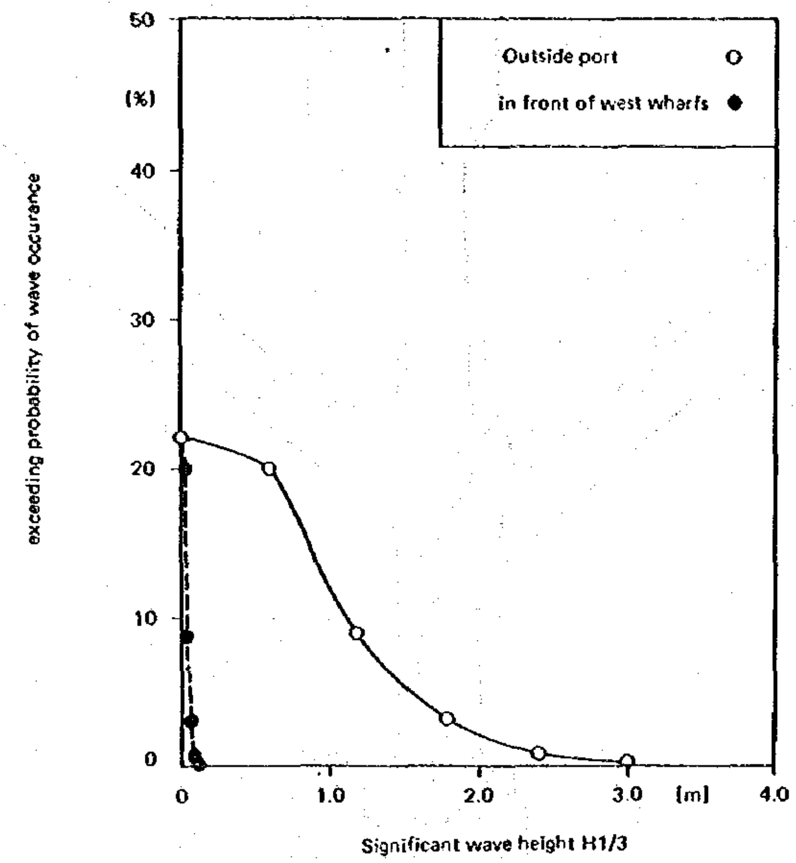


Fig. VII-9 Exceeding Probability for SW-Waves in front of the West Wharfs in the Central Channel

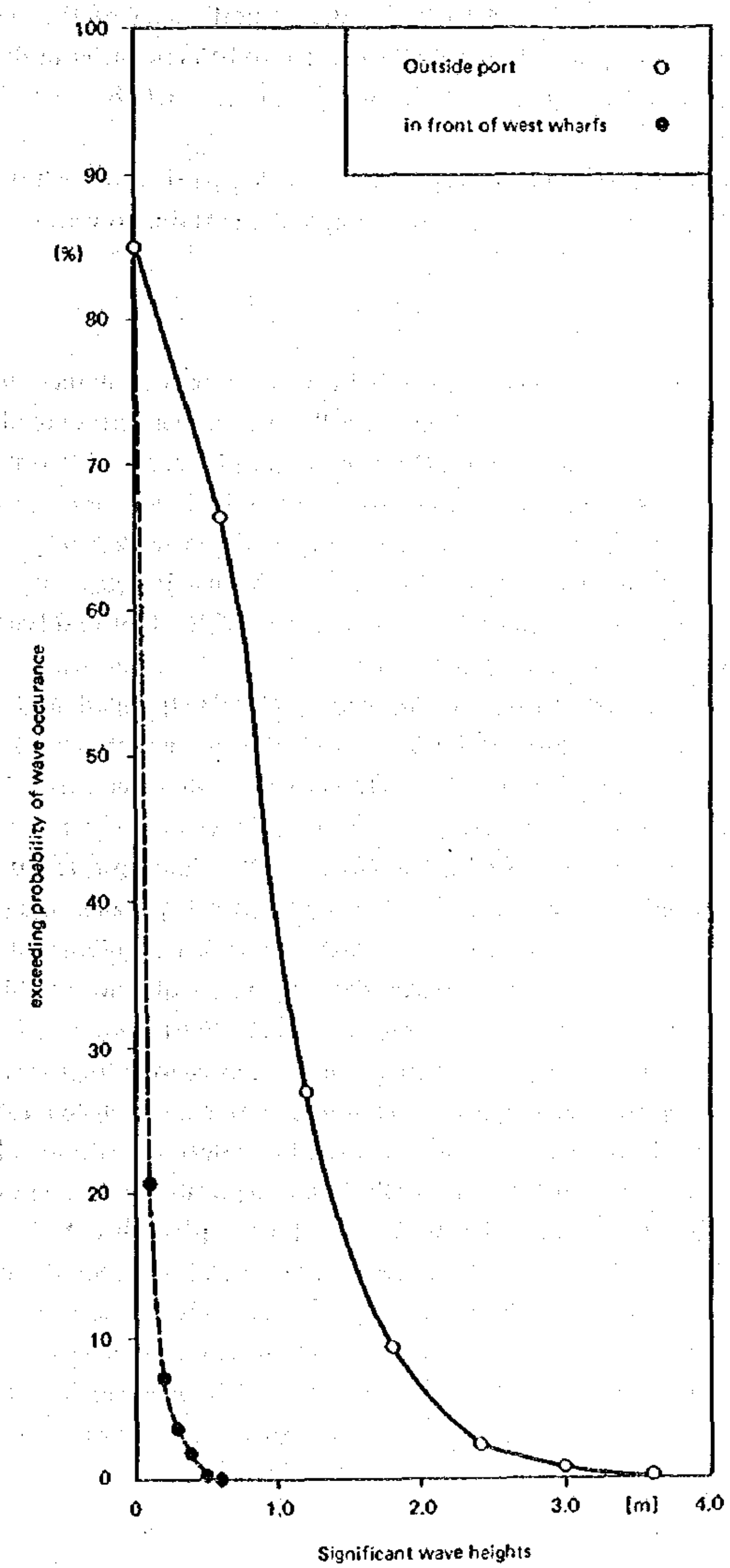


given by Fig. VII-8 (d). The ordinates denote the excess probability of wave height, probability of wave height exceeding those given as abscissas.

The solid line shows the excess probability of waves of the SW direction appearing outside the port calculated on the basis of Table VII-4, and the dotted line shows that of wave height at the wharf west of the central channel. It can be seen from the figure that the probability of the wave height exceeding 10cm for the waves of the SW direction at the front of the wharf is 0.5% and waves more than 10cm appear for only two days in a year. The waves exceeding 30cm are very rare in their occurance. Occurance frequency of port waves for wave directions SE-W may be obtained by combining the excess probability distribution in each wave direction from SE to W such as Fig. VII-9 in SW. The results are given as Fig. VII-10. The solid line denotes the excess occurance probability of waves outside the port and the dotted line gives the wave occurance probability at the front of the wharf west of the central channel.

As the figure shows, the appearance probability of the waves exceeding 50cm is only 0.4% at the front of the wharf concerned, or approximately 1.5 days per year. The ratio of the waves exceeding 30cm is 2%, or approximately 7 days per year. Since the wharf west of the central channel is planned to be used as the container berth, cargo handling is expected to be

Fig. VII-10 Exceeding Probability of Wave Occurance Infront of the West Wharfs in the Central Channel.



difficult for about 7 days annually in this area, if the maximum wave height for cargo handling is estimated to be small at 30 cm in respect to container vessels for which their oscillation due to waves should be avoided.

Our attention has so far been paid to the container berth west of the central channel. Judging from Figs. VII-8 (a)-(b), the calmness in is expected to be even better in the inner part of the port than at the container berth area of the central channel, because the diffraction coefficient is small there.

The above analysis has been made in respect to the waves passing through the enterance of the port and does not include resonanced oscillation inside the port due to waves.

VII-4. Channel siltation

The length of breakwaters was examined in light of securing the calmness in the harbour, but when the channel depth is as deep as -19m, with the dredged channel extended outside the armoring of breakwaters, the length of the breakwater must be examined also in light of preventing g the siltation of the channel by littoral drift. If the siltation is enormous, the dredging cost for the maintenance of the channel becomes high. In this case, the breakwater must be further extended to protect the channel from siltation. The channel dredging volume necessitated by littoral drift was simulated, using the calculation program of the Port and Harbour Research Institute, Ministry of Transport, Japanese Government.

The basic theory of the calculation was proposed by O.S. Madsen and W.G. Grant of MIT (Massachusetts Institute of Technology, U.S.A.), and though some modifications were made on the theory in the actual calculation, the base remains quite the same. The outline of the calculation theory is as follows:

From the water particle motion of small amplitude waves, shearing force at the bottom is estimated by using Johnson's theory, and if the shearing force is larger than the critical tractive force of shield, sand is assumed to be moved to fall in the channel. The volume of sand deposited in the channel is calculated by giving the appearance frequencies of wave heights, periods and wave directions per year as input data.

By using this computation program, calculation was carried out for the various median particle size and specific gravity of sand, and the results are summed up on Table VII-5. The appearance frequencies of deep-water waves are calculated by referring toTables VII-1 and VII-2, and the channel is assumed to be at −16.5m depth. However, in the calculated results on Table VII-5, the transformation of waves and the change of flow pattern and intensity by port structures, that is, influence of breakwaters, etc. were not taken into account, and the channel siltation only by incident waves was calculated.

Table VII-5 Results of Simulation for Shallowness in Ship-way at-16.5 m Depth

ρ	d_{50} (mm)	Us (m^3/m)
2.65	0.7	2.2
"	0.5	1.9
"	0.3	2.6
2.50	0.7	2.6
"	0.5	2.4
"	0.3	3.3

ρ : specific density of bottom material
d_{50} : median diameter of bottom material
Us : substantial volume of sediment

According to the calculation results, the substantial part of sand deposited in the channel amounts to maximum about $3m^3$ per year, and the volume of deposited sand becomes $5m^3$ at most even if the percent of void of sand is taken into account. Considering the channel width is as large as 350m, the channel becomes shallow by only about 1cm per year on the average. As the result, the channel siltation by waves can be out of consideration. However, the change of longshore current involved in the breakwater construction is not taken into consideration in this calculation. If this is taken into account, the channel siltation by become more severe, but this can hardly be grasped quantitatively with the present technology.

Fig. VII-11 shows the distribution of sizes of the bottom material collected off the construction site of the New Ocean Terminal. According to it, the median grain size at −13m depth is as large as 0.81mm, and that at −16m depth, as large as 0.74mm, and these are larger than the grain size of sand (about 0.5mm) at the bottom of the shoreline shown in Fig. VII-12. Considering this, the channel siltation by waves only can hardly take place at −16.5m depth.

Fig. VII-13 shows the comparison of the results of the depth surveys carried out in December, 1978 and July, 1979. December falls in the dry season and in a very calm period in wave conditions. July falls in the wet season and a period of high waves. Characteristics of sand movement are studied by comparing the results of depth survey conducted at periods of extremely different marine conditions.

The figure shows that in the areas deeper than −10m in depth the contour lines do not show any significant change though they have some discrepancy which may be within the range of error in depth survey. In the assumption that the grain diameter of the bottom material is 0.5mm and the wave steepness 0.005, the limit depth for sand movement on the surface of the sea bottom may be estimated to be −4.5m. This implys that in those areas deeper than −4.5m in depth the sand is virtually immobile. Accordingly, the results of depth survey show the very remote possibility of the channel being buried.

Fig. VII-11 Grain Size Accumulation Curves at Sea Depth of-13m and-16m.

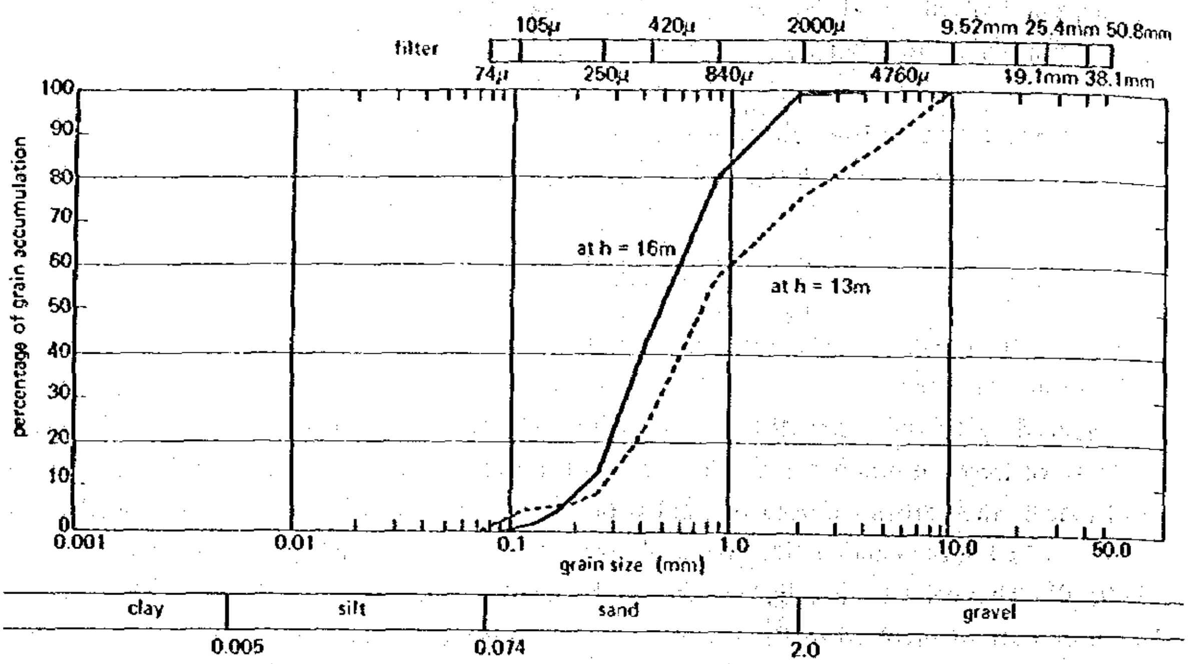
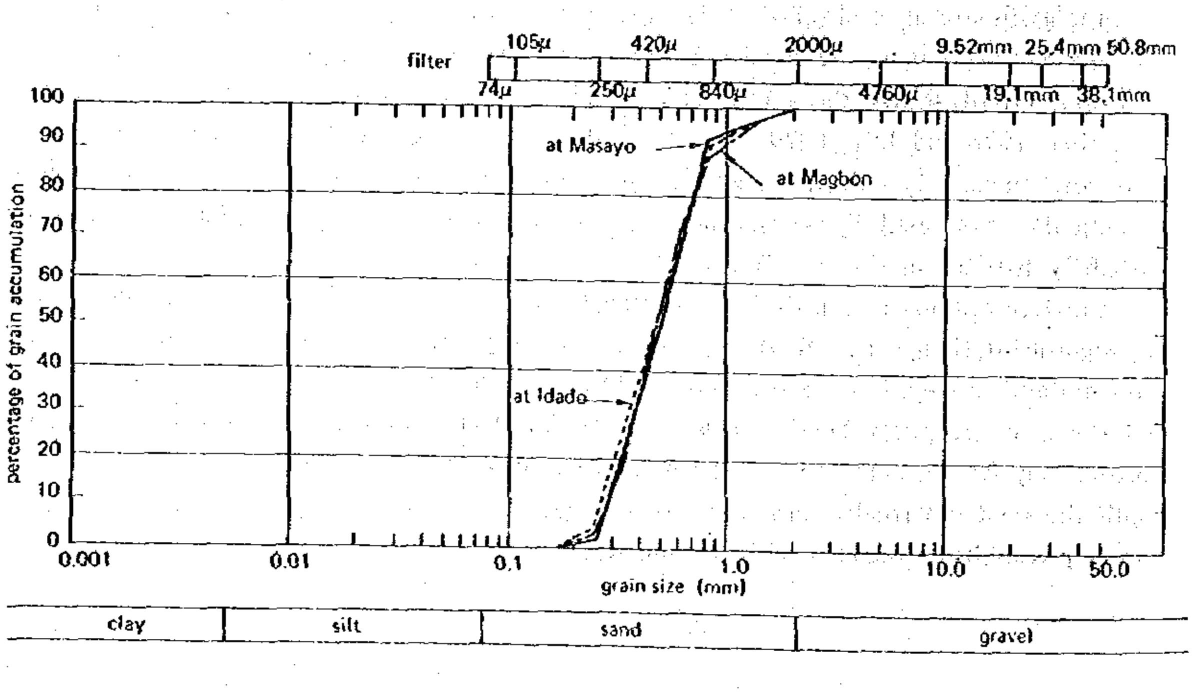


Fig. VII-12 Grain Size Accumulation Curves at Shores of Masayo, Idado and Magbon



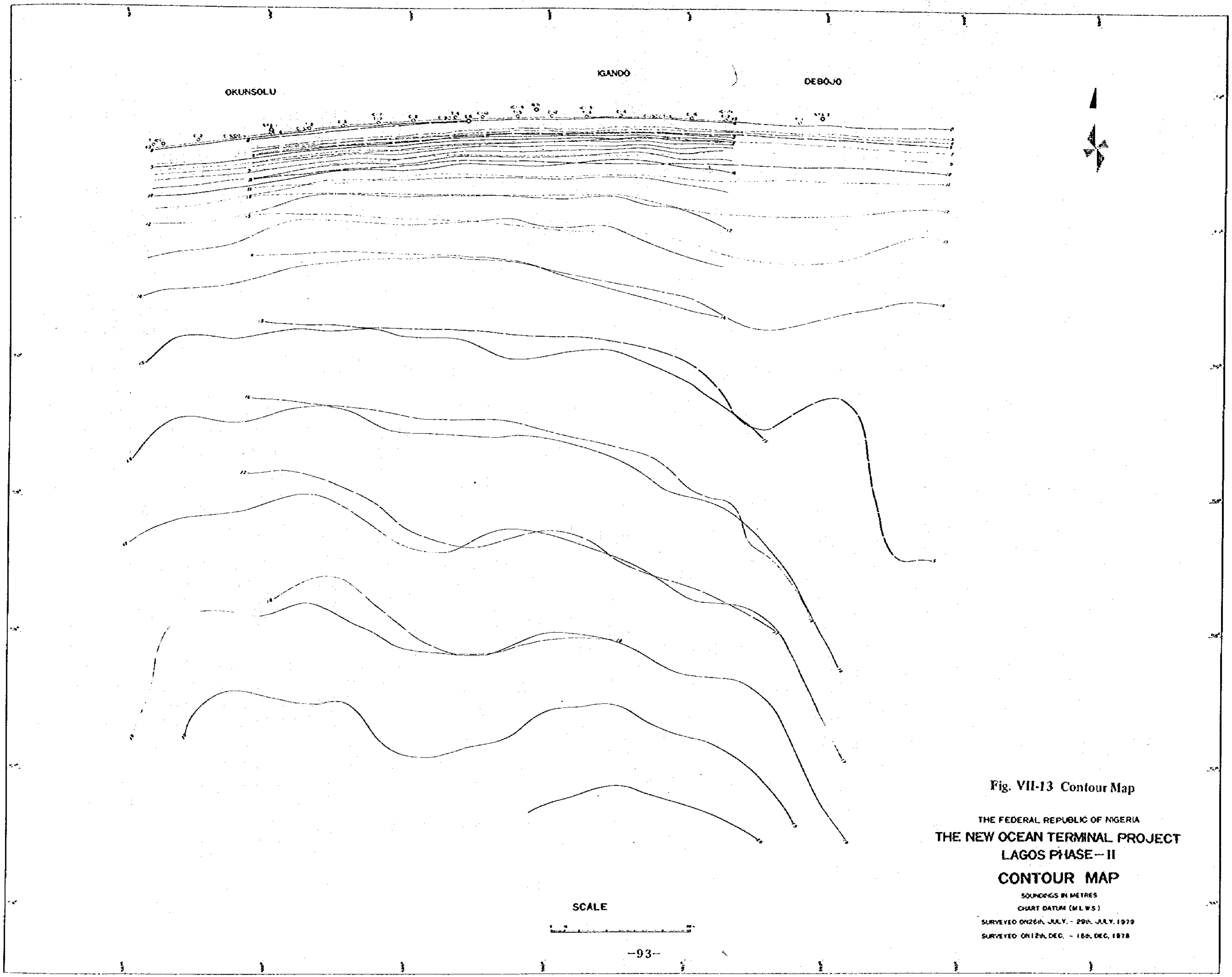


Fig. VII-13 Contour Map

THE FEDERAL REPUBLIC OF NIGERIA
THE NEW OCEAN TERMINAL PROJECT
LAGOS PHASE – II
CONTOUR MAP
SOUNDINGS IN METRES
CHART DATUM (M.L.W.S.)
SURVEYED ON 26th. JULY. – 29th. JULY. 1979
SURVEYED ON 12th. DEC. – 18th. DEC. 1978

VII-5. Counter erosion measures

If waves come in oblique direction to a coastline, longshore current occurs in the breaker zone, and the sand on the shore is carried in the direction of longshore current. The amount of sand moved depends upon the strength of the longshore current, and the strength of the longshore current depends upon the factors of incident waves. Waves with large height and long period are large in mass transport. Consequently, longshore current is intensified corresponding to the strength of mass transport. The direction of incident waves also changes the strength of longshore current. The larger the angle of incidence, the stronger the current.

According to investigation, the coastal area of the scheduled construction site of the New Ocean Terminal has the following characteristics.

a) The coastal area is monotonous, facing to the ocean.

b) The grain sizes of bottom materials are coarse, with median grain size of d_{50} = 0.5 mm as shown in Figs. VII-11 and 12.

c) The slope of the sea bottom is as steep as about 1/40 in the portion of less than −6m depth, and as gentle as about 1/1000 in the portion of more than that depth, as described in VII-13.

d) As shown in Table VII-1, about 80% of waves are in the directions of south to west in deep sea area, and particularly the wave of southwest directioh is predominant.

e) Incoming waves are swelling with long periods for wave heights. The predominant wave period is about 12 sec.

Fig. VII-14 shows the comparison of the sea bottom shapes on the survey lines in the coastal area with the characteristics described above, by referring to the results surveyed in December, 1978 and July, 1979. The number of the survey line on the figure corresponds to the position of the benchmark shown on Fig. VII-13.

Fig. VII-14 shows that the depth within the range of −3m~−13m become shallower compared with the figure obtained in December, 1978. This indicates an accumulation of sand there. That is to say, the sand near the shore line was removed in a rough season such as July, 1979 and a portion of the removed and was deposited in deeper areas. Then, the shore shows the feature of a storm beach.

The sand thus accumulated in the areas of −3m~−13m presumably moves toward the shore line during the calm dry season, restoring the sand beach to its previous condition. Fig. VII-15 shows clearly that the shore line receded in July, 1979 when the waves were rough.

Fig. VII-15 compares the cross-sectional forms near the shore line observed in December, 1978 and July, 1979. Judging from the verbal information obtained from the local residents along the coast that the sand beach returns to its previous condition during the calm dry season, the shore line receds and advances in a cycle of one year.

The wave characteristics on the coast near the proposed site for the New Ocean Terminal imply a considerable amount of littoral drift. In particular, in view of the fact that approximately

Fig. VII-14 Variation of Sea Bottom Profile at Calm and Rough Season

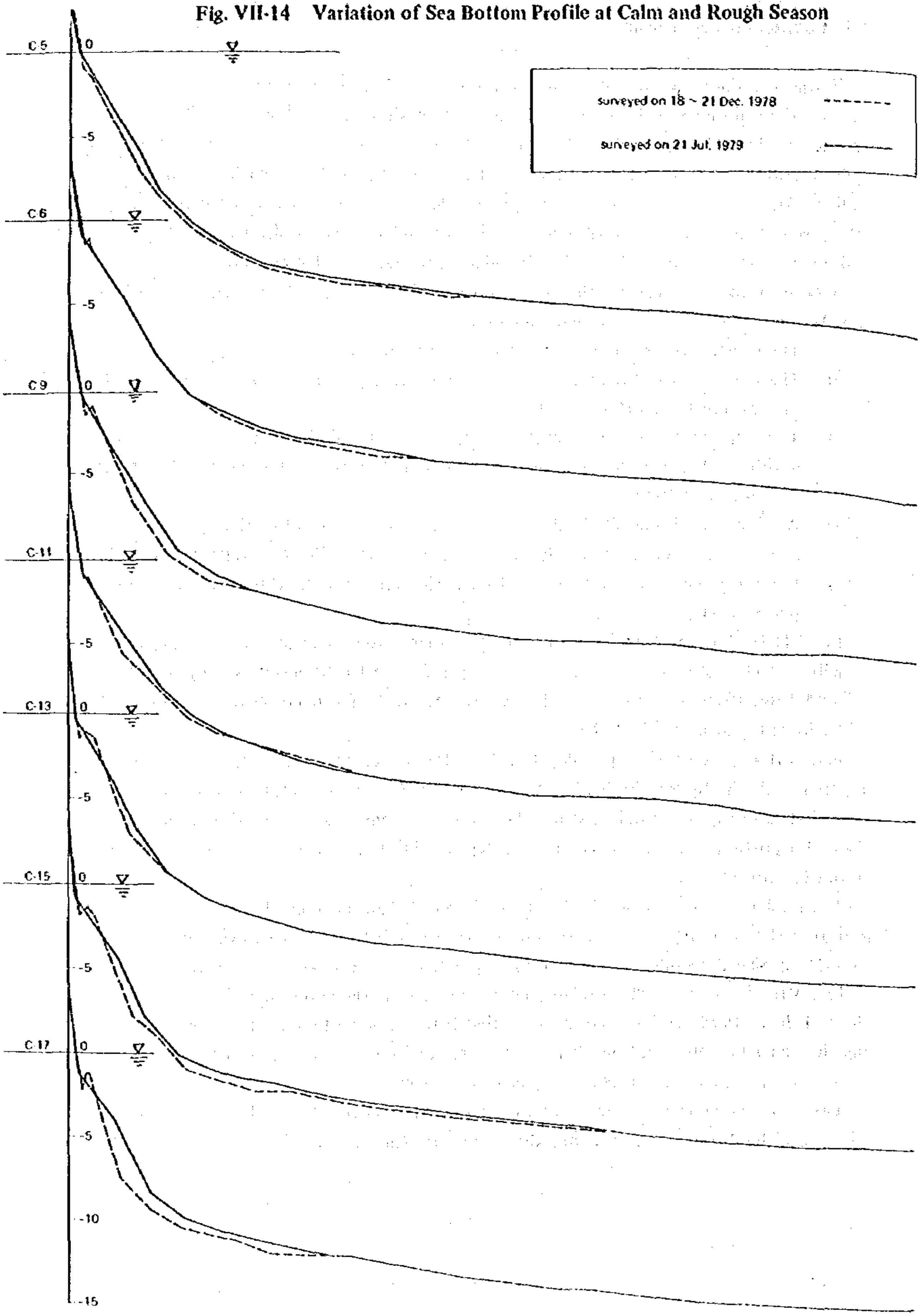
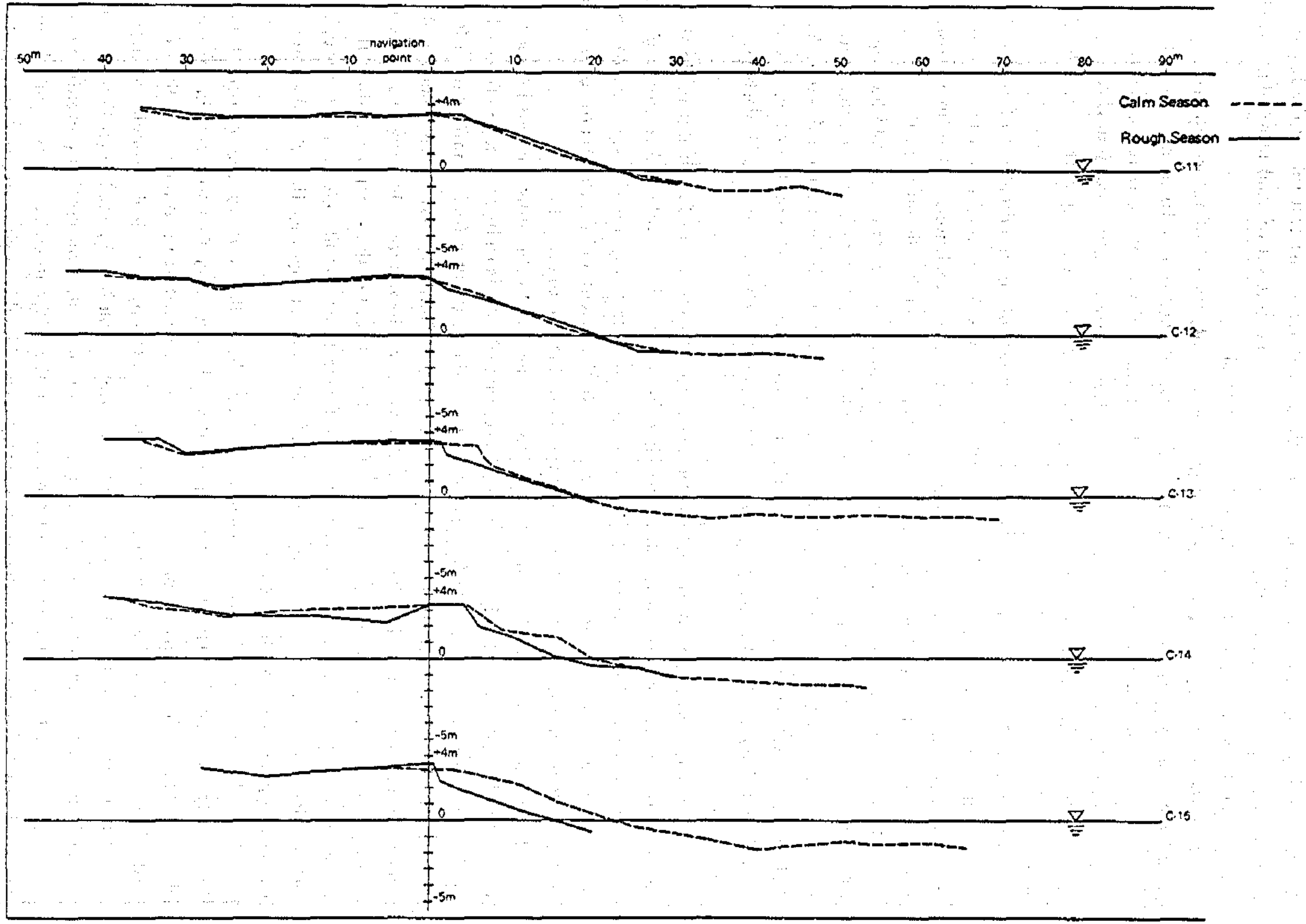


Fig. VII-15 Variation of Shoreline Feature at Calm and Rough Season



1,600,000m^3 of sand is deposited annually on Victoria Beach in the east side of the Lagos Port to prevent the recession of the shore line, roughly the same amount of sand movement may be expected at the proposed site for the New Ocean Terminal.

In order to ascertain the direction of sand movement, survey of the coastal current was conducted from July to August, 1979. The survey was carried out at 10 points shown by Fig. VII-16. The velocity and direction of the coastal current in the surbzone were derived from the positions of a float measured in a prescribed time interval. However, the float is devised in such a way that it is flowed by the bottom current Fig. VII-17 shows an example of the results of the survey.

The survey showed that the coastal current was invariably in the direction of east, and the current velocity was not particularly strong at 0.1–0.6 m/s. Wave height of over 2m with the period of approximately 15 sec. were estimated from the wave conditions at that time. However, the constant easterly direction of the current implies a considerable amount of drift.

The proposed site for the New Ocean Terminal show the coastal change and the condition of the coastal current as described above. According to our own experiences over a long period of time, however, strong scouring does not occur over the entire area behind the breakwater. As Fig. VII-18 shows, accumulation occurs on the side of wave entry and also on the other side in the area sheltered by the breakwater. Erosion occurs outside the sheltered area, particularly strong in some part.

Fig. VII-19 was obtained by applying the above to the New Ocean Terminal plan. That is to say, sand is expected to accumulate on the beach in front of the iron works and erosion begins on the beach in front of the refinery. However, since this is only a qualitative estimate based on experiences, an accurate estimate cannot be made as to the extent and the section of advance due to accumulation or the extent of recession of the shore line due to erosion.

Though simulation method may be applied as a means of estimating changes in the shore line, it has been developed only recently and leaves some doubt as to its accuracy in forecast. Its application is difficult in accurate forecast of the shore line without sufficient information.In the application of the simulation, if the past changes of the shore line have been ascertained by survey, accuracy in forecasting changes of the shore line will be improved by using the input data modified so as to re-create the past change of the shore line. On the other hand, since there is hardly any observation data which may be used for forecasting shore line changes at the proposed site for the New Ocean Terminal, any estimate of shore line changes by the valuable simulation can not stop short of a qualitative estimate.

In order to forecast possible changes in the shore line due to the construction of breakwaters for the New Ocean Terminal plan, it will be necessary first to ascertain changes in the shore line in the vicinity of breakwaters by constructing a test breakwater and then to estimate shore line changes after completion of the breakwaters by the valuable simulation method.

Since it is clear that the beach east of the breakwaters will be subjected to erosion in view of the direction of incident waves, it will be necessary to carry out some erosion prevention works. Judging from the fact that over 80% of the waves on the Nigerian coast comes from S-W directions with the SW direction predominant showing a considerably high degree of directional concentration, it seems appropriate to install a revetment to be fronted by wave absorbing works and also to install jetties of 50m each at an interval of 100m for the purpose of preventing erosion.

Fig. VII-16　Observation Points of Literal Current in Surf Zone

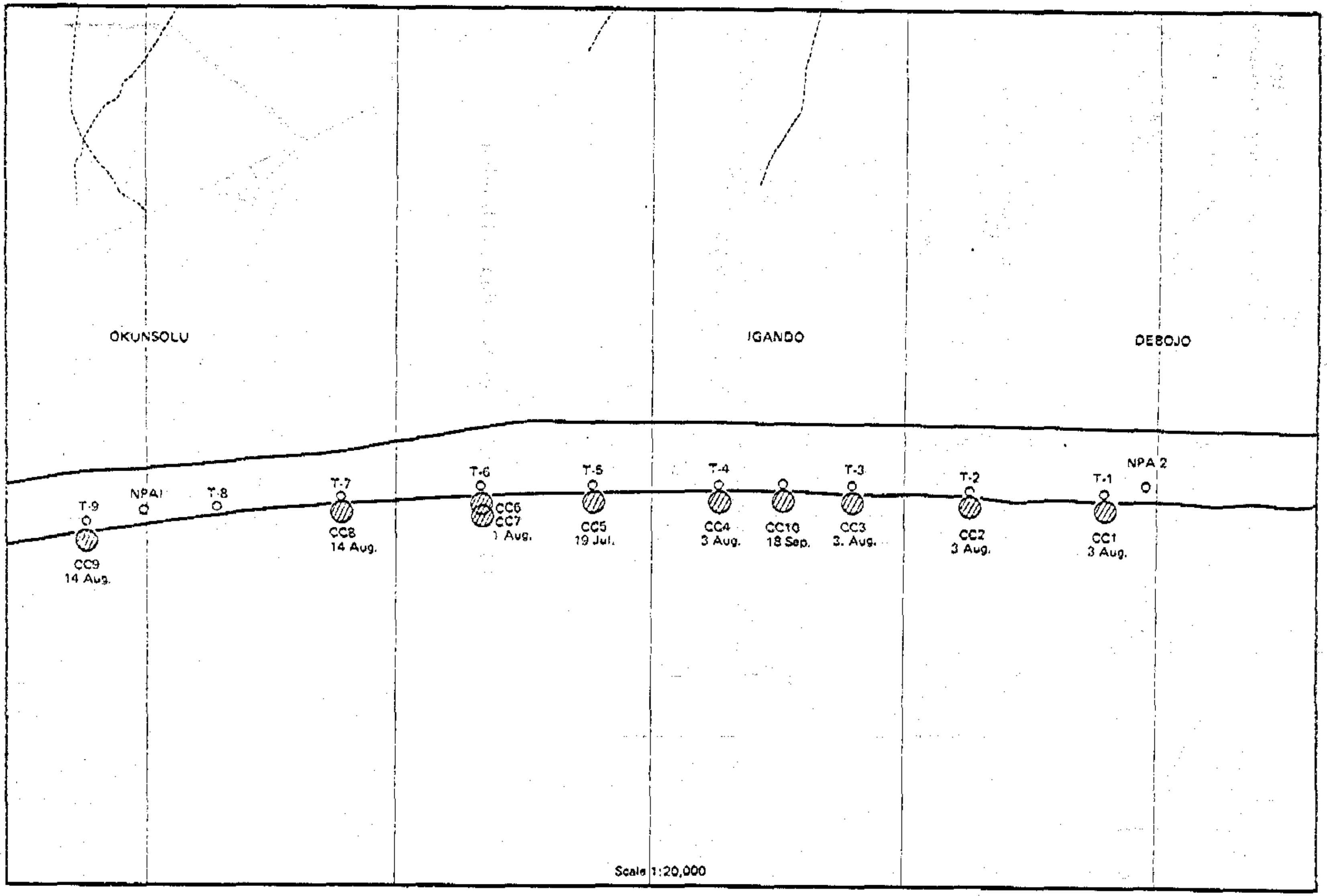
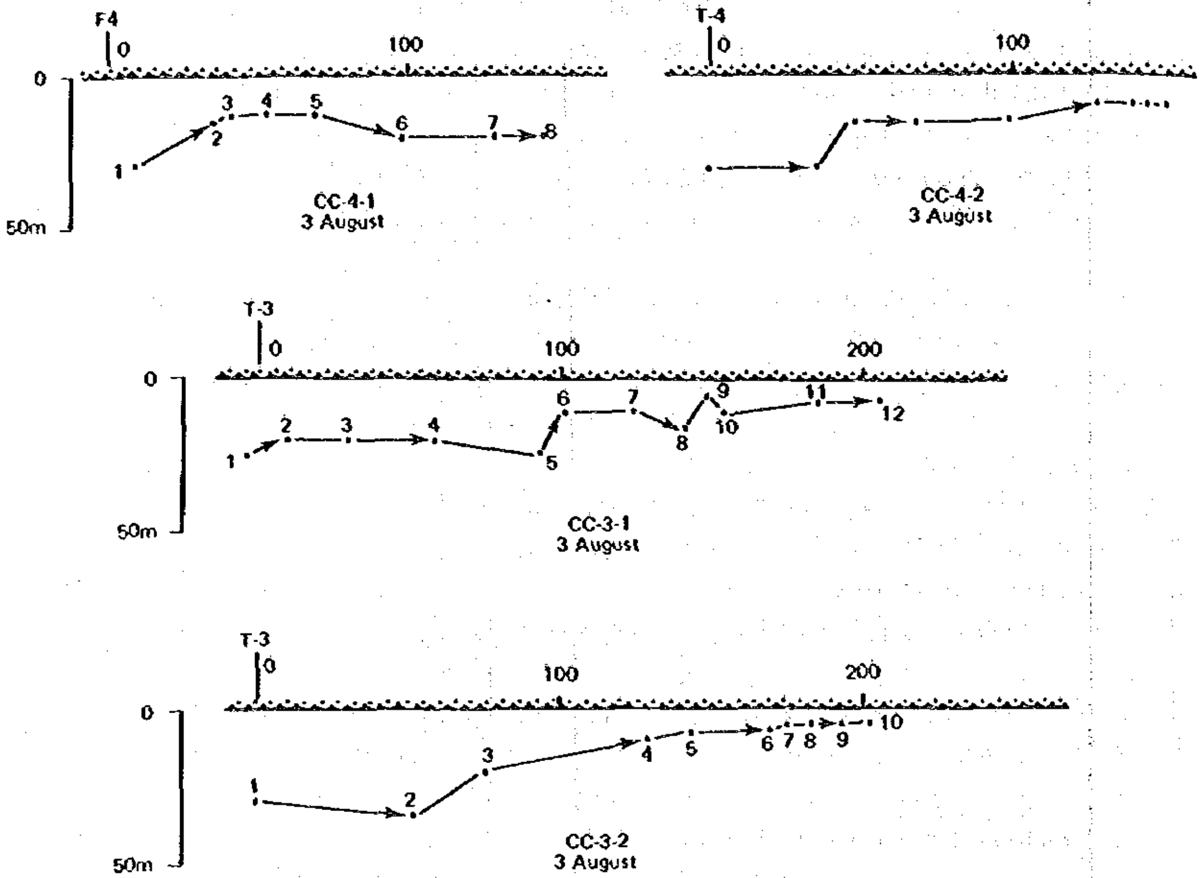
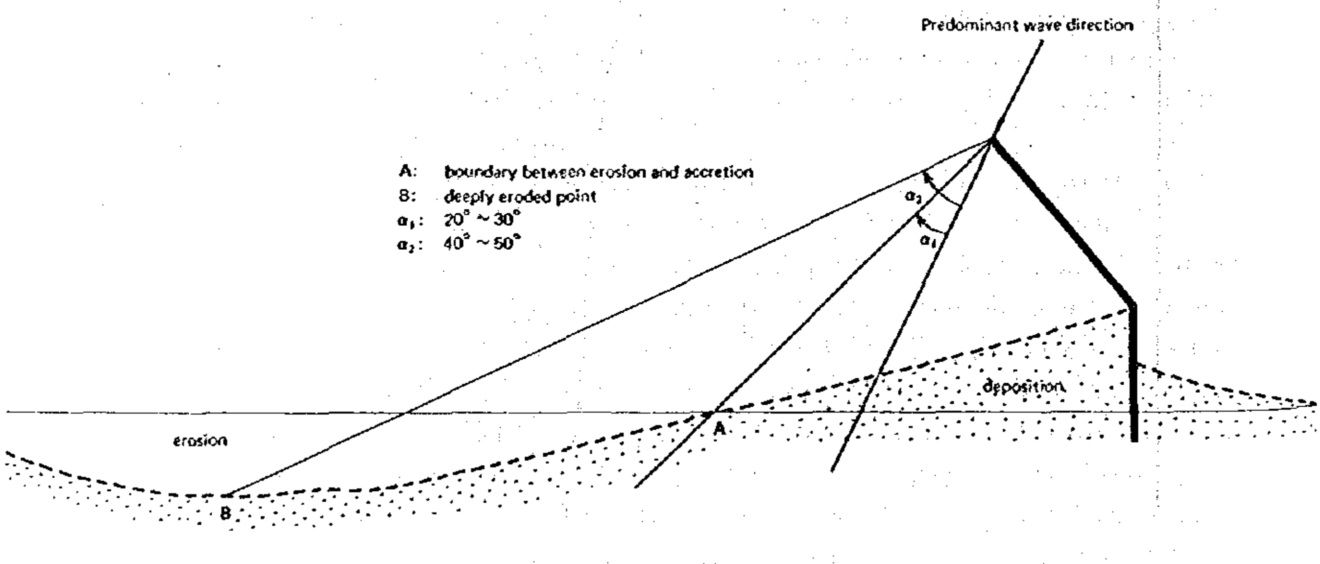


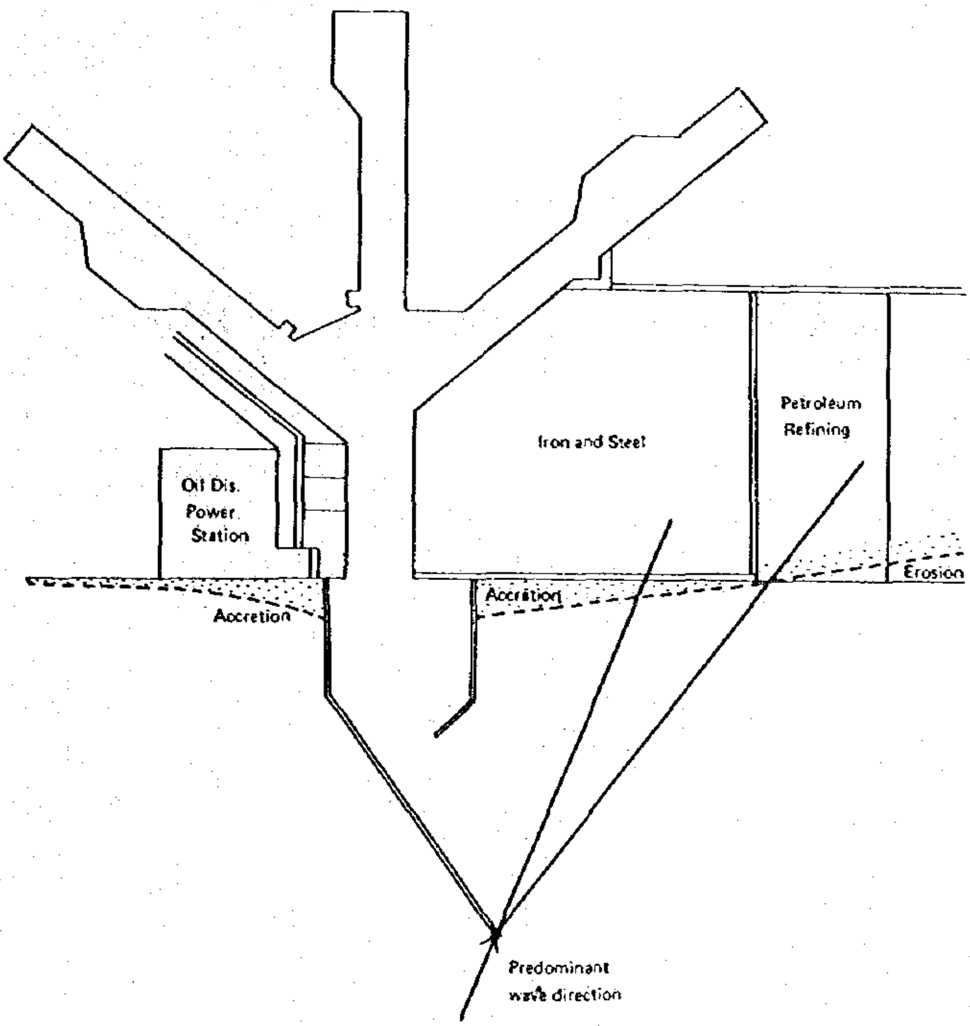
Fig. VII-17 Float Movement due to Littoral Currents



VII-18. Coastal Area of Accretion and Erosion



VII-19. Estimated Variation of Coast-line after Construction of Breakwaters.



VIII. Layout of channels and basins

VIII. Layout of Channels and Basins

VIII-1. Channels

VIII-1-1 Principles

The following principles were laid down based on the basic concept of the layout of the various functions for the New Ocean Terminal raised in Chapter III:

1) Three intra-harbour channels with one harbour entrance are excavated towards the land area (Fig. VIII-1 shows the layout of the channels).
2) The Entrance Channel is located taking account of the predominant wave direction and minimization of dredging work.
3) The width of the channel is planned for two-way traffic.
4) The areas for the future expansion of 1 km of the commercial port facilities are reserved at the end of the West, North and East Channel.

VIII-1-2 Scale and layout of the channels

(1) Entrance Channel

The Entrance Channel is planned to run along the West Breakwater and to be 100 meters out from it. The length of the channel is approximately 5,600 meters (ordinarily, it runs from the original water-front, to the point where dredging is not necessary, that is, usually until the natural water depth is sufficient to allow the largest arriving ship with loaded draft to enter.)

A two-way traffic channel is generally planned to be as wide as the length of the largest ship passing through, in the case of light traffic.

In the case of the New Ocean Terminal, the largest projected ship is a 150,000 D.W.T. class ore-carriers (overall length 300 – 320 m). As can be understood from the number of vessels entering the harbour, which is given in Table VIII-1, the annual number of ore-carriers is 85. Therefore, the frequency that these ore-carriers pass by each other in the channel is low. Considering the above points, the width of the Entrance Channel is planned to be 350 meters.

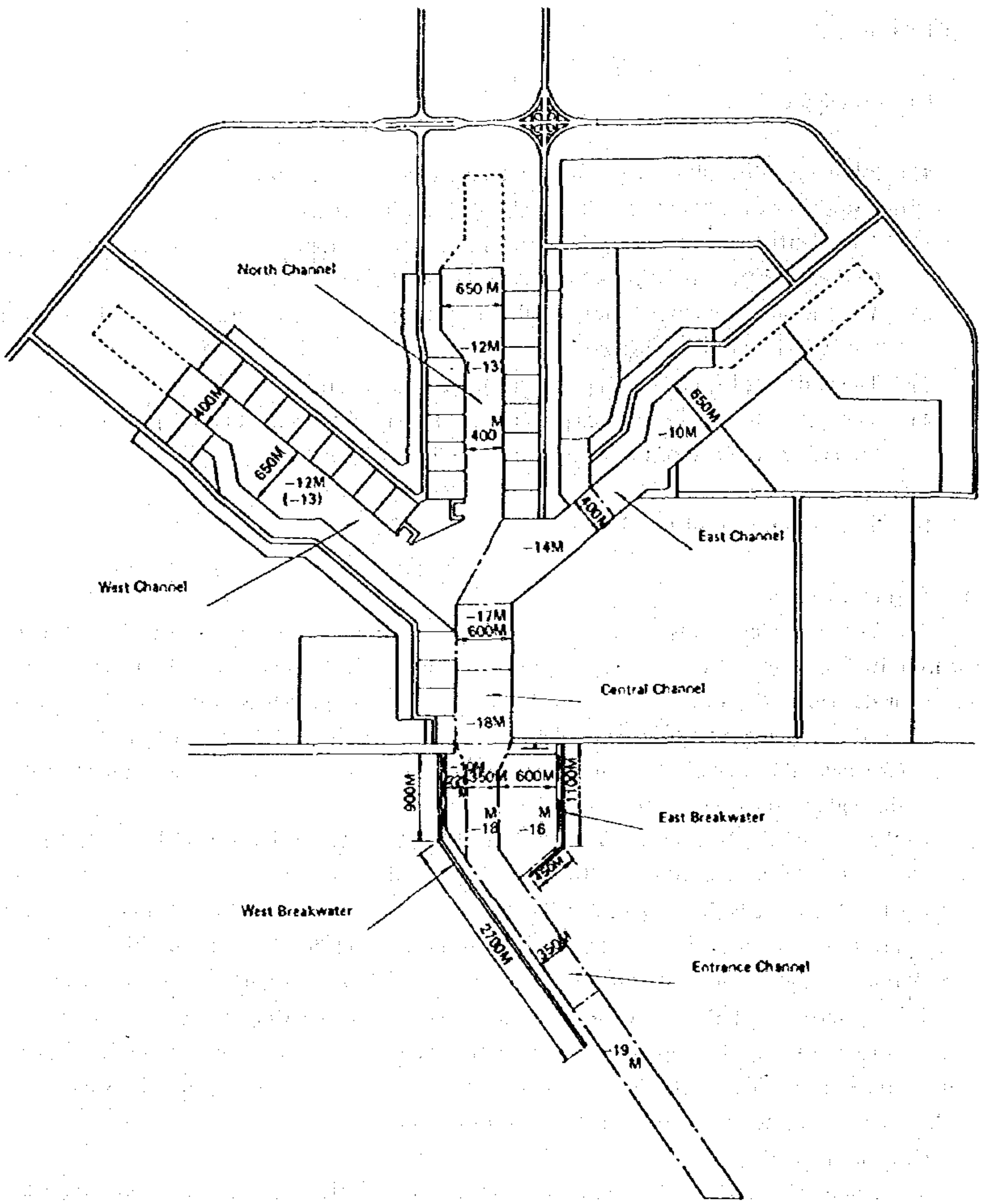
Taking account of the loaded draft of the largest projected ship, the Channel depth is 19 meters before reaching the tip of the West Breakwater and 18 meters on the inside. Since the channel outside the breakwater is exposed to waves, one more meter of under-keel clearance is needed to compensate for the ship's movement in the waves.

(2) Central Channel

The length of the Central Channel is approximately 1,600 meters running from the edge of the harbour entrance (original water-front) to the West, North and East channels. There are one grain berth and 3 container berths situated on the west side of the channel and on the east side 2 iron ore berths, 1 coal berth,and 1 limestone berth. This channel has the second largest ship traffic; following the Entrance Channel, and large ships will be moored along both sides.

Ordinarily, even in this case, the channel with 450 meter width, which consists of 350 meters width of the two way lanes and 100 meter (50m x 2) width of the mooring basin of each side, would be sufficient for the traffic. But the width of the Central Channel is made 600 meters

Fig. VIII-1 Layout of Channels



taking into account the need for to another turning basin besides the Central Basin. The water depth of the channel is 18 meters around the harbour entrance and 17 meters in the interior.

(3) West Channel

The West Channel is 3.8 km long and branches off from the Central Channel at a 130° angle to the northern side of the harbour. On both sides of the channel are a total of 11 container berths and 18 break bulk berths. The width of the channel is to be 400 meters for a 500,000 G.T.

Table VIII-1 Number of Vessels at the New Ocean Terminal: One Way Traffic

Facilities	Kind of Cargoes	Number of Vessels
Commercial Port Facilities	Containerized	1,350
	Break Bulk	1,980
	Grain	27
	Petroleum Oil Products	540
	Sub Total	3,897
Industrial Port Facilities	Iron Ore	85
	Coal	56
	Limestone	38
	Iron & Steel Products	324
	Crude Oil	236
	Refined Oil	180
	Crude Salt	30
	Petrochemical Products	160
	Grain	20
	Ship Repair	180
	Sub Total	1,309
Total		5,206
Port Facilities for Future Expansion		1,000
Grand Total		6,206

class container ship with a total length of 240 – 250 meters and mooring basin on each side. The water depth of the channel is 12 meters (in the future, according to the necessity, 13 meters) made to fit the maximum draft of container ships.

(4) North Channel

The North Channel stretches out straight northward from the Central Channel and is 2.7 km long. There are a total of 13 container berths and 5 break bulk berths positioned on both sides of the channel. Same as for the West Channel, the width of the channel is planned to be 400 meters and the water depth 12 meters (or 13 meters).

(5) East Channel

The East Channel branches away from the Central Channel in a north-eastern direction at an angle of 130° and has a length of 4.2 km. This channel, in contrast to the North and West channels which have commercial port facilities on both sides,is primarily for serving the industries located there. An iron and steel export wharf with 9 berths, a petrochemical products and raw material wharf with 6 berths, a ship repair wharf with 3 berths, a grain wharf with 1 berth and a break bulk wharf with 10 berths are positioned on both sides of the channel. Among the ships berthing these wharfs, the grain carriers are 60,000 D.W.T. class vessels, but the rest are 15,000 D.W.T. class ships. Compared with the other two channels the shipping traffic is light as well. Accordingly using the same standards as for the West and North Channels, a channel width of 300 – 350 meters could be thought of as sufficient for the time being, but anticipating the expansion of the industries to the northeast it was planned to have the same 400 meter width as the West and North Channels. The water depth of the channel, from its branching-off point to the end of the grain wharf is 14 meters (to match a 60,000 D.W.T. class grain carrier) and the rest of the channel interior to the grain wharf is 10 meter depth to fit 15,000 D.W.T. class ships.

VIII-2 Basins

The principles on the plan for the New Ocean Terminal call for providing sufficient port facilities to cope with future demands for goods distribution and large ships; it is not premised on the assumption that long waits for berths will become necessary as a result of an insufficiency of the port facilities. The New Ocean Terminal is not a lighterage port. Accordingly, inside the New Ocean Terminal there is no need for common anchorages and mooring basins for waiting or lighterage operations. So, only the basins to be used for ships' navigation could be enough.

Basins consist of mooring basins in front of the wharf, and turning basins. The scale of a mooring basin varies according to the method of mooring and unmooring, but taking the maximum figure for the width (The length at right angles out from the mooring facility), a width 1.5 – 1.8 times the total length of the largest projected ships is necessary. But this figure is for the case when a ship is moored at the quay under her own power without tugboats. So, it is not necessary to keep such a wide area for the mooring basin in the case of using tugboats.

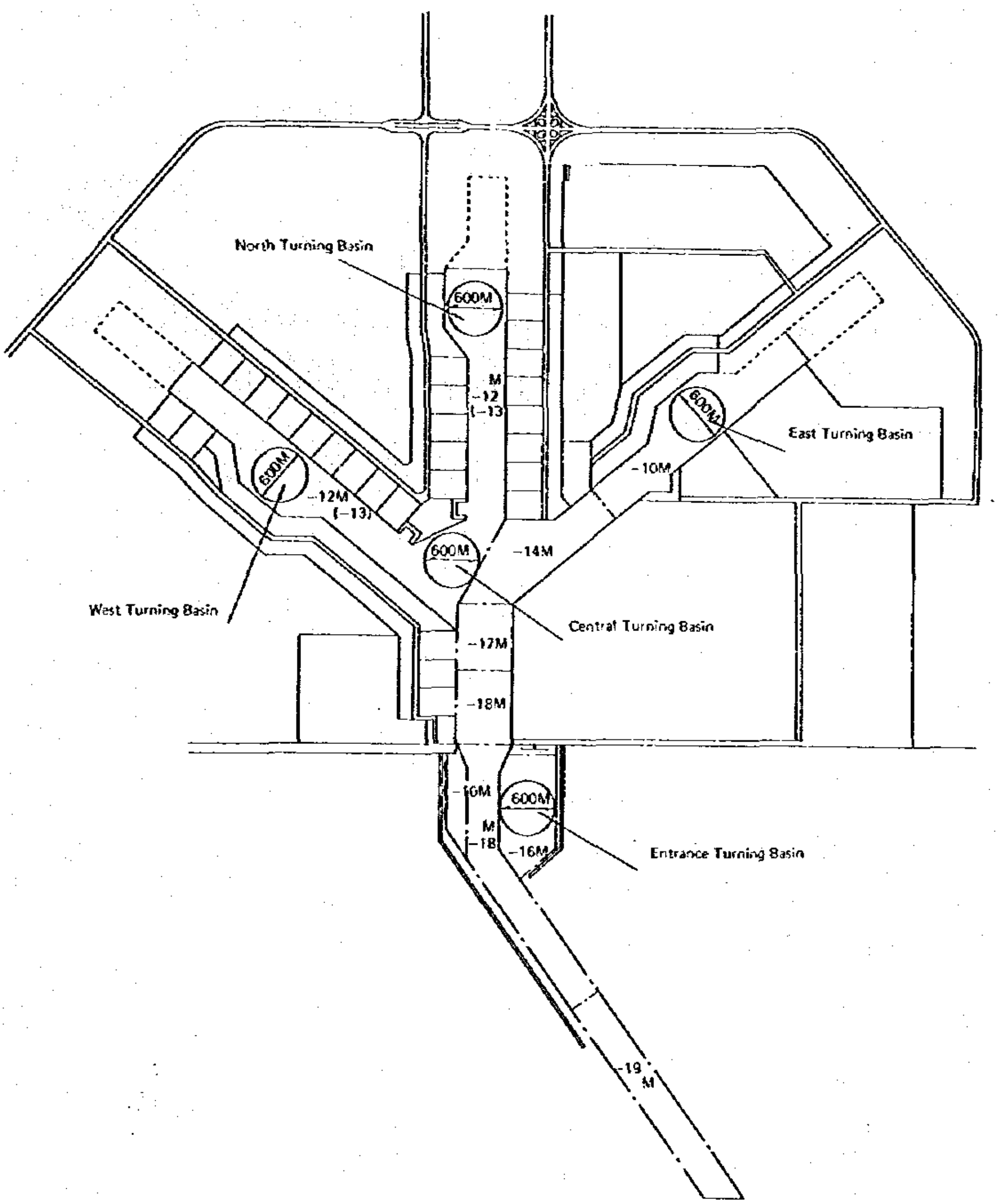
Here, it is sufficient to think a width of mooring basin as 50% of the total length of the projected ship in terms of the standard for a place protected from wave and wind. Yet, in this case, if tugboats are used, there is no need to set up this kind of mooring basin independently of the channel; it is quite all right to share the use of a channel with ship navigation use. Based upon the above way of thinking, it can be said that it would be sufficient if a 50 meter wide water surface in front of all of the New Ocean Terminal's mooring facilities is added to the ship's navigation channel.

In case like the New Ocean Terminal, where the channels are long and extend relatively deeply into the interior of the harbour and, moreover, it is not planned for separate mooring basins in front of each of the berths, turning basins become necessary at appropriate places. Fig. VIII-2 shows the scale and layout of turning basins. Setting the length of the projected ship for each of the turning basins at 300 meters, the area to be used as a turning basin comprises of a circular space, the diameter of which is twice the total length of the projected ship. The Central, West, North and East Turning Basins are positioned for multipleuse with navigation channels, but there is a low probability for turning ships to meet through traffic. With proper navigation control safety can be sufficiently guaranteed.

The Entrance Turning Basin is located just inside the harbor mouth and is used by tankers (crude oil – 100,000 D.W.T., refined oil – 50,000 D.W.T.), together with as a place for the short-time temporary anchorage of ships when they must wait out confusion in the harbour occuring in the event of a collision or something.

Ordinarily, when ships enter the harbour under their own power, they must keep up a certain level of speed in order to counter the effects of wind and waves outside of the protection of breakwaters. For this reason, the length of the channel (from the edge of the protection zone of breakwaters up to the mooring basin) should be five times the length of the projected ships (a distance sufficient to permit stopping). Here, by "the edge of breakwater protection zone", we

Fig. VIII-2 Location of Turning Basins



mean from the beginning point of the water area where the necessary degree of calmness is ensured as a result of protection of breakwaters. Also, ordinarily the speed with which ships enter the harbour is said to be 6 knots.

Because, in the case of the New Ocean Terminal, tankers (100,000 D.W.T.) going to the crude oil berth have a length of 285 meters, the required stopping distance is 285m x 5, or 1,425 meters. The distance from the head of the breakwater to the entrance mooring basin is planned to be 2,000 meters to enable ships to stop by the time they reach the entrance mooring basin.