THE REPUBLIC OF PHILIPPINES

SURVEY REPORT

ON

THE IRON SAND DEVELOPMENT IN APARRI

SEPTEMBER, 1977

JAPAN INTERNATIONAL COOPERATION AGENCY

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P R E F A C E

In an effort to find ways and means of developing the Iron Sand Deposit in Aparri which is located in the northernmost part of the Philippines, the Japanese Government through the Japan International Cooperation Agency (JICA) requested the Government of the Philippines a permission to conduct a preliminary field survey in the area to assess the feasibility of the Project.

The Agency organized an eleven-member survey team headed by Mr. Keiichi Fukuoka of Pacific Consultants International. The team conducted the survey for a period lasting 49 days from February 27 to April 16, 1977.

The main points of the survey was to appraise the cargo handling system which is a requisite for the successful implementation of the Project. These includes technical investigation on the existing roads leading to the proposed port area. A cost-benefit ratio has been prepared and is included in the text of the Report.

Through this Report, I wish to express my gratitude to all the Philippine Authorities concerned, the Japanese Embassy in Manila, the Ministry of Foreign Affairs and the Ministry of International Trade and Industries for all the courtesy and cooperation extended to the survey team which contributed greatly to the successful preparation of this Document.

September, 1977

SHINSAKU HOGEN

President
Japan International Cooperation Agency

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CHAPTER 1

CHAPTER 1. INTRODUCTION

Section 1. Purpose and Background of Survey

The present survey was conducted for construction of new port facilities and improvement of roads which are required for development of the iron sand deposit distributed in the coastal sand dune area in the western part of Aparri district, North Luzon, Republic of the Philippines.

The survey was planned to study the technical and economic feasibility of Aparri Deposit Development Project by field surveys and design work in Japan in specific relation to the port and road improvement plans for which financial aid from Japan International Cooperation Agency (JICA) is desired, as well as to evaluate the development offect derivable from the implementation of the said improvement plans.

Aparri iron sand deposit stretches westward from the estuary of the Cagayan river for a distance of about 60 km along the coast, and has a reserve of about 10 million tons.

For the promotion of Aparri deposit project, the Philippine corporation holding the mining rights approached a Japanese corporation with a proposal to develop the deposit under a joint venture agreement. JICA's cooperation in the project was occasioned by the said Japanese corporation which responded to the proposal with a cooperative attitude and requested JICA to conduct a survey on infrastructural improvement items of highly public nature.

This report contains the results of the survey conducted with the objective and background mentioned above.

Section 2. Scope of Survey

As part of the infrastructural improvement necessary for Aparri deposit development project a field survey was planned to be conducted together with design work in Japan to make a technical and economic study on the port and road improvement plans for which JICA's financial aid is possible, as well as to evaluate the development effect derivable from the said improvement plans.

The survey consists of the following activities.

Field work

1) Survey for construction of new port facilities
2) Survey for road improvement
3) Survey for analysis and evaluation of development effect

Design work in Japan

1) Design and formulation of new port construction plan
2) Design and formulation of road improvement plan
3) Study of development effect and economic evaluation of the two plans

Detailed elucidation of each survey activity is given below.

2-1 Field Work

1) Survey for Construction of New Port Facilities

i) Field survey and study of relevant data for comparison among the direct loading method (on berthed carrier), off load method (by barge and loader) and slurry pipe method in order to select the optimum method of shipping 600,000 tons of iron sand a year by 20,000 - 30,000 DWT class ore carriers.

ii) Selection of the most suitable construction site of port facilities.

iii) Observation of topography, water depth, bed materials, tide level, tidal current, waves and wind at and around the proposed construction site.

iv) Supplementary study on items not fully clarified by the survey in (Item ii) above, i.e., calculations and analysis of wind and wave data.

v) Study of socio-political restraints that may be imposed on the project.

vi) Clarification of local conditions for determination of the structural design and construction cost of port facilities.

2) Survey for Improvement of Roads

i) Study of the future construction, improvement and repair plans of road network in the project area.

ii) Study of the geometric design and traffic of existing roads as well as the condition along their routes.

iii) Survey of the surface condition, embankment material, and sections passing through low-lying area (paddy field and marshy area) of the existing roads.

iv) Survey of drainage facilities.

v) Study of past flood records (flood discharge, flood stage, flow velocity, inundated area, and inundation period).

vi) Study of the existing stage of structures such as bridges and conduits (span, width, structural type, and material of superstructure and substructure).

vii) Survey of aggregate for concrete and asphalt.

viii) Survey of embankment material and existing state of transport roads.

ix) Study of the cost or unit cost of materials and labor (skilled and unskilled workers) for estimation of construction cost.

2-2 Design Work in Japan

1) New Port Construction Plan

i) Consolidation and review of topographical and geological data.

ii) Analysis of meteorological and marine phenomena data.

iii) Preliminary design of port facilities.

a. Comparative study of cargo handling methods.

b. Comparative study of alternative layout plans of port facilities in consideration of the selected cargo handling method.

c. Comparative study of alternative plans of structural design in consideration of the recommended layout.

d. Estimation of approximate construction cost on the basis of the recommended layout and structural design.

e. Preparation of construction plan and work schedule.

iv) Analysis of development effect of the plan and its economic evaluation.

2) Road Improvement Plan

i) Consolidation and review of topographical and geological data.

ii) Analysis of hydrological data.

iii) Preliminary design of road improvement work and related structures.

a. Preliminary design of sections to be repaired or improved.

b. Preliminary design of sections where new construction or repair of structures is required.

iv) Analysis of development effect of the plan and its economic evaluation.

Section 3. Formation of Survey Team

The field survey team was organized by the following 11 members headed by Mr. Fukuoka, leader.

Name	Assignment	Affiliation
Mr. Keiichi FUKUOKA	Leader, overall supervision	Pacific Consultants International
Mr. Ken FUJITA	Liaison and coordination	Japan International Cooperation Agency
Mr. Yoshihiko KAWAGUCHI	Economic survey	Ministry of International Trade and Industry
Mr. Motoyoshi YAMADA	- do -	Pacific Consultants International
Mr. Saburo FUKAGAWA	Overall control of port construction survey	- do -
Mr. Takeji TACHIKAWA	Port facilities planning	- do -
Mr. Sadao KATO	Port construction survey	- do -
Mr. Takashi HATAMA	Surveying	- do -
Mr. Yuichi KAJI	Geological exploration	- do -
Mr. Kanenari IJUIN	Road survey	- do -
Mr. Takatomo TORII	Road structure survey	- do -

Section 4. Itinerary of Survey Team

The itinerary of the survey team is shown in Tables 1-1 ~ 1-3. The ten members not including coordinator Mr. Fujita left Japan on February 27. The team was divided into three teams, economic survey team, road survey team and port site survey team. The economic survey team and the road survey team returned to Japan on March 28 as scheduled, and the team leader and the port site survey team returned to Japan on April 16.

Official permission for conducting the field survey in the project area was not obtained in advance, although the relevant application had been submitted to the Philippine government through the Japanese Embassy in Manila. Nevertheless, the team was enabled to carry out the survey with the consent obtained from the local government organ by the endeavors of Japanese Embassy and INCO.

Despite this unexpected obstacle at the outset, the survey was conducted smoothly covering all necessary items by the effort exerted by all team members and with the full cooperation of competent Philippine authorities and INCO.

After its return to Japan, the team engaged in the analysis of the data obtained during the survey. On the basis of the results of this analysis, formulation of the two improvement plans and preliminary design of structures were completed, with an economic study also made on the two plans.

Table 1-1. Itinerary of Port Site Survey Team

Date	Day		Description	
Feb 27	Sun	Arrival at Manila		
28	Mon	Manila	Visits to competent Philippine authorities	
Mar 1	Tue	"		
2	Wed	"		
3	Thu	Manila ~ Laoag		
4	Fri	Laoago ~ Sanchez Mira		
5	Sat	Sanchez Mira	Field reconnaissance and preparations	Application for approval for survey by Tachikawa (Manila)
6	Sun	"	"	
7	Mon	"	"	
8	Tue	"	"	
9	Wed	"	Traversing.	
10	Thu	"	"	
11	Fri	"	"	
12	Sat	" (Mr. Fukagawa returned to Japan)	"	
13	Sun	"	"	
14	Mon	"	Sounding in whole bay.	
15	Tue	"	"	
16	Wed	"	"	
17	Thu	"	"	
18	Fri	Sanchez Mira	Sounding and sonic prospecting (Tagat).	
19	Sat	"	"	
20	Sun	"	Topographic survey (Centinela).	
21	Mon	"	Survey of flow condition.	
22	Tue	"	Sounding and sonic prospecting (Tagat).	

Date	Day		Description	
Mar 23	Wed	Sanchez Mira	Sounding and sonic prospecting (Centinela)	
24	Thu	"	"	
25	Fri	" (Arrival of Mr. Fujita)	Topographic survey (Centinela)	
26	Sat	"	" (Tagat)	
27	Sun	"	Sounding and sonic prospecting (Centinela)	
28	Mon	"	Topographic survey (Tagat)	
29	Tue	"	" (Tagat and Centinela)	
30	Wed	"	Consolidation of survey data and packing of survey equipment.	
31	Thu	Sanchez Mira ~ Baguio		
Apr 1	Fri	Baguio ~ Manila		
2	Sat	Manila	Analysis of survey data and preparation of progress report	
3	Sun	"	"	
4	Mon	" (Arrival of leader)	"	
5	Tue	"	"	
6	Wed	"	"	
7	Thu	"	"	
8	Fri	Manila	Analysis of survey data and preparation of progress report.	
9	Sat	"	"	
10	Sun	"	"	
11	Mon	"	"	Field reconnaissance by leader and Mr. Tachikawa.
12	Tue	Return of Mr. Fujita, Mr. Hatama, Mr. Kato and Mr. Kaji to Japan		" "

Date	Day	Description	
Apr 13	Wed		Field reconnaissance by leader and Mr. Tachikawa
14	Thu		
15	Fri		
16	Sat	Return of leader and Mr Tachikawa to Japan.	

Table 1-2. Itinerary of Road Survey Team

Date	Day	Description	
Feb 27	Sun	Arrival at Manila	
28	Mon	Manila	Courtesy call to competent Philippines authorities (Feb 28 – Mar 3)
Mar 1	Tue	"	
2	Wed	"	
3	Thu	"	
4	Fri	Aparri ~ Tuguegaro	
5	Sat	Tuguegaro ~ Ballesteros	Field survey (Mar 5 – 15)
6	Sun	Ballesteros	
7	Mon	"	
8	Tue	"	
9	Wed	"	
10	Thu	"	
11	Fri	"	
12	Sat	"	
13	Sun	"	
14	Mon	"	
15	Tue	"	
16	Wed	Ballesteros ~ Tuguegaro	Consultation with Provincial Development Staff Office.
17	Thu	Tuguegaro	Consultation with West Engineering District of Department of Public Highways.
18	Fri	Tuguegaro ~ Manila	

Date	Day		Description
Mar 19	Sat	Manila	Consolidation of survey data (Mar 19–21)
20	Sun	"	
21	Mon	"	
22	Tue	"	Progress reporting at JICA Manila Office and Japanese Embassy in Manila.
23	Wed	"	Progress reporting at Department of Public Highways.
24	Thu	"	Consolidation of survey data. (Mar 24–27)
25	Fri	"	
26	Sat	"	
27	Sun	"	
28	Mon	Return of the party(Mr. Ijuin and Mr. Torii) to Japan.	

Table 1-3. Itinerary of Economic Survey Team

Date	Day		Description
Feb 27	Sun	Arrival at Manila	
28	Mon	Manila	Courtesy calls to competent Philippines authority
Mar 1	Tue	"	
2	Wed	"	
3	Thu	"	
4	Fro	Aparri	Visit to local government agency for explanation of survey
5	Sat	Sanches Mira	Field survey (interviews and data collection).
6	Sun	Ballesteros	
7	Mon	Tuguegaro	
8	Tue	"	
9	Wed	"	
10	Thu	Sanchez Mira	
11	Fri	"	
12	Sat	"	Consolidation of data
13	Sun	"	
14	Mon	Aparri	
15	Tue	Manila	Progress reporting at JICA Manila Office and Japanese Embassy, Data collection, and interview survey.
16	Wed	"	
17	Thu	"	
18	Fri	"	
		(Mr. Kawaguchi returned to Japan)	

Date	Day		Description
Mar 19	Sat	Manila	Consolidation of data
20	Sun	"	
21	Mon	"	Data collection and interview survey
22	Tue	"	
23	Wed	"	Reviewal and consolidation of data
24	Thu	"	
25	Fri	"	
26	Sat	"	
27	Sun	"	
28	Mon	(Mr. Yamada returned to Japan)	

Table 1-4. Government Agencies that Provided Full Assistance in the Procurement Valuable Data

- Bureau of Coast & Geodetic Survey
- Weather Bureau (PAGASA)
- Philippine Port Authority (PPA)
- Bureau of Public Works (BPW)
- Bureau of Mining
- Department of Public Highways (DPH)
- National Economic Development Authority (NEDA)
- Philippine Coast Guard

CHAPTER 2

CHAPTER 2. SUMMARY AND CONCLUSION

Section 1. Fundamental Approach to Survey for Appari Deposit Development Project

For the purpose and survey items stipulated in Chapter I (Introduction), the team was divided into port site survey party, road survey party and economic survey party each assigned to survey activities in its specialized field.

The fundamental approach to the survey is given below in reference to each of these three survey areas.

1-1 Study of Development Effect Derivable from Project

This study is intended to clarify and evaluate the socio-economic development effect which could be derived from the improvement of social infrastructure in the project area consequent upon the implementation of the port and road improvement plans of the project.

It was planned to make this study to forecast the socio-economic progress in the project area, and also to clarify the position and significance of the said plans in the project area by observing the changes in socio-economic activities that may be invited by the completion of the plans.

The basic policy adopted in the execution of the survey is given below for each survey item.

1) Study of Existing State and Future Prospect of Socio-economic Condition Data showing the main economic indicators of the project area are to be collected to put them to an analysis, and field reconnaissance is to be conducted to grasp the socio-economic situation of the project area.

2) Study of Development Feasibility of Project Area

   The development feasibility of the project area is to be studied from a macroscopic point of view on the basis of the feasibility evaluation of various projects related to project area, to be made on the basis of field data collection and interview activities and with account taken of the distribution of resources, population, labor force, social condition, accumulation of industrial capital, and infrastructural improvement.

3) Macroscopic Growth Forecasting of Main Economic Indicators

Qualitative forecasting is to be made as far as practicable in respect of main economic indicators, especially those related to human and physical economy and social changes.

4) Study of Future Socio-economic Prospects

The future prospect of socio-economic progress of the project area is to be studied on the basis of the macroscopic growth forecasting in Item 3) to make clear the area's development possibility.

5) Estimation of Cargo Volume and Traffic Volume

On the basis of the studies mentioned in the preceding items, the volume of iron sand to be handled at the new port and the volume of road traffic of iron sand trucks are to be estimated. The estimation is to be made for three target years, i.e., 1975 representing the pre-development condition, 1985 representing the condition during the mining operation, and 2000 representing the post-development condition.

6) Economic Evaluation

For the purpose of economic evaluation of the project, the economic effect of the project on the communities in the project area is to be analyzed by consolidating the probability values disclosed by the studies mentioned in the preceding items.

1-2 Plan of Port Site Survey

There are three methods conceivable for loading iron sand on carriers, i.e., direct loading on berthed carrier, off load method using bargers and loaders and slurry pipe transport method. Of these methods, the direct loading on berthed carrier was given priority as it makes it possible for the constructed berths to be used for public purposes. It was planned that survey on topography, geology, marine phenomena and mateorological condition would be conducted and various other data required for the design of port facilities would be collected at the proposed construction site, Claveria bay. As for the other two methods, it was planned that they would be given general review as alternative plans in comparison with the direct loading method on the basis of field observation and existing data.

There are two sites conceivable for construction of port facilities at Claveria bay, i.e., Centinela on the east side and Tagat on the west side. Centinela site is exposed to the course of typhoons but has a point which intercepts the northeasterly monsoon. At Tagat site, on the other hand, typhoons can be intercepted but not the northeasterly monsoon. Since the two sites have their own advantages and disadvantages, it was determined to collect the data required for port planning at both sites.

The basic policy adopted in the execution of survey is as described below.

1) Field Survey

a. Meteorological Survey

Observation records of Aparri meteorological station are to be used. However, wind direction and wind speed which are required for the design but not obtainable from the said records are to be estimated by the analysis using weather charts from Japan. To increase the accuracy of estimated values, the wind direction and wind speed are to be observed during the survey period by means of a simple wind vane and anemometer.

b. Topographic Survey and Sounding

Topographic survey and sounding are to be conducted to prepare a topographic map on the scale of 1/5,000 in order to grasp the submarine topography of the whole Claveria bay. For this purpose, survey lines are to be established at intervals of 250 m.

In the area surrounding the proposed jetty construction site, sounding is to be conducted with survey lines set up at smaller intervals of 40 m to increase the accuracy of a topographic map to be prepared on the scale of 1/2,000.

c. Geological Exploration

Geophysical prospecting method is to be adopted for geological exploration of the proposed jetty site by means of a sparker. This method was selected to cover as large an area as possible within the shorted possible period in consideration of the purpose of the survey.

d. Topographic Survey of Shoreline and Deposit Area

A topographic map covering the shoreline and deposit area is to be prepared on the scale of 1/1,000 which is to be photographically reduced to 1/2,000 in the stage of data consolidation.

e. Survey of Marine Phenomena

Tide level : Tide level is to be measured and recorded by means of a recording tide gauge during the survey period, and harmonic analysis is to be made for determination of design tide level.

Tidal current : Observation is to be conducted on the day of spring tide during the survey period at the surface and at a depth of -5 m in the proposed site.

Waves : Design waves needed in the design of port facilities must be obtained by calculation as described in Item a. above. To obtain reference data, wave observation was conducted at the proposed jetty site by visual inspection using a transit.

2) Preliminary Design

a. Establishment of Design Criteria

Design criteria for port planning are to be established on the basis of the results of field survey and the data to be provided by the Japanese parties concerned.

b. Alternative Designs

In case any alternative plan is conceivable for any portion of port facilities, two or three of such alternatives are to be prepared and put to technical and economic study for selection of the most suitable one.

c. Work Schedule and Cost Estimation

Preparation of work schedule and estimation of approximate construction cost are to be conducted for the recommended port construction plan.

1-3. Plan of Road Improvement Survey

Roads to be used for transportation of iron sand from Aparri deposit are National Road Route 3 which runs along the northern coast of Luzon island, two provincial roads (one linking Zitanga and Bellesteros and the other connecting Linao and Abulug along the west bank of the Cagayan), and feeder roads connecting these roads with the deposit area.

Improvement of National Road Route 3 constitutes part of Philippine - Japan Friendship Highway Project - Phase II to be implemented with the cooperation of the Japanese government. It is therefore necessary to confirm the policy adopted by the Philippine government for implementation of this project.

Annual shipment of iron sand planned under Aparri deposit development project is as small as 600,000 tons, and consequently sets limits on the investment for road improvement. Accordingly, there is no choice but to make use of the existing roads to the maximum extent by effecting necessary improvement and repair work.

Detailed survey items are described below.

1) Field Survey

The following items are to be covered by the field survey.

a. Existing condition and geometric design of roads in the project area, and condition along their routes.

b. Details of future road construction/improvement plans.

c. Surface and bed condition and embankment material of existing roads, and condition of sections passing through low-lying land (paddy field and marshy area).

d. Drainage facilities.

e. Past flood records.

f. Existing state and surface load of structures.

g. Availability and quality of aggregate of concrete and asphalt.

h. Availability of borrow pits, and quality and transport roads of borrow for embankment and top dressing.

i. Data required for cost estimation, including unit cost.

2) Preliminary Design

A road improvement plan is to be formulated for sections requiring improvement or repair on the basis of the findings of field survey.

For improvement of national and provincial roads, the plan is to conform to the design criteria and construction standards established by the provincial or district office responsible for the maintenance of such roads. For improvement of feeder roads and gravel transport roads, design criteria and construction standards compatible with the existing situation are to be adopted.

Standard designs are to be adopted to the maximum extent for bridges and culverts to minimize the labor and cost of design and construction work.

In case any alternative plans can be conceived of in the selection of transport roads and structural design, all alternative plans are to be reviewed and compared with each other for selection of the most suitable and recommendable one. This is to be followed by the preparation of the work schedule and cost estimation of the recommended plan.

Section 2. New Port Construction Plan

On the basis of the field survey and studies made in Japan, the following conclusion was reached in connection with new port facilties to be constructed for shipment of iron sand.

2-1 Cargo Handling Method

As a result of comparative study of three loading methods, i.e., slurry pipe and mooring buoy method, off load by barge and loader method, and direct loading method (on berthed carrier), the direct loading method which permits the provision of bertha for general cargoes was selected. The new port construction was planned for adoption of this method.

2-2 Selection of Optimum Port Site

For construction of new port facilities for direct loading on berthed carriers, two construction sites were proposed, i.e., Centinela site located on the east side of Claveria bay and Tagat site on the west side of the bay. Of these two sites, Centinela site was selected because the submarine topographic survey disclosed that port facilities cannot be constructed at Tagat site by the application of present level of port and harbor construction technology due to the presence of reefs at the jetty site.

2-3 Selection of Layout

The layout of the port was so planned as will secure a depth of -13 m necessary for 30,000 DWT class ore carriers to be berthed smoothly, ensure smooth berthing and undocking of carriers as well as safety of cargo handling work, and minimize the distance to the stockyard.

As part of regional development scheme, it was planned to construct berths capable of accommodating general cargo vessels with a maximum tonnage of 2,000 DWT. For economic reasons, these bertha were planned to be constructed in parallel with the approach jetty.

However, the final construction plan is to be determined under an agreement to be reached by negotiations with local inhabitants and shipping companies concerned. 2 tug boats of 1,000 PS are required for berthing and undocking of carriers.

2-4 Cargo Handling Equipment

Considering the planned annual shipment of iron sand which is as small as 600 thousand tons and calls for a rather low operation frequency of cargo handling equipment, fixed type loaders were adopted for economic reasons. Hence, the carrier needs to be shifted several times in position during the loading work. The planned capacity of loaders is 700 t/hr.

2-5 Structural Design of Jetty

Dolphin structure using batter steel piles was adopted for iron sand berths. For 2,000 DWT general cargo berths, comparison was made between steel pile type and steel sheet pile type, and the former was selected.

2-6. Approach Passage

Since pile foundation could not be adopted because the seabed is hard bedrock in areas shallower than -3 m, the approach passage was constructed by embankment method. The passage was designed to have a width of 7 m from the shore to general cargo berths in order to allow the traffic of vehicles.

2-7 Stockyard

Iron sand loading work must be suspended during the 4-month north-easterly monsoon period. The stockyard was planned to have a capacity of 200,000 tons in order to store iron sand transported from each sector in the said period. At the center of the stockyard, an underground belt conveyor tunnel was planned to be constructed in order that iron sand dumped in the pit by bulldozers would be carried by the belt conveyor.

2-8 Work Schedule

The work schedule was prepared for the 10-month period from March to November, assuming that the construction work would be suspended during the northeasterly monsoon season.

2-9 Approximate Cost Estimation

The approximate total construction cost was estimated to be ₱53,980,000 ($7,400,000) including the costs of works at sea, a set of cargo handling equipment and levelling work of stockyard.

Section 3. Road Improvement Plan

For road transportation of iron sand from the deposit distributed in the nothern coastal area of Luzon island to the shipping jetty at Centinela Point, it is necessary to make use of National Road Route 3 (Manila North Road) which runs approximately in parallel to the deposit as well as provincial or local roads which are connected with Route 3.

Within the survey area, National Road Route 3 is a gravel road but is satisfactory in both alignment and width except in few sections, and new large bridges are built on main rivers crossed by it. In sections where the route passes through low-lying paddy field and marshy areas, however, the road surface is small in height and prone to be inundated by flood water. Most of smaller bridges built on rivers flowing through these sections are wooden bridges with a maximum allowable surface load of only about 10 tons.

From the information collected during the survey, it was learned that the improvement of the entire route of Route 3 in the survey area, including the improvement of vertical alignment, rebuilding of smaller bridges and concrete pavement work, would be undertaken under Second Phase PJHL Project. The team was informed that as soon as the consent of the Japanese government is obtained, PJHL-II will be implemented to complete the design work in the initial year and the construction work in the subsequent three years.

For the smooth progress of Aparri deposit project, it is desirable that the road improvement work under PJHL-II project will be conducted with priority given to those road sections which are important for iron sand transportation. While mining operation in the deposit is expected to be initiated in the westernmost sector near Centinela Point, a section of Route 3 which is close to this sector has a wooden bridge which needs to be repaired. Repair of this bridge must be undertaken under the present Aparri iron sand development project if the above-mentioned road improvement work under PJHL-II project is postponed until after the commencement of mining operation in deposit. In this case, an amount of ₱170,000 ($23,300) must be disbursed for the repair of the wooden bridge.

Further, in case the Japanese government does not give consent to PJHL-II project, eight bridges must be repaired or rebuilt under this project. In this case, a total repair and rebuilding cost of ₱2,296,000 ($314,520) will be required.

Improvement of provincial roads to be used for iron sand transportation is included in the road improvement work of Five-Year Capital Improvement Program of Cagayan Province. Mining operation in sectors to be connected to these provincial road is planned to be started after completion of the improvement work of National Road Route 3 (PJHL-II) and provincial roads.

For reasons described above, improvement or repair of national or provincial road is not considered under this project and only the repair of feeder roads connected therewith is planned to be implemented.

The feeder road improvement plan was formulated on the principle that the road width would be increased but the alignment would run along the existing road as far as practicable. Under this plan, wooden bridges will be rebuilt to simple new bridges using I-beam as main girder and all feeder roads excluding the approach road to jetty will be improved to gravel roads to save the maintenance and construction cost.

Further, where two or more alternative feeder roads leading to the same sector are available, comparison was made for selection of the most economical route.

Road improvement cost required for Aparri deposit project is as tabulated below.

Table 2-1. Summary Table of Feeder Road Improvement Cost

Item / Sector	Number of Roads	Total Length	Cost	Remarks
Sector I	6	3.52 km	₱556,160 ($76,200)	
Sector II	1	-	-	
Sector III	3	2.90	₱2,172,844 ($297,600)	
Sector IV	3	3.97	₱2,006,370 ($274,800)	
Outside Deposit Area	4	3.90	₱1,280,650 ($175,400)	₱1,069,150 for approach road to jetty ₱211,500 for gravel transport road
TOTAL	17	14,29	₱6,016,024 ($824,100)	

Table 2-2. Repair Cost of Smaller Bridges on National Road Route 3

Second PJHL Project	Repair under Aparri Deposit Project	
In case the project is implemented as scheduled	————	
In case the implementation or work schedule of the project is prolonged	₱170,000 $ 23,300	1 bridge
In case the PJHL project is not given the consent of Japanese government	₱2,296,000 $ 314,520	8 bridges

Sector II is situated in the cuspate bar at the estuary of the Abulug river and the Pamplona river. Overland connection of this sector with National Road Route 3 calls for the construction of a new bridge with a length of about 400 m spanning that the tributaries and inlets of these rivers, which cannot be economically justified due to the small shipment of iron sand from the sector. Since other suitable transport route should be devised, Sector II was excluded from feeder road planning.

Improvement of feeder roads was planned according to the standard planning policy which was applied to each road for preparation of plans and profiles showing the alignment, locations of structures, etc. These plans and profiles were prepared from the present-state map enlarged to a scale of 1 : 3,500 from two topographic maps (1 : 50,000 and 1 : 25,000) and by incorporating the findings of field survey. Prior to working out the construction design, however, it is necessary to conduct a detailed geological exploration and surveying.

Design Criteria of Roads for Aparri Iron Sand Development Project (Extract)

PJHL-II Road

Daily average traffic volume	400 ~ more than 2,000 vehicles/day
Design surface load of bridge	AASHO H-20
Design speed	Flat area : 80 ~ 100 km/h
	Hilly area : 60 ~ 80 "
	Mountainous area : 40 ~ 60 "
Maximum grade	6 %
Minimum radius of curvature	50 m (at design speed of 40 km/h)
	300 m (at design speed of 100 km/h)
Number traffic lanes	2
Width of pavement	6.7 m
Width of shoulder	2.5 ~ 3.0 m

Provincial Road

Daily average traffic volume	100 ~ more than 1,000 vehicles/day
Design surface load of bridge	AASHO H-10 , H-20
Design speed	30 km/h ~ 60 km/h
Maximum grade	6 %
Minimum radius of curvature	100 ~ 300 m
Number of traffic lanes	2
Width of pavement	4.0 ~ 7.3 m
Width of shoulder	1.5 m

Iron Sand Feeder Road

Design surface load of bridge	AASHO H-20
Width of bridge	5.5 m
Design speed	30 km/h
Maximum grade	6 %
Minimum radius of curvature	50 m
Number of traffic lanes	2
Width of pavement	4.0 ~ 5.5 m
Width of shoulder	1.5 m

Section 4. Impact Analysis and Economic Appraisal of the Development Projects

The purpose of the field survey and its analysis in Japan was to study the socio-economic structure at present and future development scheme of the study area where the iron sand development project and its related infrastractural development projects are to be undertaken, to analyze what roles the projects play in the process of materializing the future development scheme, and also to carry out economic appraisal of the projects. The conclusions of the study, analysis and economic appraisal are as outlined below.

4-1 Status Quo of the Study Area

The study area for which impact analysis and economic appraisal were made consists of five municipalities - Ballesteros, Sanchez Mira, Pamplona, Abulug and Claveria. By administrative classification, the study area falls under Cagayan Province in Region II which lies in the extreme northeastern end of Luzon and covers, in addition to Cagayan, the five other provinces - Kalinga-Apayao, Isabla, Ifugao, Noeva Vizcaya and Quirino.

The study area, now inhabited by some 96,000, is increasing its population at an annual rate of 6.4 %. The primary industry is the most prevalent component in the employment spectrum, and the quality of labor force available is generally far from high, or rather on nearly the same level as in the secluded hamlets in Japan in around 1950. The industry is led by agriculture centering on rice cropping, and about 60 % of farmers have their own farms of 1.0 to 3.0 ha per family and are engaged solely in farming. It is judged that the topographic and climatic conditions have served a great boon for the agricultural operations in the study area.

As regards manufacturing industry, there is seen nothing to speak of, except for wood-processing operations. The study area has five small and large wood-processing factories which have been exporting their products from Claveria Bay. The commercial activities are no better than distribution of daily necessaries.

As regards the road network, the study area is served with National Road Route 3 as an arterial and Provincial Roads Route 303 and Route 320 as service roads, but all but a part are left unimproved. The people are forced to rely on precarious, as-the-weather-may-be ferry service to come at National Road Route 5 (Aparri - Manila) for want of bridge crossing the Cagayan River. In fact, trans-Cagayan trip is really a peeve to the people living in the study area.

Against these backdrops, the study area is distressed with the following internalized problems which have helped its socio-economic structure stay deep in the bottom.

Total poverty

Unbalanced income

Low productivity, and insufficient commercialization of local produce

Shortage of employment opportunities and unemployment

Poor infrastructure

4-2 Future Regional Development Scheme for the Study Area

The "Perspective Plan for Cagayan Valley Region, 1978-2000" prepared by NEDA Region II Office having control over the study area states the following perspective plan and socio-economic development vision for the future of the study area.

Harnessing the study area with a fully development road network to connect Tuguegarao having the central administrative functions and subcenters together.

Assignment of industrial activities within Cagayan Province: agriculture to the riparian belts of the Cagayan River and to the study area (five municipalities); forestry to the zone near the east coast; and mining (iron sand development) along the coastline between Claveria and Aparri.

In addition, the study area is expected to be a promising site for wood-processing industry, and the forests in Kalinga-Apayao

Province will become an important source of supply for it.

Aparri and Claveria are planned to be the key ports of the study area with Claveria as a loading port of agricultural produce surpluses, such as rice, and wooden products.

In order to piece out the industrial and living infrastructure, the construction of irrigation canals, city water works, electric power supply facilities, educational facilities and medical facilities as well as roads, ports and harbors is planned.

With the progress of the above plans, the principal economic indices for the socio-economic activities in the study area will change for the better as projected in the following.

(1) Population

Present (1975)	:	96,400 (100)
Future (1985)	:	128,000 (133)
Future (2000)	:	174,000 (180)

(Values in parentheses denote indices with 96,400 taken as 100)

(2) Working population

Present (1975)	:	37,000 (38.4 %)
Future (1985)	:	54,000 (42.2 %)
Future (2000)	:	89,500 (51.4 %)

(Values parenthesized denote the shares to the total population)

(3) Employment structure

	Primary industry	Secondary industry	Tertiary industry
Present (1975)	74.3 %	8.3 %	17.4 %
Future (1985)	50.3 %	25.8 %	23.9 %
Future (2000)	34.4 %	36.7 %	28.9 %

(Values denote the shares to the total working population.)

(4) Output by type of industry (in pesos)

	Primary industry	Secondary industry	Tertiary industry
Present (1975)	26,000,000	15,000,000	unknown
Future (1985)	73,000,000	70,000,000	66,000,000
Future (2000)	226,000,000	437,000,000	405,000,000

4-3 Impact of Iron Sand Development Project and its Related Infrastructural Development Projects

1) Iron sand development project

The 600,000-ton-a-year iron sand development project which will last for some 15 years will have the following impact direct on the socio-economic structure of the study area.

Generation of new demand for about 700 workers and an annual total of ₱4,200,000 in wages.

Generation of tax revenues totalling ₱6,000,000 a year thanks to iron sand export.

2) Related infrastructural development projects

Prior to the iron sand development project explained in the foregoing, construction of new port and harbor facilities at Claveria Bay and Centinela Bay, including 2,000 DWT general cargo berth and 30,000 DWT iron sand berth, and of a feeder road for conveying iron sand from iron sand mines along the coastline to National Road Route 3 will be carried out. (According to the road improvement plan, 7.87 km will be constructed in the first year, and an additional 6.42 km will be constructed in keeping with the progress of the iron sand development project.) The infrastructural development projects relating to the iron sand development project will have the following impact direct on the socio-economic structure of the study area.

The costs for port, harbor and road construction projects are estimated at about ₱60,000,000 (port & harbor: ₱53,980,000; road: ₱6,040,000). Of them, about ₱9,250,000 will fall into the hands of local people, invigorating the monetary economy of the study area. (Incidentally, it is forecast that some 90 % of this local portion of the project costs, or 8,100,000 pesos, will be paid to the study area in one year right before start of the iron sand development project.) Of the local portion, about ₱2,300,000 will be accounted for by wages, and the new labor force required will amount to about 500 workers.

4-4 Cargo Volume and Traffic in Future

Of the cargo expected to be exported from the study area in future, that part which will be handled at Centinela Berth to be constructed as a link of the infrastructural development projects is estimated as follows.

In 1985, 15,000 tons of agricultural produce (rice), 30,000 tons of forestry products, 600,000 tons of iron sand and 5,000 tons of other cargo, or a total of 650,000 tons a year will be handled.

In 2000 when the iron sand development project is scheduled to end its life, the annual cargo to be handled will be 20,000 tons for agricultural produce (rice), 310,000 tons for forestry products, and 50,000 tons for others, or 380,000 tons in all.

At present, the traffic volume in National Road Route 3 is 700 vehicles/day in the lowest-traffic section, 1,750 vehicles/day in the heaviest-traffic section, and 1,280 vehicles/day on the average.

In 1985, it will be 1,470 vehicles/day, 3,680 vehicles/day and 2,700 vehicles/day, respectively.

In 2000, the daily traffic is estimated at 1,470 vehicles in the lowest-traffic section and 16,750 vehicles in the heaviest-traffic section. (Source: DPH's data)

During the life of the iron sand development project, 500 vehicles a day of additional traffic will be generated in the roads (National Road Route 3 and feeder road) within the study area, and should be added to the above projections in discussing the traffic volume in the study area during the iron sand development project.

4-5 Development Impact and Economic Appraisal

1) Direct impact of development

The iron sand development project ranks among the most important projects for the study area incorporated in the existing higher policy (NEDA Region II Office Regional Development Scheme) for regional development.

Also, its related projects, including port and harbor construction at Claveria Bay and road improvement, particularly the wholesale improvement of National Road Route 3, are the key to the infrastructural development not only in the study area, but also in the entire northern part (Cagayan Province) of Region II.

Namely, the iron sand development project and its related projects are justifiable both in the end and the means, and will bring about high direct impact effect on the study area.

The iron sand development project and its related projects are expected to create a new demand for workers which will amount to 500 to 700 as against about 3,000 now engaged in the secondary industry and to add about ₱2,300,000 to ₱4,200,000 a year to the current local annual gross income level of about ₱11,000,000. More importantly, this continues for some 16 years after start of the iron sand development project, imparting a great impact on both the employment and the economic structure of the study area.

2) Multiplied effects

While the direct impact explained above will vitalize the socio-economic structure of the study area during the stages of construction and operation of the projects, what is left of the projects - port and harbor facilities and road network - will help promote stabilized growth of economy in the study area for an extended period as they offer outlets of the agricultural and forestry products (rice, etc.) into the various parts of the Philippines.

In addition, the iron sand development project will open up frontiers in the industry as represented by automotive industry and machine industry, and its related projects will give a spur to the development of construction industry.

All these industries will whip up the demand for a variety of commodities and invigorate the tertiary industry.

The marine resources now dormant in the study area will be harnessed with the progress of commercialization and with the accumulation of industrial capital, and the fishing industry will start anew in a modern way, establish its own in the study area and prosper steadily.

The diversification and invigoration of economic activities will expand human flow and physical distribution, promoting the modernization and growth of the transportation business in the study area.

The expansion and ramification of the economic activities will develop a spectrum of kaleidoscopic changes in the social structure in the study area, and at the same time, will substantiate the amenities by piecing out public facilities such as for electricity supply, communication and medical service, speeding up the channelization of information, promoting the civilization and upgrading the living standard.

3) Economic appraisal

The implementation of the iron sand development project and its related infrastructural development projects will go a long way toward the socio-economic development of not only the study area, but the whole northern part of Region II as already seen in the discussions of direct impact and multiplied effects, phasing out the internalized problems the study area now has in its socio-economic structure and at the same time providing a powerful economic engine for the study area to make great strides toward its promising future.

CHAPTER 3

CHAPTER 3. NEW PORT CONSTRUCTION PLAN

Section 1. General

In the northern part of Luzon island where Aparri iron sand deposits are located, the natural condtions such as meteorology, geology and oceanography are extremely unfavourable for the construction of a port. These adverse natural conditions, which are impedimental to the construction of port facilities, are one of the reasons why the deposits have not been exploited to date despite the fact that their existence has been known since old.

Three methods are conceivable for shipment of iron sand: the slurry transport method, off load using barges, and direct loading on berthed carrier. In the present survey, priority was given to the last method and Claveria bay was selected as the proposed construction site of the new port. In order to select the optimum construction plan, the layout, structural design, etc. of port facilities were carefully examined on the strength of necessary field surveying and observation conducted at site.

The following are the main items overed by the field survey.

1)	Sounding	General survey of the whole Claveria bay and detailed survey of Tagat area and Centinela area.
2)	Topographical ..... survey of hinterland	Topographical survey in the neighborhood of proposed sites of storage yard in Centinela and Tagat.
3)	Submarine .... geological exploration	Sonic prospecting at Centinela and Tagat.
4)	Observation of tidal level, tidal current, waves and wind.	

Section 2. Natural Conditions

2-1 Location and Topography of Proposed Site of Port (App. Fig. 3-1)

Claveria bay is formed by an indentation in the northern coast of Cagayan province, Luzon island, and its mouth having a width of about 5 km opens widely on the north towards Babuyan channel. Hence, it is not free from the invasion of waves generated by north-easterly monsoon. However, it is the nearest bay to Aparri deposits and located at a distance of about 7 km from Pata Point at the western end of the deposits.

Claveria is a town with a population of about 32,000. In Tagat area, a saw mill with about 1,000 employees is in operation and its products are shipped by foreign carriers by loading at existing pier or by off load using barges. Claveria bay is also the base of commodity transportation to isolated islands such as Fuga. 10 ~ 20 ton class vessels are on regular service between the bay and the islands, but these vessels cast anchor in the Claveria river flowing through the central part of Claveria, handling their cargoes mostly by manual labour. The mouth of the Claveria river is heavily silted up by sediment load, making it difficult for these small vessels to navigate at ebb tide.

The topogray of Centinela and Tagat covered by the present survey is as described below.

1) Centinela

Centinela is at a distance of about 7 km from Pata Point at the western end of the deposits, and situated between Centinela point and Cumalgcan Point on the east side of Claveria bay. It has a curved topography opening to the northwest, with relatively steep moutains rising on the south and north. This mountainous district has an elevation of about 100 m and is heavily eroded. It forms a steep cliff on the coast, exposing its erosion surface. The beach which is the proposed construction site of the new port has a coastline length of about 250 m. The hinterland is flat and partly cultivated for production of paddy and upland crops and there are found not existing structures, so that it is suited to the storage of sand iron.

As for the seabed configuration at the proposed berth site, the bottom becomes deeper from the shore to the offing with a grade 1/20 ~ 1/30, and depth contour lines run parallel to each other from northeast to southwest. There is a reef exposing itself above water surface at a distance of about 70 m from the approximate center of shoreline.

2) Tagat

Tagat is situated on the west side of the bay, about 7 km further than Centinela from the deposits. In the neighborhood of the lighter berth owned by the aforementioned saw mill, the hinterland area is small and embraces a cluster of fishermen's houses. It is therefore difficult to secure a space for storage yard in this area. If berths are to be constructed at Tagat, there will be no choice but to select the open space lying close to the center of the shoreline between the said cluster of fishermen's houses and the airport on the east.

The bottom slope is steep. The gradient is 1/30 ~ 1/20 for a distance of 500 m from the shore, 1/10 between 500 and 800 m and 1/30 ~ 1/20 between 800 m and 1000 m from the shore.

2-2 Geological and Soil Conditions

1) Centinela (Fig. 3-1)

The submarine formations at the proposed berth site as judged from the findings of sonic prospecting and surface geological condtion are described below.

Asg layer (sand layer with gravels)

This constitutes the uppermost layer of the seabed in the survey area. Due to the strong reflection of sound waves, it is difficult to confirm the pattern of stratification in the layer from the record of sonic prospecting. Nevertheless, the record indicates the prevalance of a typical pattern of "compact" with a weak parallel pattern in it. It can therefore judged that the layer is a considerably compact sand layer with gravels. N values is estimated to range from 15 to 25.

Bgs layer (gravel layer with sand)

This layer underlies Ags layer. Since its upper part is very compact, its pattern and reflection surface are made obscure in the record of sonic prospecting. In general, however, a typical pattern of "strong" in parallel and cut pattern can be observed, which suggests that the layer is a gravel layer containing sand.

It is estimated that the layer has a thickness of more than 10 m and N values ranges from 30 to 40.

In the direction normal to the shoreline, the top of the layer is recoreded as a flat surface having a dip of about 1/20 toward the offing, but is rich in undulation along the transversal survey lines established across the said direction. From this fact, it can be deducted that the layer is a diluvial deposit having a sufficient bearing strength required of bedrock.

R layer (Volcanic rocks)

This layer constitutes the bedrock in the survey area, and is considered to be the extension of the layer of andesite layer and tuff distributed on land.

On the record of sonic prospecting, two typical patterns of "rough" and "thin", can be observed, but there is no clear boundary between them. Hence, it is judged that the bedrock represented by the former is weathered (R_1 layer) and that represented by the latter is not deeply weathered.

2) Tagat (Fig. 3-1)

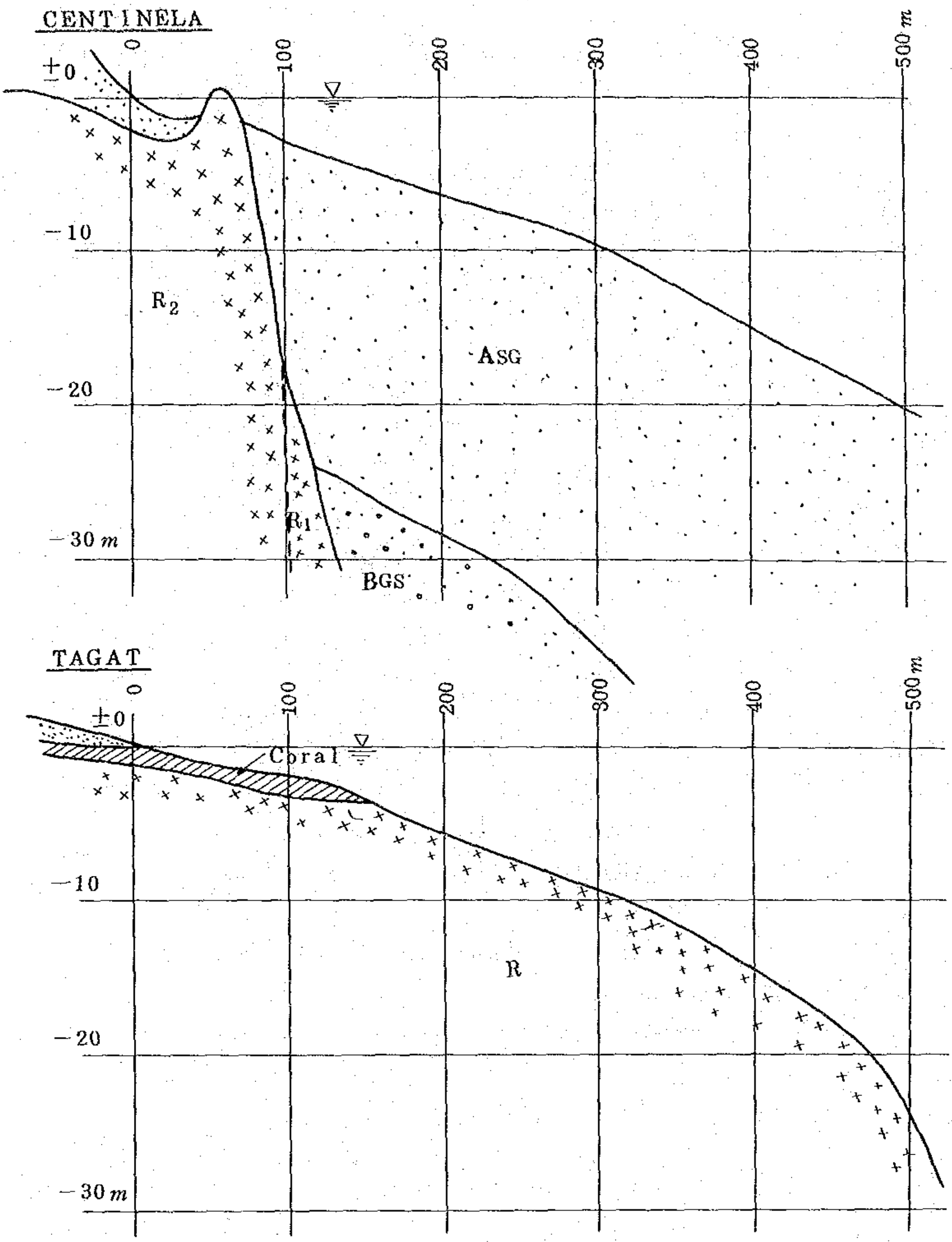
At the proposed berth site, the seabed is generally composed volcanic bedrock. In shallow water, it forms a mild slope which is judged to be a coral reef layer. On the record of sonic prospecting, the former presents typical patterns of "compact" and "dense" and the latter shows a pattern of "compact and strong irregular reflection." It was not possible to obtain data on deeper formations due to the virtually total reflection of sound waves from these two layers.

The submarine topography in the survey area can be divided into three distinctive parts, i.e., the flat bottom of coral reef in the shallow part which is a characteristic topography in southern countries, the steep slope of coral reef in the intermediate part, and the flat bottom in the deeper part. The undulating topography in the shallow part is partly covered by sandy deposit distributed as if to fill depressions in the coral reef. The deposit was estimated to be distributed partly with a thickness of 1 ~ 2 m, and this was confirmed by the simple drilling conducted on the shoreline.

From the findings of the present survey, it is considered that the seabed is free from any thick deposition of fine sand or silt.

Fig. 3-1

STRATUM CROSS SECTIONAL VIEW



Year			Classification	Thickness	Presumptive N−VALUE
Quatermary Period	Alluvium	ASG	Gravely Sand	10 m ~ 20 m	15~25
	Dilluvium	BGS	Sandly Gravel	more than 10m	30~40
Tertiary Period		R1	Lgneous rock (andesite, lava), Weathering	—	—
		R2	Lgneous rock (andesite, lava)	—	—

2-3 Tidal Level, Tidal Current, Wind and Waves

1) Tidal Level

Tide observation was conducted for a period of 23 days from March 5 to 29 using LPT type automatic tide gauge in an inlet on the west of Lacay Lacay Point of Tagat where the influence of waves was the least in the whole survey area.

After effecting corrections to the datum level and construction percentage, the observation data were subjected to harmonic analysis, whereby the constants shown in App. Table 3-1 were obtained.

The table indicates that diurnal tide is more dominant than semi-diurnal tide in Claveria bay. In an area presenting such tidal constants, it is often the case that two successive high tides and two successive low tides occuring in a same day present a large height difference, whereby the lower high tide and the higher low tide are nearly offset by each other to present diurnal tide consisting of one each of high tide and low tide. This phenomenon is prone to occur more at neap tide than at spring tide. The estimated height of spring tide and neap tide around the vernal equinox, summer solstice, autumnal equinox and winter solstice when the said phenomenon is most conspicuous is shown in App. Fig. 3-6 by way of reference.

From the data described above, the datum of tidal level in Claveria bay is set as follows.

Highest high water level	+1.42 m
Mean high water springs	+0.97 m
Mean high water	+0.89 m

Mean sea level	+0.71 m
Mean low water	+0.53 m
Mean low water springs	+0.45 m
Lowest low water level	+0.00 m

2) Tidal Current

Current observation was conducted at time of spring tide during the survey period. The tidal range on the day of current observation was only 53 cm so that the current due to tide was almost negligible. Hence, it was not possible to observe the periodical change of current direction and speed, although irregular changes due presumably to the generation of a compound current by the influences of tide, river water, wind and waves were noted. Since the influence of river water is subject to fluctuation depending on its flow rate and those of wind and waves disappear by the subsidence of the causal wind and waves, it was difficult to predict the current condition in the bay from the observation data alone.

It is likely that the proposed berthing site at Centinela, located off the mouth of the Claveria river, is subjected to the influence of the river discharge to a considerable extent, although there is an intercepting reef zone in front of Cumalagcan Point. The current observation data at this point is shown in comparison with the tide data in App. Table 3-2 and Fig. 3-7.

The observation disclosed that both surface and bottom currents flow most vigorously one and half hour before low tide, recording a speed of 0.82 m/sec for the surface current and 0.77 m/sec for the bottom current. At flood tide and high tide, however, the current is almost like a slack tide and registers a very small speed. At both flood tide and ebb tide, the current flows mostly to north or northeast by the conspicuous influence of the Claveria river, which seems to be prompted or inhibited by the current generated by tide, wind and waves.

If piers are to constructed at this site, therefore, careful consideration should be given to the current condition in the wet season.

3) Wind (App. Tables 3-3 ~ 3-10)

During the survey period, wind direction and wind speed were observed at intervals of an hour at Centinela and Tagat using a simple wind vane and anemometer.

As seen in App. Table 3-3 showing the wind observation data, the maximum wind speed recorded during the observation period was 12 m/sec (NE) at Centinela and 11 m/sec (SE) at Tagat.

App. Tables 3-4 ~ 3-10 show the wind data recorded at Aparri meteorological station from 1970 to 1974.

The prevailing winds in the northern part of Luzon island are the northeasterly monsoon in the colder season and the southwesterly monsoon in the warmer season. The former blows from October to March and the latter from June to August most conspicuously.

It is to be noted that the strong wind generated when typhoons pass this area should be taken into careful consideration in mapping out the new port construction plan.

4) Waves

Wave observation was conducted near the proposed pier site at Tagat and Centinela by visual observation using a bamboo floater. The maximum wave generated during the observation period had a height of about 1.5 m. Most of waves observed in this period were swells invading from eastnortheast, undulating heavily from about noon to impede sounding survey. According to local inhabitants, waves are too high for vessels to enter the bay from late November to late March. It appears that timber carriers (approx. 10,000 DWT) refrain from entering the bay in this period. During the period from April to October, however, it seems that the bay is calm and presents no difficulty in cargo handling work except when a typhoon hits the area.

2-4 Wave Analysis

Due to the total absence of necessary wave observation record, the following analysis was conducted for the two proposed construction sites (Centinela and Tagat) using past weather charts in order to obtain the data and characteristics of waves in Claveria bay which are indispensable for the port and harbour planning.

1) Objective and Outline

The analysis was conducted to faucast the waves at the two proposed construction sites, to clarify their characteristics, to obtain the design waves on which to base the design of structures, to estimate the rate of port operation in respect to cargo handling efficiency and berthing and undocking efficiency. Thus, the analysis was intended to produce the data required for port planning, and covered the following items.

---- Wave characteristics at the two sites.
---- Design waves at the two sites.
---- Efficiency of cargo handling work.
---- Justifiability of port construction at the two sites.

2) Wave Characteristics at the Two Sites

Wave forecasting was conducted for twice a day (8:00 hrs and 20:00 hrs) for three years from 1972 to 1974 in order to obtain the basic data for estimating the wave characteristics and there their trend which are essential for calculating the port operation rate in respect to cargo handling efficiency and berthing and undocking efficiency.

The forecasting was made by the SMB method, with Wilson's method applied when the movement of fetch and changes of wind speed and direction in the wind field were conspicuous.

In the forecasting, the ratio of wave height coefficient at the two sites shown in App. Tables 3-11 and 3-12 and the refraction of waves with a period 12 sec shown in App. Figs. 3-8 ~ 3-14 were used.

a. Wave Characteristics

Centinela

Waves from NE ~ ENE ~ E present a marked refraction effect due to the influence of topography. In perticular, waves from E have a large wave height decay ratio, their height decreasing to less than 1/4 of those of deepwater waves.

Waves from W ~ NNE have an incident wave height which is more than 80 % of the height of deepwater waves.

Tagat

Waves from E are subject to extreme decay as at Centinela. The height of waves from W ~ WNW also decreases notably by the influence of topography.

b. Occurrence Probability of Wave Height and Wave Direction (App. Table 3-13 and 3-14 and App. Fig 3-15 ~ 3-28)

Centinela

On the yearly average, "calm" ($H < 0.6$ m) has an occurrance probability of 67 %, and waves from

N ~ NNE ~ NE account for a dominant portion of 29 % of all waves with a height of more than 0.6 m.

As for the annual fluctuation, the occurrence probability of "calm" is generally below 50 % in the times December - May period and waves are mostly limited to those from N ~ NNE ~ NE.

In the warmer season, however, the occurrence probability of "calm" is as high as more than 80 %.

Tagat

The occurrence probability of "calm" through the year is 63 %, and all waves with a height of more than 0.6 m are from NNW ~ ENE, with the waves from NNE presenting an occurrence probability of 20 %. This is perhaps ascribable to the influence of topography.

As for annual fluctuation, the occurrence probability of "calm" is lower than 50 % in the colder season (November to February) but higher than 8 % in the warmer season just as at Centinela.

Notes : The occurrence probability of "calm" in July is 65.8 % at Centinela and 68.5 % at Tagat. These values are lower than registered in other months in the warm season and reflect the influence of typhoons.

c. Occurrence Probability of Wave Height and Wave Period (App. Fig. 3-29 ~ 3-41)

Centinela

Waves with a height of less than 0.6 were regarded as "calm," and those with a greater height were classified by period into four groups: waves with a period of less than 5 sec, those with a period of 6 ~ 8 sec, those with a period of 9 ~ 10 sec, and those with a period of more than 11 sec.

On the yearly average, the occurrence probability of waves with a period of 9 ~ 11 sec and more than 11 sec within each period zone from 5 to 10 sec is calculated to be 4 %. Seen by month, the period zone of 9 ~ 10 sec registers a substantially high occurrence probability in winter season (December to February), and July records a high probability of 18 % for periods longer than 11 sec.

Tagat

On the yearly average, the occurrence probability of waves with a height of more 0.6 m is somewhat higher than at Centinela, registering 13 % for a period of less than 5 sec. 12 % for 6 ~ 8 sec, and 9 % for 9 ~ 10 sec.

By month, the occurrence probability of waves with a period of 9 ~ 10 sec is relatively high in the December - February period as in Centinela. As for other months, the 25 % probability recorded in July for a period of 11 sec is notable.

d. Calculation of Design Wave Height

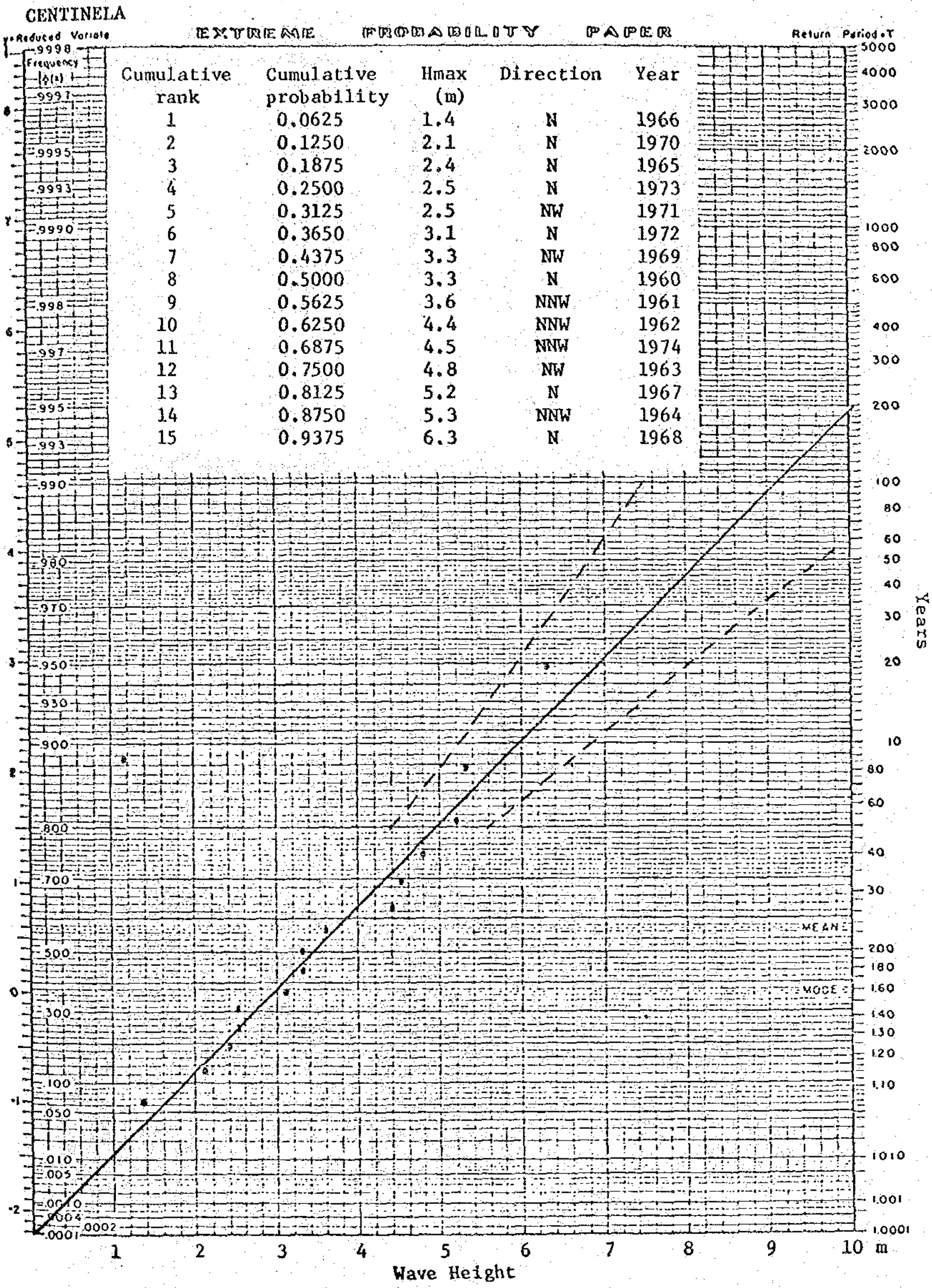
The expected return period of design waves at the two sites was obtained by probability calculation worked on the basis of the annual maximum significant wave height during the 15 year period from 1960 to 1974 using Gumbel's method. In the present survey, the design wave height with an expected return period of 30 years was adopted.

Fig. 3-2 and 3-3 show the probability distribution of annual maximum values, and Table 3-1 shows the results of calculation. As seen in these figures and table, the calculated design wave height is 7.5 m for Centinela and 6.4 m for Tagat.

Table 3-1 Design Wave Height and Probable Error

Site	Return Period (years)	100	50	30	20	5
Centinela	Design Wave Height(m)	9.2	8.2	7.5	7.0	5.0
	Probable Error (m)	1.7	1.4	1.2	1.1	0.6
Tagat	Design Wave Height(m)	7.6	6.9	6.4	6.0	4.5
	Probable Error (m)	1.3	1.1	0.9	0.8	0.5

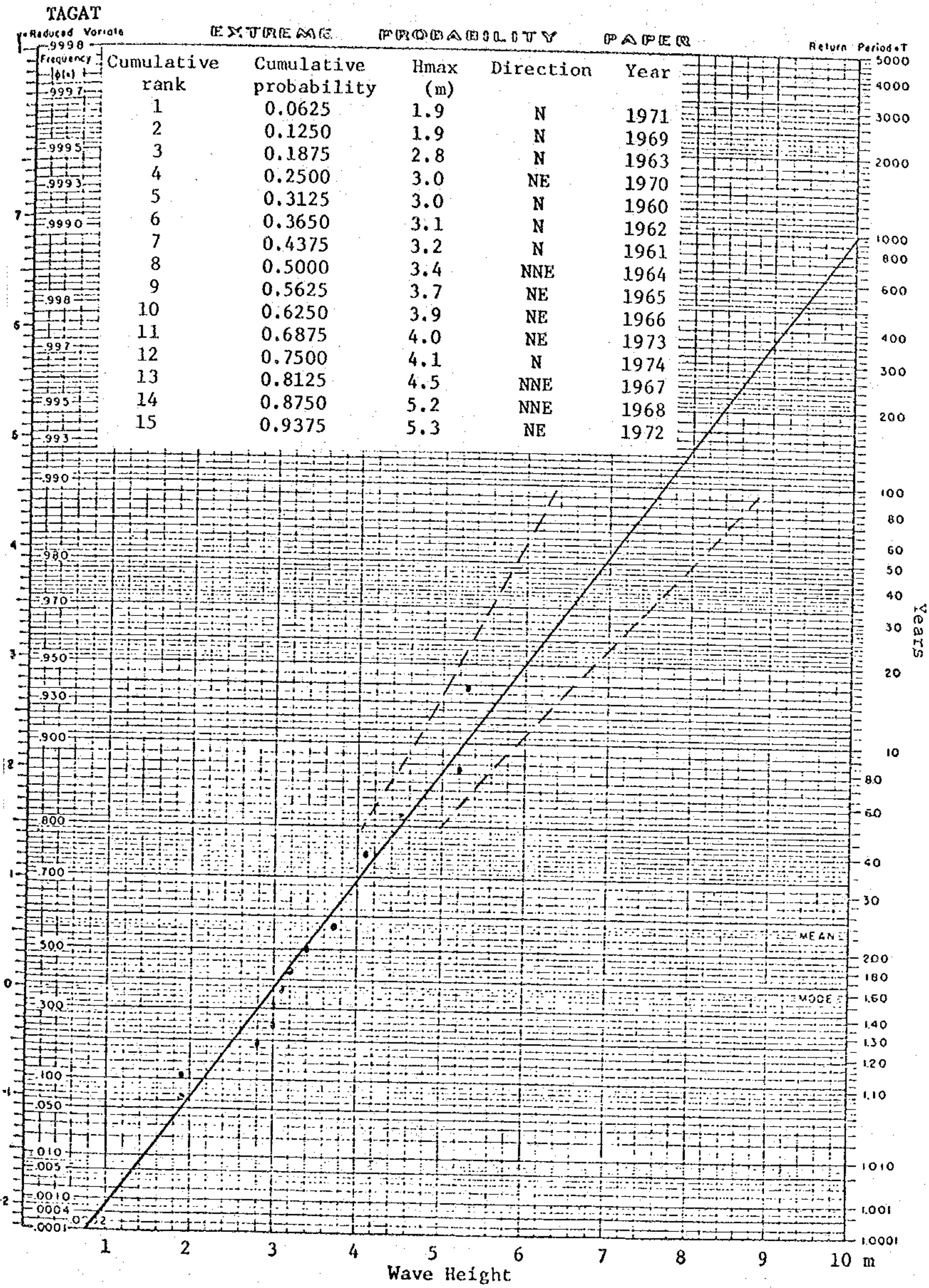
Fig 3-2 Distribution of highest Wave at Centinela



Cumulative rank	Cumulative probability	Hmax (m)	Direction	Year
1	0.0625	1.4	N	1966
2	0.1250	2.1	N	1970
3	0.1875	2.4	N	1965
4	0.2500	2.5	N	1973
5	0.3125	2.5	NW	1971
6	0.3650	3.1	N	1972
7	0.4375	3.3	NW	1969
8	0.5000	3.3	N	1960
9	0.5625	3.6	NNW	1961
10	0.6250	4.4	NNW	1962
11	0.6875	4.5	NNW	1974
12	0.7500	4.8	NW	1963
13	0.8125	5.2	N	1967
14	0.8750	5.3	NNW	1964
15	0.9375	6.3	N	1968

Fig 3-3 Distribution of highest Wave at Tagat

Cumulative rank	Cumulative probability	Hmax (m)	Direction	Year
1	0.0625	1.9	N	1971
2	0.1250	1.9	N	1969
3	0.1875	2.8	N	1963
4	0.2500	3.0	NE	1970
5	0.3125	3.0	N	1960
6	0.3650	3.1	N	1962
7	0.4375	3.2	N	1961
8	0.5000	3.4	NNE	1964
9	0.5625	3.7	NE	1965
10	0.6250	3.9	NE	1966
11	0.6875	4.0	NE	1973
12	0.7500	4.1	N	1974
13	0.8125	4.5	NNE	1967
14	0.8750	5.2	NNE	1968
15	0.9375	5.3	NE	1972



e. Efficiency of Port Operation

The following two conditions were established as criteria for estimating the efficiency of port operation in respect of cargo handling work and berthing and deberthing of vessels, and the number of operating days and the rate of operation were calculated for the two sites.

A : $H_{1/3} < 0.6$ m

B : $H_{1/3} < 1.0$ m

It was assumed that the efficiency of port operation is acceptable only when the above two conditions are satisfied at two hindcasting times a day (8:00 hrs and 20:00 hrs).

App. Fig. 3-42 ~ 3-45 show the results of calculation worked out for each of continuous operating days of 1 day, 2 days, 3 days and 4 days.

The efficiency of operation calculated for one operation day is summarized below.

Centinela

On the yearly average, the efficiency stands at 58 % for condition A and 74 % for B. By season, the efficiency in the colder season (November - February) is low and registers 32 % for condition A and 53 % for B. In the warmer season (April - September), however, the efficiency rises to 78 % and 90 % for conditions A and B respectively. In the March - October period, it stands at 71 % for condition A and 78 % for B.

Tagat

The operation efficiency is slightly lower than at Centinela both on the yearly average and by month. On the yearly average, the efficiency stands at 56 % for condition A and 69 % for B, and by season, it is 26 % for A and 42 % for B in the colder season (November - February). In the warmer season (April - September), however, the efficiency is as high as 79 % for condition A and 90 % for B. In the March - October period, the efficiency for condition A is 71 % and that for B is 83 %.

2-5 Climate

The monthly average temperature, rainfall and relative humidity at Claveria, Aparri and Laog during the period from 1951 to 1970 are shown in App. Fig. 3-46 ~ 3-48.

The average atmospheric temperature at Claveria is the highest in May (28.4°C) and lowest in January (23.5°C).

The annual average rainfall is 3,982 mm at Claveria, 2,318 mm at Aparri and 2,067 mm at Laog. Thus, the rainfall at Claveria is considerably greater than at the other two places. In particular, the monthly average rainfall at Claveria exceeds 300 m from August to February, recording as high a value as 600 mm in December.

Section 3. General Design of Port Facilities

3-1 Comparative Study of Cargo Handling Methods and Selection of Optimum Plan

At present, the following three methods are employed for shipment of iron sand.

1) Slurry pipe and offshore mooring buoy method.

2) Barge loading method (for off load).

3) Direct carrier loading method (for loading on berthed carrier).

The flow system of each of these methods is shown below.

1) Slurry pipe and offshore mooring buoy method.

Storage yard → Belt conveyor → Slurry tank → Pipeline → Mooring buoy → Carrier

2) Barge loading method

Storage yard → Belt conveyor → Loader → Barge → Loader → Carrier

3) Direct carrier loading method

Storage yard → Belt conveyor → Loader → Berthed carrier

1) Slurry Pipeline and Offshore Mooring Buoy Method

In this method, the carrier is moored to the mooring buoy anchored in a suitable place in the offing, and iron sand is loaded on it by hydraulic pressure by means of a submerged pipeline laid between the buoy and the storage yard on the shore.

This method is often applied in areas where there is no suitable site for port construction. However, it is advisable not to adopt it because the loading work must be conducted in a place exposed to outer sea and is consequently influenced greatly by the meteorological condition and marine phenomena and also because the communication between the carrier and the shore cannot be carried out smoothly. It is employed only in those cases where there is no suitable site of port or the construction of a new port incurs an extremely high cost.

There are two mooring systems, i.e., one-point mooring and multi-legged mooring, and the former is mostly employed for shipment of iron and petroleum. In the one point mooring system, special universal joints are used because the carrier is moved by wind, waves and tide current. Mooring of the carrier calls for skill because it usually enters the harbour against the wind. The anchoring efficiency of the mooring buoy varies largely by the submarine geology. In general, the efficiency is high if the seabed is a sandy ground and poor if it is a soft, clayey ground, and anchoring is not possible if the seabed is covered by hard bedrock.

If this method is to be applied in the present project, a one point buoy will have be anchored near the mouth of the Pamplona river, about 1,500 m apart from the storage yard on the shore. The seabed geology in the neighborhood of this point, as judged from charts, is a sand layer.

The location map of this method is shown in App. Fig. 3-49 and the rough cost estimate for its execution is shown below.

One point system mooring buoy	₱18,100,000
Submerged pipeline work	6,500,000
On-land facilities	22,700,000
Contingencies	1,400,000
TOTAL	₱48,700,000
	(=US$6,670,000)

In addition to the advantages and disadvantages described above, it is to be noted that this method has one noteworthy drawback when compared with the direct carrier loading method. Specifically, the mooring buoy will be anchored as an exclusive berthing facility of the iron sand development company, and construction of a public quay capable of berthing 2,000 DWT class vessels cannot be expected. In other words, construction of a public quay designed for regional development and livelihood improvement of local inhabitants is not given consideration. In addition, there is no need to construct or make use of an arterial road because a feeder road of a minimum length connecting the deposit and the berth suffices for the purpose of shipment.

2) Berge Loading Method

In this method, loading and unloading using barges and loaders must be repeated twice. Due to the long time required for such repetitive loading and unloading, and resultant increase of demurrage which is very high in recent years, this method is hardly employed these days. Loading by this method in the proposed port area is very difficult because waves are considerably high.

If this method is to be employed for the project, there will be no choice but to select Bisagu at the mouth of Cagayan river as the berthing point of barges as suggested in the report of the survey conducted by the aforementioned Japanese corporation in March 1976. In the said report, Bisagu is selected after comparative study with another point at the mouth of the Cagayan river, Linao, and this selection was found to be reasonable during the present survey. If Liano is selected for berthing barges, it is necessary to carry out dredging over a distance of about 1.2 km in order to secure the required depth, but the channel thus created is prone to be silted up soon due to heavy wind and waves from outer sea and consequently calls for constant maintenance dredging. It cannot be justified to berth barges at such a point.

As for Bisagu point, there is no need for dredging, but the poor ground condition at the suitable site of storage yard calls for reclamation work and flood control measures. In addition, a suitable means of transportation must be devised covering a distance of about 3.5 km from Linao to Bisagu. Since this 3.5 km section is a low-lying land with poor foundation, it will be necessary to resort to belt conveyor or cableway. Construction of berths at this point will therefore incur a considerably high cost.

As described at the outset, this method presupposes two loading operations, one for barges and the other for the carrier. Considering its poor working efficiency and the need for taking suitable measures for the poor ground condition and for transportation to the berthing point, this method cannot recommended for the project.

3) Direct Carrier Loading Method

If iron sand from Aparri deposit is to be shipped by direct loading on berthed carriers, the only place conditioned favourably for construction of the necessary quay is Claveria bay. During the four month period from November to March, it is difficult for ore carriers of 20,000 - 30,000 DWT class to be berthed in Claveria bay for loading work because heavy swells are generated by northeasterly monsoon. In the remaining period of the year from March to October, however, it is possible to load iron sand on such carriers on calm days and attain an annual shipment of 600,000 tons. Further, if berths for general cargo vessels of 2,000 DWT class are constructed in addition to ore carrier berths, they will serve for accelerated commodity distribution in the area and contribute largely to the improvement of livelihood of local inhabitants.

It is to be noted that Claveria bay is nearly exposed to waves due to typhoons, so that the structural design of port facilities should be such that can amply withstand the influence of all marine phenomena.

Putting the characteristics of the three methods to a rigit analysis, it can be recommended that iron sand from Aparri deposit be shipped by direct loading on carriers berthed along the quay of a new port to be constructed in Claveria bay.

3-2 Selection of Location of Port Facilities

Centinela and Tagat are the sites proposed for construction of iron sand shipping facilities in Claveria bay. Advantages and disadvantages of the two sites for construction of a new port, as disclosed by the present survey, are listed below.

Centinela

Advantages (1) Located close to the deposit.

(2) Space of storage yard is available in hinterland.

(3) Compact sandy seabed is suited to the construction of piers.

(4) Substantially large number of cargo handling days is promised because swells due to northeasterly monsoon can be intercepted to a considerable extent.

Disadvantages

(1) Port facilities need to be rigid in structure and somewhat large in size because waves due to typhoons invade with negligible attenuation.

Tagat

Advantages (1) Maximum wave height is smaller than at Centinela.

Disadvantages

(1) Located farther from the deposit than Centinela, and iron sand must be transported over a mountain pass and through the town of Claveria.

(2) Storage yard must be located at some distance from the berth because the hinterland area embraces a thick cluster of fishermen's houses and a sawmill.

(3) Seabed is covered by bedrock and not suited to pile foundation.

(4) Number of cargo handling days is smaller than at Centinela because swells from NE are not intercepted.

As can be seen from above, Centinela excels Tagat in all respects excepting design wave height. As stated in Section 2-4 (Wave Analysis). the design wave height of return period of 30 years is 7.5 m for Centinela and 6.4 m for Tagat. Although the former is slightly larger than the latter, and the difference is not large enough to give preference to Tagat because both values are very large.

It is therefore considered that Centinela is better suited as the site of the new port.

3-3 Comparative Study of Layout and Structural Design for Selection of Optimum Plan

1) Criteria for Port Planning

The following criteria were established for planning port facilities.

a.	Annual shipment	600,000 tons
b.	Storage volume	200,000 tons (4-month shipment volume)
c.	Height of storage yard	15 m

d.	Bulk density of iron sand	2.6 t/m^3
e.	Capacity of cargo handling equipment	700 t/h
f.	Tonnage of ore carrier	20,000 DWT ~ 30,000 DWT
g.	Overall length of ore carrier	164 ~ 187 m
h.	Width of ore carrier	23.4 ~ 26.6 m
i.	Full load draft	9.2 ~ 10.3 m
j.	Approaching speed	0.20 m/sec
k.	Berthing method	By 2 tug boats of 1,000 PS
l.	Design depth	-13.0 m
m.	Design tide level	HWL +1.42 m MWL +0.71 m LWL ±0.00 m
n.	Design significant wave height	$H_{1/3}$ 7.5 m $T_{1/3}$ 11 sec
o.	Seismic intensity	0.1 gal
p.	Wind speed	Max. 60 m/sec During cargo handling 16 m/sec

In addition to the above criteria, the following preconditions were adopted for planning port facilities.

1) Loading work will be suspended during the northeasterly monsoon season (November - February).

2) Fixed type loaders will be used, and carriers will maneuvered for loading iron sand.

3) Neither water nor oil will be supplied to carriers.

4) In addition to exclusive ore carrier berths, berths for general cargo vessels (2,000 DWT class) will be built for public use.

5) Port operation for clearance or entrance of vessels will be suspended at nighttime and under adverse meteorological condtion because of the limited number of ore carriers calling at the port.

2) Selection of Layout

If berths are to be constructed at Centinela, the storage yard must be located at the point shown in App. Fig. 3-50. In this case, two locations (Plan A and B) can be considered. In both plans, the face line of berth is aligned to the submarine topography. Advantages and disadvantages of the two plans are as listed below.

Plan A

Advantages

(1) Length of approach passage can be made short.

(2) Design wave height to be considered in the planning of structures can be reduced to some extent because the approach passage does not cross the direction of wave travel from N or NW.

Disadvantage

(1) Not protected from swells due to northeasterly monsoon.

Plan B

Advantages

(1) Length of approach passage can be reduced by installing a belt conveyor line along the shore.

(2) Fairly well protected from swells due to northeasterly monsoon.

Disadvantages

(1) Very far from the storage yard.

(2) Approach to berths for general cargo vessels is difficult.

(3) Liable to siltation due to sediment load from Claveria river.

Considering the advantages and disadvantages listed above, Plan A excels Plan B, provided that no cargo handling work is conducted in the November - February period when northeasterly monsoon prevails.

General layout of respective facilities is as shown in Dwg. 2.

3) Comparative Study of Structural Design

Civil engineering structures to be built at sea under the project can be classified as follows.

a. Breasting dolphin

b. Mooring dolphin

c. Loading platform

d. Trestle

e. Quay for 2,000 DWT vessels

f. Approach passage

Of these structures, a. ~ d. must be constructed at a depth of 10 ~ 14 m and withstand a lateral force of more than 100 tons. Hence, the batter pile driving method using steel pipe piles was adopted because it is most economical and easy to be executed.

The structural design of the quay for accommodating 2,000 DWT vessels and approach passage was determined after the comparative study described below.

i) Quay for 2,000 DWT Vessels

This quay was planned to have a length of 50 m and a width of 20 m in consideration of its berthing function and construction cost. There are two types of structure conceivable for this quay: the piled type structure and the sheet pile type structure. App. Fig. 3-51 shows the typical cross-section of the two structures, and advantages and disadvantages of each are listed below.

Piled Type Structure

Advantages

(1) Construction cost is low (₱105,000/m).

(2) Influence of waves during the construction is small relative to the sheet pile type.

(3) Construction work can be completed in a short period with relative ease.

Disadvantages

(1) Accommodation of small boats is made inconvenient because crown height must be increased to +6.0 m so as not to impose any uplift on slabs.

Sheet Pile Type Structure

Advantages

(1) Standard crown height of +3.0 can be maintained.

(2) Serves as breakwater for small boats.

Disadvantages

(1) Execution of work involves difficulty due to adverse wave condition.

(2) Construction cost is high (₱130,000/m).

From the comparison made above, the piled type structure which can be constructed securely at a lower cost was adopted, provided that the crown height would be increased to +6.0 m.

ii) Approach Passage

There are four types conceivable for the approach passage : piled type, bridge type, sheet pile type, and stone masonry type. App. Fig. 3-52 shows the typical cross-section of each of these structures.

Approximate construction cost incurred by each of these type of structure per meter is as shown below.

A. Pile type structure .... ₱36,000/m

B. Bridge type structure .... ₱39,000/m

C. Sheet pile type structure ... ₱53,000/m

D. Stone masonry type structure.. ₱27,000/m
(-1.0 m)

Of these different types of structures, the pile type was selected as it can be executed most securely at the lowest cost. For sections shallower than -3.0 m, however, the stone masonry type was adopted because of the low cost and the difficulty in piling work due to the small thickness of bearing stratum.

4) Outline of Recommended Layout and Structural Design

Dwgs. 1 ~ 9 show the most commendable layout and structural design which were selected from alternative plans from technical and economical points of view.

Outline of each facility is introduced below.

a. Breasting Dolphin

The berthing impact of vessels is planned to be sustained by breasting dolphins arranged at intervals of 40 m. When an ore carrier of 30,000 DWT approaching at a speed of 0.2 m/sec is berthed, it produces a berthing energy of 57.2 t-m, and 142 tons of reaction is generated if a cellular fender is used. In order to resist the carrier's tractive force which is applied to the breasting dolphin, a 100-ton mooring post will be installed. As for the structure of the dolphin, the batter pile structure is most effective and economical in resisting these lateral forces.

b. Mooring Dolphin

The mooring dolphin to be installed at either end of the berth will have a 150-ton mooring post. This dolphin will also be designed to have a batter pile structure in order to resist strong lateral force.

c. Loading Platform

In order to assure that the loading platform will not be directly exposed to berthing impact, a point little behind the face line of the breasting dolphin was selected as its location. Hence, the main load applying on the loading platform comprises the cargo load and wave force.

The slab crown height was determined to be +8.0 m to assure that the platform will resist the design wave height of 7.5 m, and the layout of piles was determined according to the arrangement and position of the supports of iron sand loading tower. Further, batter piling method was employed to cope with laterial forces such as the wave force working on piles, wind force working on the loader, and seismic load. A catwalk will be provided between platforms for communication.

d. Trestle

The trestle bridge connecting the carrier berths and the 2,000 DWT berths was designed to have a span of 20 m, with steel structure employed for its superstructure and steel pipe pile structure for substructure. The trestle was designed to have a crown height of +6.0 m and a rigid-frame of batter piles. The connecting bridge will consist of a belt conveyor line and a foothpath and reject the passage of vehicles.

e. Quay for 2,000 DWT Vessels

This quay was so designed as would be capable of accommodating general cargo vessels with a maximum tonnage of 2,000 DWT, and of withstanding a maximum allowable surcharge of 2.0 t/m^2. 15-ton mooring posts will be installed, and V-type fenders (300H) will be installed at intervals of 5.5 m to withstand the berthing impact of vessels.

f. Approach Passage

The approach passage was designed to have an overall width of 9.0 m, of which 2.0 m was appropriated to the belt-conveyor line and 7.0 m to the two-lane roadway.

Piled pier type structure was employed for the 125 m section on the sea side, and stone mansory type for the 145 m section on the land side. The latter type was employed because the seabed is covered by hard bedrock and rejects the application of the former type.

g. Storage Yard

The storage yard was designed to have an area of about 20,000 m^2 and a maximum height of 15 m, so that it can store more than 200 thousand tons of iron sand even if the angle of repose is taken at 15°. From the center of the yard, a belt conveyor will run through the underground tunnel. Iron sand will be loaded on the carrier by the simple method of dropping it in the pit by a bulldozer.

h. Cargo Handling Equipment

The fixed type and semi-swing type leader were adopted. It is planned that the carrier will be moved by the tug boat (1000 PS) when loading iron sand. This method involves substantial time and labor, but it was adopted because of the small amount of shipment and for economic reasons.

3-4 Cost Estimation

1) Conditions for Cost Estimation

a. Commodity price as of July 1977 was adopted as the basis of calculation.

b. The following exchange rate was adopted.

US$1.00 = ¥270 = ₱7.30

c. Taxes and public charges leviable in the Philippines were disregarded.

d. Scope of estimation

Breasting dolphin, Mooring dolphin, Loading platform, Trestle, 2,000 DWT class quay, Approach passage, Belt conveyor tunnel, Grading of storage yard, Loader and belt conveyor.

e. Items excluded from the scope of estimation

Land acquisition cost, electric power, lighting facilities other than those for loading equipment, water and oil supply facilities, port administration and management office, navigation aids, and other facilities necessary for port management.

2) Estimation of Rough Construction Cost

1.	Mobilization/Demobilization	₱2,244,000
2.	Preparatory works	2,460,000
3.	Breasting dolphin	5,966,000
4.	150 t mooring dolphin	2,022,000
5.	Loading platform	3,256,800
6.	Conveyor pier	₱ 873,000
7.	2,000 DWT class quay	5,226,500
8.	Approach passage (piled pier section)	4,493,000
9.	" (stone masonry section)	3,932,900
10.	35 t mooring dolphin	414,000
11.	Grading of storage yard	466,000
12.	Conveyor tunnel	2,095,800
13.	Loaders and belt conveyors	13,500,000
14.	Sub-total	46,940,000
15.	Contingencies (15 %)	7,040,000
	TOTAL	₱53,980,000 (US$7,400,000) (¥1,996,500,000)

Notes : Breakdown of each cost is shown in App. Table 3-15.

3) Reference

The costs for iron sand port facilities and general cargo berth are as follows.

Iron-sand port facilities	₱39,577,000 ($5,420,000)
General cargo berth	₱14,403,000 ($1,980,000)
TOTAL	₱53,980,000 ($7,400,000)

3-5 Construction Plan and Work Schedule

The construction works can be broadly classified into steel pipe pile work, concrete work, stone masonry work, and installation of loading equipment.

1) Steel Pipe Pile Work

In this work, about 267 steel pipe piles measuring 800 mm in diameter, 12 mm in thickness and 30 m in average length, all to be imported from Japan, will be used. The quickest and most economical way of landing them is to use barges which will ply between the ocean-going vessel anchored at a point off the coast of Claveria and the shore.

For the purpose of driving piles, the use of D40 diesel hammer is proposed. Since many batter piles must be driven in under unfavourable marine conditions, it is recommended that SEP pontoon (Self-Elevating Platform) be used.

The pile driving work should preferably be carried out in the March ~ October period to avert the influence of northeastern monsoon which blows in the remaining period of the year. However, since typhoons are prone to hit the project area even in this season, the pile head should be fastened securely soon after driving.

2) Concrete Work

Aggregate for concrete is to be transported from the river reservation of the Pamplona. Since the greater part of concrete work is to be conducted at sea, it is advisable to carry out concrete placing using a floating mixing plant.

The concrete work should be conducted consecutively, starting with the structure for which pile driving work is completed, so that it can be completed by October.

3) Stone Masonry Work

About 15,000 m^3 of stones, required for pitching the approach passage, can be obtained by blasting the rocky hill behind the stockyard. On the embankment surface, precast concrete blocks manufactured at land will be laid.

4) Loading Equipment

Loading equipment such as loaders and belt conveyors should be assembled to the maximum extent at factory so as to minimize the volume of site installation work. A floating crane will be used for installation of loading equipment.

5) Main Construction Machinery

The following are the main machines required for the construction work.

Stone Masonry and Works at Land

(Machine)	(Capacity)	(Quantity)
Power shovel	1.5 m^3	3 units
Dump truck	8 t	17 "
Bulldozer	11 t	2 "
Batcher plant	65 m^3/d	1 "

Mixer truck	6 m^3	2	units
Crawler crane	40 t (hoisting cap.)	1	"
Truck crane	25 t (")	5	"
Pontoon	40 t	10	"

Pier and Dolphin Works

Pile driving barge D40		1	units
Anchor barge		1	"
Pontoon	200 t	9	"
Trailer	25 t	1	"
Crawler crane	40 t	3	"
Batcher plant	65 m^3/d	1	"
Mixer truck		2	"
Hopper	1.5 m^3	2	"
Welding machine		10	"
Generator	250 KVA	3	"
Tug boat	500 PS	1	"
Pontoon	500 t	1	"

Table 3-2 shows the recommended work schedule. If this schedule is adopted, the construction work will have to be completed in 10 months, starting in February and ending in November. The length of construction period is thus short and has no margin, but it is necessary to make concentrated effort to complete the whole construction work before the northeasterly monsoon season. Otherwise, the construction period is prone to be prolonged largely.

Table 3-2 CONSTRUCTION SCHEDULE

Work Item \ Month		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mobilization & Preparation Work													
Piling Work													
Approach Passage	V 75 piles B 0 "												
Quay	V 34 " B 32 "												
Mooring Dolphin & Pier	B 16 "												
Loading Platform	V 2 " B 32 "												
Breasting/Mooring Dolphin	B 72 "												
Concrete Work													
Approach Passage	893 m^3												
Quay	709 "												
Mooring Dolphin & Pier	166 "												
Loading Platform	315 "												
Breasting/Mooring Dolphin	936 "												
Fender Installation													
Rock Mound Approach Passage													
Grading for Yard													
Tunnel for Belt Conveyor													
Erection of Belt Conveyor and Loader													