REPUBLIC OF CHINA

REPORT OF TAICHUNG HARBOUR CONSTRUCTION PROJECT

JUNE 1970

GOVERNMENT OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of the Republic of China, decided to undertake a series of surveys for the Taichung Harbour Construction Project and entrusted the implementation of these surveys to the Overseas Technical Cooperation Agency.

The Agency organized a survey team comprising nine specialists in various fields and headed by Mr. Yonekichi Yanagisawa, a Permanent Advisor to the Agency, and sent the team to the Republic of China for field investigations during the period from December 10, 1969 to January 29, 1970.

The prime objectives of the survey were to formulate a master plan for the harbour project for the construction of a new commercial port situated in the middle of Taiwan's west coast and to conduct various investigations required for planning on installation project and related city planning projects, all of which were aimed at coping with the increasing volume of cargoes in foreign trade following the rapidly growing economy of the country.

Thanks to the unlimited cooperation of officials of the Government of the Republic of China, the survey was carried out smoothly and a report of the survey is now complete for presentation.

Nothing would be more gratifying than to see the report serves as a means to contribute to the promotion of foreign trade as well as regional development and economic growth of the Republic of China.

Finally, I would like to take this opportunity to express my appreciation and gratitude to the officials of the Government of the Republic of China for their support and cooperation extended to the survey team and for making the survey mission a success.

June, 1970

K. Tatsuke

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

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Comments on the Taichung Harbour Construction Project

The survey team for the Taichung Harbour Construction Project has the pleasure to announce that the report of the survey has been completed and is now ready for presentation. At the same time, the team ardently hopes that the report serves as a means of early realization of the Taichung International Port.

The survey for the new international port construction project was inaugurated in August 1968 in response to the request of the Government of the Republic of China. From the comprehensive point of view with regard to the economic growth and regional development of Taiwan, the survey team recommended Wuchi situated in the middle of Taiwan's west coast for the site of the new port. After making a careful study of the recommendation, the Government of the Republic of China made a final decision in July 1969 to select Wuchi as the site of the new harbour. Upon this, the team carried out a survey necessary for Taichung Harbour construction project.

In compliance with the request of the Government of the Republic of China, the activities of the survey team were aimed at formulating a master plan for the Taichung Harbour Construction Project. The team made an estimate of construction cost of the project and made studies on various problems that had to be solved for the effective and successful implementation of the project.

As stated in the report in detail, the emphasis in formulating the master plan was placed on the project up to 1980 on the assumption that the volume of cargo handled by the commercial port would reach 8 million tons by that time in consideration of vigorous economic activities in Taiwan. It is necessary, therefore, to make a restudy at a later stage on the prospect of future economy.

For the realization of this project, the following points should be given immediate attention by the Government of the Republic of China.

Firstly, in view of the urgent need for opening the Taichung Harbour an efficient system must be established in order to accelerate construction work and at the same, basic surveys for detailed engineering such as topographic, sounding and geological surveys as well as observations and experiments of littoral drift must be carried out as early as possible.

Secondly, in order to undertake this gigantic project and complete it within a shortest possible period, there must be a suitable system established for the promotion of construction work. The most important of all would be the availability and effective utilization of the able staff and required manpower. As other important projects are also in progress for other harbours, there may be difficulties in securing required personnel. However, in view of the scale of the project which offers a rare opportunity for leveling up the nation's technical standards, efforts should be made to secure required personnel and make effective use of them in each stage of the construction shcedule.

Thirdly, though it is conceivable that the execution of the entire project is undertaken by foreign contractors in view of the urgency of the project, there are many aspects in which the domestic technologies could be effectively applied. It is considered more appropriate economically and also from the standpoint of upgrading the level of domestic technologies to ascertain the availability of domestic technologies first and then rely on the foreign technology for the portions which cannot be handled by domestic engineers.

In addition, the shifting of the existing telephone system to the dial telephone system for intra-city communication in conjunction with the Taichung Harbour Construction Project is not only important for communication during the construction work but also is indispensable for the commercial port to fully demonstrate its functions. The dial telephone system will also serve as an effective means of promoting the establishment of industries in the reclaimed area and accelerating the development of the region.

Lastly, of the problems associated with the urbanization of the hinterland of the Taichung Harbour, the ones that require an immediate solution are the drainage of rainwater and the development of Mt. Tatu. It is recommended that preparations and arrangements be made at the earliest opportunity for the implementation of these projects.

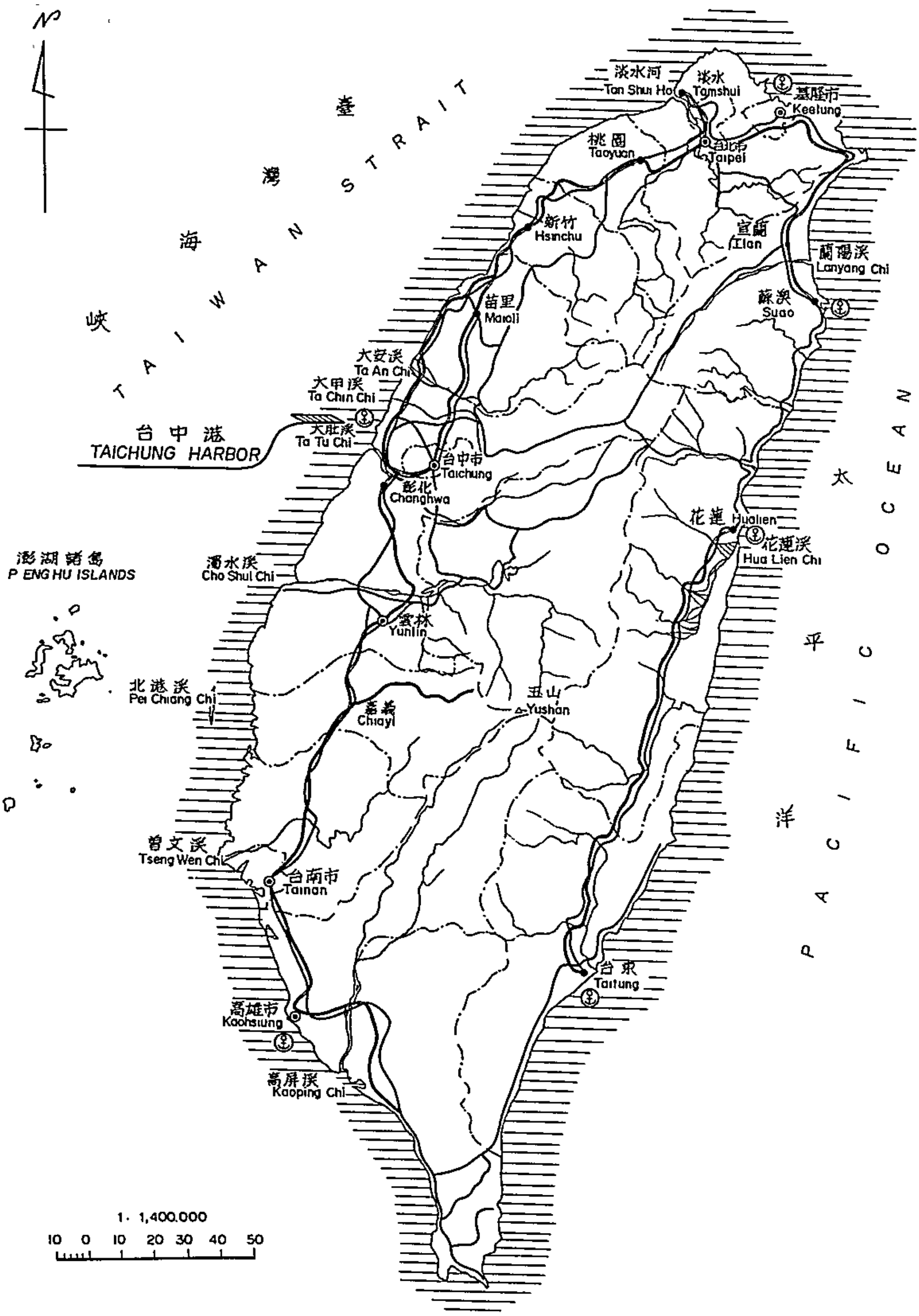
This report consists of seven parts and the outline of the project is given in Part II, "General Description". Part III and the rest of the report, dealing with the detailed discussions in respective aspects of construction provided necessary information, data and drawings and give the process and results of surveys as well as recommendations based thereon.

On behalf of the survey team I would like to express my heartfelt thanks to the Government of the Republic of China for their unlimited cooperation extended to the survey team in the preparation of the report.

June, 1970

Y. Yanagisawa

Yonekichi Yanagisawa
Chief of Survey Team
for the Taichung Harbour
Construction Project



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I INTRODUCTION

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1. Purpose of Survey

The only international commercial ports in operation in Taiwan at present are Keelung, Kaoshiung and Hualien. With the recent rapid economic growth of the Republic of China, the volume of cargoes handled by these ports is increasing steadily and the lack of port facilities is causing constant piling-up of cargoes at harbours.

The ports of Keelung and Kaoshiung, in particular, are facing an urgent need for the expansion of their capacity and as a result, construction work is being carried out vigorously in the two ports to augment the present port facilities. However, the expansion of the port of Keelung, the only international commercial port in northern Taiwan, is limited mainly due to its geography and there will be no more room for additional expansion of the port after the completion of the present Four-Year Project which extends up to 1972.

Consequently, in order to cope with the growing volume of cargoes in the future, there must be another international commercial port constructed at the new location. For this reason, the Government of the Republic of China, while making various studies on the selection of the site for the construction of a new harbour, made a request to the Government of Japan in August 1968 to conduct a feasibility study on both economical and technical aspects of the project with consideration given to the impact of the project on the whole Taiwan Island.

In response to the request, the Government of Japan organized a survey team, which made various systems analyses by taking into account every correlated factor such as harbour construction technologies, harbour operation and its relations to inland transport facilities, land use, city planning, location of industries, etc., and present a report on the result of its studies and at the same time made several recommendations.

Based on this report, the Government of the Republic of China made a further study on the project and decided in July 1969 to construct a new port at Taichung Harbour at the first step and to consider the construction of a port at Tamsui in the future, in line with the recommendations made by the survey team.

After making a final decision to select the coast of Taichung Hsien for the site of the new harbour, the Government of the Republic of China requested the Government of Japan to conduct surveys and draft a plan as in the previous case to finalize the master plan for port construction as early as possible. Upon this request the survey team conducted a feasibility study for the Taichung Harbour and prepared a report on its findings.

2. Outline of Survey

The recent survey is directly related to the previous survey. The team, in order to work out a plan and make recommendations for the realization of the project in a short period of time, reviewed the result of the previous survey once again prior to the start of field survey. Since December 10, 1969 the efforts of the team were directed to the field survey, collection of various data and the exchange of views with officials of the Chinese Government agencies concerned. It was decided that recommendations would be made after studying the result of analysis and activities of the survey and related matters.

3. Scope of Survey

As the previous survey was aimed mainly at selecting a site for harbour construction, the harbour project for each proposed site was not comprehensive and gave only the outline of the plan which was only sufficient for systematic comparative analysis of each proposed site.

However, with the final selection of Taichung Harbour as the site of a new port, more detailed surveys and investigations had be planned for the establishment of a concrete project plan.

For this reason, the survey team for the Taichung Harbour Construction Projects, sent by the Japanese Government, decided to conduct its surveys and investigations on the following items as a means to furmulate a detailed project plan.

1) Drafting of a master plan for the Taichung Harbour Project
2) Drafting of a construction project up to 1980
3) Studies on the outline of construction methods
4) Studies on the traffic network in the hinterland and related city planning projects
5) Studies on the benefits desirable from investment
6) Studies on the problems expected to be encountered in the execution of the project

4. Organization of Survey Team

	Name	Assignment	Occupation
Chief	Yonekichi Yanagisawa	Overall responsibility	Advisor to the Overseas Technical Cooperation Agency President of Japan Society of Civil Engineers (Former Director General of the Maritime Safety Agency)
Deputy Chief	Kiichi Ohkubo	Planning	Chief, Planning Section, Bureau for Ports & Harbours, Ministry of Transport
Member	Kazuo Tabata	Design and construction	Chief Engineer, Japan Port Consultants Co. Ltd.
"	Soichi Isonaka	Regional planning	Planner, Regional Planning Section, Planning Bureau, Ministry of Construction
"	Yoshiyuki Ito	Coastal Engineering	Chief, Breakwater Laboratory, Hydraulics Division, Port & Harbour Institute, Ministry of Transport

Member	Ken Kato	Tranportation	Chief Planner, Comprehensive Development Section, Economic Planning Agency
"	Kazuo Kudo	System planning	Chief, Computation Center, Design Standard Division, Port & Harbour Research Institute, Ministry of Transport
"	Yoshihiro Toya	Land facilities	Staff, Engineering Division Mitsui Consultants Co. Ltd.
"	Yoshio Mukunoki	Coordination	Staff, Development Research Division, Overseas Technical Cooperation Agency

5. Counterpart Cooperation

In the course of field survey in Taiwan, cooperation and assistance were extended by various agencies of the Chinese Government. In particular, the Taichung Harbour Project Office (台中港建港籌備處), established at the site by the Chinese Government and staffed by many personnel including Mr. Chih-Li Wang, Director of the office and Mr. Chia-Chieh Chang, Deputy Director of the office, in an attempt to complete the port construction at Taichung, conducted a joint survey with the Japanese team and contributed greatly to the accomplishment of many important works. Acknowledgement is made to the following agencies of the Government of the Republic of China which extended cooperation and assistance to the survey team.

1. Ministry of Communications (行政院交通部)
2. Fund Preparation Division, Council for International Economic Cooperation and Development (CIECD・経合会資金籌劃處)
3. Urban and Housing Development Committee, CIECD (都市及住宅計劃小組)
4. Communications Committee, CIECD (交通小組)
5. Department of Communication, Taiwan Provincial Government (台湾省交通處)
6. Keelung Harbour Bureau (基隆港務局)
7. Taichung Harbour Project Office (台中港建港籌備處)
8. Kaohsiung Harbour Bureau (高雄港務局)
9. Department of Reconstruction, Taiwan Provincial Government (台湾省建設庁)
10. Department of Finance, Taiwan Provincial Government (台湾省財政庁)
11. Department of Accounting & Stations, Taiwan Provincial Government (台湾省主計處)
12. Public Works Bureau, Taiwan Provincial Government (台湾省公共工程局)
13. Water Conservacy Bureau, Taiwan Provincial Government (台湾省水利局)
14. Taiwan Railway Administration, Taiwan Provincial Government (台湾省鉄路局)
15. Highway Bureau, Taiwan Provincial Government (台湾省公路局)
16. China Engineering Consultant (中華民国顧問工程公司)
17. Taichung Hsien Government (台中県政府)

6. Itinerary of Survey Team

The field survey which was carried out from December 10, 1969 to January 20, 1970 included field explorations, collection and compilation of data and exchange of views with officials concerned.

An interim report of the survey was presented to the Chinese Government. The following is a summary of the itinerary of the survey team.

Itinerary of the Survey Team

Date			Description
Dec. 10,	1969	Wed	Departed Tokyo and arrived in Taipei. The team was greeted at the airport by Mr. Chih-Li Wang and many other officials. Paid a visit of courtesy to Mr. H. C. Pan, Director of Fund Prep. Divisions, Mr. H. S. Fan, General Manager of CEC and exchanged views with them.
Dec. 11,	"	Thu	Paid a visit of courtesy to Mr. C. C. Chang, Minister of Communications, Mr. Watter Fei, Vice Chairman of CIECD and Mr. Shigeru Kino, Counsellor at the Japanese Embassy and exchanged views with them.
Dec. 12,	"	Fri	Departed Taipei and arrived in Wuchi via Taichung.
Dec. 13,	"	Sat	Held a coordination meeting with the Chinese counterparts. Heard explanations from the Chinese counterparts on the plan drafted by the Chinese Government and exchanged views with them.
Dec. 15,	"	Mon	Started activities in group. 1. Drafting of project planning 2. Determination of basic policy for the project planning 3. Field exploration and collection of data
Dec. 18,	"	Thu	Paid a visit of courtesy to Commissioner L. C. Chen at the Taiwan Provincial Government and exchanged views with them.
Dec. 21,	"	Sun	Deputy Chief of the Team Mr. Ohkubo arrived in Taipei.
Dec. 22,	"	Mon	Mr. Ohkubo paid a visit of courtesy to the Japanese Embassy. Mr. Ohkubo departed Taipei and arrived in Wuchi.
Dec. 23,	"	Tue	Paid a visit of courtesy to Governor T. C. Chen at the Taiwan Provincial Government.
Dec. 25,	"	Thu	Chief of the team Mr. Yanagisawa left Wuchi for Taipei.
Dec. 26,	"	Fri	Mr. Yanagasawa had an informal talk with Ambassador Itagaki at the Japanese Embassy.
Dec. 28,	"	Sun	Mr. Yanagisawa departed Taipei for Tokyo.

Dec. 30, 1969	Tue	Held a meeting with Mr. C. K. Chao, Mr. C. L. Wang and other Chinese counterparts. Commissioner L. C. Chen paid a visit to Taichung Harbour Project Office and was briefed on the progress of the survey to the date. Views were exchanged with him.
Jan. 3, 1970	Sat	Held an intra-team meeting. Works to be accomplished were determined as follows: 1. Preparation of layout plans 2. Preparation of a preliminary design 3. Studies on financial plans
Jan. 6, "	Tue	Exchanged views with officials of the Taiwan Provincial Government at the government building on related city planning projects, road and railways, and other related matters.
Jan. 7, "	Wed	Exchanged views with Chinese advisors to this project; Messrs. R. S. Hsu, C. K. Chao, P. J. Yung and Dr. L. W. Tang. Deputy Chief of the team Mr. Ohkubo departed Wuchi and arrived in Taipei.
Jan. 8, "	Thu	Mr. Ohkubo paid a visit to the Japanese Embassy, the Highway Bureau and the Taiwan Railway Administrations of the Chinese Government and reported on the result of field survey.
Jan. 9, "	Fri	Mr. Ohkubo left Taiwan for Japan. Preparation of an interim report on the survey.
Jan. 12, "	Mon	Met with the Mayor of Taichung City and other municipal officials.
Jan. 15, "	Thu	All members of the team departed Wuchi and arrived in Taipei.
Jan. 16, "	Fri	Reported to the Taiwan Provincial Government agencies concle concerned on the result of the survey.
Jan. 17, "	Sat	Reported to the Japanese Embassy on the result of the survey.
Jan. 19, "	Mon	Reported to MOC and CIECD and other government agencies of the Republic of China on the result of the survey.
Jan. 20, "	Tue	Departed Taiwan for Japan

II GENERAL

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1. Master Plan of Taichung Harbour

1.1 Significance of Master Plan

Ports are expected to contribute to economic development through the improvement of security and economy of transportation and the offering of a better basis for production activities.

Hence, the development of a port must be proceeded in close relation to the economic activities and planning. Especially, where an extensive land becomes available by the port construction as in the case of Taichung, future development of regional economy is largely affected by whether the port construction is carried out with consideration given to effective land use in the surrounding area.

It is therefore necessary to plan and execute the construction with due regard to its effect on the economic planning and the existing economic activities. In a country like the Republic of China where the economic growth is very rapid, however, the state of economic activities varies remarkably and it is quite difficult to forecast its long-term tendency with accuracy.

Construction of the Taichung Harbour will cause so great changes in the basic conditions of economic activities of the country that it becomes even more difficult to forecast the future state of economy.

The port planning must therefore be conducted based upon a careful long-term economic prediction covering as long a period as possible. It must be noted, however, that a plan formulated on the basis of economic forecast involving many unknown factors incidental to the construction of the Taichung Harbour cannot be regarded as the only and unchangeable one for the far future, though it may be justified at the time of preparation. This means that some adjustments must be effected to the port plan in the future to cope with unpredicted changes in the surrounding economic and other conditions.

The significance of mapping out a long-term plan in spite of the probable future adjustments lies in averting the demerit of a plan which is liable to lead to the construction of an unefficient port and a loss of investment.

Thus, the long-term planning has the significance in its basic principle, and details of the plan must be revised by modifying the original plan in the course of construction so as to meet the future changes in economic conditions. It is to be taken into consideration that the basic principle itself must be modified if occasion so demands. The basic principle of the planning is called the Master Plan in the following description.

The survey team predicted the future state of economic activities in Taiwan with utmost care and completed the Master Plan for the Taichung Harbour.

1.2 Outline of Master Plan

The primary function of the Taichung Harbour will be that of a commercial port for handling a lot of import-export cargoes. It will also have the function of an industrial port because of its construction will make it possible to reclaim an extensive water front industrial estate. The port already has the nature of a fishery harbour at present, and it is expected that the completion of the port will accelerate the fishermen's demand to use the port facilities. The port will therefore be provided with the function of a fishery harbour.

Assuming that the gross national product (G.N.P.) grows at a rate of 8.0% per annum, it is justifiable to estimate that the volume of cargoes handled at the Taichung Harbour would reach 8 million R/T in 1981.

There is a high probability that in years after 1981, the abovementioned cargo handling capacity will be required to be more than doubled. The scale of the port as a commercial port should therefore be large enough to cope with the expected increase in the volume of cargoes. Since the proposed harbour site is the flat sand beach, a huge amount of dredged material produced by the construction of the commercial port will make it possible to form a large scale sea front industrial estate in its neighbourhood.

To construct a large scale sea front industrial estate in Taichung area is the prerequisite to the economic development of not only the central district of Taiwan but also the entire Taiwan island. Taiwan Power Co. has already expressed their intention to establish a large thermal power station in the industrial port. Future economic development of Taichung area calls for the establishment of such industries as oil refinery, petrochemical, ship building, iron and steel and its corelated industries in this sea front industrial estate. It can be safely expected that such other industries as the food industry, flour milling, feed industry and wood and timber industry will also be located there with the increasing commercial function of the port. In anticipation of the establishment of these industries, an area of about 900 ha and shore line of about 7,000 m should be secured, with the main navigation channel dredged and maintained at a depth of -15 m for big tankers and ore carriers to enter the port.

It is expected that the demand by fishing boats to use the port will increase with the progress of construction work. It is therefore proposed to construct a new fishery harbour having a pier with a shallow water depth of about 1,570 m and an anchorage of 16 ha to allow for the performance of all functions related to fishing activities.

1.3 Harbour Entrance and Main Navigation Channel

The shore near the Taichung Harbour is subjected to the severe influence of littoral sand drift and wind-blown sand. Therefore, the location of the harbour entrance and arrangement of breakwaters and groynes sould be so selected that the silting up of the harbour will be minimized. Especially, breakwaters must be designed to prevent high waves and to keep the harbour inside calm during the st stormy weather.

To maintain the water depth of -15 m at the harbour entrance for big tankers to enter into the port, it is necessary to extend the head of the north breakwater to the place where the water depth is -15 m and the head of the south breakwater to the place where the water depth is approximately -12 m so that the disturbance due to waves during the winter monsoon may be reduced.

The head of the south breakwater should be in a little shallower water than the north breakwater for the security of ships entering into the port during the stormy weather in winter.

The littoral sand drift will vary with the progress of breakwater construction. Hence it is necessary to observe constantly the varying state of drift sand before and after the commencement of breakwater construction and conduct model experiments for clarification of its phenomena and cause so that optimum modification may be effected to the planning and design of breakwaters and groynes.

However, since the above measures do not promise complete prevention of siltation, certain amount of maintenance dredging with a trailing dredger must be planned in advance.

The increasing demand for using the port will invite shipping congestion at the harbour entrance. The future amount of navigation traffic was therefore estimated based on the planned scale of both commercial and industrial ports as well as on the tonnage of ships which enter into the port.

The conclusion of the estimation indicates that one port entrance will be sufficient for future navigation traffic when the plan described in II-1-2 is put in full operation.

Since the construction of more than one entrance in such a port incurs an increased investment in breakwaters, the port plan was drawn up with one harbour entra

1.4 Plan of Commercial Harbour

The optimum allocation of import-export cargo to this harbour, as estimated from the viewpoint of nation-wide economic efforts, is about 8 million R/T in 1981. In this estimation, 8.0% of average annual growth rate of GNP (gross national product) is assumed with 1969 taken as the base year.

Estimated volumes of major trade items are as follows:

Export	(Unit: 1,000 R/T)
Cement	1,500
Banana	1,000
Canned foods	250
Fertilizer	240
Glass (Plate)	180
Sub Total	3,170
Import	
Wheat Beans Corns	1,500
Total	4,670
Other export and import items	3,330
Grand Total	8,000

Figures listed above do not involve the import of timbers for the timber industry which will be located in the harbour area, nor do they include cargoes to be handled at the fishery harbour and industrial harbour. Estimated number of berths and their dimensions needed for major cargo items are as follows:

1) Grain berths
   Handling volume: 1,500,000 R/T per annum
   Maximum size of grain carrier: 50,000 D/W
   Depth of berth: -13 m
   Length of each berth: 250 m
   Number of berths: 3

2) Cement berths
   Handling volume: 1,500,000 R/T per annum
   Maximum size of cement carrier: 20,000 D/W
   Depth of berth: -11 m
   Length of each berth: 200 m
   Number of berths: 4

3) Container berths
   Handling volume: 1,500,000 R/T per annum
   Maximum capacity of full container ship: 2,000 containers
   Depth of berth: -13 m
   Length of each berth: 300 m
   Number of berths: 3

At present, the depth of berth required by container ships does not exceed -12 m. But, in an official letter to Keelung Harbour Bureau, a shipping company has asked for a depth of -13 m. The team adopted -13 m in order to meet the future enlargement of container ships.

4) Ore berths
   Handling volume: 200,000 R/T per annum
   Maximum size of ore carrier: 50,000 D/W
   Depth of berth: -13 m
   Length of each berth: 250 m
   Number of berths: 2

These berths are intended for public use so that ores imported by factories in hinterland will be handled. As some ores require covered storage, one of the two berths will be equipped with a transit shed and the other with open storage.

5) Berths for general cargo
   Handling volume: 3,300,000 R/T per annum
   Maximum size of vessel: 20,000 D/W
   Depth of berth: -11 m
   Length of each berth: 200 m
   Number of berths: 22

6) Timber berth
   Maximum size of vessel: 20,000 D/W
   Depth of berth: -11 m
   Type of berth: dolphin berth
   Number of berth: 1 set

Total number of berths in 1981 is estimated at 35, and this means that all berths must be constructed by the end of 1980. Since the recent economic growth of Taiwan is quite rapid, it is probable that the annual growth rate of GNP will exceed the aforementioned value of 8%. In addition, many unknown factors are involved in the trends towards containerization. Accordingly, it is preferable to provide some allowance in the berth number. Principles of berth arrangement are as follows:

1) Berths for imported grains, the most reliable cargo, are planned to be constructed on the north side of the 1st slip and put into operation at first, and silos installed with these berths are expected to act as a kind of wind screen.

2) On the other side of the 1st slip, berths for cement export are arranged since cement was noted to be another reliable cargo through the planning period.

3) Then, 3 successive berths for container ships are placed. These container berths are planned to meet the development of containerization in this island. Recent modernization of banana transportation, i.e., use of carton boxes in place of cages, is an important incentive to containerization. Canned food for export will be another major potential cargo to be containerized.

4) At the base of the 1st channel, one dolphin berth and a timber basin are arranged to handle imported timber separately from other cargoes. The team expects that the import of timber will be started at an early date after opening the port.

5) Next to the container berths, general cargo berths are arranged towards south. At the base of the 2nd channel, shallow water wharves are planned with facilities for port service crafts. At the top of the central pier (inversed L shaped pier), 2 berths of bulk cargo wharves are planned, with transit shed and open storage for common use.

6) Therefore, a total of 25 general cargo berths can be arranged as follows within the area north of the central road before 1980. This figure includes an allowance of 3 general cargo berths.

East side of 2nd channel ---------- 8 berths
West side of 2nd channel -------- 6 berths
Base of 2nd channel -------------- 2 berths
(depth is -7.5 m and length of each berth is 130 m)
Top of central pier -------------- 1 berth
West side of central pier ------- 8 berths
Sub Total -------- 25 berths

The south side of the central pier will be utilized as the 2nd container complex. The last berth on the west side of the pier would therefore be used for container feeder service.

7) The 1st container complex included in the plan up to 1980 will handle mostly large lot or consignor/consignee oriented container cargoes. Therefore, no C.F.S. (container freight station) will be needed outside the container berth. However, the 2nd container complex will be equipped with a rather large C.F.S. which will concurrently serve as the distribution center to meet the development of commodity distribution through this harbour. After 1981, therefore, 3 container berths for this purpose will be arranged at first.

8) 36 general cargo berths are planned for the period after 1981.

9) Since the 2 bulk cargo berths included in the plan up to 1980 are considered to be sufficient to handle the estimated volume of bulk cargoes, arrangement of additional berths is not planned at present for years after 1981. It may be added, however, that the west side of the south pier (2nd inversed L shaped pier) affords a continuous water front line of 1.7 km which can be readily converted into bulk cargo berths with a length of 250 m/berth.

10) The turning basin with 1,000 m diameter is arranged in the main entrance channel to provide an ample allowance for the navigation through the fairway.

11) In order to make full use of the given space, several buoys or dolphins are arranged for ships waiting for berth.

12) In the early stage of construction, small boats and port service crafts can use the small boat basin designed originally for boats for harbour construction. As these small boats are expected to increase year by year, a small boat basin will be provided at the base of the 2nd channel. When fully developed, the commercial port will be capable of handling more than 16 million R/T of commercial cargoes per annum.

1.5 Plan of Industrial Harbour

Development of water front industrial estates is generally achieved by the establishment of heavy and chemical industries and large scale thermal power stations. In the case of Taichung, Tiawan Power Company has already expressed its intention to build a thermal power station in this harbour, and this will be the leadoff for future development of the combinated complex of oil refinery, petrochemical, and power station.

This size of harbour will require ship repairing docks which will naturally be developed into a ship building yard. In the near future, an integrated steel manufacturing and its related industries will be located, and their first customer will be the abovementioned ship building yard. In the commercial port area, light industries such as flour milling, food and feed industries will be located to process imported grains. Timber processing factories will also be located around the timber basin. Precise estimation of the space required by respective industries cannot be made unless their final plans of establishment are available. The following estimation, in which actual examples in Japan have been utilized, is therefore intended to give a general idea.

1) Thermal power station, oil refinery, and petrochemical plant will be connected by pipe lines, and will require a relatively small number of workers for the area they would occupy. Therefore, they are arranged on the west side of the main channel.

As for land requirement, Taiwan Power Company is asking for 50 ha, and it is considered that 50 to 100 ha of space will be adequate for a 750,000 KW class power station. Future demend for fuel oil and gasoline will require another 200,000 bl/day class oil refinery. Space for this plant will be 100 to 200 ha. In order to form a well balanced petrolium complex incorporating the abovementioned thermal power station and oil refinery, petrochemical industries occupying an area of 100 ha to 200 ha will be developed. Required length of water front line for handling crude oil and refined oils is estimated to be about 2,000 to 3,000 m. This length will be secured by utilizing the west side water front of the main channel.

2) The ship building yard is planned in the immediate south of the commercial port. An anchorage basin for entrance and waiting of ships is arranged in front of ship building docks. About 500 m water front line is allocated to the quay wall for fitting out. A space of 60 ha will be sufficient for the shipbuilding yard including the dry dock for repairing large oceangoing vessels.

3) Space for the integrated steel manufacturing is arranged in the south of the ship building yard, and the assumed plant layout is as follows:

a) Blast furnaces must be located in the southwest end of the industrial harbour, for the convenience of clinker disposal, and

b) Construction will carried out sequentially starting with the rolling mill followed by the converter plant, and blast furnaces.

Space of 350 ha is allocated for the integrated steel manufacturing for production of 4.0 million ton/year of blister steel. Space including 4,000 m of water front line which is required to provide loading and unloading quay walls is arranged from the south to southwest of the channel.

4) Industries related to the integrated steel manufacturing will be located behind the shipbuilding yard and steel mill, and an area of 50 to 100 ha just behind the harbour area will be allocated for them. When fully developed, the industrial port will be able to handle 16 to 20 million R/T per annum of industrial cargoes such as raw materials and products.

1.6 Plan of Fishery Harbour

Taichung Harbour is utilized as a fishery harbour at present. A number of fishing boats are found in it and many people in its vicinity depend on fishery directly or indirectly. As there are few good fishery harbours in the neighbourhood of Taichung, development of this harbour will result in an increasing number of fishing boats entering it.

In order to maintain the safety of navigation through the fairway, it is not desirable to allow both large vessels and small boats to navigate inside the harbour. Therefore, the fishery harbour is located immediately inside the northern inner breakwater to separate it from the commercial port. By this arrangement, a fairway for small boats can be secured on the north side of the main fairway, assuring safe and free passage of fishing boats. Entrance of the fishery harbour is severed from the commercial port by a jetty located inside the northern inner breakwater and covered by a groyne, so that the safety of fishing boats going in and out of the basin will be secured. Basin of the fishery harbour has an area of 16 ha, and its depth is -6 m near the entrance and -4.5 m in the inner part.

About 1,570 m of shallow water wharves will provide fishing boats with facilities far improved than the present ones. Though there is a space on the northern side for further extension of the basin, such extension is not desirable if it deters the safe navigation through the harbour entrance, because the Taichung Harbour construction is intended primarily for the promotion of international trade.

About 150,000 R/T per annum of marine products will be handled at the fishery harbour upon completion of its construction.

1.7 Plan of Transportation Facilities within Harbour Area

The 8-lane main harbour highway will separate the harbour area from the city area. Roads within the harbour area branching off from this main highway to the wharf area are planned to have 4 to 6 lanes. Existing road connecting Salu and Wuchi will temporarily be extended into the harbour area with 15 m width and used as the construction road. At the same time, it will serve to secure access to the west side of main channel.

Harbour railway will be branched off from the trunk line at two points, namely Chianan and Lonchien, and extended to the harbour area. There will be arranged three sorting yards from which the siding railway runs to each wharf.

This harbour railway between Chianan and Lonchien will constitute, together with the trunk line, a loop line system for passenger service. Therefore, spaces for stations are taken into consideration, with the elevation of the harbour railway in the urbanized area also considered.

1.8 Land Use Plan of Harbour Area

For the commercial port, following facilities are planned and their arrangements are shown in the Master Plan.

i) Transit shed
ii) Warehouse
iii) Open storage
iv) Container yard and C.F.S.
v) Transportation facilities
vi) Spaces for office (official and private)
vii) Truck terminal
iix) Parking area
ix) Green belt and small park

For flour mill ng and food and feed industries which are closely related to grain handling, sites of factories are arranged behind grain berths. Sites of timber processing plants are arranged around the timber basin. Area for processing industries of import-export goods is also included in the commercial port. Land use plan for the industrial port is explained in Section II.1. 5.

In the fishery harbour, sites of enterprises relating to fishery are arranged around the basin of fishing boats in conformity to the fishery harbour plan mentioned in Section II. 1. 6.

The extensive seaside area on the northern side of the north breakwater, which will be reclaimed by the harbour construction, will be protected against blown sand by the wind break forest to provide for future development.

1.9 Others

With the increasing utilization of the port, there will occur the need to handle fuel oil for ships and other dangerous cargoes. These commodities should be handled at places segregated from the commercial port facilities for security's sake. If facilities for handling these commodities are needed, an additional plan must be drawn up for their construction near the harbour entrance in the industrial harbour area.

2. Construction Plan

2.1 Assumed Construction Speed

According to the commodity flow which will minimize inland transportation cost, the potential transport demand of Taichung Harbour in 1969 is about 3.5 million R/T. Report of New Harbour Project - 1969 recommended that the Port of Taichung be put into operation in the year of 1973. This potential transport demand could not be fulfilled due to the limited construction capability. Since there is a prospect that the saturation of cargo handling capacity of Keelung will be delayed by the construction of container wharves now in progress, the following construction schedule can be proposed as a realistic plan.

i) Taichung Harbour is to be put into operation in June 1974.

ii) 4 million R/T of import-export cargoes is to be handled in 1977.

iii) 8 million R/T of import-export cargoes is to be handled in 1981.
In order to materialize the above plan, the following schedule should be adopted for construction of berths.

1) First stage:

up to June 1974 -----
berth No. 1 to berth No. 7

2) Second stage:

July 1974 to December 1976 -----
berth No. 29 to berth No. 37, and berth No. 8

3) Third stage:

January 1977 to December 1980 -----
berth No. 9 to berth No. 28

4) Fourth stage:

after 1981 -----
from berth No. 38

Major part of breakwater construction and dredging work at the entrance channel should be completed in the first stage of this schedule. Therefore, even if the main part of detailed design is completed and the construction work started in January 1972, maximum efforts will be required to execute the construction as scheduled.

2.2 Preliminary Design of Main Structures

In order to estimate the construction cost and review the construction schedule, preliminary designs of main structures planned to be constructed in the three stages (up to 1980) were prepared with the cooperation of counterparts. counterparts.

Following are the design conditions for main structures which were agreed upon between Chinese engineers and the survey team after repetitive and active discussions.

(1) North breakwater

Wave height	$H_{1/3}$ = 6.0 m
Period	$T_{1/3}$ = 12 sec
Direction	NNE
Crown height	+12.5 m

(2) South breakwater

Wave height	$H_{1/3}$ = 4.0 m
Period	$T_{1/3}$ = 10 sec
Direction	SW
Crown height	+7.4 m

(3) Shore protection wall

Wave height	H_b = 4 m
Period	$T_{1/3}$ = 10 sec
Crown height	+10 m

(4) Deep water wharves (depth : -11.0 m ~ -13.0 m)

Crown height	+6.2 m	
Horizontal seismic acceleration		0.1
Surcharge	Normal	4 t/m^2
	Seismic	2 t/m^2

(5) Shallow water wharves (depth: less than -7.5 m)

Crown height	+5.7 m	
Horizontal seismic acceleration		0.1
Surcharge	Normal	3 t/m^2
	Seismic	1.5 t/m^2

(6) Landing place

Crown height	+5.7 m	
Horizontal seismic acceleration		0.1
Surcharge	Normal	2 t/m^2
	Seismic	1 t/m^2

Breakwaters are proposed to be of the rubble mound type with armors of tetrapod for the shallower portion (less than -5.0 m), and composite caisson type for the deeper portion.

Structures of groyne and shore protection wall are similar to those of the breakwaters in the shallower portion.

Main structure of wharves is steel sheetpile, and considerations are given to the horizontal seismic acceleration of the wharf crane in anticipation of its possible employment. Preliminary designs were also prepared for the dry dock for manufacturing caissons, shallow wharves and pontoons for work boats.

2.3 Construction Schedule

Outlines of construction schedule are as follows:

1) The outline structures for protecting harbour, such as north and south breakwaters, groynes, jetty, and protecting sea-walls, should be completed within the shortest possible period. Construction works must be expedited so as to complete most of these structures in the first stage.

2) Number of deep water wharves constructed shall meet the transport demand in each stage, but dredging shall be limited to -11 m in the first stage. In the second stage when the front of -13 m berths shall be deepened to -13 m, larger vessels demanding a -13 m berth must make use of tidal range. Main channel and access to -13 m berth shall be dredged to -13 m in the third stage.

3) 2/3 of total dredging work shall be carried out by suction dredgers of non-propelling type for reclamation of the wharf area, west side of main channel, and area immediately north of the commercial port. The remaining 1/3 of dredging work shall be carried out by trailing dredgers for disposal of dredged soil and sand in the deep sea south of the Tatu River. The reclaimed land in the immediate north of the commercial port must be protected against blown sand during the winter monsoon.

The first stage will be the busiest period among the three because of the concentrated construction work of outline structures. Though this construction schedule assumes full use of up-to-date dredgers, work boats, and other construction equipments, there will remain some works that must resort to manual labour.

Transportation, placing and leveling of 900 thousnad m^3 of rubble-mound for breakwaters and shore protecting walls could become the bottleneck of this construction schedule.

In order to complete the first stage construction by 1974 as scheduled, preparations for the main construction work -- including preparatory construction and acquirement of dredgers and other equipments -- must be finished by the end of 1971, construction work should be started from 1972 making full use of manpower and construction equipments.

Further studies on the construction schedule must be made according to the progress of detailed design of structures.

2.4 Estimation of Construction Cost

Estimated cost of the third stage construction work which should be completed by the end of December 1980 is about 8 billion NT$. This, however, does include the construction cost of two dangerous cargo berths and one fuel oil berth which is estimated to amount to about 103 million NT$. After the construction, littoral sand drift and blown sand will bring about the silting up of the dredged area. Therefore, a dredging cost of about 20 million NT$ per annum, which corresponds to the cost of maintenance dredging of one million cubic meter -- the maximum volume of estimated littoral drift entering the harbour -- will be needed for maintenance of the water area.

3. Recommendations on Construction System of Taichung Harbour

The key factor of the construction of Taichung Harbour is the establishment of a well organized and coordinative construction system embracing i) investigation and research division, ii) designing division, and iii) construction division.

1) Investigation and research division

Since the proposed site of Taichung Harbour is a flat sand beach subjected to severe littoral sand drift, it presents many problems of coastal engineering that demand further studies.

These problems will require model experiments on sheltering effects and stability of breakwaters, and field investigations of waves, littoral sand drift and blown sand to be conducted with the aid of model experiments. Such experiments and investigations should be regarded not as mere daily routine work but as real engineering research. Investigation and research activities must be launched at an earliest date so that their outcome may be fully incorporated in the detailed design. Construction of investigation and research facilities is therefore urgently called for, but what in more important is to recruit engineers who will be engaged in these activities. Therefore, serious considerations must be given to this point.

For detailed design, sounding of proposed harbour site, topographical survey and soil survey should be started immediately. If there are any difficulties in obtaining a sufficient number of engineers needed for the field survey, cooperation of consultants firms must be sought.

2) Design division

In preparing the detailed design, fullest use should be made of the abovementioned investigation and research works. They have had little experience in large scale breakwater construction in Taiwan over the past 20 years, though they have enough experience of constructing wharves. Therefore, utilization of an experienced consultants firm for the detailed design of breakwaters is recommendable in view of the required construction speed and the severe natural conditions under which the construction must be carried out. For the detailed design of wharves, utilization of an experienced consultants firm is also recommendable. However, since there are many local engineers who are well experienced in this task, cooperation of a consultants firm may not be required if the required number of engineers can be transferred to Taichung Harbour from Keelung Harbour Bureau or Kaohsiung Harbour Bureau. For determination of design conditions which is the first important step of detailed design, careful consideration should be paid to the Report of New Harbour Project - 1969 and to this report, with maximum efforts made to collect necessary data.

3) Construction division

A comprehensive bidding by international contractors for the construction of Taichung Harbour is not recommended for the following reasons: i) it will be of little help to the elevation of engineering capabilities of Taiwan, ii) as already mentioned, trailing dredgers will be required for the maintenance dredging and these dredgers should be purchased and used for construction, iii) experiences in the construction of wharves and other harbour structures in Keelung and Kaohsiung must be utilized.

Therefore, construction work which will be carried out over a long period in future should be undertaken by domestic contractors, and the remaining portion of the work which will fluctuate in volume and in which domestic contractors are not fully experienced due to its rather special nature should preferably be undertaken by foreign contractors. Hence it is hoped that a construction system will be established which ensures balanced coordination between domestic and foreign engineering techniques. In order to minimize the construction cost in the midst of the prevailing upward trend of commodity prices, it is necessary to strive for productivity improvement through application of the modern construction management throughout the entire construction period.

4. Administration and Operation of Port

In order to promote the utilization of the Port of Taichung in her early stage of operation, it is necessary to take proper administrative measures whereby the transportation route of the commodities relating to Taichung district may be shifted to the Port of Taichung. These commodities include banana for export, and beans, wheat and scrap iron for import.

Although the development of Taichung Harbour incurs an enormous cost for the construction of breakwaters and groynes, it assures the reclamation of an extensive area with the huge amount of sand obtained by dredging the navigation channel and the anchorage.

Therefore, if it is desired to attain the investment effect in a short period, the reclaimed land should be developed into a seafront industrial estate in addition to enhancing the utilization of the commercial port. Construction, maintenance and operation of wharves should be considered from the viewpoint of public benefit. This is of particular importance in an artificial harbour like Taichung for the following two reasons:

i) wharves become useful only after investing a huge amount for construction of outer facilities such as breakwaters and sea walls, and ii) space within the harbour area is limited.

Considering these conditions, it is desirable that the port authority adopts a unified administration and operation system as in the case of the Port of Keelung. And to accelerate the use of the commercial port, it will be imperative to furnish and operate facilities for rationalization and modernization of cargo transportation and handling. Opinions are split at present as to the necessity of constructing container-wharves. However, if careful consideration is given to the future transport conditions, all doubts about the need for container-wharves will be dispelled. The appropriate time to commence the container-wharf construction is to be determined after observing the general tendency of containerization, shippers' demand for container-wharves, and the state of utilization of container-wharves in the Port of Keelung.

It is the common practice that in case of commercial ports, the rent of port facilities collected over a long period is appropriated to cover the construction cost or to recover the investment. In an industrial port, however, a portion of the expenditure for furnishing port facilities can be collected by including it in the selling price of the reclaimed land.

In order to induce enterprises into the industrial estate around the Port of Taichung and to strengthen its function of commodity circulation, measures should be taken to facilitate the establishment of an efficient information system by respective enterprises and dial telephone circuits should be set up to assure direct communication with such cities as Taichung, Wuchi, Taipei, Keelung, Kaohsiung, Hualien with which the estate is closely affiliated.

By establishing an information system connecting the Ports of Keelung, Taichung, Kaohsiung, unified operation of those ports will become possible with better service also made available to shippers.

5. Planning of Related City Planning

5.1 Estimation of Population

Development of Taichung Harbour will increase the population in the neighbouring area, namely Wuchi, Chingsui, Salou and Lungchin, which will be developed into a city with a population of about 500,000. Therefore, a Master Plan should be formulated to carry out the systematic and orderly construction of the New City.

5.2 Land Use Plan

Land use plan should be mapped out to develop this area into lands full of green and not densely populated, and to prepare for future development of the New City which will afford comfortable urban life. To this aim, following principles are proposed.

1) Rough estimation of required spaces is as follows:

Commercial and business area	400 ha
Residential area	3,100
Seafront industrial area	900
Industrial area for related industries	600
Parks	
Truck terminals	
Educational district and community centers	
Sorting yards	
Others	

2) Three commercial and business districts are to be planned. One of them should be located in the area adjacent to the harbour, and the other two around the existing urbanized area of Salou and Chingsui which are already included in the city planning.

3) Residential areas should be planned in the area extending from behind the harbour area to Salou and Chingsui and in the west side slope of Tatu Mountain.

4). A large scale seafront industrial estate should be planned in the harbour area, with another area also arranged just behind this seafront industrial estate for related industries.

5). Shelter belts should be arranged along the roads running to the coast line at right angle. Afforestation to provide shelter belts is recommended along the railways and borders of residential area.

6) Followings should be included in this land use plan: parks, greens, educational district, community centers, water sewerage plant, truck terminal and a golf link.

5.3 Plans for Transportation Facilities

5 trunk roads will be required to connect the harbour area with Taiwan Highway No. 1. Since the width of Taiwan Highway No. 1 is insufficient, improvement work to widen it to 4-lane road is needed. This highway runs through the urbanized area between Chingsui and Salou. A by-pass must therefore be planned for this section. Traffic volume between Taichung Harbour and Taichung City will be increased, and improvement of the existing road must be carried out. In future, a free way must also be planned to connect the N-S Free Way with the New City which is proposed to be established in the neighbouring area of Taichung Harbour. In order to meet the demand for container transportation in this area, existing bridges in the hinterland must be improved. Construction of shelter belts is recommended along the main harbour road and the trunk road that connects this harbour with Salou and Chingsui.

Harbour railway will be branched off from the trunk line at two points, namely Chianan and Lungchien, and extended to the harbour area. This harbour railway between Chianan and Lungchien, together with the trunk line, will con stitute a loop line system for passenger service. Spaces for stations are taken into consideration, with the elevation of the harbour railway in the urbanized area also considered.

5.4 Drainage of Water

In order to avoid silting up of harbour by sedimentation caused by rain water, rain water from Tatu Mountain and from the area along the Taiwan Highway No. 1 should not be allowed to flow into the harbour area. Rain water in the area just behind the harbour area should be gathered into two main drainages and led into the harbour area. If sediment transportation by rain water is excessive, the drainages may have to be extended to outside the harbour area.

Sanitary sewerage system must be planned separately from the rain water drainage system, and sewerage system for industrial use is recommendable to meet the future demand.

Two water sewerage plants are to be arranged, one located on the northern side of the river mouth of the Tatu, and the other in the north of the proposed harbour area.

5.5 Water Supply

Estimated amount of water supply to Taichung Harbour and New City is about 750,000 m^3/day. At present, this is planned to be supplied by the development of the Tachia river. In order to secure water supply to a wider area in future, a unificated development plan of three rivers, Ta-Chia, Tatu and Ta-an, must be pushed forward.

6. Analysis of Investment Effect

Purpose of constructing the new harbour is to furnish facilities necessary for economical transportation of increasing import-export cargoes. Construction of the new port, however, will have an immense effect not only on promotion of trade but also on regional development. The construction is also expected to promote the well balanced development of the whole country, and become an effective means to stabilize and elevate the national living. The expenditure needed for the construction up to December 1980 is estimated to be approximately 8 billion NT$ as mentioned in II. 2. 4.

When the investment effect on the regional economy is analyzed based on the estimated construction and maintenance cost as well as on the benefit derivable from the construction, it can be clearly recognized, as briefed below, that the investment effect is extremely large.

1) If the Port of Taichung is not constructed and the Ports of Keelung and Kaohsiung are enlarged and improved into international trading ports, the following demerits will be invited.

There will be incurred a large amount of demurrage since ships will stay many days in the Port of Keelung, and an increase in land transport cost will be brought about as a large volume of road traffic will be generated as the potential transport routes to Taichung Harbour are shifted to these two ports.

By constructing the Port of Taichung, not only the above situation can be mitigated, but also an extensive land can be obtained by reclamation with the dredged soil and sand.

The internal rate of return is about 28-35% when estimated on the following assumption: i) the value of the reclaimed land is 400 NT$ per 3.3 m^2, ii) harbour construction and reclamation are carried out in conformity to the plan described in this report, iii) the amount of cargoes handled in this port is as supposed in other parts of this report. This indicates that the Taichung Harbour Construction Project promises a larger investment effect than other projects of similar kind.

2) Examination of an alternative plan which is intended for expansion of Kaohsiung Harbour justifies the construction of Taichung Harbour.

3) Comparison of two plans, the one for construction of the Port of Taichung and the other for expansion of the Port of Keelung or construction of a new port in the outer port area of the Port of Tamsui, shows that the former is more advantageous.

4) The volume of import-export cargoes is estimated to reach 54.6 million R/T in 1981 in the entire Republic of China and 8 million R/T in the Port of Taichung. Therefore, it can be said that approximately 15% of the whole economic activities of the country is largely affected by whether the construction of the Port of Taichung is carried out successfully.

As described above, the construction of the Port of Taichung has a large effect on the economic development of the Republic of China.

To make this effect larger, it is necessary to reduce the construction cost by rationalizing the plan, design and execution of the new harbour construction and to put the port facilities in use as soon as possible, with additional facilities provided in accordance with the increase of demand.

III SOME CONSIDERATIONS FROM THE POINT OF VIEW OF SYSTEM DESIGN

III SOME CONSIDERATIONS FROM THE POINT OF VIEW OF SYSTEM DESIGN

1. Cargo Handling Volumes of Import-Export Goods at Taichung Harbour

1.1 Economic Activities

Recent economic growth in Taiwan is remarkable and the average annual growth rate of GNP (in 1966 constant price) from 1964 to 1968 was 10.5%, the highest rate in the world. Moreover, the figure in 1969 is expected to be about 9.0%. Above figures exceed considerably the estimated growth rate (8.0%) set in the Report of New Harbour Project -1969-, therefore the estimated figures need to be refined and the base year which was set at 1966 should be moved to 1969.

As reported previously, the real average annual growth rate of GNP is forecasted to be 8.0% using the base year of 1969 for the next two decades, and estimated figures are shown in Table III-1-1.

Table III-1-1 Estimated Value of Gross National Product
(1966 constant price)

Year	Estimated Figure		Actual Figure		Former Estimated Figure	
	Value (million NT$)	Average Growth Rate (%)	Value (million NT$)	Average Growth Rate (%)	Value (million NT$)	Average Growth Rate (%)
1966			125,554		125,496	
1967			138,730	10.5	135,500	8.0
1968			152,760	10.1	146,400	8.0
1969	166,685		166,685	9.1	158,000	8.0
1972	210,000	8.0			198,700	8.0
1973	210,000	8.0				
1974	245,000	8.0				
1975	265,000	8.0				
1976	286,000	8.0				
1977	309,000	8 0				
1978	333,000	8.0			316,000	8.0
1979	360,000	8.0				
1980	390,000	8.0				
1981	421,000	8.0				
1988	720,000	8.0			682,000	8.0
1989	778,000	8.0				
1990	840,000	8.0				

Remark: Preliminary estimate for 1969 is shown by CIECD.

1.2 Optimum Cargo Handling Capacity of Taichung Harbour

The volumes of import-export commodities in this island continued to increase rapidly together with the economic development. And it is well recognized that shipping congestion is now taking place at Keelung and Kaohsiung Harbour.

In order to meet the future economic development, harbour construction programmes for foreign trade promotion should be accelerated on not only existing but also new harbours, as recommended in the former report. Future cargo handling volumes for import and export newly estimated by the regression model employed in the former report are as shown in Fig. III-1-1.

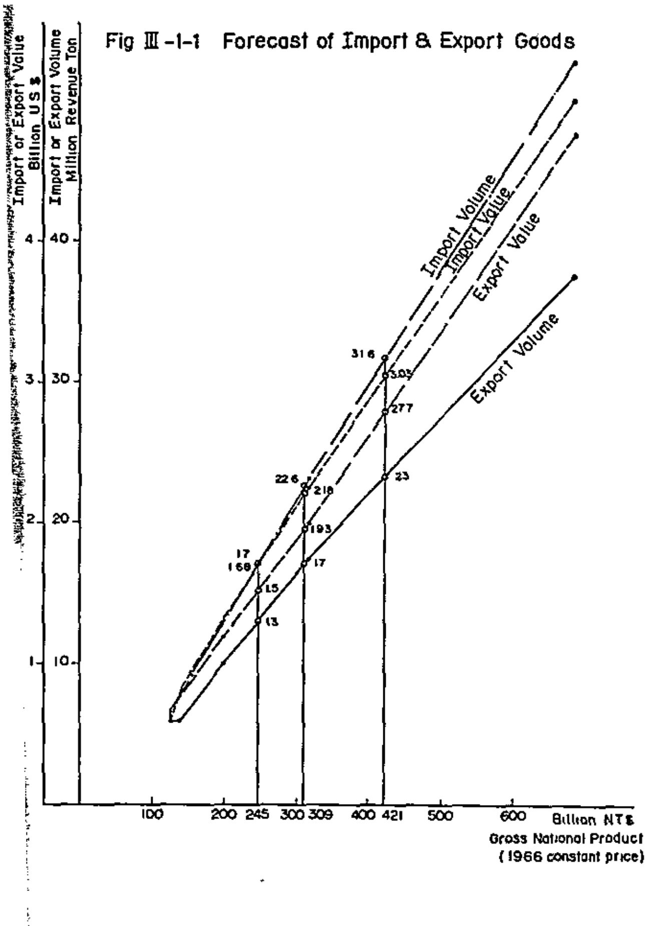


Fig III-1-1 Forecast of Import & Export Goods

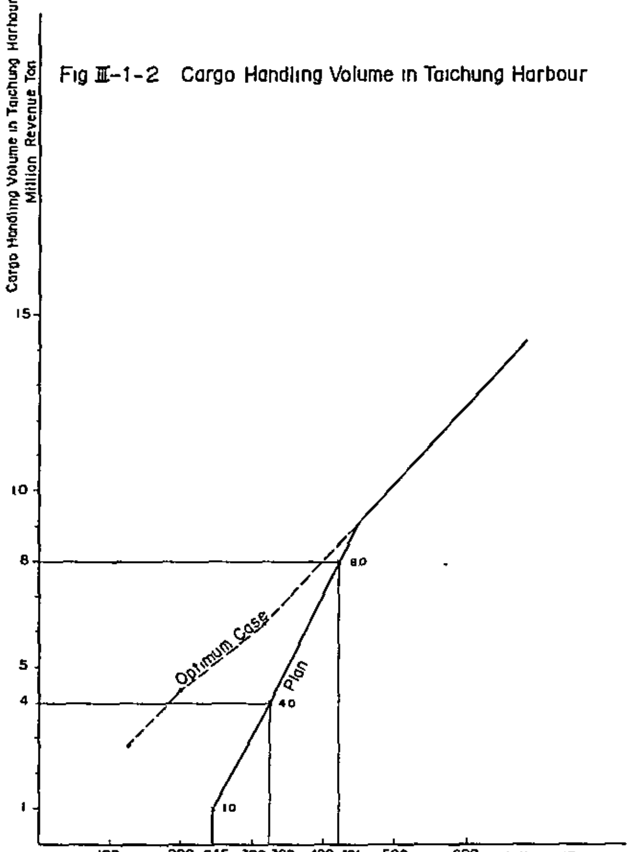


Fig III-1-2 Cargo Handling Volume in Taichung Harbour

As the result, optimum cargo handling volume at Taichung Harbour is estimated as shown in Fig. III-1-2 bearing in mind the necessity to keep the transportation cost of import-export commodities at minimum. Assuming that Taichung Harbour is open and GNP is about 160 million NT$ which represents the current economic level of Taiwan, the optimum import-export cargo handling volume of Taichung Harbour will be 3.5 million R/T. Therefore, construction of Taichung Harbour is urgently needed. However, it is still in the planning stage and the construction period is subject to enforcing capacity.

Considering the construction capability, the schedule of Taichung Harbour construction is estimated as follows:

(1) Beginning of operation in the middle of 1974

(2) Cargo handling of 4.0 million R/T per year in 1977

(3) Cargo handling of 8.0 million R/T per year in 1981

2. Harbour Entrance

The estimated cargo handling volume of Taichung Harbour corresponding to this master plan is about 40 million R/T per year in her fully developed stage. In the commercial harbour area, 16 million R/T of export-import goods will be handled and about the same amount of cargoes in the industrial harbour area. Major items will be industrial raw materials, and the remaining 8 million R/T will be cargoes for timber basin, fishery harbour area, and domestic marine transport. Since 40 million R/T of cargo handling volume is quite large, the question is raised as to whether one harbour entrance or two should be planned in the Master Plan. Construction of the second harbour entrance in Kaohsiung may be the back-ground of this question. Analysis of this problem is as follows.

i) Estimation of number of ships calling at Taichung Harbour

To estimate the number of ships to the estimated cargo volume at the port they call at, average lot size of cargoes per ship should be figured out. Though the value thus estimated may change to some extent by the characteristics of the given harbour, a macroscopic analysis is made here using statistical data of Kaohsiung.

Tables III-2-1 and III-2-2 show the cargo handling volume and the number of ships calling at Keelung and Kaohsiung respectively. Data are cited from "Communication and Transportation Information" complied by the Communication Committee of C.I.E.C.D.. Vessels less than 300 G/T are not included in these figures.

Figure III-2-1 is also express the relationship between the number of ships and the cargo handling volume, and there is no significant difference between the data of Keelung and Kaohsiung. As the first order approximation, linear approximation will be enough. Averange lot size of cargoes per ship is estimated at 3,330 R/T/ship by this figure. Based on these assumptions, number of ships calling at Taichung Harbour in her fully developed stage is calculated as follows.

Non-Operating Vessel	600	ship/year
Commercial Harbour	4,800	" "
Industrial Harbour	1,000	" "
Toal	6,400	" "

Table III-2-1 No. of ships calling and cargo handling volume at Keelung

Year	No. of ships (entering)	No. of ships (leaving)	Mean	handling (1,000 R/T)
1957	1,112	1,129	1,121	1,922
1958	1,336	1,341	1,339	2,229
1959	1,436	1,437	1,437	2,327
1960	1,509	1,506	1,508	2,371
1961	1,429	1,419	1,424	2,656
1962	1,429	1,434	1,432	2,520
1963	1,474	1,469	1,472	2,943
1964	1,648	1,642	1,645	3,303
1965	1,820	1,823	1,822	4,116
1966	1,987	1,975	1,981	4,769
1967	2,337	2,339	2,338	5,729
1968	(2,713)			(6,474)

Table III-2-2 No. of ships calling and cargo handling volume at Kaohsiung

Year	1955	1956	1957	1958	1959	1960	1961
No. of ships (entering)	1,202	1,192	1,408	1,716	1,876	1,935	1,941
Cargo handling volume (1,000 R/T)	2,648	2,792	3,204	3,616	3,930	4,236	4,643
	1962	1963	1964	1965	1966	1967	1968
	2,007	2,137	2,302	2,484	2,995	3,453	4,050
	5,014	5,820	6,660	7,856	9,000	9,637	11,777

Fig. III-2-1 Cargohandling Volume and Number of Ships Calling

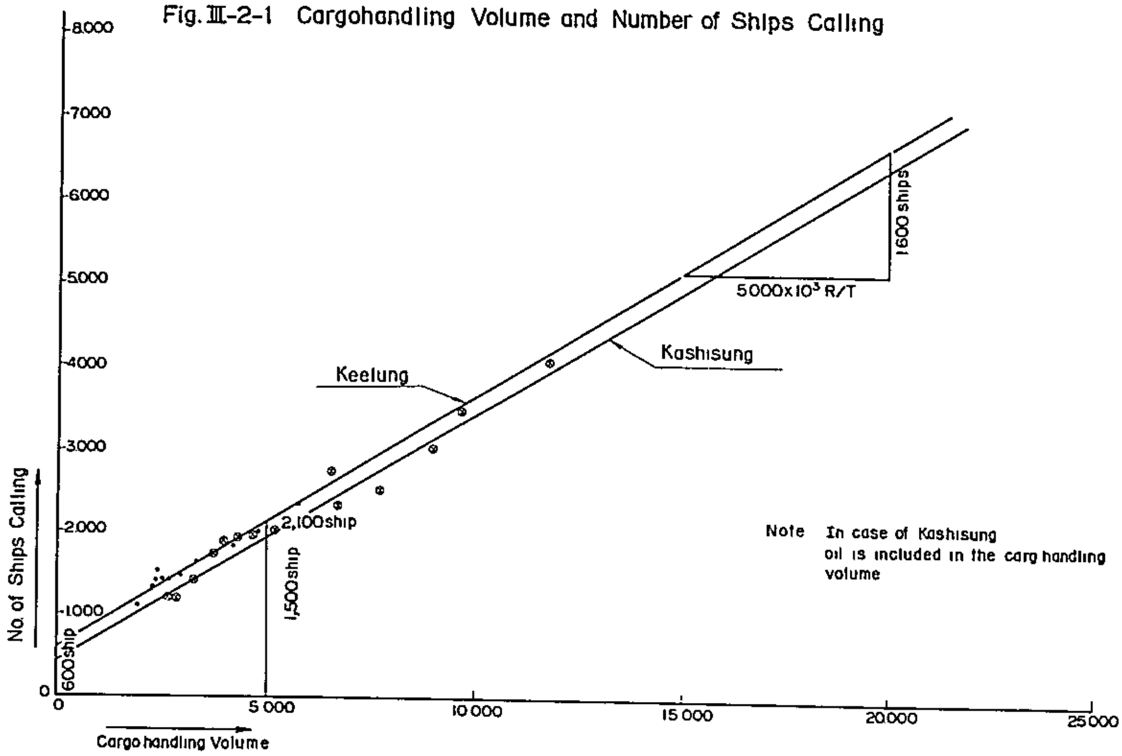
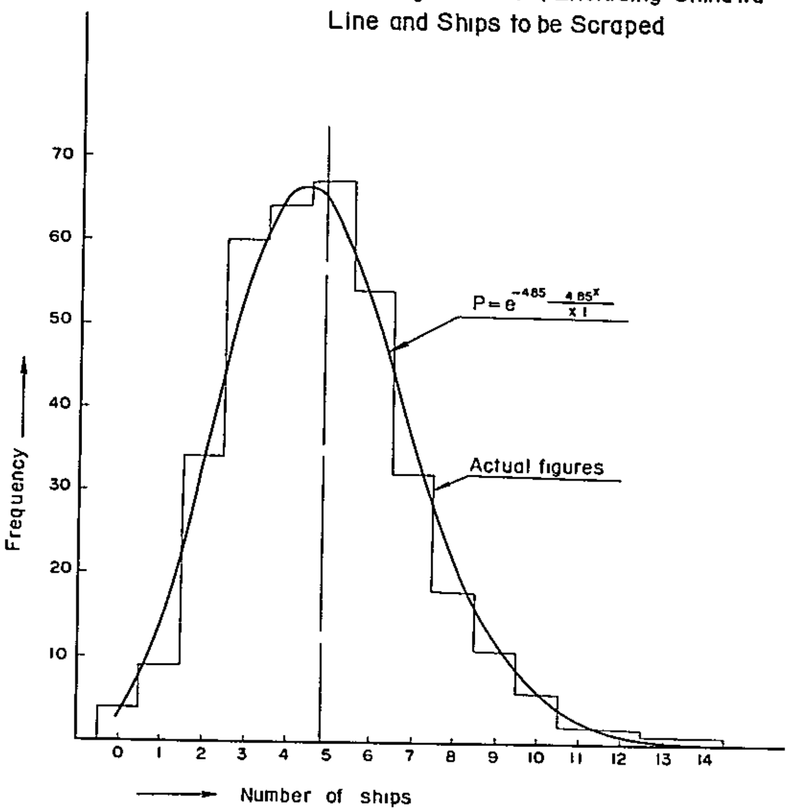


Fig III-2-2 Distribution of Ships Arrival at Keelung Harbour (Excluding Okinawa Line and Ships to be Scraped



The first one is corresponding to the constant term of linear approximation, the second one is the quotient of 16 million R/T devided by 3, 330 R/T/ship and the third one is calculated on the following assumptions:

Major items of cargoes handled in the industrial harbour area will be imported industri al raw materials, and the tonnage of larger bulk carrier will be increased.

ii) Daily fluctuation of entering vessels

The most important task of this section is to determine appropriate probabilistic distribution of number of vessels entering the harbour per day. Many of the studies made for this purpose show that the so-called Poisson distribution is applicable, and this is confirmed by the studies in Ports of Yokohama and Kobe. The Report of New Harbour Project-1969 contains a case study of Keelung Harbour which satisfactorily confirmed the applicability of Poisson distribution.

Figure III-2-2 is cited from the above report.

According to the previous disccussions, number of ships entering Taichung Harbour per day is estimated by Poisson distribution.

The values of

$$P(x) = \frac{\lambda^x}{X!} \, E_{xp}(-\lambda)$$

are calculated for λ = 25, 30, 35, 40, and 45, and shown in Figs. III-2-3 and III-2-4. Corresponding values of number of ships entering the harbour per year to λ (average number of ships entering per day) are as follows:

λ	Number of ships entering (per year)
25 ships/day	4, 500 ships/year
30 " "	5, 400 " "
35 " "	6, 300 " "
40 " "	7, 200 " "
45 " "	8, 100 " "

Note: One year is treated as 360 working days.

In case of λ = 35, 50 ships will be entering this harbour with probability of 5.0×10^{-3} (about two days per year). Therefore, one harbour entrance is recommendable for the Master Plan of Taichung Harbour. There is enough allowance in this estimation, so if λ increase to 40 or 45 as shown in Fig.III-2-4 one harbour entrance will be still workable.

As a check, value of λ which corresponds to probability of more than 49 ships entering this harbour throughout the year (which equal 0.005) is calculated by x^2table.

$$P_r\{x \leq y\} = 1 - G_2(y+1)(2\lambda)$$

Since f = 2(y + 1) = 100 and y = 49, $x^2 \cdot 995$ = 67.3 and λ = 33.6, therefore, this estimation is also in safe side.

Fig Ⅲ-2-3 Number of Ships Incomming & Outgoing

$$P(x) = \frac{\lambda^x}{x!} e^{-\lambda}$$

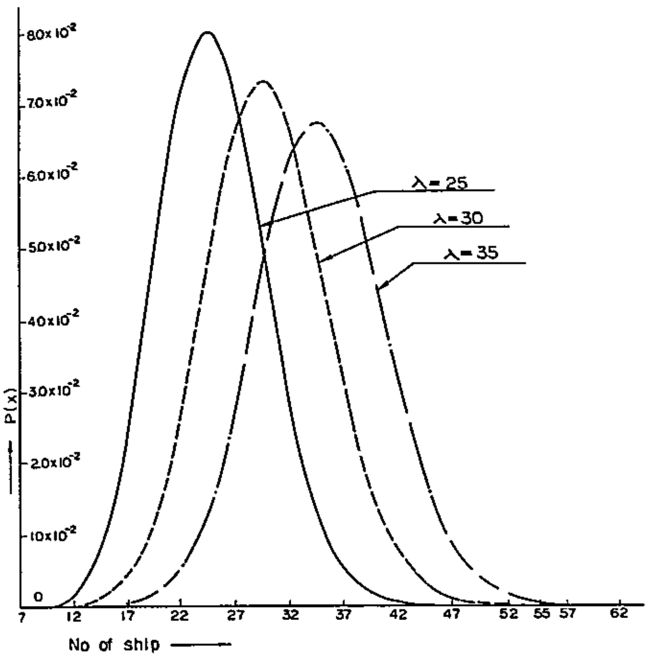
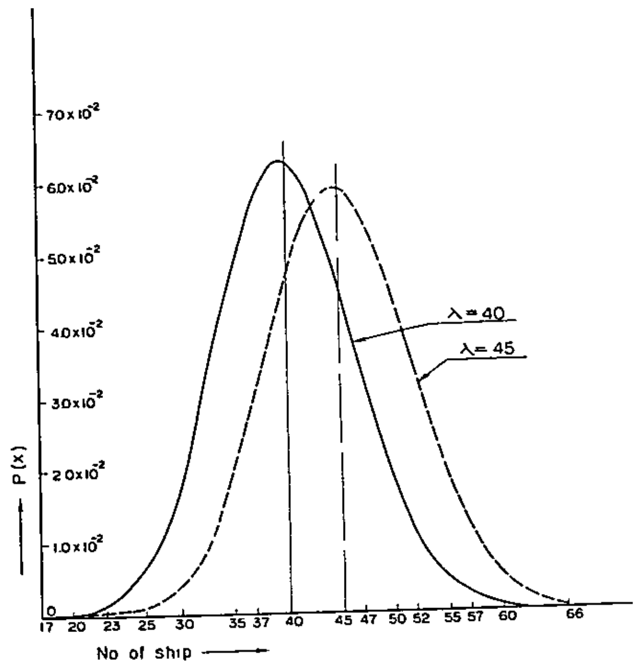


Fig Ⅲ-2-4 Number of Ships Incomming & Outgoing

$$P(x) = \frac{\lambda^x}{x!} e^{-\lambda}$$



Values of P_r and corresponding λ are listed bellow as a reference:

P_r	0.005	0.010	0.025	0.050	0.100
λ	33.6	35.05	37.1	38.75	41.2

3. Required Berths

3.1 Grain Berth

Following cargo handling equipments are proposed in the master plan:

Pneumatic sucker .... 200 Ton/hr., 2 sets per berth

Silo .... 40,000 Ton per berth

Cargo handling speed is assumed to be 8,000 tons per day per berth.

At first, the most severe case of handling 500,000 tons of imported grains at one berth is taken up. Estimation of average waiting time (W_q) by M/D/1 (∞) type waiting line model will be sufficient for this case.

The M/D/1 (∞) type model presumes the following conditions:

i) Ships' arrival at the berth follows Poisson distribution.

ii) Service time distribution is uniform.

iii) Service principle is "First come, first served".

The values of W_q corresponding to various $\lambda/\mu s$ are shown in Fig.III-3-1. If the size of bulk carrier is assumed to be 32,000 D/W class, fully loaded 16 vessels will be enough for 500,000 tons of grain and 4 full days will be required for unloading each vessel. Accordingly, the corresponding value of $\lambda/\mu s$ is 0.18. From Fig. III-3-1 W_q = 0.45 is obtained. In term of A.W.T./A.S.T. (average waiting time vs. average service time) this is 11% in average. In case of chartered vessels this amount of waiting time will be acceptable. If 16,000 D/W class is assumed instead of 32,000 D/W bulk carriers ρ and W_q will be 0.18 and 0.2 respectively, but A.W.T./A.S.T. will be about the same.

Through the above calculation, Poisson arrival is assumed as ships' arrival at the berth, so if efforts are made to make ships' arrival regular by the scheduled purchasing, smaller values of W_q will be attainable.

In this case, the use of larger bulk carrier will be preferable because of the larger expectation of successive open berth hours. Since grain berth will be occupied 52-53 days throughout the year by bulk carriers (in case of 32,000 D/W are chartered), they can be used for tramp ships. Expectation of successive open berth hours is about 20 days.

3.2 General Cargo Berth

In this Master Plan cargo handling capacity of 150,000 R/T/berth per year is assumed. As this figure is rather low for the actual performance of Keelung Harbour, severe port congestion will not be occurred in this harbour.

Analysis of M/M/S (∞) type model, which was used in the REPORT OF NEW HARBOUR PROJECT -1969 is presented herein. At first calculations are made on the following statistical data of Keelung Harbour against the situation in 1980 when 23 of general cargo berth will be completed. i) cargo handling speed is assumed 950 R/T/ship · day, ii) lot size of cargo for one ship will be 2,500 R/T/ship. In this case number of vessels berthing is 60 ships/berth/year and corresponding figures of $\lambda/\mu s$ is 0.425. If the lot size of cargo for one ship becomes

1, 500 R/T/ship, number of vessels berthing for one berth will be 100 ship/berth/ year and corresponding λ/μs will be 0.465. Using Fig. III-3-2, it is easily concluded that operation of general cargo berths will be carried out with enough allowance under the above conditions.

Expected cargo handling speed of 950 R/T/ship.day may be a strong assumption but, value of $\lambda/\mu$is still 0.6 to 0.7 if it becomes 600 R/T/ship/day.

Therefore, there will be no severe port congestion, if the 23 berths are operated as an integral whole.

3.3 Cement Berth

Ships' size for exporting cement is assumed to be about 20,000 D/W class, but there are some uncertainty on the lot size of cement. Cement berths are therefore two groups, i.e. berths for exporting bagged cement and those for exporting cement clinker.

Two berths of - 11^m x 200^m wharf with loaders for bagged cement are allocated as the first group and the capacity of these loader is designed 300 ton/hr. for each berth. To the second group two berths of - 11^m x 200^m are also allocated, and a loader for cement clinker with a capacity of 500 ton/hr. will be installed at each berth.

M/M/2 (∞) type model is used for analysis and this type of model will cover fluctuation of lot size.

Clinker berth: As the safe side assumption, distribution of lot size is assumed as negative exponential with a mean value of 8,000 tons.

By the above assumption, loading capacity at one berth is estimated at 4,000 ton/day (8 working hours per day). Then each berth will be occupied about 125 days throughout the year for loading 500,000 tons of cement clinker. Corresponding berth occupancy will be 0.34 and A.W.T./ A.S.T. about 0.12. Averagy waiting time is nearly 5 hours per ship. This figure is considered rather high, but the assumed working hour which is too short for a well equipped and specialized berth will be the remedy.

Bagged cement: If the mean value of lot size is assumed to be 4,800 tons, 300,000 tons of bagged cement will be exported through each berth on the same condition as applied to the clinker berth.

Under these conditions, probability of one of the two berth being idle, given the condition of all berth are not idle, is calculated by the following formula.

$$P_o = 1/\left\{\sum_{n=0}^{S-1} \frac{a^n}{n!} + \frac{a^S}{(S-1)!\,(S-a)}\right\}$$

where P_n is the probability of n ships (of this group) staying in harbour, S is number of berth (of this group) and a is λ/μ. The result of P_1 is 0.335.

Therefore, loading machines should be designed to cover each two berths so as to assure quick dispatch of ships and reduce their waiting time for berthing.

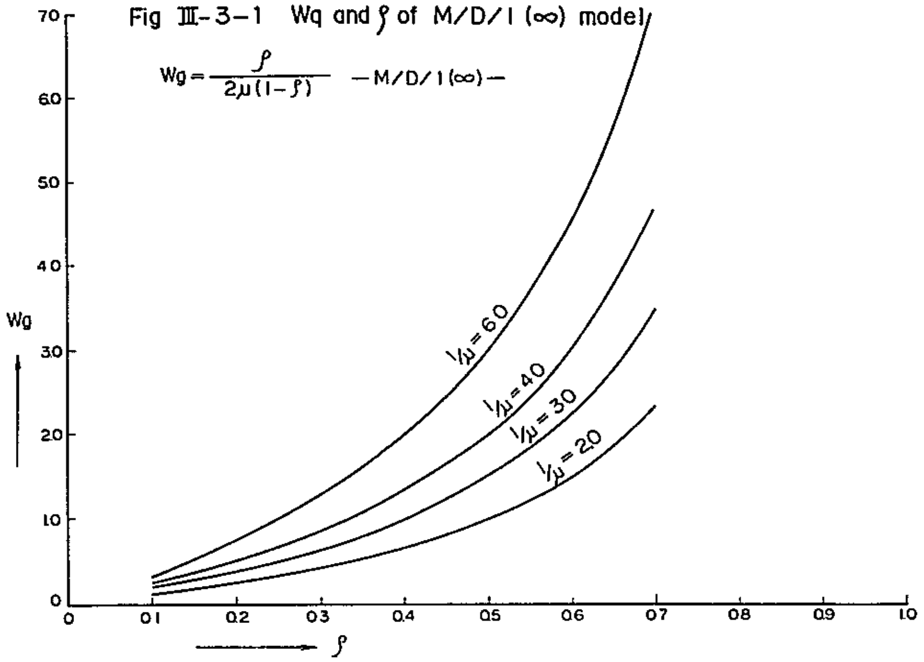


Fig III-3-1 Wq and ρ of M/D/1 (∞) model

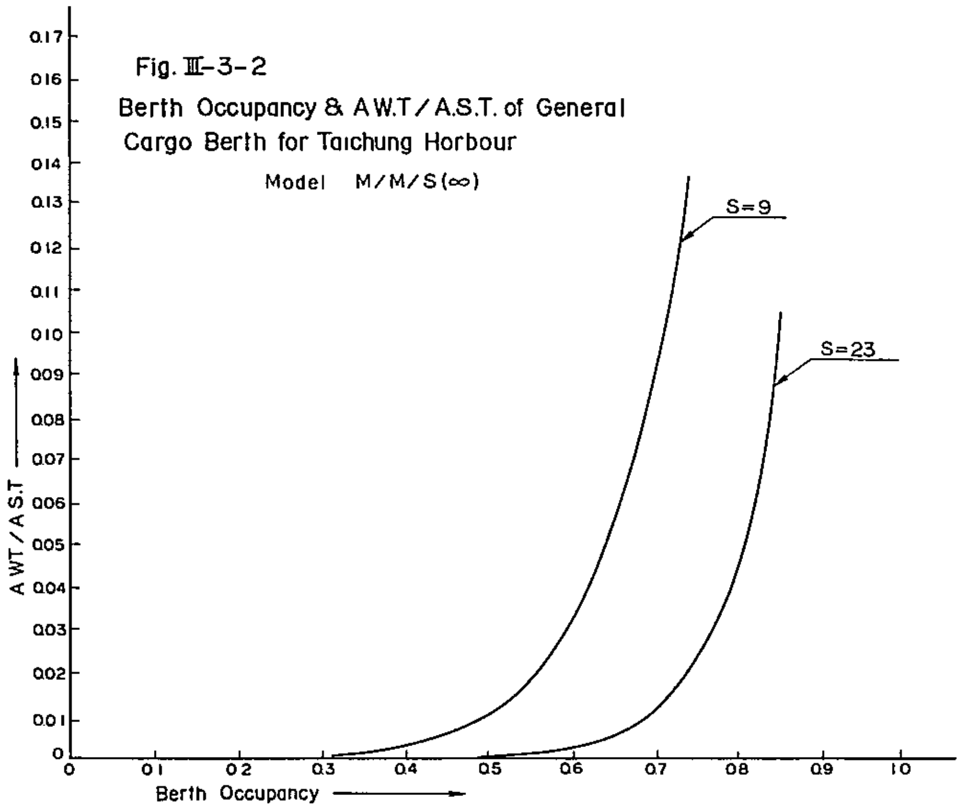


Fig. III-3-2
Berth Occupancy & A.W.T / A.S.T. of General Cargo Berth for Taichung Horbour

3.4 Container Berth

It is rather difficult to make analysis of the operation of container berths with the same level of accuracy as shown in the previous sections (3.1 to 3.4). The reasons are i) estimation of cargoes which will be containerized could not be precise at present, and ii) type of container berth is likely to change (for example, Matson type (straddle carrier) or Sea-Land type (trailer chassis)) by which shipping company will be the terminal operator or user of the berth. However, analysis based on the currently available information, may it be poor, will be useful as an approach to the containerization problem of Taichung Harbour.

According to the proposed Master Plan, 1.5 million R/T of cargo will be containerized and 3 of container berth will be construxted before 1980. Major items of containerized cargoes will be canned food, carton-boxed banana and so-called general cargo for export, and general cargo such as machinery and their parts for import.

Firstly, it is assumed that number of loading containers and unloading ones, except empty ones, will be balanced by the effort of shipping company who is intensively trying to eliminate transport of empty containers. But, the diference between container ships and conventional ships should be clearly recognized.

In case of containerized shipping operation, the balance between export cargo and import cargo should not be considered in terms of revenue tons.

Based on the experience in Japan, volume of cargo which can be accomodated in one standard size container (8' x 8' x 20'), is estimated for major container cargoes of this harbour and expressed in terms of metric tons and revenue tons.

cargo items	M/T	R/T
banana	10	33
canned food	15	33
general cargo (I)	5	10
general cargo (II)	7.5	10

Secondly, the use of ordinary type container is assumed for export of banana. Under these assumptions, number of containers which will be handled through Taichung Harbour in one year is estimated.

Putting x, y and z as number of containers of canned food and banana for export, general cargo for export , and general cargo for import, respectively, with θ as y/x, values of x, y and z are calculated as follows:

θ	0.1	0.2	0.3	0.4	0.5
x	32,600	31,250	30,000	28,850	27,780
y	3,260	6,250	9,000	11,540	13,890
z	35,860	37,500	39,000	40,390	41,670

If weekly container ship service is assumed, number of containers which will be handled at one container berth by one calling is estimated to be about 500 to 550. Corresponding total cargo volumes per year of major cargo items

Fig. III-3-3
Berth Occupancy & A.W.T/A.S.T of Cement Berth for Taichung Harbour

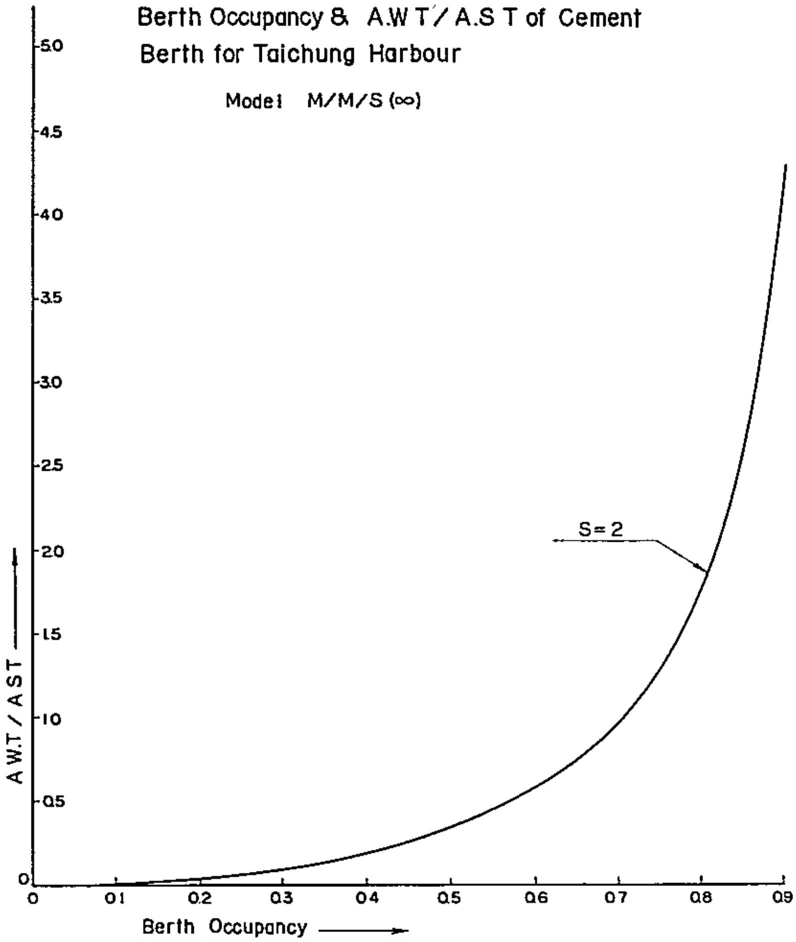
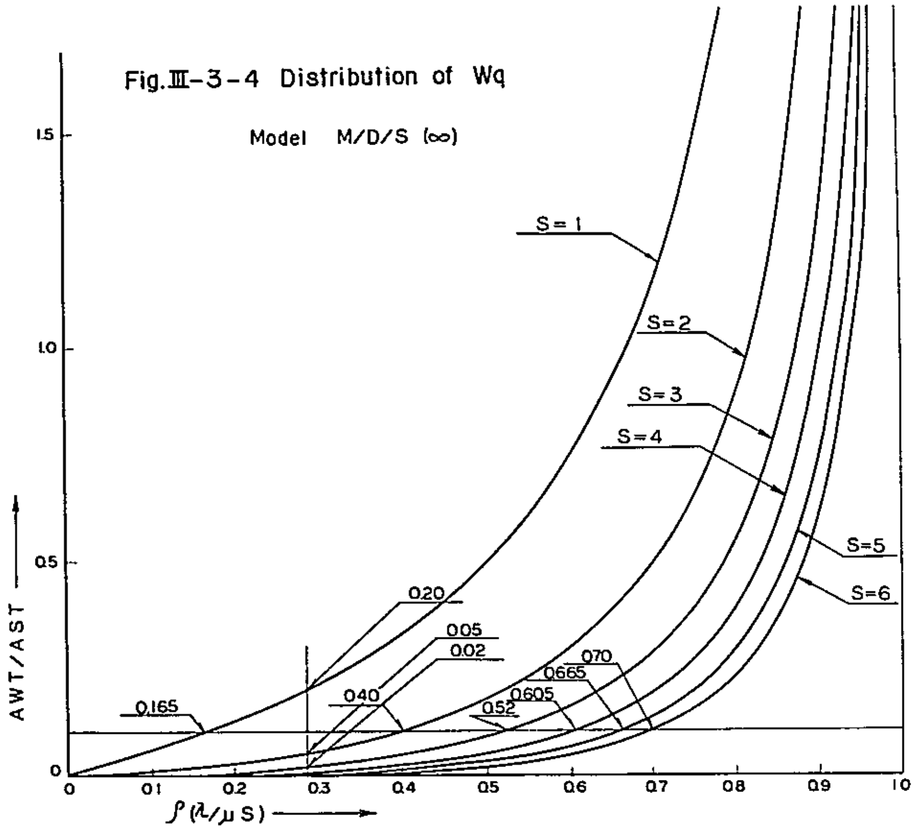


Fig. III-3-4 Distribution of Wq



are as follows: canned food and banana is one million R/T, general cargo (export) 0.1 million R/T, and general cargo (import) 0.4 million R/T. But, seasonal fluctuation of banana export may increase the above figure up to 600 to 800.

Since handling capacity of one container crane is well over 20/hr. in average against total berthing time of a container ship, 2 days will be quite a safe estimation of average berthing time for one calling.

Under the normal berth operating condition, no container ship need to wait for berthing because ships' arrival at the port is controlled and regular. Proposed size of container wharves will also be wide enough for this level of transport demand. The value of ρ is 0.286 ($\rho = \lambda / \mu s = 2/7$). As an extreme case, analysis by M/D/S (∞) type model -- which is made on the assumptive case of random arrival of ship -- is shown in Fig.III-4-1.

Even in this extreme case, value of A.W.T. /A.S.T. is low for 2 and 3 berths, while in the case of one berth it is rather high with 0.2.

Probabilities of n container ships staying in harbour as calculated by M/D/S (∞) type model are shown below.

S \ Pn	P_0	P_1	P_2	P_3 and over
2	0.709	0.244	0.042	0.005
3	0.738	0.224	0.034	0.004

Above figures indicate that in case of 2 berths, 83% of container ships calling at this container terminal can be served with two container cranes at once, though each berth is equipped with one container crane. In case of 3 berths, almost all container ships can be served with two container cranes. Therefore, all container cranes should be so designed as to cover all container berths.

IV COASTAL ENGINEERING PROBLEMS

IV COASTAL ENGINEERING PROBLEMS

1. Planning of Outer Protective Works

1.1 Problems Related to Sand Drift

(1) The proposed layout of outer protective works follows in general the previous plan which had been examined by model experiment. The location of each pierhead (-15 m for north breakwater, -12 m for south breakwater, approximately -5 m for groyne) is based on the sounding map of 1964 at the time of interim report and is later corrected on the basis of local sounding carried out up to April 1970. At the same time, the alignment of north breakwater is slightly modified by extending the existing part straight up to -5 m. The shallower part of south breakwater is also modified in similar way. The groyne is slightly diverted northwards.

(2) At the time of Niitaka Harbour construction, the entrance channel (-7 m) was rapidly silted up. This is mainly because that the dredging was started before sufficient extension of north breakwater and without any shelter by south breakwater (the water depth of the temporary north breakwater-head had been -5~ -7 m before its construction). Sand drift along this coast seems to be the most remarkable in a zone approximately from +2 m to -5 m. Rapid silting up of the proposed entrance channel will be avoided by extending north breakwater to deep water through this zone as quickly as possible and by obtaining the sheltering effect of south breakwater.

(3) However, the maintenance dredging will be inevitable to a certain extent, due to the deposit of suspended load brought into the harbour basin with tidal current, some amount of blown sand and direct invasion of materials from the harbour entrance. It is impossible to evaluate definitely the amount and the location of maintenance dredging. 0.5 - 1 million m^3/year will be taken as a rough figure for the time being. A part of deposit will be effectively used for reclamation together with the materials trapped around the groyne in north beach. It will be a matter of reconsideration whether to extend the groyne rapidly up to deeper part in the present topography or to continue gradual extension of simple profile making use of the advance of the beach.

(4) One of the noticeable phenomena as to the sand drift along the north beach between Ta-Chia river mouth and north breakwater is a remarkable projection of +2 m contour line and its southward migration, which is similar to a sand spit and is always found in sounding maps during 1957 64. The highest ground level of the bar is mostly around + 3.4 m. The migration of the head of the bar is about 800 m during 4 years from 1957 through 1961 and about 900 m during 3 years from 1961 through 1964. The average speed of migration is therefore 200~300 m per year.

(5) The contour line of + 2 m was surveyed on 25th December 1960. It was confirmed that the bar has migrated by about 500 m since 1964 and approached the north breakwater. The average speed is reduced to 100 m/year, probably due to the influence of the north breakwater.

(6) A similar bar is also clearly perceived in the aerial photograph taken on 24th November 1958, but is not found in the photograph of 21st August 1931. It is impossible to trace back the behaviour of the bar in the past, because the sounding before 1957 was limited within only around the harbour entrance.

(7) Similar projections are found in + 3 m contour line between the Ta-an and Ta-Chia river mouth and also on the south beach near the Tatu river mouth. No remarkable projections are found along the narrow beach in front of the existing south breakwater.

(8) The mechanism of such a southward migration of a bar like sand spit cannot be easily explained. It seems, however, that the action of littoral drift due to breaking wave and wind is most remarkable in a zone of around + 2 ~ + 3 m which nearly coreesponds to the mean sea level in this coast.

(9) The contour lines of ± 0, -5, -10, -15 m are more or less projected in front of the above-mentioned bar and also show a tendency of southward migration with the bar. The average speed is also about 300 m/year.

(10) The sounding map of 1957 shows three such projections (between Ta-an and Ta-Chia river mouth, between Ta-Chia river mouth and north breakwater, and in front of south breakwater) with intervals of 5 ~ 7 km. Sounding maps of the following years show the tendency of their southward migration but the bar in front of south breakwater seems to have disappeared after approaching the Tatu river mouth.

(11) Similar tendency is also suggested by the variation of contour lines in sounding maps during the construction of Niitaka Harbour. Although the situations are unknown in north and south beaches, a part of wave breaking line is projected offshore to some extent even in the above-mentioned aerial photograph of 1939.

(12) If the projections with an interval of several kilometers migrate at a speed of 300 m/year or so, they are to appear and disappear every 15 or 20 years. Such a long term variation may be derived from the change in sediment discharge by rivers and in wave conditions. Although the sediment discharge from adjacent rivers is unknown, the records of precipitation in the upstream suggest its secular variation. Namely, the total precipitation during the passage of a typhoon is usually 50 ~ 200 mm, whereas in some exceptional cases the precipitation reaches 1200 mm, for example, in case of Typhoon Gloria of 11th September 1963 or 800 mm in case of a small typhoon of 7th August 1959. Moreover, the material deposited in front of river mouth due to flood discharge will not be readily transformed into littoral drift, but will show a long term variation together with the secular change of wave conditions.

(13) It is probable that the sea bottom configuration around the proposed entrance has changed even in the deeper part accompanied by the aforementioned approach of + 2 m line to north breakwater. It is necessary to examine such a change by immediate sounding and to make a constant observation.

(14) Accuracy of the past sounding maps is the vital factor in justifying the above description. Careful attention should be paid hereafter to the accuracy of sounding and the phenomena of sand drift should be examined taking into account such features.

1.2 Problems Related to Waves

(1) Wave estimations carried out for Taichung Harbour and several other locations along Taiwan Coast are summarized in "Report of New Harbour Project - 1969". Based on these data, the design wave for breakwaters in Taichung Harbour are estimated as follows.

North Breakwater: (for the strongest winter monsoon and for big typhoons)

$H_{1/3}$ = 6.0 m, $T_{1/3}$ = 12 sec.

South Breakwater: (for big typhoons)

$H_{1/3}$ = 3.5 m, $T_{1/3}$ = 10 sec.

(2) Above-mentioned data contain the estimated wave for Typhoon Pamela on 12th September 1961. The procedure of wave estimation employed in this case is one of the methods established at present, namely a modification of Wilson's graphical method for deep water waves due to moving fetch to numerical calculation with electronic computer taking into account the effect of bottom friction in shallow water.

(3) Typhoon Pamela while around Taiwan is counted as the second largest typhoon during 1948~1966 and as the largest of those having traversed the middle part of Taiwan. On 27th September 1969, Typhoon Elsie caused damages to Taichung Harbour and at various places in Taiwan, following a similar course to Pamela. Although Elsie seems to be a little smaller than Pamela on weather map (Fig. IV-1-1), the records at Taichung Observatory and Taichung Harbour Office show that the former surpassed the latter as shown in Table IV-1-1.

Table IV-1-1 Comparison of Typhoon Pamela and Elsie

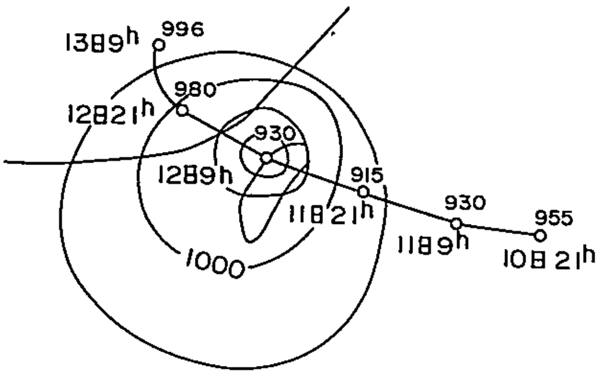
	Max. Wind Speed				Lowest Atm. Pressure
	Taichung Harbour		Taichung Observatory		Taichung Observatory
Pamela	28 m/s.	S*	16.5 m/s	NNW	962.6 mb
Elsie	33	NNE	21.5	NNW	950.6

* Max wind speed from northward direction might be about 25 m/s (uncertain due to accident of the anemometre).

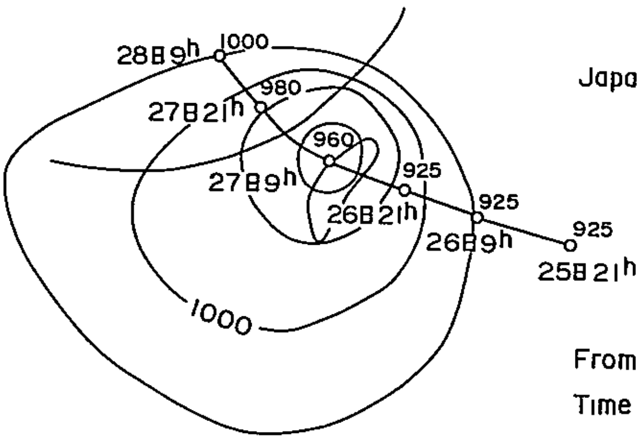
(4) The central pressure of Pamela when passing by Taichung was 930 mb on the weather map, but it was afterwards corrected to 980 mb in the typhoon report by Taiwan Provincial Meteorological Department. For wave estimation, however, a model typhoon was used assuming the central pressure of 930 mb, r_0 (radius to maximum wind speed circle from the center) of 87 km, moving speed of 30 km/hr, moving direction of NNW and the maximum gradient wind speed on sea surface of 30.7 m/s. The difference in wind record between the two typhoons was caused not only by their size but also by slight changes in their course. Insofar as the size of the above-mentioned model typhoon is used for Pamela, estimated wave of Elsie may be almost the same as or rather smaller than that of Pemela.

Fig. IV-1-1 Typhoon Pamela and Elsie

(a) Typhoon Pamela (Sept. 1961)



(b) Typhoon Elsie (Sept. 1969)



Japan Meteorological Agency

From daily weather map of
Time : Japan Standard Time

(5) Wave estimation for Typhoon Grace of 3rd September 1958, which surpassed Pamela, has already been carried out for Kin-Shan. A model typhoon (central pressure of 915 mb, r_0 = 87 km, moving speed of 20 km/hr, moving direction of NW) was assumed to pass directly over Kin-Shan. The maximum estimated wave is: NNE $H_{1/3}$ = 7.1 m. $T_{1/3}$ = 9.5 sec.

(6) It is to be desired to carry out wave estimation for Elsie, applying the same method as used for Pamela and Grace. However, as the accuracy of wave estimation is limited, the dimension of design wave should be studied together with the structural type of breakwater and the method of calculating wave force and stability.

(7) According to wave estimation for Kin-Shan conducted on 22 prominent winter monsoons during 1957 ~ 67, $H_{1/3}$ of 7.4 ~ 4.4 m was obtained. If 0.8 times of these wave heights are simply assumed to be valid for Taichung Harbour, taking into account the effect of limited fetch width in Taiwan Straits, $H_{1/3}$ will become 6 ~ 3.5 m.

(8) Waves from southward direction are also caused by typhoons moving northwards through Taiwan Straits though. There are scarcely found actual typhoons of this route. A wave estimation by Wilson's method was carried out with a model typhoon modifying Typhoon Patty (1951.9.26), Bess (1952.11.13 ~ 14), Judy (1966.5.30). This model was assumed to have the central pressure of 970 mb, r_0 of 50 km, maximum gradient wind speed on sea surface of 25.4 m/s, and to pass 50 km off Taichung Coast in NNE direction at a moving speed of 20 km/hr. The estimated wave is : WSW, $H_{1/3}$ = 3.5 m, $T_{1/3}$ = 9 sec.

(9) The wave pattern of various incident waves is shown in Fig. IV-1-2 which was prepared by making use of wave diffraction diagram and data of model experiments for similar conditions. The details will be further examined by model experiment.

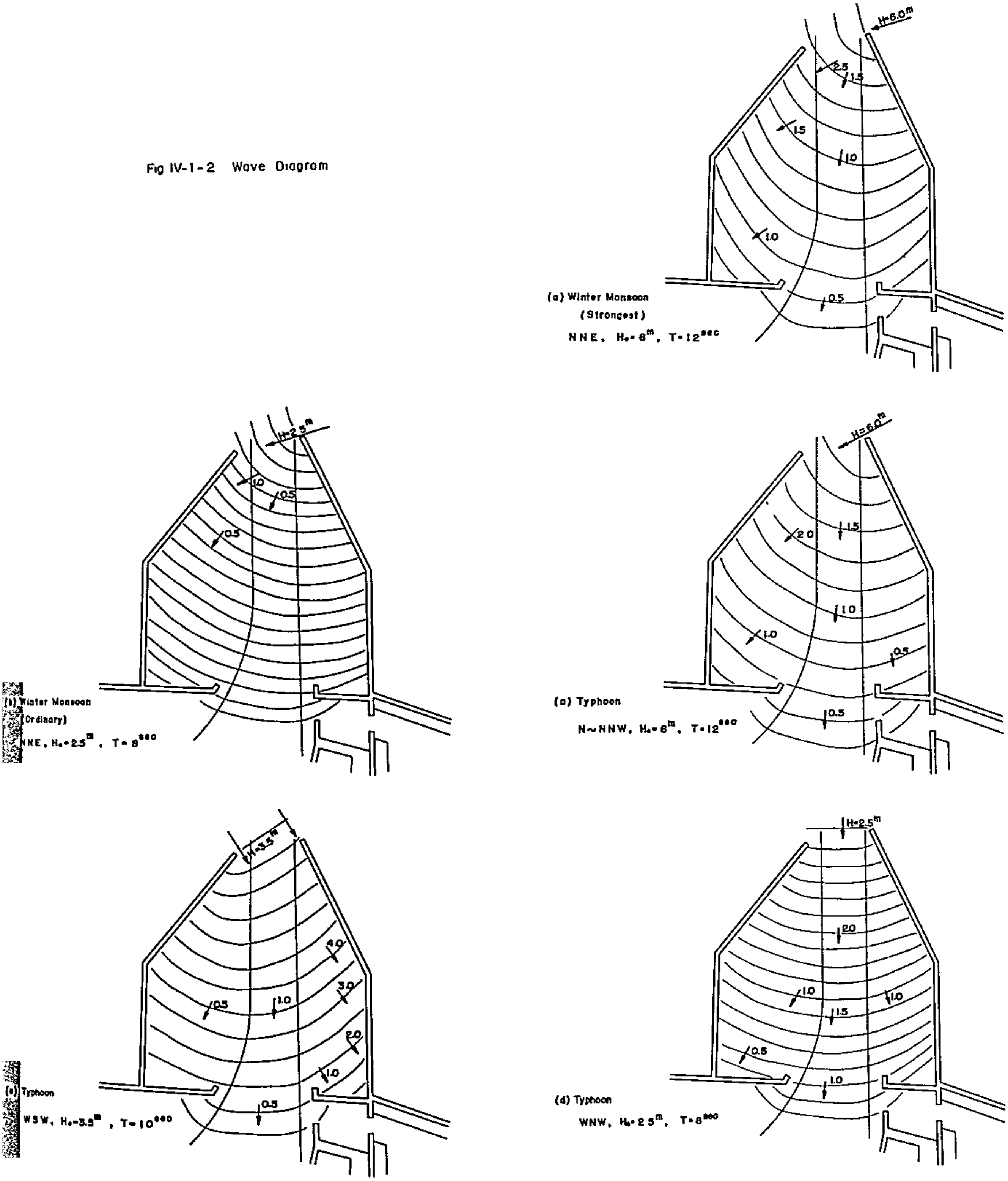
(10) As the proposed main navigation channel in the inner harbour basin has the direction coincident with that of the prevailing winter monsoon, the local wave is estimated as follows:

Max. fetch: F = 8 km
Fetch width: W = 500 m ∴ W/F = 0.06
Effective fetch: Fe = 0.25 x 8 = 2 km
$H_{1/3}$ = 0.4 ~ 0.6 m, $T_{1/3}$ = 2.2 ~ 2.5 sec, t min ≒ 20 min.
for wind speed of 10 ~ 15 m/s.

(11) Wave estimation ordinarily gives deep the water wave height (or equivalent deep water wave height). The incident wave to structures is affected by refraction and shoaling. Diffraction and breaking should be considered if necessary. However, owing to the variation of wave direction around that of main wind, uncertainty of refraction of waves generated in shallow water, accuracy of wave estimation and so on, it will be allowed to regard the above-mentioned estimated wave height as the incident wave height to the north and south breakwaters.

(12) The above-mentioned design waves are represented by significant waves. These wave groups include all the waves from Hmax to Hmin and the

Fig IV-1-2 Wave Diagram



structures should be designed to resist the maximum wave force exerted by Hmax, which will be either almost 2.0 $H_{1/3}$ or breaking wave height Hb restricted by the water depth. The wave height to be used for stability calculation should be considered in combination with the wave force formula for design purpose.

(13) The crest height of mixed type breakwater in outer harbour is, in the present Japanese practice, usually about 0.6 $H_{1/3}$ above high water level ordinary spring tide. In this criterion there will be certain amount of wave overtopping under design wave (wave transmission ratio is 10~15% when the crest height of the wall is 0.6 H above still water level), but it will not be so remarkable under normal conditions. The increase of the crest height is certainly effective for reducing wave overtopping but should be considered also from the viewpoint of construction cost.

(14) The Japanese design standard has so far adopted Hiroi's and Sainflou's formula for designing vertical wall in mixed type breakwater, using significant wave height for calculation. This regulation does not fully take into account the wave irregularity and the reliability of each formula, and there remain some questions to be discussed. The recently proposed method of "probable sliding distance", recently proposed by author, has solved these problems and is going to be adopted in the design standard.

(15) The basic idea of this method is to evaluate the final stability of structures by examining their degree of damage, under waves exceeding design condition. Monographs have been prepared to calculate the amount of sliding of the wall under any incident wave. Economical design is possible if a certain amount of displacement is allowable under very rare waves. The following wave pressure intensity is applied in this method for design purpose.

$$\frac{p}{wH} = 0.7 \qquad \frac{H}{d} < 1$$

$$= 0.15 + 0.55\frac{H}{d}, \qquad \frac{H}{d} > 1$$

where, p is pressure intensity on vertical wall, w is unit weight of water, H is wave height, and d is water depth above rubble-mound. The wave pressure distribution is assumed to be uniform from the base of the wall up to the crest (or 1.25 H above still water level) and the uplift to have a traiangular distribution equal to p at front toe and zero at rear toe. The smaller value of 2.0 $H_{1/3}$ or Hb (nearly equal to 0.8 times the water depth) should be used as wave height H.

(16) Even in Hudson's and other formulae for block weight in armour layer, the wave height for calculation is not always clearly defined. According to author's examination of model experiments and actual examples, the smaller value of either $H_{1/3}$ or Hb seems to be applicable for practical purpose.

(17) The wave irregularity should be also taken into consideration for wave overtopping sea walls. A new concept of "expected overtopping discharge" has recently been proposed and is already applicable to a certain extent for practical use.

(18) More careful examination should be made for detailed design, taking into account the variability of wave characteristics, wave irregularity, incident wave angle, variation of sea bottom, function and stability to be required for structures.

1.3 Others

(1) The record of wind speed at Taichung Harbour shows a noticeable feature that it is generally weak from the midnight to the morning and fairly strong during the daytime and reaches the maximum around 15:00 hr. This tendency is also clearly found in the monthly average wind speed at each hour during 4 years from 1939 to 1942.

(2) Making use of this tendency, the plotted the variation of wind speed at 2 a.m. and 2 p.m. of each day during the past 10 years (The graphs are reserved in Taichung Harbour Office). These graphs are very convenient to get a clear idea of meteorological conditions, as the curve is continuous without decay in the night during the strong winter monsoon and typhoons while the crests and troughs are repeated day and night under normal conditions.

(3) Table IV-1-2 is the statistics showing average days in a year of daily highest wind speed.

Table IV-1-2 Statistics of Daily Highest Wind Speed
(at Taichung Harbour, 1959 ~ 1968)

Class \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Year
~ 4.9 m/s	3.2	3.1	6.3	9.8	9.5	9.5	10.9	13.1	9.3	5.5	4.9	2.8	87.9
5.0 ~ 9.9	12.2	13.1	15.6	15.1	16.7	16.4	16.9	14.7	13.4	9.4	11.6	12.3	167.4
10.0 ~ 14.9	13.0	9.7	7.4	4.3	4.6	3.8	2.7	2.1	5.5	10.8	9.7	11.4	85.0
15.0 ~ 19.9	2.6	2.2	1.1	0.8	0.2	0.1	0.3	0.6	1.8	3.9	3.6	3.2	20.4
20.0 ~	1.1	0.1	0.1	0	0	0	0	0.3	0.6	0.1	0.2	0.1	2.6

(4) From the data of the inundation due to Typhoon Elsie, the tide level at that time is estimated to be about +6 m. The astronomical tide is calculated using the tide table issued by Japan Meteorological Agency (Standard port is Sasebo. Time difference and tide ratio are assumed to be 2h 45 ^{m} and 1.75, respectively.)

26/9/1969 23h 40^{m} : + 5.3 m

27/9/1969 05h 40^{m} : + 0.3 m

(Taiwan standard time)

The maximum wind speed was recorded at 01 o'clock on 27th and the tide then was + 4.7 m. The storm tide (departure from astronomical tide) is therefore estimated to be 1 m or so.

The astronomical tide at the time of Typhoon Pamela is as follows.

12/9/1966, 00h 10^{m} : + 5.1 m

06h 10^{m} : + 0.9 m

The maximum wind speed before the change of wind direction was recorded at 4 o'clock, when the tide was + 2.5 m. This is very low as compared with that during typhoon Elsie.

2. Program for Further Investigation

2.1 Model Experiment

(1) There are a lot of items to be further studied on coastal engineering problems related to Taichung Harbour Construction. It is necessary to promote the investigation by intensifying the organization for investigation which includes experimental facilities, holding the connection to detail design.

(2) Model experiment is to deal with the functional and structural problems of breakwaters, groynes, sea walls and so on. It will also deal with the problem of wave dissipation to imporve the calmness in harbour basin.

(3) As the experimental facilities, a wave basin for sand drift and sheltering problem and a wave channel (or basin) for structural problem are to be constructed.

(4) The size of the experimental basin may be of about 50 m, 40 m, 1 m. The general phenomena along Taichung Coast will be observed in a fixed and partly movable model of horizontal scale of 1/300 and vertical scale of 1/50 or so.

(5) The experiment for sheltering may be made with a scale of more than 1/150, and incident waves for each structure before the completion of main breakwaters are also to be examined. This sheltering experiment will be carried out either in the sand drift wave basin or in the wave basin for structural problem referred to in the next item.

(6) The experiment for structural problem requires a wave channel (30 m x 1 m x 1 m) or a wave basin (30 m x 10~20 m x 1 m). The latter is convenient for studying the effect of oblique waves or stability of pierhead. A larger basin is necessary when the basin is also used for sheltering experiment.

(7) The details of experimental facilities are to be designed through further examinations.

(8) The staff for experimental investigation is to be composed of a supervisor, two engineers responsible for each basin and several assistants. Several workers are occasionally required for model construction and so on.

2.2 Field Observation

(1) The most urgent task is re-opening of sounding, which has been suspended since 1964. Careful attention should be paid to the projections of contour line as already mentioned. It is desirable to repeat sounding twice a year or more for certain parts of the coast. The accuracy of sounding should be confirmed by repeating sounding in a certain area of, for example, 2~3 km wide around the proposed entrance.

(2) Aerial photograph should be usefully applied for obtaining general conditions of the vast area of this coast.

(3) The establishment of tide gauge is also urgently called for. This will be done by either a temporary tide gauge capable of recording down to low water and being replaced time to time with the progress of construction work, or a permanent observatory located at -15 m or so to record meteorological and wave data at the same time. For these measurements, long term auto-recording apparatus or telemetering system will be applicable.

(4) Tracers such as fluorescence will be useful for sand drift observation.

(5) Measurement of suspended load is recommended in order to examine the invasion of sediment discharge from river flood into harbour basin.

(6) The detailed program for field observation will be examined together with that for model experient.

2.3 Others

(1) Even if quantitative data is not easily obtained, general information should be collected as to discharge and sediment transport of the Ta-An, Ta-Chia and Tatu rivers.

(2) In order to investigate the phenomena at Taichung Coast as a part of of coastal problems along the west coast of Taiwan, the adjacent coast should also be occasionally observed. Exchange of obtained data is recommended between organizations interested in this problem.

(3) Damage of structures, inundation due to storm tide, variation of beach configuration and so on should be immediately investigated after typhoon and other abnormal conditions.

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- o F.L.W. Tang, C.T. Kuo : Wave Estimation Report of King-Shang Nuclear Power Plant Site (1968)
- o Y. Ito et al : On the Stability of Breakwaters (Report of Port and Harbour Research Institute, Vol. 5, No. 14, 1966)
- o Others (Weather Maps, Tide Table, etc.)

V CONSTRUCTION PLAN

V CONSTRUCTION PLAN

1. Principal Facilities

1.1 Premise of Construction Plan

As stated in Chapter I (General), the construction plan is mapped out in consideration of the necessity of improving handling capacity of foreign trade cargoes from the viewpoint of national economy, the execution capability of portworks and the economy of exectuion (Balance of workload over construction period). Therefore, the project covering the period from 1970 to 1980 is divided int o the following four stages:

(1) Preparatory stage (1970 - December 1971)

In order to ensure that the permanent works may be commenced from early 1972, the following preliminary works should be completed during this stage: construction facilities (the sitework, a ship basin, mooring facilities, a dry dock; concrete plants, etc.); access roads; repair of the existing north breakwater; procurement of floating equipment and construction machinery; detailed design of structures and hydraulic model tests.

(2) First stage (January 1972 - June 1974)

With the aim of opening this harbour upon completion of this stage, emphasis shall be placed on the rough formation of the basic facilities such as breakwaters and channels. That is, the north breakwater will be extended for a total of 940 m to a depth of -12 m and the south breakwater 1,020 m to -7 m. And, the groyne will be constructed for a length of 790 m to a depth of about -5 m to let it display the function of preventing drift sand as much as possible. Besides, the greater parts of the seawall and inner breakwaters will be constructed. Thus, a regime to protect the inner harbour from the waves and swells will be established though it may still be imperfect.

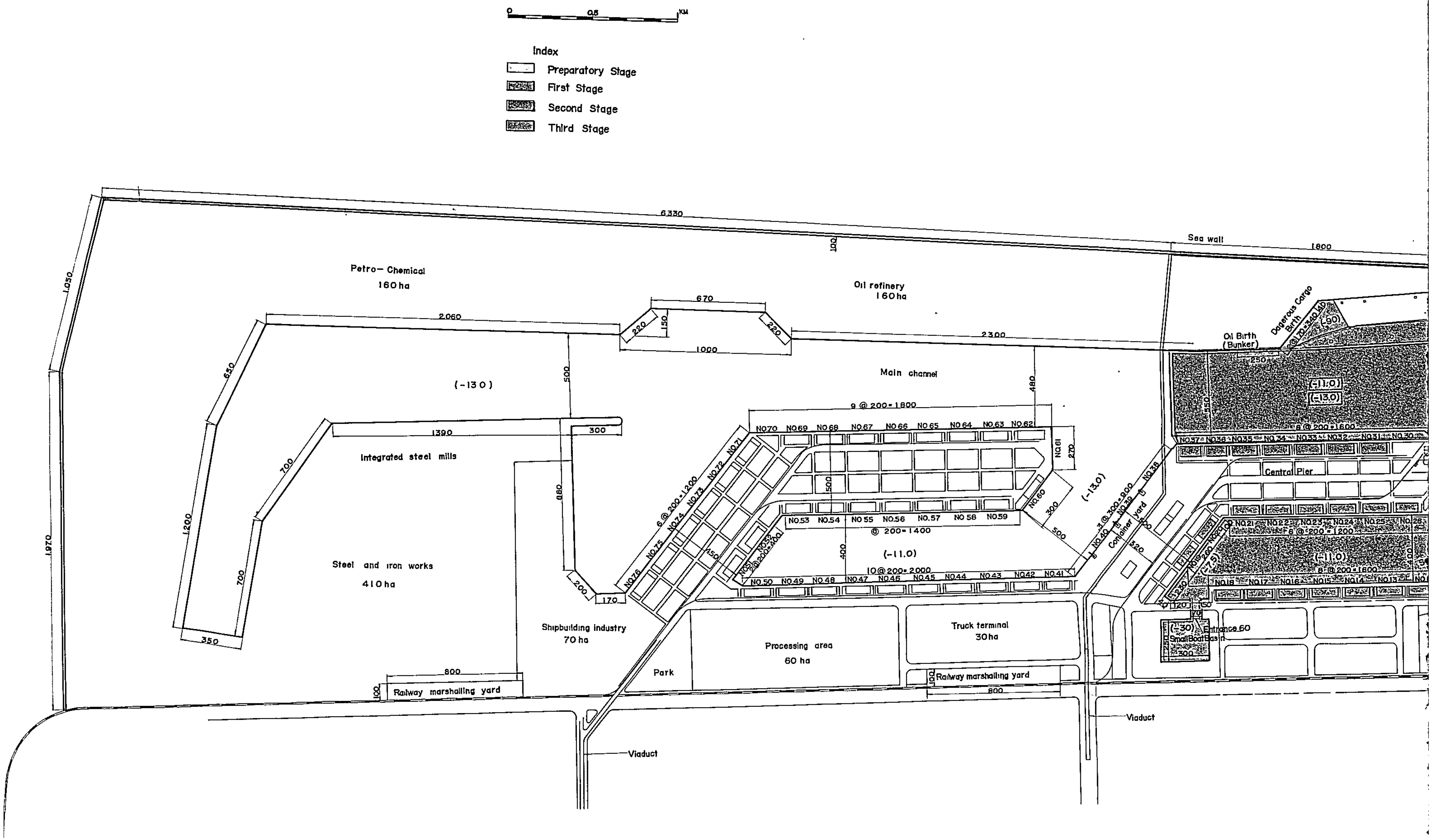
As for the mooring facilities, the berths No. 1 to 7 on the First Channel Channel will be completed firstly for the handling of cement, grains and general cargoes. The channel from the harbour entrance to the First Channel and the turning basin will be dredged to -11 m. In parallel with these works, facilities of the fishery harbour will be partially improved so that the local fishermen may be able to use the facilities on opening of this harbour.

(3) Second stage (July 1974 - December 1976)

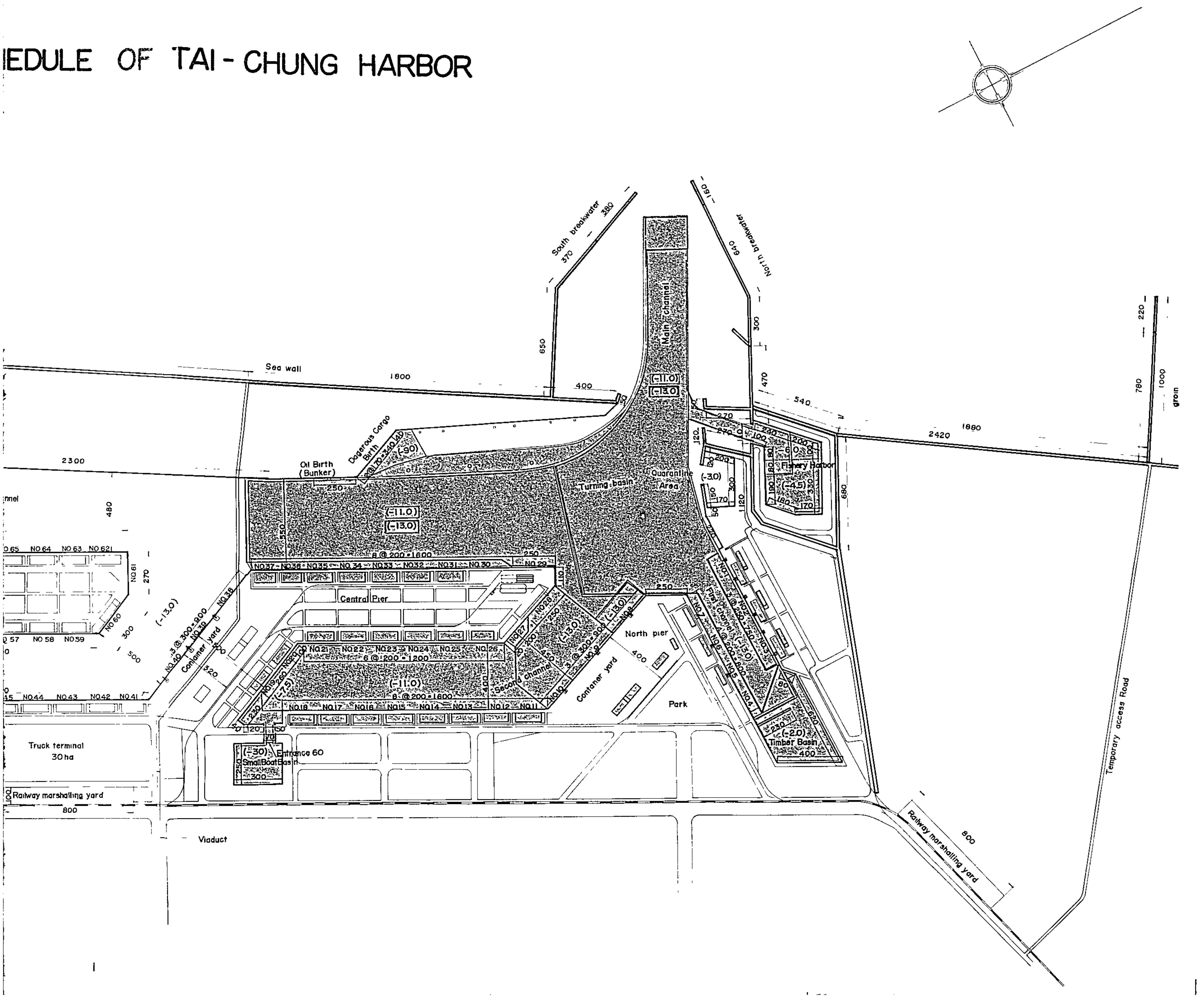
Efforts will be directed to early completion of the remaining works of the north and south breakwaters, groyne and seawall, and also to the improvement of wharf facilities and channels for the goal of handling four million tons of foreign trade cargoes a year.

For the mooring facilities, a total of 10 berths comprising berth Nos. 29 - 37 and No. 8 (container berth) on the western coast of the central pier will be constructed. And, the main channel running along these berths will be dredged to -11 m.

Fig. V-1-1 CONSTRUCTION SCHEDULE OF TAI-CHUNG HARBOR



IEDULE OF TAI-CHUNG HARBOR



The frontage of -13 m quay wall built after the first stage will be dredged to -13 m in an early period of this stage so that vessels up to 30,000 dwt may be berthed if timed at high tide. A timber basin sited at an innermost point in the first channel will be constructed during this stage.

(4) Third stage (January 1977 - December 1980)

During this stage, Taichung Harbour will be endowed with perfect function as an international trade port. With this in view, the plan shall be worked out for general reinforcement of the quay facilities with the specific aim of bringing up its import-export cargo handling capacity to eight million tons and also for improvement of small boat basin, mooring buoy, fishery harbour and other ancillary facilities.

For the mooring facilities, 20 berths of No. 9 to 28 will be constructed along the second channel, together with two berths for the dangerous cargo and a dolphin berth for fuel oils on the west side of the main channel. In addition to the dredging of the second channel, the navigation channels from the harbour entrance to the main and first channels and the turning basin will be dredged to 13 m.

Also required under the project besides the above works assigned to each stage is the construction of cargo-handling facilities such as transit sheds, silos and open storage yard, and of such necessary facilities as harbour traffic facilities, water and power supplies, navigation aids, vehicular routes in and around the harbour, drains and windbreak forests.

The types of works for different stages are colour-coded in Fig. V-1-1.

1.2 Preliminary Design

The preliminary design was prepared on major structures with the co-operation of engineers of the Taichung Harbour Project Office, for the purpose of cost estimation as well as for working out an execution plan of the project.

(1) Design conditions

Design conditions shown below were determined as the result of discussions between the engineers of the Taichung Harbour Project Office and the members of the survey team.

1) North Breakwater
Wave height: $H_{1/3}$ = 6 m　Period of wave: $T_{1/3}$ = 12 sec
Wave direction: NNE　Crown height: +12.5 m

2) South Breakwater
Wave height: $H_{1/3}$ = 4 m　Period of wave: $T_{1/3}$ = 10 sec
Wave direction: SW　Crown height: +7.4 m

3) Seawall
Wave height: H_b = 4 m　Period of wave: T = 10 sec
Crown height: +10 m

4) Quay Wall (-11 and -13 m)
Crown height: +6.2 m Horizontal seismic coefficient: 0.1
Surcharge: Normal 4t/sq.m ; in earthquake 2t/sq.m

5) Quay Wall (-7.5 m or less)
Crown height: +5.7 m Horizontal seismic coefficient: 0.1
Surcharge: Normal 3t/sq.m ; in earthquake 1.5t/sq.m

6) Lighter's Wharf (-2 and -3 m)
Crown height: +5.7 m Horizontal seismic coefficient: 0.1
Surcharge: Normal 2t/sq.m ; in earthquake 1.0t/sq.m

Among the above items, the crown height of the north breakwater and the surcharges for the -13 m and -11 m quay walls should be noted for large figures given. This has resulted from the strong request expressed by the representatives of the Republic of China. It is recommended that the points be further considered in relation with construction cost when the detailed design is laid on the table.

(2) Soil conditions

Only a brief outline will be given on the soil conditions at the site as they were described in detail in the Report of New Harbour Project - 1969, pp. 232 to 243.

The boring tests conducted at seven selected points on the First and the Second Channels during 1968 revealed that the soil is generally of silty sand; loose silty sand with N value of 10 or less at a depth of 3 to 4 m below the ground surface, underlain by a layer with N value of 10 to 20 at a depth of -5 to -10 m, and a very compact silty sand with N value of 30 or more at a depth of more than -10 m.

Soil conditions of the area not covered by the boring tests are considered, stratigraphically and from its terrain, to be similar to those of the tested area.

In the preliminary design of the mooring facilities, the internal frictional angle of sand behind the quay walls is assumed to be 30° at depths shallower than -11 m, and 35° at depths deeper than -11 m.

(3) Basic policy of designing

In preparing the preliminary design, the following points were taken into consideration:

a. Breakwaters and groynes

1) Since large stones suitable for the rubble-mound of breakwater, etc. are not produced anywhere around the site, there is no choice but to use boulders available from the Ta-Chia River. Consequently, the breakwater as well as groyne will be of a composite structure with a caisson or concrete block set upon the rubble-mound made up of such boulders.

2) The rubble-mound of boulders is considered to be less stable than that of rubbles. This point will be given further attention when a study is made on the overall structural aspects of the breakwaters in working out the detailed design therefore.

3) It is feared, in consideration of the time limit set on the construction period, that the transport and tipping of boulders may become a bottleneck in the construction of a breakwater, judging from the time-consuming overland transportation from the producing area and placing of the stones. Therefore, efforts should be made to minimize the volume of the stones to be used.

4) Special concrete blocks will be substituted for armour rocks to protect the rubble mound.

b. Quay walls and lighter's wharf

All the quay walls and lighter's wharf will be of a steel sheet pile construction in view of relatively good soil conditions and a high ground level of more than + 3.0 m. Steel pipe piles will be used for the anchor wall for efficiency and simplicity of construction though reinforced concrete anchor wall is also usable. It seems that steel sheet piles or steel pipe piles of large diameter are not yet manufactured in Taiwan. In the detailed design, therefore, efforts should be directed to enable full utilization of reinforced concrete sheet piles or reinforced concrete anchor wall in place of steel materials. A gravity-type structure is also considered workable in some cases.

(4) Outline of design

The standard section of the major structures is as shown in Fig. V-1-2. The following are the outline of the major structures:

a. North Breakwater (shown in Figs. V-1-2, 1, 2, 3 & 4)

The breakwater will be of a caisson structure at depths of -5 m or deeper, and a concrete block structure covered with tetrapods weighing 25 tons at depths of -5 m or shallower. The width of caisson will be 20 m at the far end of the breakwater and between 14 and 18 m elsewhere, depending on water depth. The length of a caisson is uniformly 20 m. As fill for the caisson of this breakwater, sand and concrete will be used in about equal amount. Nylon mattress will be spread under the rubble-mound for the entire length of the breakwater to prevent the sucking out of sand from its toe, and special concrete blocks with a void ratio of approx. 50% will be placed for the protection of the slope of the rubble-mound.

b. South Breakwater (shown in Figs. 5, 6, 7 & 8)

This breakwater will be constructed identically with the North Breakwater, namely, of a caisson structure at depths of -5 m or deeper and a concrete block structure covered with tetrapods weighing eitht tons at depths of -5 m or shallower. The caisson measures 16 m in width at the far end of the breakwater and 14 m at all other points. Sand will be used as fill for the caisson. Similarly to the North Breakwater, nylon mattress and special concrete blocks will be used for this breakwater.

c. Groyne (shown in Figs. 9 and 10)

The groyne will be of a caisson structure at depths of -5 m or deeper and of a concrete block structure covered with tetrapods weighing 12.5 or 25 tons at depths of -5 m or shallower. The crown height is set at a level of +6.5 m. Like in the North and South Breakwaters, the slope of the rubble-mound will be covered with special concrete blocks for protection. But the use of the nylon mattress will be limited to the portion of caisson. Although the extension of the caisson for 220 m is presently scheduled in the second stage, it is desirable to re-examine the extension works and the type of structure upon completion of investigation on drift sand and changes in water depth in the first stage.

d. Seawall (shown in Fig. 11)

As shown on the drawing, the retaining wall will be built of concrete blocks, and will be protected by stones and eight ton tetrapods placed in the front as wave-breakers. In order to minimize the overtopping of the waves, the crown height of the retaining wall is set at a level of +10 m, and its back is paved with concrete to form a 10-m wide apron with drains. The seawall in the back of the fishery harbour is designed to be of a simpler structure as it is intended for use for a very short period of time. Its crown height, for instance, is set at a comparatively low level.

e. -13 m Quay wall (shown in Fig. 12 and 13)

Fig. 12 shows the quay wall for containers while Fig. 13 for corns and grains. Steel sheet piles of ϕ 1000 mm will be used for both quay walls. The heads of the seaside foundation piles of the crane, and the steel sheet piles are linked together for mutual reinforcement. As the crane's gauge on the container wharf is 16 m, the anchor piles and the foundation piles of the crane are built as a monolith.

f. -11 m Quay walls (shown in Figs. 14 and 15)

Fig. 14 shows the standard section of -11 m quay wall equipped with a crane while Fig. 15 the one without crane. Steel pipe piles of ϕ914 mm and ϕ700 mm will be used for the sheet pile wall and anchor wall respectively. For economy of costs, the steel sheet piles will be concurrently used as the seaside foundation piles of the crane.

g. Quay walls of -9.0 m and -7.5 m (shown in Figs. 16 and 17)

Steel sheet piles of ϕ711.2 mm and Z-45 type will be used for the -9.0 m quay wall, and the -7.5 m quay wall respectively. As the anchor piles, steel pipe piles of ϕ8 12.8 mm and ϕ700 mm will be used respectively. The quay walls of -6.0 m and -4.5 m, though not shown on any drawings, will be of similar construction.

h. -3.0 m Lighter's wharf (shown in Fig. 18)

This wharf will be built with U-type steel sheet piles and steel pipe piles. It is conceivable, however, that the small boat basin, construction of which is scheduled in the third stage, may be built with either concrete sheet piles or in the gravity-type. These lighter's wharves including the -2.0 m wharf will be inconvenient for small ships to moor at during the low tide because of the high crown height. This will be another point to be re-examined in the detailed design.

i. Dry dock (shown in Fig. 19)

A dry dock is to be constructed in the workyard for the manufacture of caissons for breakwaters. The dock, with the dimensions of 95 m x 25 m, is capable of casting four caissons at a time. The depth of the dock being -3 m, caissons will have to be launched during the high tide. The sidewalls of the dock will be of steel sheet piles, and its bottom made up of pre-packed concrete. Foundation piles will be driven down the bottom so that they, plus the weight of the bottom, may serve to resist the buoyancy. The gate shall be of a floating type.

j. Floating stage (shown in Fig. 20)

A floating stage comprising two steel pontoons will be established in the basin for mooring small crafts such as launch and diver boat. In the preliminary design, the size of pontoon is decided tentatively to be about 20 m long, 7.5 m wide and 2 m deep, and connected with the shore by a 15 m long access bridge. These, together with the lighter's wharf, should be re-examined during the preparation of detailed design. Fig. 20 shows only a sketch of the floating stage.

Besides the structures mentioned above, the preliminary design covers also inner breakwaters, the breakwater for the basin, dolphin and the approaches of quay walls. But, no reference is made to their standard sections, nor is any explanation given on them as the basic concept of design is the same as that of the above quoted structures.

(5) Quantity of major materials required

The quantities of major materials and levelling works required are as shown in the following table. Covered by the table are only the outer harbour facilities, mooring facilities and construction facilities, and materials required for roads, railway and transit sheds are described in the following section.

Table V-1-1 Breakdown of Principal Materials Used in Construction of Taichung Harbour by Stage

	Item description	Unit	Preparatory stage	1st stage	2nd stage	3rd stage	Total
1	Stone for rubble mound	m^3	10,180	855,491	353,694	-	1,219,365
2	Levelling of foundation	m^2	-	31,054	13,378	-	44,432
3	Formation of slope	m^2	-	241,349	112,269	-	353,618
4	Nylon mattress	m^2	-	90,890	46,544	-	137,434
5	Concrete block	m^3	-	56,514	26,048	-	82,562
6	Tetrapod	m^3	920	101,485	21,126	-	123,531
7	Reinforcing concrete	m^3	5,856	67,238	79,639	76,161	228,894
8	Concrete	m^3	16,616	181,158	91,866	23,927	313,567
9	Steel material	t	4,338	33,907	43,328	73,920	155,493
10	Crushed stone	m^3	2,228	21,356	31,504	51,573	106,661
11	Reinforcing bar	t	585	7,344	8,698	7,616	24,244
12	Cement	t	6,939	117,069	64,891	32,311	221,210
13	Fine aggregate	t	15,917	276,998	150,734	70,382	514,031
14	Coarse aggregate	t	30,158	527,158	280,354	125,031	962,701

1.3 Execution Plan

(1) Construction schedule

Major works of the project by stages are as stated in the preamble to to construction plan (1-1). The volume of works and construction schedule by the type of works are as shown in Table V-1-12.

(2) Methods of execution

Stated below are the execution methods proposed for major structures:

a. Breakwaters and groynes

To a depth of about 3 m, the north and south breakwaters and groynes will be constructed for the most part by tipping out materials from the shore, using dump trucks (for transport and tipping of rubble stones) and crawler cranes (for placing of concrete blocks and tetrapods), while at depths deeper than 3 m, they will be built by means of floating equipment; stones barges will be used for the transport of rubble stones and the floating cranes for placing concrete blocks and tetrapods. To expedite works of the first stage, both works of the tipping out materials from the shore and works on waters shall be proceeded simultaneously.

Concrete caissons shall be manufactured four at a time in the dry dock stated above. For those caissons for greater depths having a larger draft, it may become necessary to cast concrete for the top course while they are moored at the revetment after the launching from the dock. Concrete mixing boats shall be used for concrete placing of the upper part of the breakwaters, except the portion formed by tipping out materials from the land.

b. Mooring facilities

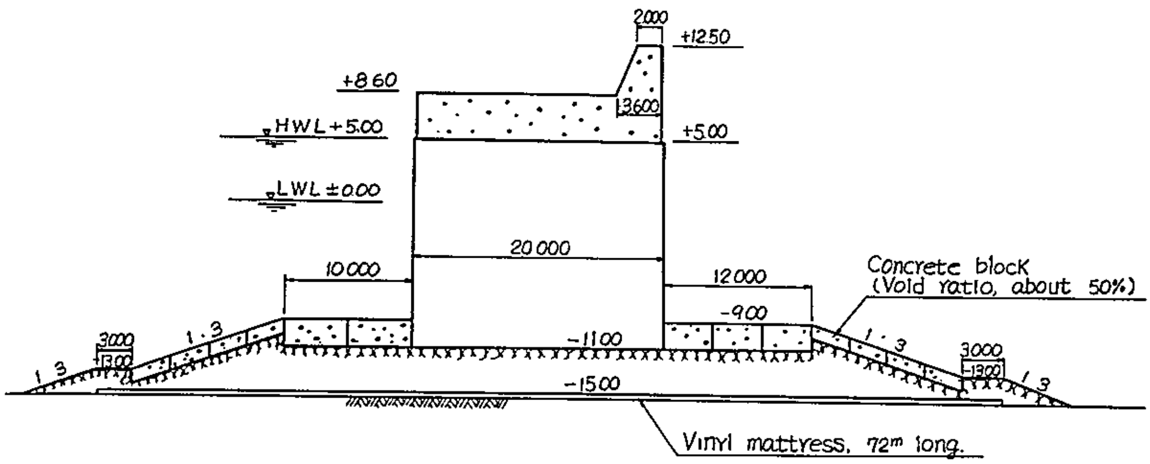
The quay wall and lighter's wharf shall be constructed by reclaiming the site in advance to a level of about +5 m and then driving steel sheet and pipe piles, using pile driving frame fixed on the crawler crane. The reclamation can be dispensed with for the quay wall works scheduled in the second and subsequent stages as the worksite should have been reclaimed with dredged materials by then. The dredging in front of the quay wall may be carried out by combined use of the pump dredger and grab dredger after the driven sheet piles are steadied by tie rods.

c. Dredging

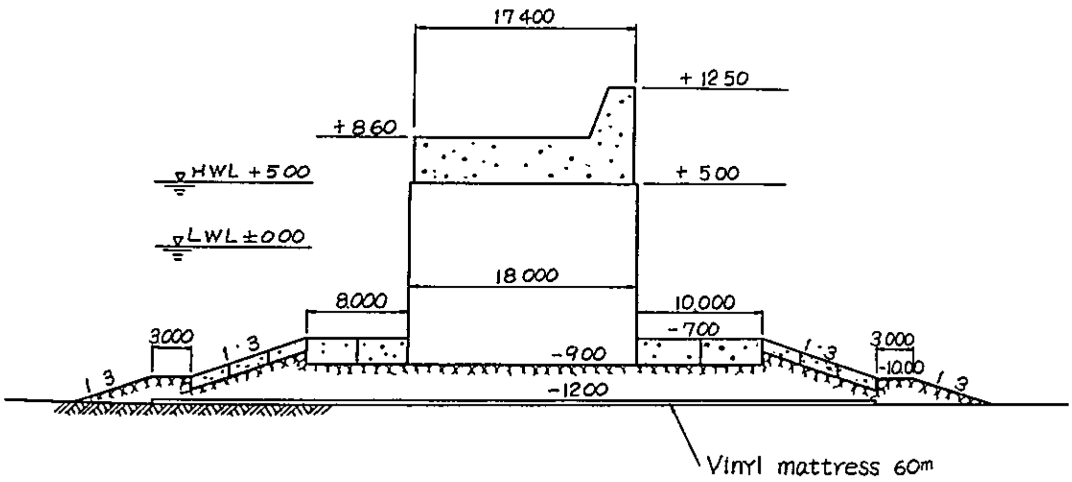
Of the total dredging requirements of 60,100,000 m^3 from the first to the third stage, a little over one third, namely 21,300,000 m^3, is allocated for the first stage. But when the maintenance dredging is taken into account, the dredging requirement of each stage may be safely assumed to be properly balanced. However, since the fill required for site reclamation is smaller than the materials to be dredged, about a third of the total quantity will be dredged by drag suction dredgers and be dumped outside the harbour. The remainder shall be dredged by two non-navigating dredgers (one each of electric type of 3,000 PS and diesel type of 4,000 PS), and used as fill for the reclamation of the wharf site and others.

Fig.V-1-2 Standard Sectional View of the Major Structure

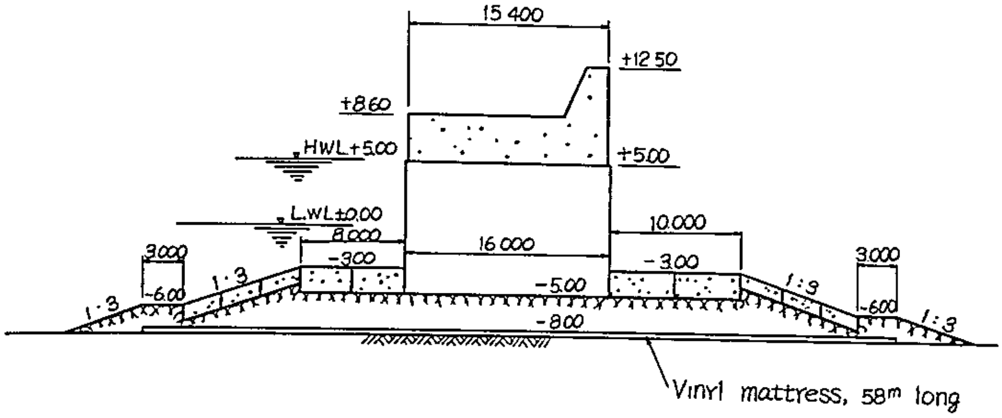
① North Breakwater −15M



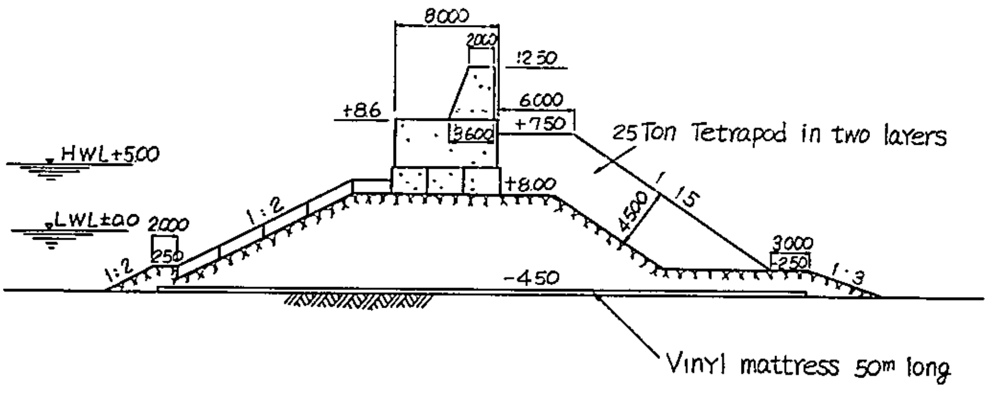
② North Breakwater −12.0M



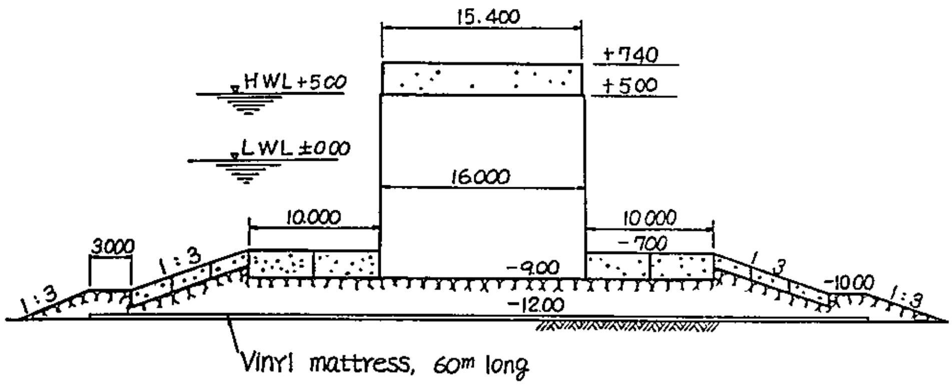
③ North Breakwater −80M



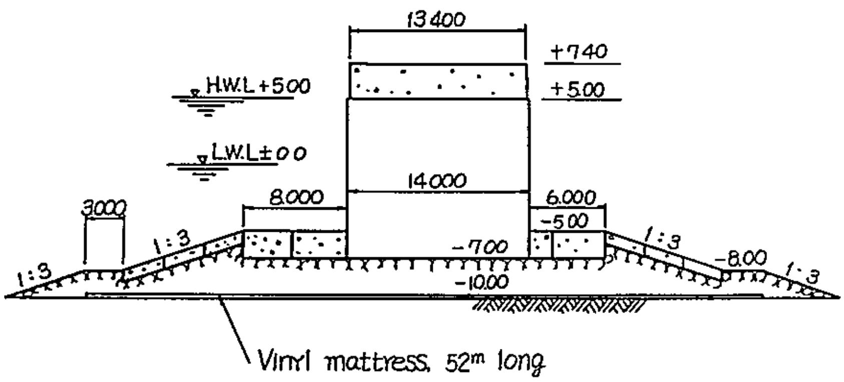
④ North Breakwater −45M



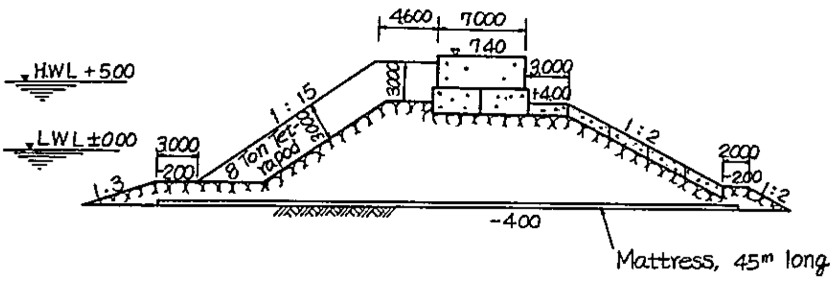
⑤ South Breakwater -12.0M



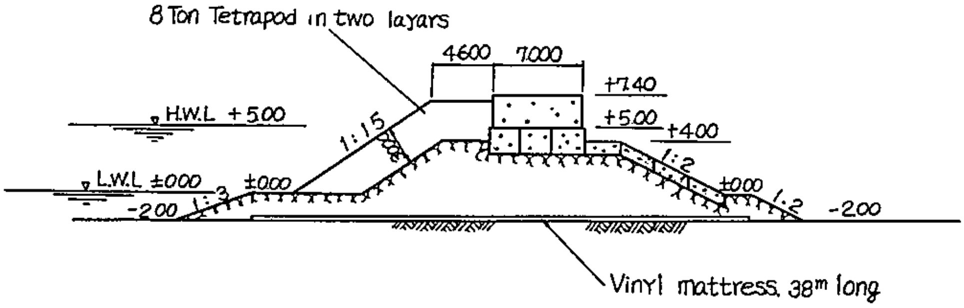
⑥ South Breakwater -10.0M



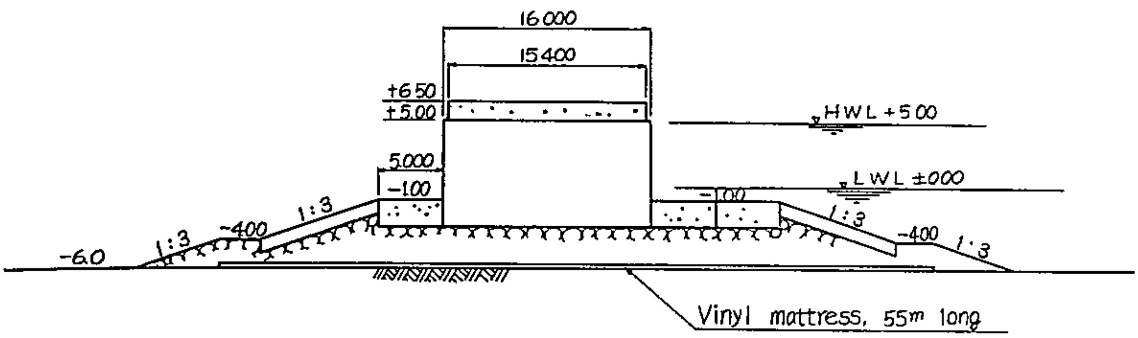
⑦ South Breakwater -4.0M



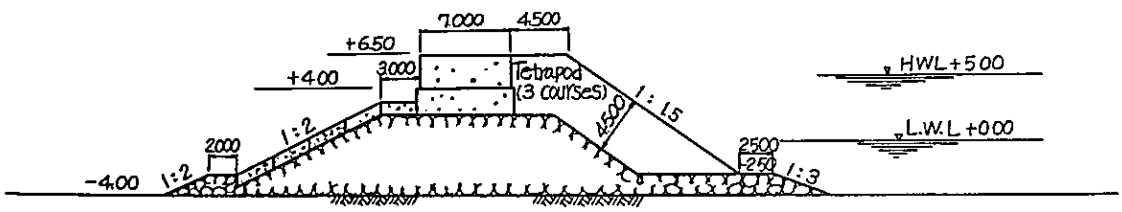
⑧ South Breakwater -2OM



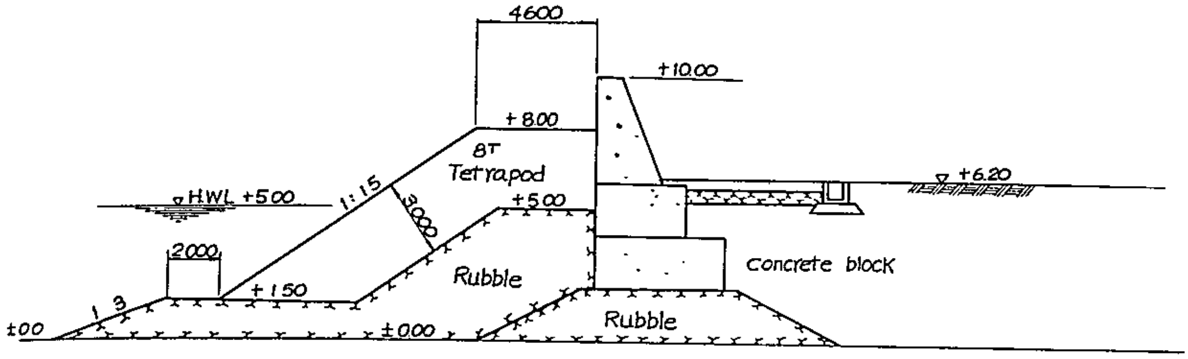
⑨ Groyne −6.0M



⑩ Groyne −4.0M

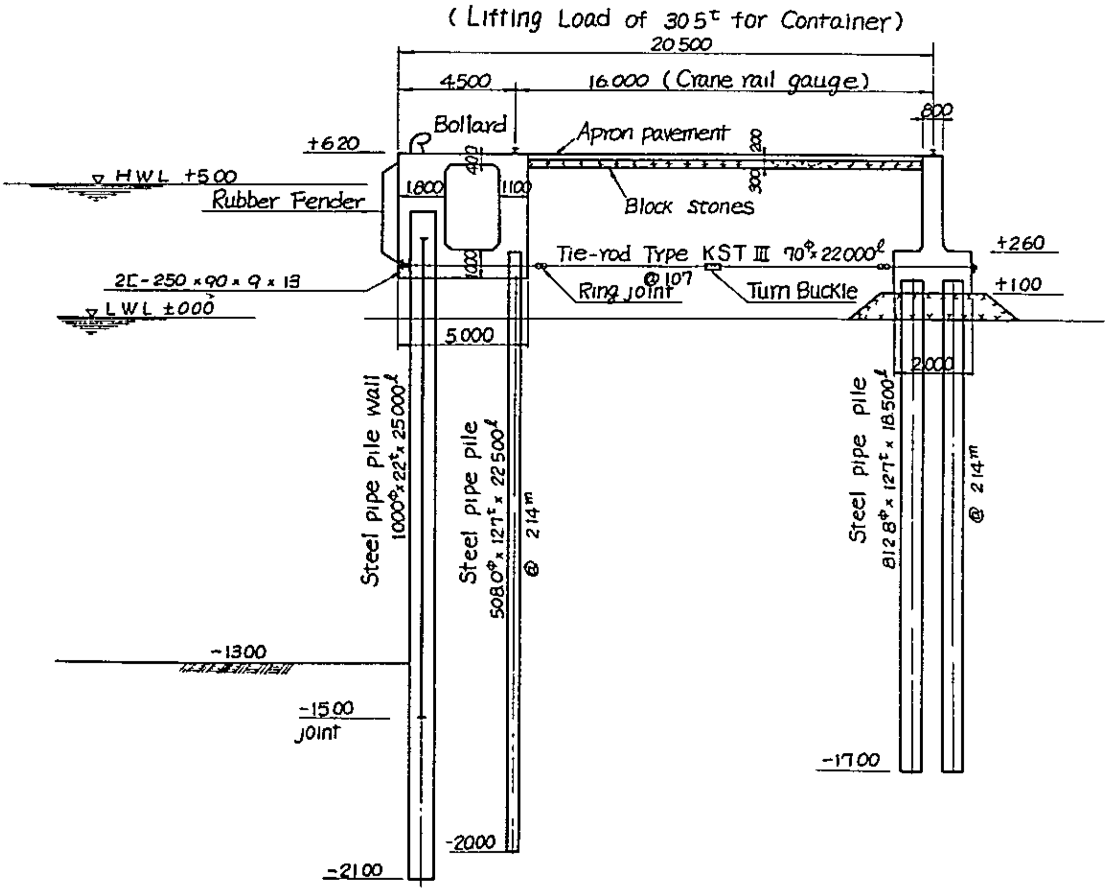


⑪ Sea Wall



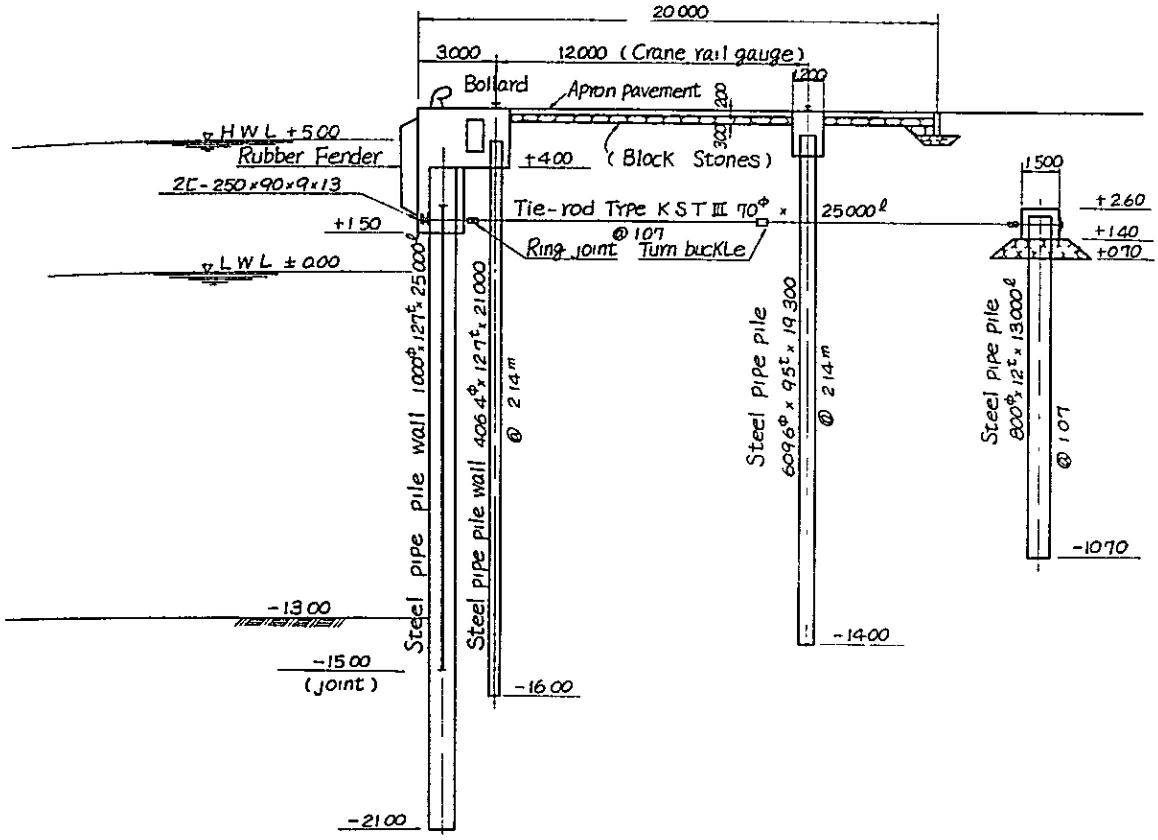
⑫ −13.0M Quay Wall

(Lifting Load of 30.5t for Container)

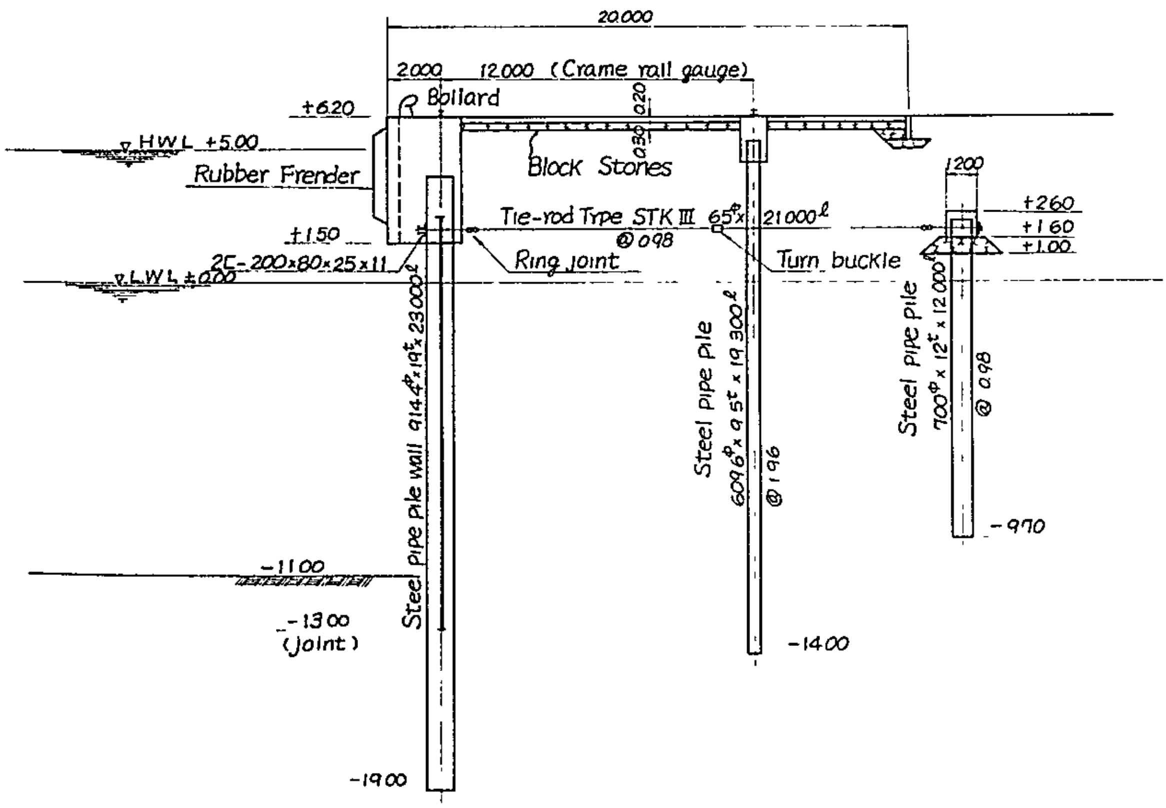


(13) −13M Quay Wall

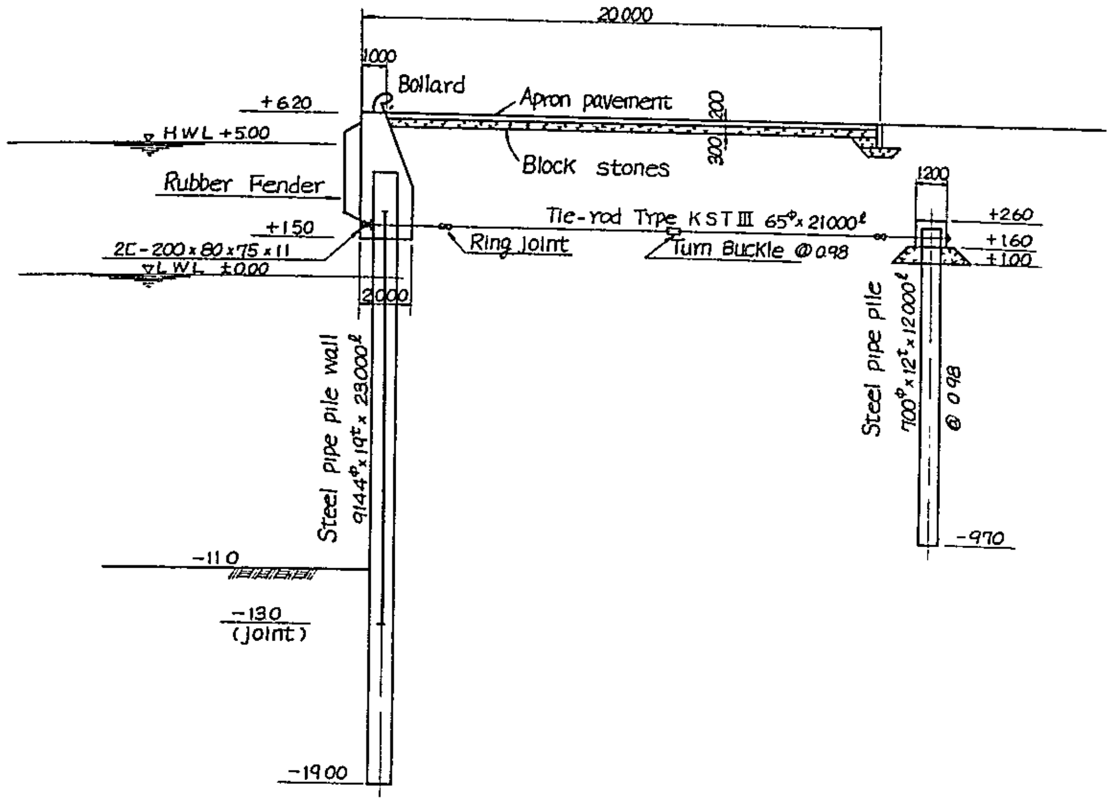
(Newmar 350 t/h)



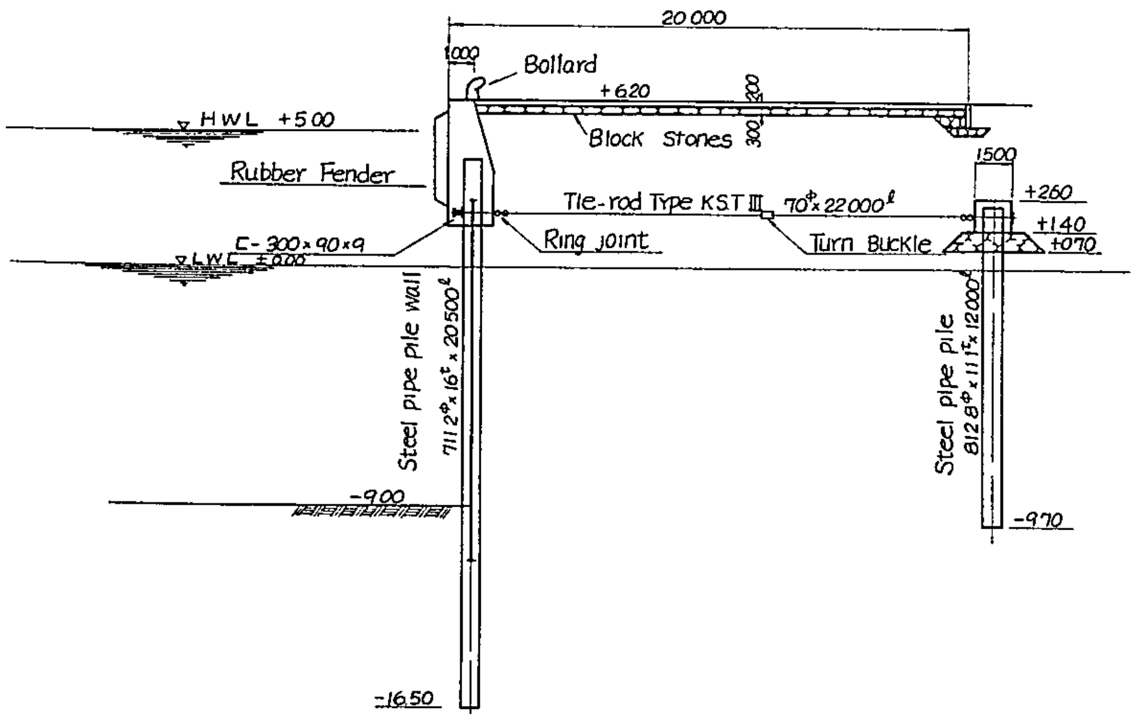
14. −11M Quay Wall (With Crane)



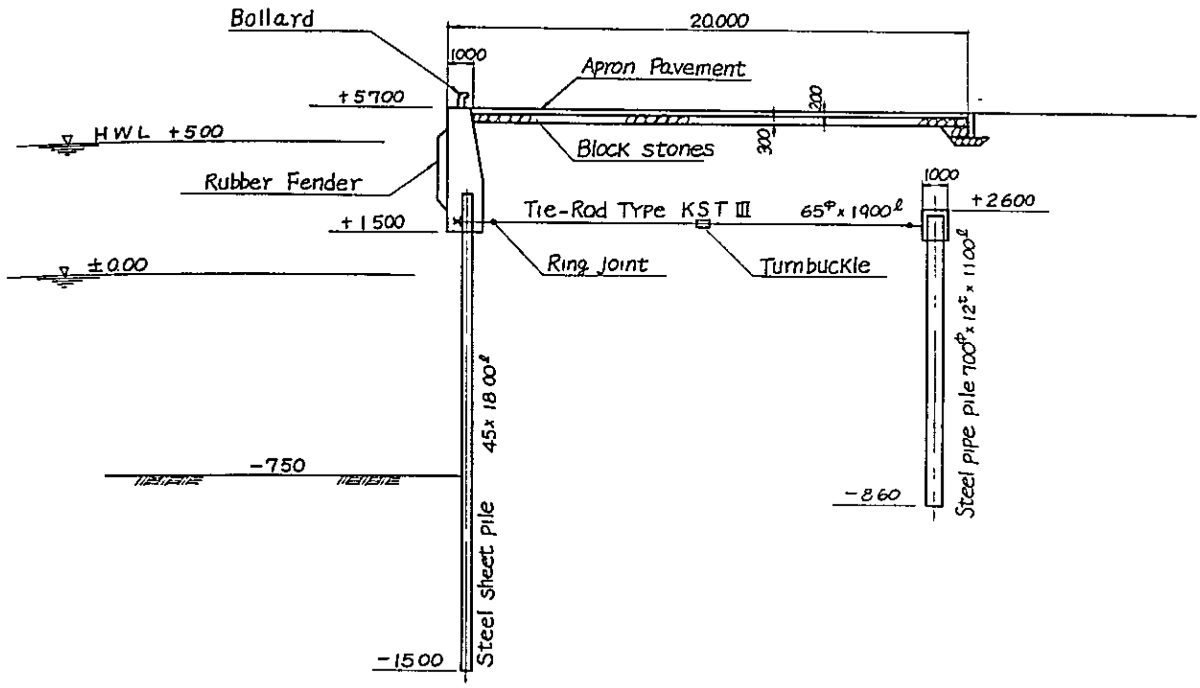
⑮ -11M Quay Wall



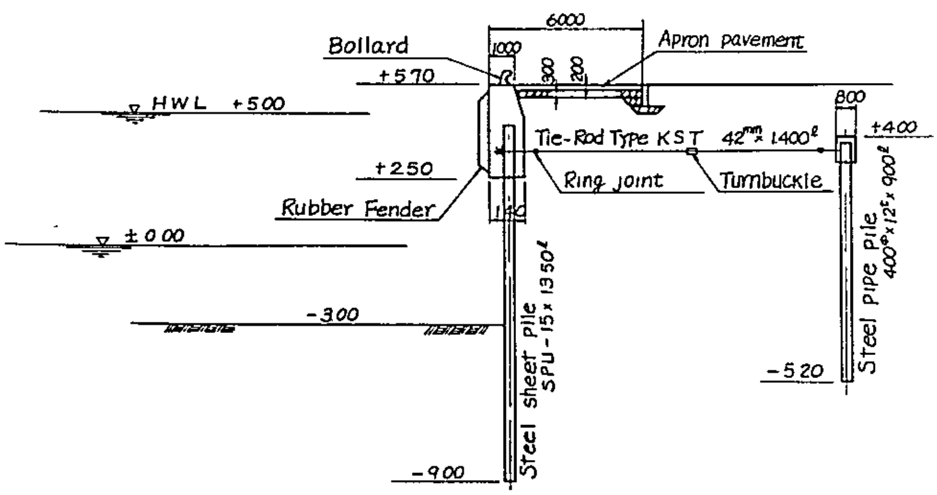
⑯ -9M Quay Wall



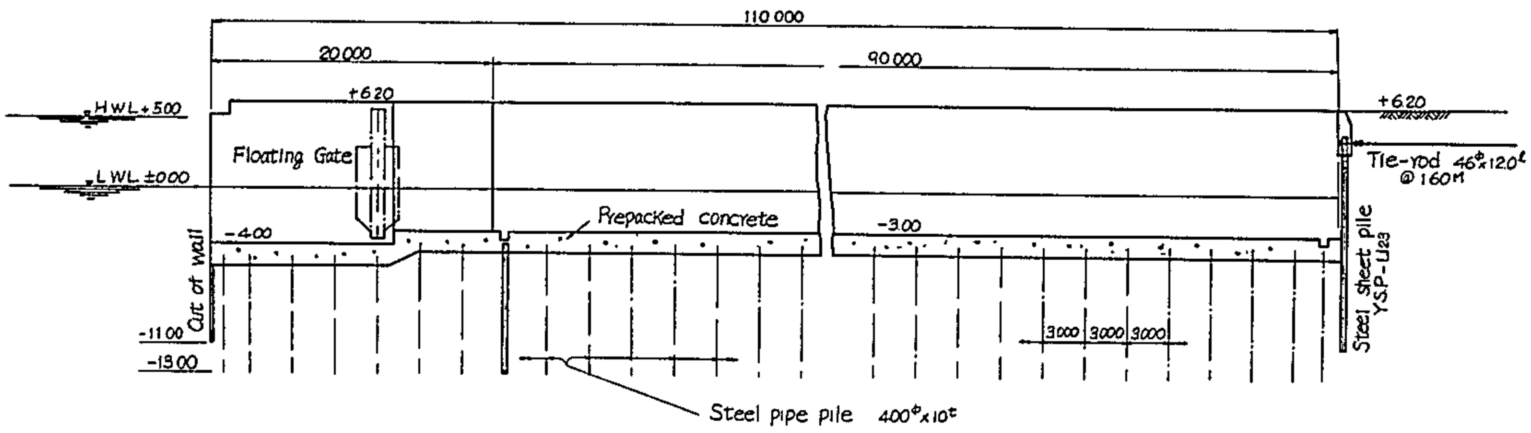
⑰ -75M Quay Wall



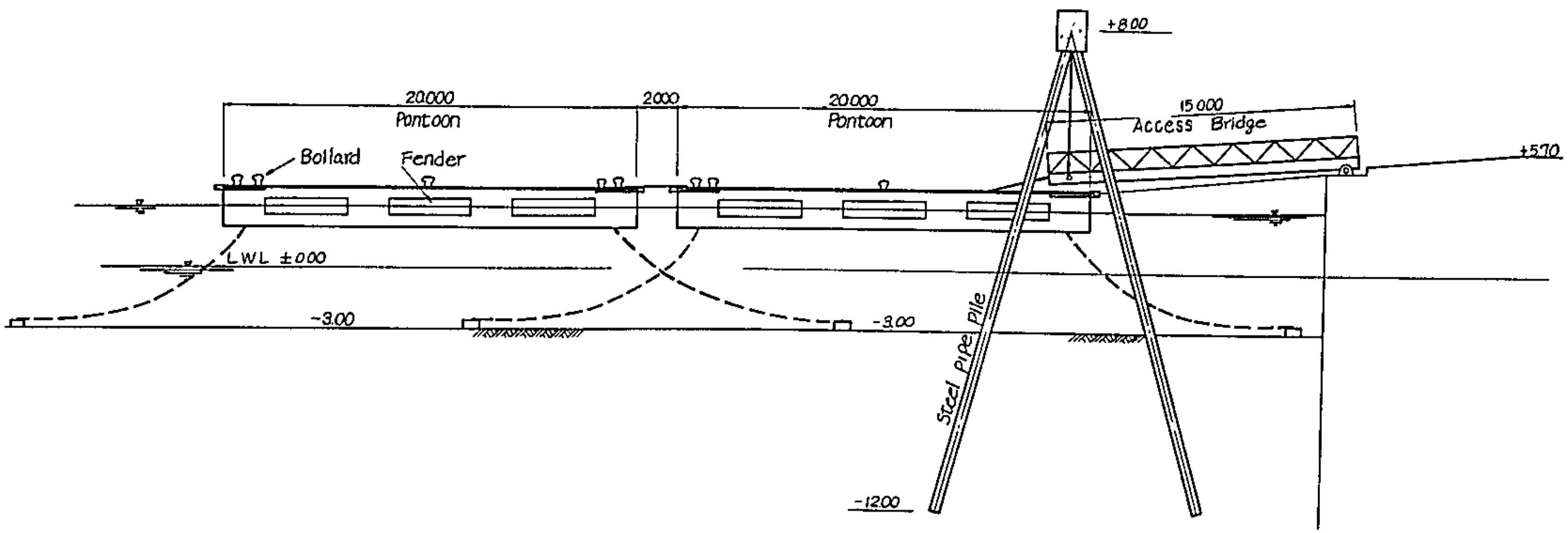
⑱ -3M Lighter's Whart



⑲ Dry Dock



⑳ Floating Stage



Depending on the power situation at the site, the aforementioned electric pump dredger may be substituted for a diesel type.

In the third stage, a relay pump will have to be installed on one of the pump dredgers as the distance to the northern lowland which is to be covered by discharge pipes will reach somewhere close to 6,000 m.

Besides, it will be necessary to provide a transportable pump dredger of 250 PS or so for use in the dredging at shallow depths of 2 to 3 m, for examples, the basin for floating equipment, timber basin and small boat basin in the second channel, since the large pump dredger is awkward at such works.

A further consideration should be given to the proposed use of a part of dredged materials for the elevation of lowland behind the harbour by means of onshore excavation although no reference is made to the matter in the present construction plan. It will be best to leave the lowland stretching to the north of the harbour untouched for the maintenance dredging or deepening of channels in future.

d. Supply and transport of stones

Total stone requirement in this project amounts to 3,750,000 m^3, including boulders for the rubble-mound and aggregates for concrete, roads and railway. All the stones will be obtained from the riverbed of the Ta-Chia River about 7.5 kilometers from the site of this harbour.

The stones shall be collected by the shovel excavator or by clamshell, and hauled by dump trucks to the hopper of the screening machine. After screening according to sizes for the rubble mound of the breakwater, for crusher plant and for concrete, the stones will be transported to the worksite, crusher plant and concrete plant respectively. The use of railway wagons for transporting these stones from the Ta-Chia River to the workyard does not appear to be economical because the initial investment is high and one extra handling process is required in loading. About 40%, or approximately 1,500,000 m^3 of the total stone requirement is consumed in the first stage so that the supply and transport of stone materials in this stage are feared to form a bottleneck in the execution of the whole project. It is recommended, therefore, to start stock piling stones in the preparatory stage and to be on the safer side, be prepared for possible purchase from private sectors as well.

(3) Problems foreseen in the execution of works

This project is very large in scale; a works of this scale is ranked among the largest in Japan. It will not be without some difficulty to complete the whole of the works within a period of ten years. In particular, a considerable hardship is predicted during the first and second stages in which many breakwater works are scheduled, because the number of days suitable for maritime works is limited to about 210 to 235 days a year as the worksite is exposed to strong north-northeastern wind during October to March. It is essential, therefore, to carefully work out a very detailed programme in relation with the detailed design and also to secure required number of manpower, materials and equipment. Enumerated below are some of the problems foreseen in the execution of this project:

a. Completion of construction facilities and procurement of floating equipment, etc.

The commencement of the permanent works in January 1972 is nearly an indispensable condition to open the harbour in June 1974 on schedule. It is necessary, therefore, to complete the construction facilities and temporary access roads as aforesaid, and to have the floating equipment and construction machines ready for use in the first stage, all by the end of 1971. It would be extremely difficult to make up the leeway within the limited time of mere two and a half years, should the commencement of the permanent works be delayed.

b. Arrangements for divers and skilled workers

The number of divers required for levelling stones for breakwaters and groynes is estimated to total 35 - 40 gangs in the first stage. In order to secure the required number of divers, it will be necessary to start their training from now since the diver is said to be very scarce on the site. It will also be essential to train and secure required number of operators for construction machines such as dump truck power shovel, crawler crane and concrete plant, and crews for various types of floating equipment. Besides, at the peak of the works, a total f about 60 dump trucks will have to be engaged.

c. Establishment of motor pool

The construction schedule cannot possibly be adhered to if the repair and maintenance of various construction equipment and vehicles are left to private repair shops. So, it will be necessary to establish and operate a motor pool of the Government's own. Also a repair dock run by the Government will be needed for the floating equipment.

d. Execution by overseas contractors

The above execution plan is prepared assuming that all the necessary floating equipment, construction machines and major construction materials will be purchased by the Government, and that the works will be executed in part by the Government and the rest by the domestic contractors. It is possible, however, that depending on the type of works or from the necessity of securing the scheduled rate of progress, some parts of the works may have to be sublet to overseas contractors. In such a case, the tender will be made on the basis of international competition among overseas contractors because it is difficult to invite both overseas contractors, who will be possessing and prepared to bring into site all the necessary floating equipment and construction machines, and domestic contractors who are likely not. When the works are sublet to overseas contractors experienced in portworks, a saving is expected to the Government in the acquisition cost of construction machinery which will otherwise be incurred. It must be noted, however, that the cost of amortization plus the expenses for the site supervision incurred by such contractors will amount to a sum nearly equivalent to the acquisition cost to the Government. Further, the personnel cost of overseas contractors is generally higher than that of the domestic counterparts. For the above reasons, it can not always be expected that the subletting to overseas contractors would prove cheaper than otherwise. Therefore, it seems advisable that the execution of the works be done primarily by the domestic contractors and that the subletting to overseas contractors be limited to such types of works as would require many special equipment in a

TABLE V-1-2 TAICHUNG PORT CONSTRUCTION SCHEDULE

DESCRIPTION OF WORKS	QUANTITY	REMARKS
I CONSTRUCTION FACILITIES		
Construction Site.	Center: 80,000 sq.m. South: 15,000 sq.m. North: 15,000 sq m.	
Lighter's Wharf.	Inside Basin: 630m. South Side: 270m.	
Breakwater	270 m.	
Dredging	600,000 cu.m.	
Dry Dock.	1	
Floating Pier.	1	
Quarry Facilities.	Two Places.	
Repairing Facilities of Floating Plant	1	
Buildings.	Material Stores 1	
II. OUTER HARBOUR FACILITIES		
North Breakwater	1st Stage: 940 m. 2nd Stage: 160 m	
South Breakwater.	1st Stage: 1,020 m. 2nd Stage: 380 m.	
Groyne	1st Stage: 780 m. 2nd Stage: 220 m.	
Sea Wall	1st Stage 3,020 m. 2nd Stage 1,880 m	
North, South Inner Wave Breakers.	1st Stage: 670 m. 2nd Stage 100 m.	
Breakwater & Revetment for Fishery Harbour.	1st Stage: 390 m.	
Breakwater for Timber Basin.	2nd Stage: 230 m	
Repair of Existing North Breakwater.	Prep. Stage: 1,560 m 1st Stage: 960 m	
Demolition of Existing North Breakwater	Prep. Stage: 340 m. 1st Stage: 2,700 m.	

TAICHUNG PORT CONSTRUCTION SCHEDULE

PREPARATORY STAGE: 1970 (7-9, 10-12) – 1971 (1-3, 4-6, 7-9, 10-12); FIRST STAGE: 1972 – 1974 (1-3, 4-6); SECOND STAGE: 1974 (7-9, 10-12) – 1976; THIRD STAGE: 1977 – 1980; 1981 (1-3, 4-6, 7-9, 10-12)

DESCRIPTION OF WORKS	QUANTITY	Schedule	REMARKS
III MOORING FACILITIES			
Quay Wall, - 13 m.	1st Stage: 750 m. 2nd Stage: 550 m. 3rd Stage: 850 m.	1972 1-3 – 1980 10-12	
Quay Wall, - 11 m	1st Stage: 800 m. 2nd Stage: 1,600 m. 3rd Stage: 3,000 m.	1972 1-3 – 1980 10-12	
Revetment.	1st Stage: 500 m. 2nd Stage: 360 m. 3rd Stage: 480 m.	1973 1-3 – 1974 10-12; 1975 10-12 – 1977 4-6; 1980 1-3 – 1980 10-12	
Quay Wall, -7.5m	3rd Stage: 260 m.	1979 7-9 – 1980 4-6	
Quay Wall for Fishery Harbour.	1st Stage: 400 m. 3rd Stage: 1,170 m.	1973 1-3 – 1974 4-6; 1977 1-3 – 1979 4-6	
Dolphin for Timber Basin.	2nd Stage: One Job.	1976 1-3 – 1976 10-12	
Lighter's Wharf for Timber Basin.	2nd Stage: 1,150 m.	1975 1-3 – 1976 10-12	
Lighter's Wharf for Basin.	3rd Stage: 1,480 m.	1979 1-3 – 1980 10-12	
Mooring Buoy.	3rd Stage: 3 each.	1978 7-9 – 1978 10-12	
IV. DREDGING & RECLAMATION			
Dredging.	1st Stg: 21,300,000cu.m. 2nd Stg: 17,000,000cu.m. 3rd Stg: 21,800,000cu.m.	1972 1-3 – 1980 10-12	
Reclamation.	1st Stg: 6,000,000sq.m. 2nd Stg: 2,800,000sq.m. 3rd Stg: 3,900,000sq.m.	1972 1-3 – 1980 10-12	
V. CARGO HANDLING FACILITIES			
Silo	1st Stage: 1 2nd Stage: 1 3rd Stage: 1	1973 7-9 – 1974 4-6; 1976 1-3 – 1976 10-12; 1978 7-9 – 1979 4-6	
Transit Shed.	1st Stage: 7 Bldgs. 2nd Stage: 10 Bldgs. 3rd Stage: 16 Bldgs.	1973 1-3 – 1974 4-6; 1975 7-9 – 1976 10-12; 1978 7-9 – 1980 10-12	
Open Storage	1st Stage: 130,310 sq.m. 2nd Stage: 116,330 sq m. 3rd Stage: 302,380 sq.m.	1973 7-9 – 1974 4-6; 1976 1-3 – 1976 10-12; 1978 7-9 – 1980 10-12	
Container Yard.	2nd Stage: 98,200 sq.m. 3rd Stage: 181,660 sq.m.	1975 7-9 – 1976 4-6; 1978 7-9 – 1979 4-6	

TAICHUNG PORT CONSTRUCTION SCHEDULE

DESCRIPTIONS OF WORKS	QUANTITY	PREPARATORY STAGE						FIRST STAGE										SECOND STAGE										THIRD STAGE																						REMARKS
		1970		1971				1972				1973				1974		1974		1975				1976				1977				1978				1979				1980				1981				
		7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	1-3	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10 12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	1-3	4-6	7-9	10-12	
VI HARBOUR TRAFFIC FACILITIES																																																
Beltline Highway	Prep Stage. 496,600 sq.m 1st Stage. 185,960 sq.m. 2nd Stage 118,320 sq.m. 3rd Stage 296,920 sq.m	■	■	■	■	■	■			■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	■	■	■	■					
Beltline Railway.	Prep. Stg: 7,000 m. 1st Stage: 5,850 m. 2nd Stage: 16,800 m. 3rd Stage: 6,200 m.			■	■	■	■					■	■	■	■	■	■					■	■	■	■	■	■					■	■	■	■	■	■	■	■	■	■	■	■					
VII. ANCILLARY FACILITIES																																																
Signal Tower.	2nd Stage: one.																							■	■	■	■																					
Navigation Aids.	1st Stage: 16 2nd Stage: 5															■	■							■	■	■	■																					
Power Distribution.	Prep Stage: 5,000 m. 1st Stage: 10,000 m. 2nd Stage: 11,000 m 3rd Stage: 10,000 m.			■	■									■	■	■	■							■	■	■	■							■	■							■	■					
Water Supply	Prep. Stg. 3,000 m. 1st Stage: 10,000 m. 2nd Stage: 9,000 m. 3rd Stage: 8,000 m.			■	■									■	■	■	■							■	■	■	■							■	■							■	■					
Drainage System.	1st Stage. 600 m. 2nd Stage: 600 m. 3rd Stage. 200 m.											■	■	■	■	■	■					■	■	■	■	■	■							■	■	■	■											
Wind Break Forest. (Wind Screen) ---	1st Stage: 225 ha. 2nd Stage: 225 ha. 3rd Stage: 1,000 m.											■	■	■	■	■	■	■	■	■	■	■	■											■	■	■	■											
VIII OTHERS																																																
Floating Equipment	Refer to Table V-1-3	■	■	■	■	■	■	■	■	■	■							■	■	■	■							■	■	■	■																	
Construction Machines	Refer to Table V-1-3.	■	■	■	■	■	■	■	■	■	■							■	■	■	■							■	■	■	■	■	■	■	■													
Execution Facilities	Refer to Table V-1-3.			■	■	■	■	■	■	■	■																																					
Testing Equipment of Facilities.	Prep. Stage: 1 set.			■	■	■	■																																									
Office Buildings	1st Stage: 2,000 cu.m. 2nd Stage: 2,000 cu.m.							■	■	■	■							■	■	■	■																											
Living Quarters.	Prep. Stage: 7,000sq.m. 1st Stage: 5,000sq.m.	■	■	■	■	■	■	■	■	■	■																																					
Survey Design; Inspection, Test and Supervision.		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					

short period of time or would need many skilled workers scarce in the country, or very special types of works in which the domestic contractors have little experience.

1.4 Floating Equipment and Construction Machines

It is assumed that all the floating equipment, construction machines, etc. necessary for the completion of this project will be purchased by the Government, the executing agency. Types and quantities of equipment required in each stage are as shown on Table V-1-3. The procurement of the floating equipment and construction machines will have to be made well in advance allowing time for manufacture. Those to be needed from the beginning of the first stage are listed up for procurement during the preparatory stage, and those from the early second stage likewise during the first stage as shown in the table. As attention may be directed to the fact that the procurement of floating equipment and construction machines is concentrated almost in the first stage, it will be necessary, even after the first stage, to replenish or replace some of the construction machines such as dump truck, truck, pile driving rig and discharge pipe as their durable lives are rather short.

The prices quoted in the above table of the floating equipment and construction machines, excepting those presently manufactured or assembled in the Republic of China, are those of the selected equipment having higher performance and available in Japan. The prices of certain construction machines include the provision of some spare parts. (Only the total sum of these floating equipment and construction machines are entered under respective items in the summary sheet of construction cost.)

1.5 Construction Facilities

The principal facilities consist of the basin to accommodate floating equipment and the workyard adjacent to it with total approximate area of 80,000 m^2. Besides, auxiliary workyards will be established for the convenience of the execution of groynes and seawalls near the base of groyne and the southern end of the south seawall. Further, two quarries will be opened up in the riverbed of the Ta-Chia River for the collection, screening and loading of stones.

The following is a proposed layout of the main workyard; A lighter's wharf with an overall length of 630 m and a depth alongside of -3 m is sited around the basin for the mooring of floating equipment and for loading of stones, concrete blocks, etc. In addition, two floating stages, a dry dock and ship repairing facilities are provided. The western half of this basin will, after the opening of the harbour, be used as the basin for government's crafts such as quarantine boats, tugboats, etc. The seawall south of the main workyard will be used for mooring drag suction dredgers and for transit storage of caissons completed and launched. The body of the breakwater of the basin should be designed in upright type like the double steel sheet pile structure to enable the mooring of small crafts on both sides. In the workyard, a concrete plant with a capacity of 100 m3/h will be built next to the dry dock. Surrounding this plant, storages of cement and aggregates and a crusher plant of 100 m3/h will be erected. The casting yards of concrete block and tetrapod will be sited facing the lighter's wharf. The area north of the basin shall be fully utilized for the piling ground of stones for the rubble-mound. The workyard will further be provided with the Resident Engineer's Office, materials storages, a test laboratory and a motor pool.

Table V-1-3 FLOATING EQUIPMENT & CONSTRUCTION MACHINES

Sheet 1

ITEM	DESCRIPTION	TYPE OF CAPACITY	QUANTITY
PREPARATORY STAGE:			
Floating Equipment.	Drug-suction Dredger	5,200 p.s., 2,500 cu.m./hr. Hopper capacity, 2,500 cu.m.	1
	Electrically Driven Suction Dredger	3,000 p.s., 1,000 cu.m./hr.	1
	Diesel Driven Suction Dredger	4,000 p.s., 1,200 cu.m./hr.	1
	Transportable Suction Dreger	250 p.s.	1
	Tugboat	750 p.s.	1
	"	250 p.s.	3
	Floating Crane	100 tons, revolving	1
	" "	30 tons, revolving	2
	Launch	8 tons	2
	Survey Boat	With echo sounder	2
	Anchor Boat	100 p.s., self-propelling	2
	Stone Carrier	Capacity, 300 cu.m.	6
	Barge	Capacity, 100 tons	2
	Water-supplying Boat	Capacity, 80 tons	1
	Fuel-supplying Boat	Capacity, 150 tons	1
	Concrete-mixing Boat	40 cu.m. per hour, 600 tons	1
	Grab Dredger	4 cu.m., non-propelling	1
	Spoil Barge	200 cu.m., hull made of steel	2
	Driver Boat	For two gangs	20
	Float, discharge pipes	660 mm. in diameter	1 set
	" " "	710 mm. in diameter	1 set
Sub-total:			(51)
Construction Machines.	Bulldozer	10 tons	6
	Dump Truck	Capacity, 11 tons	52
	Shovel Excavator	Dipper Type, 2 cu.m.	9
	" "	Back Hoe Type, 2 cu.m.	1
	Crawler Crane	Lifting Capacity, 35 tons	7
	Shovel Loader	Capacity, 1.2 cu.m.	2
	Truck, mixer	4 cu.m.	8
	Truck Crane	Lifting Capacity, 35 tons	3
	" "	" " 90 tons	1
	Semi-trailer	50 tons	4
	Road Roller	Capacity, 10 tons	1
	Pile Driver	Model 40	4
	" "	" 22	4
	Pile Driving Frame	With crawler track, Model 40	3
	" " "	" " " " 22	3
	Pile Extractor	Lifting Capacity, 30 tons	2
	Grout Pump	With mixer	2
	Truck	Capacity, 8 tons	7
	Jeep		7
	Other Miscellaneous Items		(As required)
Sub-total:			(126)

ITEM	DESCRIPTION	TYPE & CAPACITY	QUANTITY
Construction Facilities	Concrete Plant	100 cu.m. per hour	1
	" "	50 cu.m. per hour	2
	Rock Crusher	100 cu.m. per hour	1
	Screening Machine	200 cu.m. per hour	2
	Power Generator	300 KVA	2
Sub-total			(8)
FIRST STAGE:			
Floating Equipment.	Tugboat	750 p.s.	1
Sub-total:			(1)
(FIRST STAGE)			
Construction Machines.	Crawler Crane	Capacity, 35 tons	2
	Shovel Excavator	Dipper Type, 2 cu.m.	2
	Shovel Loader	Capacity, 1.2 cu.m.	2
	Dump Truck	Capacity, 11 tons	26
	Bulldozer	10 tons	2
	Truck	Capacity, 8 tons	5
	Jeep		4
	Pile Driver	Model 40	3
	" "	" 22	2
	Other Miscellaneous Items		(As required)
Sub-total:			(48)
SECOND STAGE:			
Floating Equipment.	Booster Pump	Capacity, 3,000 p.s.	1
	Float, discharge pipes	660 mm. in diameter	1 set
	" " "	710 mm. in diameter	1 set
Sub-total:			(3)
Construction Machines.	Crawler Crane	Capacity, 35 tons	4
	Shovel Excavator	Dipper Type, 2.0 cu.m.	2
	Shovel Loader	Capacity, 1.2 cu.m.	2
	Dump Truck	Capacity, 11 tons	14
	Pile Driver	Model 40	3
	" "	" 22	2
	Pile Driving Frame	With Crawler track, Model 40	2
	" "	" " " " 22	1
	Truck, mixer	Capacity, 4 cu.m.	2
	Truck	Capacity, 8 tons	4
	Jeep		4
	Other Miscellaneous Items		
Sub-total:			(40)
THID STAGE:			
Floating Equipment	Float, discharge pipes	660 mm. in diameter	1 set
	" " "	710 mm. in diameter	1 set
Construction Machines Machines	Other Miscellaneous Items Items		

The workyards to be sited at the base of the groyne and on the southern seawall will have an area of about 15,000 m^2, respectively. The space is believed to be sufficiently large. Each workyard will have a concrete plant of about 50 m^3/h, casting yards of concrete block and tetrapod in addition to the office and canteen for the Engineer and workpeople, store houses and garage. High tension cables should be drawn in to the main workyard and the sub-station established within the yard for power supply to all the construction facilities. For two other workyards, however, it appears more economical to install power generators because these yards will not be in use for a long time at a place. (These workyards will be moved to other worksites, for example of the quay wall, upon completion of works they are originally intended for.)

The site of the workyards can be easily prepared; All required is to excavate materials found nearby using the shovel excavator and to transport it to the site. The dredging of the basin, however, is not that simple because no dredger can be brought into the site; First, a "pocket" large enough to accommodate a dredger will be excavated, and a transportable pump dredger of about 250 PS will be assembled at the site, then lowered down into the pocket.

The construction facilities with the exception of the dry dock and floating stages must all be completed by the end of 1971. In particular, the construction and preparation of the access roads, quarries and worksite should be preferably completed in early part of the preparatory stage.

2. Cargo Handling Facilities and Harbour Traffic Facilities

2.1 General

It is a matter of course that the harbour facilities, especially facilities for cargo handling and harbour land traffic, have a vital role in effecting prompt and economical cargo handling which is the prerequisite of attaining full performance of the harbour functions. Regarding the cargo handling facilities, the following matters must be taken into consideration at the initial planning of the harbour.

As already described, if the growth rate of G.N.P. keeps on registering 8.0%, this harbour will certainly contribute to the growth of whole Taiwan when it comes to demonstrate its function of an international trade port, particularly to the growth of her economy, and improve the local economic conditions and increase the employment opportunities of labour. That the increased employment and national income will bring about a change in population distribution by industry is apparent from the examples of the advanced nations. That is, industries which require heavy labour such as mining industry and harbour cargo handling industry have to face difficulty in securing the required labour. As described in the "Report of New Harbour Project - 1969", income differences among industries are expected to become increasingly distinct during the coming 10 years and labour population of the primary industries such as agriculture and fishery will certainly decrease. As to harbour workers, the availability will begin to decline before the decrease of labour force in the primary industries because of the hardness of work and irregularity of working hours and so forth.

With regard to the maritime transport industry, there is the world-wide tendency towards the construction of larger ships, automation of all works involved, higher sailing speed, and use of exclusive ships for a single kind of cargo resulting from the remarkable advance of shipbuilding techniques. Thus, the mechanization of transportation will be prompted more and more in future. Such a tendency of automation and mechanization has caused that portion of the shipping cost incurred in harbours to become higher than that portion which is required for the ocean travel. For the reduction of shipping cost of import and export cargoes, the only possible means left is to shorten the time at anchor in harbour, and shipping companies have taken up this problem as an urgent matter to be solved. The wasteful expenses caused by ships in harbour arises, for one thing, from the waiting for the available berth, and for the other, from the prolonged mooring due to diminished cargo handling efficiency. Although both factors are closely interrelated, the former is invited chiefly by the scale of harbour, number of berths and harbour services. These should therefore be carefully examined when planning. The latter factor requires solution by providing for proper and adequate cargo handling facilities and their efficient operation.

Rational cargo handling and transport facilities of a harbour serve not only to satisfactorily cope with the expected shortage of labour, but also to save the shipping cost by the quick dispatch of cargoes and reduce the freight of import-export goods, and subsequently save the overall transportation costs. This will assure smooth commodity flow between the harbour and the hinterland economic sphere and boost the national and regional economy. Harbours are thus expected to play an important role in the economic activities of a nation.

The latest and most effective cargoes handling system is contemplated in consideration of the role Taichung Harbour should assume in the international economic competition.

1) Safe and secure handling without injury to goods in any way.
2) Prompt work cycles of land and sea transportation facilities, which will expedite flow of goods
3) Rational and economical channel for collection and distribution of goods

The plan is made to fulfil the above objectives.

Following description deals with the construction of facilities in each stage.

A. First stage construction

a) Handling facilities

(1) Berths No. 1 - 3

These berths are to be completed in the first construction stage, and the cargoes handling facilities are designed mainly for the import of grains. Grain laden ships of average tonnage of 20,000 DWT (max. 30,000 DWT) are expected to enter the harbour and if the capacities are planned for unloading more than 8,000 T. the general facilities will be as follows:

(a) Pneumatic unloader - 350 t/h x 2/berth
During the initial period, however, it is made 200 t/h x 2/berth because of the shortage of available funds

(b) Silos 40,000 t/berth

Operation cycle of the silo is planned to be 12 cycles/berth.

Grains are at present being bagged and carried by r ailway and trucks for the inland transportation. Future transportation of grains is expected to be by bulk transportation by trucks or, when food and feed industries are developed in the hinterland, even by direct conveyor transportation from silos of harbour. With this in view, construction of silos should accompany installation of mechanical bagging shop, sheds for bagged grains, their truck loading facility and railway waggon loading facility, and truck loading and railway loading facilities of bulk grains.

Consideration should be given also for future conveyor transportation of grains in the layout planning.

Since these berths will be built during the first stage of harbour development work, handling of sundry goods is naturally anticipated at the same berths. It will therefore be necessary to construct sheds for these sundry goods at each of the berths. Arrangement of these facilities shall be apron→ shed for sundry goods→ silo with mechanical bagging shop→ shed for bagged grains, and railway siding should be laid between the silo and the bagged grains shed for inland transportation.

Inbound and outbound transportation of sundry goods is considered to be limited to short distance transportation by trucks, at least during the early period of the harbour development. So, railway siding exclusive for sundry goods is not considered, and for sundry goods for demanding railway transportation, siding for the grain loading will be utilized.

No. 3 berth is not considered to require grain unloading facility until the second stage construction work is completed. So, some area is reserved for the facility, but for the time being, No. 3 berth will be used for handling sundry goods. In the third construction stage, grain handling facilities and silos will be installed there.

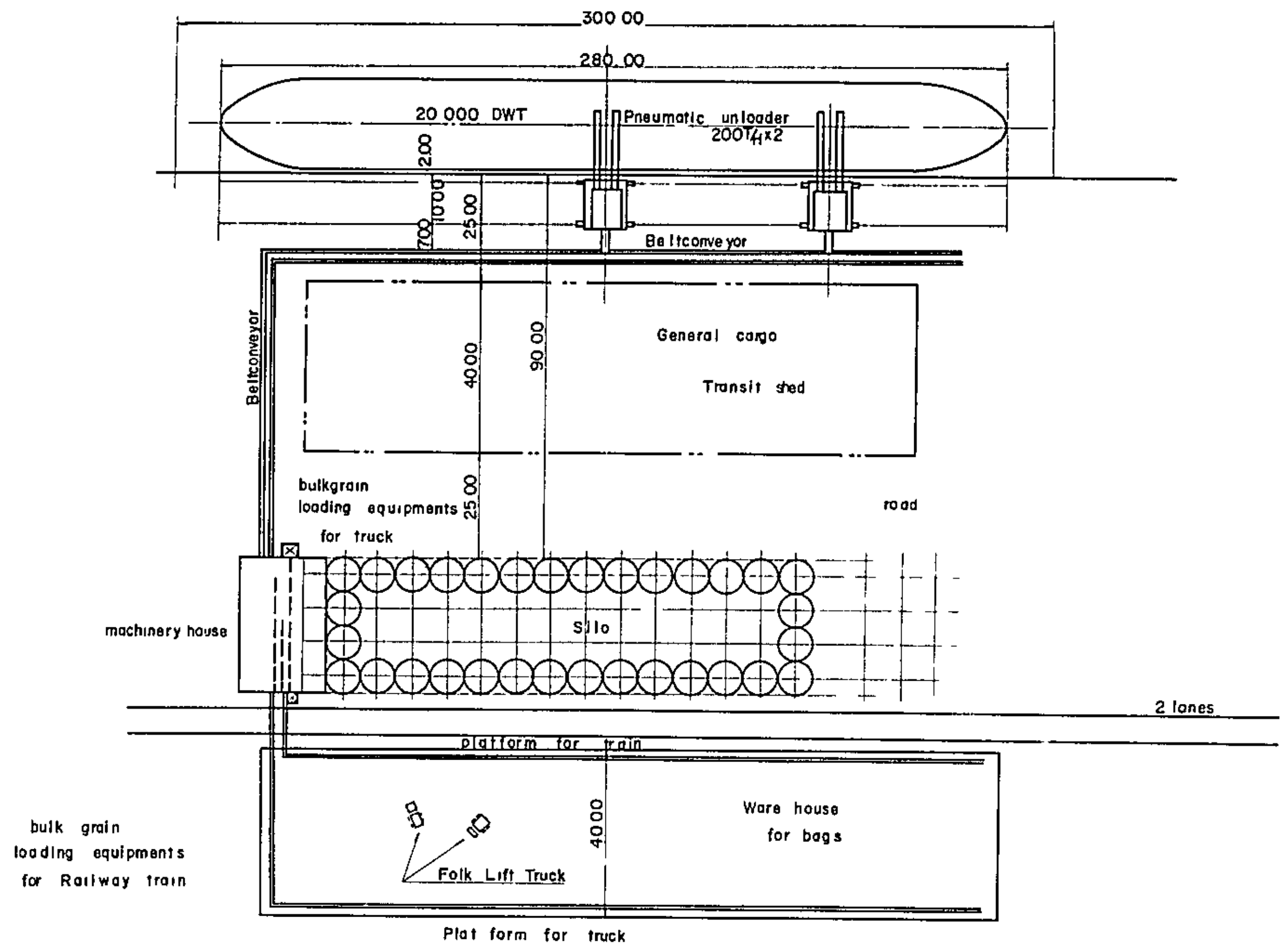
It is preferable that, in consideration of available funds, silo of No. 2 berth shall be constructed in the second construction stage, and one shed each shall be constructed first at each of the berths for the bagged cargoes and sundry goods.

(2) Berths No. 4 - 7

These berths are planned for loading cement and fertilizers. Both bagged and clinker cement and bagged fertilizers will be brought from the factories by railways on exclusive waggons of respective industries to the harbour terminal. As exported cement tends to be more and more transported in bulk (clinker), No. 4 berth will be arranged for handling both bagged and bulk cargo, and No. 5 - No. 7 berths for bulk clinker. No. 4 berth shall have the following facilities:

(a) Ship loader for bagged goods and bulk material .... 1 ea.
(b) Transit shed for bagged cargoes
(also for sundry goods) .... 1 set

Fig V-2-1 Arrangement of NOI~3 Berth grain handling equipments



The shed shall have a railway siding and the platform. Cargoes will be unloaded from waggons by means of portable belt conveyors and fork lift trucks for temporary storing in the shed, and from there loaded into the ship by belt conveyor loading machine or conventional apron conveyor. So, the shed is to be installed in front of the apron conveyor.

(c) Silo for bulk cargo (clinker) .... 1 set

Cement clinker brought to the harbour by the exclusive train is received by the dumping hopper below the rail track. It is further carried through belt conveyors, bucket elevator, and flow conveyor into the silo for temporary storing. Thereafter, it is loaded by means of belt conveyor, and ship loader into the ship's hold. As seen above, the belt conveyors play the main role in the loading work, and the silos are located behind the said shed for bagged cargoes. The belt conveyor system is planned to enable direct loading of the arrival cargoes in train to the ship without temporary storing in the silo.

(d) Conveyor system .... 1 set
(e) Portable conveyors for cargo handling within shed .... 1 set
(f) Fork lift trucks for same .... 1 set

No. 5 - No. 7 berths shall be for exclusive handling of bulk materials, and shall be equipped as such (quantity indicated is for each berth).

(a) Ship loader for loading cement clinker .... 1 set
(b) Silo for same .... 1 set
(c) Conveyor system for same .... 1 set

No. 5 berth should be built in the second construction stage, and No. 6 and No. 7 berths in the third stage. With these berths, one each of shed shall be constructed at the back of the apron for sundry goods to be unloaded by use of ships' winches. Until the construction of cement clinker handling facilities, these berths shall be used as general goods berths.

b) Harbour traffic facilities

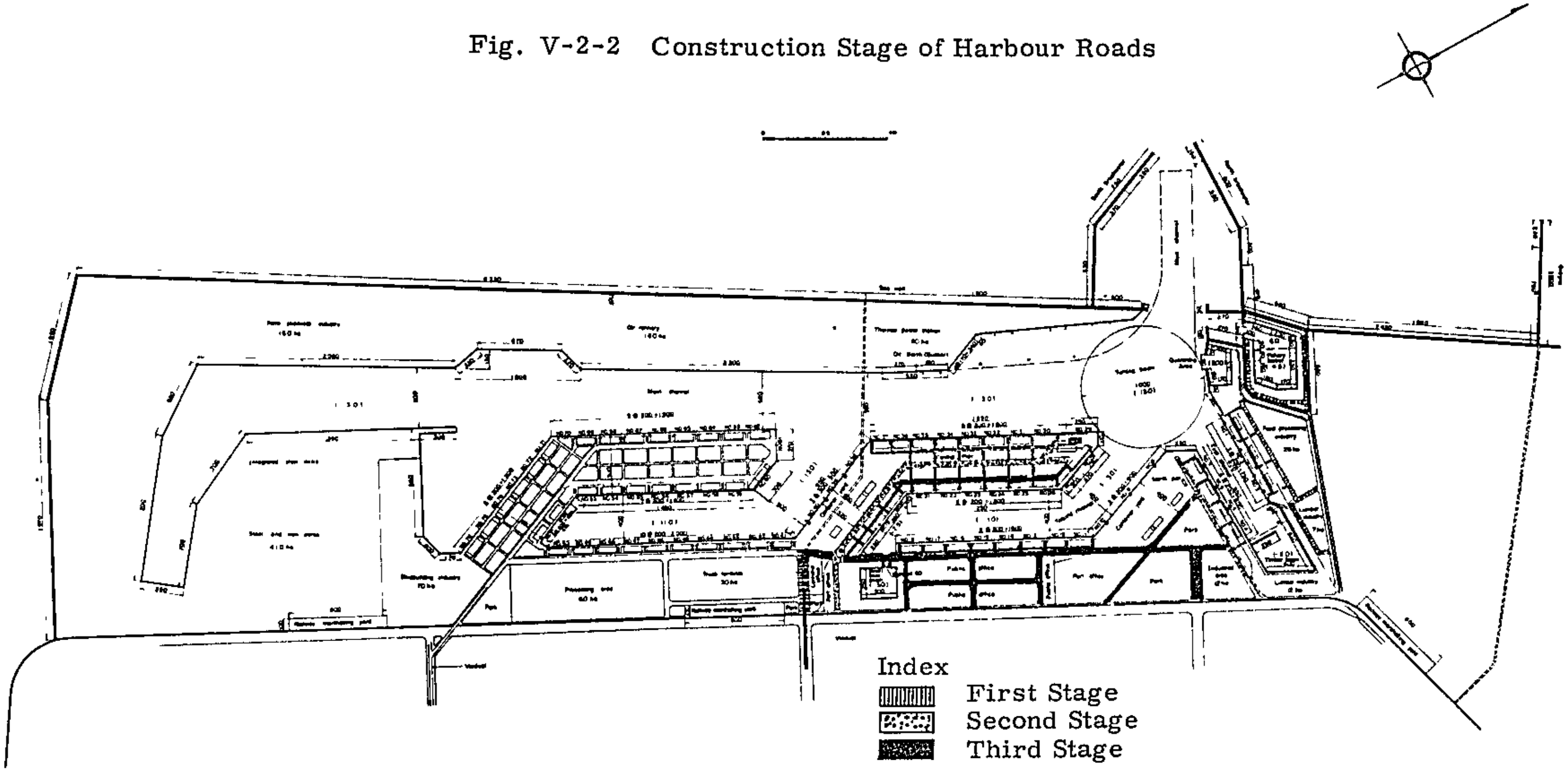
(1) Harbour railways

In the first stage of construction work, railway for the construction work which is branched off at Chianan from the Western Through Line is to be used for the initial traffic. The sorting yard shall be located at the entrance to harbour area, and the boat-train lines extended to No. 1 - No. 3 berths for the inland transportation of grains, and to No. 4 - No. 7 berths for bringing in fertilizer and cement from the hinterland.

Depending on the trend of volume and kind of collected cargoes, railway transportation of general goods may become possible by extending the boat-train line for fertilizer and cement transportation to open yard for temporary storing, and extending the line to berth No. 4 further to No. 5 - No. 7 berths for general goods.

(2) Harbour roads -- Refer to Fig. V-2-2 Harbour Roads.

Fig. V-2-2 Construction Stage of Harbour Roads



B. Second stage construction work

a) Cargo handling facilities

(1) No. 8 berth

This berth shall be planned for handling containers, and shall have one crane which handles containers of 8' x 8' x 40' dimension. When adjacent container berths, No. 9 and No. 10, have been completed during the third construction stage, the said crane may be jointly used to increase the handling efficiency.

Behind the apron, there shall be a sorting yard and a storage yard, with a freight station and a repair shop. Each of the several container ship operating companies usually uses different kinds and types of equipment such as straddle carrier, transfer crane, and forklift trucks are in the possession of and operated by the container terminal operating company. Therefore, these handling equipments are excluded from the present planning.

Scale of container handling, in terms of handling volume per berth, shall be 600 containers (1 container = 8' x 8' x 20').

Capacity of a container crane is 20 cycle/hr. So, in order to handle the above volume, one crane is insufficient. Therefore, depanding on the progress of containerization for cargo transportation, it may become necessary to install the second crane sooner than expected.

(2) Berth No. 29

Equipment of this berth shall be planned for handling imported phosphate of lime, sulphur and other ores in bulk cargoes. Loading and unloading of these shall be tentatively planned for ships of 20,000 DWT, but in consideration of future cargo boats of 50,000 DWT order, layout of conveyor at the back of apron, shed and ore yard shall be designed to enable installation of semiman trolley type unloader.

Major equipment at the back area of the apron shall be:

a) Level luffing crane	1 ea.
b) Belt conveyor system	1 set
c) Shed	1 ea.
d) Open ore yard	1 ea.
e) Stacker-reclaimer in ore yard	1 ea.
f) Platform for loading both trucks and waggons	1 ea.
g) Shovel loader	1 ea.

The shovel loader is used to carry out phosphate of lime, sulphur etc. which are not to be even temporarily placed in the open yard and are placed in the shed.

Design shall be made so that, when the adjacent Berth No. 28 is completed in the third construction stage, this shed and open ore yard can be jointly used for both berths.

Since the lot of handled goods will be greater when 50,000 DWT ships begin to enter the harbour, layout shall be planned to facilitate expansion of the shed and the open yard. In order to assure full and economical use of the crane, the crane shall be designed also for hoist work by attaching the hook device to it, when there is not much ore to be handled. Capacity of the hook shall be less than 10 t, and it should also permit handling of long bars and bulky equipment which cannot be easily handled by ships' winches.

(3) Berth No.30 - No.37

These berths should be allocated for handling general goods which are, in principle, to be handled by use of ships' winches. Therefore, in the space behind the apron, 1 shed shall be located per each berth with roadway and temporary open storage between those sheds. It is planned, however, that the shed will not be constructed, but only temporary open storage will be provided at Berth No.3 in order to reserve the space for future expansion of the shed for Berth No. 29, and open storage of ore, and also for railway line.

For handling of cargoes at this berth, winches of ships will be used, and for moving cargoes within the shed and apron, small trucks and forklift trucks will be used as appropriate. If, in future, labour shortage comes to require mechanization of the handling, installation of level luffing crane should be considered. At a berth like this where tidal range is large, use of truck crane and mobile crane is very limited in time and the cost of this installation does not pay. Then, idea to use these equipments should be discarded.

b) Harbour land traffic facilities

(1) Harbour railways

From the Western Main line at Tatu area a branch line is drawn into the center of the harbour area, where sorting yard No. 2 is installed and, lines branch therefrom to berths No. 29 - No. 37.

Line to Berth No. 29 for carrying out bulk materials shall be a temporary line, and when construction of Berth No. 21 - 26 is completed during the third construction stage, it will be drawn from No. 26 berth, and so the land for the line shall be reserved. Berth No. 8 (for containers) is to have a line branched from the boattrain line for berths No. 4 - No. 7. Sorting yard No. 2 should, after completion of the third stage construction work, be the main sorting yard, and 800 m x 100 m area should be secured for it.

(2) Harbour roads

Regarding the harbour roads, see Fig. V-2-2.

C. Third stage construction work

a) Cargo handling facilities

(1) Berths No.9 - No.10

These two berths are planned to be similar to Berth No. 8 in general, for handling containers.

(2) Berths No. 11 - No. 26

These berths are planned for handling general goods, similar to berths No. 30 - 37.

(3) Berth No. 27

This berth is planned for handling imported bulk materials, and sheds and open storage for ore of the adjacent Berth No. 28 shall be used in common.

Otherwise, the layout of the berth shall be the same as that of Berth No. 28.

b) Harbour land transportation

(1) Sidings to berths No. 11 - No. 18 are taken from sorting yard No. 1. Sidings to Berths No. 19 - No. 26 shall be taken from sorting yard No. 1.

Sidings to carry bulk materials from Berths No. 27 and 29 will be temporarily led off from the boat-train line for Berths No. 29 - 37 during the second construction stage; and during the third construction stage it will be taken from the line leading to Berth No. 26.

(2) Harbour roads

For the road planning, see Fig. V-2-2.

.2.2 Volume of Handling and Method of Inland Transportation

1) Handling volume

For the planning of handling facilities, temporary open storage, and railway and road construction, handling volume at each berth are determined as shown in Table V-2-1.

This table indicates the handling volume after completion of the third stage construction work to provide a basis for the planning of these facilities. So, the total figures of handling volume are somewhat greater than the volume of cargoes indicated in Chapter III.

2) Cargo volume by the type of inland transportation

For the inland railway installation and road planning, cargo volume by railway and road transportation is shown in Table V-2-2. Following are the criteria for allocating volume to respective transportation media.

a) As to grains to be handled at Berths No. 1 - No. 3, distance to Yuan Lian area only is planned for railway transportation from the viewpoint of distribution of factories. Volumewise, road transported grains will be 65% and railway transported grains will be 35%.

Table V-2-1 Cargo Volume/Berth

Berth No.	Cargo	Handled Volume T	Handling equipments	Remarks
1	Grain (Sundry goods)	525.000 (50.000)	Pneumatic unloader	Import
2	ditto (ditto)	525.000 (50.000)	ditto	ditto
3	ditto (ditto)	525,000 (50.000)	ditto	ditto
4	Fertilizer (bags) Cement (bags) Clinker (bulk)	240,000 100,000 150.000	Shiploader (For bags and bulk)	Export
5	Clinker (bulk) (Sundry goods)	500.000 (50.000)	Shiploader (For bulk)	ditto
6	ditto (ditto)	500,000 (50,000)	ditto	ditto
7	ditto (ditto)	500,000 (50,000)	ditto	ditto
8 10	Container	500.000 x 3 = 1,500,000	Crane	
11 26	Sundry goods	150.000 x 17 = 2,550.000		
28	Bulk cargo (Heavy cargo, less 10T)	100.000 (150,000)	10T crane	Import
29	ditto (ditto)	100,000 (150.000)	ditto	ditto
30 37	Sundry goods	150,000 x 8 = 1,200.000		
	Total	9,015,000 (600,000)		

b) Cement and fertilizer handled at Berths No. 4 --No. 7 should be carried by exclusive trains, and so, entire grain loads are planned for railway carriage.

c) As to containers handled at Berths No. 8 - No. 10, it is anticipated that they are mostly for food produced in the vicinity.

Therefore, all these containers are planned for road transportation.

d) General goods and ores to be handled at other berths are considered to be transported to districts within 40 km from the harbour in view of the harbour sphere of traffic. Road transportation is considered more advantageous for these goods. Therefore, 70% of the total goods are planned for road transportation and 30% for railway transportation.

e) Cargo volume by road transportation and railway transportation are divided as above, but the figures in the Table show the transportation volume just for the planning of transportation facilities. So, the figures indicated are added with 50% margin. With regard to the containers of Item c) consideration is given so that about 40% of the total volume of goods can be transported by railway.

2.3 Plan for Handling Facilities

(1) Grain unloading facilities (Berths No. 1 - No. 3)

1) Conditionsof the planning

a) Annual volume of handling	500,000 t/berth
b) Material handled	Grains
c) Unloading capacity	4,500 ton/day
d) Turnover rate of silo	12/year
e) Method of carrying out cargoes	Railway and trucks
f) Capacity of ships involved	20,000 DWT

2) Transportation system

Regarding transportation of unloaded cargoes to respective inland terminals and the storing involved, refer to Flow Chart V-2-3.

3) Major specification of equipment

a)	Unloader (Fig. V-2-4)	Capacity 200 t/h/ea			2 ea.
b)	No. 1-A B.C.	L = 210 m,	H = 0	200 t/h	1 ea.
c)	No. 1-B B.C.	L = 210 m,	H = 0	200 t/h	1 ea.
d)	No. 2-A B.C.	L = 86 m,	H = 20 m,	200 t/h	1 ea.
e)	No. 2-B B.C.	L = 86 m,	H = 20 m,	200 t/h	1 ea.
f)	Receiving bin charging feeder (reversible)	L = 12 m		100 t/h	4 ea.
g)	Receiving bin			100 m^3	2 ea.

Table V-2-2 Distribution of Railway Cargo and Road Cargo

Berth group			Export cargo 1000T	Import cargo 1000T	Total cargo 1000T	Remarks
1	No.1−3	Railway	37.5	870	907.5	
		road	112.5	1,642.5	1,755	
		Subtotal	150	2,512.5	2,662.5	
	No.4−7	Railway	2,650	45	2,695	
		road	105	105	210	
		Subtotal	2,755	150	2,905	
	Total	Railway	2,687	915	3,602.5	
		road	217.5	1.747.5	1,965	
		Total	2,904 5	2,662 5	5,567.5	
2	No.8−10	Railway	300	300	600	
		road	1,125	1,125	2,250	
		Subtotal	1.425	1,425	2,850	
	No.29−37	Railway	270	345	615	
		road	742.5	817.5	1.560	
		Subtotal	1,012.5	1.162 5	2.175	
	Total	Railway	570	645	1.215	
		road	1.867.5	1,942.5	3.810	
			2.437.5	2,587.5	5,025	
3	No.11−18	Railway	270	270	540	
		road	630	630	1.260	
		Subtotal	900	900	1.800	
	No.19−20	Railway	0	0	0	
		road	225	225	450	
		Subtotal	225	225	450	
	No.21−26	Railway	202.5	202.5	405	
		road	472 5	472.5	945	
		Subtotal	675	675	1,350	
3	No.27 28	Railway	0	75	75	
		road	225	300	525	
		Subtotal	225	375	600	
	Total	Railway	472.5	547.5	1,020	
		road	1.552.5	1,627.5	3,180	
		Total	2,025	2,175	4,200	
	Grand Total	Railway	3.730	2 107 5	5,837.5	
		road	3,637.5	5.317 5	8,955	
		Total	7,367 5	7,425	14,792.5	

h) Classifier	100 t/h	4 ea.
i) Hopper scale	100 t/h	4 ea.
j) Bucket elevator	200 t/h	2 ea.
k) Receiving flow conveyor	200 t/h	2 ea.
l) Flow conveyor for delivery	60 t/h	4 ea.
m) Bucket elevator	60 t/h	4 ea.
n) Bin for outgoing grain	20 t	4 ea.
o) Automatic weighing and bagging machine		8 ea.
Type - Measuring hopper scale type		
Weighing - Max. 100 kg/cycle		
Measuring frequency - 300 cycle or over		
Capacity - 30 t/h		
Accuracy - ±10/1000		
Bagging machine	330 bags/h or over	
p) Automatic bag sealing machine	330 bags/h or over	8 ea.
q) Bag delivery (discharging) B.C.	2,400 bags/h	2 ea.
r) Bag train loading B.C.	2,400 bags/h	2 ea.
s) Bulk grain receiving bin		2 ea.
t) Bulk grain delivery bin	60 m^3	2 ea.
u) Dust collector		1 set
v) Fumigator (smoking machine)		1 set
w) Thermometer		1 set
x) Level gauge		1 set
y) Electricals		1 set

(2) Ship loading facilities of fertilizer and cement

1) Conditions for the planning

a) Annual handling volume

Fertilizer	100,000 t
Cement	123,000 t
Clinker	300,000 t

b) Material handled

Fertilizer and cement bags (50 kg) 50,000 t

c) Volume of handling per ship

Dependent on the volume handled at Port of Keelung

d) Capacity of ship involved 20,000 DWT

2) Transportation line

Regarding the transportation line between railway siding (platform) ship's loading, refer to Fig. V-2-5.

Fig V-2-3 Flow chart of grain handling

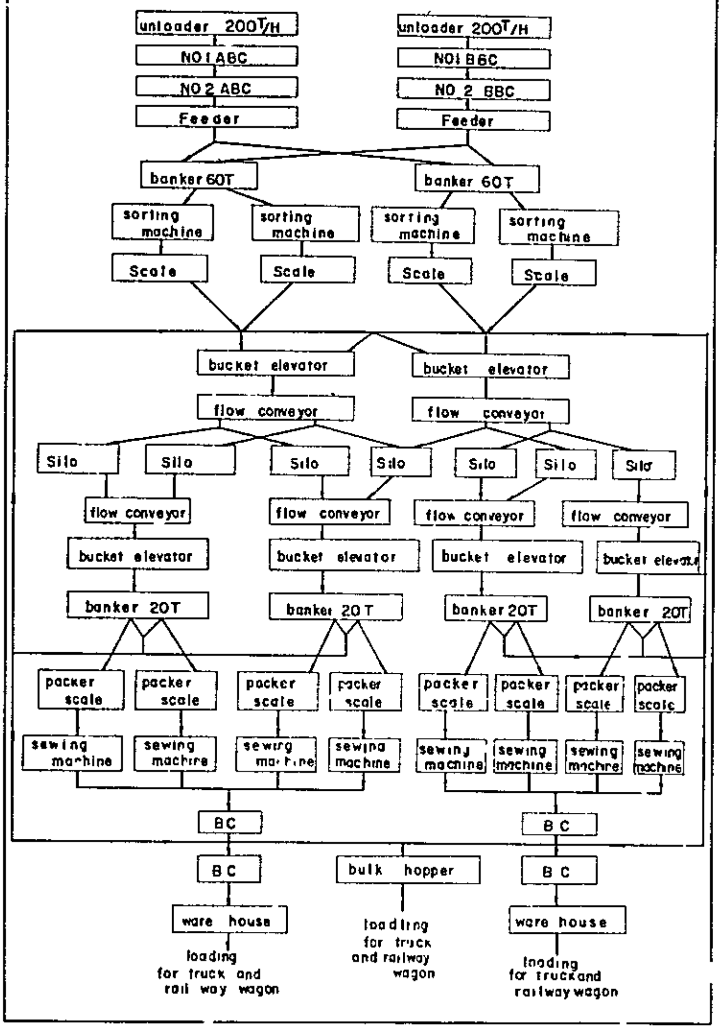
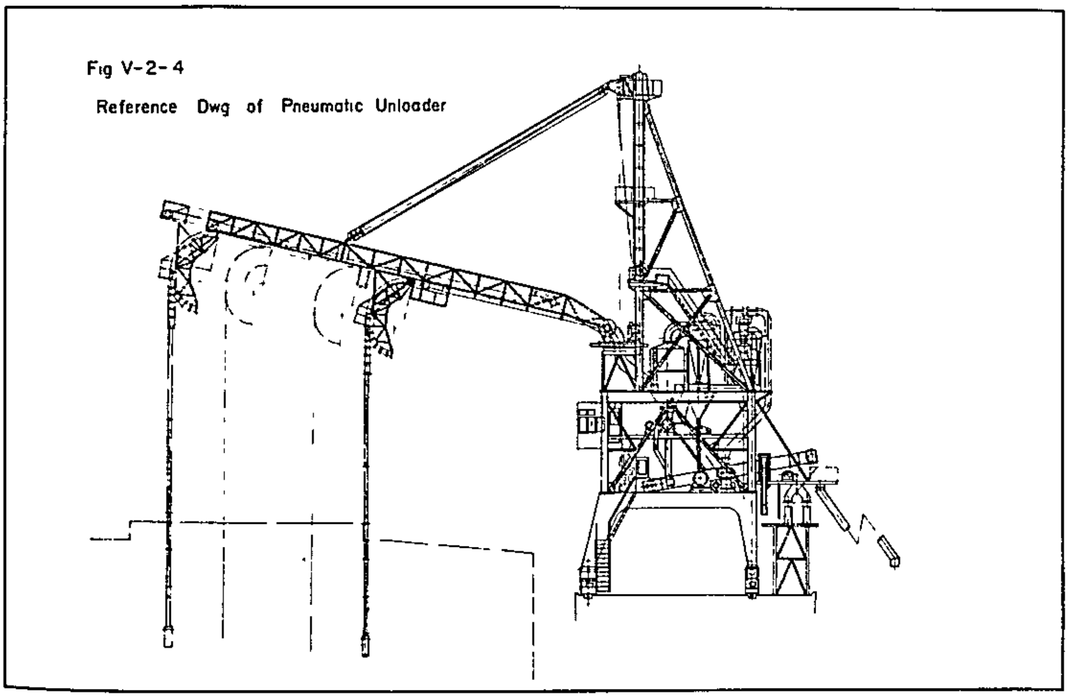


Fig V-2-4

Reference Dwg of Pneumatic Unloader



3) Major equipment specification

a) Ship loader (common to bags and bulk clinker) See (Fig. V-2-6)		2,400 B/h 300 t/h	1 ea.
b) No. 1 B.C.	L = 175 m	2,400 B/h 300 t/h	
c) No. 2 B.C.	L = 48 m	2,400 B/h	1 ea.
d) No. 3 B.C.	L = 135 m	2,400 B/h	1 ea.
e) No. 4 B.C. (with belt scale)	L = 20 m	300 t/h	1 ea.
f) No. 5 B.C.	L = 60 m	300 t/h	1 ea.
g) No. 6 B.C.	L = 18 m	300 t/h	1 ea.
h) No. 7 B.C.	L = 18 m	300 t/h	1 ea.
i) No. 8 B.C.	L = 30 m	300 t/h	
j) Bucket elevator	H = 30 m	500 t/h	1 ea.
k) Flow conveyor	L = 15 m	500 t/h	1 ea.

(3) Clinker ship loading equipment (berths No. 5, 6 and 7)

1) Planning conditions

a) Annual volume of handling	500,000 t/berth
b) Material handled	Bulk clinker
c) Ships involved	20,000 DWT

2) Transportation line

As to the transportation line of the goods between the railway siding and the loading ship refer to Fig. V-2-7.

3) Major equipment specification

a) Ship loader (Fig. V-2-8)		500 t/h	1 ea.
b) B.C. No. 1	L = 175 m	500 t/h	1 ea.
c) B.C. No. 2 (with belt scale)	L = 68 m	500 t/h	1 ea.
d) B.C. No. 3	L = 60 m	500 t/h	1 ea.
e) B.C. No. 4	L = 30 m	500 t/h	1 ea.
f) B.C. No. 5 - No. 10	L = 18 m	500 t/h	6 ea.
g) Feeder from silo	L = 18 m		17 ea.
h) Bucket elevator	H = 30 m	500 t/h	1 ea.
i) Flow conveyor	L = 56 m	500 t/h	1 ea.
j) Wagon dump receiving hopper, with belt feeder			1 ea.
k) Electricals			

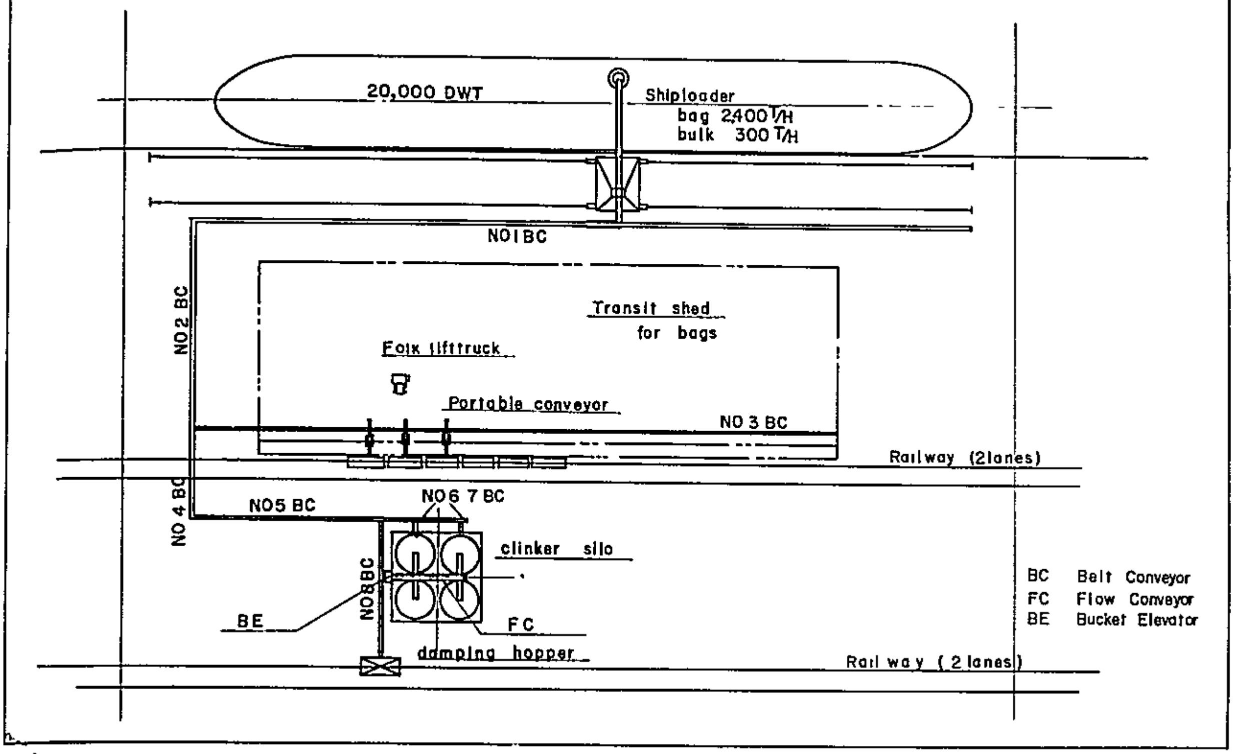
Remark : Above indicated volumes are for each one berth.

(4) Container handling equipment (Berths No. 8, 9 and 10)

1) Conditions for planning

a) Annual volume of handling	500,000 tons
b) Size of container	max. 8'-8'-40'
c) Ship involved	max. 30,000 DWT

FigV-2-5 Arrangement of NO4 Berth handling equipments



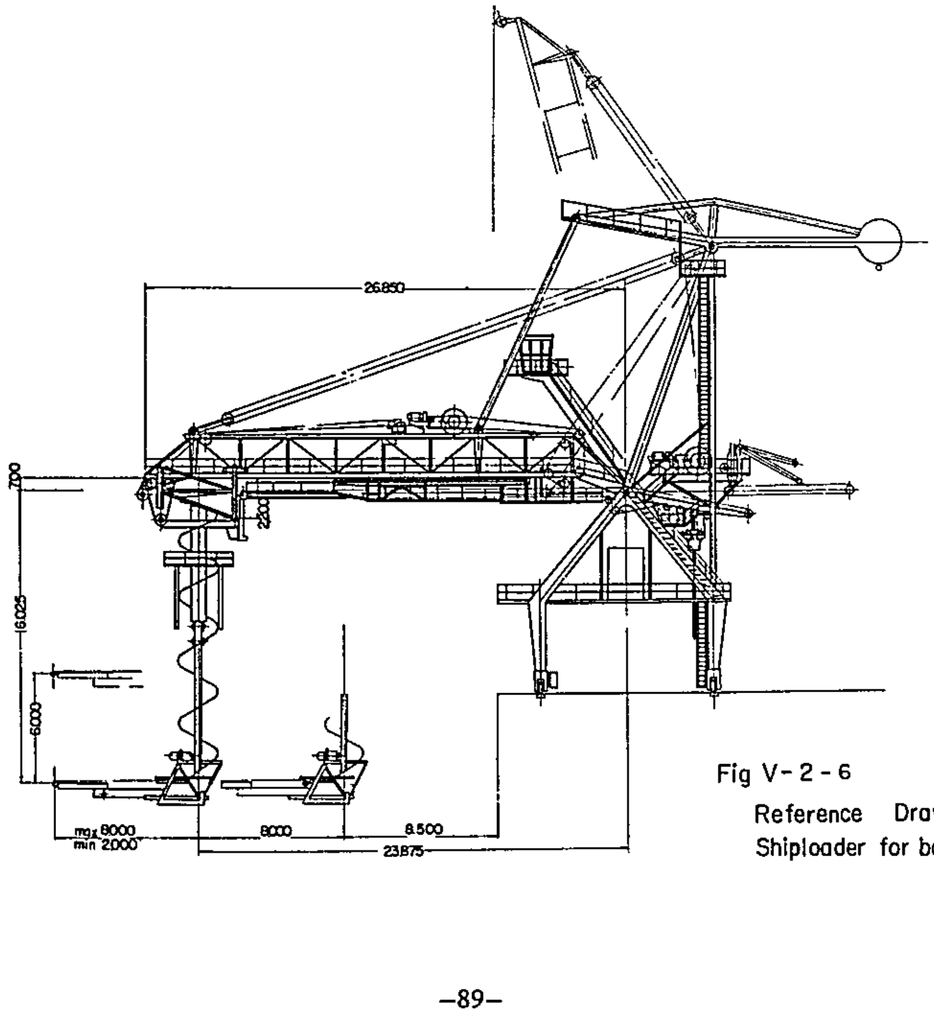
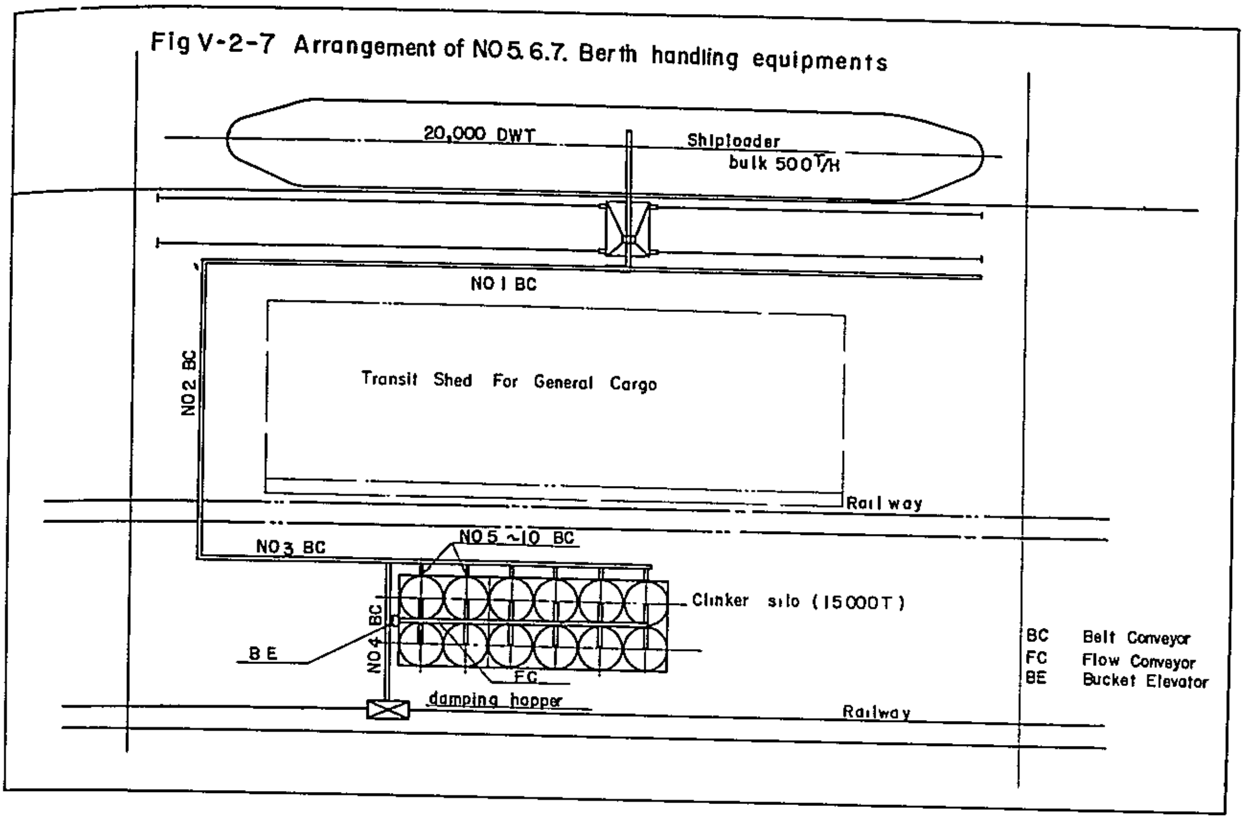


Fig V-2-6
Reference Drawing
Shiploader for bags



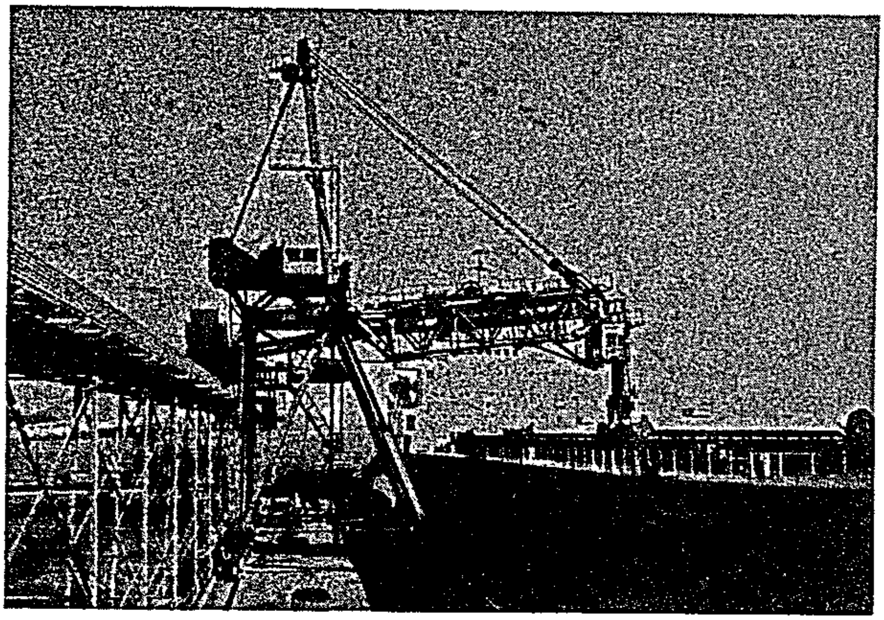


Fig. V-2-8 Reference Photo of Ship Loader for Bulk

2) Major equipment specification

Container crane, hoisting load 37.48 t — 1 ea.

Remark : Those above figures indicate volume per one berth.

(5) Bulk cargo handling facilities (Berths No. 28 - 29)

1) Conditions for planning

a)	Annual volume of handling	200,000 t
b)	Type of goods	Bulk ore
c)	Ships involved	20,000 DWT (Future expansion to 50,000 DWT is contemplated.)

2) Transportation line

Regarding cargo unloading from ships and inland transportation refer to Fig. V-2-10, "Layout Chart"1

3) Major equipment specification

a)	Level luffing crane - 10 t hoist load (Fig. V-2-11)			1 ea./berth
b)	No. 1A - B.C.	L = 240 m	360 t/h	1 ea.
c)	No. 2A - 1B.C. (with belt scale)	L = 20 m	360 t/h	1 ea.
d)	No. 2A - 2B.C.	L = 45 m	360 t/h	1 ea.
e)	No. 3A - B.C.	L = 125 m	360 t/h	1 ea.
f)	No. 1B - B.C.	L = 220 m	360 t/h	1 ea.
g)	No. 2B - B.C. (with belt scale)	L = 25 m	360 t/h	1 ea.
h)	No. 3B - B.C.	L = 125 m	360 t/h	1 ea.
i)	No. 4A - B.C. (with tripper)	L = 145 m	360 t/h	1 ea.
j)	No. 4B - B.C. (with tripper)	L = 120 m	360 t/h	1 ea.
k)	No. 5A - B.C.	L = 220 m	360 t/h	1 ea.
l)	No. 5C, D B.C.	L = 15 m	360 t/h	1 ea.
m)	No. 6 - B.C.	L = 75 m	360 t/h	1 ea.
n)	No. 5B - B.C.	L = 250 m	360 t/h	1 ea.
o)	Stack-reclaimer (Fig. V-2-12) with rotary bucket wheel, swivelling radius - 33 m		360 t/h	1 set
p)	Loading facility to waggon and truck, with feeder			1 set
q)	Dust collector			1 set
r)	Electricals			1 set

Total volume of handling by use of the above equipment being only 200,000 t, the cost of equipment is comparatively higher for the unit volume of handling. Therefore, it is advisable to withhold construction and installation of the whole of the above equipment until such time as there will occur the demand for handling volume of 1,000,000 t.

Fig. V- 2-9 Reference Dwg of Container Crane

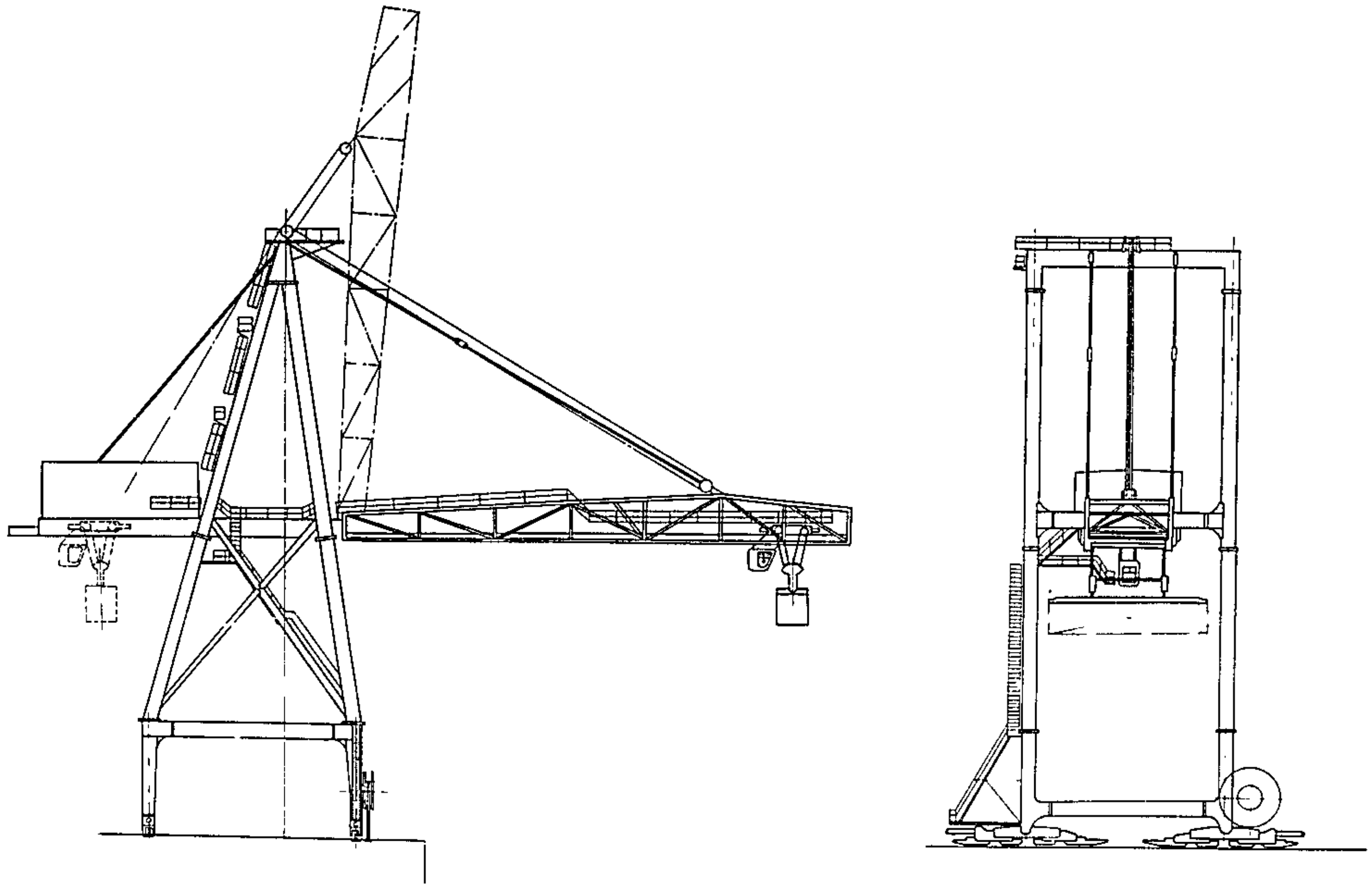
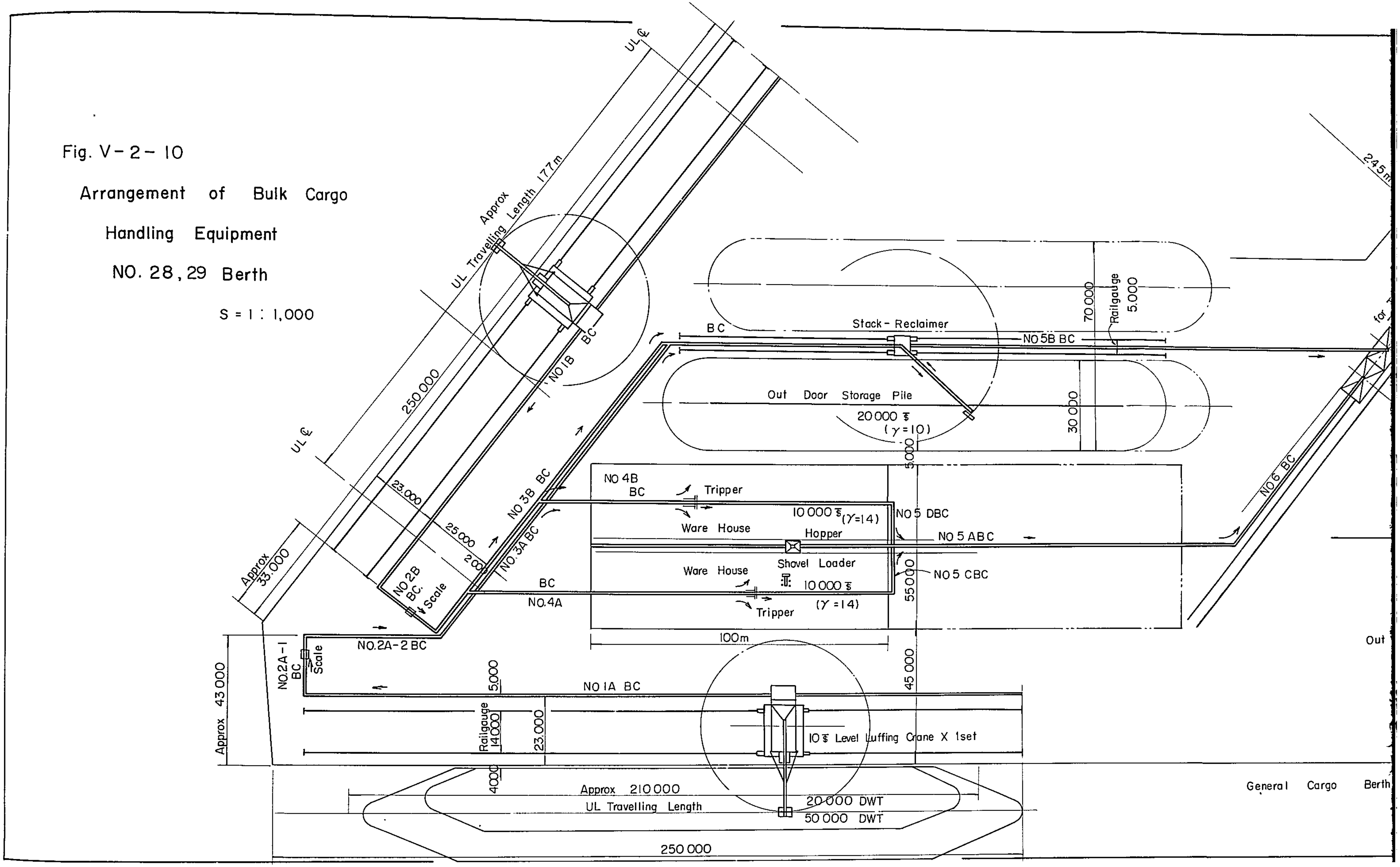


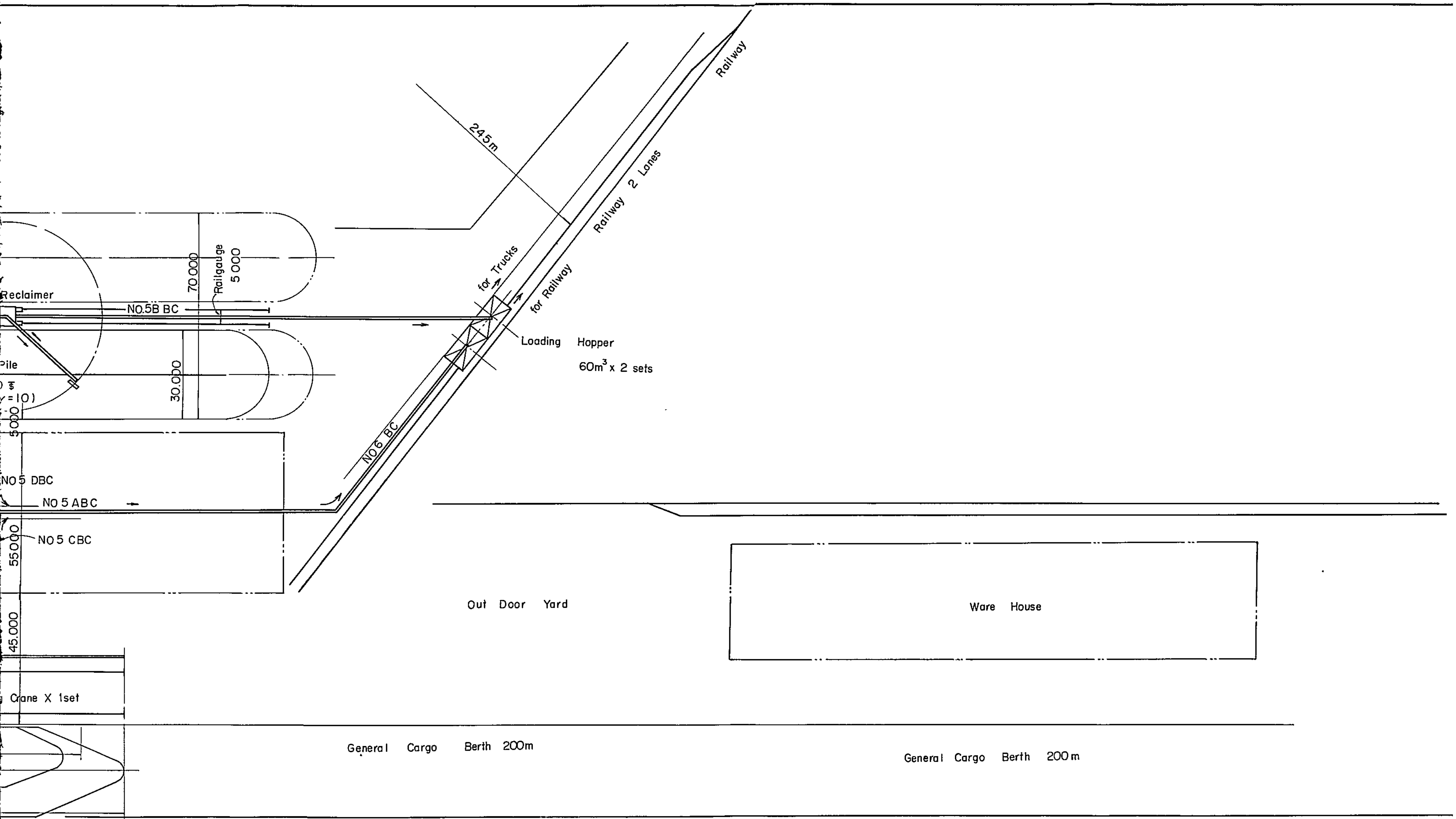
Fig. V-2-10

Arrangement of Bulk Cargo Handling Equipment

NO. 28, 29 Berth

S = 1 : 1,000





Railway
245m
Railway 2 Lanes
for Trucks
for Railway
Reclaimer
NO.5B BC
70.000
Railgauge
5 000
Loading Hopper
60m^3 x 2 sets
Pile
30.000
5000
NO 6 BC
NO 5 DBC
NO 5 ABC
NO 5 CBC
55000
45.000
Out Door Yard
Ware House
Crane X 1set
General Cargo Berth 200m
General Cargo Berth 200m

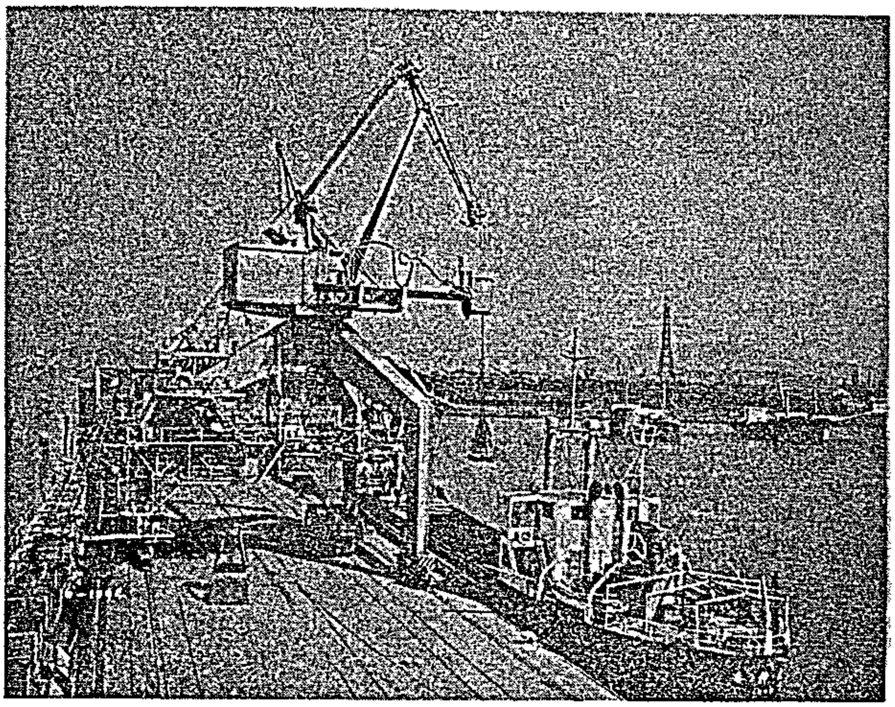


Fig. V-2-11 Reference Photo of Level Luffing Crane

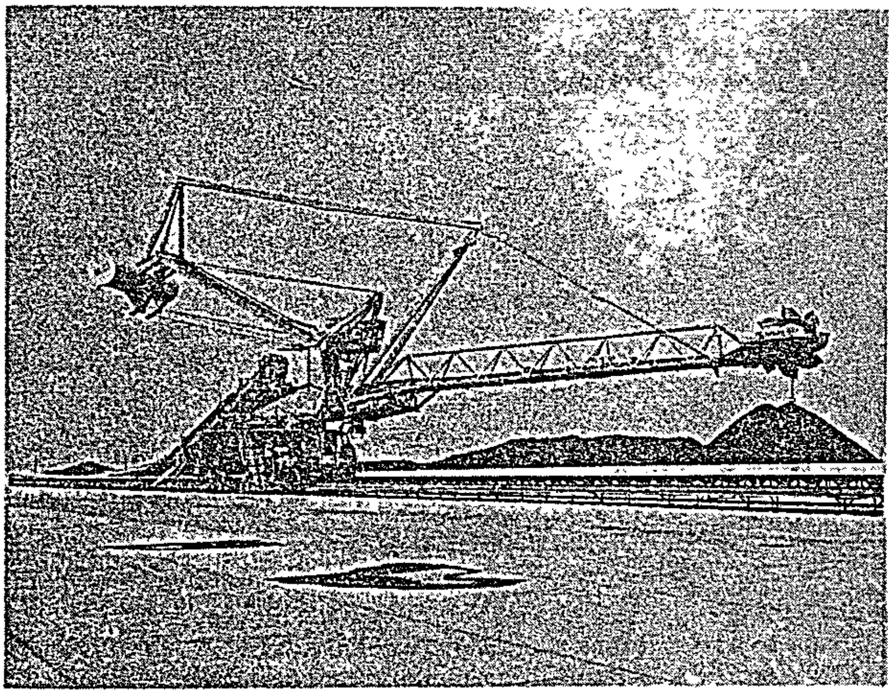


Fig. V-2-12 Reference Photo of Stack-reclaimer

2.4 Plan for Transit Shed and Open Storage

1. General conditions of the plan

Preface

Of the various land facilities of the harbour, hereunder outlined are the major functions and plans for the sheds, warehouses, open storages and other yards of ores. Also review will be made on the shape and capacity of each of these facilities, suitable to the kinds and quantity of cargoes handled in Taichung Harbour.

Sheds and warehouses are generally expected to perform the functions described below.

1) A warehouse is a building intended to provide custody and storage to cargoes, as well as shelter from wind and rain. It also provides adjustment between the time of goods' production and their time of consumption. Of these purposes, the main purpose of a warehouse is to provide storage and custody of cargoes.

2) Transit shed

Sheds are installed along a wharf, mainly for handling and classification of goods, and it is not a place to store and keep cargoes in custody for long.

It must have a sufficient area to receive all the cargoes unloaded from a ship, to handle and classify them, and also to receive outgoing cargoes immediately before arrival of the ship for loading.

3) Open storage

Open storages are used as temporary storage of construction materials and sundry goods, and recently there is an increasing tendency to use them for temporary storing of containers. With a view to the above tendency, it is advisable to secure wider spaces of open storage between sheds.

2. Structure and scale of respective facilities

1) Structure of warehouse and shed

Where much area is available, single floored building is more convenient.

In Japan, warehouses and sheds are often located in one building; and the first floor is used as the shed and the second floor as the warehouse. It is because of the convenience such an arrangement provides, and of the narrowness of the land.

Whereas, in the case of Taichung Harbour, sufficient area is available for the handling facilities, and it permitting construction of sheds solely for their own purpose of receiving and classifying goods, and in some case, temporarily storing goods, sheds are planned to be single floor buildings.

a) Floor

The floor in direct contact with the ground withstands 1 t/m^2 load even at a reclaimed soft land. Ordinarily, floor of warehouse is laid with 25 cm thick cobbles, 15 - 20 cm thick concrete in 1 : 3 : 6 ratiorand 3 cm finishing mortar.

b) Wall

Fire-proof building is the most desirable, but in consideration of cost, generally it is made single floored building of skelton frame with fire proof wall.

In the case of iron skelton framed building, the frontage distance between cross beams 4.0 m x span of 15 - 20 m will be the most convenient and economical.

c) Roofing

Shed construc tion of warehouse usually has a broad area of rain fall, and in case of iron sheet or slate roof, the valley gutter is made larger, and the roof sheathing is made stronger and overlapped.

2) Scale of shed and warehouse

Dimension of shed or warehouse is determined to satisfy the ›llowing equation.

$$W = \frac{N}{nR} = w.1.b$$

'here W = goods storing capacity/day (ton)
N = quantity of goods handled during life (ton)
R = frequency (cycle) of goods circulation in warehouse (time/year)
w = weight of goods stored per unit area (ton)
l = frontage (m)
b = depth (m)
n = number of ridges
α = rate of goods storing (ordinarily 0.7 approx.)

The operation cycles of a shed and warehouse "R" may vary with he port, but usually it is set at 20 - 25 times for a shed, and 8 - 12 times for ⁄arehouse. Dimension of the frontage, depth and height of ceiling should have .ppropriate values to suit the kinds of goods handled, method of handling, trans- ›ortation in and out of the building and kinds of handling equipment used.

The commonly accepted standards are;

Table V-2-3 Standard dimension of frontage, depth and ceiling height of shed and warehouse

Frontage at wharf	for greater ship for smaller ship	70% of length of berth 30 - 60 m
Depth at wharf	for greater ship for smaller ship	25 - 45 m 15 - 30 m
Height to ceiling		4.5 m - 7 m

3. Determination of handled cargoes and capacity of sheds

(1) Berths No. 1 - No. 3

Length of berth : 250 m

1) Planning of grain silos

a) General

Assuming annual operation cycles of silo is 12 cycles, required capacity of silo will be

500,000 t x 1/12 = 40,000 t (equivalent to two ships of 20,000 DWT)

b) Shape, size, etc. of 40,000 t silo

Shape and dimension of the 40,000 t silo of reinforced concrete will be designed as shown in Fig. V-2-13.

Its foundation is planned presuming there is a firm supporting rock or stratum at 30 m below the surface.

Capacity of silo	40,000 ton
Effective storing capacity of silo:	ϕ7,700 x H22,500 - 770 m^2
Quantity of main silos:	64
Storing capacity of silo:	49,280 m^3
Storing weight of main silos:	34,496 t (= 0.7 t/m^3)
Effective volume of intermediate silos:	220 m^3
Quantity of intermediate silos:	42
Storing capacity of intermediate silos:	9,240 m^3
Storing weight of intermediate silos:	6,468 t
Total effective storing quantity:	40,964 t

2) Shed for sundry goods

Since berths No. 1 - No. 3 are built in the first construction stage, sheds at these berths will handle sundry goods besides grains. Sheds for those sundry goods are planned as below:

Volume of sundry goods hnadled: 50,000 t/berth

However, size of sheds is planned to be similar to that of berths No. 4 - No. 7, No. 11 - 26, No. 30 - 37. (Refer to Fig. V-2-14 for shape and dimension).

Capacity of sheds:	7,500 t/shed
Frontage:	140 m
Depth:	40 m (20 m x 2 spans)
Height of eaves:	5.5 m
Area:	5,600 m^2

Structure:	
Frame work:	Skelton flat truss structure
Roof:	Coloured iron strip

Fig V-2-13 40,000 TON GRAIN SILO S = 1 : 500

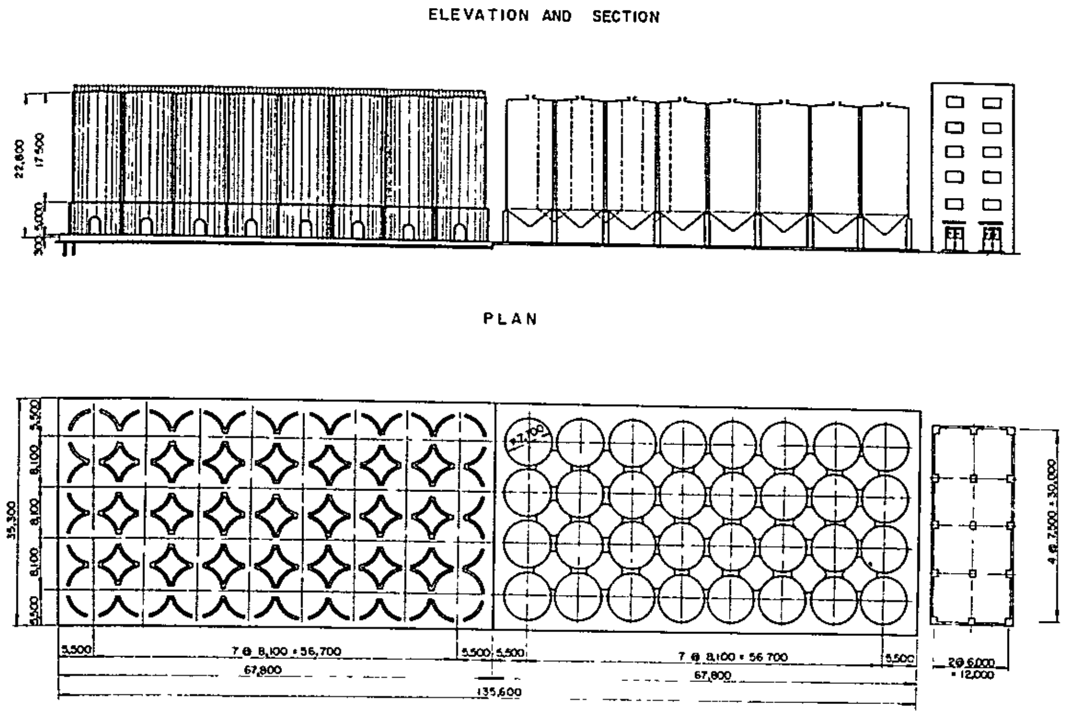
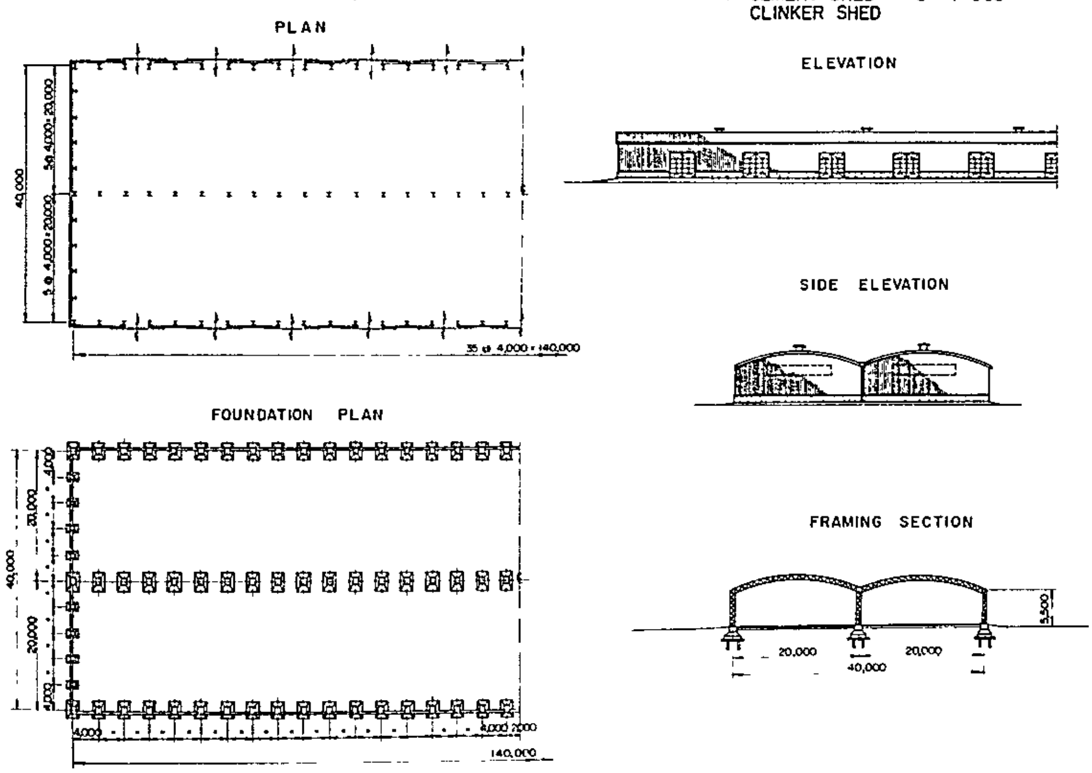


Fig V-2-14 GENERAL CARGO SHED AND FERTILIZER SHED / CEMENT SHED / CLINKER SHED S = 1 : 500



Wall:	Coloured iron sheets
Panel work:	Reinforced block heap
Floor:	Cobble bed and concrete paving

(2) Shed of No. 4, 5, 6 and 7 berths for cement, fertilizer, clinker and sundry goods

Sheds for bagged cargoes and general sundry goods are provided at Berth No. 4. At No. 5 - 7 berths, sheds for sundry goods are installed. Their shape and dimension shall be similar to those of No. 1 - 3 berths because of the planning conditions.

(3) Clinker silos

a. Clinker silos for No. 5, 6 and 7 berths

Annual volume handled:	500,000 t/berth
Annual operating cycles:	33

Then, capacity of those silos will be,

500,000/33 = 15,000 t/cycle

Weight of clinker:	1,450 kg/m^2
Angle of repose:	32°

Based on the above particulars, shape and dimension of those silos will be designed as indicated in Fig. V-2-15. Particulars of silos shall be:

Capacity of silos:	15,000 t/berth
Main silos, 12	ϕ9,000 m, H 21.0 m
Intermediate silos,	5
Effective storing capacity:	15,445 t (10,652 m^3)

Structure of silos:

Silo: Reinforced concrete construction, mortar finished
Foundation: Reincorced concrete floor
Reinforced concrete piling

b. Silos for berth No. 4

Annual handling volume: 150,000 t
Following the silos design for Berths No. 5, 6 and 7
Following the silos design for Berths No. 5, 6, and 7, 5,000 t/silo will be planned as shown in Fig. V-2-15.

(4) Berths No. 11 - 26 and No. 30 - 37 for sundry goods

Weight of sundry cargo handled:	2 t/m^2
Tonnage of ship:	20,000 DWT
Annual volume of handling:	150,000 t/berth
Operating cycle of shed:	20 cycles/year

Particulars assumed as above, sheds similar to those of Berths No. 1 - 3 will do. (Fig. V-2-14).

Fig V-2-15 CLINKER SILO S = 1 500

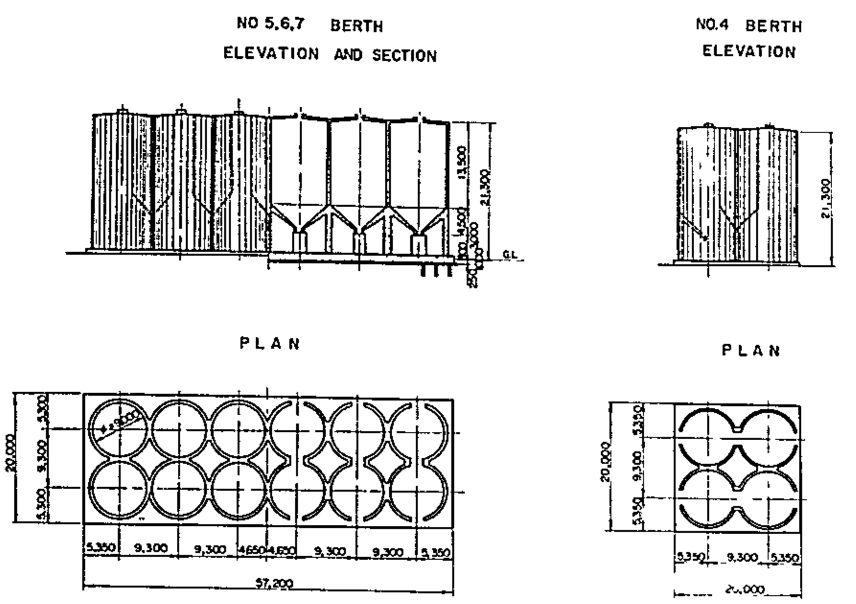
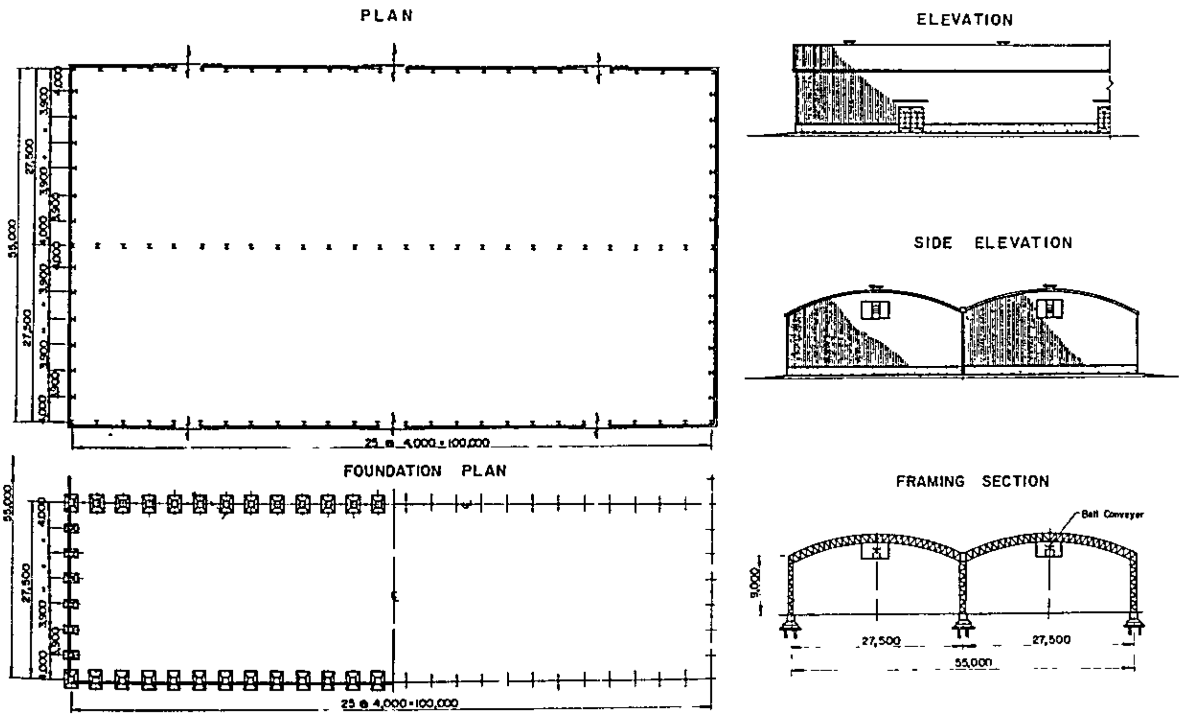


Fig V-2-16 ORE SHED S = 1 500



(5) Berth No. 29 for ore handling

Shed for storing ores shall have a capacity of 20,000 t, and designed as shown in Fig. V-2-16.

(6) Berths No. 8 - 10 for containers

Freight stations

500,000 t cargoes are handled annually by each of these freight stations. Weekly serviced quantity of containers is estimated at 900 pcs. with some mergin, and the freight stations should be designed as such.

Dimension of 1 block: 160 m^2 (40 m x 4 m)
Quantity of container handled per week per block: 30 pcs.

Then, scale of freight station to handle 900 pcs. of containers shall be:

30 blocks x 160 m + 400 m (electric room and office) = 5,200 m^2

Besides, repair shop of 1,100 m^2 area and office of 240 m^2 area will be necessary.

Freight station is shown in Fig. V-2-17, and container yard in Fig. V-2-18.

2.5 Railway Installations

1. Design conditions

1) Volume of cargoes transported

Plan shall be made based on the volume of cargoes calculated in the preceding paragraph 2.4.

2) Number of operation days

In the case of train operation, 365 days/yr is usually adopted, but in the present case, it is planned on the basis of 360 days/yr in consideration of cargo handling of harbour.

3) Waggons operation

At Nos. 1 - 7 berths, greater part of train carried import cargoes are grains, and greater part of train carried export cargoes comprise cement and fertilizer. Therefore, the idea of utilizing waggons for transportation of various kinds of cargoes is discarded in the present plan. Cargoes of other berths being mostly sundry goods, utilization of waggons should usually be considered. But in this particular case, the total volume being rather small, utilization of waggons is not contemplated either.

4) Railway capacity

Trains temporarily composed at harbour's sorting yard shall be

Fig V-2-17 Freight Station

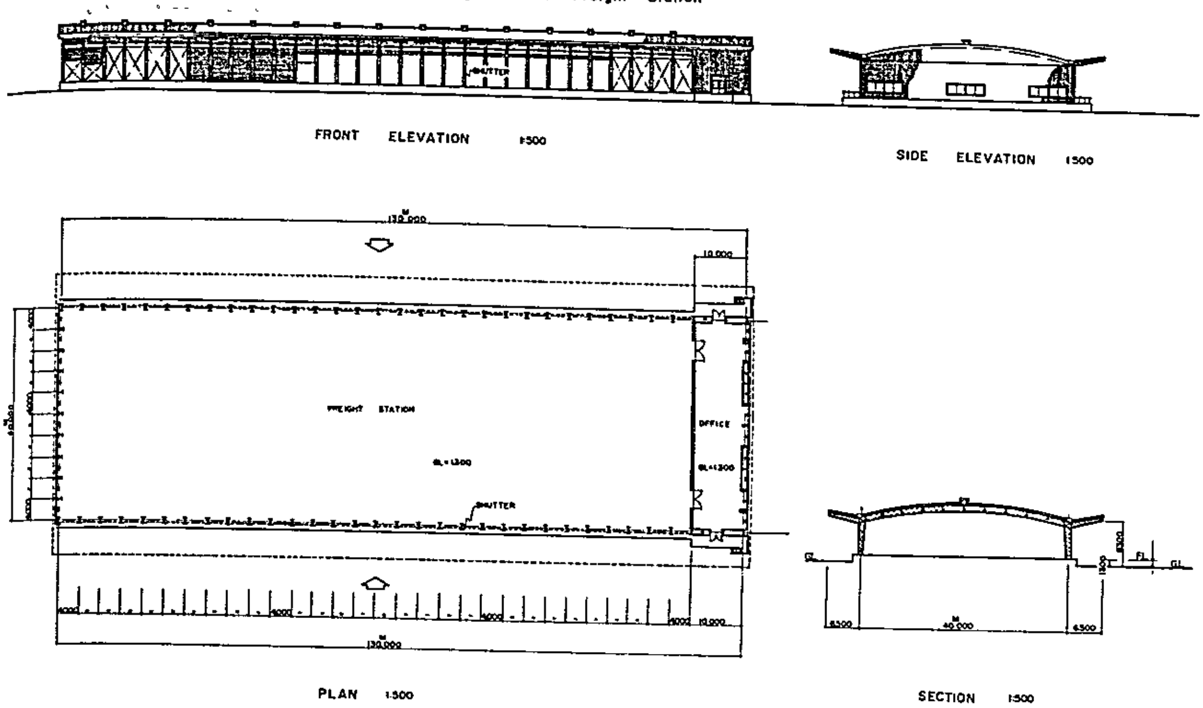
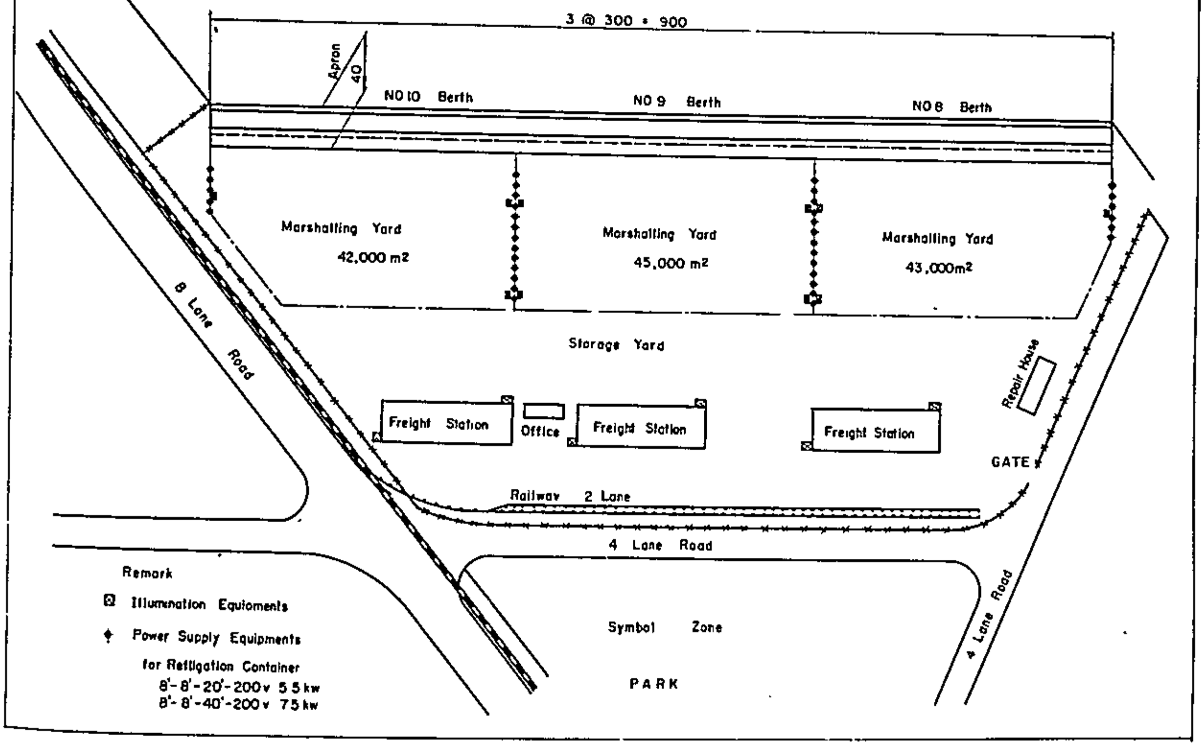


Fig V-2-18 CONTAINER YARD S = 1:4000



finally composed at a newly built Tatu sorting yard. It is provided that incoming trains can enter the harbour directly without reorganization at Tatu.

Capacity of the Western Through Line will be:

	Railway capacity Times/day	Max. Traction T/Times
Down train	35	1250
Up train	35	950

Arrival of trains of maximum traction, 1250 t, should be expected.

5) Container train

Containerization of cargoes is considered to start with such food stuffs as banana and canned food. Thus, major part of transportation media will be trucks and sea-land system of vehicles, and organizing a container train is not being considered for carrying containers exclusively.

6) Waggons

Waggons are planned based on the following standard:

Average loading capacity:	15 t
Average length of waggons:	8.2 m

Traction constant is set at 80 between the harbour sorting yard and Tatu sorting yard. Accordingly, number of waggons in a train will be,

Nr. waggons = 80/2.2 = 36 waggons/train

The divider, 2.2 = conversion rate of loaded waggon. If an empty waggon, it should be 1.0.

7) Empty waggons

Number of empty waggons shall be increased by 20%, which is the difference between the arrival and leaving waggons.

8) Busyness factor

Usually busyness factor of 1.2 should be considered, but in the present case, volume of carried cargoes being given 50% allowance, this factor is omitted from calculation.

2. Planning sorting yard

1) Quantity of waggons handled:

$N = W/T \times w$, where W = annual volume of cargoes (in ton) handled
T = number of operating days = 360 days
w = average loaded tonnage per waggon = 15
N = per day waggons handled

a) 1st sorting yard (1st construction stage)

	Ar.	Lv.	Empty	Total
Volume of cargo	2,687,000	915,000		3,692,000
Nr. of waggons	500	170	400	1,070

b) 1st sorting yard (2nd construction stage)

Volume of cargo	300,000	300,000		600,000
Nr. of waggons	54	54	0	108

c) 1st sorting yard (3rd construction stage)

Volume of cargo	270,000	270,000		540,000
Nr. of waggons	50	50	0	100

d) 2nd sorting yard (2nd construction stage)

Volume of cargo	270,000	382,500		652,500
Nr. of waggons	50	70	24	144

e) 2nd sorting yard (2nd construction stage)

Volume of cargo	240,000	240,000		480,000
Nr. of waggons	45	45	0	90

2) Plan for siding tracks

$$\text{Required length of siding track} = \frac{\text{Av. waggon handling} \times 8.2}{0.7 \times 3}$$

where, 3 = waggons turnover rate

0.7 = rate for possible shunting

Length of one siding track is 300 m in effective length.

a) 1st sorting yard (1st construction stage)
Required length of siding track = 4,170 m
Required quantity of siding tracks = 14 tracks

b) 1st sorting yard (additional in 2nd construction stage)
Additional length of siding track = 430 m
Additional quantity of siding tracks = 2 tracks

c) 1st sorting yard (Additional in 3rd construction stage)
Additional length of siding track = 390 m
Additional quantity of siding tracks = 1

d) 2nd sorting yard (2nd construction stage)
Required length of siding track = 560 m
Required quantity of siding tracks = 2

e) 2nd sorting yard (3rd construction stage)
Additional length of siding track = 350 m
Additional quantity of siding tracks = 2

Remarks: The 2nd sorting yard will bandle quite a number of waggons and will become the center of sorting yards of the commercial port and take on the characteristic of cargo stations. So, in consideration of allocating adequate space for future expansion, 800 m x 100 m land is secured for this.

3) Arrival and departure track

It should be planned to permit the arrival train with the greatest traction force of 1,250 t of the Western Through Railway Line.

Effective length = EL = 1N/n + L + c = 557

where, 1 = length of waggon - 8.2 m average
N = traction constant = 125
n = conversion constant of one waggon = 2.0
L = length of locomotive = 20 m approx.
c = allowance in front and back of a train = 25 m

The tracks shall have an effective length of 600 m.

a) 1st sorting yard (1st construction stage)

Average number of train arrivals per day;

S = 500 x 1/36 ≒ 14
However, busyness factor 1.0
Number of waggon/train = 36 (traction constant of average 80 is assumed.)

Then, trains arriving and leaving will be 28/day. So, two tracks will be installed.

b) 1st sorting yard (additional in 2nd construction stage)

Added number of trains arriving and leaving in 2nd construction stage will be 4/day. Total trains (Ar. & Lv.)/day will be 32 then, and the two tracks will be busy in its shunting work, but anyhow they will do the work.

c) 1st sorting yard (additional in 3rd construction stage)

Increased trains (Ar. & Lv.) will be 4/day, which makes the total of trains arriving and leaving 36/day. Depending on the busyness factor 1, track should be increased.

d) 2nd sorting yard

Trains arriving and leaving are 5/day even if added with those additional tracks in the 2nd and 3rd construction stages. So, one rail track will be planned for this sorting yard. However, there should be sufficient land reserved for future extension.

3. Plan for marine rail tracks

Transportation volume per day, loading and unloading ability, number of waggons per train, and frequency of trains' run, must be taken into consideration in the planning of marine railway. Tracks for loading and unloading are conditional on the layout of berths, so when the length of loading and unloading track becomes insufficient, side tracks should be provided.

1) No. 1 - 3 berths

Volume of transportation being 907,500 t (of which export is 37,500 t and import 870,000 t), 4 trains/day is considered, and the per berth loading and unloading railway of 120 m will be sufficient.

Approximately 200 m track being allocated per berth for this, there will be sufficient tracks for holding empty waggons.

2) No. 4 - 7 berths

If the front space of No. 4 berth is considered for unloading of fertilizer bags, 4 trains will be necessary to carry 510,000 t/year cargoes, and siding of 200 m length is necessary. Therefore, one track for holding shall be provided beside the siding track.

Presuming that the back area of berths No. 4 - 7 is used for unloading bulk cement, and that the maximum volume is 750,000 t/yr, a waggon holding track becomes necessary in addition to this siding track.

3) No. 8 - 10 berths

These berths being allocated for container handling, one track for unloading and another for holding waggons will be provided, and the whole length of the track will be directly connected to the permanent way.

4) Berths No. 11 - 18

These berths are for handling of sundry goods. Siding for the loading and unloading will be sufficiently taken care of by one track, and one cycle of train run.

5) No. 21 - 26 berths

Same as above, 1 track is provided.

6) No. 30 - 37 berths

Same as above, 1 track is provided.

7) No. 28 - 29 berths

These berths are for ship loading of bulk cargoes consisting of ores and etc. As the equipment have a large loading capacity, the one siding track will be sufficient.

Remarks: With the track for loading sundry cargoes, a lot for future construction of holding track should be reserved in view of the future increase of train cargoes.

2.6 Road Traffic

Complexity of mechanism in the developing traffic in harbour area makes it difficult to establish prerequisites of road planning for the harbour.

From the volume of traffic estimated from the volume of cargoes handled shown in Table V-2-2, studies were made on the necessary number of lanes, width and stages of construction of each roadway.

1) Planning of annual road construction and operation and the scale of roads

In the annual road construction planning, volume of cargo handling of each and all berths becomes the governing condition.

Taichung Harbour has rather concrete future plan up to the year of 1980.

The planning after 1980 is in a stage of master plan. Fortunately, up to the year 1980, volume of cargoes handled at each of the berths is considered to remain constant. If in some future time, the volume should show a substantial increase, the pier's construction work will be started in accordance with the master plan. Therefore, roadways which are considered to come under the influence of the master plan is covered by the master plan, and the rest are included in the plan for the year of 1980. The ratio, traffic volume/traffic capacity is set at 0.75 which is similar to the highest ratio in Japan.

2) Road structure designing (width and lanes)

Harbour roads are planned to have 2 lanes (width - 12 m and 15 m), 4 lanes (width 30 m), 6 lanes (width - 40 m including 2 lanes for slow moving vehicles), and 8 lanes (width - 47 m including 2 lanes for slow moving vehicles).

Excepting the 2-lane roads, dividing strips are provided for positive separation between opposing traffic streams.

See Fig. V-2-19 for width of respective lanes and dividing strips.

3) Traffic volume by time, and the design of road

Road width is designed for presumed 30th hour volume at the converging point of traffics from each and all the berths. The basis of traffic volume estimation are:

(1) Average carrying volume of a large truck 5 tons
(2) Traffic volume of harbour visitors and harbour workers are assumed to be similar to the quantity of large trucks, and all the people are presumed to be car riders.
(3) Planned daily traffic volume:
Average daily traffic volume of a year is presumed to be same in the case of general roads.
(4) Annual operating days: 360 days
(5) Peak load coefficient "K"/or 2 lane road's hourly traffic volume
Ratio of the 30th hour traffic volume to the annual average daily traffic volume is made the maximum (K = 14%) in the case of Japanese ordinary roads. However, as it is the value to be determined by the road characteristic, it is made 21%, the measured maximum value according to the "Highway Capacity Manual".

Fig V-2-19 (1) TYPICAL CROSS SECTION OF ROAD

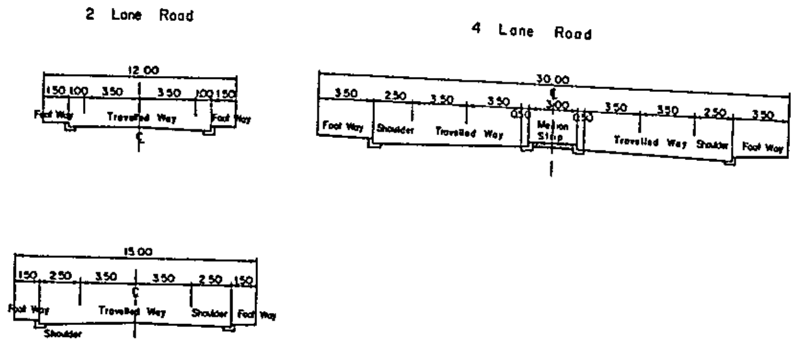


Fig. V-2-19 (2)

6 Lane Road

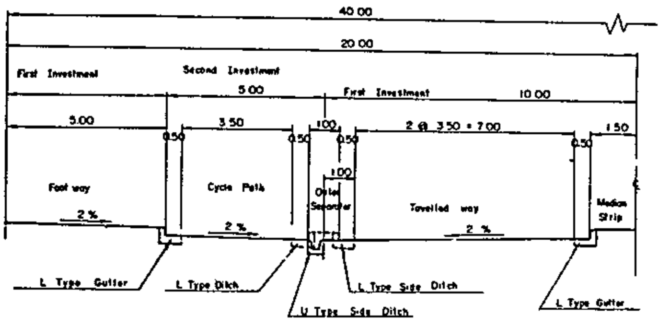
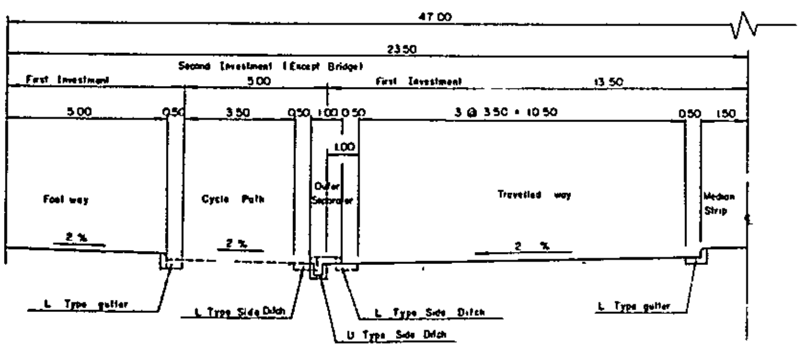


Fig. V-2-19 (3)

8 Lane Road



(6) The peak hourly traffic volume "D" on a heavier traffic lane, being about 2/3 of the total of bothway traffic volume as a rule, is made 70%.

(7) Design hourly traffic volum , V_D:

The designed hourly traffic volume, V_D, is obtained by the following equation:

(2 lane Bothway) $V_D = \frac{\text{Annual vol. of cargo handled x 2 x 2}}{360 \times 5} \quad \frac{K}{100}$

(Heavier traffic lane) $V_D = \frac{\text{Annual vol. of cargo handled x 2 x 2}}{360 \times 5} \quad \frac{K}{100} \quad \frac{D}{100}$

The design hourly traffic volume calculated by the above equation is shown in Table V-2-4.

Table V-2-4 Design Hourly Traffic Volume

Construction Stage	Berth No.	Annual vol. of cargo handled (t)	Designed hourly traffic volume	
			2 lane road	Heavier loaded lane
1st stage	1 - 3	1,755,000	900	700
	4 - 7	210,000	100	70
2nd stage	8	750,000	400	300
	29 - 37	1,560,000	800	600
3rd stage	9 - 10	1,500,000	750	600
	11 - 18	1,260,000	600	450
	19 - 20	450,000	300	250
	21 - 26	945,000	500	350
	27 - 28	525,000	300	250

4. Design hourly traffic volume

With the basic traffic volume set at 2,500/hr/lane, the factors to reduce traffic volume is represented in Japanese value. The design hourly traffic volume, Vc, is obtained by the following equation:

$$Vc = C_B \times \gamma_L \times \gamma_C \times \gamma_T \times \gamma_I \times \gamma_P$$

where,
C_B = basic traffic volume (cars/hr)
γ_L = compensating rate depending on width of lane
γ_C = adjusting rate depending on edge clearance
γ_T = compensating rate depending on large trucks (longitudinal slope)
γ_I = " " " on interval of intersection
γ_P = " " " on design level

With the longitudinal slope set at below 3%, design traffic volumes per road is shown in Table V-2-5.

Table V-2-5 Design Hourly Traffic Volume

	2 lane road 12 mW	2 lane road 15 mW	4 lane road 30 mW	6 lane road 40 mW	8 lane road 47 mW
Number of lane	1		2	3	4
Edge clearance	1.00 m	2.50 m	1.50 m	0.50 m	0.50 m
Lateral truck tresspassing	50%	50%	50%	50%	50%
Interval of Intersection	2.0/km or more		2.0/km or more	2.0/km or more	2.0/km or more
Design level	1	1	1	1	1
Design hourly traffic volume	850	900	1800/one side	2500/one side	3300/one side

5. Review of lane numbers

From Tables V-2-4 and V-2-5, number of lanes was determined as follows:

1) 8-lane road (sea side road)

Traffic volume generated by berths No. 4-18 will be 1,420 cars/hr in the heavier traffic lane, and the volume will be taken care of adequately by a 4-lane road. However, when the Master Plan is completed, the net work of roads to hinterland will have been completed, and rate of road utilization will be high.

Supposing traffic volume will be two times the present volume when the Master Plan is completed, it will be 2800 cars/hr, which will require a 8-lane road.

In order to cater for the recent sudden increase of motor cycles and bicycle riders in Taiwan, one each slow runners' lanes will be constructed on either side of roads.

For the road construction, land for 8 lanes shall be reserved, but 4 lanes will be actually constructed for the time being. Separation of lanes for fast and slow moving vehicles will be put away until completion of the Master Plan, because the road is designed with an adequate allowance by calculating all bicycles and motorcycles as motorcars.

2) 6-lane roads

The artery branched off from the seaside road to the central pier has a traffic volume of 1450 cars/hr which will be sufficiently met with 4 lanes. However, if the increased traffic volume is presumed to be about the same as the volume generated from berths No.s 8 - 10, when berths No. 38 - 40 of the Master Plan are completed Vp = 2,350 cars/hr, and 6-lane road will become necessary.

From the bifurcating point to the end of the container yard, traffic volume is considered to be greater due to the commutators' slow moving cars, and lanes of slow speed cars shall be constructed upon completion of the Master Plan. The land for 6 lanes will be allocated, but for the time being only 4-lane road shall be constructed. The section shall include the distance between thesseaside road and the harbour road.

3) 4-lane roads

a. The 6-lane road mentioned in the preceding paragraph covers the distance between the harbour road and the end of the container yard. Farther from the end of container yard, Vp = 1200 cars/hr, which will be taken care of adequately by a 4-lane road. As the slow moving cars will be taken care of by roads branching off from this road, it will not be necessary to construct lanes for slow moving cars.

b. Traffic volume produced by berths No. 1 - 3 will be only 700 cars/hr in the heavier loaded lane, but some allowance will be given and 4 lanes will be allocated with no lanes for slow moving cars.

c. Berths No. 4 - 7 will give rise to 360 cars/hr both directions, and 2 lanes will adequately take care of the volume. However, in view of the traffic volume generated from the part symbolyzing Taichung Harbour, a 4-lane road is planned.

d. With the road to and from container yards of No. 8 - 10 berths, the traffic volume in the heavier loaded lane will be 900 cars/hr, and it was designed as a road of 4 lanes.

e. The road between the harbour road and the seaside road is made a 4-lane road.

4) 2-lane roads

Those roads mentioned so far make the arteries among harbour roads, but roads branching off from them are considered to have a maximum volume of 500 cars/hr or less, and so they are made 2-lane roads.

Design of the above-mentioned roads is shown in Fig. V-2-2. 8-lane and 6-lane roads are planned finally for construction in steps. Generally, construction in steps believed to be advantageous if secondary investment is provided in 5 years or so. When, as in the present case, construction schedule is not definitely decided, construction in more than 2 steps will be more advantageous.

6. Bottleneck

There runs a railway at the grade intersection of the seaside road and the artery of the central pier. This railway could become a bottleneck in future. But at present trains pass the intersection only several times a day, and the crossing gate is brought down to block the traffic only a few minutes in a whole day.

Reduction of traffic volume due to the passing trains at the place is utterly negligible. Further, the dependence on the railway transportation is on the decrease. However, it will become necessary to construct grade separation, when the railway comes to impede the smooth traffic flow.

3. Cost Estimate

3.1 Introduction

Shown in Table V-1-4 is the estimated construction cost of the project by sections of works and by stages, based on the preliminary design of major structures and the estimates of ancillary facilities.

The estimate is prepared on the assumption that the works will be executed using locally produced materials and by the domestic contractors, excepting that part of construction materials such as steel sheet piles, channels and rubber fenders, and the majority of large floating equipment, construction machines and cargo handling equipment which will be imported from abroad. For the stated reason, most of the estimates were obtained by the engineers of the Republic of China. All the quoted prices are as of January 1970 and do not allow for the fluctuation of prices in future.

Explanations are given on the estimate of each facility in the following sections:

3.2 Construction Facilities

Costs of all the items are shown under the opeparatory stage for the sake of convenience although there are items, among the construction facilities, like the dry dock and floating stages, construction of which are carried over totthe first stage. The total cost of construction facilities are as shown in column (1), Table V-1-4.

All the amounts shown in US$ represent the acquisition cost of steel sheet pile and steel pipe pile used in the basin, breakwaters, lighter's wharf, dry dock, etc. as well as the machinery installed in the ship repairing facilities. They are all FOB prices. The cost of marine transportation, customs duties and the transportation cost on destination are shown in NT$.

3.3 Principal Facilities

Costs required for the principal facilities such as the outer harbour facilities, mooring facilities and dredging of channels (including reclamation) are as shown in columns (2) to (4), Table V-1-4. Of the outer harbour facilities, part of the repair and demolition of the existing north breakwater will, in connection with the construction of access roads and the basin of the floating equipment, be carried out in the preparatory stage. The great percentage of US$ in the cost of the mooring facilities reflects the use of the larger quantity of imported materials such as steel sheet pile, steel pile pile, steel channel and rubber fender which are inevitable due to the type of structure. The acquisition cost of the floating equipment and construction machines used in these works is shown as a lump sum in column (8) of the said table. The cost of repair is distributed among the cost of each section of the works in proportion to the scheduled usage of these equipment.

3.4 Handling Facilities

1. All the required equipments are estimated for imported ones.

2. The unit cost for silos, freight stations and office buildings, etc. is NT$2,800/$m^2$.

Table V-1-4 Quantities of Works and Fund Required, Staged Over 10 Year's Period
(1)

Section of Works \ Stage / Quantity & Amount	I Preparatory Stage 1,970-1971.12			II Stage 1 1,972.1 - 1974.6			III Stage 2 1974.7 - 1976.12			IV Stage 3 1,977.1 - 1,980.12			Total			Remarks
	Quantity	Amount N.T.$	Amount U.S.$	Quantity	Amount N.T.$	Amount U.S.$	Quantity	Amount N.T.$	Amount U.S.$	Quantity	Amount N.T.$	Amount U.S.$	Quantity	Amount N.T.$	Amount U.S.$	
1 Construction Facilities																
Work Site	110,000 m^2	5,280,000											110,000 m^2	5,280,000		
Breakwater	270 m	17,415,000	448,000										270 m	17,415,000	448,000	
Lighter's Wharf	630 m	31,223,000	365,400										630 m	31,223,000	365,400	
Revetment	270 m	18,024,000	476,500										270 m	18,024,000	476,500	
Dredging	600,000 m^3	18,000,000											600,000 m^3	18,000,000		
Dry Dock		34,650,000	430,000											34,650,000	430,000	
Floating Stage		4,410,000												4,410,000		
Ship repairing facilties		23,000,000	500,000											23,000,000	500,000	
Quarry		1,400,000												1,400,000		
Buildings (Material Stores etc.)		5,500,000												5,500,000		
Total		158,902,000	2,219,000											158,902,000	2,219,900	
2. Outer Harbour Facilities																
North Breakwater				940 m	227,000.000		160 m	65.600.000					1,100 m	292,600,000		
South Breakwater				1,020 m	134,600.000		380 m	86,100.000					1,400 m	220,700,000		
Sand groyne				780 m	73.000.000		220 m	45.400.000					1,000 m	118,400,000		
Sea Wall				3.020 m	174.881,000		1,880 m	108,866,000					4,900 m	283,747,000		
North & South Inner Breakwaters				670 m	20,552,000		100 m	15.810.000					770 m	36,362,000		
Breakwater for fishery harbor				120 m	4,828,300								120 m	4,828,000		
Revetment for fishery harbor				270 m	5.912.000								270 m	5,912,000		
Breakwater for timber basin							230 m	3.439.000	116,000				230 m	3,439,000	116,000	
Repair of existing north breakwater	1,560 m	24,035.000		960 m	14.790,000								2,520 m	38,825,000		
Demolition of existing north breakwater	340 m	434.500		2.700 m	3,450.000								3,040 m	3,884,500		
Total		24,469,500			659,013,300			325,215.000	116,000					1,008,697,800	116,000	
3. Mooring Facilities																
- 13 m Quay Wall				750 m	90.750,000	3,345.000	550 m	70,600.000	2.477.000	850 m	110,950,000	3,839,000	2,150 m	272,300,000	9,661,000	
- 11 m Quay Wall				800 m	84,000,000	2.880.000	1,600 m	141.440,000	5.280.000	3,000 m	265,200,000	9,900,000	5,400 m	490,640,000	18,060,000	
- 7.5 m Quay Wall										260 m	17,446,000	392,600	260 m	17,446,000	392,600	
Revetment				500 m	33,247,000	947.200	360 m	24.267,000	725.600	480 m	31,002,000	858,000	1,340 m	88,516,000	2,530,800	
- 6 0 m Quay Wall, Fishery, Harbor				320 m	22.782.000	535,400				300 m	21,358,000	502,000	620 m	44.140,000	1,037,400	
- 4.5 m Quay Wall, Fishery. Harbor				80 m	4.711,000	88,200				870 m	51,229,100	959,500	950 m	55,940,100	1,047,700	
- 3.0 m Lighter's Wharf, Basin										1,480 m	69,856,000	858,400	1,480 m	69,856,000	858,400	
- 2.0 m Lighter's Wharf. Timber basin							1.150 m	42,270,000	664,800				1,150 m	42,270,400	664,800	
Dolphin, Timber basin							I	6,420.000	76,000				1	6,420,000	76,000	
Mooring buoy										3	1,200,000	60,000	3	1,200,000	60,000	
Total					235,490,000	7.795,800		284.997.400	9,223,400		568,241,000	17,369,500		1,088,728,500	34,388,700	
4. Dredging and Reclamation																
Dredging				21,300,000 m^3	289,680.000		17,000,000 m^3	231.000,000		21,800,000 m^3	392,400,000		60,100,000 m^3	913,080,000		
Reclamation				6,600,000 m^2	6,800,000		2,800,000 m^2	9,500,000		3,900,000 m^2	7,800,000		13,300,000 m^2	34,100,000		
Total					306,480,000			240.500,000			400,200,000			947,180,000		

Table V-1-4
(2)

Section of Works \ Stage, Quantity & Amount	I Preparatory Stage, 1,970-1971.12 Quantity	Amount N.T.$	U.S.$	II Stage 1 1,972.1 - 1974.6 Quantity	Amount N.T.$	U.S.$	III Stage 2 1974.7 - 1,976.12 Quantity	Amount N.T.$	U.S.$	IV Stage 3 1,977.1 - 1,980.12 Quantity	Amount N.T.$	U.S.$	Total Quantity	Amount N.T.$	U.S.$	Remark
5. Cargo Handling Facilities																
Silo (Including cargo handling equipment)				1	102,635,500	1,787,500	1	102,635,500	1,787,500	1	102,635,500	1,787,500	3	307,906,500	5,362,500	
Transit shed				7	109.760,000		10	143,808,000		16	280,000,000		33	533,568,000		
Open Storage				130,310 m²	15,637,200		116,330 m²	13,959.600		302,380 m²	36,285,600		549,020 m²	65,882,400		
Container yard							98,200	35,352,000		181,660 m²	65,397,600		279,860 m²	100,749,600		
Total					228,032,700	1,787,500		295,755,100	1,787,500		484,318,700	1,787,500		1,008,106,500	5,362,500	
6. Harbour Transportation Facilities																
Beltline highway	496,600 m²	125,700,000		185,960 m²	55,788,000		118,320 m²	35,496,000		296,920 m²	148,044,000		1,097,800m²	365,028,000		
Beltine railway	7.0 km	9,380,000	112,000	5.85 km	9,539,000	93,600	16.8 km	31,012,000	268,800	6.2 km	10,408,000	99,200	3,585 km	60,339,000	573,600	
Total		135,080,000	112,000		65,327,000	93,600		66.508,000	268,800		158,452,000	99,200		425,367,000	573,600	
7. Ancillary Facilities																
Signal tower				1	1,000,000								1	1,000,000		
Navigation aids				light-house 6 light-buoy 10	5,894,800	48,000	light-house 5	4,190,000	122,000				light-house 11 light-buoy 10	10,084,800	170,800	
power distribution within port area	5,000 m	15,000,000		6,000 m	20,000,000		11,000 m	26,200,000		10,000 m	24,200,000		32,000 m	85,400,000		
Water supply within Port area	3,000 m	2,000,000		10,000 m	13,000,000		9,000 m	10,520,000		8,000 m	10,000,000		30,000 m	35,520,000		
Drainage system				600 m	16,800,000		600 m	7,800,000		200 m	5,600,000		1,400 m	30,200,000		
Windbreak (or Shelter belt)				225 ha	22,500,000		225 ha	22,500,000		1,000 m	22,000,000			67,000,000		Stage 3 Wind Screan
Total		17,000,000			79,194,800	48,800		71,210,000	122,000		61,800,000			229,204,800	170,800	
8. Constructional Plants and Facilities																
Floating equipment	51	16,490,400	13,742,000	1	312,000	260,000	misc.	23,597,000	985,000	Misc.	15,505,000	337,000	52	55,904,400	15,324,000	
Construction machines	126 no.s	52,896,400	3,698,000	48 no.s	12,480,000	853,000	40 no.s	13,605,000	957,000	Misc.	870,000	58,000	214 no.s	79,851,400	5,566,000	
Execution facilities	8 no.s	4,332,000	722,000										8 no.s	4,332,000	722,000	
Testing facilities	sum	10,300,000	57,000										sum	10,300,000	57,000	
Total		84,018,800	18,219,000		12,792,000	1,113,000		37,202,000	1,942,000		16,375,000	395,000		150,387,800	21,669,000	
9. Others																
Office building				2,000 m²	8,000,000		2,000 m²	6,000,000					4,000 m²	14,000,000		
Living guarters	7,000 m2	17,400,000		5,000 m²	12,600,000								12,000 m²	30,000,000		
Survey, test, design, training	sum	23,910,000	500,000	sum	3,000,000		sum	25,000,000		sum	4,800,000		sum	56,710,000	500,000	
Costs of supervision		23,819,200			69,920,100			70,391,500			107,531,000			271,661,800		
Total		65,129,200	500,000		93,520,100			101,391,500			112,331.000			372,371,800	500,000	
Grand Total		484,599,500	21,050,900		1,679,849,900	10,838,700		1,422,779,000	13,459,700		1,801,717,800	19,651,200		5,388,946,200	65,000,500	

3. For the unit cost for construction of open storage and container yards, the paving cost only is calculated pursuant to the data of Taiwan. The unit cost of open storage is thus NT$120/m^2, and that of container yard NT$360/m^2.

Rough estimation of these handling facilities is shown in Table V-1-4 (5).

3.5 Harbour Traffic Facilities

(1) Estimated railway construction cost

1) The unit cost of construction pursuant to the calculation procedure of the Taichung Harbour Project Office shall be as follows:

Unit cost of construction (per meter)

a. Main line:

NT$3000 = NT$2100 + US$16 (for rails) + NT$240 (Tax) (Land cost for the track inclusive)

b. Main line and siding

NT$2000 = US$1100 + US$16 (for rails) + NT$240 (Tax)

2) Communication and signal equipment, lighting and safety equipment are not included in this estimate.

3) Equipment for railway crossing are estimated as grade crossings, and the unit cost of construction is calculated pursuant to the procedure of Taichung Harbour Project Office.

Cost of crossing is estimated at NT$400,000 for a width of 40 m. In this estimate, calculation is based on NT$/m 10,000.

(2) Estimate of cost for road construction

1) Prerequisite:

a. Unit cost of construction is based on the procedure of Taichung Harbour Project Office.

Unit cost of construction (per m^2)

a) Earth work NT$300
b) Bridge and viaduct NT$3000
c) Road lightings, lane dividing strips, guard rails, traffic signals, traffic signs and trees are not included in this estimate.
d) Road for construction work is constructed in the preparatory stage.

Quantity list of transit sheds, silos, railways and roads, etc. is shown in the following table.

Rough estimation of these traffic facilities is shown in Table V-1-4 (6).

3.6 Ancillary Facilities

As for the ancillary facilities, the signal tower, navigation aids, power supply, water supply, drainage system and windbreak are incorporated in the project. The costs of these items are shown in column (7) of the table. The windbreak planned in the third stage is a wind screen with overall length of 1,000 m to be installed on the north of the fishery harbour.

The costs of the field Government Office, living quarters of the staff and, test, survey, designing works, training of engineers throughout the entire period of the works and the cost of construction supervision are compiled under column (9) of the table. (The costs of facilities used in tests and experiments and equipment and instruments used therewith are counted up in column (8), Testing Facilities.)

3.7 Summation of Estimated Costs

The costs required for the above facilities amount to NT$5,388,946,200 + US$65,000,500, or in New Taiwan Dollars 7,988,966,200. The total being a rough estimate, it is subject to minor modifications depending on the results of the detailed design and hydraulic model tests.

It is predicatable that the re-execution of dredging and other works may become necessary due to the littoral drift and deflation during the construction of this project. However, the costs of the possible re-dredging and maintenance are not included in the summation of construction cost because of the difficulty of estimating littoral drift and deflation.

Table V-1-4 does not include the costs of two berths of -9.0 m quay wall (for the handling of dangerous goods) and one berth of -11.0 m dolphins (for the handling of fuel oil) which have been requested by the Republic of China after the submission of the interim report. These berths are planned for implementation in the third stage and their rough estimates are as shown below:

Table V-1-5 Estimated Cost of Additional Works

Works	Quantity	Amount		Remarks
		NT$	US$	
-9 m quay wall	340 m	26,520,000	833,000	3rd stage
-11 dolphin	1 berth	2,707,000	96,500	3rd stage
Revetment	290 m	17,891,000	473,800	
Total		47,118,000	1,403,300	= NT$103,250,000

Quantity List

	Material	Preparatory	First	Second	Third	Total	Remarks
1	Subbase material	267,966 m3	102,567 m^3	65,736 m^3	143,774 m^3	580,043 m^3	for road
2	"	--	--	89,362 m^3	165,311 m^3	254,673 m^3	for container yard
3	"	--	84,704 m^3	75,615 m^3	196,547 m^3	356,866 m^3	for open storage
4	Base material	109,650 m^3	36,613 m^3	22,344 m^3	51,129 m^3	219,736 m^3	for road
5	"	--	--	38,298 m^3	70,848 m^3	109,146 m^3	for container yard
6	"	--	--	--	--	--	for open storage
7	Asphalt pavement	35,374 m^3	12,819 m^3	8,065 m^3	18,837 m^3	74,645 m^3	for road
8	"	--	--	10,802 m^3	19,983 m^3	30,785 m^3	for container yard
9	"	--	6,516 m^3	5,817 m^3	15,119 m^3	27,452 m^3	for open storage
10	Ballast	6,300 m^3	5,309 m^3	15,185 m^3	5,635 m^3	32,429 m^3	for railway
11	P.C.	--	68 m3	100 m3	84 m3	252 m3	"
12	Gravel	--	13,523 m^3	16,981 m^3	31,740 m^3	62,244 m^3	for shed and silo
13	Plain concrete	--	8,715 m^3	11,839 m^3	22,106 m^3	42,660 m^3	"
14	Reinforced concrete	--	10,368 m^3	11,992 m^3	18,154 m^3	40,514 m^3	"
15	Cement	--	6,642 t	8,305 t	14,055 t	29,002 t	"
16	Fine aggregate	--	11,450 m^3	14,339 m^3	24,154 m^3	49,943 m^3	"
17	Coarse aggregate	--	18,129 m^3	22,640 m3	38,247 m3	79,016 m3	for shed and silo
18	Steel bar	--	1,356 t	1,553 t	2,236 t	5,145 t	
19	Steel skelton	--	1,960 t	2,915 t	5,180 t	10,055 t	
20	Reinforced concrete pile	--	6,948 piles	7,476 piles	11,212 piles	25,636 piles	

Remark: Asphalt pavement of 370 m in bridge section and 500 m in viaduct are inclusive, but other materials are exclusive.

VI MASTER PLAN OF NEW CITY FOR TAICHUNG HARBOUR

VI MASTER PLAN OF NEW CITY FOR TAICHUNG HARBOUR

1. Present Situation of Planning Area

1.1 Planning Area

Construction plan of Taichung harbour, as described before will realize a large-scale international harbour and seafront industrial area along the coast from the south-shore of the Tachia River to the north-shore of the Tatu River. The scale of this harbour is larger than that of Keelung or Kachsiung harbour at present, and 900 ha. of seafront industrial area is to be reclaimed. In connection with the construction of the port and industrial estate, the New City which has a pupulation of about 500,000 will be constructed. Required area for this development covers the districts of Chingshui Chin, Wuchi Chin, Lungching Shiang where the New Harbour is planned as well as the district of Shalu Chin.

Therefore, the planning area of the New City covers Lungching Shiang and three Chins, namely Wuchi, Chingshui and Shalu.

This area consists of the coastal plain of about 4 kilometers in width, located between the Tachia River and the Tatu River and the western slope of Tatu mountain, and covers an area of 16,018 ha.

As to these three Chins and one Shiang, the Taiwan Provincial Government has already taken the following measures to help construct the new town smoothly. The Executive Yuan decided early in November 1969 that UHDC should complete the sketch plan on the development of the Taichung harbour area in the comming six months. And the detail plan derived from this sketch plan is to be worked out by Department of Reconstruction of the Taiwan Provincial Government.

Prohibition of buying, selling, exchange or donation of land.

The order of President issued on April 17, 1969 prohibits for the coming one year, the buying, selling, exchange or donation of land in planned area of new harbour construction, which covers Tamsui-chin (total area) and Sanchi-Shiang (partial) of Taipei-Hsien, and Wuchi-Chin (total), Chingsui-Chin (total) and Lungching Shiang (total) of Taichung Hsien. The summary of this order is as follows:

As the steady progress of Taiwan's economy which in recent years resulted in the increase of sea-borne cargoes, two existing international ports, Keelung and Kaohsiung, are not sufficient to meet the future demand of export and import.

In order to construct a new port to cope with this industrial development of northern and central districts of Taiwan, Ministry of Communications, CIECD and the Taiwan Provincial Government designated two sites (Wuchi and Tamsui) as planned areas of the new port construction after careful considerations. In these planned areas, land price is liable to be boosted up by speculators who wish to make excessive profits. This will not only obstruct the development of the future port area and national construction policy but inflict damages on the inhabitants. In prevention of such undesirable condition, following matters are prohibited for one year according to the provisions of Article 16 of Land Act, in Wuchi-Chin, Shalu-chin, Chinshui-chin and Lungching-Shiang of Taichung Hsien and Tamsui-chin and Sanchih-Shiang of Taipei Hsien.

(1) Buying, selling, exchange or donation of private land in these areas are prohibited. Transfer of effected in violation of this provision is invalid.

(2) The surface rights, permanent tenant rights and mortgage of private land in these areas should not be valued over the stipulated price or assessed real estate price. In case where this provision is violated, the settlement of rights is invalid.

This order shall be put in force according to the provisions of Article 16 of Land Act through application to the President from the Executive Yuan.

Prohibition of constructing buildings, etc.

Following the decision of construction of Taichung Harbour, The Taiwan Provincial Government designated the area of Wuchi-Chin, Chingshui-Chin, Shalu -Chin and Lungching-Shiang, which is the planned area of the new harbour construction, as the special area of Taichung Harbour on December 30, 1969 according to the provisions of the City Planning Act. Construction of buildings, whether new or additional, picking soil and sand, and transformation of land are prohibited for two years from January 1970 according to the provisions of Article 11, Clause 3 and Article 13 of the City Planning Act.

Note: Article 11 A city plan shall be fixed by local governments or Hsiang Chin public office according to the following clauses, ...

3 Special area shall be planned by Province, Hsien (Bureau).

Article 13 In case of fixing a city plan, extent of the city planning area may be designated in advance, and by the proclamation according to the provisions of Articles 16 and 18, new or additional construction of the whole or portions of a building, picking soil and sand, and transformation of land shall be prohibited after the proclaimed day.

Establishment of Committee of Wuchi and Tamsui Harbour Area Construction

The Executive Yuan adopted the proposal of establishing a New Committee for Wuchi and Tamsui Harbour Area Construction. The commottee is authorized to plan, design and control the construction of these two harbours and the planned area, and is composed of the Ministry of Interior Affairs, the Ministry of National Defence, the Ministry of Finance, the Ministry of Economic Affairs, CIECD and the Taiwan Provincial Government.

1.2 Natural Conditions

i) Topography

Planned area is located on the Taichung coastal plain between the Tachia River and the Tatu River, with Tatu Mountain dividing it at the back from the Taichung basin.

The coastal plain, extending 15 - 16 kilometers north-south and about 4 kilometers east-west, is a alluvial plain with a mild slope of about 1/2,000 from the skirt of Tatu hill to the coast.

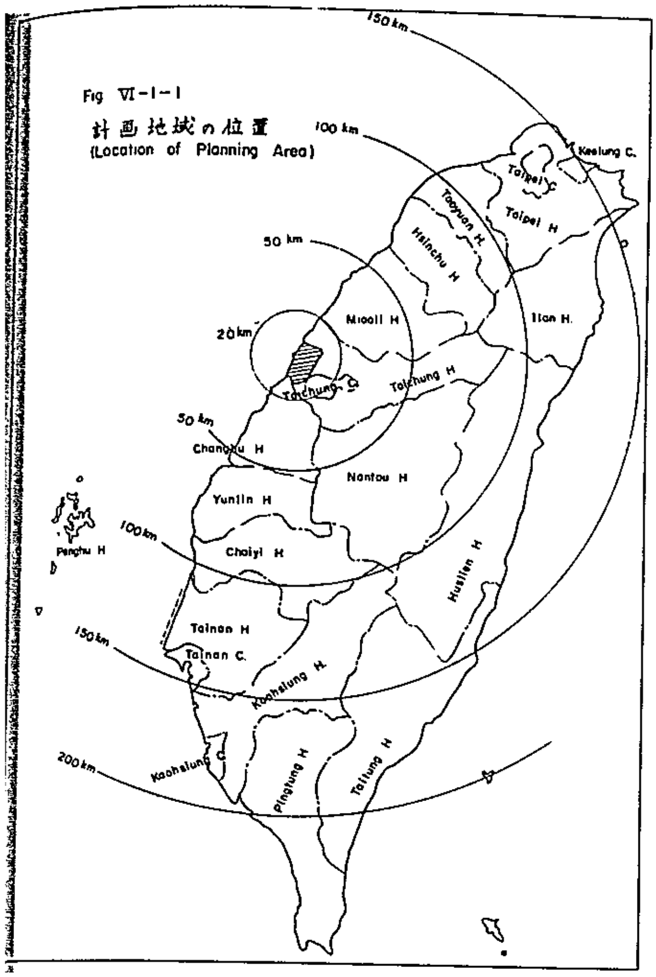


Fig VI-1-1
計画地域の位置
(Location of Planning Area)

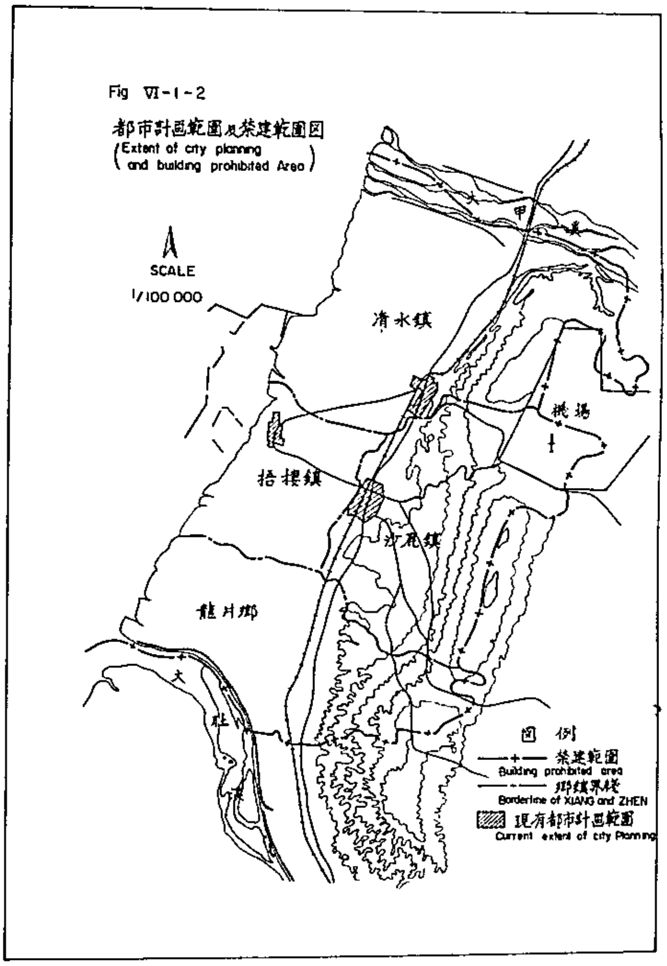


Fig VI-1-2
都市計画範圍及禁建範圍図
(Extent of city planning and building prohibited Area)

Tatu hill is about 300 meters high from the sea level and has a gentle slope on the side of Taichung basin but a steeper slope on the coast side. On the latter side there are some eroded points where the soil contains much conglomerate and is easy to be degraded.

ii) Climate

The central region of Taiwan being located nearer to the steep mountain range at the back and against the continent across the Taiwan channel, its climate conditon has both continental and oceanic features. Generally speaking, it belongs to the sub-tropical zone with high temperature and humidity.

The data of the climate condition of the planned area of Taichung harbour is not sufficient. However on the anology of the report of Taichung Regional Plan published by UHDC and CIECD on March 1969, average temperature is 23^{o} - 24^{o} annually, 17^{o} - 18^{o} C January and 29^{o} C in July. These values are higher than those of Taichung basin by about 1^{o} C respectively. The average annual precipitation is about 1500 milimeters, which is less than in Taichung basin. It rains much in the typhoon season lasting from August to September and very little from October to February. The consipicuous climatic feature of this region is the north-northeast monsoon which keeps blowing from October to March. For this reason, wind break forests are required for protection of agricultural crops.

According to the data of Taichung Harbour Construction Office, there are annually twenty days when the wind speed exceeds 15 meters per second by winter monsoon on 20 days of the year. The south-southeast summer monsoon weaker than the winter monsoon. Summer is, however, the typhoon season and the landing frequency of typhoon is 3.67 times annually.

1.3 Land Use

Coastal plain of planned area is utilized as paddy fields and the gentle slope (less than 15 degrees) of Tatu Mountain as farm lands. Composition of land utilization is shown below, and mountains and forests occupy only 5% of the total area.

Classification	Area (hectars)	Composition (%)
Mountains & Forests	831	5.5
Agricultural land	10,292	67.7
Rivers & lakes	342	2.2
Residential areas, parks & areas for public use	1,743	11.5
Non-registered areas	2,001	13.1
Total	16,019(15,209)	100.0

Paddy fields have already been readjusted and produce three crops a year. Generally, paddy is planted twice a year and barley is cultivated as the third crop. The reclaimed land along the coastline was severely damaged by the typhoon in November 1969.

Fig VI-1-3

地形図

(Topographical map)

SCALE 1/100 000

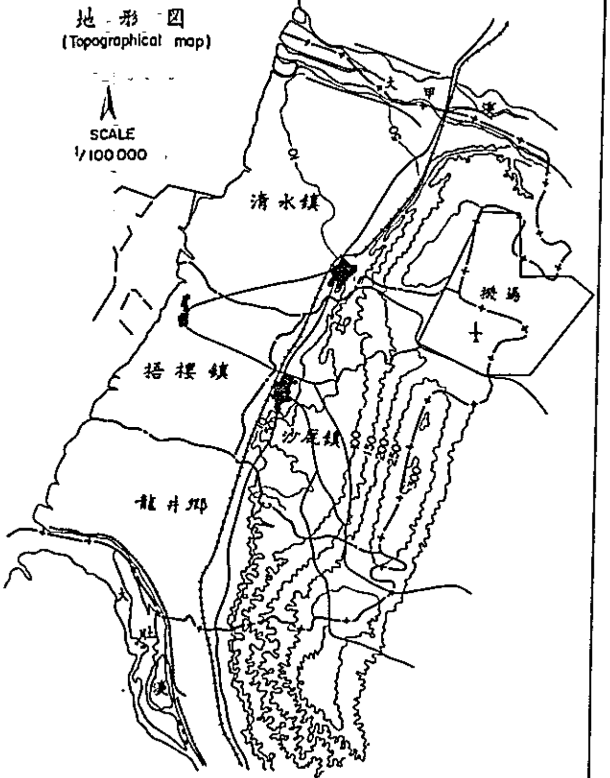


Fig VI-1-4

土地の傾斜図

Inclination of Land

SCALE 1/100 000

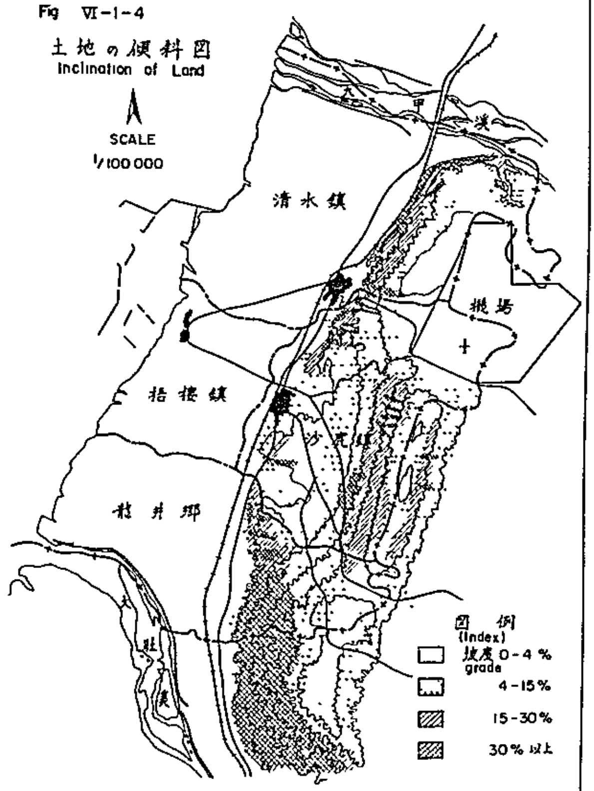


Fig. VI-1-5 台中地域地質圖

Geologicalmap of Tai Chung Region

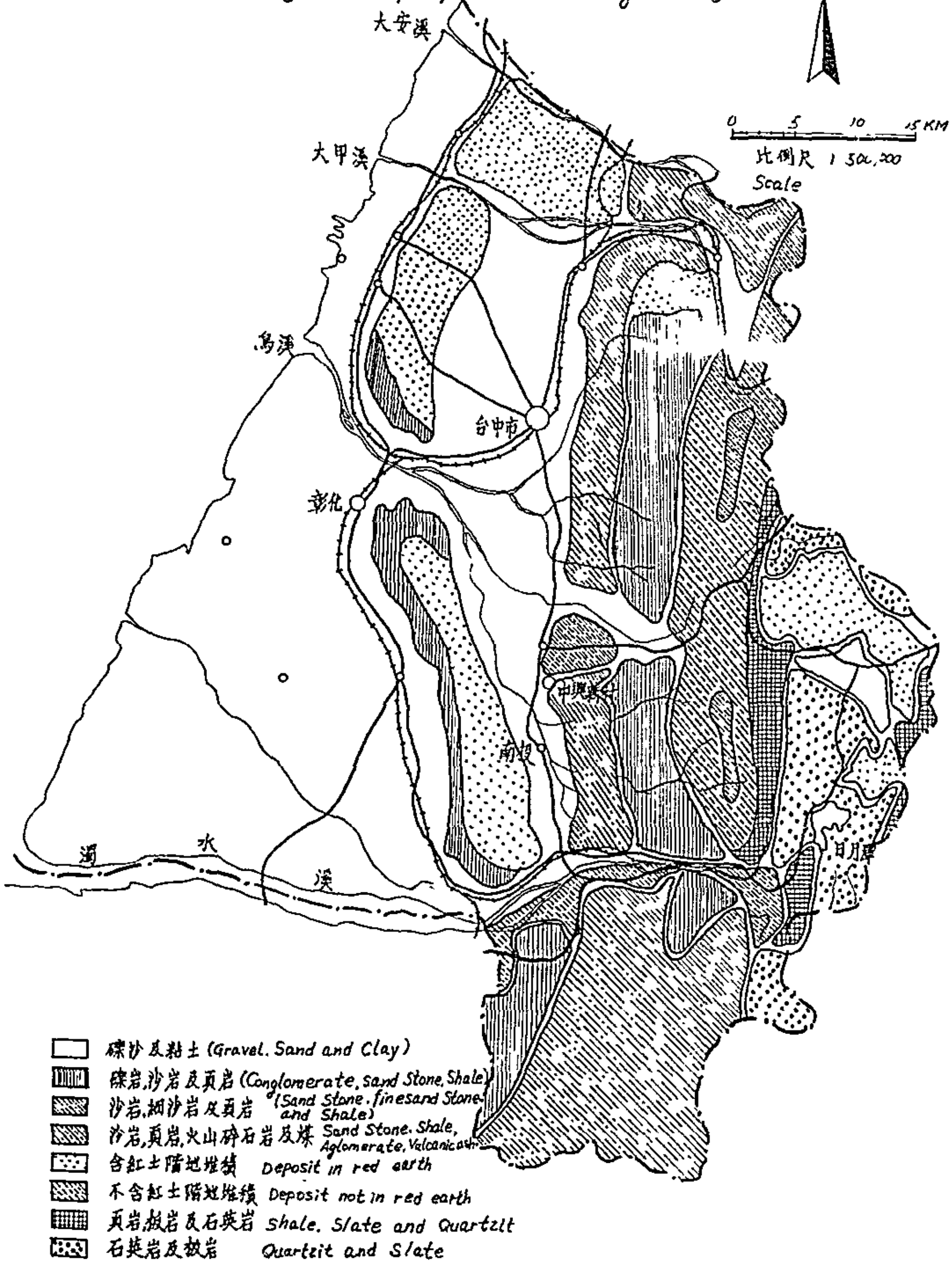


Fig VI-1-6 台中地域土壤圖
Soil of Tai Chung Region

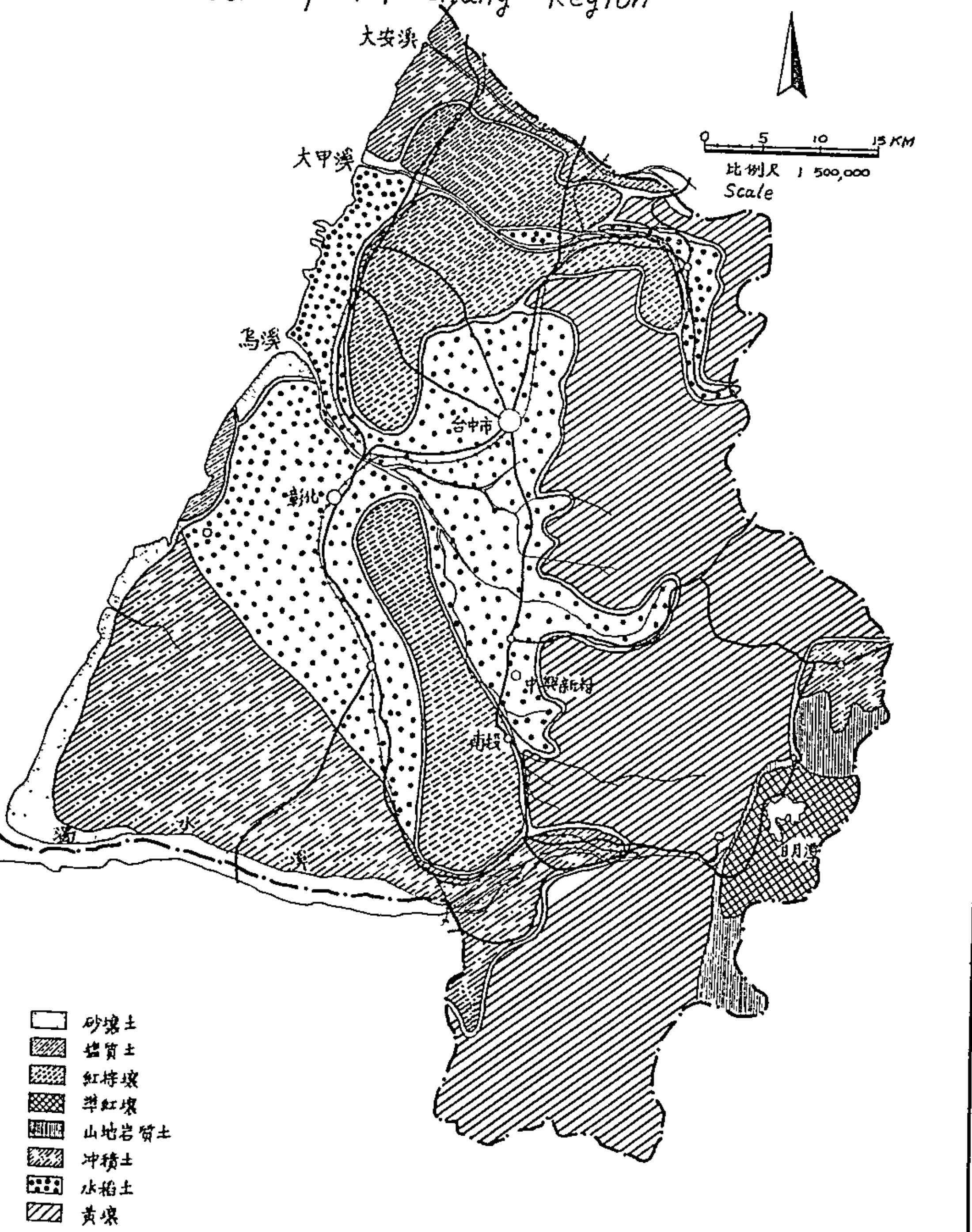
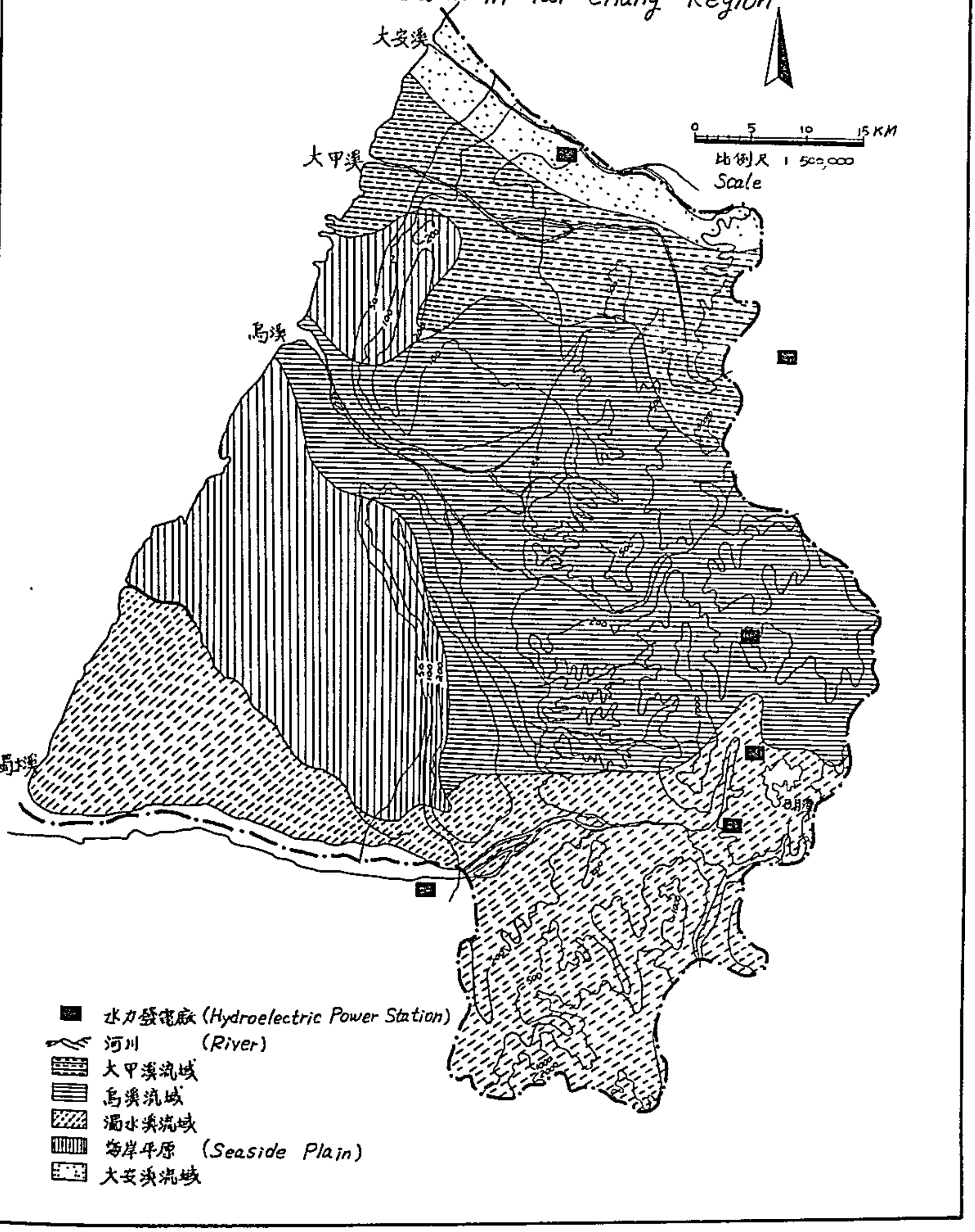


Fig. VI-1-7 台中地域河川流域圖
River basin in Tai Chung Region



Farm lands on the slope of Tatu Mountain are utilized, though not of fully, for raising sugar cane and vegetables. Steep slope of the mountain is covered by forests, and on the west there are many degraded points obstructing the land use. Forests are composed of Sheangayshuh trees and bamboos whose growth condition is rather poor.

According to the economic classification of land by the Institute of Agricultural Economic Research of Chungshing University, the productivity of paddy fields in the central part of coastal plain is high, whereas that of reclaimed land along the coast line and farm lands on the slope of Tatu Mountain is low.

1.4 Population and Industry

In 1968, the planned area had a population of 155, 011 and a population density of 9.68 persons per hectar. 21% of the total population in concentrated in three towns, that is to say, Chingshui and Shalu along the West Trunk Line via Sea and Wuchi situated on the sea shore. These three towns have their city plan already fixed and are anticipated to be developed into urban areas. Rural areas are not only distributed along the proposed route of Taiwan Highway No. 1 and the road running north-south through central part of coastal plain but scattered on the skirt of Tatu Mountain and along the trunk roads.

With regard to the index of population increase between 1956 and 1968, the index of the planned area is only 1.23 (=155 thousand persons/126 thousand persons), while the nation's total is 1.45 (13, 650 thousand persons/ 9, 390 thousand persons). This means that the population outflow from this area has been going on. Especially, it is noteworthy that thepopulation of Wuchi Chin in 1968 is less than in 1966 though by a small margin of 9 persons.

Employed workers in the planned area in 1968 is 51, 669, and its ratio to the total population is 33.3% (nation's total: 30.96%). The ratio has gone up remarkably in comparison with 25.5% in 1966. Number of employed workers increased by 13, 222 persons between 1966 and 1968. Entering into detail, it has increased by 3, 823 in primary industries and 11, 754 in the secondary industries, but decreased in the tertiary industries.

As the result of the increase in employed workers in the secondary industries, the composition of workers by industries has changed during the two years as shown below.

	1966 (%)	1968 (%)
Primary	60.8	51.4
Secondary	7.5	28.1
Tertiary	31.7	20.5
Total	100.0	100.0

The change in the composition in such a short period seems to be due to the industrial development of the region along the Taiwan Highway No. 1 as well as statistical problems.

Industries of the planned area are not clear due to the lack of data. However, the composition of employed workers indicates that major industries are agriculture and manufacturing.

Table VI-1-1 Present State of Land Use

土地利用現況一覧表

unit:ha

	総面積	農業用地	湖泊池沼	山林	建築基地	公園緑地	交通設施用地	未登録地	備考
梧棲鎮	1,752	1,444	93	–	76	86	53	–	
清水鎮	6,417	3,974	109	255	623	206	83	1,169	
沙鹿鎮	4,046	2,476	11	121	153	103	43	329	
龍井郷	3,804	2,398	129	457	122	114	81	503	
合計	16,019	10,292	342	831	974	509	*260	2,001	

資料，55年台中県統計要覧

Fig VI-1-8 土地利用現況図
Present state of Land Use

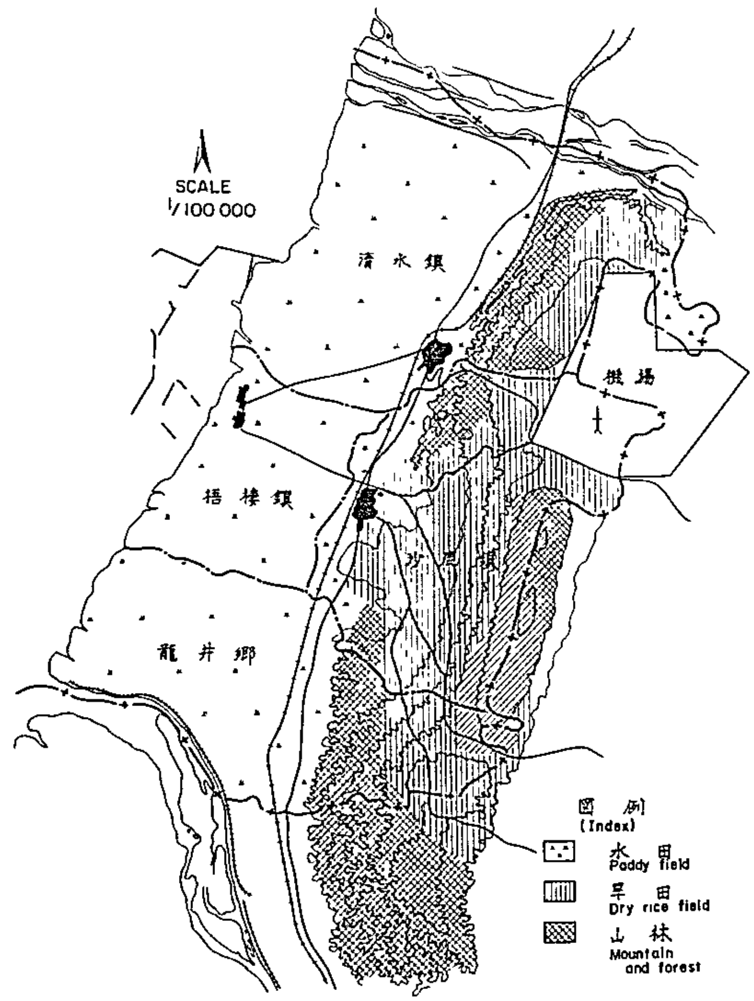
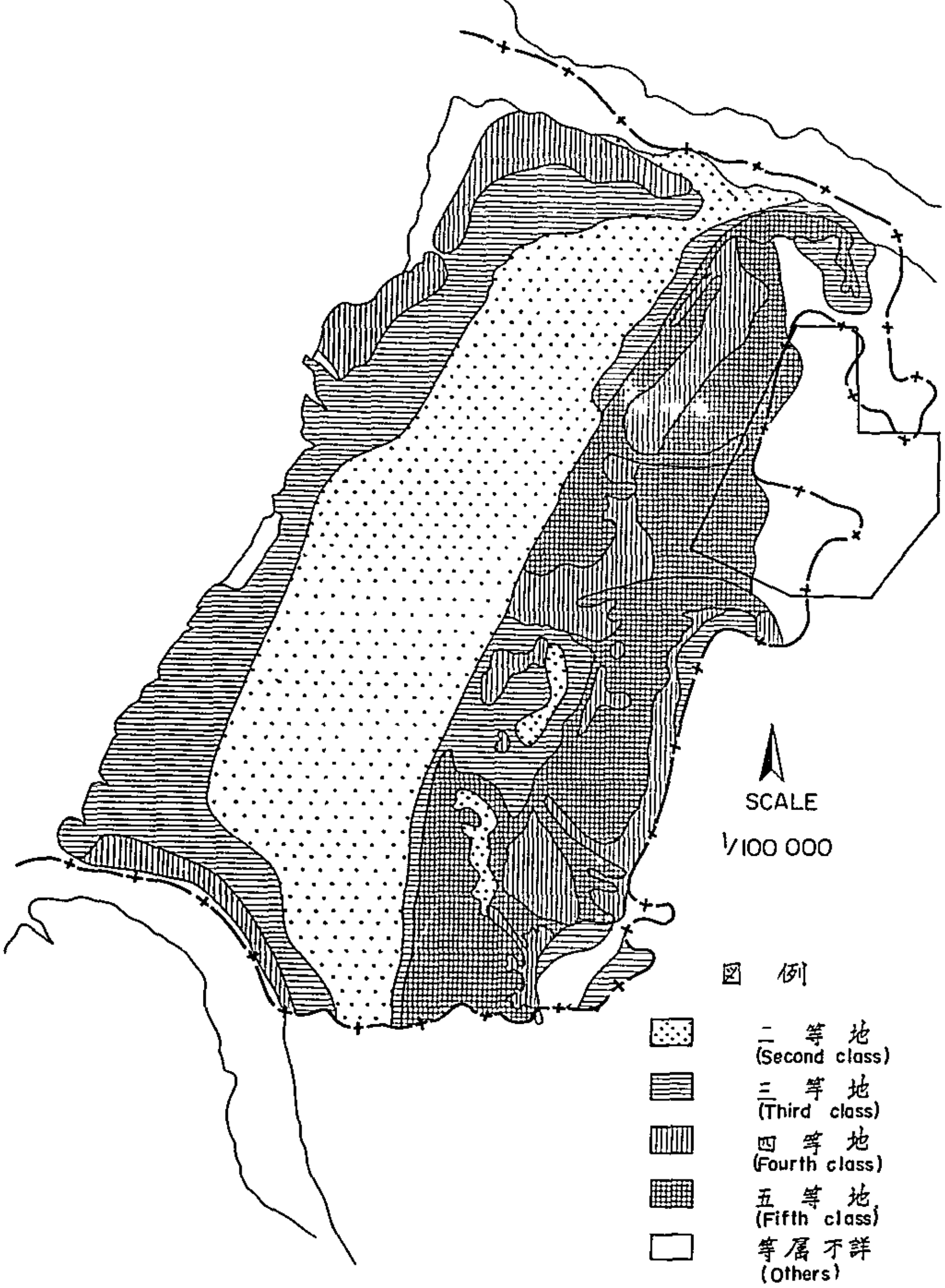


Fig VI-1-9 土地経済分類図
Classification of Land by Economy



資料：中興大学農経研究所

According to the survey of UHDC and CIECD (executed in December 1969), there are 114 factories and 11, 029 persons are employed. Major manufacturing industries are spun yarn and facrics, food and chemicals. Generally speaking, the scale of factories is small and there are only 4 factories employing more than 500 workers.

Taiwan Spinning and Weaving Co.	--	Spun yarn and fabrics	Shalu
Taiwan Fruits Co.	--	Food	
Taichung Spinning and Weaving Co.	--	Spun yarn and fabrics	
Chylay Special Godds Co.	--	Food	

1.5 Transportation Facilities

i) Railways

On the inland of planned area the West Trunk Line via Sea runs north-south and there are four stations of Chianan, Chingshui, Shalu and Lungching. Long-distance rapid transit trains stop at Chingshui and Shalu. Time required to reach major cities from Shalu is as shown below.

Shalu - Keelung	3 hours and 3 minutes	(Haikuai)
Shalu - Taipei	2 hours and 52 minutes	(Haikuai)
Shalu - Taichung	24 minutes	(Diesel Express)
Shalu - Tainan	3 hours and 14 minutes	(Haikuai)
Shalu - Kaohsiung	4 hours and 2 minutes	(Haikuai)

Although the West Trunk Line via Sea is a single track line, the operating quency of trains amounts to 70 times a day due to its nature of trunk railway. This frequency is close to the maximum capacity of the line. Stations in the planned area, however, seem to have a sufficient capacity.

ii) Roads

As to the Provincial Highway, Taiwan Highway No. 1 run in parallel with the West Trunk Line via Sea. Taiwan Highway No. 10 communicates with Taichung City through Taga, branching off from Taiwan Highway No. 1 at Chingshui. Hsien Road No. 134 passes through Chingshui, Wuchi, Shalu and Taichung. All these roads are two-laned and asphalt-paved, forming main lines of transportation. And these are well maintained.

According to the traffic survey of UHDC and CIECD (excecuted in 1969), traffic volume of Taiwan Highway No. 1 is partially exceeded its capacity. Measures to bring remedy to the situation are to be taken immediately.

The network of Chin-Shiang roads is as shown in Fig. VI-1-12, "Present Situation of Transportation Network of Wuchi District". The main portion of these roads is 1 to 2 laned and simply paved, and communicate with each village.

Table VI-1-2 Statistics of Population Density

人口密度統計表

年份	郷鎮別	面積 (ha)	総人口 (人)	人口密度 (人/ha)
民国57年 (1968)	A. 梧棲	1,751.67	24361—	13.91
	B. 清水	6,417.09	62,078—	9.67
	C. 沙鹿	4,046.04	37,848—	9.35
	D. 龍井	3,803.00	30,724—	8.08
	梧棲港区	16,017.80	155,011—	9.68

Table VI-1-3 Statistics of Population

人口調査統計表

年份	郷鎮別	総人口	有業人口		年令組成		
			人数	%	0–15	16–59	60以上
民国45年 (1956)	A. 梧棲	20,572—	5,293—	25.7			
	B. 清水	50,495—	12,996—	25.7			
	C. 沙鹿	30,569—	8649—	28.3			
	D. 龍井	23,966—	6,381—	26.6			
	合計	125,602—	33,319—	26.5			
民国50年 (1961)	A. 梧棲	22,739—	5,563—	24.5			
	B. 清水	55,109—	14,176—	25.7			
	C. 沙鹿	31,715—	8,192—	26.2			
	D. 龍井	26,807—	6,577—	24.5			
	合計	136,370—	34,508—	25.4			
民国55年 (1966)	A. 梧棲	24,383—	5,995—	24.7			
	B. 清水	60,189—	15172—	25.2			
	C. 沙鹿	35,909—	9,437—	26.0			
	D 龍井	30,214—	7,843—	25.5			
	合計	150,695—	38447—	25.5			
民国57年 (1968)	A. 梧棲	24361—	7,707—	31.2	7,682—	15,506—	1,173—
	B. 清水	62,078—	19,487—	31.4	28114—	30,994—	2,970—
	C. 沙鹿	37,848—	12,856—	34.0	16,394—	19543—	1,911—
	D 龍井	30,724—	11,619—	37.9	13,782—	15,309—	1,632—
	合計	155,011—	51,669—	33.3	65972—	81,352—	7,686—

資料 梧棲，清水，沙鹿，龍井，郷鎮公所

Table VI-1-4 Change of Working Population by Industry

産業別就業人口の推移

年別	郷鎮別＼種別	第一次産業 人数	%	第二次産業 人数	%	第三次産業 人数	%	備考
民国45年 (1956)	梧棲鎮 A	3,522	66.5	253	4.8	1,518	28.7	
	清水鎮 B	7,953	61.2	348	2.7	4,695	36.1	
	沙鹿鎮 C	4,645	53.7	1,437	16.6	2,565	29.7	
	龍井郷 D	4,701	75.6	134	2.2	1,383	22.2	
	計	20,821	62.8	2,172	6.6	10,161	30.6	33,154
民国50年 (1961)	梧棲鎮	3,738	67.3	317	5.7	1,502	27.0	
	清水鎮	8,302	58.8	425	3.0	5,449	38.2	
	沙鹿鎮	4,251	51.9	1,119	13.7	2,822	34.4	
	龍井郷	5,399	76.3	188	2.7	1,485	21.0	
	計	21,690	62.0	2,049	5.8	11,258	32.2	34,997
民国55年 (1966)	梧棲鎮	3,965	66.2	408	6.8	1,614	26.9	
	清水鎮	8,926	58.8	647	4.3	5,599	36.8	
	沙鹿鎮	4,606	49.4	1,540	16.5	3,193	34.1	
	龍井郷	5,214	79.2	199	2.6	1,430	18.2	
	計	22,711	60.8	2,794	7.5	11,836	31.7	37,341
民国57年 (1968)	梧棲鎮	4,116	53.4	1,814	23.5	1,777	23.1	
	清水鎮	9,132	46.9	4,836	24.8	5,519	28.3	
	沙鹿鎮	6,019	46.8	4,605	35.8	2,232	17.4	
	龍井郷	7,267	62.5	3,293	28.3	1,059	9.2	
	計	26,534	51.4	14,548	28.1	10,587	20.5	51,669

資料 UHDC/CIECD 1969年12月調査

Table VI-1-5 Overall Status of Industry

工 業 概 況

郷鎮別＼種別	工廠総面積 (坪)	工廠建築面積 (坪)	員工人数 (男+女) (人)	食品,飲料,煙草業 A (家)	紡織,服飾,皮革業 B (家)	木製品家俱 C (家)	造紙,印刷 D (家)	橡膠,化学製品,石油,煤製品,窯業 E (家)	基本工業,金属 F (家)	機器,電機交通器材 G (家)	其他 H (家)	総計 A+B+C+D+E+F+G+H= (家)	註
梧棲鎮 A	3,782	2,031	673	—	2	—	—	1	—	3	3	9	
清水鎮 B	58,174	36,363	4,388	11	18	—	1	18	2	5	2	57	
沙鹿鎮 C	97,448	38,405	5,151	11	13	1	—	4	—	4	1	34	
龍井郷 D	19780	8,585	817	3	3	—	3	4	—	1	—	14	
合計	180,184	85,384	11,029	25	36	1	4	27	2	13	6	114	

資料 1969年12月四郷鎮資料調査結果

UHDC/CIECD

Fig. VI-1-10

人口密度図
(Population desity)

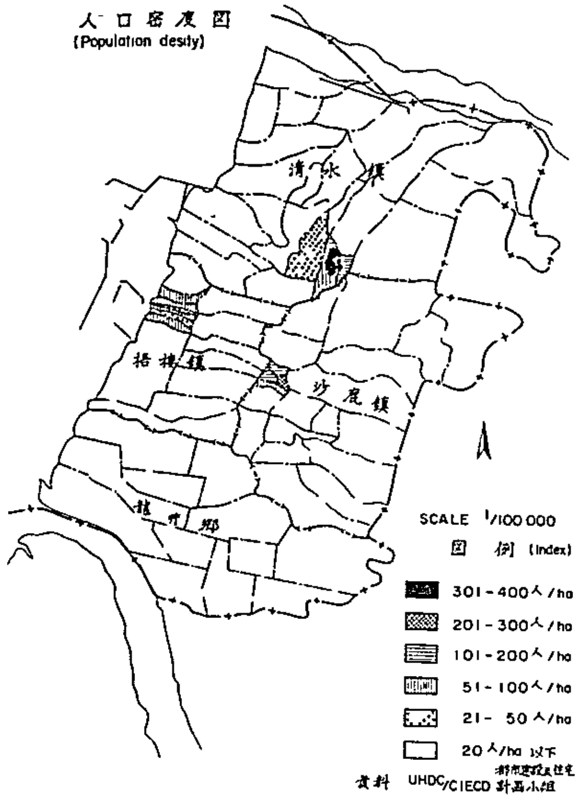


Fig. VI-1-11 産業構造三角図
(Triangular coordinates of Industry)

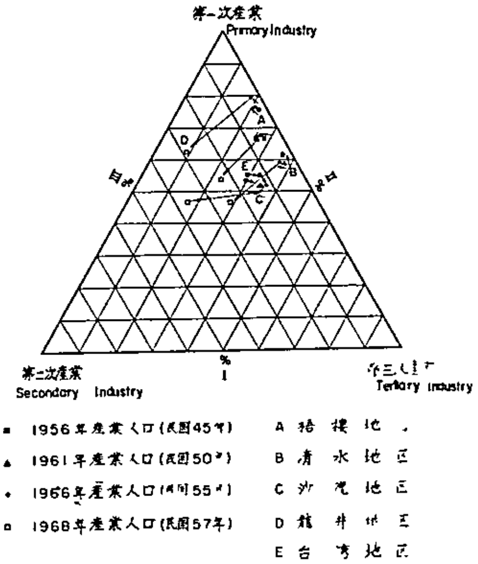


Table VI-1-6 Classification of Road and Traffic

交 通 分 類 表

交 通 量 UHDC/CIECD

資料：公 路 局

道路区段 Road Section	道路分類 Jurisdiction	公路局編号 Route No	区域編号 Traffic Classification	路段里程 Length (KMS)	路宽 Over All Width (M)	舗面情形 Pavement 種類 Type	宽度 Width (M)	車道数 No of Lanes	行駅客運名称 Bus Co. Route	交通量 (1969) Traffic Volume Vehicles/Day 機動車 (車輛) CARS, TRUCKS BUSES, ETC	機踏車 (車輛) Motor Cycle	総数 (車輛) Total Vehicles
范里一大甲 Fanli Tachia	省道 P	台1号	C	12.9	15	瀝青 Asp	7	2	T.H.B	3,290—	4,150—	7,440—
大甲一清水 Tachia Ching Shui	省道 P	台1号	C	10.6	15	瀝青 Asp	7	2	T.H.B	3,490—	5,440—	8,930—
清水一沙鹿 Ching Shui Shalu	省道 P	台1号	C	3.8	15	瀝青 Asp	17	2	T.H.B	3,440—	6,120—	9,560—
沙鹿一南王田 Shalu Nawanton	省道 P	台1号	C	16.3	12	瀝青 Asp	7	2	T.H.B	4,550—	4,170—	8,720—
大雅一清水 Taya Ching Shui	省道 P	台10号	D	11.6	8	瀝青 Asp	6	2	T.H.B F.Y	2,310—	1,460—	3,770—
台中一沙鹿 Taichung Shalu	県道 H	134	D	18.9	14	瀝青 Asp	7	2	T.H.B	1,830—	2,220—	4,050—
清水一梧棲 Ching Shui Wu Chi	県道 H	134	D	4.0	10	瀝青 Asp	6	混合 Mix	T.H.B	710—	2,290—	3,000—
沙鹿一梧棲 Shalu Wu Chi	県道 H	134	D	4.2	8	瀝青 Asp	6	混合 Mix	T.H.B	900—	1,500—	2,400—

Key :

Jurisdiction .

P — Provincial Road

H — Hsien Road

Traffic Classification :

A — Over 15,000 Motor Vehicles Per Day

B — 10,001 — 15,000 〃 〃

C — 5,001 — 10,000 〃 〃

D — Under 5,000 〃 〃

Pavement Type :

Asp — Asphalǂ. G — Gravel.

Bus Company Routes .

Y L. — Yuan—Lin Bus Co.

C.H. — Chang—Hua 〃 .

F.Y. — Feny—Yuan 〃 .

N.T. — Nan—Tou 〃 .

T.H.B. — Taiwan Highway Bureau.

C.B. — City Bus.(Tai Chung City).

Fig. Ⅵ-1-12

交通施設現況図
Present state of Traffic Facilities

SCALE 1/100 000

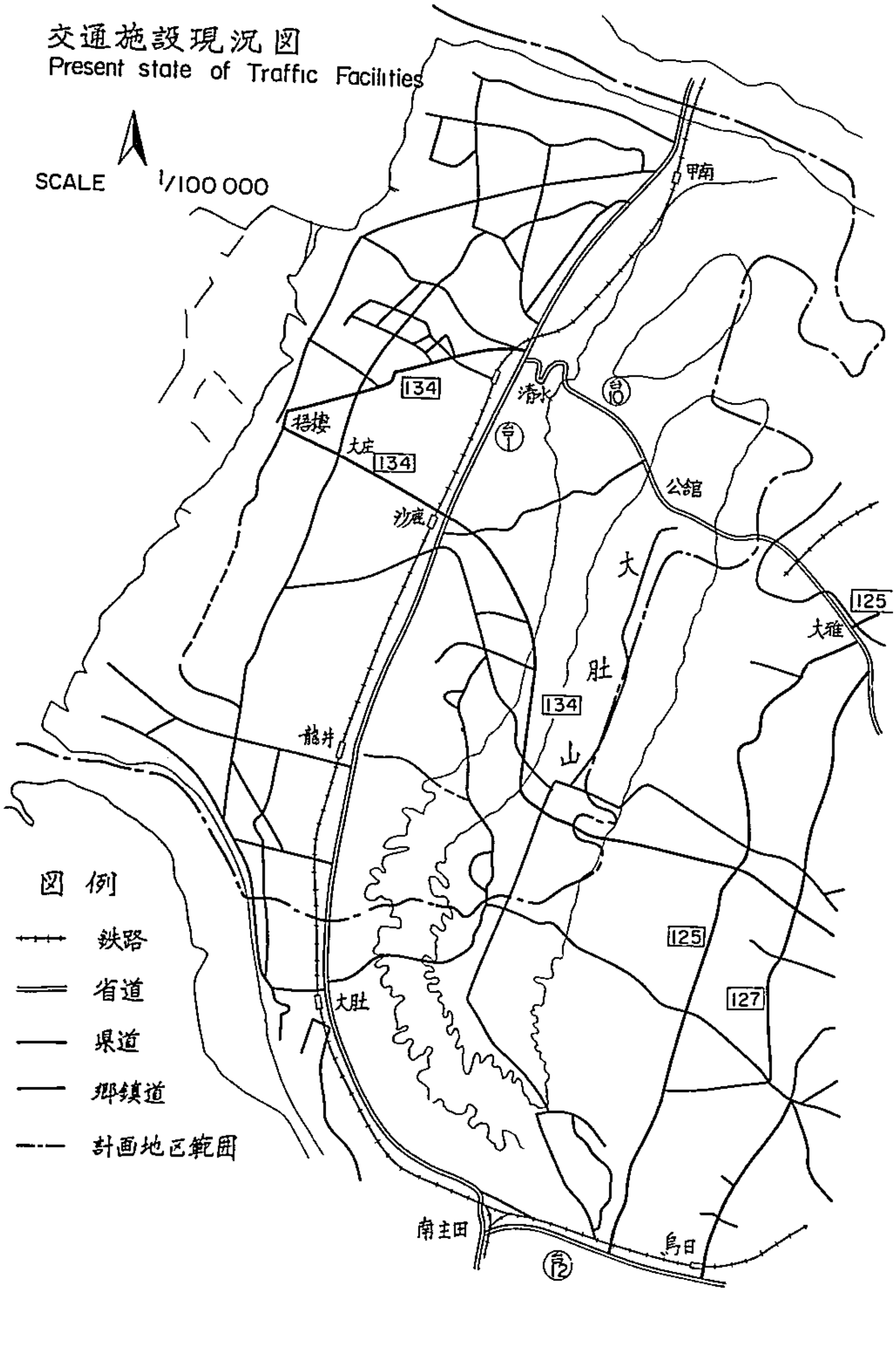
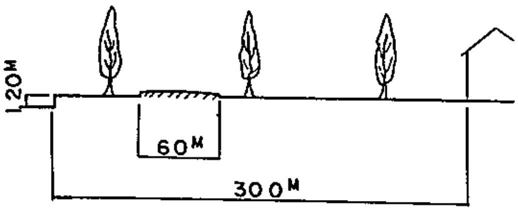
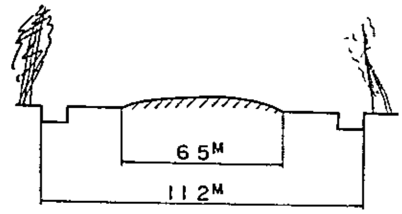


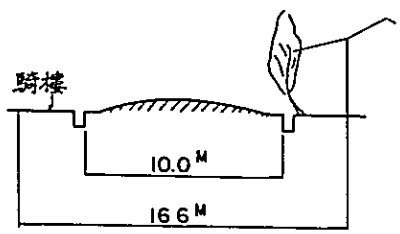
Fig. Ⅵ－Ⅰ－13　主要道路の断面現況
(Typical cross section of Trunk roads)



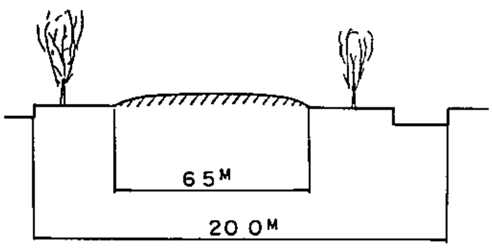
A. 沙鹿. 楼綫 ：梧棲国小前



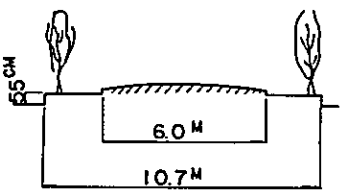
D　大雅 ―豊原　　125号



B　梧棲主街 ：廟 前



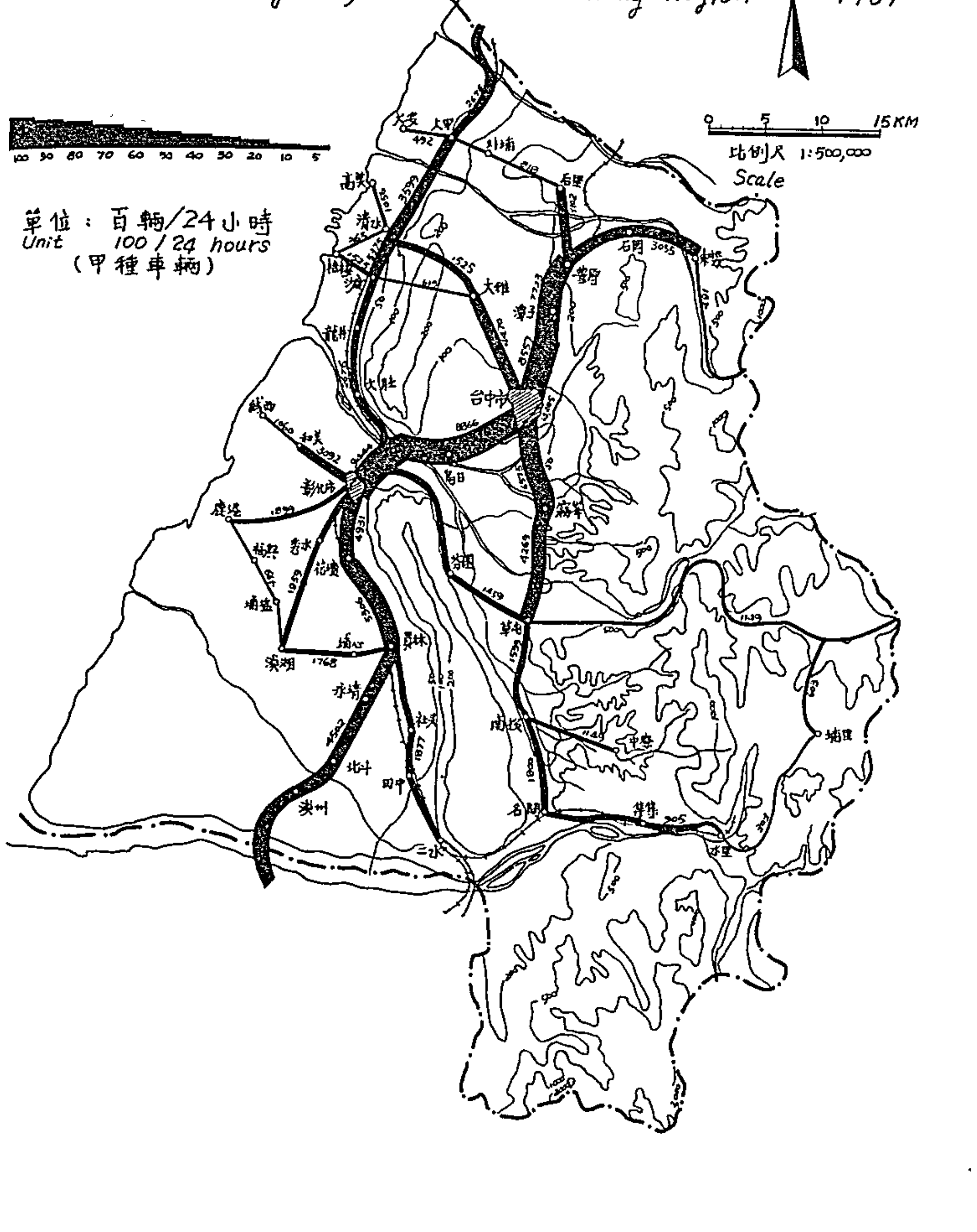
E　大 雅 ―沙鹿　　台 地



C.　清水梧棲綫 ：近 梧 棲

Fig. VI-1-14 台中地域平均一日交通量圖 民國五十六年

Arerage daily traffic in Tai Chung Region 1967



2. Some Considerations From The Regional Point Of View

2.1 Subjects on National Land Development

Although the purpose and significance of Taichung Harbour construction have already been described in the preceding section, it can be pointed out, main roles from the viewpoint of national land development, that the construction will play the following two major roles.

i) Role in economic and industrial development

The economic growth rate in Taiwan has been indeed notable. The team estimates that will keep 8% annually and GNP will reach 840,000 millionNT$ in 1990. The per capita income in the same year will amount to more than 800 US$/person or possibly 1,000 US$/person in nominal value. (See Table VI-2-1)

What supports the remarkable economic growth is nothing but the industrial development, especially development of machinery, heavy and chemical industries. By exporting these manufactured goods, the scale of the economy will be enlarged and an affluent industrial society is expected to come into existence in the next twenty years.

Where such core industries are to be located is an important question in Taiwan because resources such as iron ore and crude oil must be all imported. These industries are called seafront equipped industries forming "Kombinats" (combinated industrial complexes) and possessing harbour facilities. The scale of these seafront industrial complexes is required to be more than 500 hactars.

Taiwan, however, is not blessed with favourable natural conditions for harbour construction. Therefore, the location of large-scale seafront equipped industries is restricted. At present, Kaohsiung Harbour seems to be the only site suitable for the location, but with the development of Taiwan's economy, another site will be required.

For this reason, it is proper that seafront industrial complexes of about 900 ha are planned to be located around Taichung Harbour for the future development of Taiwan's economy. And this region will certainly become one of the key important industrial zones that lead Taiwan's industry in the future.

ii) Role in the sound land development of the nation

In the Report of New Harbour Project published in June 1969, present status of population and industry is analyzed as given below, dividing Taiwan into 4 blocks, northern, central, southern and eastern regions.

"Population and employed persons in secondary and tertiary industries keep on expanding in the north. And there exists the overcongestion of population and industries in Taipei City and its hiterland. On the other hand, population in the central has notably decreased by migration, producing improper balance in national development."

Although the imbalance of regional development may be inebitable in the rapid growth of Taiwan's economy, it is to be noted that, from the view points of national land development, the efficient utilization of all land areas is the key to secular expansion of the economy.

Population in the central block around Taichung City keeps on decreasing due to the lopsided industrial structure of the primary. However, as there are abundant resources such as land, water, hydroelectric power, forests and also labour force in the central, the region can be said to posses the potentialities of industrial development.

Consequently, to avoid outflow of population and to utilize resources efficiently, the industrial development in the central block is one of the important subjects in Taiwan's development. In the south, the construction of Kaohsiung Harbour incited the development of heavy and chemical industries. The industrialization of the central is also promoted by the construction of Taichung Harbour. As the result, proper balance in industrial development will be brought about in all 4 blocks to facilitate efficient expansion of Taiwan's economy.

Table VI-2-1 Estimation of GNP and Income per capita

Year	GNP	Income	Income/per capita		Total population
	million NT$	million NT$	NT$ person	US$ person	1,000 person
1967	138,730	111,860	8,412	210	13,297
1976	286,000	229,000	13,984	350	16,373
1980	390,000	312,000	17,623	441	17,704
1990	840,000	672,000	32,861	822	20,450

Note:

i) 1966 is adopted as the base year for price.

ii) The ratio of $\frac{\text{National Income}}{\text{GNP}}$ is assumed at about 80%, actual figure of 1967 is 80.63%.

iii) Estimations of total population for 1976 and 1980 are taken from the estimation of "Taiwan Population Studies Center" with family plan.

iv) Estimation of total population of 1990 is carried out based on the method which is used in the above mentioned report.

2.2 Relationship with "Regional Plan of Taichung"

CIECD and UHDC are working out the regional plan for a number of blocks into which the entire Taiwan is divided. Taipei regional plan has been fixed already. As to Taichung region including Taichung Harbour, the first report of Regional Plan of Taichung published on March of 1969 is now under consideration. As outlined below, the report proposes forming a regional community around Taichung City to develop agriculture and manufacuring through industrial development, utilization and conservation of land, increase of traffic capacity and creation of tourism area.

The report, however, does not contain the Taichung Harbour construction plan. This is because the construction of harbour was not decided when the plan was worked out. With the decision of constructing Taichung Harbour made on August of 1969, UHDC and CIECD are now in the course of revising the regional plan of Taichung including Taichung Harbour and planned area.

As described formerly, construction of Taichung Harbour and the seafront industrial area will give an impact on the industrial development of the central and serve for its transformation into a highly industrialized region. Therefore, the objectives of the regional plan would have to be largely revised. However, basic principles of the plan such as sound development of agriculture and manufacturing, .measures for urbanization, formation of a reginal community around Taichung City, etc. would not be altered.

"Outline of the First Report of Regional Plan of Taichung"

This report was published by UHDC, CIECD on August 1969. It is the master plan of regional development involving Taichung City, Taichung Hsien, Changhwa Hsien and Nantou Hsien. The outline is as follows:

Extent of the region

Taichung City, Taichung Hsien, Changhwa Hsien (excluded Hopin Shiang) and Nantou Hsien -- 3, 650 square kilometers

Period of the plan

25 years from 1966 to 1991

Estimated population

1966 ----- 2, 513, 600
1991 ----- 4, 427, 000
Urban population
in 1991 ---- 3, 080, 000

Objectives

a) Sound development of agriculture and manufacturing
b) Coping with urbanization
c) Formation of a community around Taichung City

d) Industrial development to avoid outflow of population
e) Conservation of fertile cultivated lands, and development and conservation of hills
f) Increasing traffic capacity and construction of S-N Freeway
g) Development of tourist industry and recreation areas

Concept of urban development

a) Development of Taichung City into the region's central city having a population of 750,000. New town with 150,000 population will be constructed at the skirt of Tatu Mountain.
b) Total population of Changhwa, Fengyuan, Yenlin, Pohli, Nantou, Shihma, Tachia, Changsui, Luhgang, Erhllin, Peidoou, Chushan is planned about 1.3 million. And other core cities are: Wuhfeng, Tsaoton, Hombi, Tonshyh, Shaluh, Hermei, Tarntzyy, Sherngang, Taga and Uryh.
c) Urban population in 1991 will ammount to 3,080,000, and Residential and industrial areas will be secured. City water is to be supplied by the dam construction and underground water.

Land use in rural area. By dividing the entire area into agricultural area, slopes that can be utilized, conservation area and forestry, proper protective and control measures are to be taken for each area. Scenic spots are to be developed into recreation areas.

Transportation network

a) Seven radial roads and a link road are to be constructed in Taichung City.
b) S-N Freeway which runs through Tachia, Sherngang, Taichung, Changhwa, Shihwu and Shijou is to be constructed.
c) Inter-Chien-Shaing roads are to be improved. Road which connects S-N Freeway with Fengyuan is to be improved, and Changhwa plain coastal road is to be constructed.
d) Rapid transit service is to be provided on the route which passes through Kori, Hogen, Taichung, Changhwa and Inlin.
e) Shoeinan airport is to be removed. Gonggoan airport is to be utilized for both civil and military use in case the airborne traffic increases in the future.

3. Basic Conditions for the Planning of New City

3.1 Characteristics of New City

Along with the construction of Taichung Harbour, New City with a population of 500,000 will emerge in the coastal area of Taichung plain within a very short period.

This New City is quite unique in her chracteristics; it will have two functions, one is the function as an international commercial harbour and the other is as a large scale industrial city. Besides, New City will be constructed a very limitted time span, and this rapid development may induce various difficulties which will not appear in ordinary cities developed through their history.

As the guide line of planning, functions and characteristics of New City are defined as follows:

i) Basic functions of New City are those of a city with international commercial harbour and large scale heavy and chemical industries which will have nation-wide importance.

ii) New City could not have functions of serving surrounding areas as their central city because of her too rapid development.

iii) Owing to the abovementioned reason, accumulations of functions of tertiary industries such as higher education, commercial and financial activities, and amusement in this city will not be in time. Therefore, New City will depend on Taichung City for these activities.

iv) New City will be a modern and dfficient city, by the scheduled construction, but it should be clearly recognized that she has no historical background as a city.

v) Since most of residents of New City will come from all over the island, it will be difficult to form consensus of citizens to the development and administration of New City.

Accordingly, planning of New City should satisfy two basic requirements i.e. support of the activities of the international commercial harbour and development of large scale heavy and chemical industries.

But, stress should be put on the construction of various kinds of facilities to support forming of sound community of citizens. These facilities will include schools, grounds, gymnasiums, libraries, theaters, community centers, hospitals, shopping areas, water supply and sewerage system, parking areas and parks, and all of them should be coordinated with each other to achieve higher educational and cultural standard in the best living environments of the New City. The New City should be so constructed as to make her citizens feel proud of it.

3.2 Estimation of population

Estimation of the population of the surrounding cities of Taichung Harbour is the basis for mapping out the master plan. However, since large-scale commercial and industrial port will suddenly come into existence on Taichung coastal plain where there is nothing at present, there are practically no data on which the estimation is to be based.

Consequently, the population of planned area was estimated toreach 500,000 in 1990 by the following method utilizing data of Keelung Harbour, and the estimated scale of industries, etc.

i) Persons engaged directly in port business

According to the data of UHDC, CIECD, persons engaged directly in port business of Keelung are 7,000 in 1967. As the tonnage of cargoes handled by Keelung harbour was then 5,729,000 R/T annually, persons per unit tonnage (1,000 R/T) were 1.2 annually. As tonnage of goods handled by the new commercial port is estimated to be more than 16,000,000 R/T annually, it is inferred that persons engaged in port business will be 19,000 (=16,000 x 1.2)

ii) Employed workers in manufacturing industries

Estimated number of workers engaged in manufacturing industries are likely to be induced is 80,000 (see Table VI-3-2). Adding this number to 11,000, the employed persons in planned area in 1969, the total number of workers engaged in manufacturing industries will become 91,000 in the target year.

iii) Employed workers in primary industries

Number of employed persons in primary industries is 26,500 and cultivated land area is 10,000 hactars in 1968. By construction of new city, cultivated land area is estimated to become a half of the present. Therefore, employed persons in primary industries will also be decreased to 13,000 in proportion to the reduction of cultivated area (=26,500 x 1/2)

iv) Employed workers in tertiary industries

It is said that the correlation between employed persons in the tertiary and total employed persons is clearly established. Then, utilizing the composition ratio of employed persons in the entire Taiwan in 1967, employed persons in the tertiary is estimated to be 55,000, as given below.

$$\frac{(91,000 + 13,000) \times 0.347}{(1 - 0.347)} \fallingdotseq 55,000$$

91,000 : Employed persons in manufacturing

13,000 : Employed persons in primary

0.347 : Ratio of employed persons in tertiary to total employed persons (entire Taiwan in 1966)

In the above calculation, persons engaged directly in port business is excluded, since they are regarded as specially required persons for port operation. Ratio of employed persons in the tertiary to the total employed persons is higher in urban than in rural. For example, the ratio in major cities in 1966 is as follows:

Taipei	0.68
Taichung	0.57
Keelung	0.58
Tainan	0.44
Kaohsiung	0.72

In this calculation, 0.347 is adopted as the ratio in the entire Taiwan. This is because, for one thing, persons engaged directly in port business, to be included in the tertiary are treated seperately, and the other, the ratio in the planned area of new harbour will be low since the area differs from Taichung City which functions as a regional hub-city.

v) Total employed persons

Summing up the above estimated figures, a total of 178,000 is obtained, and the composition ratio is as follows:

Primary	13,000 persons	7.4%
Secondary	91,000 "	51.1%

Tertiary	74,000	persons	41.5%
Total	178,000	"	100%

vi) Population

Mutiplying employed persons by the dependency rate (population/employed persons), population can be estimated. Dependency rate of nation's total in 1966 and 1968 is 3.55 and 3.24 respectively, which is higher than those of Europe and America. This is because Taiwan has a large population under 14 years of age, but with the fall of birth rate dependency rate will be decreased.

In the Report of New Harbour Project published in June 1969, dependency rate in 1988 is estimated at 2.55 in nation's total. This estimate is based on the planned figure of Taiwan Population Studies Center. UHDC, CIECD stated in the first report of regional plan of Taichung that it would be proper to estimate the future population at the average of the planned figure and the figure not counting the family plan.

Consequently, assuming that the dependency rate in 1990 will be 2.8, population in the planned area of Taichung harbour will become 500,000 (= 178,000 x 2.8)

Note: Dependency rate in the world (1966)

Country	Population	Employed Persons	Dependency Rate
Taiwan	12,993	3,870	3.4
Japan	98,864	48,470	2.0
Korea	29,208	8,659	3.4
United Sates	196,907	72,895	2.7
Canada	20,015	7,152	2.8
West Germany	57,485	26,601	2.2
Italy	51,973	18,884	2.8
Great Britain	54,744	24,974	2.2

3.3 Estimation of Manufacruring Industries

As a seafront industrial area of about 900 hactars will be formed neighbouring the commercial port by master plan of Taichung harbour, the composition and scale of industries induced in this area are to be planned.

Among seafront industries, integrated steel mill, oil refinery, petrochemical, aluminium and milling are indispensable for Taiwan's economic development, and must resort to import for the supply of raw materials required.

From the correlation between the per capita income and the per capita production of crude steel, gasoline and aluminium in major countries, required output of these products is estimated to decide the scale of industries to be located around Taichung Harbour.

The data of the per capita income and the per capita production of crude steel, gasoline and aluminium of major countries is as shown in Table VI-3-1. The per capita income in Taiwan estimated to reach 822 U.S.$/persons in 1990 (See Table VI-2-1).

i) Oil refinery and petrochemical

The relationship between the percapita income and production of gasoline is as shown in Fig. VI-3-1. Establishing a correlation expression from the data of six countries where United States, Canada and Australia are excluded because of their uncommonly high per capita income, the per capita production of gasoline in 1990 in Taiwan is calculated. Annual production of gasoline as obtained by multiplying this figure by the population in 1990 is 2,200,000 tons yearly which is 5.6 times the present production.

Supposing that the required capacity of oil refinery in 1990 in Taiwan must be multiplied 5.6 times, it will be 340 thousand barrels (= 60,000 x 5.6)

Oil refinery industry is located at Kaohsiung where 60,000 barrels per day is produced at present. A new factory with a capacity of 60,000 barrels is planned to be constructed in the north. To secure a capacity of 340 thousand barrels per day, factories having a capacity of about 200 thousand must be planned.

Consequently, it is planned to establish the oil refinery industry of which the scale is about 200 thousand barrels in the seafront industrial area of Taichung Harbour for establishment of the petrochemical industry is planned for production of about 20 thousand t/day of ethylene.

ii) Steel and allied industries

Calculating the required production of crude steel from Fig. VI-3-2 by the same method as applied to oil refinery, the annual production is estimated at 6,200 thousand tons (= 0.31 x 20,000,000).

Considering that the construction of integrated steel mill is planned at Kaohsiung, the scale and location of factories to secure the production of 6,200 thousand tons yearly is planned as follows:

t/year

Kaohsiung Harbour: A plast furnace of 2500m^3, production 2,000,000

Taichung Harbour: Two plast furnaces of 2500m^3 " 4,000,000 t/year

In connection with integrated steel mill, the construction of metal fabricating factories of which the scale is about 200,000 tons/year in rolled steel is planned.

iii) Aluminium

Estimating the required production of aluminium from Fig. VI-3-3 by the same method as applied to oil refinery, the production will be 60,000 tons/year (= 0.003 x 20,000,000). The required production can be sufficiently secured by a middle-scale factory. Construction of the aluminium factory is not planned, because its scale is small and one factory suffices to obtain the required output. It holds true, however, that aluminium production suitable for this industrial estate.

iv) Thermal electric power station

As the large-scale industrial area demands a large quantity of electric power, construction of power stations are required. Electric power is properly thermal in connection with the oil refinery. The construction of a power station of which the capacity is 750 thousands KW is planned by China Electric Power Company. The capacity will be required to be enlarged in the future.

v) Shipbuilding

As the tonnage of cargoes handled through Taichung Harbour will finally amount to 30 million tons per year, construction of a shipbuilding yard where vessels are constructed or repaired is required. The planned shipbuilding yard will have the dockage of 100 thousands tons and an area of 70 hactars.

vi) Milling, food, feed and forage

Along with economic growth, industrial area for milling, food, feed and forage industries must be secured to cope with the increasing demand for export of food and import of food and feed. Industrial area of about 30 hactars is planned for these industries.

vii) Timber and wood products

Timber prosessing and wood product industry has developed in Taichung region, and this industry will expand further by timber import. Therefore, 30 hactars of area is allocated for this aim.

viii) Other manufacturing industries

Heavy and chemical industries such as oil refinery, steel petrochemical, shipbuilding, thermal electric power, etc. located within Taichung harbour will induce allied factories related with port and city activities.

To secure the land for these allied industries, an inland industrial area of about 600 hectares is planned. A portion of this area will have to be designated for processing import and export goods.

The summary of the above-mentioned is as given in Table VI-3-2. Planned factories area is 1, 550 hactars and estimated number of employed workers is 80, 000.

4. Basic Planning

4.1 Basic Structure of Proposed City Plan

The area which will be included in this project consists of flat paddy field and gentle slope of Tatu hill. This condition gives a high degree of freedom to the planner. Therefore, many basic ideas or alternatives are sketched and examined. Finally, basic plan of New Town in decided as shown in the attached map, "Master Plan of New City for Taichung Harbour".

Following four characteristics are taken into consideration as the basis of the planning:

Table VI-3-1 Income and Production Per Capita (Gasoline, Crude Steel and Aluminum)

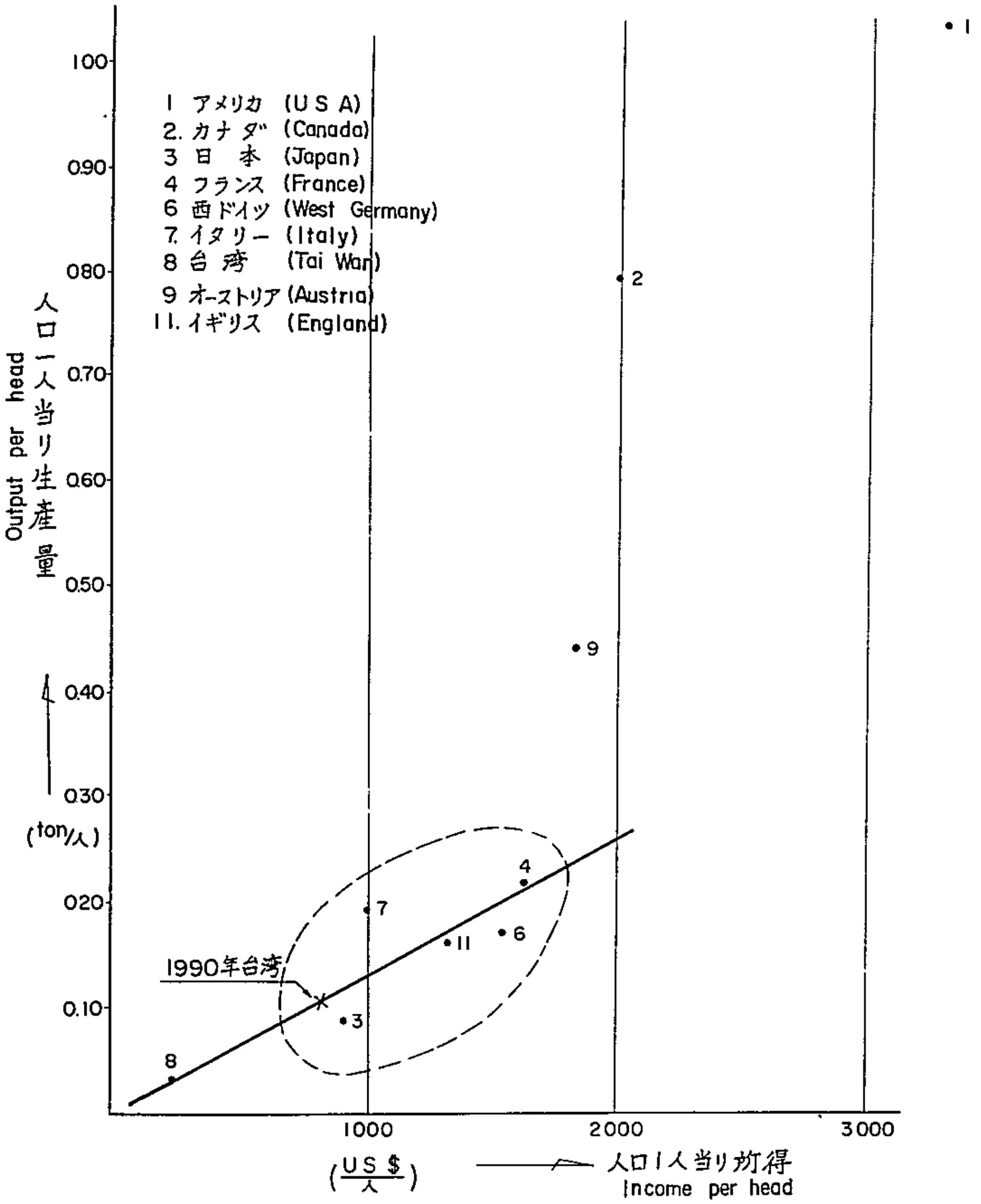
Country	Total Population (1967)	Per Capita Income (1967)	Gasoline (1966)		Crude Steel (1967)		Aluminum (1967)	
			Total Production	Per Capita Production	Total Production	Per Capita Production	Total Production	Per Capita Production
	(Thousand persons)	(US$/person)	(Thousand tons)	(t/person)	(Thousand tons)	(t/person)	(Thousand tons)	(t/person)
1. United States	199,118	3,305	209,787	1.0535	115,404	0.5795	2,964	0.0148
2. Canada	20,441	2,086	16,159	0.7905	8,796	0.4303	823	0.0402
3. Japan	99,920	921	9,320	0.0932	62,148	0.6219	382	0.0038
4. France	49,890	1,644	10,775	0.2159	19,656	0.3939	361	0.0072
5. Norway	3,784	1,672					362	0.0956
6. West Germany	57,699	1,568	10,324	0.1789	36,744	0.6368	253	0.0043
7. Italy	52,334	1,020	10,158	0.1946	15,876	0.3033	128	0.0024
8. Taiwan	13,142	217	390	0.0297			15	0.0011
9. Australia	11,751	1,830	5,494	0.4675	6,288	0.5351	92	0.0078
10. Austria	7,323	1,092					79	0.0107
11. Great Britain	55,068	1,350	8,944	0.1624	24,276	0.4408		
12. Belgium	9,581	1,599			9,720	1.0145		

Source: U.S. Statistical Year Book - 1967.

Table VI-3-2 Major industries and their scale

Industries	Production capacity	Required area	Numbers of employees	Remarks
Oil Refinaery	200,000 B/day	160 ha	500 person	
Petrochemical	ethylene 200,000 T/day	160	1,500	
Thermal Power Plant	equiped capacity 750,000 kW	80	300	
Shipbuilding	-	70	3,000	
Integrated Steel Mill	pig steel 4,000,000 T/year	350	10,000	
Special Steel	rolled steel 200,000 T/year	50	1,500	
Milling, Food and Feed Processing	-	30	500	
Timber Processing	-	30	700	
Subtotal		930	18,000	
Related Industries		560	56,000	100 person/ha.
Export Processing Zone		60	6,000	100 person/ha.
Ground Total		1,550	80,000	

Fig Ⅵ-3-1 揮発油 (Naphtha)



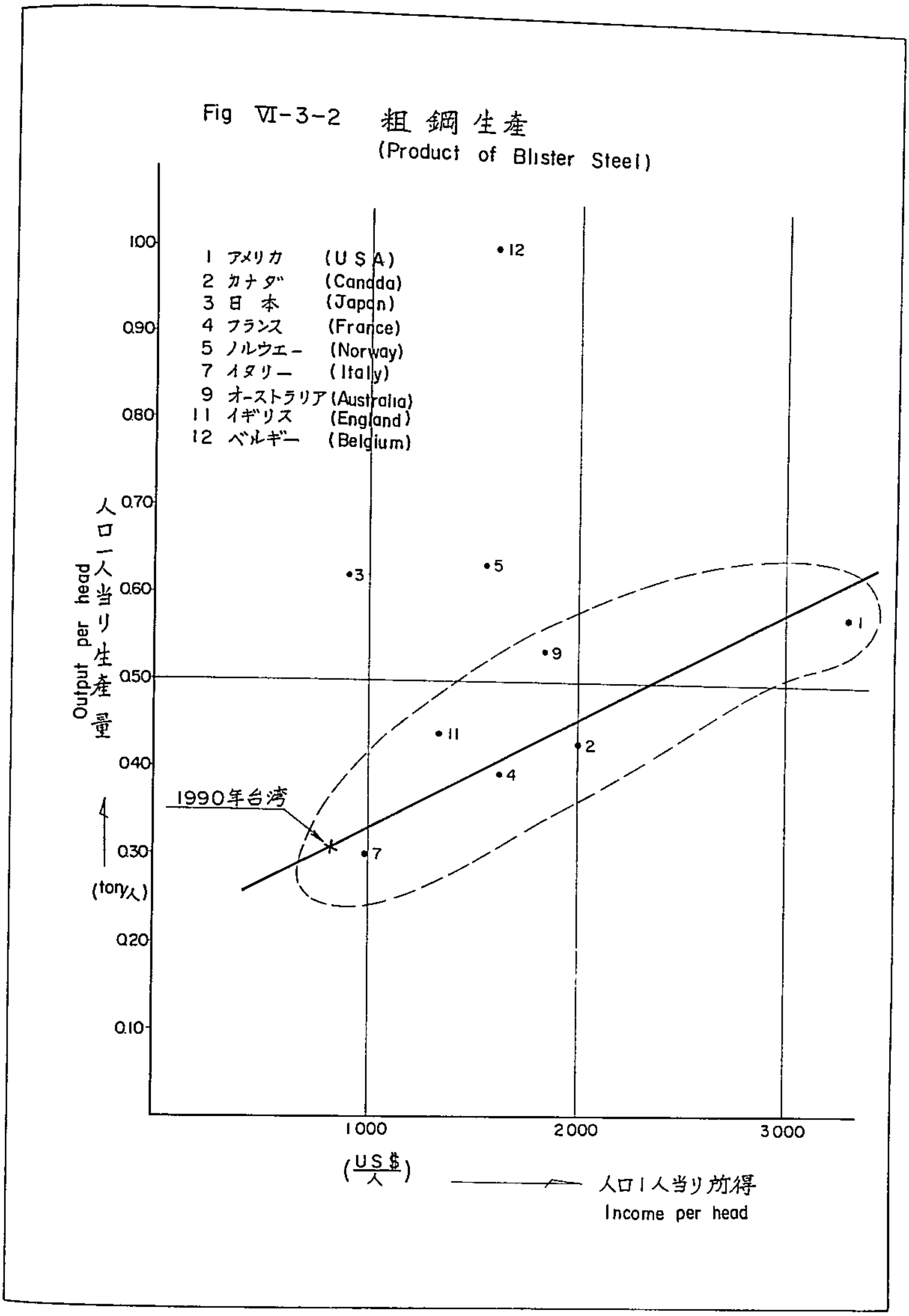
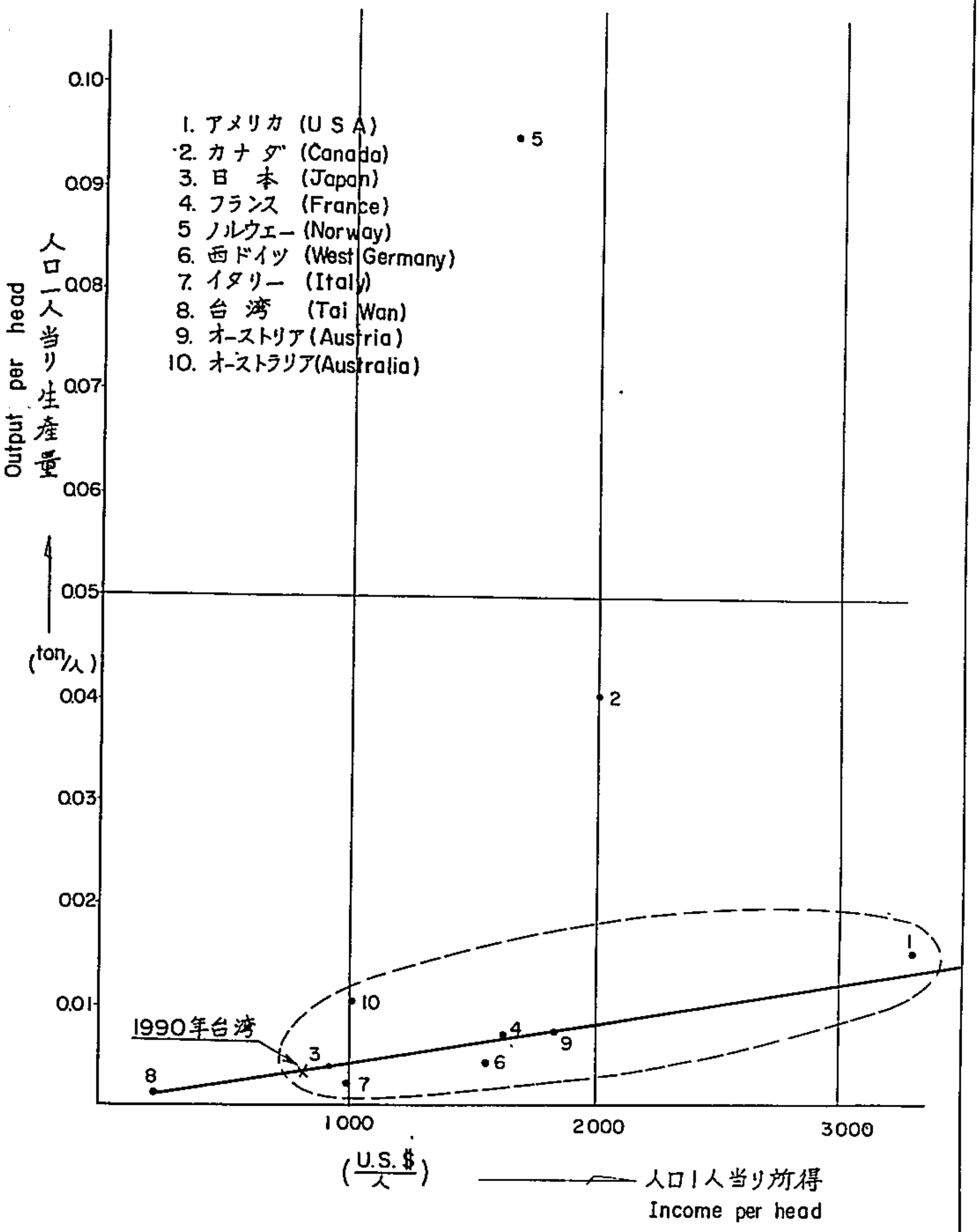


Fig Ⅵ-3-2 粗鋼生産
(Product of Blister Steel)
1 アメリカ (USA)
2 カナダ (Canada)
3 日 本 (Japan)
4 フランス (France)
5 ノルウエー (Norway)
7 イタリー (Italy)
9 オーストラリア (Australia)
11 イギリス (England)
12 ベルギー (Belgium)
人口一人当り生産量
Output per head
(ton/人)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
1990年台湾
1000
2000
3000
(US$/人)
人口1人当り所得
Income per head

Fig. Ⅵ-3-3　アルミニューム（Aluminium）



i) West front of the city will be the sites of a large scale international commercial port and chemical industries.

ii) Trunk lines of both railway and highway run north to south and the distance from the coast line to these is about 4km.

iii) Hinter land of New Harbour is a alluvial plain.

iv) Along these trunk lines, cities such as Chinsui and Salou are found.

v) Gentle slope of Tatu hill prives an excellent site for urban development.

At first, the course of urban development and resulting pattern of cities are figured out from the above five conditions, and this is used as the starting point of this planning.

To work out the plan, following items are carefully considered:

i) Convenient communication to the hinter land by land transportation should be realized.

ii) Enough open spaces, such as greens and parks, should be secured to make residential circumstances comfortable.

iii) For the better residential circumstances, counter-measures against the winter monsoon, selter belts, for example, should be arranged.

iv) In order to meet the development of the so-called motorization, safe and well organized network of highways and roads should be planned. Width of highways and roads should also be wide enough.

v) Considerations should be taken for the maximum utilization of benefits and conveniences derivable from the existing cities.

vi) Considerations must be taken to reserve good farming areas as much as possible.

vii) Structure of the city should be so organized that the city development may be carried out in line with the programme.

With due considerations given to the above, this New City is expected to become unique and her population density very low.

Outline of this plan is explained in the following parts focusing on her land use plan.

(1) Commercial and business districts

Three commercial districts are planned, Shinsui, Salou and a new one will be developed into the center of New City.

(2) Residential Area

High and moderately populated residential areas are planned between the harbour area and line connecting Chinsui and Salou. Low density residential areas are planned in the west slope of Tatu hill.

(3) Industrial area

Following industries will be located in the proposed seafront industrial estate:

Oil refinery	160 ha
Petrochemical industry	160 "

Thermal power station	80 ha
Shipbuilding	70 "
Integrated steel mill	350 "
Steel related industries	50 "

Another industrial area with 560 ha space is planned in the inland just behind the seafront industrial area. This industrial area will be allocated to urban-oriented industries and industries related to seafront industrial complex.

The above arrangement of industrial areas will minimize public nuisances such as air pollution.

(4) Harbour area

As mentioned in the previous section, harbour area is planned in the proposed relaimed land which will be on the shore side of the existing road running immediatly behind the coast line. In this area following facilities will be located; harbour facilities, government or public agencies, private offices, truck terminals, sorting yards, container freight station, parks and shelter belts. Processing zone and light industries such as food industry and timber processing industry will be located within this area.

The area between the harbour area and the area for New City (which will be planned by U.H.D.C.) should be planned with careful consideration as it is the joint of two areas having different functions. Public facilities for this purpose should be planned with greens for separation and shelter belts orivided if necessary.

Outline of land use plan is shown in Fig. IV-4-1. Followings are proposed as reference for the planning of New City:

i) Development of Tatu hill as recreation area for New City should be positively examined.

ii) Shelter belts against the winter monsoon should be arranged along the main roads which are planned at right angle to the coast line.

iii) To construct comfortable residential circumstance, shelter belts must be located in various places such as parks, open spaces, borders of communities and sides of channel.

4.2 Allocation of population

The allocation of population corresponding to the above mentioned land use plan is planned as follows:

i) Population density of 300/persons/ha. is assumed for the three commercial and business districts. Total of 120,000 persons will be accommodated within these districts.

ii) A high density residential area with a population density of 200/persons/ha. will be established by constructing high-storied apartment houses in the area surrounded by these three commercial and business districts. Total population of this area is planned to be about 140,000.

iii) Medium density residential area with a population density of 100/persons/ ha. is planned around the above mentioned high density residential area and 90, 000 persons are allocated.

iv) Since greens for land preservation should be arranged besides roads and other public facilities, proposed residential area in Tatu hill slope should be planned with enough open space. Average population density is assumed to be about 60/persons/ha. and 90, 000 persons are allocated.

v) About 60, 000 persons will be accommodated in the harbour area, seafront industrial area, greens and farm land.

Therefore, allocation of pupulation to each area will be as follows.

Land Use	Area(ha.)	Population Density (person/ha.)	Total Population
Commercial and business districts	400	300	120, 000
Central	(280)		
Salou	(60)		
Chinsui	(60)		
Residential area	3, 100		320, 000
High density area	(700)	200	(140, 000)
Medium density area	(900)	100	(90, 000)
Tatu hill	(1, 500)	60	(90, 000)
Others			60, 000
Total			500, 000

Naturally, residential areas should be planned to assure safe and comfortable daily life.

4.3 Planning of Transport Facilities

(1) Regional transport system

Proposed New City of Taichung Harbour has two characteristics, one is that it has an international commercial port and the other is that large-scale heavy and chemical industries are established in it. Therefore, smooth communication to and from her hinterland must be ensured. For the regional transport system, followings should be planned: i) Highway network which will connect S-N Freeway and New Harbour or New City must be planned. ii) Highway connecting neighbouring cities such as Taichung and Changhua and providing high service level should be constructed. iii) Branch lines should be planned which connect the New Harbour to the West Trunk Line via Sea.

A sketch plan of regional transport system based on the above idea is shown in Fig. IV-4-4. Since the extention of highways branching off from

Fig Ⅵ-4-1 土地利用構想図
(Tentative Master-plan of Land Use)

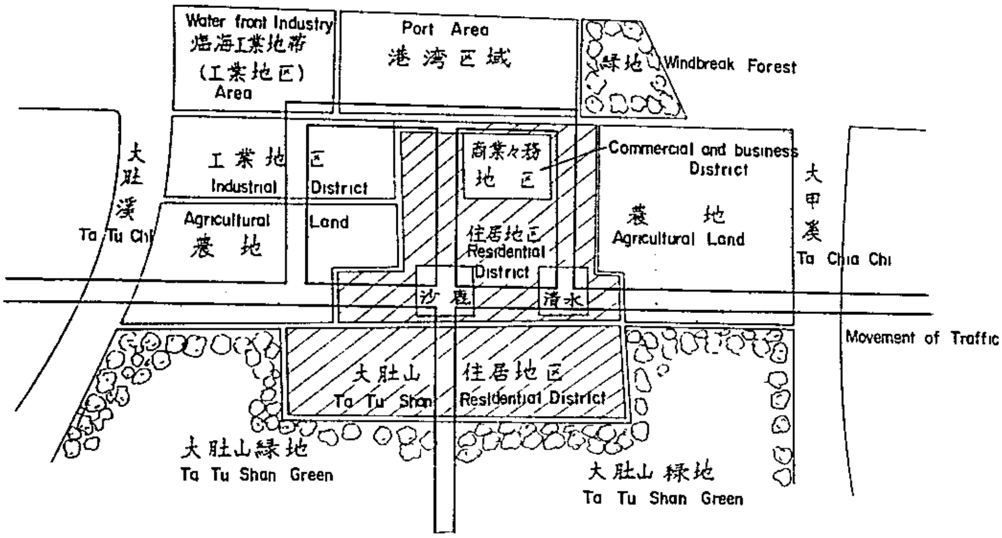


Fig Ⅵ-4-2 人口密度図 (Population Density)

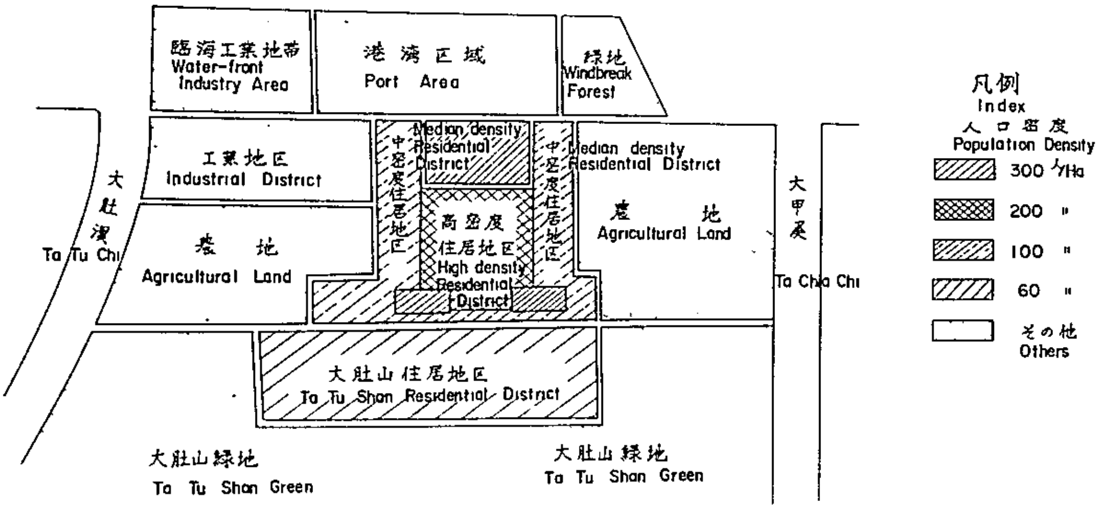
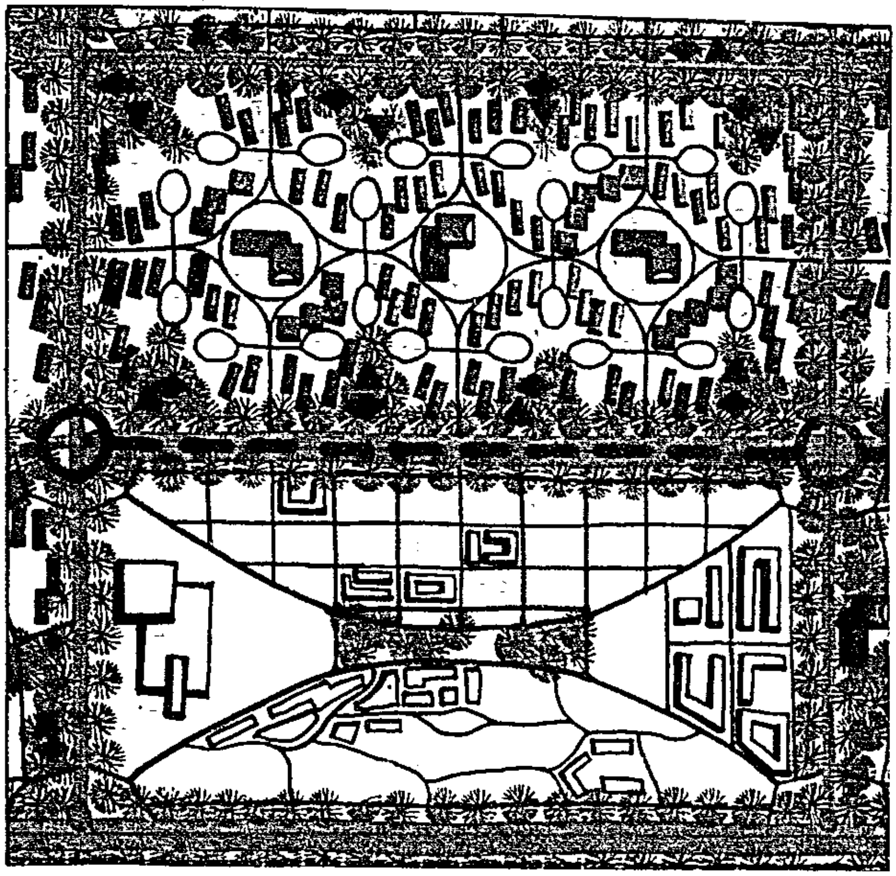
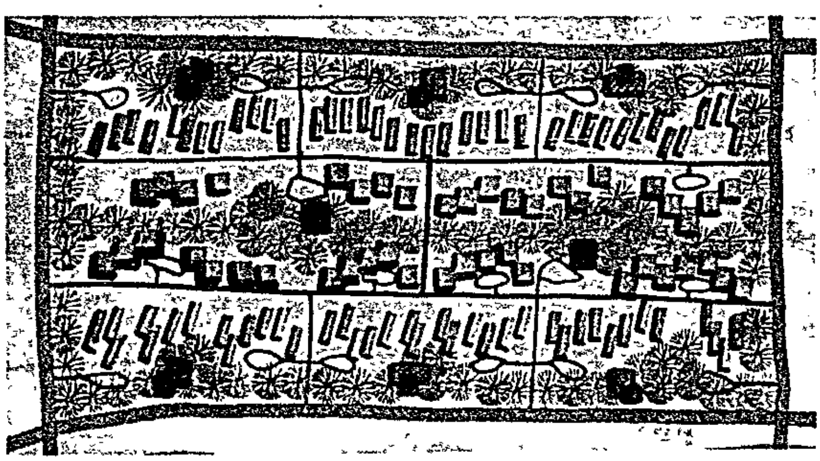


Fig VI-4-3 (1) Arrangement plan of Residential district



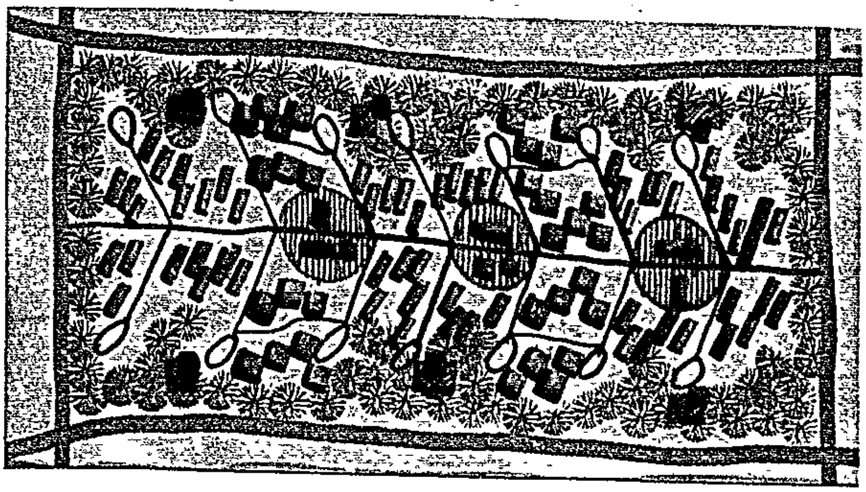
Community Center
School
Shopping Center

Fig VI-4-3 (2) Arrangement plan of Residential district



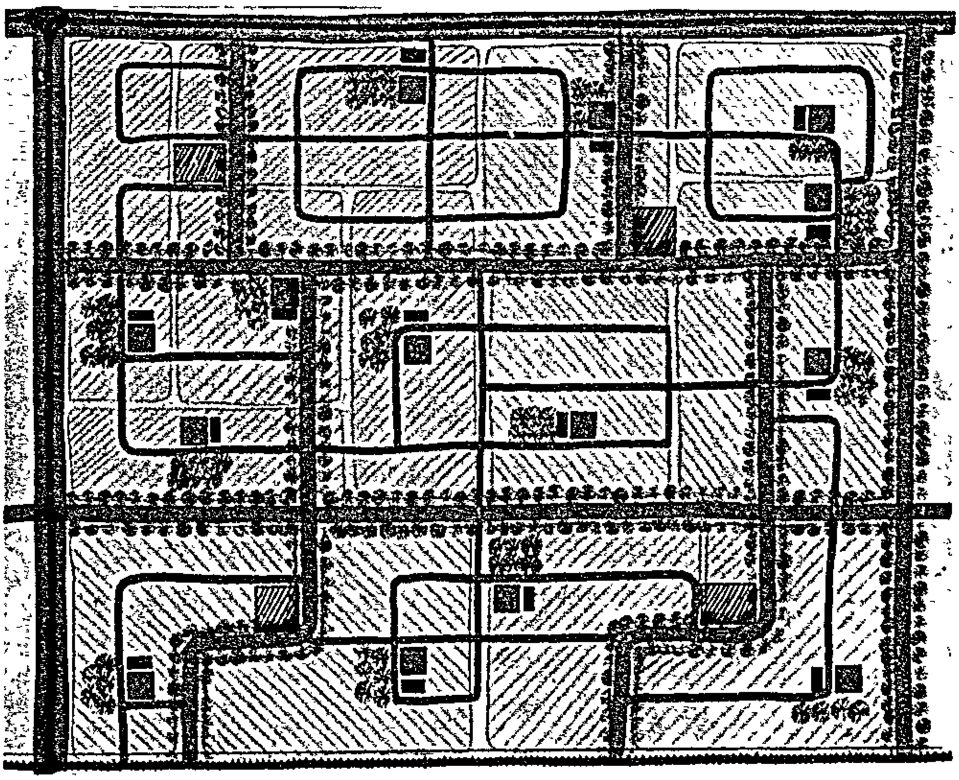
Community Center
School
Shopping Center

Fig VI-4-3 (3) Arrangement plan of Residential district



Community Center
School
Shopping Center

Fig VI-4-3 (4) Arrangement plan of Residential district



Index

Shopping Center
School
Community Center

S-N Freeway to New Harbour and Chungshingshintsun is not so long, service level of these highways need not necessarily be high.

(2) Arterial roads in New City

Lattice type is recommended as the basic pattern of arterial roads in the urbanized area. Highway to the harbour should be so arranged as to pass through the southern outskirt of the city.

Arrangement of arterial roads and highways is shown in the attached drawing, "Tentative Master Plan of New City for Taichung Harbour."

Amoung the five trunk roads running in the east-west direction, three of the roads connecting the harbour area with Chingshui, Shalu and Tantzu should be planned to have a width of 100 m with shelter belts provided along their west side.

In order to handle the traffic in the north-south direction, a by-pass should be constructed in the south of West Trunk Line because the existing Taiwan Highway No. 1 is runs through the highly populated urban area of Chingshi, Shalu and Lungchien, making its improvement difficult.

Main roads in the proposed residential area in Tatu hill slope will be attained by the improvement of existing roads.

To achieve smoother handling of truck cargoes, large scale truck terminals are also planned in the harbour area.

(3) Railways

Two branch railways from the West Trunk Line are planned, one from Chanan and another from Lungchien, and they will form a loop line. At present, three sorting yards are planned. One will be located near the Lungchien station and other two in the harbour area. to meet the transport demand raised by harbour activities and industrial production. Passenger service will be considered in the near future and 4 to 5 stations are planned to this aim.

4.4 Water Supply and Sewerage System

(1) Water supply

Demand for water supply raised by the construction of New Harbour, industrial area and New City will amount to 750, 000 m^3/day and details are shown in the following table.

City water (including supply to inland industrial area)
......500, 000 persons x 0.4m^3/day = 200, 000m^3/day

Industrial water (including supply to seafront industrial estate)
......900ha. x 600m^3/day = 540, 000m^3/day

Water supply for vessels .... 10, 000m^3/day

Total .... 750, 000m^3/day

In the early stage of construction, water will be supplied by the development of Tachia-chi (Tachien dam). However, comprehensive water resources development plan covering Taan-chi, Tachia-chi and Tatu-chi is to be formulated with the due considerations to the future demand for water supply. To work out the above mentioned comprehensive water resources development plan, extensive surveys and investigations must be carried out.

(2) Sewerage

As to the sewerage system for New City, separate systems are recommended for rain water and sanitary sewerage. A water sewerage plant will be located on the north side of the mouth of the Tatu from the points of view of topography and land use. But, the huge population of New City will required another wat er sewerage plant in the near future. The south side of the Ta-Chia river mouth will be the site of this water sewerage plant.

For the rain water drainage system, following two items should be taken into consideration: i) Existing channels must be fully utilized. ii) Run-off coefficient will be increased by a large margin due to the urbanization of farm land. The location of drainage channels of rain water is extremely restricted because New City embraces the harbour along the coast line. This gives severe conditons for planning rain water drainage.

Therefore, sewerage system of rain water for New City must be planned on careful investigations. Fig. IV-4-7 should be taken as one of alternatives.

For the development of residential area in Tatu hill slope considerations must be given to the soil condition from the viewpoint of land conservation.

4.5 Problems to be Solved Through the Planning

Most of cities in Taiwan have developed over many years in the past, and each has its own history and character. In contrast with this, the expected construction speed of New City is so high that many problems will be induced.

The first basic problem is that the rapid increase of population in this area may induce some unbalance between the demand and the supply of public facilities such as roads, water supply and sewerage system, and parks. This may cause the so-called urban.

The second one is the difficulties in forming the social solidarity among the citizens because this New City will be inhabited by people who come from all over this island within a short period.

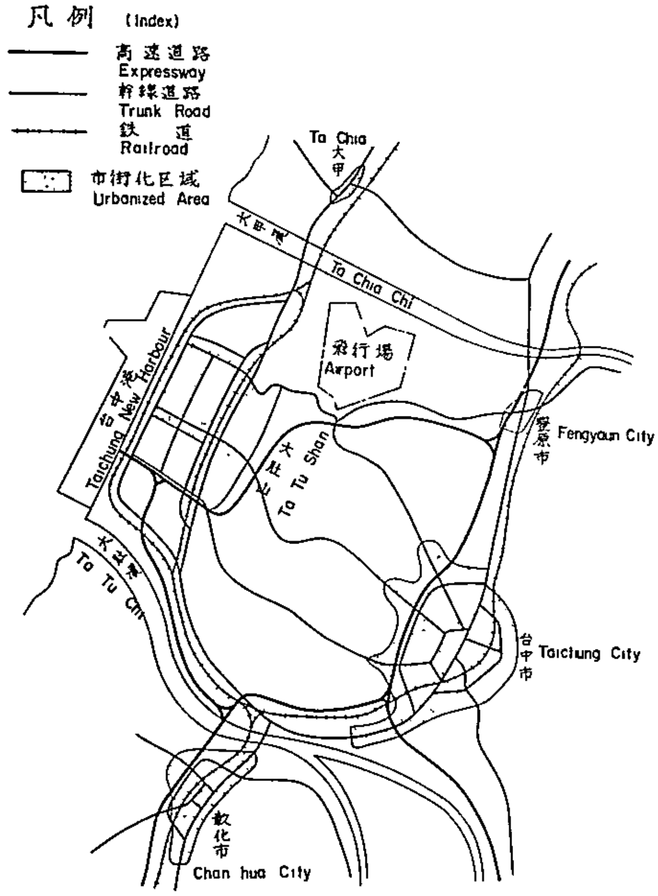
Efforts should be concentrated to solve this hard problem, otherwise New City will become an area where there is no real community.

In order to prevent this unfabourable situation, following two should be carried out: i) Enough surveys and research should be carried out with the integrated service of experts to work out a well balance plan for New City. ii) Schedule of New City construction should be consistent with construction of New Harbour, development of seafront industrial area and national policy of public investment. Construction of New City should be carried out in conformity to the above mentioned schedule.

It is hoped that proposals and comment stated above are carefully examined and improved. It is to be remembered, however, that the basic principle of planning which aims at "Construction of a city with comfortable environments for citizens" should be maintained.

For the smooth execution of New City construction, voluntary cooperation of residents of planned area is indispensable. Therefore, excellent public relations and a system for participation of citizens should be worked out.

Fig VI-4-4 広域交通計画構想図
Tentative Traffic Master-plan for the Region



Fig— VI-4-5 幹線道路の標準断面
Typical Cross Section of Trunk Roads

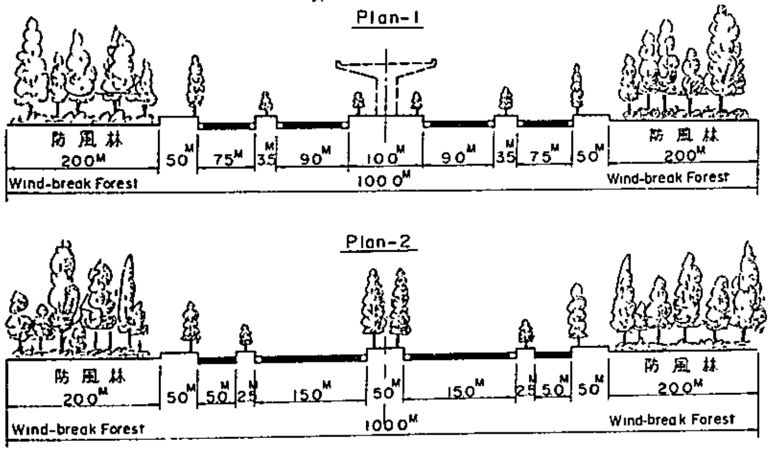


Fig VI-4-6

灌漑用排水路現況図

Present state of Drainage for Irrigation

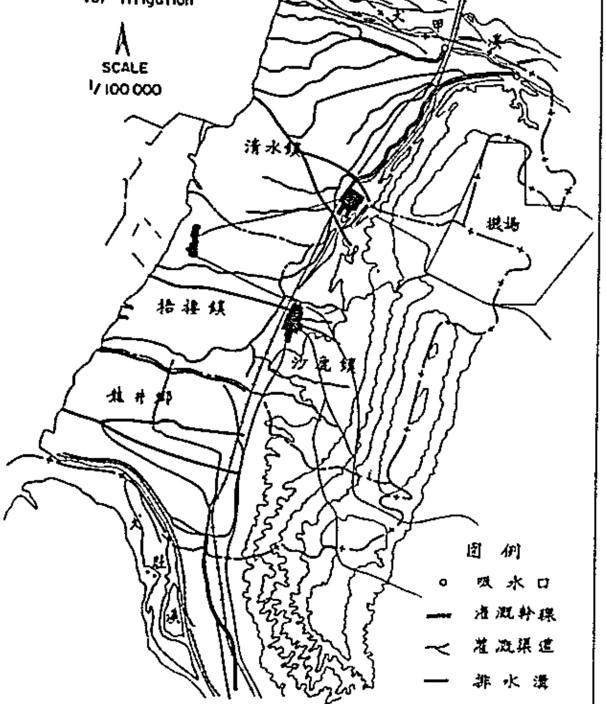
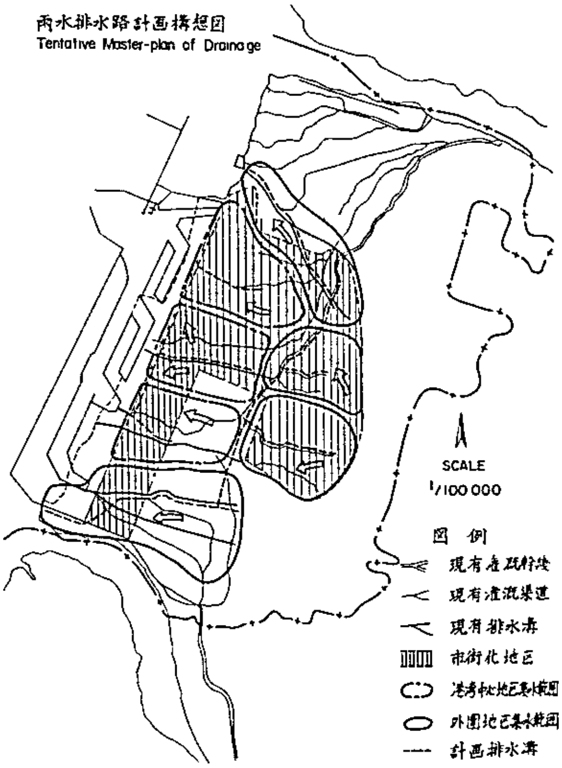


Fig VI-4-7

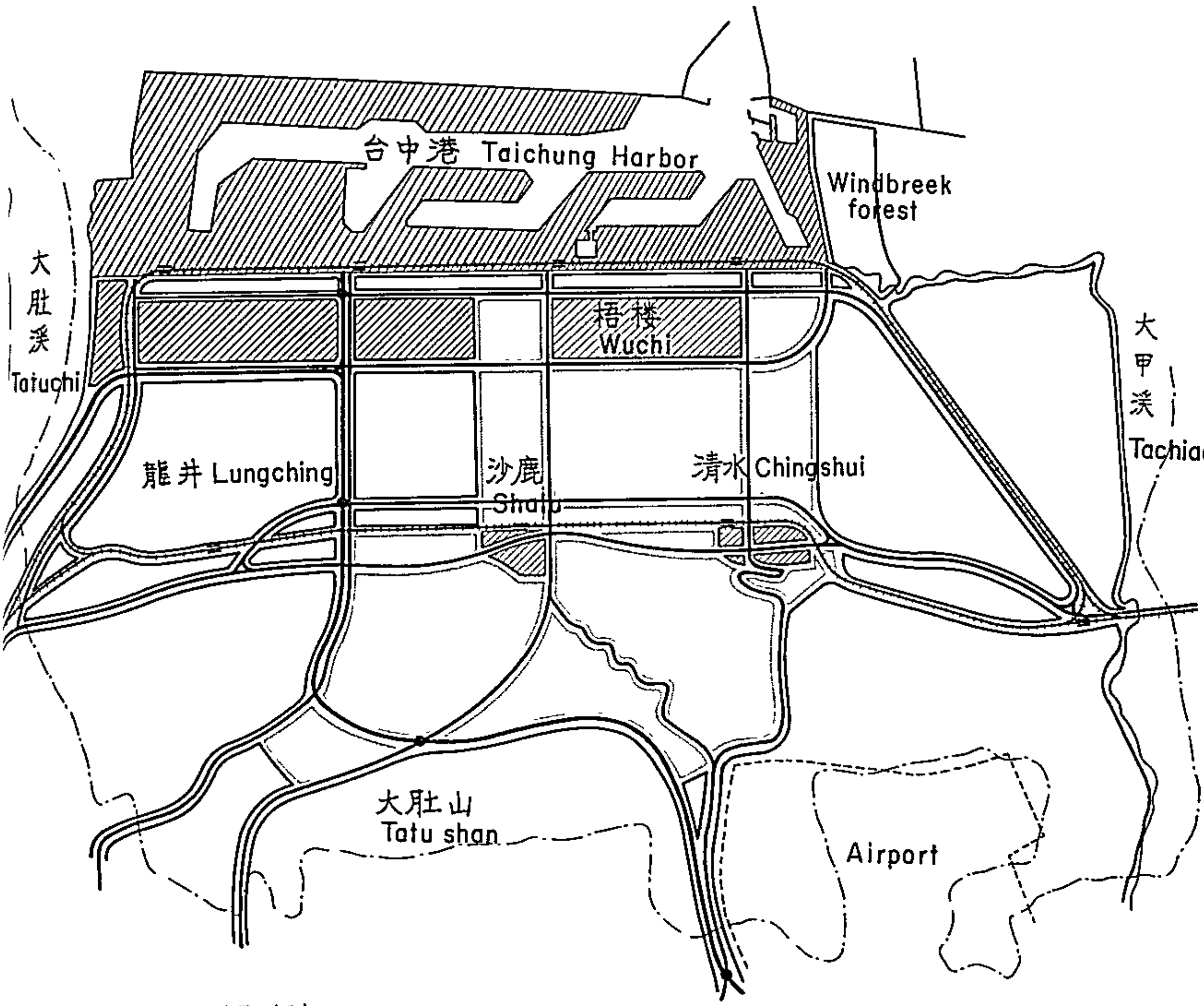
雨水排水路計画構想図

Tentative Master-plan of Drainage



台中港関連都市計画基本構想図

Tetative Master-plan New City for Tai-chung Harbor



凡例 Index

- 鉄道 Railway
- 高速道路 Expressway
- 幹線道路 Trunkroad
- 商業業務地区 Commercial and business distrist
- 住居地区 Residential distrist
- 工業地区 Industrial distrist
- 農耕地,山林,その他 Agricultural land mountain, forests and others
- 調整地帯 Adjustment zone

VII COST EFFECTIVENESS AND CONSIDERATIONS ON INVESTMENT

VII COST-EFFECTIVENESS AND CONSIDERATIONS ON INVESTMENT

1. Cost-Effectiveness Analysis

1.1 Project Goals

Since Taiwan is surrounded by the ocean and is not blessed with sufficient natural resources, promotion of international trade is absolutely essential for her long range economic and social development. For this purpose, international harbours have to be completely equipped at any time on an appropriate scale.

At present, however, three international harbours in this country, Keelung, Kaohsiung and Haulien, cannot be said to be equipped adequately. All of them suffer from the shortage of cargo handling capacity in spite of their highly efficient operation, and are subjected to the shipping congestion. It is evident that the improvement of these harbours fails to catch up with the increase of traffic demands.

The expansion plans for these three harbours were worked out as a part of the Fifth Four-Year Economic Development Plan of Republic of China and have been carried out preponderantly. However, the increase of import-export cargoes tends to exceed the construction speed of these harbours. From the view-point of transportation economy, therefore it is considered most reasonable to construct a new international harbour as soon as possible.

Taichung region has no international harbours, and has resorted to inland transportation facilities so far. By the operation of Taichung Harbour, Taichung region will have a new window for international trade which will serve as the base of economic and social development. At the result, potentiality of regional development will be accelerated, and this is expected not only to promote the economic activities in Taiwan but also to increase the employment opportunities in this region and prevent the outflow of population, relieving indirectly the concentration of population in the northern region.

It is clear that the construction of Taichung Harbour will contribute to the promotion of international trade, and at once promote the progress of national welfare. Therefore, the project should be put into execution as soon as possible as a national enterprise.

1.2 Method of Cost-Effectiveness Analysis

The effect of public investment is extremely difficult to evaluate in market price as compared with private ones because its object is to achieve the progress of national welfare.

It is essential to determine the priority of public investment in order to make best use of the limited national resources. Studies for this purpose have recently been given much importance. Special consideration is demanded to assure reasonable allocation and efficient utilization of national resources in developing countries where limited availability of funds is impeding economic and social development. Accordingly, a proper method of allocating funds should be established as soon as possible.

Cost-effectiveness analysis for public investment is most advanced in the United States. The relationship between the cost and the benefit of public investment was established by the "River and Harbour Act" which was applied in 1902 in in framing policies for public investment. The study has been developed since then, and in 1950 a report commonly called "Green Book" was published, which fixed the general principle and the method of evaluating cost and benefit in the development project of water resources. The "Green Book" could be said to have provided a tentative criterion for the cost-benefit analysis. Many studies have been made on this subject in the academic circles. The most representative of them are the studies by Dr. O. Eckstein, Dr. F. S. Feldstein and Dr. S. A. Marglin. These studies are carried on by the U.S. federal government in its P.P.B.S. (Planning-Programing-Budgeting System).

Although the theory on cost-benefit analysis has progressed considerably as mentioned above, its application has not yet been established systematically because of the lack of data, difficulty in finding the calculation criterion and other factors. Therefore, the cost-effectiveness analysis in the construction of Taichung Harbour is to be made on some assumptions which are given below.

(1) The period of construction project is 11 years between 1970 and 1980. Annual amount of construction is assumed according to the construction schedule shown in Chapter V.

(2) Taichung Harbour should be operated in the middle of 1974 and handle 1 million R/T of import-export commodities in the same year, 4 million R/T in 1977 and 8 million R/T in 1981.

This analysis discusses only the construction project up to 1980, though the construction will continue thereafter.

(3) Generally, the project life of facilities to be analyzed can be represented by their physical, functional or economical life. A project life of 20 years after 1981 is adopted in this analysis because the technology is expected to achieve a remarkable progress through the rapid growth of national economy for many years to come. The experience in Japan would support this figure, and the analyzed period is, therefore, 31 years from 1970 to 2000.

(4) The discount rate in this analysis must be over 13%, the official rate in this country.

At the result, the cost-effectiveness analysis for the construction of Taichung Harbour is performed based on the above-mentioned assumptions, though it is mainly the cost benefit analysis because there are some intangible items of effect. The analysis is conducted as follows.

1.2.1 Case 1

The cost benefit analysis for the construction of Taichung Harbour is aimed at clarifying the cost of construction and maintenance as well as the benefit produced by the construction; after that, the internal rate of return is calculated.

For this purpose, the comparison of the cases with and without Tai chung Harbour is made.

Without Taichung Harbour, the expansion projects of each of the three existing harbours are assumed to be carried out only under the Fifth Four-Year Economic Development Plan without any additional construction programs. Accordingly, the cost of the project consists of expenses for the construction and maintenance of Taichung Harbour.

On the other hand, the benefit of the project consists of three effects by Taichung Harbour construction, i.e., the effect of relieving the shipping congestion in Keelung Harbour, the saving of inland transportation cost of import-export goods, the effect of new reclamation accruing from the construction. Thus, the cost benefit analysis of Case 1 can be formulated as follows.

$$Bt = Ft + Tt + Lt$$

$$Ct = It + Mt$$

$$\frac{B}{C} = \frac{\Sigma Bt\,(1+r)^m}{\Sigma Ct\,(1+r)^n}$$

where

B : Benefit (NT$)
C : Cost (NT$)
F : Effect of relieving the shipping congestion in Keelung Harbour by the operation of Taichung Harbour (NT$)
T : Saving of inland transportation cost of import-export goods (NT$)
L : Effect of new reclamation in Taichung Harbour (NT$)
I : Expenses for construction of Taichung Harbour (NT$)
M : Expense for maintenance of Taichung Harbour (NT$)
r : Discount rate or internal rate of return (%)
t : Time (year)

The analysis of Case 1 is to obtain the value of "r" (internal rate of return) which gives B/C = 1. It will be a tentative criterion for determining the priority between the construction of Taichung Harbour and other public investments.

1.2.2 Case 2

Supposing that the new international harbour is constructed in other suitable site than Wuchi for an operation scale similar to that of Taichung Harbour, cost and benefit are compared with those of Taichung Harbour as follows.

In Case 2, it is assumed that the expansion project of Kaohsiung Harbour is accelerated by cargoes which are expected to be handled at Taichung Harbour. The comparison of cost and benefit between this expansion and the construction of Taichung Harbour shows a more advantageous choice among the two projects. This procedure can be expressed in the following formula.

$\Delta B - \Delta C$ = { (benefit for Taichung Harbour) - (benefit for Kaohsiung Harbour)} - { (cost for Taichung Harbour) - (cost for Kaohsiung Harbour) }

= {(Saving of inland transportation cost of import-export goods between with and without Taichung Harbour) + (effect of new reclamation in Taichung Harbour)} - { (expenses for the construction and maintenance of Taichung Harbour) - (additional expenses for the expansion of Kaohsiung Harbour)}

1.2.3 Case 3

The construction of an international harbour contributes directly to the national economy through the handling of import-export cargoes. It is necessary, therefore, to take its whole effect into account from the macroscopic viewpoint for Taiwan's economy. It may be analyzed by input-output technique, but this method is not employed because of the limited time allowed for the survey term. Accordingly, as the preliminary approach and partly as the complementary analysis for Case 1, the analysis of Case 3 is done.

This analysis calculated the elasticity of cargo handling volume for GNP by regression model and by extraporating the past trend to the future, whereby the effect of the change in the handling volume of import-export cargoes on GNP is obtained.

1.3 Calculation of Cost-Benefit Analysis

1.3.1 Case 1

In this case, the cost for Taichung Harbour consists of the construction expenses (for 11 years from 1970 to 1980) and the maintenance expenses (for 20 years from 1981 to 2000). The construction cost is, as mentioned in Section 3, Chapter V, NT$7,989 million in total, of which NT$5,389 million is in local currency and US$65 million in foreign currency in 1969 constant price, but in the cost benefit analysis, transfers such as custom duties are subtracted and this amounts to US$9,625 thousand (NT$385 million) as shown in Table VII-1-1. At the result, the cost incurred by the construction is NT$5,004 million plus US$65 million in this analysis. On the other hand, Taichung Harbour being subjected to plenty of drift sand caused by natural conditions, maintenance dredging must be carried out on a large scale every year. As the other maintenance expenses are assumed to be the same as those in other harbours, the dredging expenses alone is the cost which should be taken into account for the analysis. Supposing that the dredging of 1500 thousand m^3/year will be carried out with the dredgers used in the construction works, the annual expense is estimated at NT$22.5 million, with the unit cost being 15.0 NT$/$m^3$ (the depreciation for the dredgers is assumed to have been finished during the construction period).

In this case, it must be noted that the internal rate of return might be different according to the method of raising funds for the construction, that is, by whether the total expenses for the construction is covered domestically (Case 1.1) or a part of expense for the construction (imported machines, etc.) is supplied by foreign loans (Case 1.2).

In Case 1.2, a part of the expense for the construction is to be repaid by amortization schedule. The cost of Case 1.1 is calculated to be NT$8,054 million in total and that of Case 1.2 NT$9,273 million in total assuming that the repayment conditions are the same as in the first yen credit and the amortization schedule is as shown in Table VII-1-2. At the result, the yearly schedule of cost requirement is as shown in Table VII-1-3.

In the mean while, the benefit in Case 1 is the effect produced by the construction of Taichung Harbour, which consists of the effect of relieving the shipping congestion in Keelung Harbour, saving of inland transportation cost of import-export goods and utility of reclaimed land. These three effects alone are discussed here, although some other effects such as employment promoting effect and repercussion effect which are intangible are listed up.

(1) The effect of relieving the shipping congestion in Keelung Harbour

Assuming that Taiwan will keep its economic growth at an annual rate of 8.0% without Taichung Harbour, the cargo handling volume of Keelung Harbour estimated by reference to the Report of New Harbour Project - 1969 is as shown in Fig. VII-1-1. However, Keelung Harbour is supposed to be limited in its cargo handling facilities by the natural conditions and after conpletion of the existing expansion program up to 1972, its cargo handling capacity will reach the maximum of 8.5 million R/T of import-export commodities with 30 berths.

Accordingly, when the cargo handling volume exceeds 8.5 million R/T, there will appear some ships waiting for their berth. The analysis by queuing model of M/M/S (∞) type, which was given in the former report, shows the relationship between waiting hours and the rate of berth utilization in Keelung Harbour as shown in Fig. VII-1-2, and the physical limitation of cargo handling facilities is estimated to be 30 berths including 2 container berths and to handling of 11.2 million R/T (ρ = 1.0).

In this case, the demands of cargo handling in Keelung Harbour should appear as above-mentioned, and then it is assumed that the operation in Keelung Harbour is actually put in trouble after 1978, and the cargo handling volumes exceeding 11.2 million R/T are forced to be converted to other harbours, or the economic activities get stagnant. In this analysis, the demurrage is estimated by simple extrapolation supposing that waiting hours shows a linear increase, that is, the moorage cost is estimated at NT$66,800 per day from the actual examples in Japan when the average amount of cargoes handled by a ship is 2,600 R/T and the handling capacity is 1,000 T/berth per day. Accordingly, the demurrage in each year is as shown in Table VII-1-4. It will be appropriate to regard the demurrage as the benefit of the construction of Taichung Harbour. For the estimation on assumptions after 1978, the analysis of Case 3 will check.

The effect of relieving the shipping congestion in Keelung Harbour is supposed to amount to NT$119,950 million during the period of the analysis from 1974 to 2000.

(2) Saving of inland transportation cost of import-export goods

Inland traffic flow of import-export commodities might be different between with and without Taichung Harbour.

Inland transportation costs of import-export goods in both cases estimated by reference to the former report are shown in Fig. VII-1-3 and saving of the cost with Taichung Harbour is estimated in Fig. VII-1-4. However, the amounts saved, which are shown in 1967 constant price, are converted into 1969 constant price (rate of conversion: 1.108) in Table VII-1-5.

Table VII-1-5 Saving of Inland Transportation Cost of Import-Export Goods

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982 2000
Saving	55.4	99.7	144.0	166.2	182.8	199.4	221.6	243.8	243.8

Remarks: Unit-million NT$/year, price - 1969 constant price

Fig VII-1-1 Cargo Handling Volume at Keelung Harbour

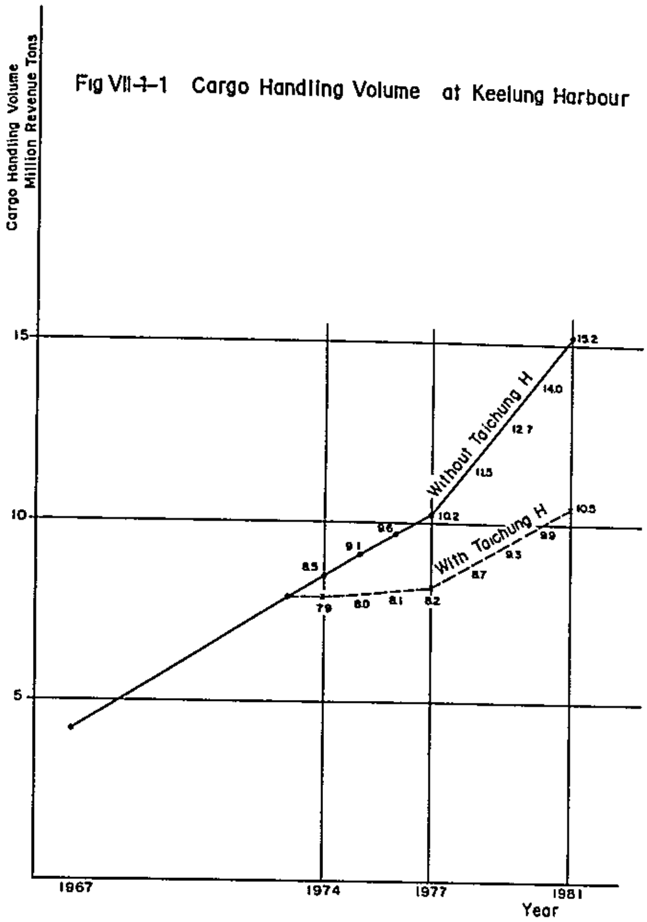


Fig. VII-1-2 Berth Occupancy & AWT/AST

Model M/M/S (∞)

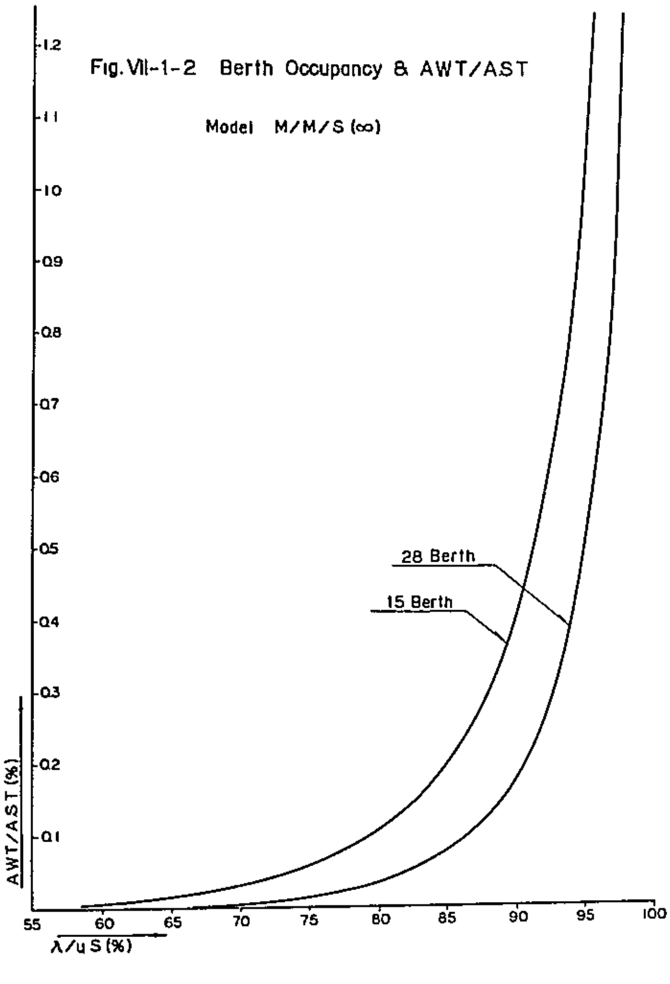


Fig VII-1-3
Inland Transportation Cost on Export-Import Goods

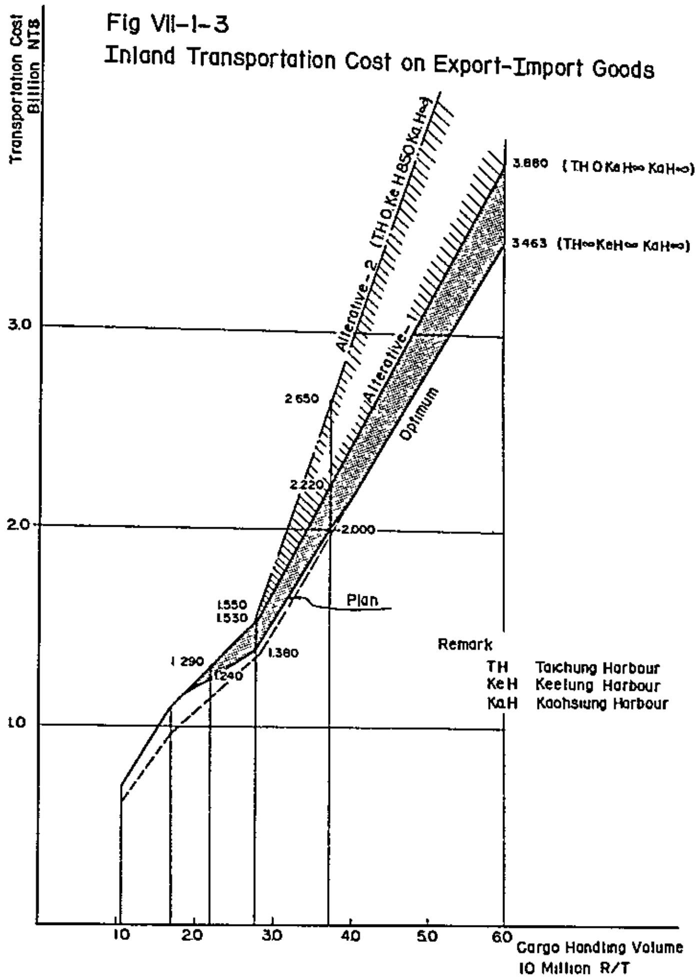


Fig VII-1-4 Saving of Transportation Cost

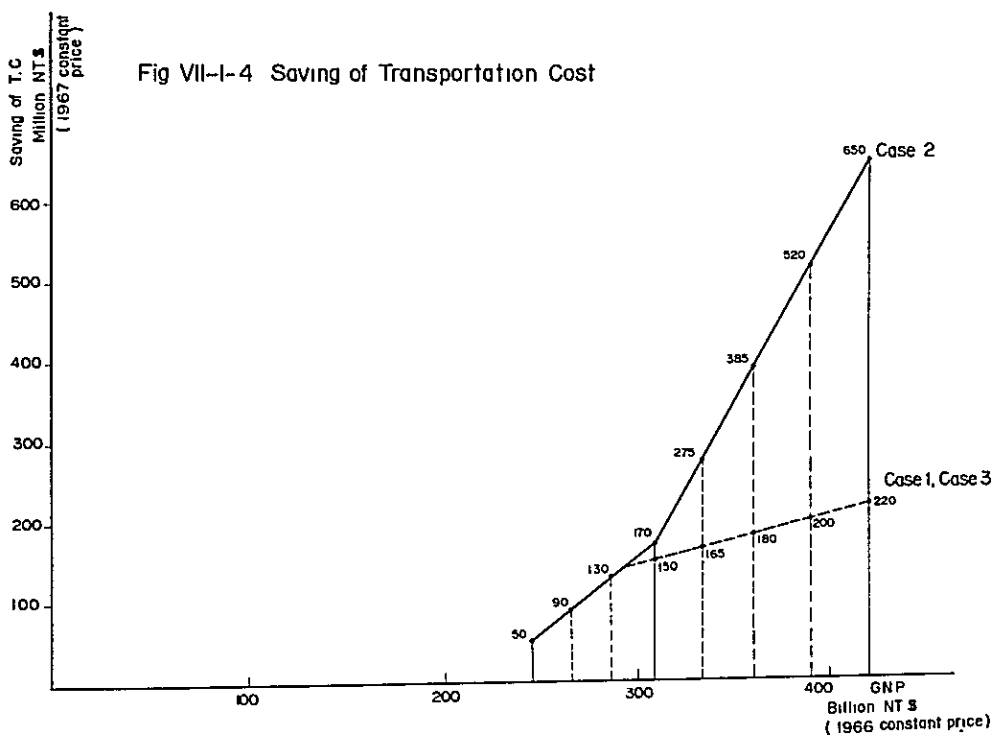


Table VII-1-1 Discount of Foreign Exchange

Unit: 1,000 US$

		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Table	Discount Rate
Provisional Facilities	Foreign Exchange	700	1,519.9	-	-	-	-	-	-	-	-	2,219.9	15 %
	Discount	105	228	-	-	-	-	-	-	-	-	333	
Break Water and Sea Wall	Foreign Exchange	-	-	-	-	116	-	-	-	-	-	116	15 %
	Discount	-	-	-	-	17	-	-	-	-	-	17	
Quay Wall and Retaining Wall	Foreign Exchange	-	-	3,100	3,100	3,395.8	3,600	3,823.4	6,300	6,300	4,769.5	34,388.7	15 %
	Discount	-	-	465	465	510	540	574	945	945	716	5,160	
Special Experiment Facilities	Foreign Exchange	57	-	-	-	-	-	-	-	-	-	57	35 %
	Discount	20	-	-	-	-	-	-	-	-	-	20	
Portside Transpor tation Facilities	Foreign Exchange	40	72	20	20	103.6	100	118.8	33	33	33.2	573.6	35 %
	Discount	14	25	7	7	36	35	42	12	12	12	202	
Cargo Handling Equipment	Foreign Exchange	-	-	-	1,200	587.5	1,200	587.5	600	600	587.5	5,362.5	25 %
	Discount	-	-	-	300	147	300	147	150	150	147	1,341	
Dredger Ship etc.	Foreign Exchange	-	354	8,000	5,388	545	-	-	500	537	-	15,324	3 %
	Discucunt	-	10	240	162	16	-	-	15	16	-	459	
Construction Machine etc.	Foreign Exchange	-	1,196	2,000	1,224	905	-	-	500	463	-	6,288	35 %, 15 %
	Discount	-	372	639	428	317	-	-	175	162	-	2,093	
Others	Foreign Exchange	500	-	-	170.8	-	-	-	-	-	-	670.8	
	Discount	-	-	-	-	-	-	-	-	-	-	-	
Total	Foreign Exchange	1,297	3,141.9	13,120	10,932	5,823 7	4,900	4,529.7	7,933	7,933	5,390 2	65,000.5	
	Discount	139	635	1,351	1,362	1,043	875	763	1,297	1,285	875	9,625	
	Discount Value (1,000 NT$)	5,560	25,400	54,040	54,480	41.720	35,000	30,520	51,880	51.400	35,000	385,000	

Table VII-1-2 Amortization Schedule of Foreign Loan

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Procedure of Foreign Loan (1,000 US$)	1,297	3,141.9	13,120	10,932	5,823.7	4,900	4,529.7	7,933	7,933	5,390.2	-	-	-	-	-	-
Amortization Schedule (1,000 US$)																
Borrowing in 1970	-	45.4	45.4	45 4	45.4	45.4	111 9	111.9	111.9	111.9	111 9	111.9	111.9	111.9	111.9	111.9
Borrowing in 1971	-	55.0	110.0	110.0	110.0	110.0	190.5	271.0	271.0	271.0	271 0	271.0	271.0	271.0	271.0	271.0
Borrowing in 1972	-	-	229.6	459.2	459.2	459.2	459 2	795.5	1,131.7	1,131.7	1,131.7	1,131.7	1,131.7	1,131.7	1,131.7	1,131.7
Borrowing in 1973	-	-	-	191.3	382.6	382.6	382.6	382.6	662.8	943 0	943.0	943.0	943.0	943.0	943.0	943.0
Borrowing in 1974	-	-	-	-	101.9	203.8	203.8	203.8	203.8	353.1	502.4	502 4	502.4	502 4	502 4	502.4
Borrowing in 1975	-	-	-	-	-	85 8	171 5	171 5	171.5	171.5	297.1	422.7	422.7	422.7	422.7	422 7
Borrowing in 1976	-	-	-	-	-	-	79 3	158.5	158 5	158.5	158.5	274 7	390.7	390.7	390 7	390.7
Borrowing in 1977	-	-	-	-	-	-	-	138.8	277.7	277.7	277.7	277 7	481.0	684 3	684.3	684.3
Borrowing in 1978	-	-	-	-	-	-	-	-	138.8	277 7	277 7	277.7	277.7	481.0	684.3	684 3
Borrowing in 1979	-	-	-	-	-	-	-	-	-	94.3	188.7	188.7	188.7	188.7	326 8	465.0
Total (1,000 US$)	-	99.4	385.0	805.9	1,099.1	1,286 8	1,598 8	2,233.6	3,127 7	3,790.4	4,159.7	4,401.5	4,720.8	5,127.4	5,468.8	5,607.0
(1,000 NT$)	-	3,976	15,400	32,236	43,964	51,472	63,952	89,344	125,108	151,616	166,388	176,060	188,832	205,096	218,752	224,280

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total
Procedure of Foreign Loan (1,000 US$)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65,000.5
Amortization Schedule (1,000 US$)																
Borrowing in 1970	111.9	111 9	111.9	111 9	111.9	-	-	-	-	-	-	-	-	-	-	
Borrowing in 1971	271.0	271.0	271.0	271.0	271.0	135.5	-	-	-	-	-	-	-	-	-	
Borrowing in 1972	1,131.7	1,131.7	1,131 7	1,131.0	1,131.7	1,131.7	565 9	-	-	-	-	-	-	-	-	
Borrowing in 1973	943.0	943.0	943.0	943.0	943.0	943.0	943.0	471.5	-	-	-	-	-	-	-	
Borrowing in 1974	502 4	502.4	502 4	502.4	502.4	502.4	502.4	502.4	251.2	-	-	-	-	-	-	
Borrowing in 1975	422.7	422.7	422.7	422 7	422.7	422.7	422.7	422.7	422.7	211.3	-	-	-	-	-	
Borrowing in 1976	390.7	390.7	390 7	390.7	390.7	390 7	390.7	390.7	390.7	390.7	195.4	-	-	-	-	
Borrowing in 1977	684.3	684.3	684.3	684 3	684.3	684.3	684.3	684.3	684.3	684.3	684.3	342.3	-	-	-	
Borrowing in 1978	684.3	684.3	684.3	684.3	684.3	684.3	684.3	684.3	684.3	684 3	684.3	684 3	342.3	-	-	
Borrowing in 1979	465 0	465.0	465 0	465.0	465 0	465 0	465.0	465.0	465.0	465.0	465.0	465 0	465.0	232.5	-	
Total (1,000 US$)	5,607.0	5,607.0	5,607 0	5,607 0	5,607.0	5,359 6	4,658.3	3,620.9	2,898 2	2,435.6	2,029.0	1,491.5	807.2	232 5	-	95,479.7
(1,000 NT$)	224,280	224,280	224,280	224,280	224,280	214,384	186,332	144,836	115,928	97,424	81,160	59,660	32,288	9,300		3,819,188

Remarks Terms of repayment is as follows.

(1) Interest at 3.5% per annum

(2) Loan period 20 years (include grace period 5 years)

(3) Repayments payable from the sixth months after total with drawal.

(4) Equal semi-annual instalments of principal and payments of interest after 5 years.

(5) Ratio of the instalments to the total loan amount 0 04313035.

Table VII-1-3 Estimated Cost and Benefit of Case 1

		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
(1)	Construction Cost in Local Currency (1,000 N.T.$)	117,300	306,6119	584,000	746,000	624,7455	602,500	582,746	446,100	446,100	457,100	475,742.8					
(2)	Discount of Foreign Exchange (1,000 N.T.$)	5,560	25,400	54,040	54,480	41,720	35,000	30,520	51,880	51,400	35,000						
(3)	(1) - (2) (1,000 N.T.$)	111,740	281,2119	529,960	691,520	583,0255	567,500	552,226	394,220	394,700	422,100	475,7428					
(4)	Construction Cost in Foreign Currency (1,000 U.S.$)	1,297	3,1419	13,120	10,932	5,8237	4,900	4,5297	7,933	7,933	5,3902						
(5)	" (1,000 N.T.$)	51,880	125,676	524,800	437,280	232,948	196,000	181,188	317,320	317,320	215,608						
(6)	Amortization of Foreign Loan (1,000 U.S.$)	-	994	385,0	8059	1,0991	1,2868	1,5988	2,2336	3,1277	3,7904	4,1597	4,4015	4,7208	5,1274	5,4688	5,6070
	" (1,000 N.T.$)	-	3,976	15,400	32,236	43,964	51,472	63,952	89,344	125,108	151,616	166,388	176,060	188,832	205,096	218,752	224,280
(8)	Maintenance Cost (1,000 N.T.$)	-	-	-	-	-	-	-	-	-	-	-	22,500	22,500	22,500	22,500	22,500
(9)	Effectiveness of Relief of Shipping Congestion (1,000 N.T.$)	-	-	-	-	-	10,000	30,000	80,000	1,220,000	2,640,000	4,170,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000
(10)	Saving of Inland Transportation Cost (1,000 N.T.$)	-	-	-	-	55,400	99,700	144,000	166,200	182,800	199,400	221,600	243,800	243,800	243,800	243,800	243,800
(11)	Effectiveness of Reclamation (1,000 N.T.$)	-	-	-	-	242,000	-	-	242,000	-	-	-	145,000	-	-	-	-
(12)	Objective Cost of Case 1 - 1 (3) + (5) + (8) (1,000 N.T.$)	163,620	406,8879	1,054,760	1,128,800	815,9735	763,500	733,414	711,540	712,020	637,708	475,7428	22,500	22,500	22,500	22,500	22,500
(13)	Objective Cost of Case 1 -2 (3) + (7) + (8) (1,000 N.T.$)	111,740	285,1879	545,360	723,756	626,9895	618,972	616,178	483,564	519,808	573,716	642,1308	198,560	211,332	227,596	241,252	246,780
(14)	Objective Benefit of Case 1 (9) + (10) + (11) (1,000 N.T.$)	-	-	-	-	297,400	109,700	174,000	488,200	1,402,800	2,839,400	4,391,600	5,978,800	5,833,800	5,833,800	5,833,800	5,833,800

		1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total
(1)	Construction Cost in Local Currency (1,000 N.T.$)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,388,946.2
(2)	Discount of Foreign Exchange (1,000 N.T.$)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	385,000
(3)	(1) - (2) (1,000 N.T.$)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,003,946.2
(4)	Construction Cost in Foreign Currency (1,000 U.S.$)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	65,000 5
(5)	" (1,000 N.T.$)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,600,020
(6)	Amortization of Foreign Loan (1,000 U.S.$)	5,607.0	5,607 0	5,607 0	5,607.0	5,607.0	5,359 6	4,658.3	3,620.9	2,898.2	2,435 6	2,029.0	1,491.5	807.2	232 5	-	95,479.7
	" (1,000 N.T.$)	224,280	224,280	224,280	224,280	224,280	214,384	186,332	144,836	115,928	97,424	81,160	59,660	32,288	9,300	-	3,819,188
(8)	Maintenance Cost (1,000 N.T.$)	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	450,000
(9)	Effectiveness of Relief of Shipping Congestion (1,000 N.T.$)	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	5,590,000	119,950,000
(10)	Saving of Inland Transportation Cost (1,000 N.T.$)	243,800	243,800	243,800	243,800	243,800	243,800	243,800	243,800	243,800	243,800	243,800	243,800	243,800	243,800	243,800	5,945,000
(11)	Effectiveness of Reclamation (1,000 N.T.$)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	629,000
(12)	Objective Cost of Case 1 - 1 (3) + (5) + (8) (1,000 N.T.$)	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	8,053,966.2
(13)	Objective Cost of Case 1 -2 (3) + (7) + (8) (1,000 N.T.$)	246,780	246,780	246,780	246,780	246,780	236,884	208,832	167,336	138,428	119,924	103,660	82,160	54,788	31,800	22,500	9,273,134.2
(14)	Objective Benefit of Case 1 (9) + (10) + (11) (1,000 N.T.$)	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	5,833,800	126,524,100

Table VII-1-4 Congestion Fee at Keelung Harbour

	Without Taichung Harbour		With Taichung Harbour	
	Cargo Handling Volumes 10,000 R/T	Congestion Fee Million NT$	Cargo Handling Volumes 10,000 R/T	Congestion Fee Million NT$
1974	850	0	790	0
1975	910	10	800	0
1976	960	30	810	0
1977	1,020	80	820	0
1978	1,150	1,223	870	3
1979	1,270	2,640	930	20
1980	1,400	4,170	990	50
1981	1,520	5,590	1,050	146

Remark: Congestion Fee is extimated from Report of New Harbour Project - 1969-

At the result, total benefit of saving is NT$5,945.1 million during the period of the analysis from 1974 to 2000.

(3) Effect of Reclamation

The construction of Taichung Harbour will produce a lot of dredged sand with which a new land can be reclaimed. According to the construction schedule, the reclaimed land for commercial and industrial areas is assumed to be 200 ha in 1974 when the Harbour is to be put in operation, 200 ha in 1977 and 124 ha in 1981.

Effect of new reclamation is estimated at NT$1.21 million/ha by an impact study by which a comparable land use in Kaohsiung seaside area is investigated of the price.

Accordingly, the benefit will amount to NT$242 million in 1974, NT$242 million in 1977 and NT$145 million in 1981, totalling NT$629 million.

The cost benefit analysis based on the estimation mentioned above results in Table VII-1-6, and the internal rate of return in Case 1 is calculated to be 28% in Case 1.1 wherein all the expense required is supplied domestically and 35% in Case 1.2 which depends partly on foreign credit.

1.3.2 Case 2

In this case, the cost to be discussed is the difference in the expense for construction and maintenance of Taichung Harbour subtracted the expense for the expansion and maintenance of Kaohsiung Harbour in case of equal cargo handling.

The difference lies in the following items.

(1) Expense for provisional facilities including the roads etc. for construction works in Taichung Harbour.

(2) Expense for breakwaters and sea wall in Taichung Harbour

(3) Expense for the construction of quay wall and retaining wall corresponding to 3 m difference in the tidal range between the two harbours

(4) Expense for special experiment facilities for drift sand etc. in Taichung Harbour

(5) Expense for windbreak and drainage facilities in Taichung Harbour

(6) Expense for dredging and dredgers for the construction of Taichung Harbour

(7) Cost for maintenance dredging

These are shown in Table VII-1-7 and the total to be analyzed here is NT$3,022 million in local and US$25,548 thousand in foreign currency since the discount value of US$2,028 thousand (NT$81,120 thousand) in regard to the foreign exchange can be expected as shown in Table VII-1-8.

The benefit to be discussed here is the saving of inland transportation cost of import-export goods and the effect of new reclamation in Taichung Harbour. The former is as estimated in Table VII-1-9 by reference to the former report, its total during the period from 1974 to 2000 being NT$16, 773 million.

Table VII-1-9 Saving of Inland Transportation Cost of Import-Export Goods

Year	1974	1975	1976	1977	1978	1979	1980	1981	1982	2000
Saving	55.4	99.7	144.0	188.4	304.7	426.6	576.2	720.2	720.2	

Remarks: Unit-million NT$, Price-1969 constant price

Consequently as shown in Table VII-1-10, the difference in benefit, NT$16,778 million surpasses that in cost, NT$4,044 million, and marginal cost benefit ratio (B/C) at a discount rate of 13% is 1.06. This clearly shows that the construction of Taichung Harbour is more advantageous than the expansion of Kaohsiung Harbour.

1.3.3 Case 3

The items to be discussed as the cost here are the same as those given in Case 1, and the benefit is the effect on GNP correlated with the increase of import-export goods handled at Taichung Harbour. Assuming that the total cargo handling volume in Taiwan increases by the additional volume handled in Taichung Harbour, the effect of cargo handling in Taichung Harbour on GNP is assumed as follows.

A regression analysis indicates, as shown in Table VII-1-11, that the elasticity of handling volume of import-export goods for GNP is recently changing and gradually approaching 1.0. Accordingly, the effect of GNP is assumed from the yearly ratio of the handling volume in Taichung Harbour to the country's total on the assumption that the future elasticity is 1.0.

Table VII-1-12 and Fig. VII-1-5 show the result in 1969 constant price, which totals to NT$1,418 billion whereby B/C of 176.0 is obtained to prove the high efficiency of this project.

It is quite natural that the construction project of an international harbour should be given high priority, which is clearly shown in the process of past development of Taiwan's economy.

2. Total Construction Cost of Taichung Harbour

2.1 Total Cost in 1969 Constant Price

Total construction cost of Taichung Harbour in 1969 constant price is expected to be about NT$5,389 million in local currency and US$65,001 thousand in foreign currency as shown in Chapter 5, and its yearly distribution in 1969 constant price is as shown in Table VII-2-1. However, necessary construction cost should be assumed at current price as follows.

Table VII-1-6 Cost Benefit Analysis of Case 1

Unit: million NT$

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
(1) Discount Rate = 28%	0.78125	0.61035	0.47684	0.37253	0.29104	0.22737	0.17764	0.13878	0.10842	0.08470	0.06617	0.05170	0.04039	0.03155	0.02465	0.01926
Objective Cost of Case 1-1	127.8	248.3	503.0	420.5	237.5	173.6	130.3	98.7	77.2	54.0	31.5	1.2	0.9	0.7	0.6	0.4
Objective Cost of Case 1-2	87.3	174.1	260.0	269.6	182.5	140.7	109.5	67.1	56.4	48.6	42.5	10.3	8.6	7.2	6.0	4.8
Objective Benefit	-	-	-	-	86.6	24.9	30.9	67.8	152.1	240.5	290.6	309.1	235.6	184.1	143.8	112.4
(2) Discount Rate = 30%	0.76923	0.59172	0.45517	0.35013	0.26933	0.20718	0.15937	0.12259	0.09430	0.07254	0.05580	0.04292	0.03302	0.02540	0.01954	0.01503
Objective Cost of Case 1-1	125.9	240.8	480.1	395.2	219.8	158.2	116.9	87.2	67.1	46.3	26.5	1.0	0.7	0.6	0.4	0.3
Objective Cost of Case 1-2	86.0	168.8	248.2	253.4	168.9	128.2	98.2	59.3	49.0	41.6	35.8	8.5	7.0	5.8	4.7	3.7
Objective Benefit	-	-	-	-	80.1	22.7	27.7	59.8	132.3	206.0	245.1	256.6	192.6	148.2	114.0	87.7
(3) Discount Rate = 33%	0.75188	0.56532	0.42505	0.31959	0.24029	0.18067	0.13584	0.10214	0.07680	0.05774	0.04341	0.03264	0.02454	0.01845	0.01388	0.01043
Objective Cost of Case 1-2	84.0	161.2	231.8	231.3	150.7	111.8	83.7	49.4	39.9	33.1	27.9	6.3	5.2	4.2	3.4	2.6
Objective Benefit	-	-	-	-	71.5	19.8	23.6	49.9	107.7	163.9	190.6	195.1	143.2	107.6	80.9	60.8
(4) Discount Rate = 35%	0.74074	0.54870	0.40644	0.30107	0.22301	0.16520	0.12237	0.09064	0.06714	0.04974	0.03684	0.02729	0.02021	0.01497	0.01109	0.00822
Objective Cost of Case 1-2	82.8	156.5	221.7	217.9	139.8	102.3	75.4	43.8	34.9	28.5	23.7	5.4	4.3	3.4	2.7	2.0
Objective Benefit	-	-	-		66.3	18.1	21.3	44.3	94.2	141.2	161.8	163.2	117.9	87.4	64.7	48.0

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total	
(1) Discount Rate = 28%	0.01505	0.01176	0.00918	0.00718	0.00561	0.00438	0.00342	0.00267	0.00209	0.00163	0.00127	0.00100	0.00078	0.00061	0.00048		
Objective Cost of Case 1-1	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-	-	-			2,107.8	$B_1/C_{1-1} = 1.07$
Objective Cost of Case 1-2	3.7	2.9	2.3	1.8	1.4	1.0	0.7	0.4	0.3	0.2	0.1	0.1	0.1		-	1,490.2	$B_1/C_{1-2} = 1.52$
Objective Benefit	87.8	68.6	53.6	41.9	32.7	25.6	20.0	15.6	12.2	9.5	7.4	5.8	4.6	3.6	2.8	2,270.1	
(2) Discount Rate = 30%	0.01156	0.00889	0.00684	0.00526	0.00405	0.00311	0.00239	0.00184	0.00142	0.00109	0.00084	0.00065	0.00050	0.00038	0.00029		
Objective Cost of Case 1-1	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	1,968.3	$B_1/C_{1-1} = 0.944$
Objective Cost of Case 1-2	2.9	2.2	1.7	1.3	1.0	0.7	0.5	0.3	0.2	0.1	0.1	0.1	-		-	1,378.2	$B_1/C_{1-2} = 1.353$
Objective Benefit	67.4	51.9	39.9	30.7	23.6	18.1	13.9	10.7	8.3	6.4	4.9	3.8	2.9	2.2	1.7	1,859.2	
(3) Discount Rate = 33%	0.00784	0.00590	0.00443	0.00333	0.00251	0.00189	0.00142	0.00107	0.00080	0.00060	0.00045	0.00034	0.00026	0.00019	0.00015		
Objective Cost of Case 1-2	1.9	1.5	1.1	0.8	0.6	0.4	0.3	0.2	0.1	0.1	0.1	0.1	-	-	-	1,233.7	$B_1/C_{1-2} = 1.132$
Objective Benefit	45.7	34.4	25.8	19.4	14.6	11.0	8.3	6.2	4.7	3.5	2.6	2.0	1.5	1.1	0.9	1,396.3	
(4) Discount Rate = 35%	0.00609	0.00451	0.00334	0.00247	0.00183	0.00136	0.00101	0.00075	0.00055	0.00041	0.00030	0.00022	0.00017	0.00012	0.00009		
Objective Cost of Case 1-2	1.5	1.1	0.8	0.6	0.5	0.3	0.2	0.1	0.1	0.1	0.1	-	-	-	-	1,150.5	$B_1/C_{1-2} = 1.011$
Objective Benefit	35.5	26.3	19.5	14.4	10.7	7.9	5.9	4.3	3.2	2.4	1.8	1.3	1.0	0.7	0.5	1,163.8	

Table VII-1-7 Difference of Construction Cost between Taichung and Kaohsiung Harbour

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total	Remark
(A) In Local Currency (1,000 NT$)													
Provisional Facilities	47,000	111,902	-	-	-	-	-	-	-	-	-	158,902	
Break Water and Sea Wall	-	24,465.5	264,000	264,000	201,013.3	130,000	125,215	-	-	-	-	1,008,697.8	
Quay Wall and Retaining Wall													
- 13 m	-	-	12,000	1,2000	10,950	10,000	9,200	9,200	9,200	9,200	9,200	91,150	0 333
under - 11 m	-	-	10,200	10,200	13,800	15,700	15,500	20,700	20 700	20,700	21,000	148,500	0.182
Dredging	-	-	120,000	120,000	113,480	99,500	94,000	96,000	96,000	96,000	112,200	947,180	
Dredger Ship etc.	-	424.8	6,000	6,000	7,065.6	7,000	3,409	6,500	6,500	6,500	6,505	55,904.4	
Special Experiment Facilities	10,300	-	-	-	-	-	-	-	-	-	-	10,300	
Windbreak	-	-	6,000	6,000	5,800	4,000	2,800	-	-	-	5,600	30,200	
Drainage Facilities	-	-	-	12,000	15,500	8,000	9,500	-	-	11,000	11,000	67,000	
Portside Transportation Facilities	45,000	90,080	-	-	-	-	-	-	-	-	-	135,080	
Sub-total	102,300	226,876.3	418,200	430,200	367,608.9	274,200	259,624	132,400	132,400	143,400	165,705	2,652,914 2	
(B) In Foreign Currency (1,000 US$)													
Provisional Facilities	700	1,519.9	-	-	-	-	-	-	-	-	-	2,219.9	
Break Water and Sea Wall	-	-	-	-	116	-	-	-	-	-	-	116	
Quay Wall and Retaining Wall													
- 13 m	-	-	440	440	401	333	325	433	433	413	-	3,218	
under - 11 m	-	-	324	324	399	473	518	910	910	643	-	4,501	
Dredger Ship etc.	-	354	8,000	5,388	545	-	-	500	537	-	-	15,324	
Special Experiment Facilities	57	-	-	-	-	-	-	-	-	-	-	57	
Portside Transportation Facilities	40	72	-	-	-	-	-	-	-	-	-	112	
Sub-total	797	1,945.9	8,764	6,152	1,461	806	843	1,843	1,880	1,056	-	25,547.9	
Sub-total (1,000 NT$)	31,800	77,836	350,560	246,080	58,440	32,240	23,720	73,720	75,200	42,240	-	1,021,916	

Table VII-1-8 Discount of Foreign Exchange and Objective Cost of Case 2

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
(1) Discount of Foreign Exchange (1,000 US$)												
Provisional Facilities	(740) 119	(1,591.9) 253	-	-	-	-	-	-	-	-	-	(2,331.9) 372
Break Water and Sea Wall	-	-	-	-	(116) 17	-	-	-	-	-	-	(116) 17
Quay Wall and Retaining Wall	-	-	(764) 115	(764) 115	(800) 120	(806) 121	(843) 127	(1,343) 202	(1,343) 202	(1,056) 158	-	(7,719) 1,160
Dredger Ship etc.	-	(354) 10	(8,000) 240	(5,388) 162	(545) 16	-	-	(500) 15	(537) 16	-	-	(15,324) 459
Special Experiment Facilities	(57) 20	-	-	-	-	-	-	-	-	-	-	(57) 20
Total (1,000 US$)	139	263	355	277	153	121	127	217	218	158	-	2,028
" (1,000 NT$)	5,560	10,520	14,200	11,080	6,120	4,840	5,080	8,680	8,720	6,320	-	81,120
(2) Objective Cost of Case 2 (1,000 NT$)												
Difference of Construction Cost in Local Currency	102,300	226,876.3	418,200	430,200	367,608.9	274,200	259,624	132,400	132,400	143,400	165,705	2,652,914.2
Discount of Foreign Exchange	5,560	10,520	14,200	11,080	6,120	4,840	5,080	8,680	8,720	6,320	-	81,120
Total	96,740	216,356.3	404,000	419,120	361,488.9	269,360	254,544	123,720	123,680	137,080	165,705	2,571,794 2

Remarks (1) Objective Cost of Case 2 excludes maintenance cost, 450 million NT$ for twenty years from 1981 to 2,000

(2) Value of provisional facilities includes value of portside transportation facilities

(3) Figures in brackets show foreign exchange

Table VII-1-10 Cost and Benefit of Case 2

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
(1) Objective Cost of Case 2 (1,000 NT$)																
In Local Currency	96,740	216,356.3	404,000	419,120	361,488.9	269,360	254,544	123,720	123,680	137,080	165,705	22,500	22,500	22,500	22,500	22,500
In Foreign Currency	31,800	77,836	350,560	246,080	58,440	32,240	33,720	73,720	75,200	42,240	-	-	-	-	-	-
Total:	128,540	294,192.3	754,560	665,200	419,928.9	301,600	288,264	197,440	198,880	179,320	165,705	22,500	22,500	22,500	22,500	22,500
(2) Objective Benefit of Case 2 (1,000 NT$)																
Saving of Transportation Cost	-	-	-	-	55,400	99,700	144,000	188,400	304,700	426,600	576,200	720,000	720,000	720,000	720,000	720,000
Effectiveness of Reclamation	-	-	-	-	242,000	-	-	242,000	-	-	-	145,000	-	-	-	-
Total	-	-	-	-	297,400	99,700	144,000	430,400	304,700	426,600	576,200	865,000	720,000	720,000	720,000	720,000
(3) Marginal Cost Benefit Analysis																
discount rate = 13%	0.88496	0.78315	0 69305	0.61332	0 54276	0.48032	0.42506	0.37616	0.33288	0.29459	0.26070	0.23071	0 20416	0.18068	0.15989	0 14150
Marginal Cost	113.8	230.4	522.9	408.0	227 9	144.9	122 5	74.3	66.2	52.8	43 2	5.2	4 6	4.1	3.6	3.2
Marginal Benefit	-	-	-	-	161.4	47.9	61 2	161.9	101.4	125.7	150.2	199.7	147.0	130.1	115.2	101.9

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	Total	
(1) Objective Cost of Case 2 (1,000 NT$)																	
In Local Currency	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	3,021,794.2	
In Foreign Currency	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,021,916	
Total:	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	22,500	4,043,710.2	
(2) Objective Benefit of Case 2 (1,000 NT$)																	
Saving of Transportation Cost	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	16,149,000	
Effectiveness of Reclamation	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	629,000	
Total	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	720,000	16,778,000	
(3) Marginal Cost Benefit Analysis																	
discount rate = 13%	0.12522	0.11081	0.09806	0 08678	0 07680	0.06796	0.06014	0.05323	0.04710	0.04168	0.03689	0.03264	0.02889	0.02557	0.02262		
Marginal Cost	2.8	2.5	2.2	2.0	1 7	1.5	1.4	1.2	1 1	0.9	0.8	0 7	0.7	0.6	0.5	2,048.2	B_2/C_2 = 1 06
Marginal Benefit	90 2	79.8	70 6	62.5	55.3	48.9	43.3	38 3	33.9	30 0	26.6	23 5	20 8	18.4	16.3	2,162.0	

Fig. VII-1-5
Macro Economic Effect of Cargo Handling at Taichung Harbour

Mark ( ) is shown at 1969 constant price

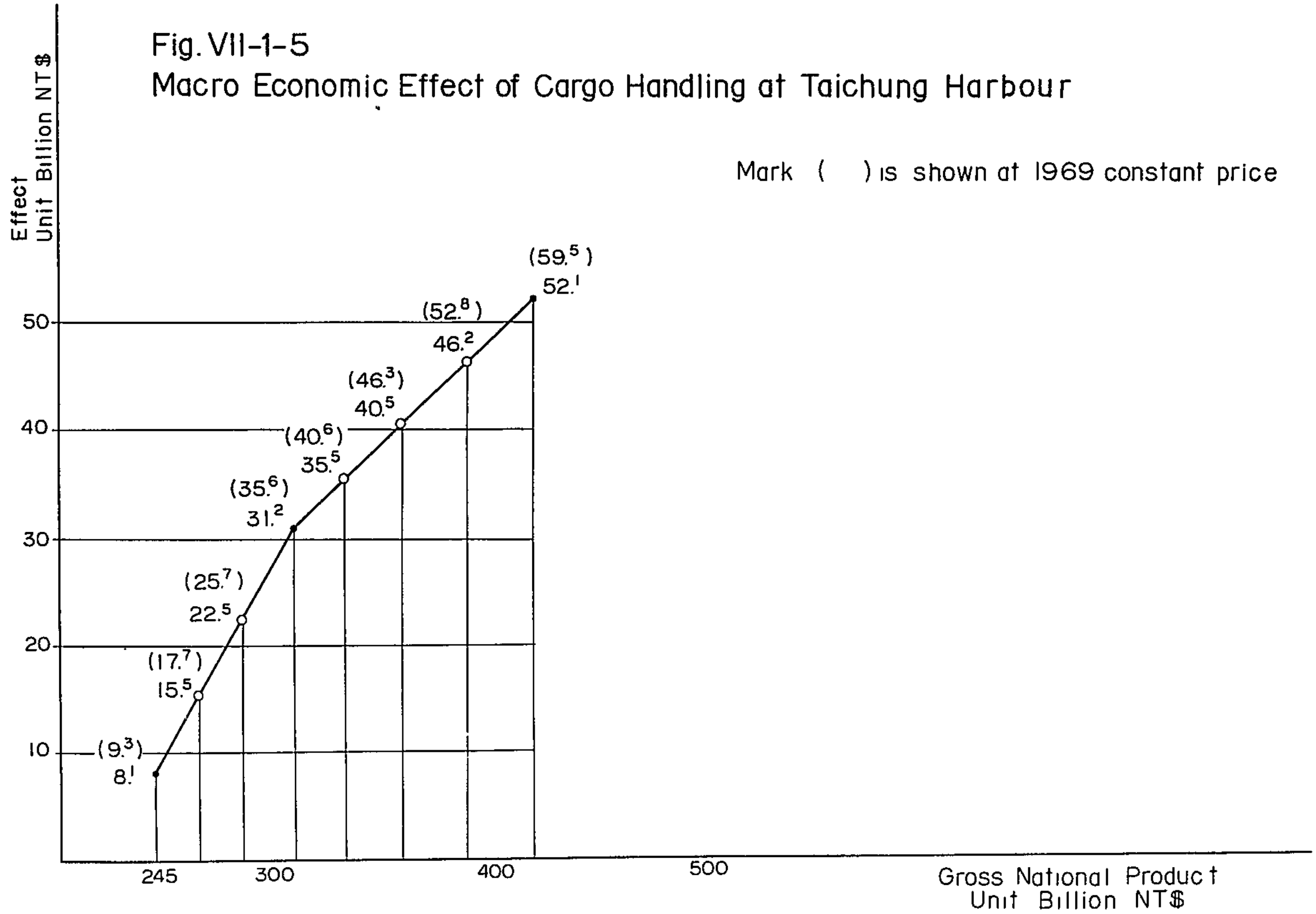


Table VII-1-11

Elasticity of Cargo Handling Volumes for GNP

Period	Elasticity
1952 - 1967	1.0210
1957 - 1964	1.0224
1958 - 1965	1.0193
1959 - 1966	1.0160
1960 - 1967	1.0125

Table VII-1-12

Macro Economic Effect of Cargo Handling at Taichung Harbour

Item		1974	1977	1981	Remark
Cargo Handling at Tacichung Harbour	(A)	1,000	4,000	8,000	1,000 R/T
Total Cargo Handling	(B)	30,200	39,600	54,600	1,000 R/T
A/B	(C)	0.0331	0.101	0.124	
GNP (1966 price)	(D)	245,000	309,000	421,000	Million NT$
(C) x (D) Effect (1966 price)		8,113	31,212	52,136	Million NT$
(1969 price)		9,300	35,600	59,500	Million NT$

2.2 Estimation of Deflator on Taichung Harbour Construction

It is desirable to speed up the construction of Taichung Harbour from the point of view of national economy. Therefore, construction schedule prepared by the survey team includes rush work. Accordingly the construction price will go up, but the productivity will increase on the other hand.

Taking into account the above-mentioned facts, estimated deflator on the construction of Taichung Harbour is reached by regression models based on national income statistics using the deflators of domestic fixed capital formation and of gross national expenditure. Estimated figures are shown in Table VII-2-2, and the average annual growth rate is estimated at little over 3.0%.

In order to check the above-mentioned deflator, the method using implicit deflator is adopted. Unit cost of Keelung Harbour construction over the past five years is classified into wages, materials, chemicals and others, and the trend of each is estimated by regression model. On the other hand, the weight of aggregate materials on the construction of Taichung Harbour is gotten by the construction schedule. Then, the implicit deflator is estimated as shown in Table VII-2-3, in which the growth rate shows a rapid increase. But, these figures are based upon the construction in the area near Taipei City which includes a large amount of small scale construction works. In case of construction of Taichung Harbour in Taichung region, there are enough labour force and few construction programmes. Therefore, it is not appropriate to apply the figures using the implicit deflator. Moreover, by the advanced productivity of large scale construction project, estimated figures will be lowered. In consequence, the figures estimated from the national income statistics are used as the deflator on construction of Taichung Harbour. Increase in productivity should be taken into special account.

The deflator on import machines, etc. for the construction is estimated to show no remarkable fluctuation because of the trend of deflator on world import shown in Table VII-2-4.

2.3 Total Amount of Construction Cost at Current Price

According to the assumption of construction schedule of Taichung Harbour shown in Table VII-2-1 and the estimation of above-mentioned deflator, the construction cost at current price is expected to reach the value shown in Table VII-2-5 and the total amount for eleven years from 1970 to 1980 is estimated to be about NT$6,423 million in local currency and US$65,001 thousand in foreign currency. These figures presuppose the advancement in productivity, therefore, rationalization of construction administration process utilizing electronic computers is necessary.

2.4 Considerations on Domestic Fixed Capital Formation and Application of Foreign Funds

Together with economic development, domestic fixed capital formation in Taiwan also progressed remarkably and its ratio in GNE continued to grow from 13.11% in 1957 to 22.10% in 1968 as shown in Table VII-2-6. The investment by public sector, mainly the central government and the provicial government, was predominant in domestic capital formation before 1963, but after 1964 private investment continued to increase very rapidly and its share in total investment was also expanded. This is the result of successful policy implemented to elevate the investment volition of private enterprises and to keep the long-range economic development of Taiwan.

On the other hand it is evident that the public investment has been executed successfully as one of the most important policies of Republic of China. The ratio of government fixed capital formation in GNE continued to go up steadily, although it is under 10%. The public investment as an essential infrastructure of economic development should be insured as much as possible,and considering the process of Japanese economic development, its share should be over 10% at least to assure the long-range economic and social development in Taiwan. Although it is not appropriate to compare Taiwan with Japan, the role of public sector in Taiwan is far more important than in Japan.

Moreover, social overhead capital for transportation was invested ambitiously, and its effect was very remarkable. Its share in total was approximately 35% to 45% for the past decade.

It is well known that the most strategical means for economic and social development in developing countries is the equipment of arterial transportation facilities. It is therefore necessary to expand the investment, especially because of the increasing pressure of the traffic congestion. Efforts should be also made for the establishment of modern transportation system to cope with the future progress of economic and social development and the growing demands for better transportation service.

However, in order to meet the demand for improvement of transportation facilities with limited domestic funds and to achieve maximum performance of such facilities, the investment should be made more efficiently with the investment priority given stricter examination than before. In addition to the domestic funds, foreign funds should be induced positively for the equipment of social overhead capital which is an efficient means of accelerating the national economy and the social development.

Allocation of domestic funds is greatly influenced by Taichung Harbour construction since it is profitable for national economy that the construction is materialized by a great amount of short term investment. This calls for appropriate distribution of domestic funds and procurement of foreign funds.

Table VII-2-1 Construction Schedule of Taichung Harbour

Unit: 1,000 NT$ (1969 price)
1,000 US$ (1969 price)

	Preparatory Stage			First Stage			Second Stage			Third Stage			Total
	1970	1971	1972	1973	1974 (1 - 6)	1974 (7 - 12)	1975	1976	1977	1978	1979	1980	
Construction Cost in Local Currency	484,599 5			1,679,849.9			1,422,779			1,801,717.8			5,388,946.2
Construction Cost in Foreign Currency	21,050.9			10,838.7			13,459.7			19,651.2			65,000.5
(A) In Local Currency													
Provisional Facilities	47,000	111,902	-	-	-	-	-	-	-	-	-	-	158,902
Break Water and Sea Wall	-	24,469.5	264,000	264,000	131,013.3	70,000	130,000	125,215	-	-	-	-	1,008,697 8
Quay Wall and Reteining Wall	-	-	92,000	92,000	51,490	57,000	115,000	112,997 4	141,600	141,600	141,600	143,441.1	1,088,728.5
Dredger and Construction Machine	29,100	44,618.8	5,312	7,480	-	7,600	15,200	14,402	4,200	4,200	4,200	3,775	140,087 8
Dredging	-	-	120,000	120,000	66,480	47,000	99,500	94 000	96,000	96,000	96,000	112,200	947,180
Portside Transportation Facilities	45,000	90,080	26,000	26,000	13,327	13,000	26,000	27,508	40,000	40,000	40,000	38,452	425,367
Cargo Handling Equipment	-	-	-	150,000	78,032 7	-	150,000	145,755 1	120,000	120,000	120,000	124,318 7	1,008 106 5
Others	25,300	67,129.2	58,000	70 000	44,714.9	34,000	68,000	70,601 5	38,000	38,000	49,000	49,131	611,876.6
Sub-total	146,400	338,199.5	565,312	729,480	385,057 9	228,600	603,700	590 479	439 800	439,800	450,800	471,317 8	5,388,946 2
(B) In Foreign Currency													
Provisional Facilities	700	1,519.9	-	-	-	-	-	-	-	-	-	-	2,219.9
Break Water and Sea Wall	-	-	-	-	-	116	-	-	-	-	-	-	116
Quay Wall and Retaning Wall	-	-	3,100	3,100	1,595.8	1,800	3 600	3 823.4	6,300	6,300	4,769.5	-	34,388 7
Dredger ship and Construction Machine	6,700	11,462	1,113	-	-	400	800	742	395	-	-	-	21,612
Portside Transportation Facilities	40	72	20	20	53 6	50	100	118 8	33	33	33 2	-	573 6
Cargo Handling Equipment	-	-	-	1,200	587 5	-	1,200	587 5	600	600	587 5	-	5,362.5
Others	557	-	-	-	48 8	122	-	-	-	-	-	-	727 8
Sub-total	7,997	13,053.9	4,233	4,320	2,285.7	2 488	5 700	5,271 7	7,328	6,933	5,390 2	-	65,000 5

Table VII-2-2 Estimated Deflator

Base year 1969 = 100

		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Remark
Deflator of Fixed Capital Formation	(A)	103.2	106.3	109.4	112.6	115.7	118.9	122.0	125.2	128.3	131.5	134.6	1951 - 1968
Deflator of GNE	(B)	103.6	107.3	110.9	114.5	118.1	121.8	125.4	129.0	132 7	136.3	139.9	1951 - 1969
"	(C)	102.5	105.0	107.5	110.0	112 5	115.0	117.5	120.0	122 5	125.0	127.5	1960 - 1969
Estimated Deflator 1/3 (A + B + C)		103.1	106.2	109.3	112.4	115.4	118.6	121.6	124.7	127.8	130.9	134.0	

Table VII-2-3 Implicit Defloator by Construction Materials

Base year 1969 = 100

		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Remakr
Wages	Deflator	110.0	121.0	133.1	146.1	161.1	177.2	194 9	214.4	235.8	259.4	285.3	
	Weight	0.10	0.10	0.10	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	
Metal and Gravel	Deflator	108.0	116.6	126.0	136.1	146.9	158.7	171.4	185.1	199.9	215.9	233.2	
	Weight	0.04	0.04	0.30	0.30	0.27	0.23	0.23	0.30	0.30	0 30	0.30	
Other Materials	Deflator	101.2	102.4	103.6	104.9	106.2	107.4	108.7	110.0	111.3	112.7	114.0	
	Weight	0.01	0.01	0.12	0.12	0.12	0.13	0.15	0.15	0.15	0 15	0.15	
Construction Machine	Deflator	100.0	100 0	100.0	100 0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
	Weight	0.80	0.80	0.08	0.08	0.09	0.10	0.10	-	-	-	-	
Others	Deflator	103.0	106.1	109.3	112 6	115.9	119.4	123.0	126.7	130.5	134.4	138.4	
	Weight	0.05	0.05	0 10	0.10	0.11	0.12	0.12	0.15	0.15	0.15	0.15	
Implicit Deflator		101.6	113.3	122.4	131.2	138.6	145.6	158 4	176.8	190.6	205.6	221.9	

Table VII-2-4 Deflator on Warld Import

Base year 1965 = 100

Fiscal Year	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Deflator	99.7	102 9	104.2	98.2	97.3	97.3	97.1	96.3	97.8	99.4	100 2	101.2	101.0	100 5
Increase rate	-	3.3	1.2	-5.7	-1.0	0.0	-0 3	-0.8	1.6	1.7	0.8	1 0	-0.2	-0.5

Data source: Economic Planning Agency of Japan

Table VII-2-5 Construction Cost at Current Price on Taichung Harbour

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Total
Construction Cost in Local Currency												
1969 constant price (1,000 NT$)	146,400	338,199.5	565,312	729,480	613,657.9	603,700	590,479	439,800	439,800	450,800	471,317.8	5,388,946.2
estimated deflator	1.032	1.062	1.093	1.124	1.154	1.186	1.216	1.247	1.278	1.309	1.340	
current price (1,000 NT$)	151,084.8	359,167.9	617,886.0	819,935.5	708,161.2	715,988.2	718,022 5	548,430 6	562,064.4	590,097.2	631,565.9	6,422,404.2
Construction Cost in Foreign Currency												
(1,000 US$)	7,997	13,053.9	4,233	4,320	4,773.7	5,700	5,271.7	7,328	6,933	5,390.2	-	65,000.5
(1,000 NT$)	319,880	522,156	169,320	172,800	190,948	228,000	210,868	293,120	277,320	215,608	-	2,600,020
Total Construction Cost												
1969 constant price (1,000 NT$)	466,280	860,355.5	734,632	902,280	804,605.9	831,700	801,147	732,920	717,120	666,408	471,317.8	7,988,966.2
current price (1,000 NT$)	470,964.8	881,323.9	787,206	992,735.5	899,109.2	943,988 2	928,890.5	841,550.6	839,384.4	805,705.2	631,565 9	9,022,424.3

Table VII-2-6 Statistics of GNP and Fixed Capital Formation

Item	Mark	Unit F.Y	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Gross National Product (at current price)	PV	million NT$	40,291	44,752	51,727	62,561	69,792	76,882	87,134	102,209	112,867	125,554	143,045	167,975	190,421
Gross National Product (at constant price of 1966)	V	"	59,903	63,433	67,901	71,605	77,443	83,640	93,241	106,059	115,147	125,554	138,730	152,760	166,685
Fixed Capital Formation (at current price)	PI	"	5,283	6,765	8,595	10,361	11,349	11,623	13,335	14,872	19,090	23,974	30,185	37,130	
Fixed Capital Formation (at constant price of 1966)	I	"	6,147	7,461	9,048	10,292	11,682	12,061	14,131	15,183	19,172	23,974	29,865	35,541	
Government F.C.F. (at current price)	PIg	"	2,977	4,089	4,618	4,910	5,588	5,611	6,006	5,816	6,395	8,635	11,500	14,572	
Government F.C.F. (at constant price of 1966)	Ig	"	3,464	4,510	4,862	4,877	5,752	5,822	6,364	5,938	6,423	8,635	11,378	13,949	
Private F.C.F. (at current price)	PIp	"	1,865	2,101	3,097	4,175	4,672	4,909	5,648	7,815	10,984	13,088	15,498	18,187	
G.F.C.F. in Transportation (at current price)	PIgt	"	578.9	821.8	949.5	1,531.5	1,788.5	1,719.9	1,129.9	2,218.1	2,842 9	3,877.6	4,193.4	5,145.0	
G.F.C.F. in Transportation (at constant price of 1966)	Igt	"	673.6	906.4	999.6	1,521.3	1,841.0	1,784.7	1,197.3	2,264.5	2,855.2	3,877.6	4,149.0	4,924.9	
PI/PV		%	13.11	15.11	16.61	16.56	16.26	15.11	15.30	14.55	16.91	19.09	21.10	22.10	
I/V		"	10.26	11.76	13.32	14.37	15.08	14.42	15.15	14.31	16.65	19.09	21.52	23.26	
PIg/PV		"	7.38	9.13	8.92	7.84	8.00	7.29	6.89	5.69	5.66	6.87	8.03	8.67	
Ig/V		"	5 78	7.10	7.16	6.81	7.42	6.96	6.82	5.59	5.57	6.87	8.20	9.13	
PIg/PIp		"	159.62	194.62	149.11	117.60	119.60	114.30	106.33	74.42	58.22	65.97	74.20	80.12	
PIgt/PI		"	19.44	20.09	20.56	31.19	32.00	30.65	18.80	38.13	44.45	44.90	36.46	35.30	
PIgt/PV		"	1.43	1.83	1.83	2.44	2.56	2.23	1.29	2.17	2.51	3.08	2.93	3.06	
Igt/V		"	1.12	1.42	1.47	2.12	2.37	2.13	1.28	2.13	2 47	3.08	2.99	3.22	
Deflators of G.N.P.	1966 base year		67.26	70.55	76.18	87.37	90.12	91.92	93 45	96.37	98.02	100.00	103.11	109.96	114.24
Deflators of I, Ig Ip, Igt	1966 base year		85.94	90.67	94.99	100.67	97.15	96.37	94.37	97.95	99.57	100.00	101.07	104.47	108.79

MASTER PLAN

OF

TAI·CHU HARBOR

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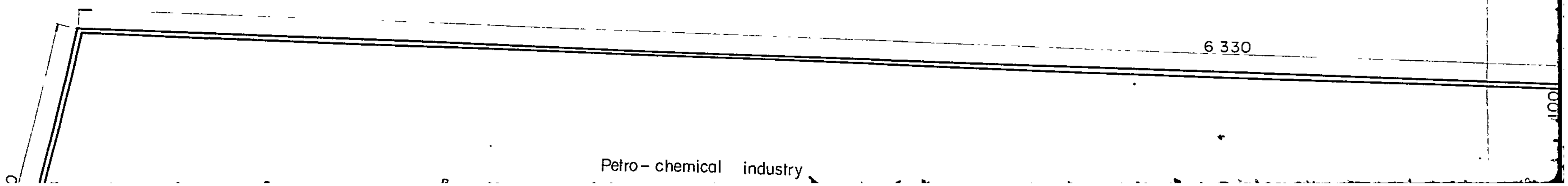
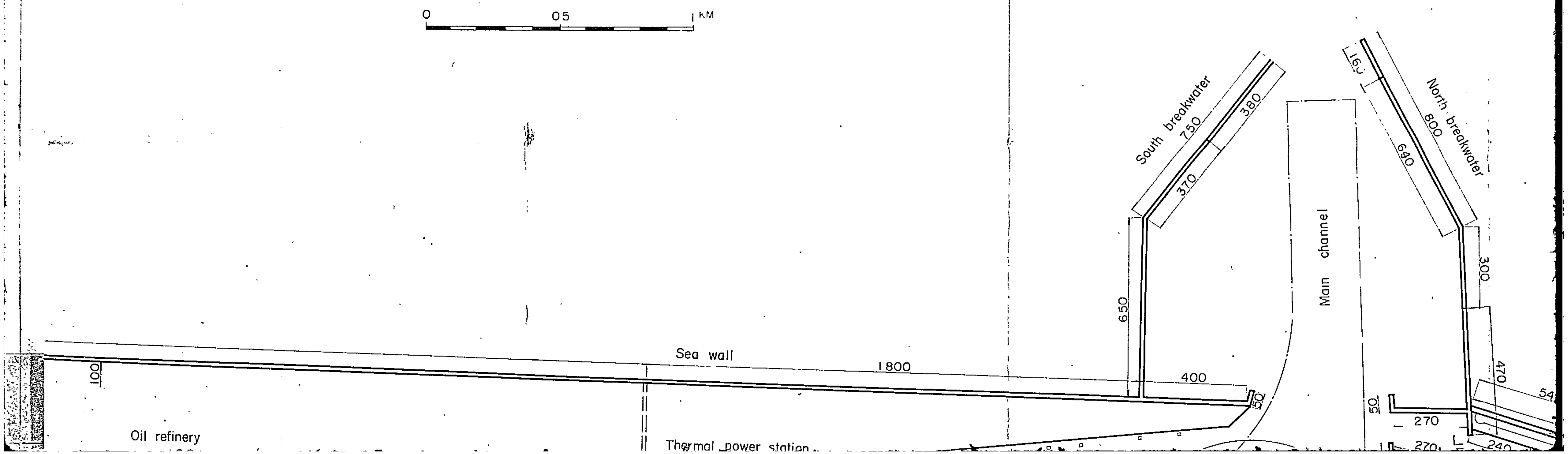
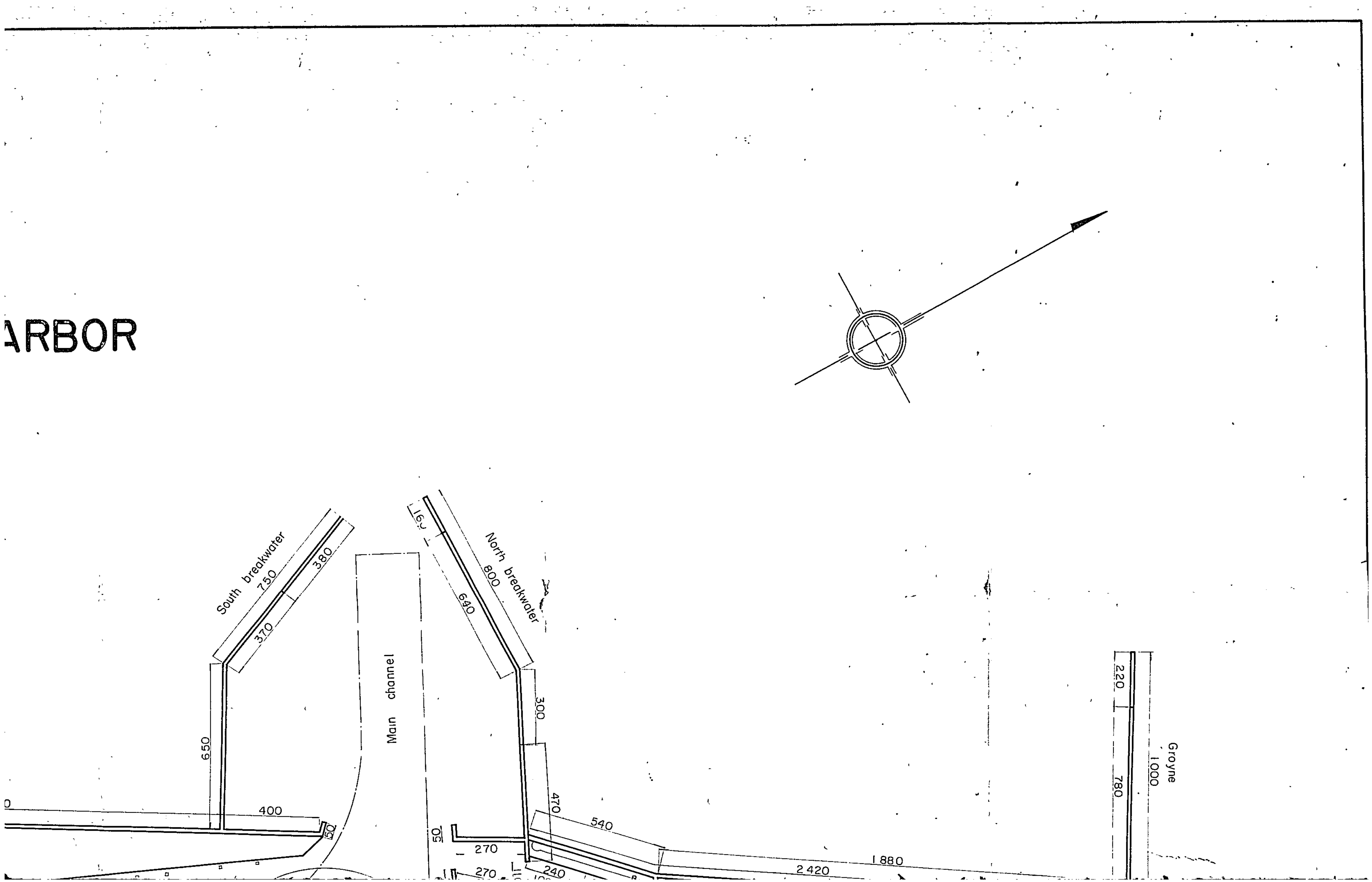
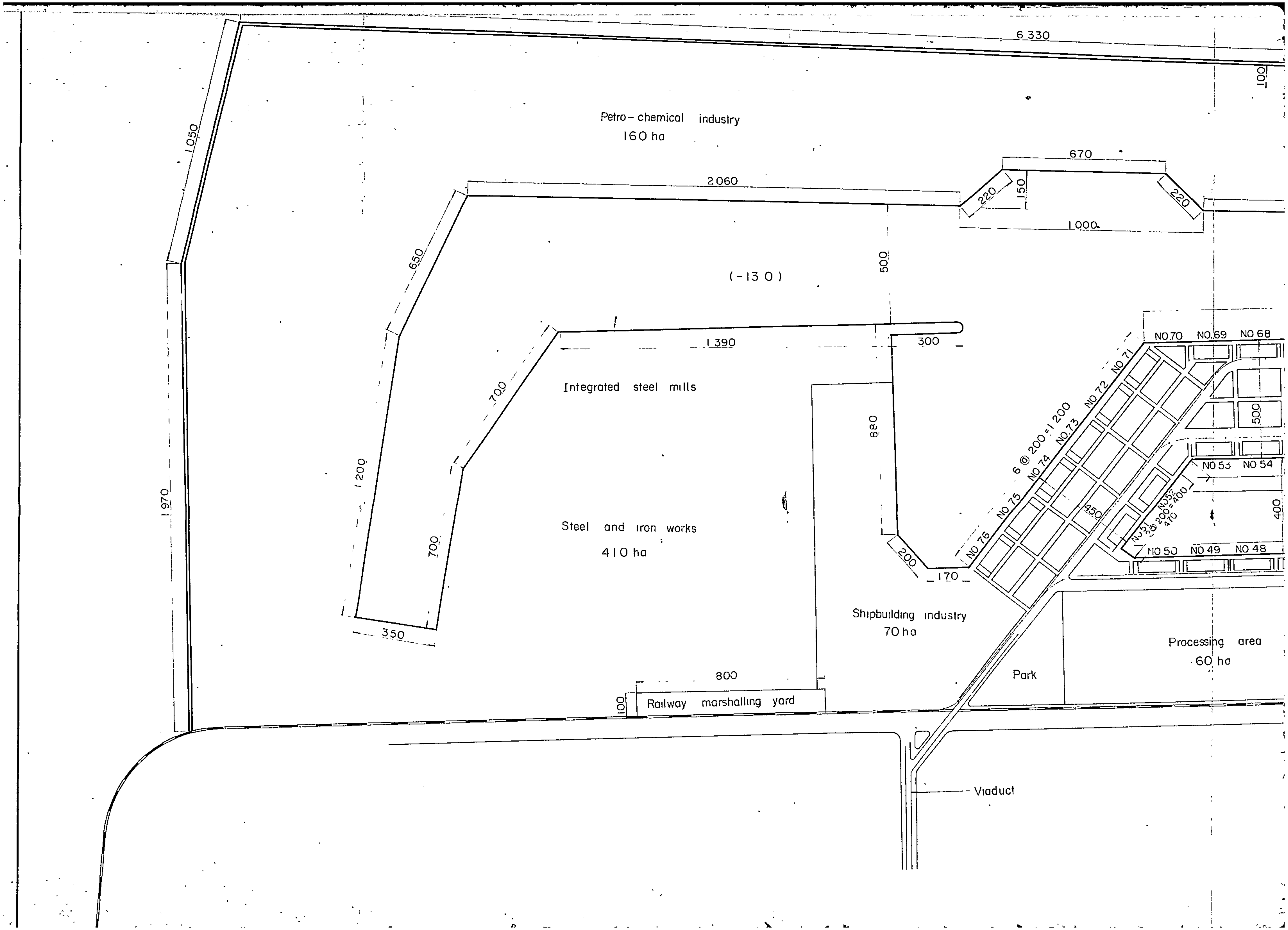


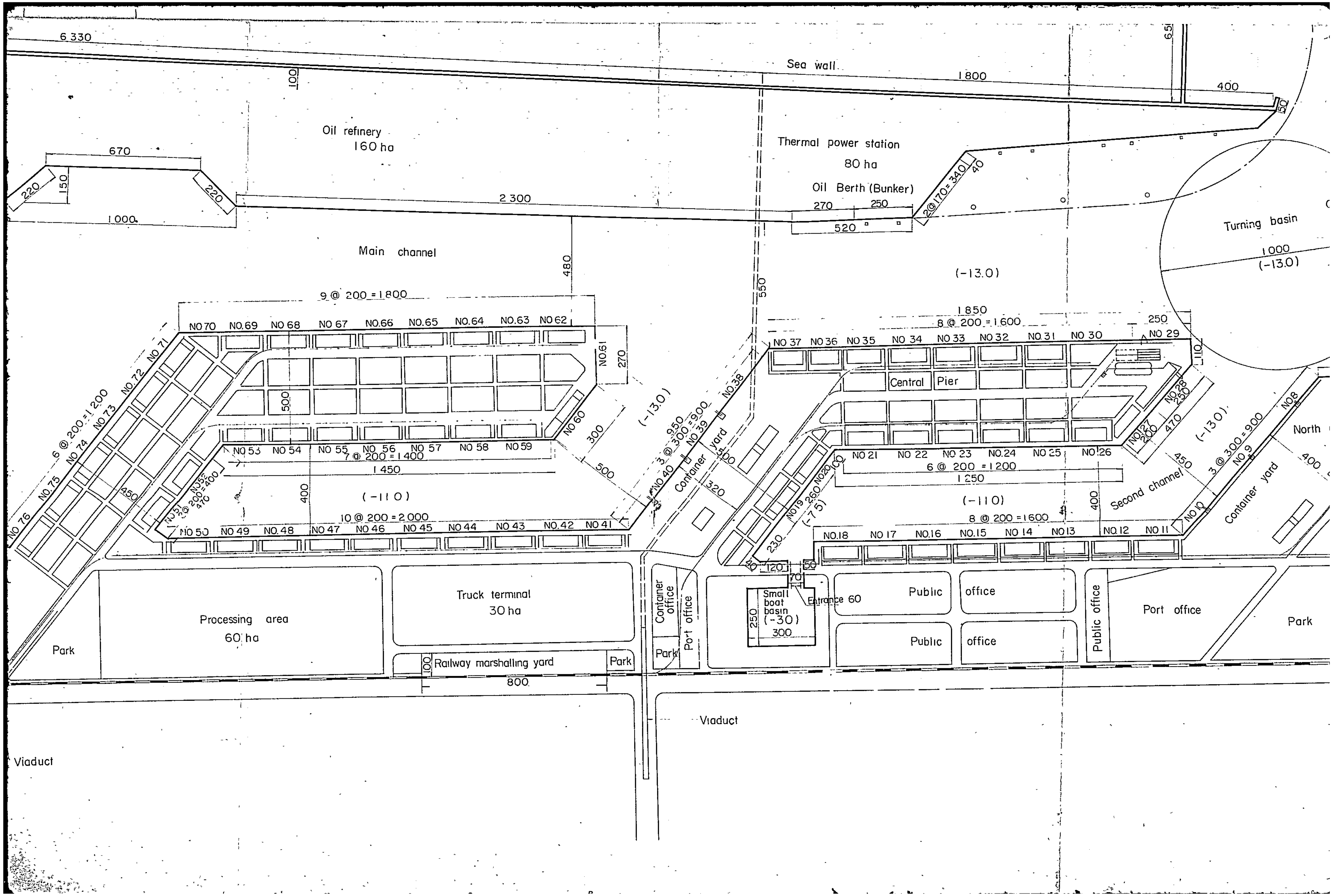
MASTER PLAN OF TAI·CHUNG HARBOR



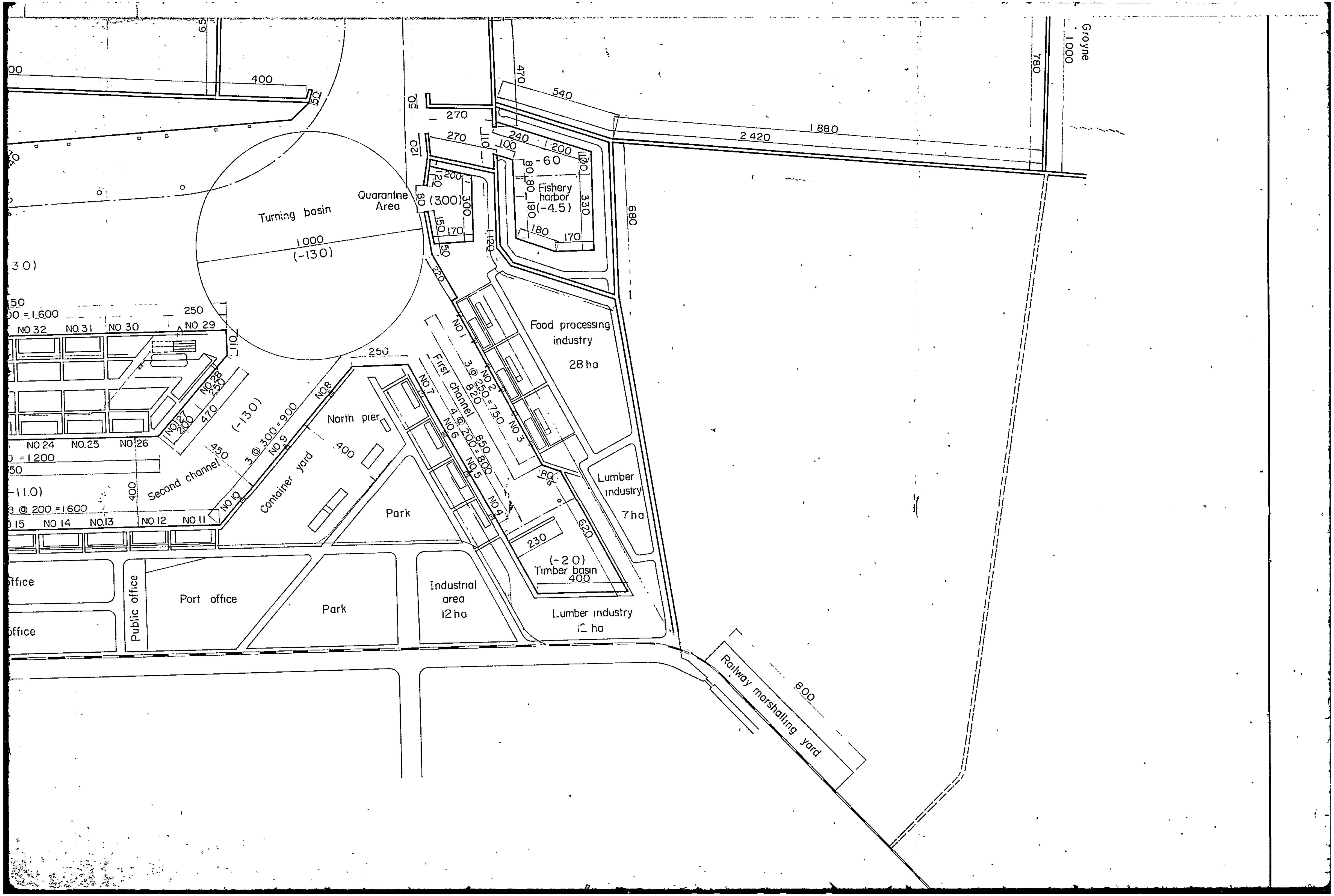

ARBOR
South breakwater
750
380
370
650
400
50
Main channel
North breakwater
800
640
300
470
540
50
270
270
240
2 420
1 880
220
780
Groyne
1 000

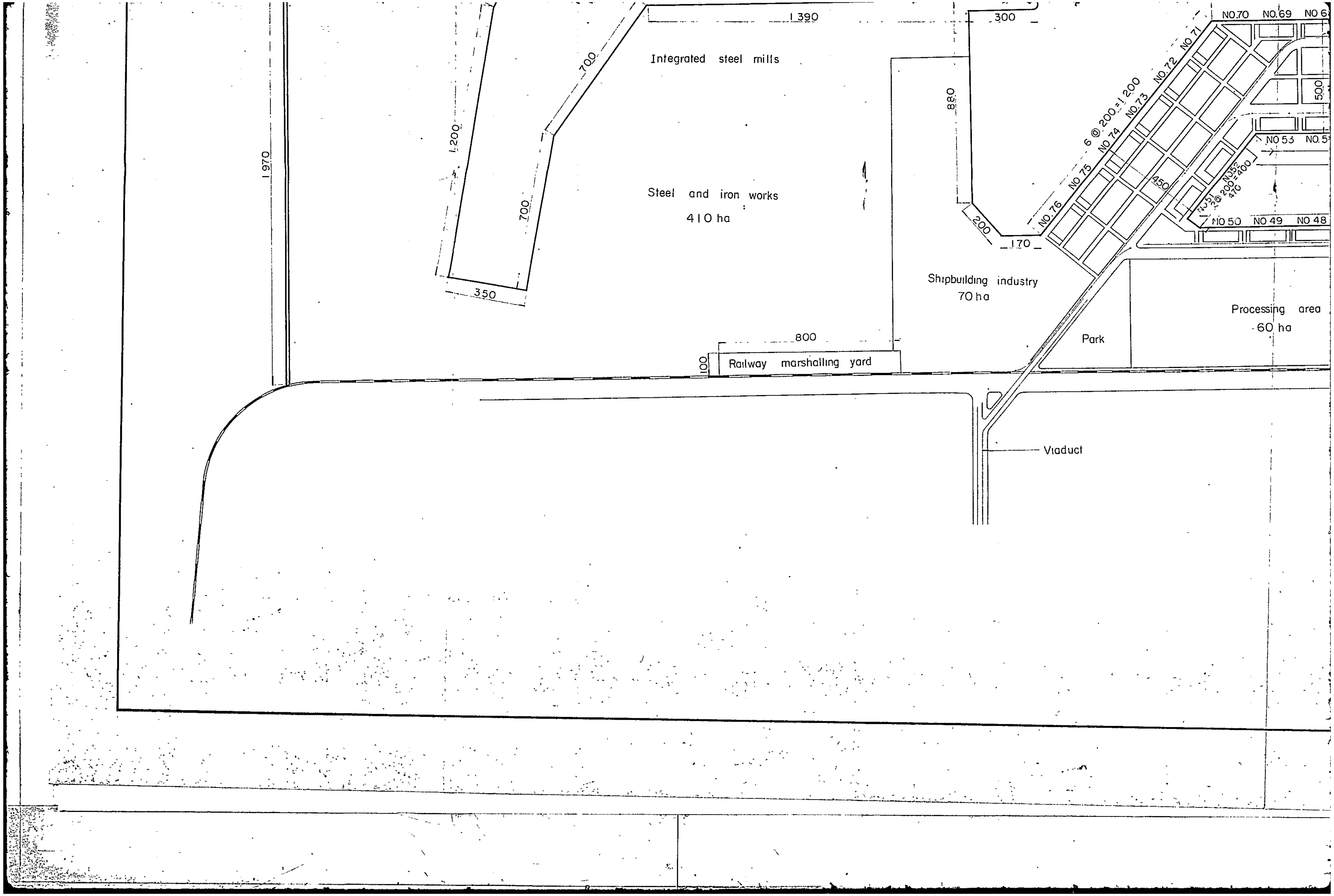


Petro-chemical industry
160 ha
Integrated steel mills
Steel and iron works
410 ha
Shipbuilding industry
70 ha
Processing area
60 ha
Park
Railway marshalling yard
Viaduct
(-13.0)
6 330
100
1 050
2 060
670
220
150
220
1 000
650
500
1 390
300
700
880
6 @ 200 = 1 200
1 200
1 970
700
200
170
350
800
100
450
500
400
NO 70
NO 69
NO 68
NO 71
NO 72
NO 73
NO 74
NO 75
NO 76
NO 53
NO 54
NO 50
NO 49
NO 48

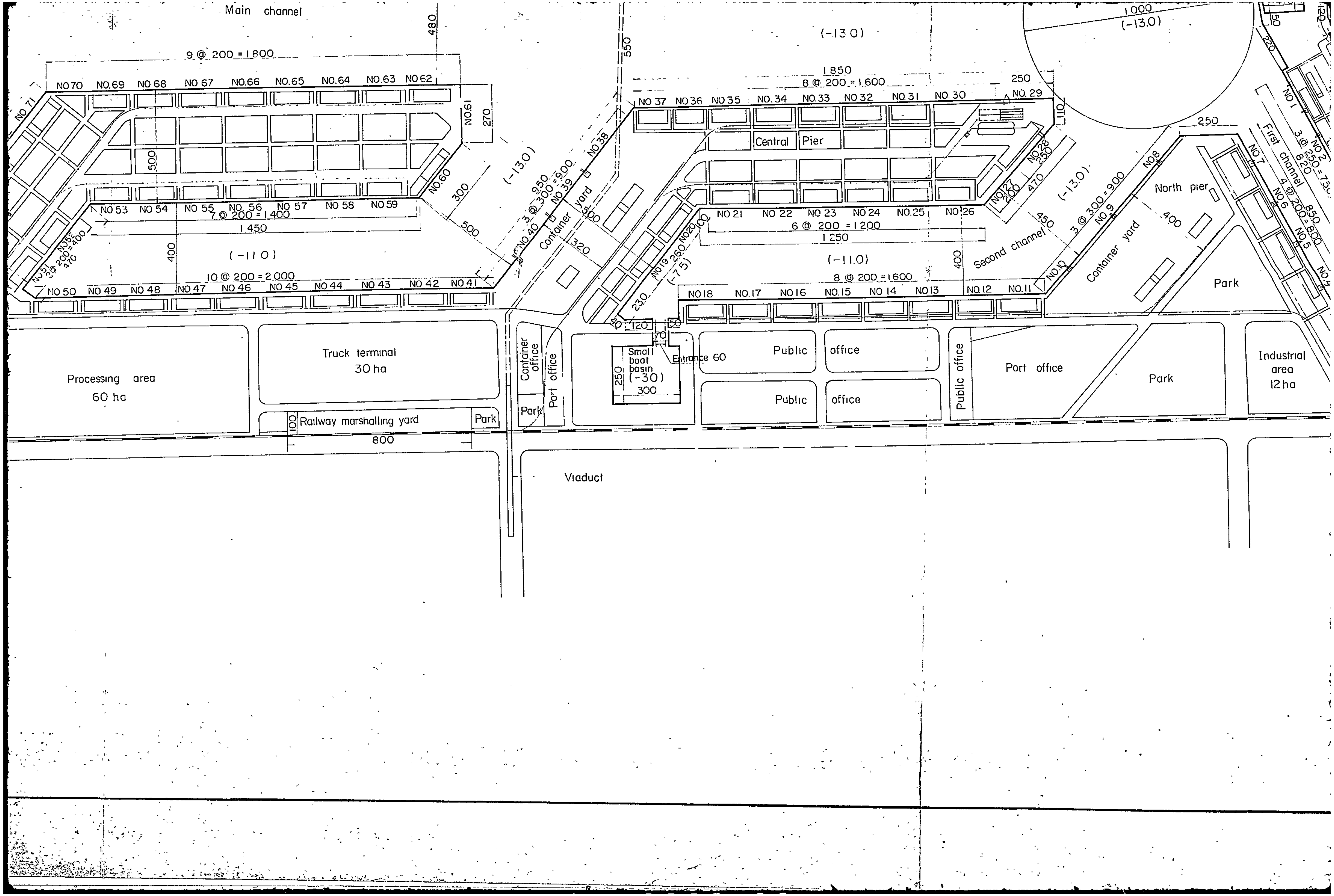


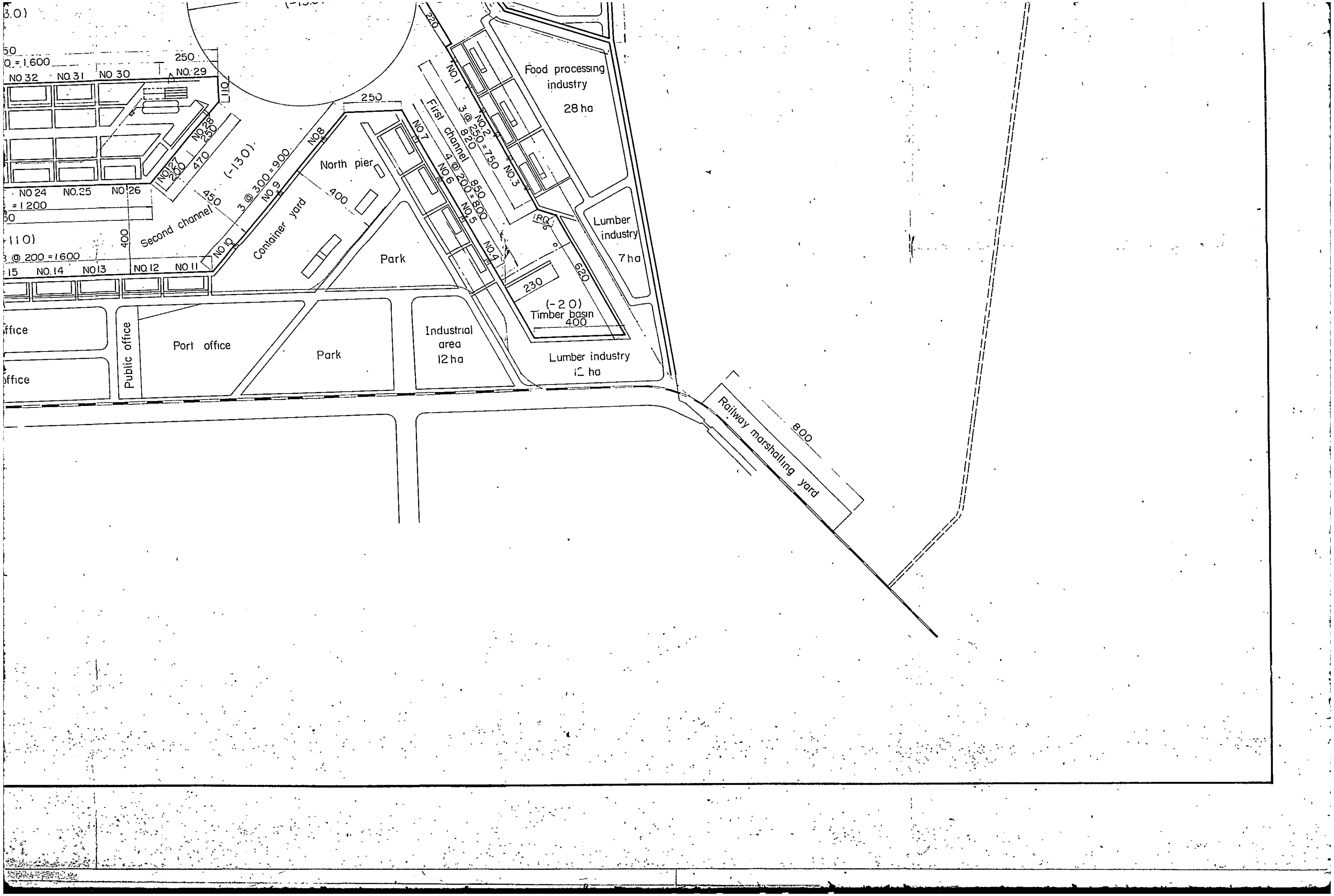
Sea wall
Oil refinery
160 ha
Thermal power station
80 ha
Oil Berth (Bunker)
Main channel
Turning basin
1 000
(-13.0)
9 @ 200 = 1 800
8 @ 200 = 1 600
6 @ 200 = 1 200
7 @ 200 = 1 400
10 @ 200 = 2 000
6 @ 200 = 1 200
8 @ 200 = 1 600
3 @ 300 = 900
Central Pier
Container yard
Second channel
North
(-11.0)
Small boat basin
(-3.0)
Entrance 60
Processing area
60 ha
Truck terminal
30 ha
Railway marshalling yard
Container office
Port office
Public office
Public office
Public office
Port office
Park
Park
Park
Park
Viaduct
Viaduct


Turning basin
Quarantine Area
(300)
1 000
(-130)
Fishery harbor
(-4.5)
-60
Food processing industry
28 ha
Lumber industry
7 ha
First channel
Second channel
North pier
Container yard
Park
Park
Industrial area
12 ha
(-20)
Timber basin
Lumber industry
12 ha
Port office
Public office
Office
Office
Railway marshalling yard
800
Groyne
1 000
2 420
1 880
540
3 @ 250 = 750
4 @ 200 = 800
3 @ 300 = 900
8 @ 200 = 1 600
NO 1
NO 2
NO 3
NO 4
NO 5
NO 6
NO 7
NO 8
NO 9
NO 10
NO 11
NO 12
NO 13
NO 14
NO 24
NO 25
NO 26
NO 27
NO 28
NO 29
NO 30
NO 31
NO 32
(-130)
(-11.0)



1 390
300
Integrated steel mills
700
1 200
700
350
1 970
Steel and iron works
410 ha
880
200
170
Shipbuilding industry
70 ha
6 @ 200 = 1 200
NO 70
NO 69
NO 71
NO 72
NO 73
NO 74
NO 75
NO 76
500
NO 53
450
NO 50
NO 49
NO 48
Processing area
60 ha
Park
800
100
Railway marshalling yard
Viaduct


Main channel
(-13.0)
(-13.0)
(-11.0)
(-11.0)
(-13.0)
(-13.0)
(-7.5)
9 @ 200 = 1 800
1 850
8 @ 200 = 1 600
7 @ 200 = 1 400
1 450
10 @ 200 = 2 000
3 @ 300 = 900
6 @ 200 = 1 200
1 250
8 @ 200 = 1 600
3 @ 300 = 900
3 @ 250 = 750
4 @ 200 = 800
1 000
NO 70
NO 69
NO 68
NO 67
NO 66
NO 65
NO 64
NO 63
NO 62
NO 61
NO 60
NO 59
NO 58
NO 57
NO 56
NO 55
NO 54
NO 53
NO 50
NO 49
NO 48
NO 47
NO 46
NO 45
NO 44
NO 43
NO 42
NO 41
NO 40
NO 39
NO 38
NO 37
NO 36
NO 35
NO 34
NO 33
NO 32
NO 31
NO 30
NO 29
NO 28
NO 27
NO 26
NO 25
NO 24
NO 23
NO 22
NO 21
NO 20
NO 19
NO 18
NO 17
NO 16
NO 15
NO 14
NO 13
NO 12
NO 11
NO 10
NO 9
NO 8
NO 7
NO 6
NO 5
NO 4
NO 2
NO 1
Central Pier
Container yard
Container yard
Second channel
First channel
North pier
Park
Truck terminal
30 ha
Processing area
60 ha
Container office
Port office
Park
Small boat basin
(-3.0)
Entrance 60
Public office
Public office
Public office
Port office
Park
Industrial area
12 ha
Railway marshalling yard
Park
800
Viaduct


NO 32
NO 31
NO 30
NO 29
NO 24
NO 25
NO 26
NO 27
NO 28
NO 14
NO 13
NO 12
NO 11
NO 10
NO 9
NO 8
NO 7
NO 6
NO 5
NO 4
NO 3
NO 2
NO 1
(-13.0)
3 @ 300 = 900
Second channel
Container yard
North pier
First channel
3 @ 250 = 750
4 @ 200 = 800
Food processing industry
28 ha
Lumber industry
7 ha
Park
Port office
Public office
Industrial area
12 ha
(-2.0)
Timber basin
Lumber industry
Railway marshalling yard
800