

CHAPTER 189

ON THE CONSTRUCTION OF HSIN-TA LNG TERMINAL IN TAIWAN

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ABSTRACT

Since 1984 Hsin-Ta LNG Terminal has been under construction for the purpose of importing liquefied natural gas because of increasing demand and possible depletion of natural gas in Taiwan. Several alternatives were taken into account during the feasibility study. The Terminal is built with only a southern breakwater due to its good natural coastal conditions. Each construction item has been coordinated closely in order to advance the schedule. The first phase of land reclamation was finished by 1986. Three tanks have been under construction since soil improvement was finished. The entire project will be completed in 1989.

1. INTRODUCTION

With a booming of economics in Taiwan, there is an increasing demand for natural gas as new energy resources. In addition, the possible depletion of local natural gas reserves has been taken into account. Hence the Chinese Petroleum Corporation studied the feasibility of importing liquefied natural gas (LNG) in 1979. Since the utilization of LNG is helpful in diversifying the supply of energy resources and decreasing environmental pollution, the government of the Republic of China approved the project in 1984 and decided to establish the LNG Terminal in the Yung-An area. Because there should be no resident within a radius of 1.5 kilometers around the quay of the LNG unloading arm, spacious land is necessary. All of the required area is to be reclaimed by dredging from the locations of navigation channel and turning basin. Because the site for LNG tanks will be built prior to the offshore breakwater, the structure of the revetment should be able to withstand the open sea before the completion of breakwater.

2. PLANNING OF HSIN-TA LNG TERMINAL

2.1 Site Selection

The site selection criteria for LNG terminals are quite different from those for typical ports or harbors. In addition to desirable coastal conditions, special considerations must be examined .

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2.1.1 Soil stability

Taiwan is on the actively seismic circum-Pacific belt. Because of high safety requirements for LNG storage tanks, seismic effects must be taken into consideration. Furthermore the settlement of reclaimed land should be well treated. The sand compaction pile method and the sand drain method have been adopted to improve the soft soil.

2.1.2 Environmental safety

Environmental impacts related to human beings, aquatic vegetation, animals, water and air pollutions must be considered carefully. The required seawater circulation or dredging must not ruin valuable aquatic habitats or ecological systems. In addition, the site should not be chosen in an area where there might be a potential conflict with military training or important public utilities such as gunnery ranges or offshore oil/gas wells.

2.1.3 Storage facilities

There should be large territory available for the building of storage tanks, a regasification system, and control facilities. A buffer zone and a reserve for possible extension must also be included.

2.1.4 Economical transportation cost

The LNG terminal site should have the lowest unit cost for the total transportation system of freight and delivery.

All possible sites in western Taiwan were thoroughly investigated, including Tamsui, Taoyuan, Taichung, Changhau, Yung-An, and Kaohsiung. Since the Yung-An area satisfies the constraints stated above, it was selected to be the site of the first liquefied natural gas terminal in Taiwan, Republic of China.

2.2 Design of Hsin-Ta LNG Terminal

2.2.1 Littoral conditions

The coastline along the site is in the direction of NNW, which is favorable for a harbor in southwestern Taiwan. Since the local coastal data recorded from 1978 were not enough for analysis, data from Kaohsiung harbor had to be frequently referred to.

- * Wind: The directions of strong blowing winds range from NW to NNE with the northern direction most prevailing. Winds less than 10 m/sec occur 96.5% of the year.
- * Fog: There are an average of 16.5 days per year.
- * Water and tidal level: The highest high water level (HHWL) is 1.99 m above from the local chart datum. The maximum tidal range is 1.30 m in January. The astronomical tide and storm surge with return period of 100 years are +1.36 m and +1.5 m respectively. Hence the tidal level used for the design is +2.86 m.
- * Current: Most currents are along the direction of SE-NW. The longshore current speed near the seabed is about 0.5~1.0 m/sec.

*Wave: Wave data show that 93% of the significant wave heights ($H_{1/3}$) are smaller than 1.0 m. Eight model typhoons passing through the site were adopted to calculate the design waves under typhoon conditions.

The simulated maximum significant wave is of $H_{1/3} = 9.2$ m, $T_{1/3} = 12.7$ sec, S direction, with a return period of 100 years.

* Littoral drift: Since there is a lack of sand for littoral drift and most of the waves approach the beach perpendicularly, the coast is highly eroded with its relatively steeper slope.

2.2.2 Evolution of the Terminal

There are five design alternatives for Hsin-Ta LNG Terminal. They can be classified into three categories: on-shore, off-shore, and shelterless. Each of the former two categories comprises two kinds of storage tank: in-ground and above-ground. The last one is with in-ground tank. Although the general coastal conditions around the site are rather fair, the shelterless layout still can't meet economical and safety requirements. Through various comparisons such as investment, construction period, benefits, etc., on-shore layout is always preferable to off-shore layout except maneuvering security. Hence the general layout of Hsin-Ta LNG Terminal was decided to be an on-shore harbor with in-ground storage tanks, as shown in Fig.1.

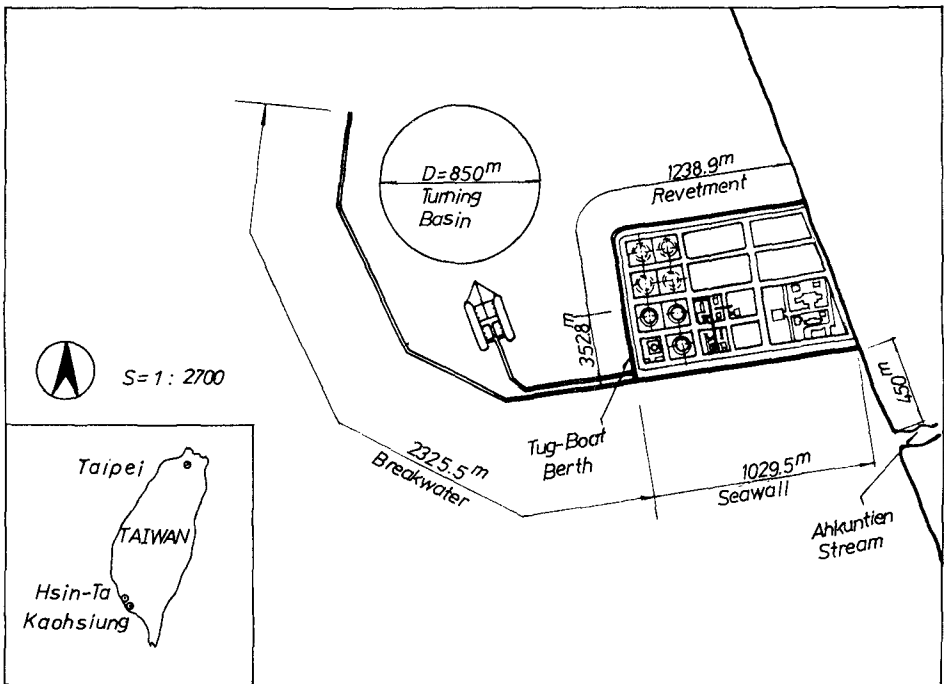


Fig. 1. General Layout of Hsin-Ta LNG Terminal

2.2.3 Cross sections of seawall and revetment

The seawall and revetment of Hsin-Ta LNG Terminal were first divided into a number of sections, and then designed according to each corresponding water depth and local wave conditions. The typical cross sections of rubble mound and composite caisson type structures are plotted in Fig.2~Fig.4.

2.3 Feather of the Project

Perhaps the most interesting feature of this project in comparison with other typical ports is the single-armed southern breakwater. The orientation of the coastline along the site is in NNW direction, which effectively protects the Terminal against waves from N to E, whereas waves can approach the site directly from S to W. Hence the single-armed southern breakwater is secure enough to protect the berth from incident waves. The problem of seich is then relatively trivial, due to the opening nature of this harbor entrance.

3. Construction Process

This project has been scheduled to be completed within a short period of 5 years. Therefore the building procedure of the breakwater, land reclamation, storage tanks, and transportation pipes system need to be closely coordinated. In general, Hsin-Ta LNG Terminal consists of three major tasks, i.e., 1) construction of on-shore harbor; 2) land reclamation (about 70 hectares) for working-yards; 3) construction of in-ground LNG storage tanks & associated facilities. The actual execution of the project was started in September, 1984.

3.1 On-shore Harbor

In order to execute the project, BES Engineering Corporation has mobilized a lot of machines, vehicles, agitators, and working vessels. First of all, the rubble mound seawall and revetment were built to protect the reclaimed land from being washed away by waves. Graded seasands were dredged to supersede the soft soil for improving some parts of the foundation of seawall and revetment. Filter fabric was spread out along the orientation of the coastal structure against settlement. Next the rubble was dumped over the filter fabric by dump trucks or bottom-opening stone carriers. After being leveled by bulldozers or divers, the crown wall was then cast in place. The seaward toe of the rubble mound has been protected first by cobble of 4.0cm~10.0cm in size with a slope of 1:1.5 which is 1.5 m thick, and second by 2 layers of concrete armor units which are about 2.0 m thick with a slope of 1:2. On the other side, i.e. harbor side, the coastal structure was backfilled by dredged seasand and covered with a layer of masonry for protection.

As the water depth got deeper than - 8.5 m, the composite caisson type structure was adopted. Caissons were made in Anping harbor where is about 30Km to the north of the site, and were towed to the site during suitable maritime conditions. Once the caisson was placed on the designated position, concrete blocks were sunk immediately to guard the toe of the caisson. in order to keep facilities inside the Terminal safe enough during storms, a "curtain wall" has been built up along the harbor side of the seawall and revetment against wave overtopping. Thus far, 1030.0 m of

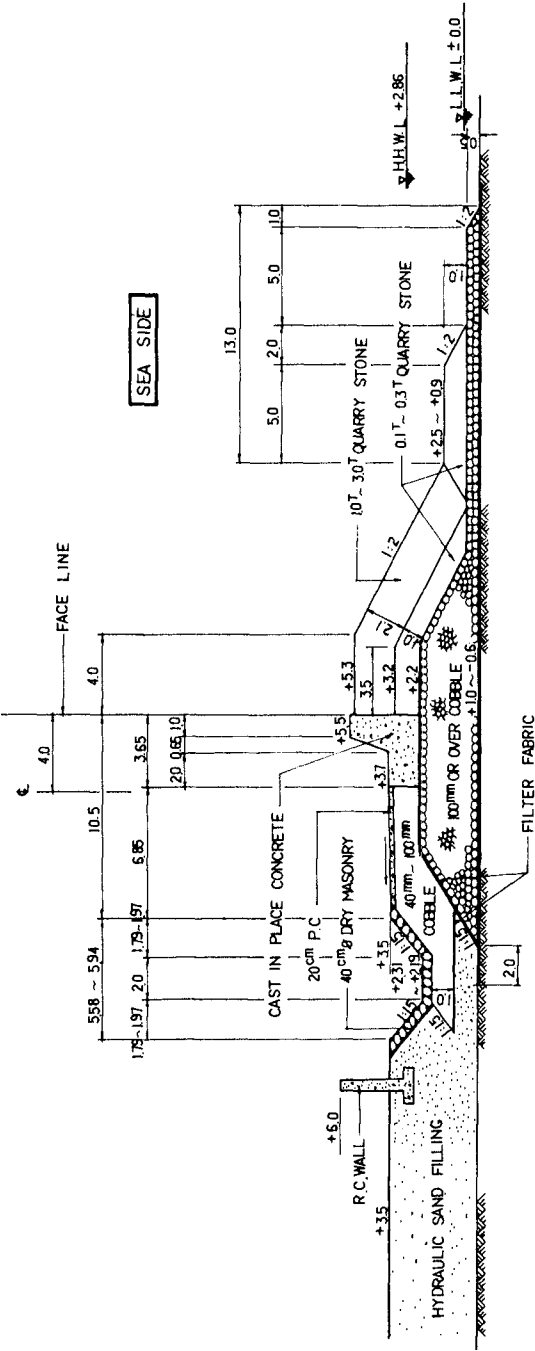


Fig. 2. Typical Cross Section of Revetment (rubble mound)

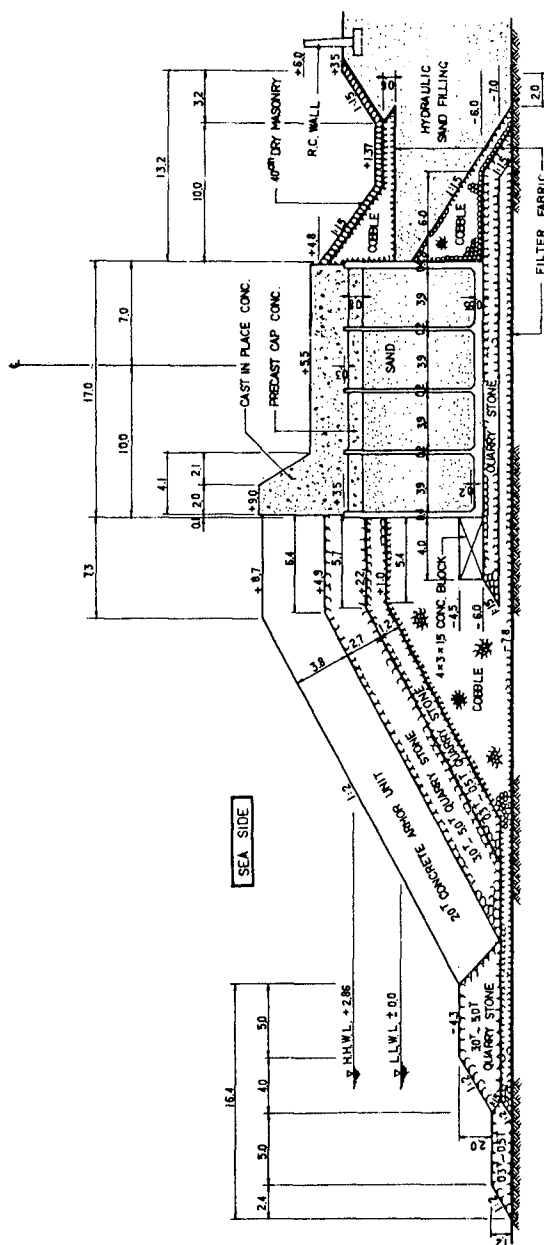


Fig. 4. Typical Cross Section of Seawall/Breakwater (composite caisson type)

seawall, 670.0 m of revetment, 703.0 m of permanent and temporary workingboat wharves, and 730.0m of temporary revetment have been completed.

3.2 Land Reclamation

The required working-yards were reclaimed by hydraulic backfilling while building seawall and revetment, as shown in Photo. 1. More than 4.1 million cubic meters of filling volumes have been executed by suction dredger. The total dredged volumes will come to 7.1 million cubic meters.

Owing to the desire of completion by 1989 the storage-yards for the LNG Tanks were reclaimed prior to other places. Several types of concrete armor units were put in place to protect the reclaimed land after each subphase had been finished.

3.3 In-ground LNG Storage Tanks

The tanks are being constructed using the top-down method. The slurry wall was built first. After the excavation of earth was finished, draining filters and steel/butyl waterstops were fixed upon the slurry wall in order to drain and resist possible permeating groundwater respectively. Steel work and form work were subsequently installed. After adjusting each section into its designated position, concrete was then cast in place. With the similar procedure performed downwards, three tanks are expected to be completed by late 1988.



Photo 1. Aerophoto of Hsin-Ta LNG Terminal (under construction)

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