PLANNING OF A COAL AND CONTAINER SHIPMENT TERMINAL AS A DEEP WATER PORT OF TAIWAN DISTRICT, R.O.C.

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Abstract

Taiwan now has five international ports, Taichung and Su-Ao ports were newly opened since 1970. They have been under continuous expansion in recent years to meet the needs of the island's burgeoning foreign trade. Due to recent trend of vessel developed to huge load-capacity, the existing port of Taiwan district is inconvenient to the ULCC or VLCC. For decreasing the shipping cost and accommodating the cargo handing of over 150,000 DWT, the deep water port is urgent to be developed in order to promote the competent capability of port cargo handling, especially for coal cargo imported from foreign country and container shipment increased in this country.

This research is divided into two parts, at first, oceanographical data for the design and the planning of deep water wharf and breakwater need to be surveyed around this island for possible site of deep water port, the next, this study will deal with the design and construction method of the deep water wharf and breakwater, and then checked by both numerical model and physical model tests.

I. Introduction

In 1980's the second impact of energy crisis, the world treat the energy policy is used as the uncertainty to adopt multi-policy. Our government try to treat the development and change of the world energy situation and determine to use coal instead of oil. Therefore, Taiwan power company decides to change gradually from oil fuel to coal fuel for the existing thermal power plant. For the new constructed thermal power plant, coal is used as the fossil fuel. Our government also urges the civic industries, such as cement industry, oil chemical industry to use coal as fuel. In addition, steel industry continuously grows, the demand of the coal is relatively increased.

Due to production of the coal is limited in this country, most of the coal is imported from foreign country, it is expected to import 30,000,000 tons/yr or so, in the year of 2000, therefore the deep water coal port, need to be planned for the future demand of large vessel over 150,000 DWT to ship those coal cargo from U.S.A. or Australia to this deep water port for distributing to the consumption unit.

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—569—
The Ministry of Communications, Republic of China has recognized that the present port facilities in Taiwan are very limited in their capability to handle large ships (100,000 to 200,000 Ton) New port developments are being considered which will be designed to handle present and future large ships for coal cargo imported from U.S.A., Australia and S.A., etc. The site selection is still being reviewed but will most likely be on the West side of Formosa, generally sheltered from the worst typhoons but nevertheless affected by them.

A phased study has been underway for some time by the Institute of Transportation, Ministry of Communications. The first phase is essentially completed and has established the need for the addition of a major deep water port capability for Taiwan. The second phase will be the gathering and analysis of hydrographic and oceanographic data. Following this phase, conceptual and preliminary designs are needed and eventually final design, construction specification preparation and construction itself.

The overriding concern in the development of new port facilities is the desired throughput. Once that is decided (or forecasted), the appropriate number and types of ship berths is determined. The key factor in all subsequent studies is cost. A way has to be found to provide the desired facilities with the least cost. In the present day political climate environmental costs as well as monetary costs have to be considered.

The early site investigation work established the basis for judgement regarding monetary and environmental costs. It is at this stage that the proposed project team can be most helpful. Also during the early site investigations a parallel effort to develop conceptual port configurations and alternates should be performed such that the benefits of an integrated engineering approach guides the field investigations towards the engineering decision making needs.

II. Field Measurements

As an early step, the general preferred port site location and any desirable alternates sites must be identified. A recent publication by Hou (1986) in the latest International Coastal Engineering Conference Proceedings appears to have identified potential sites. Existing bathymetric and oceanographic data for these sites should be further reviewed, reasonable assumptions concerning soil properties made and some preliminary port layout concepts developed and costed. This will identify the most desirable site or sites and detailed investigations can be started.

The type of data required are:

(a) Bathymetry
(b) Soils and Foundation
(c) Oceanographic
(d) Meteorologic

Data acquisition and analysis in each of these fields presents its own specific problems. The planning for the acquisition of the necessary field
data should be carefully planned. It would be desirable to prepare preliminary concepts of desired port facility layouts to guide the acquisition of detailed field data. During this phase, some of the basic oceanographic data collection could be initiated in order to provide a data base.

Often the development of conceptual designs is performed using existing information. More specific site details such as bathymetry and soils would be most efficiently carried out after the conceptual designs are developed and the data used to refine and optimize the "conceptual designs" leading towards the "preliminary designs." At this stage fairly detailed cost estimates can be prepared which will be refined as the results of the site investigations become available.

2.1 Bathymetry:

For the reception of ships of the size being considered detailed bathymetry in the water depth range or 10 to 30 meters is needed. These depths can also be obtained by dredging so detailed surveys between about 5 and 60 meters are required. It is important to establish the relationship between seal level and land benchmarks. To do this, a tide gage has to be established in the area and maintained over a period of at least one year.

Accurate offshore positioning is best achieved by range-range radar positioning. Similarly, a wide experience in the use of accurate sonar depth sensing devices is also required. Usually the appropriate equipment is leased as needed from third party equipment owners. This ensures the capability to use the best equipment for particular survey or measurement rather than propose to use some particular "owned" equipment which may not be the best.

2.2 Oceanography:

The choice of instruments and recording periods for currents, tides, waves, water temperature, dissolved oxygen, and pollutants depends on the available budgets and the degree of concern for the pertinent parameters. Before proposing a specific program a serious review of costs and benefits of the measurements would be undertaken. For example, tide measurement is absolutely essential to define bathymetry but wave measurements may not be useful as the chance of recording a design wave event during a one year survey is small and the risk of losing the instrument during a severe storm is high. Design waves can be better estimated from hindcast studies (See Section 3).

2.3 Soils and Foundations:

The potential cost impact on any port design of sub-surface conditions is very large. Ports are almost always constructed in the coastal areas which are relatively flat since any port requires a large area of level land for cargo handling, particularly bulk products and containers. Such areas are typically
located on recent marine or land outwash deposits which may vary from good sand to soft marine oozes. The sub-surfact geology can make any proposed site practically infeasible, if the conditions are unfavorable.

At a very early stage in the investigations extensive seismic surveys and soil coring must be undertaken. Initially, available geological studies can be utilized to evaluate the most promising sites. Generally the soils studies require the use of a team of specialists. Amongst the proposed staff for this project there are a number of personnel with the background to direct the necessary specialist geotechnical and geophysical subcontractors who would be hired to perform the works.

The interaction of soils and foundations during earthquakes need to be extensively investigated. Problems of potential wave induced liquefaction and seismic effects on slope stability have also to be investigated. Taiwan is located in a seismically active region of the world and will require investigation of the impacts of such activity on the foundations of any deep water port structures.

Sediment studies will be necessary to evaluate initial and maintenance dredging requirements and potential sedimentation problems. Another supporting geological task is the determination of sources and costs of various construction materials such as fill material and rock.

2.4 Water Quality:

Factors which will affect water quality include physical ones such as tidal range and currents and external ones as sources of pollutants and locations of such sources.

An early be to identify such factors, physical measurements of temperature, salinity, dissolved oxygen, and nutrients can be undertaken by the survey team as they gather other data.

The impact on an existing environment has to be evaluated by an experienced marine biologist.

III. Numerical Modeling

Numerical modelling has a strong place in the analysis of the field data, in the interpretation of its significance, and in the prediction of future impact. Clearly local phenomena such as wave action, circulation, sediment transport etc. will be different from the presently existing conditions once a major port is constructed.

Numerical modelling (economic) is used for the determination of the number of ship berths. More berths cost more money but an insufficient number causes cost increases for demurrage when excessive waiting times arise. The most economical solution can be found from an analysis based on queueing theory.

Wave hindcasting from known historical storms is done using numerical
modelling of the storms with some coefficients selected based on the available storm information. Statistical interpretation has to be applied and the waves have to be corrected for any local shallow water effects. In a similar manner, storm surge computations have to be performed to evaluate design extreme water levels.

Numerical models for sediment transport and water quality are also needed to evaluate the impact of a new port.

In areas with difficult foundation problems, finite element analysis can be used to support the design analysis.

IV. Physical Scale Modeling

Based on the income requirement of the future coal import until 2000 D.C., in the eastern Taiwan district, coal import to Hualien harbor and then distributed to coal required plants. Accommodation of the construction of coal terminal of the Hualien harbor, it does meet the requirement. In the northern Taiwan district, import from Su-Ao harbor could accommodate the civil use, and the coal restoration center of Su-Al harbor area has much space to use. Therefore, there is no need of any harbor extension for the purpose of coal import either in Hualien port or in Su-Ao harbor.

In the middle of Taiwan district, Taichung harbor could be enlarged as large scale of coal port. Since coal supplied to Seng-Ao power plant, Linkou power plant and Taichung thermal power plant (under construction) etc., need to use Taichung port coal terminal as the transshipment station. For the demand of huge coal carrier, it is economic to select the vessel of 200,000 DWT or over (see Table 1, 2 & 3). Then, coastal shipping system needs to be planned for transshipment of coal to the above mentioned area. For constructing the deep water coal port, it would be a good idea to take the coal port as the coal storage center and then transferred by coastal shipping or inland transportation toward the consumption unit or power plant as shown in Fig. 5. The alternative deep water harbor sites are (1) the outer area of Taichung port industrial water front, dredging the outer navigational channel and reclaiming the coal wharf space. The layout of the Taichung deep water port is shown in Fig. 1. (2) An offshore island of the Wai-San-Ding Sand Barrier, is planned as a deepwater coal terminal, the layout is shown in Fig 2. (3) Hisn-Ta thermal power plant or LNG terminal will be another deep water port site as shown in Fig 3. (4) For the northern port site Taoyuan coast offshore area including the single mooring buoy (SMB) for oil unloading toward Taoyuan oil refinery plant will be also the alternative harbor site of deep water port., it is shown in Fig.4 Kaohsiung port off-shore deep water terminal as shown in Fig.9 is planned for coal, and container deep water terminal. For the above harbor sites, their orientation and arrangement are determined by using the typhoon attacking track and wind rose and wave distribution. Coal import and shipping cost are also analyzed as shown in Fig.6 & Fig.7.
VI. An Idea Of A Central Deepwater Port

The main characteristics of a deepwater port is its ability to permit large vessels of over 150,000 DWT to enter the port by virtue of its depth, entrance channel, turning basin and other special provisions. The primary advantage of a deepwater port lies in its capability to receive large bulk carriers, thus reducing shipping costs for the commodities considerably. The lower handing cost per unit of cargo is, the higher flexibility of a large terminal will be. Therefore, the large investment required for opening up and developing a deep-water port makes it necessary to adopt policies to concentrate the handling of certain commodities as to make the port feasible by the savings thus gained.

For a deepwater port of the Taiwan district, it may be of interest for the extended quantities of coals (see Fig. 8) and containers (Since Keelung port is congested) to be handled in the near future. A deepwater port would creates a large, additional capacity, which would serve as a buffer for Taiwan port developments which cannot be foreseen at this moment. It may become possible to concentrate the capital outlays in one location and to construct, at a lower of total costs, a safe and well-designed deepwater port instead of having a number of ports complete for the status of deepwater port - at a far higher combined cost - a status which most of the ports can never attain as a result of their physical and hinterland limitations.

Transshipment of containers, fertilizer and other products are considered as potentially promising port activities of Taiwan district. If Transshipment for the East or South-east Asia region is to play an important role, an additional amount of port capacity is to be created over, Taiwan may be called upon to take over one or more port and economic functions from Hong Kong. In the future, Taiwan will import LNG for which a port with relatively large dimensions would be required.

The combined effect of these arguments, an investigation into a possible deepwater port of Taiwan district is warranted to be necessary.

VII. Economical And Technical Adaptability Of The Proposed Deepwater Harbor Sites

A. Domestic transportation patterns of export and import commodities.

In order to carry out system analysis of the proposed deepwater harbor sites from the viewpoint of transportation economics, domestic transportation patterns of export and import commodities must be estimated. For this purpose, it is desirable to investigate the commodity flow in detail, and to make up the tables of origin and destination. Thereafter, regional demand for international cargo transport is estimated on major items of export and import by above mentioned pattern.

It is difficult to assume that the present pattern of regional distribution can be applied for the future without adjustment, but the changes
are considered to be usually gradual. Our investigation based on present pattern, and modified cases are also calculated for check.

B. Study on proposed deepwater harbor sites based on transportation economics.

The investigation made clear that all the four sites are technically feasible and can reasonably be taken up as alternatives. Thereafter, adaptability of each proposed site is divided by her locational characteristics as a deepwater port.

C. Natural conditions at the proposed deepwater harbor sites

For the field oceanographic measurements, it is scheduled to be surveyed for the coming fiscal year, the items is listed as follows:

1. Hydrographic survey: The deeper part from -20M to -30M to -40M needs to be thoroughly surveyed. Since for the previous data, even nautical chart, there is not so detailly described.

2. Coastal morphological investigation: The measurement includes the shoreline change, and topographic change of the nearshore area.

3. Geotechnical investigation: Subsurface boiling, soil sampling and foundation exploring are included.

4. Wind, wave and current measurements: The offshore measurements are emphasized in each proposed deepwater harbor site.

5. Coastal hydrologic survey: The survey consists of measurements of water temperature, salinity, concentration, and conductivity etc., for sufficiently analyzing horizontal & vertical distribution.

6. Tidal records: This measurement need to be long-term records, at least one-year continuous record.

7. Sea-bottom topographic change process: The survey need to be detailly measured for realizing the deposition and scour around the proposed deepwater harbor sites, especially, for evaluating the littoral transport rate of the harbor sites.

8. Seismic measurement: Geological distribution of deep layer of the sea-bottom needs to be surveyed in detail. For complete seismic survey of the deepwater harbor sites, the design of breakwater and wharf could be carefully considered. The construction of those harbor structure will be safe.

VIII. Concluded Remarks

From the above measurement and investigation, the natural conditions of the proposed deepwater harbor sites could be compared, the best conditions of the harbor site is then determined.
References

CEPD, executive Yuan, Taiwan, ROC "Port Development Study Taiwan" under Supervision of NEDECO Dec. 1982.

Table 1 Coal Supply and Demand
Unit: Thousand Tonnage

<table>
<thead>
<tr>
<th>Year</th>
<th>Own Product</th>
<th>Import</th>
<th>Power Use</th>
<th>CSC Use</th>
<th>Other Use</th>
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Yearly Mean Growth Rate

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<td>1985-00</td>
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CSC: China Steel Corporation
### Table 2 Cost of Island Transportation by Barge

**Unit: US Dollars/ton**

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<th>Ship Tonnage DWT</th>
<th>5000</th>
<th>10000</th>
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<td>Navigational Distance (N.M.)</td>
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<tr>
<td>100</td>
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N.M. = Nautical Mile

### Table 3 Shipping Cost of Coal Import from Different Navigational line

**Unit: US dollars/ton**

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Remark: ( ) indicates the navigational distance.
Planning of a Coal and Container Shipment Terminal as a Deep Water Port of Taiwan District, R. O. C.

Fig. 1. Sketch of Extended Coal Port of Taichung Harbor

Fig. 4. Sketch of Shores off Shore Harbor Side

Fig. 2. Sketch of Taiwan off Shore Harbor Side

Fig. 5. Sketch of the Coal Deposited and Transported System

Fig. 6. Distribution of Coal Import from Foreign Countries
Fig. 7. Coal Shipping Cost of Each Navigation Line

Fig. 8. Coal Shipping Quantity Record & Prediction

Figure 9. Offshore Deep Water Terminal of Kaohsiung Port
台灣地區煤港埠站規劃深水港之研究

侯和雄

摘　要

目前臺灣地區有五大國際性港口在營運，其中有兩個是於 1970 年代開始營運的。這些港口近年來不斷地擴建，以適應本島快速發展之國際貿易需要。在現代發展巨大容載量船舶的趨勢下，臺灣地區現有的港口對超大型油輪 (ULCC) 或極大型油輪或散裝貨輪 (VLCC) 之營運是無法容納的。為了要降低船運費用，並使超過 150,000 載重噸以上的貨輪之貨物裝卸，興建深水港為一不容緩之事，俾能提昇貨物裝卸能力，尤其對由國外進口的燃煤裝卸更有助益。

本研究可分為二部分：首先對本島周圍實施設計規劃此深水港之碼頭與防波堤所需的海況資料進行調查觀測，以選定候選深水港埠興建之適當處地點。而後，以此調查資料來決定此深水碼頭及防波堤的設計與興建方案，並以數值模擬及物理水工模型試驗來検核其佈置。

在 1980 年代第二次能源危機的衝擊下，世界各國採取多元化的能源政策以為因應。我政府為應付世界能源情況的變動及發展，遂決定以煤為主要能源以替代石油。因此臺灣電力公司決定將現有的火力發電廠所用之石油燃料逐漸改為煤燃料。對於新建的火力發電廠也以煤為主要燃料；政府亦鼓勵民營工業如水泥工業、石化工業等以煤為主要能源。此外，由於鋼鐵工業的持續成長，煤礦的需求也相對的增加。

因爲臺灣的煤產量有限，故大部分的燃煤皆由國外進口，預期在西元 2000 年時，其進口量將達 30,000,000 噸／年，因此為了將來超過 150,000 載重噸的大型散裝貨輪能自由靠泊裝卸煤炭，此等深水碼頭乃必須加以規劃興建，以便大量自美國、澳洲及南非輸入的煤炭能快速裝卸並轉運至電廠、水泥廠及各消費單位使用。

中華民國交通部體認到當前臺灣之港口設備在處理巨大貨輪（100,000 噸至 200,000 噸級）的能力是非常有限的。因此對於深水港的開發及設計已考慮到能處理目前及未來來自美國、澳洲及南非等輸入的大宗煤炭。此深水港址的選定仍在反覆考量選擇中，但最大的可能是在臺灣西海岸。