KAWASAKI STEEL TECHNICAL REPORT
No.15 ( October 1986 )

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The body can be viewed from the next page.

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# Project Engineering for the Leyte Industrial Port Construction*



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## 1 Introduction

The Leyte industrial estate development project of the Philippines makes full use of electric power generated from geothermal energy in the Togonan district on Leyte Island. By constructing a copper smelting plant in this central region of the country using locally available copper ores which are a foremost natural resource, the project aims at a production of high value-added products. Further, in the neighborhood of the copper plant, the project plans to construct a chemical fertilizer plant using sulfuric acid to be byproduced at the copper plant, and ammonia and phosphate ores both to be imported.

The Leyte Public Port was planned by National Development Company (NDC) as the public port complex for this industrial development, as shown in **Fig. 1**, and this project was carried out by Kawasaki Steel Engineering Division with Pacific Consultants International (PCI) appointed as consultant.

The previous technical report[1] detailed results of engineering concerning the survey, planning, designing and execution of work for the harbor structures of this project and the structural characteristics of the wharf. This report describes results of the engineering work under a full-turnkey contract from the stand point of project management. The engineering included planning, construction work, adoption of special construction technique, and operational guidance of harbor facilities listed in **Table 1**, such as ship unloaders and ship loaders installed on the wharf.

## 2 Development of Project Engineering

Engineering activities were carried out properly in each phase of a project from order receiving to completion. How efficiently to carry out this comprehensive project engineering was the role of engineering management techniques.

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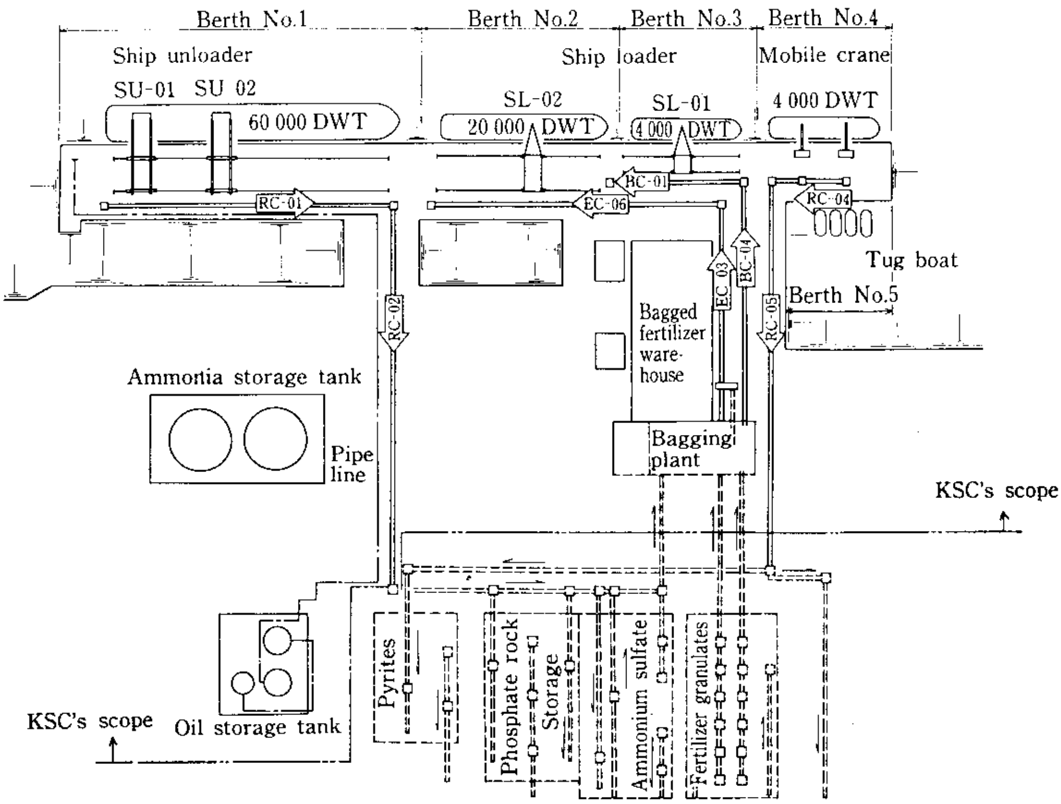


Fig. 1 Outline of layout

Photo 1 The whole view of the Leyte Port project

Kawasaki Steel submitted a proposal after 18 months of order receiving activities and was awarded the contract in nine months. After the signing of the contract, the various phases of the project until mechanical completion were smoothly carried out in 27 months as prescribed in the contract. The general view of Leyte Public Port after completion is shown in **Photo 1**.

Final acceptance was successfully made, although the period from mechanical completion to the performance test was as long as three months due to a delay in power supply from NDC. The full-turnkey project for the construction of harbor facilities ranging from civil engineering work to the hot run of unloaders was finished in 30 months after the award of the contract. Counting the activities before receiving the order, this project continued for 4 years and 9 months. **Figure 2** shows the phases of this project.

## 3 Flow of Engineering Work

The engineering work of this full-turnkey project for constructing harbor facilities was designed to flow as shown in **Fig. 3**. Conceptual plan and basic plan were made based on the contract specifications agreed upon between Kawasaki Steel and NDC. Execution plan was formulated in full consideration of actual conditions found by preliminary site survey and operational requirements for the harbor.

Special attention was paid to the following points as important key factors in engineering harbor facilities:

(1) Weather and sea conditions were thoroughly investigated and routes and wharf positions were so planned that vessels can safely enter and leave port.

(2) The number of vessels expected to enter and leave port and the amount of cargoes to be handled were thoroughly examined and cargo handling facilities were so planned that the berth occupancy will be equalized and demurrage can be minimized.

Table 1 Summary of equipment list

| Berth | Mechanical and liquid handling equipment | Handling materials (t/year) | |
|---|---|---|---|
| Berth No. 1<br>Wharf Length 280 m<br>Sea Bottom −12.7<br>Vessels<br>2 000～60 000 DWT | Shipunloader 880 t/h × 2 units<br>Belt coveyor<br>RC-01/02: 1 670 t/h × 2<br>Pipe line and load facilities<br>· 10″-sulphuric acid<br>· 10″-phosphoric acid<br>· 16″-ammonia<br>· 8″-fuel oil<br>· 6″-diesel oil<br>· 8″-fire water<br>· 6″-potable water<br>· 2″-steam and air<br>Storage tank<br>· Ammonia 15 000 t × 2<br>· Fuel/diesel oil 3 000 kl × 3 | Phos-rock<br>Potash<br>Urea<br>Sand<br>Sulphuric acid<br>Phosphoric acid<br>Ammonia<br>Fuel/diesel<br>Others<br>· Cathod coppor<br>· General | 900 000<br>25 000<br>10 000<br>15 000<br>373 000<br>140 000<br>200 000<br>35 000<br><br>138 000<br>10 000 |
| Berth No. 2<br>Wharf length 165 m<br>Sea Bottom −9.0<br>Vessels<br>4 000～20 000 DWT | Shiploader × 1<br>Bagged fertilizer 2 000 bag/h<br>Bulk fertilizer 300t/h<br>Belt conveyor<br>EC-03/06: 2 400 bag/h·max<br>330 t/h | Bagged fertilizer<br>Bulk fertilizer | 226 000<br>474 000 |
| Berth No. 3<br>Wharf length 110 m<br>Sea bottom −5.5<br>Vessels 4 000 DWT | Shiploader<br>Bagged fertilizer 2 000 bag/h × 1<br>Belt conveyor<br>BC-04/01 2 400 bag/h·max | Bagged fertilizer | 160 000 |
| Berth No. 4<br>Wharf length 110 m<br>Sea bottom −5.5<br>Vessels 4 000 DWT | Mobile crane with grab bucket<br>50 t × 1<br>40 t × 2<br>Belt conveyor with hoppor<br>RC-04/05 120 t/h·max | Pyrite<br>Coal | 280 000<br>25 000 |

(3) In view of soil conditions, interlocked steel pipe pile bulkheads were adopted in principal parts to construct economical and functional wharf structures.
(4) Ship unloaders provided with dust prevention devices for unloading phosphate ores, spiral chute type ship loaders for loading bagged fertilizer, and flexible loading arms for handling liquid ammonia and sulfuric acid were installed.
(5) Facilities necessary for berthing and unberthing were installed on the wharfs, with tugboats and line boats suitable for sea conditions arranged.
(6) Ancillary facilities necessary for harbor management, such as warehouses, weighing and measuring equipment, weather station, and communications system, were installed.

These points were incorporated in basic plans and detailed engineering was conducted.

## 4 Project Schedule

In this project, schedule control was set up as the most important control item of project management.

The project schedule was laid out by examining a master network schedule with about 350 nodes, which contains the term of the contract, milestone schedule, linkage work at battery limits and period of supply of electricity and utilities to be supplied by the owner as well as the linkage of each work package, main work within work packages and time of loading. The schedule control of important items, such as the early use of the wharf used for unloading materials and equipment, period of roll on-off activities, loading schedule of equipment, schedules of construction of each equipment and period of comissioning, was carried out using this master schedule.

The master schedule was then subdivided for each work and scheduling was performed using bar charts. At the same time, the work volume was set up for each

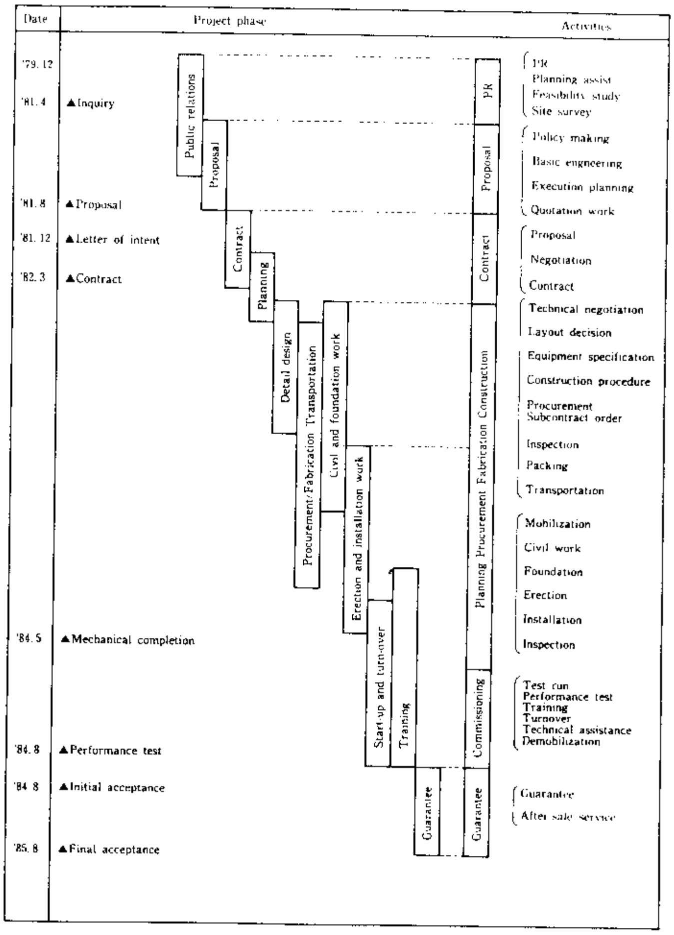


Fig. 2 Construction phase cycle in Leyte Port project

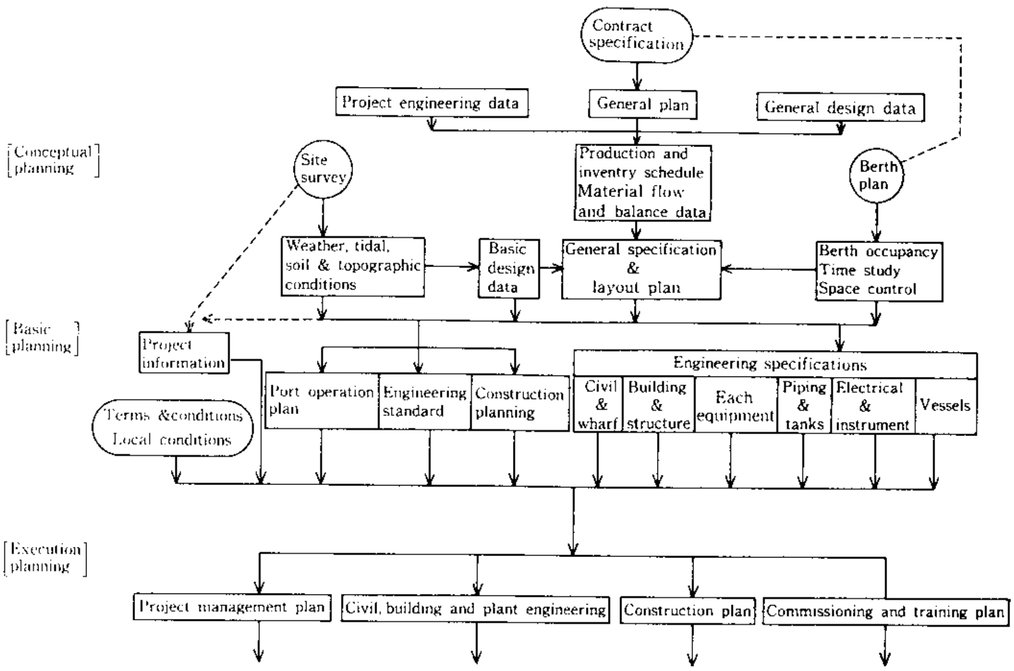


Fig. 3 Engineering work flow diagram

work and the schedule and progress were controlled by adding progress schedules (S-curve method). The amount of each work volume was calculated by the cost ratio, weight ratio and accomplishment percentage (determined by the rating of such main process factors in a series of work procedure as on-ground assembly, welding and inspection). These data are the same as entered on bills of materials submitted to the owner and bills of quantities used for sub-contracts. The data were processed by a personal computer carried into the site, and such clerical work as for demand for progress payments from NDC and monthly payments for subcontractors, were smoothly carried out in a simplified manner due to the use of the computer. The construction schedule and progress table shown in **Fig. 4** is an example of control chart composed of a bar chart and S-curve.

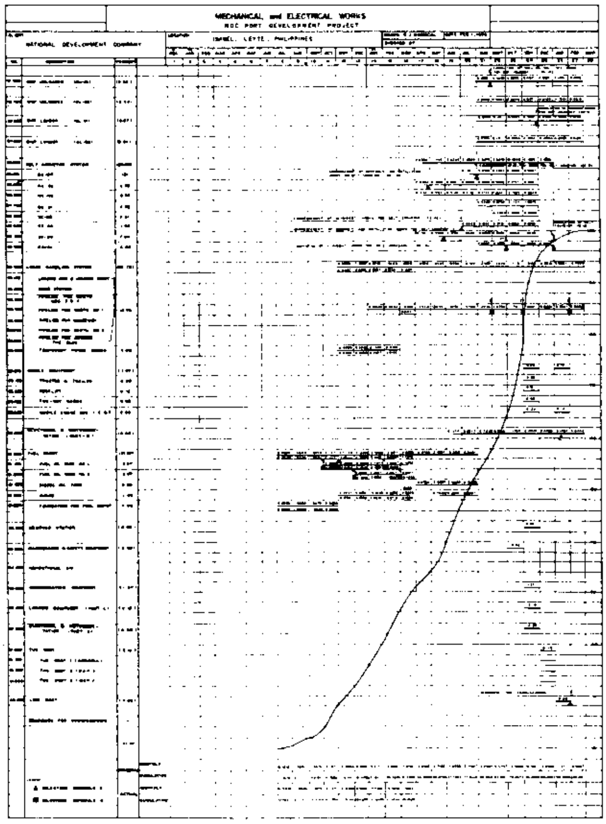

Fig. 4 An example of construction schedule and milestone control chart

## 5 Organization of Project

How to organize a project is the basis of project management and it is necessary to select and allocate persons properly to answer specific purpose. It is important to establish an organization capable of bringing individual abilities of many people in related fields into a fully totalized power of an organization.

In this organization of the subject project, the work of the project was divided into a phase of civil and building construction in the first half of the project and a phase of plant construction in the second half, and efforts were made to allocate persons best suited to each phase. Members including project coordinators and site managers were selected for each phase of the project. The site organization chart is shown in **Fig. 5**.

Three offices were opened; one at the Engineering

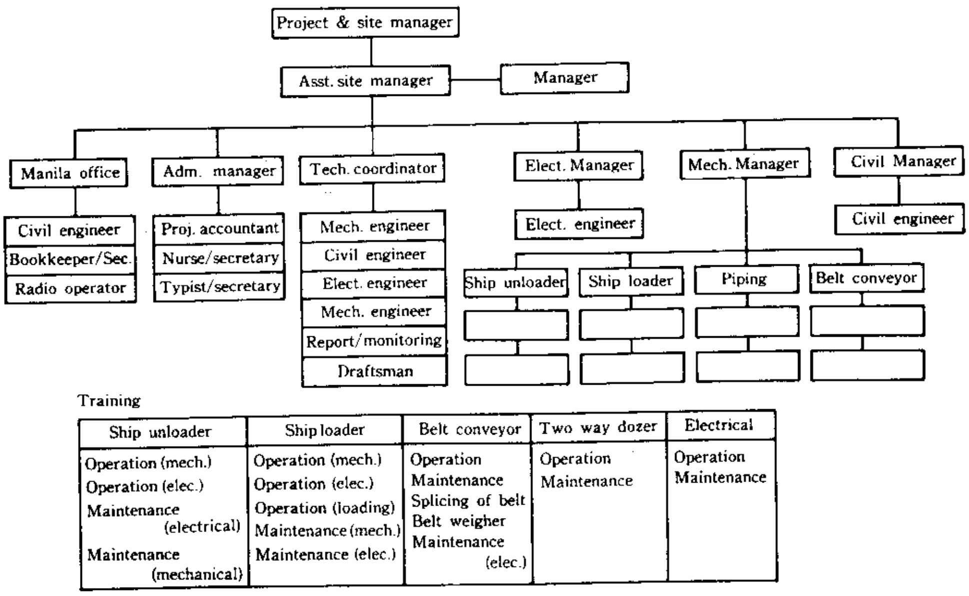


Fig. 5 Site organization chart

Division of Head Office and two local offices in Manila and Leyte. The Manila office served as a liaison and relay point between the Leyte site office and the home office. The Manila office played an important role in information control and transportation control in addition to the liaison business with the head office of the owner.

To perform smooth negotiations and communication in project management meetings, reportings, etc., with NDC, consultant and subcontractors who are all English culture-based people, Philippinos were incorporated into the staff of the organization of this project. Especially at the site, Japanese-Philippine combined teams were very active.

At the Head Office, the project members and line staff were assigned into a matrix-form management project organization and a project committee that supervises them was formed under the control of project manager.

## 6 Construction Management

In an oversea project, the construction work at site is the kernel of the project, and the capability of managing construction is a key point in project engineering.

The site work of this project was carried out based on multiple subcontracts and optimal Philippine subcontractors suitable for work unit, such as civil engineering work, building construction, plant construction and tank construction.

Construction management involves the management of both the contract with NDC and contracts with subcontractors, and greatest attention was paid to keeping a good balance between both because the former had to be executed in parallel with the latter.

Needless to say, the promotion of construction work as scheduled under the project schedule mentioned above requires an elaborate execution of plans from one stage to another in each scope of various types of equipment. In managing the execution of construction, a project activity management system was established for the purpose of meeting requirements for quality, cost, and schedule. The basic function of this system is composed of a management cycle of planning, supervision, management, and reporting. Work carried out for each scope of various type of equipment unit is thoroughly controlled and reported, and the result is reflected in the next work schedule. This cycle is repeated until the completion of the project.

The work units of construction management of this project were divided as shown in **Fig. 6** based on the concept of work breakdown structure (WBS)[2] in consideration of the equipment constitution and site organization. Work management was carried out according to these work units and the construction of each equipment was managed and carried out.

## 7 Control of Man-Hour and Construction Machinery

Important points of construction management are

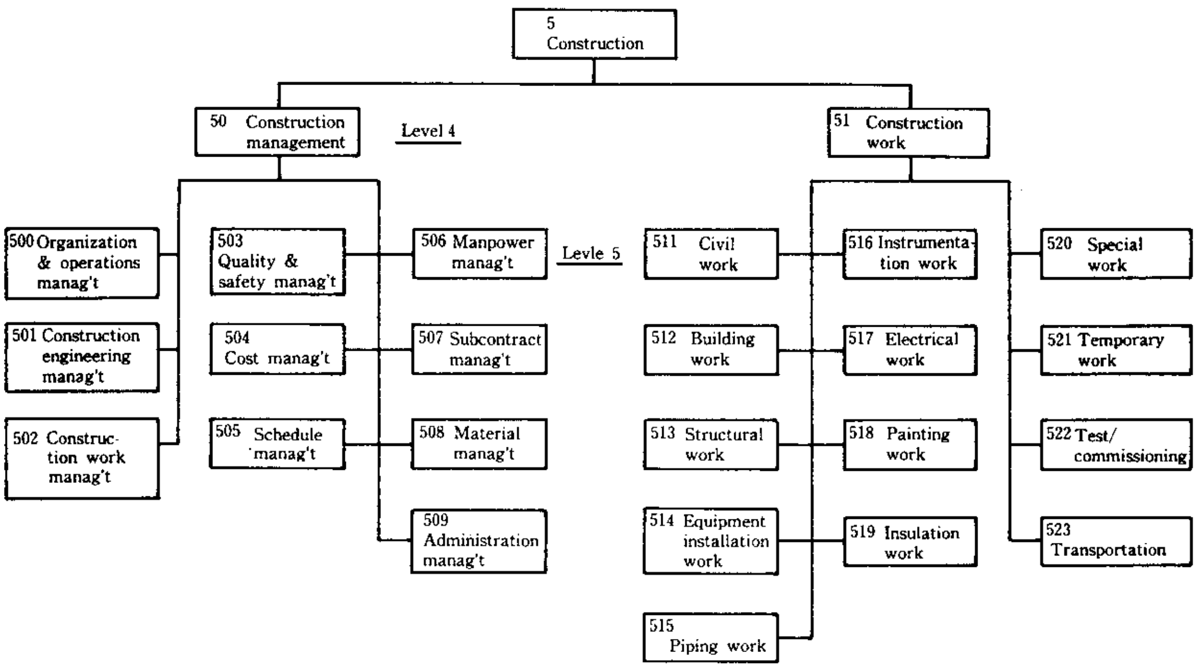


Fig. 6 Construction work breakdown structure

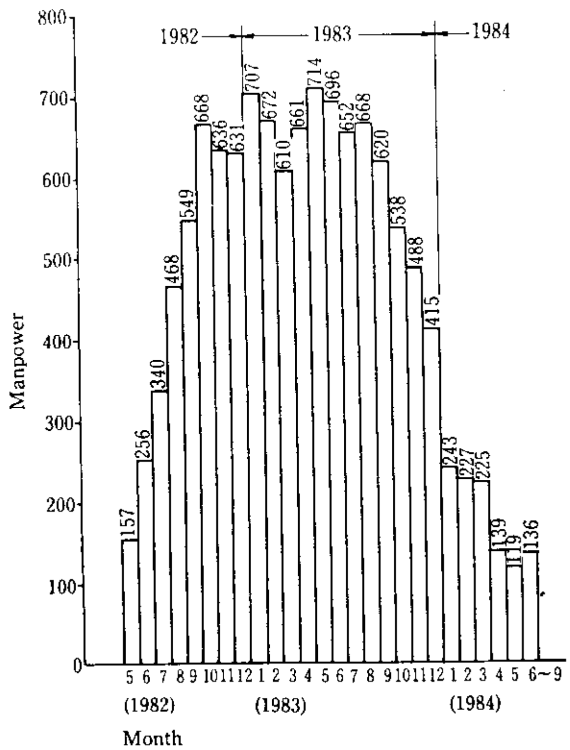


Fig. 7 Total manpower pile

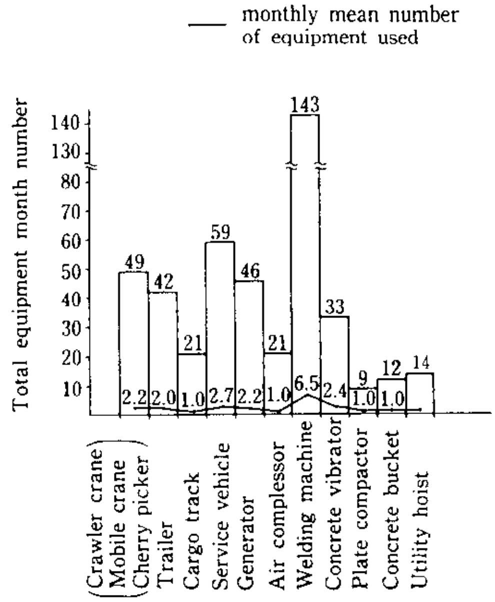


Fig. 8 Construction equipment pile

periods and costs. It is not too much to say that the control of these important governing factors consists in the rational allotment of man-hours and construction machinery both required for construction.

This project is in the shape of subcontracts. In construction management, planned work volume, installation weights, etc., were indicated to subconstructors in laying out the construction schedule, and subconstrators were requested to prepare manpower schedules and construction machinery schedules. In the course of execution of the construction schedule, results were gathered and were immediately reflected in the next phase of construction. **Figs. 7** and **8** show actual results for each work category.

The number of structures fabricated and machines installed was large and the site installation work was very complex. Therefore, the importance of schedule control was high in each work category. Furthermore, effective utilization of workers and construction equipment was one of the most important routine management activities.

## 8 Installation of Ship Unloaders and Loaders

Most noteworthy in the construction work of this project is the adoption of the roll-on-off process. Two 800-t/h unloaders and two 2 400-bag/h loaders were fully assembled in Japan and these large cargo handling machines were transported by a roll-on-off ship to the site (**Photo 2**). These cargo handling machines were unloaded in a short time using winches of the ship at the site and were installed on the wharf rails.

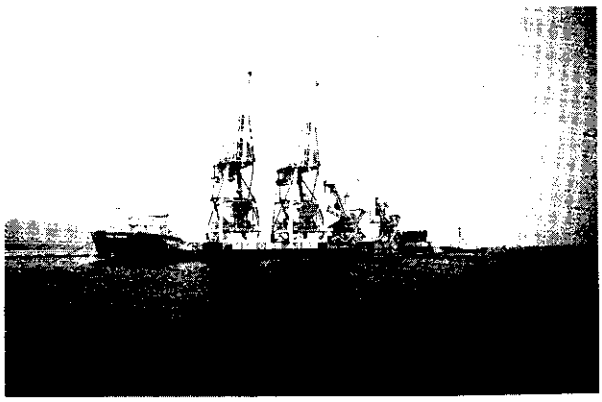

Photo 2 Transportation of loaders/unloaders to site

This roll-on-off process provided the following advantages:

(1) Since the cargo handling machines were fully assembled in Japan, they were fabricated into high-quality machines within a prescribed period.
(2) Elimination of unpredictable risk inseparable from field assembly work.
(3) Exclusion of floating cranes and large assembling crane required for field assembly work.
(4) Exclusion of assembling space and crane foundations on the wharf.
(5) The civil engineering works period was so selected that the work can be economically carried out. It was possible to bring in the cargo handling machines after the completion of civil works.
(6) Since trial load tests were conducted in Japan, com-

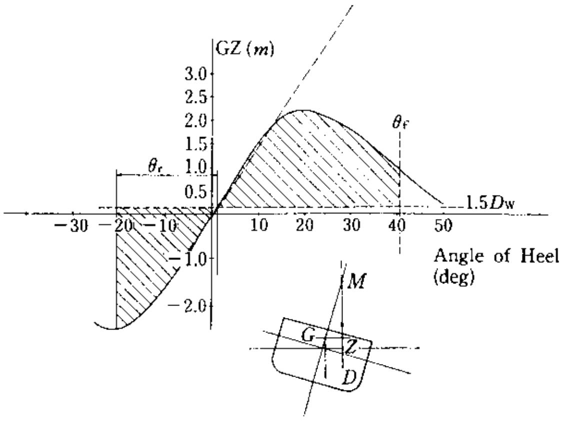


Fig. 9 Stability curve of roll-on/off vessel

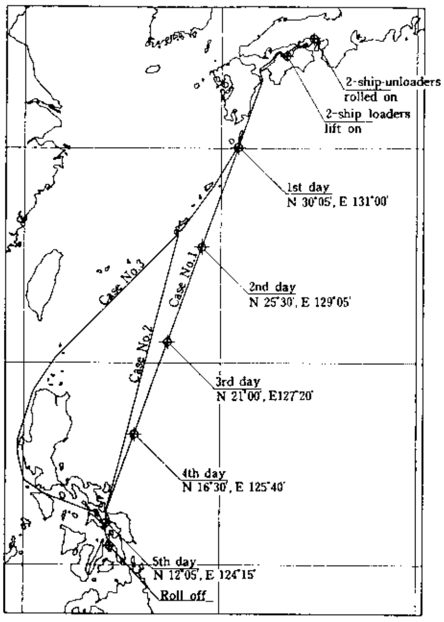


Fig. 10 Navigation routes map

**************************
**** ROUTE DATA ****
**************************

| | |
|---|---|
| SHIP NAME | GULF BRIDGE |
| ROUTE | JAPAN-PHILIPPINE |
| VOY. NO. | 25 |
| SEASON | JUN-AUG. |
| FILE NAME | STAMOTN |
| COMMENT | UNLOADER |
| DATE | 1982.09.21 |
| OPERATOR | DOI |

** CALCULATION CONDITIONS **

TW; ORDINARY
HW; NV CONVERSION
WAVE FREQ.; NV CONVERSION

** WAVE CONDITIONS **

MEAN WAVE PERIOD (SEC) .............. 6.39
MEAN WAVE HEIGHT (M) ................ 2.25
SIGNIFICANT H1/3 (M) ................ 3.94

| 0 | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16.8 | 13.8 | 9.3 | 6.4 | 4.9 | 4.2 | 3.9 | 4.2 | 4.9 | 6.4 | 9.3 | 13.8 |

** WAVE DIRECTION FREQUENCY **

| WAVE DIRECTION (DEG) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 30 | 80 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 |
| 12392 | 10290 | 9064 | 11166 | 7667 | 3572 | 2542 | 2910 | 3379 | 6156 | 13627 | 15513 |

TOTAL=100000 (CALM= 3285)

** ROUTE DATA **

| P.NO | LATITUDE (D.M) | LOGITUDE (D.M) |
|---|---|---|
| 1 | N 34.00 | E 135.00 |
| 2 | N 13.14 | E 124.36 |

Fig. 11 Example of output data used in stability calculation

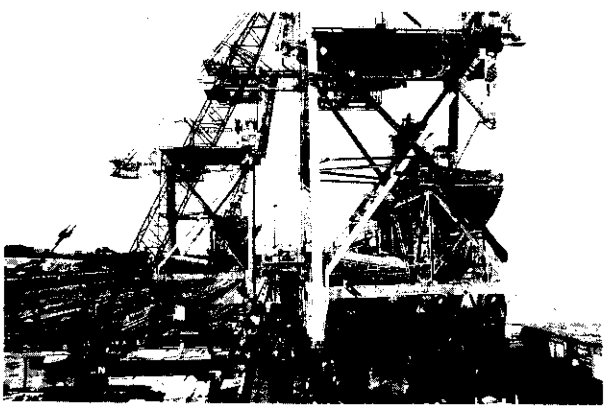

Photo 3 Roll off work at site

mercial operation at site was immediately made possible.

Kawasaki Steel had already transported two 1 800-t/h unloaders in four divided portions to Mindanao Plant of Philippine Sinter Corp. (PSC). After that, two 600-t/h unloaders were transported to Trinidad and Tobago, and one 300-t/h unloader to PASAR in the Philippines. These experiences helped achieve full assembling in stages. The company has this time established techniques for one vessel transportation of fully assembled harbor cargo handling machines comprising 4 unloaders and loaders.

Weather forecast and communication techniques for predicting the generation of typhoons and avoiding them have made progress with the aid of space communication techniques. These techniques, along with the progress in dynamic oscillation analysis on rolling and pitching of ship[3], have now permitted the marine transportation of such large cargo handling machines which are fully assembled beforehand.

The relationship between the integrated center of gravity and stability in a loaded condition is shown in **Fig. 9**. The planned navigation routes and actual route data are shown in **Figs. 10 and 11**, respectively. The roll-off work at the site is shown in **Photo 3**.

## 9 Technology Transfer and Performance Test

The scope of technology transfer agreed upon in the contract with the owner covered a wide range from the training of operators in the operation and maintenance of supplied equipment to techniques for harbor management. Furthermore, there was a severe stipulation for the final acceptance in that the specified performance shall be achieved in the operation conducted with the techniques of the owner within one year after the delivery of equipment.

Training was conducted thoroughly according to an elaborately thought-out training program, which covered the training in practical techniques and control techniques using similar facilities at Kawasaki Steel's Chiba Works and at PSC in the Philippines and the training at the site using actual facilities.

The performance test conditions and test methods for the unloaders are shown in **Table 2** and **Fig. 12**, respectively. Item 3 in Table 2 indicates the average unloading capacity of an unloader which essentially is to be achieved within one year after delivery. This performance test can be achieved by total combination of excellence in facilities, techniques of operators, hatch scheduling, etc. In this project, the average capacity was achieved already in the initial acceptance test of the equipment. This was a glorious undertaking. As a result, the project cost was substantially reduced and NDC was satisfied with the high quality of supplied equipment and the complete technology transfer.

Various engineering techniques as mentioned above are required for carrying out a large-scale turnkey project of this kind. The authors deeply felt the significance of the experience with the operation at their own company, along with the construction experience, as the basis of these engineering techniques.

Table 2 Performance test conditions of shipunloader

| Performanc Test on the Contract | | Actual Performance Test | |
|---|---|---|---|
| Item | Capacity (t/h) | Condition | Actual capacity (t/h) |
| 1. Unloader | | | |
| 1 3 points unloading | | | |
| SU-01 | 970 | Vessel: | 1 102 |
| SU-02 | 970 | 30 000 DWT | 1 029 |
| 2 One hour unloading | | Handling material: Phos-rock | |
| SU-01 | 750 | | 873 |
| SU-02 | 750 | | 822 |
| 2. Belt conveyor | | | |
| RC01/02: Max. cap | 1 670 | | 1 737 |
| 3. Unloader | | Vessel: 60 000 DWT | |
| 3 Average unloading (90% total Q'ty) | 500 | Handling material: Phos-rock | 510 |

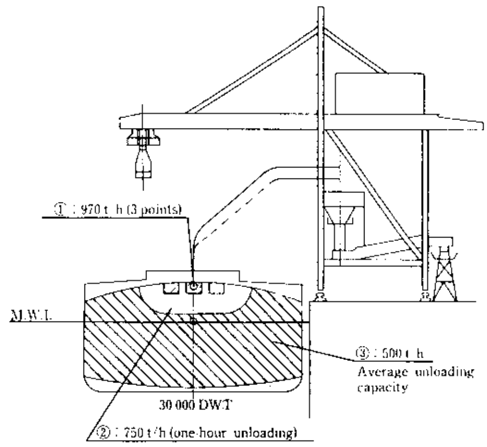

Fig. 12 Illustration for performance test condition

## 10 Conclusions

It may be said that the techniques employed for the Leyte industrial port facility project were completed as a combination of the port construction techniques and material handling techniques accumulated during the constructuion of the company's integlated Chiba and Mizushima Works and the project management techniques for oversea plant construction at Philippine Sinter Corp. and Brazil's Tubaro Steel Works.

With the world's physical distribution flows expanding more than before, the demand for such port facilities has been increasing in resources-rich countries and developing countries.

It is a matter of a great significance that the Engineering Division of Kawasaki Steel has completed this port facility project on a full-turnkey basis by combining the strengths of the people related to engineering works, civil construction and plant building. This is an example of application of techniques developed in the steel industry to the non-steel fields of copper and fertilizer. It is expected that the engineering techniques obtained from this project will further be employed for the expansion of public infrastructures and for the construction of port facilities in a wide range of industrial spheres.


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