CHAPTER 99

Closure of Tidal Channel in Land Reclamation

Chin-I Liu *

Ruey-Shyong Chang *

Abstract

The land reclamation of Lunwei subdistrict A in the development of Changhua Industrial Estate Project was commenced in May 1980. Fill sand was dredged by suction dredgers from borrow area and placed in the south and central parts of this subdistrict. Bamboo fence was used as sand retaining structure. In November, a new tidal channel occurred between two fill sand islands and across the head of seawall, it caused the increase of materials and the difficulty of construction of the seawall.

Closure of the tidal channel was completed by constructed a sand embankment dike with low cost materials such as; bamboo piles, bamboo mattress and sand bags.

1. Introduction

The Changhua Industrial Estate Project, located on the west coast of Central Taiwan on a stretch of tidal land, has a total area of about 6,292 hectares divided into six districts, namely, Shingkang, Yupu, Lunwei, Lukang, Fushin and Hanpao (Figure 1). The Yupu, Lunwei and Lukang districts with a total area of about 3,780 hectares were planned for phase 1 development to accommodate heavy industries such as machinery, steel, power and petrochemical.

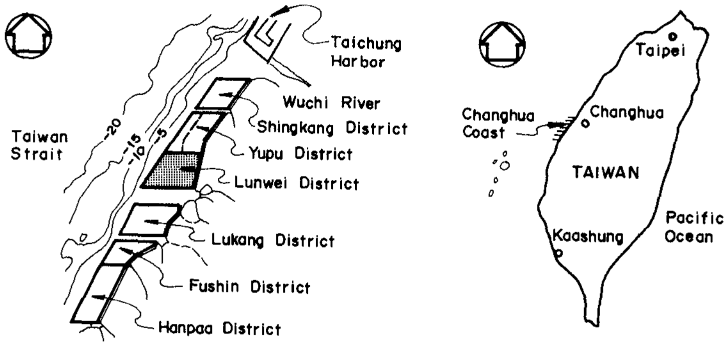

Figure 1 Key Plan of Changhua Industrial Estate

* Engineer, Sinotech Engineering Consultants Inc. No. 171, Sec. 5, Nanking East Road, Taipei, Taiwan, R.O.C.

The 406-hectare subdistrict A of the Lunwei district in the west has now been partially completed. Its development called for the construction of a 3,800 m long seawall and hydraulic fill of 18,800,000 m^3. A tidal channel runs southward through the center of this subdistrict and a sand bar lies west of the channel.

The development work commenced in May 1980. The rubblemound seawall was constructed from north to south along a planned line. Hydraulic fill was placed in the south and central parts of the subdistrict by using five suction dredgers positioned in borrow areas. By November 1980, a 2,700 m length of the seawall had been completed and the sand fill totaled about 4,000,000 m^3. In that month, a new tidal channel occurred between two fill sand islands and it flowed west through the head of the seawall. The original sea bed was scoured down to El.-8.0 m. As a result, the development work was slowed down and the quantities of seawall construction materials had had to be increased. Because the reclamation work must be completed in time to supply the future demand for land, closure of the tidal channel was considered the best solution, and a sand-made embankment dike was selected for this purpose. The dike was constructed within one tide cycle, involving 6 bulldozers and 100 workmen and using steel pipe piles, bamboo piles, mattress and sand bags as retaining structures.

This paper describes the formation and closure of the new tidal channel, the morphological variation and the low cost materials used.

2. Topography and Geology of Lunwei District

Figure 2 shows the boundary line and topography of the Lunwei district. On the north, the boundary is formed by the existing south seawall of the Yupu district, extending west for about 1 km; on the west by a 3.8 km long seawall which has been completed; on the south by a planned 4.8 km long revetment; and on the east by a planned inner dike, separated from an existing seawall by a proposed 200m wide waterway. The total area of the Lunwei district is 1,251 hectares.

A tidal channel runs NE-SW through the center of this district. The width of this 5.5 km long channel below El.-1.0 m ranges from 220 m to 550 m. The channel bed, with a 0.001 slope, has an elevation of -5.5 m at its deepest part, and the side slope is 1:10 below mean water level and 1:5 above mean water level.

The elevation of land on the east side of this tidal channel is +1.8 m, which dips gently on a 1:800 slope westward to the zero line of the channel.

A sandbar lies in a N-S direction along the west side of the tidal channel. Its highest elevation is +1.8 m in the northern part, sloping at 1:1,200 eastward to the tidal channel, and at 1:100 westward to El.-2.00 m. The slope to the south along the seawall line is 1:1,400, and that to the north is nearly flat.

The average elevation of the Lunwei district is about +0.3 m.

The geology of this district is divided into three zones. (1). The first zone is between the existing seawall and a line about 2.5 km to the seashore, which is an area of river deposit composed of yellowish gray fine sand and medium-grain sand in the top layer and fairly fine sand in the bottom layer. The grain size is from 0.2 mm to 0.5 mm. The second zone lies west of the first zone up to the low tide line. Coarser sand is found all over the place. The third zone is located at the river mouth, where the soil consists of silty-sand with a thin clay layer.

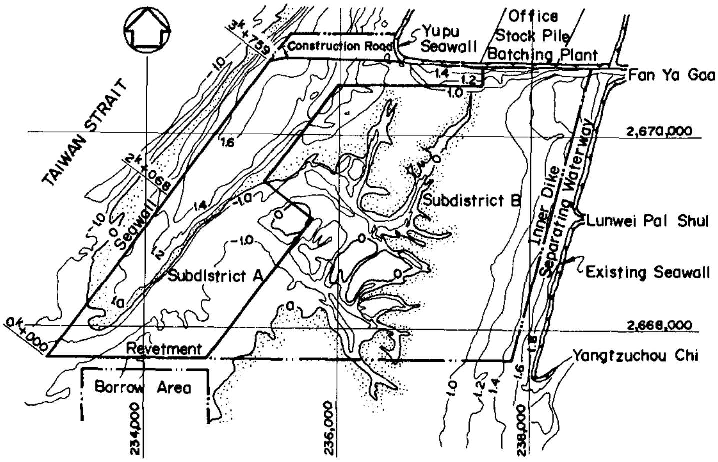

Figure 2 Topography of Lunwei District

3. Main Engineering Works

3.1 Land Reclamation

The Lunwei district is divided into two parts; subdistrict A and subdistrict B. Subdistrict A, with an area of 406 hectares, is planned to be filled to elevation +5.5 m, which will required about 18,800,000 m^3 of fill sand and 540,000 m^3 of cover material. For subdistrict B, which has an area of 845 hectares to be filled to elevation +4.2 m, about 32,000,000 m^3 of fill sand and 1,200,000 m^3 of cover material will be needed.

The reclamation work for subdistrict A started first. Fill sand is dredged from the proposed harbor basin and waterway to the south and east of this district respectively.

3.2 Seawall

The seawall line was set on the sandbar for easy construction and to get the land needed. Typical section of the seawall are shown in Figure 3. Type A which has a sand core was adopted for the 1,691 m long northern section, while type B with a cobble core was used for the 2,068 m long sourthern section. The access road for the seawall was connected to the existing south seawall of the Yupu district. Bamboo fence was used as sand retaining structure for the sand core of type A seawall. Toe elevation was at El.+0 m, and synthetic mattress was placed between sand and cobble as filter to prevent sand from being sucked away by wave. Five-ton wave dissipation blocks were used to protect the seawall against storm wave.

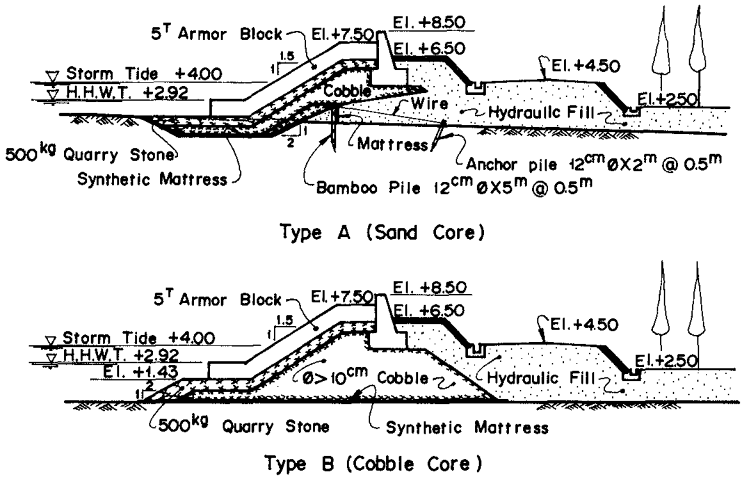

Figure 3 Typical Section of Seawall

4. Land Reclamation for Lunwei Subdistrict A

4.1 Distribution of Fill Sand

The total amount of fill sand required for Lunwei subdistrict A is about 18,800,000 m^3, which is supplied from borrow areas. Of this, about 17,200,000 m^3 is dredged from the south borrow area and the remaining 1,600,000 m^3 from the relocated tidal channel. The material for a 15 cm thick cover, totaling 540,000 m^3 in volume, comes from the Tatu mountain about 20 km away. (2).

4.2 Dredgers

Five suction dredgers with capacities as shown in Table 1 were used for the rclamation work. The arrangement of dredgers is shown in Figure 4.

Table 1 Characteristics of Dredgers

Name	Dimension (m)				Engine Power		Dia. of PiPe (")	Dredging Capacity (m^3/hr.)	Discharge Distance (Km)	Dredging Depth (m)
	Length	Width	Depth	Draft	Type	(HP)				
Taichun 1	34	11	3	1.8	Diesel	3,600	24	300-600	2.5	16
Taichun 2	58	18	3	2.1	Diesel	8,000	32	500-1000	5.5	20
Taichun 3	35	11	3	1.8	Diesel	3,000	24	300-600	2.0	16
Taichun 6	36	11.5	3	2.0	Diesel	3,000	24	300-600	2.0	20
Taichun 7	34	11	3	1.5	Diesel	3,000	24	300-600	1.8	16

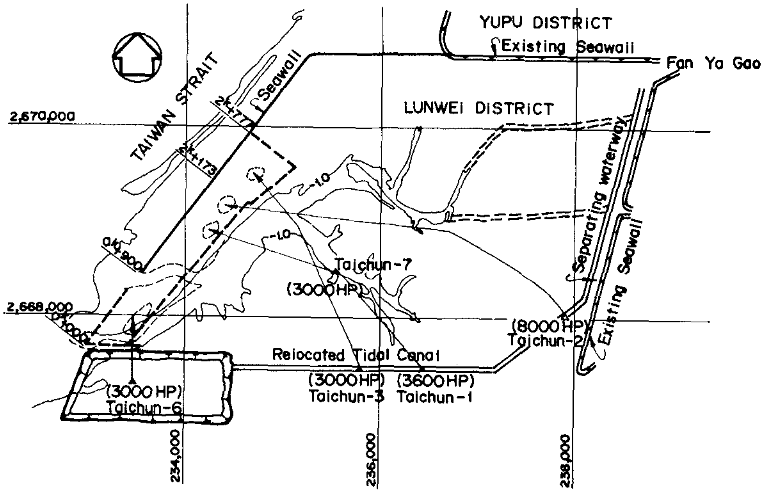

Figure 4 Arrangement of Dredgers for Land Reclamation

4.3 Sand Retaining Structure

Because construction of the seawall was from north to south, while the sand filling work proceeded from south to north. Bamboo fence of a simple type as shown in Figure 5 was used to retain the sand along the west and south boundaries. Bamboo fence consisted of bamboo pile, iron wire, anchor pile, bamboo mattress, etc. Two rows of bamboo fence were erected to prevent swell invasion.

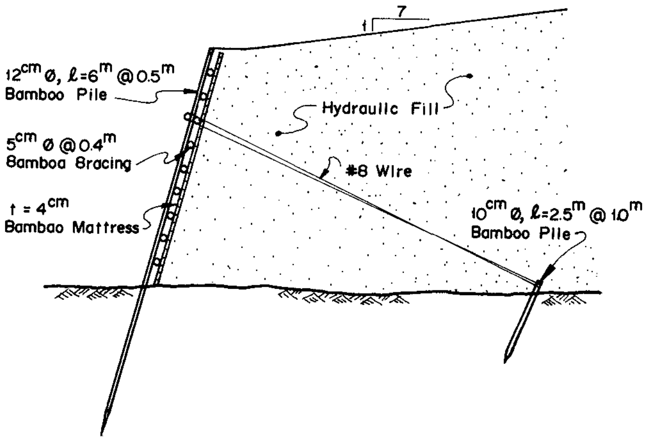

Figure 5 Typical Section of Sand Retaining Structure

5. Formation of Tidal Channel

The reclamation work for Lunwei subdistrict A was started in May 1980. Three 3,000 hp suction dredgers positioned in the south borrow area placed the fill sand in the southern part of this subdistrict. In July, one 3,600 hp and one 8,000 hp dredger positioned in the proposed relocation site for the tidal canal and the east waterway respectively placed sand in the middle part of the subdistrict. In October, two 3,000 hp dredgers in the south borrow area moved to the tidal canal to accelerate the dredging work, placing sand also in the middle part. Bulldozers were used for the earth moving work, which ran between the two sand islands at low tide, but in November the bulldozers could walk no more. The original sea bed was scoured, as even at low tide water still existed. The occurrence of the new tidal channel could be attributed to: (1) The bamboo fence used as retaining structure was partially destroyed by typhoon waves, so sand entered the original tide channel and reduced its flow section; (2) The two fill sand islands approached each other gradually and increased the tidal current velocity to scour the sea bed.

6. Morphological Variation

Figure 6 and Figure 7 show the morphological variation of the proposed closure section of the channel and the head of seawall. The deepest elevation was -6.0 m in the channel, and -8.0 m in the head of seawall.

The current velocity in the closure section was also measured under different tidal conditions. The maximum velocity was 2.25 m S^{-1} at the center during high tide. (3).

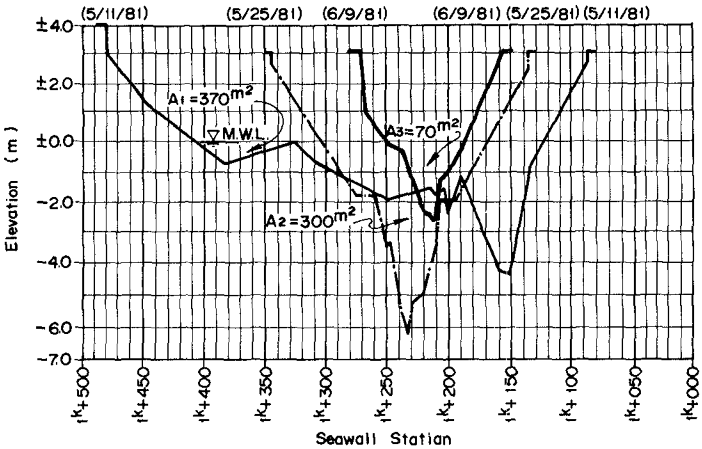

Figure 6 Morphological Variation of the Closure Section of the Tidal Channel

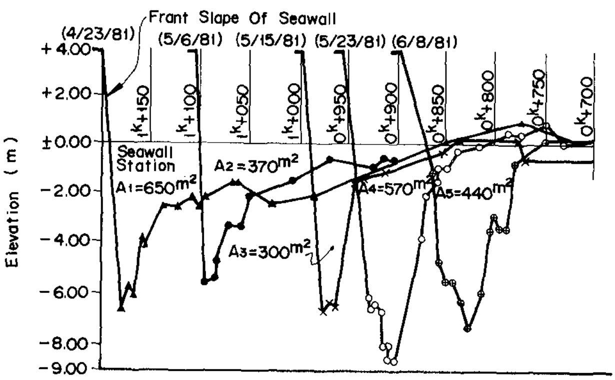

Figure 7 Morphological Variation of the Head of Seawall

7. Closure of Tidal Channel

7.1 Reasons for Closure of Tidal Channel

The scouring phenomenon occurred in November 1980, but land reclamation and seawall construction proceeded until May 1981. Due to the following reasons the closure of the tidal channel was decided.

(1) The scouring of seawall head resulted in construction diffi-

culty and the need for increased use of the construction materials.

(2) A large amount of the fill sand was washed away by tidal current.

(3) The typhoon season would come soon, so the finished part of the work must be preserved.

(4) The development work must be completed as soon as possible.

7.2 Construction of Closure Dike

Several field surveys were made to study the closure location and estimate the work quantity. After considering the construction feasibility, an upstream location was selected where the channel width was the narrowest, due to continued supply of sand. The selected closure date was June 10, 1981, the lowest tide time. Three alternative construction methods for the sand embankment dike were considered: (4).

(1) Use of steel sheet piles as temporary retaining structure and fill sand.

(2) Use of cobbles dumped from truck or barge.

(3) Use of bamboo piles and steel pipe piles as retaining structure and fill sand.

The last method was selected after comparing the material available, degree of difficulty of construction, and haul road condition. When the new channel occurred, about 78 sets of bamboo spurs were constructed along either bank for retaining sand and along the east side slope for reducing current velocity. Three 3,000 hp dredgers continuously supplied sand from each side to raise the channel bed from El.-6.0 m to El.-2.8 m. Prior to the closure date, about 10,000 m^3 of sand, 12,000 sand bags, 8"ø steel pipe piles, bamboo piles, mattresses, etc., were stocked on the banks for dike construction. At 10:00 p.m., June 9, 1981, the piling work started with the use of water jet during ebb tide, and bulldozers moved the sand from both banks to fill the dike until 5:00 a.m., June 10, 1981 when the dike was closed. Spurs made of bamboo piles and sand bags were constructed on the east slope to prevent scouring by the original tidal channel.

Eventually, the dike was completed, which has a top width of 10 m with top elevation at +3.0 m as shown in Figure 8.

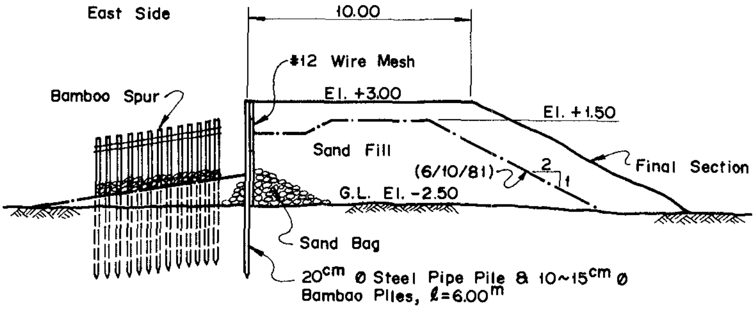

Figure 8 Typical Section of Embankment Dike

8. Conclusion

From our experience with this closure work the following conclusions can be drawn:

(1) Land reclamation from the south in this project has the advantages of higher dredging efficiency and ease of construction of the sand retaining structures, but this decision was risky, as it resulted in the need for closure of a new tidal channel.

(2) The success of the closure work was due to the dredgers' large capacity for supplying sand to reduce the channel depth, and to the use of spurs constructed of bamboo piles and sand bags to retain the fill sand and reduce the channel width so that the dike could be completed within one tidal cycle.

(3) The reclamation sequence must be carefully arranged. If the work started from inshore to offshore or proceeded simultaneously with seawall construction, the new tidal channel might not have occurred.

9. Acknowledgements

The anthours wish to extend their thanks to the field engineers of BES Engineering Corporation for their supply of the field data.

10. References

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