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Inlet Improvement on the Chinese South Coast

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ABSTRACT

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This paper deals with the exploration of three inlets on the Chinese south coast to determine the feasibility of implementing improvements and the prospect for the development of the region.

ADDITIONAL INDEX WORDS: *Coast, tide, inlet, silt, bar, shoal, channel improvement.*

INTRODUCTION

The Chinese south coast faces the South China Sea and is a largely low, sandy deep water area where littoral drift and sediment are minimal. There are eight main inlets in the center section of the coast along the Pearl River Delta. These inlets are connected with the South Sea and the inland waterway network in the Pearl River Delta, including the deltas of the West River, North River and East River and the regions of Hong Kong, Macao, *etc.* The water depth in the inlet channels in these areas is generally very deep, and therefore suitable for navigation, but the problem is the shallow depth on the bars and shoals at the seaward entrance of the inlets.

Due to the economic development in the coastal region, it has become vital for the Chinese to improve and develop the inlet channels of the South Coast in order to connect these inland rivers to the sea. Thus, there will be direct navigation routes from the mainland to Hong Kong, Macao and the Taiwan regions and Eastern and Southern Asian countries (Figure 1).

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DEVELOPMENT AND IMPROVEMENT OF THE INLETS

Yamen

Yamen is located on the west part of the Pearl River Delta. The inlet from Yamen crosses a submerged sand bar which has a length of 8–12 km, has a water depth of only 2.8 m during low tide and is a total distance of 38 km from the sea. From Yamen, it passes through a Yinzhou lake (a total length of 30 km, a width of 1.5–2 km and a water depth of 8–15 m) to Tanjiang. Turning northward from there it connects with the West River.

The inlet is a dynamic tidal way in which the yearly volume of runoff is only 7% of the tidal current with sand bars and shoals created by the tide-current action. The tide is irregular and semidiurnal, the current is reciprocating and the waves are mixed. The maximum flood tidal range is 2.42–2.73 m with a maximum ebb tide range of 2.6–2.95 m and the average tidal range is 1.11–1.24 m. Since the bay is protected by the sea shore from three directions, the wind and wave action is very weak.

The inlet stands today in its natural state. Vessels of a 2,000 dwt class can only enter the Yinzhou

Lake and Zinhai Port during a period of flood tide. Passenger and cargo ships have navigated to and from Hong Kong and Macao through the Yamen inlet since 1985; from 1985 to present, the oceanic traffic along this navigation route has increased at a rapid rate. The port of Xinhui is now being expanded; berths of 3,000–50,000 dwt class will be built along both banks of the Yinzhou Lake and a new port, Gaolan Port, will be constructed on Gaolan Island and will include 20,000 dwt-class berths. In order to connect river transport with sea transport, it is imperative that the inlet channel be dredged to a proper depth and improved to facilitate the navigational needs of the area.

Presently, the initial surveys, model test and a feasibility study have been completed by the Guangdong Waterway Bureau in joint venture with several institutes and universities. A dredged experimental channel with a length of 8 km, width of 60 m, depth of 4.47 m, slope of 1:6 and 500,000 cubic meters was completed on submerged Sand Bar 'D' in 1990 (Figure 1). One year later, the measured water depth in the dredged channel showed that the average depth had increased from 3.21 m to 4.47 m and the average thickness of sediment accumulation was 25 m; the cross section has a clear outline and stable shape. With this data in hand, the experiment was determined to be a success. Another measured data taken in 1970–1980 ascertained a stable water depth of 3 m over the sand bar.

Based on the above result, two schemes for navigational lines have been compared (Figure 1). One line called East Channel which is plotted to cross a submerged bar has an isobath of −3 m through whole line; the other called West Channel has an isobath of −3 m broken by a submerged sand bar at 5,500 m. This shallow section has increased over the years from 2,500 m in 1936 to 3,500 m in 1989. It is difficult to maintain the water depth of the sand bar in the West Channel, while the East Channel continuously maintains a stable depth.

Both the East and the West Channels are controlled mainly by flood currents. The East Channel runs through in the same direction as the tidal current and the waves from the South Sea but the West Channel flow pattern includes an additional direction (Figure 1). Thus, the East Channel is easier to maintain than the West Channel. The East Channel passes through shallow waters between Sanjiao and Daman Island; these shallow areas extend into the Port Gaolan

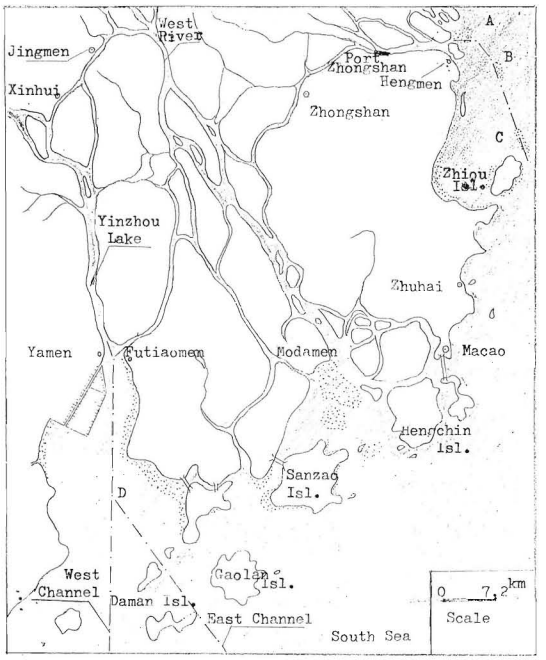

Figure 1. The chart of Pearl River Delta.

area. After considering the facts and data as presented above, it was reasonable to select the East Channel as the deep water channel for the port; the plan is for a 120 m wide, 5.5 m deep channel with a 1.8 slope. The dredging volume of sand and clay is about 7.24 million cubic meters. Presently, the required research and designs for the channel are completed and the project is in the preconstruction stage.

Hengmen

Hengmen is located on the eastern section of the Pearl River Delta. The total length of the inlet from Port Zhongshan to Zhiou Island is about 30 km, while the length of the inlet channel from Port Zhongshan to Hengmen is about 9–11 km; the inlet is 300–700 m wide, 7–10 m deep with a sandy bed. From Hengmen to Zhiou Island, there is a 20 km crossing with three submerged sand bars, A, B, and C (Figure 1). The minimum water depth is 2 m at A, 3.2 m at B and 4.5–5.5 m at C.

The runoff from Hengman Inlet is stronger than the tidal current and plays a major role in the dynamics of the channel. The ratio between the

year's average discharge of runoff and tidal current is about 2.75:1 at Hengmen; the tide is an irregular semi-diurnal type; and the maximum flood tidal range is 2.27 m, ebb tidal range is 2.48 m with an average range of 1.09 m. The tidal current flows along the axis of the deep channel in a reciprocating pattern.

Due to the shallow water depth on the bars and shoals, the navigable channel can only be used by vessels of 500–1,000 dwt. In recent years, some berths of 3,000–5,000 dwt class have been built, but vessels of 3,000–5,000 dwt class cannot enter or leave the port except during the flood tide period. It is necessary to improve the navigable channel and bring it up to the standards for passing vessels. The inlet traffic is continually increasing and will soon necessitate that berths of 3,000–5,000 dwt be added at Zhongshan Port. It is necessary to improve the navigable channel in order to allow vessel traffic of 3,000–5,000 dwt class and to make the inlet compatible with port development. This project will include the improvement of the three sand bars, A, B, and C.

A channel was dredged in an experiment at Bar A in 1984 in which sand was silted. Further, the data from a math model test for dredged channels showed that the silt was very deep and illustrated that dredging alone will not maintain a navigable water depth and is cost prohibitive.

When the original evolution of the three bars as well as the facts and data as presented above were taken into consideration, it was obvious that improvements to the inlet should be a combined method of dredging, training, and reclaiming the land for cultivation. This approach would be divided into the following two phases:

Phase 1—would include dredging the channel, building dykes on both banks of the channel, narrowing the width of the channel and training the water into the channel. These improvements would train flood as well as ebb currents and use runoff for deepening the channel, which would help to stabilize the channel and decrease siltation.

Phase 2—work included would be based on the results of Phase 1.

Further tests and research are anticipated in order to determine a reasonable and reliable economic and technological scheme for improving the Hengman Inlet.

Madaomen

The mainstream of the West River from Zhaoging city via Madoamen runs into the South Sea and is 185 km in length and 5 m in water depth with a deep water width and stable river bed. The Madaomen Inlet is a main thoroughfare for discharging flood water and silt. There are five small islands and four by-passes around the inlet entrance area where the flow pattern is very disorderly and the flow direction changes frequently. The water depth is only 2 m on a submerged bar of 32 m long in neap tide, so improving the scheme is very complicated in this section of the inlet channel. In order to seek an appropriate scheme, the improvement of the inlet should combine dredging, training and reclamation with surveying and research carried out in the next phase.

PRELIMINARY CONCLUSIONS

As described above, it is necessary to open up navigation between the river and the sea by improving the three inlets which is technically feasible.

However, the concrete aspects of the three channels are different. The first, Yamen, has favorable natural conditions, a stable channel, and will be easy to improve and cost less. Feasibility and design studies have been carried out. Based on the above factors, it is suggested that Yamen Inlet should be improved first. The second to be improved should be Hengmen and the next logical step is a feasibility study.

The third, Madaomen, will require an extended period of evaluation due to heavy siltation and unfavorable geomorphology. Future improvement of the Madaomen seaward inlet as a deep water channel in the West River is necessary in order to have complete navigational access to this important South China region.

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