

CHAPTER 224

Port Site Selection on Coast with Radial Sandbanks

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Abstract

Along the silty coast of the Jiangsu Province, it was found that on the coast stretch which we call the "Radial Sandbanks" coast stretch, deepwater port sites could be created if suitable tidal inlets were selected and provisions were made to maintain the required deepwater areas for port development.

Introduction

The Jiangsu Province, facing the Yellow Sea and the East China Sea, is one of the most developed provinces of China in industrial and agricultural production. China's policy of reform and opening to the outside world has greatly enhanced the economic development of this province. It is therefore urgently needed to build deepwater ports to meet the demand of increasing sea-going traffic. For a long time, the difficulty was to find suitable port sites, because along the entire 1000km coastline of this province, most of the coast stretches are silty coast with very gentle beach slope composed of fine sand and silt, very susceptible to changes under the action of waves and currents. Therefore it was considered impracticable to construct deepwater

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ports on such coast. However, during the Nationwide Comprehensive Assessment of Coastal Zone Resources which was carried out from 1980 to 1985 along the entire 18,000 km coastline of China's mainland it was found that there is a coast stretch in the Jiangsu Province where the early and late deposited submarine sediments were disturbed and scoured by waves and currents, sorted, coarsened and redeposited. At last, an extensive area of well sorted fine sand and all kinds of sediments are radially extended towards the sea, thus forming the coast with radial sandbanks. Between the sandbanks are tidal inlets leading to the coastline, and deepwater port sites could be created if suitable tidal inlets were selected and provisions were made to maintain the required water depth for port development.

Morphological and Hydrological Features of the Radial Sandbanks

The Radial Sandbanks, extending from northwest to southeast along the coast of North Jiangsu, cover an area of the South Yellow Sea from the mouth of Sheyang River to the Yangtze River Estuary and to the east up to 25 m water depth, nearly 20,000 km². About 70 sandbanks lie radially from Jianggang towards the sea, of which 8 are above the Abandoned Yellow River Datum, with total area of 1268 km², the biggest one called Dongsha is 694 km² (Fig.1). The rest are underwater sandbanks. Between the sandbanks are tidal channels, the largest one, called Huangsha Yang, is located at the middle of the Radial Sandbanks and extends from the sea westward to the coast near Jianggang. The second large tidal channel, Xi Yang, is located at the west and the third one, Xiaomiao Hong, at the south of the Radial Sandbanks. All these three tidal channels ended in the proximity of the coastline and could therefore be utilized as approach channels for port development.

The Radial Sandbanks were essentially the ancient submarine delta of the Yangtze River. The formation of such typical topography may be attributed to the existence of two tidal systems, one comes from southeast, being a progressive tidal wave from the Pacific, and the other from northwest, being a reflected tidal wave from the Shandong Peninsula. The concurrence of these two tidal systems gives rise to a rotary standing tidal wave with the node point somewhere 80 km beyond the

Abandoned Yellow River Mouth, where the tidal range is nearly zero. Figure 2 shows the M_2 constituent of the tide in harmonic

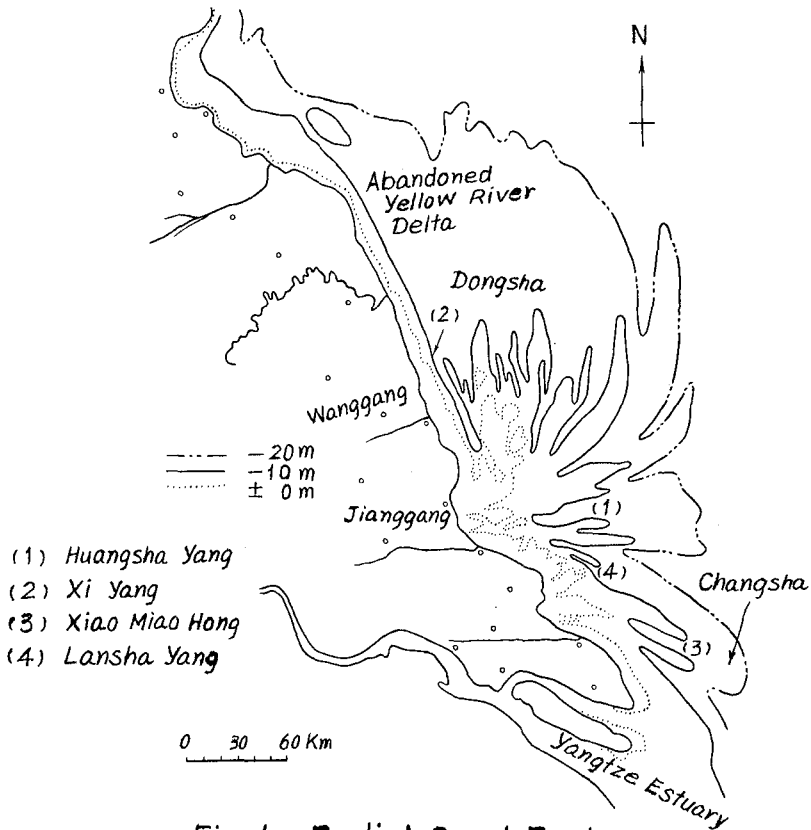


Fig. 1. Radial Sand Banks

analysis. The converging point of the two tidal waves is in the vicinity of Jianggang. Here we find a region of strong tide, the mean tidal range at Jianggang is 3.9 m. It increases to 4.9 m at Yangkou, the end of the main channel of Huangsa Yang, here a max. tidal range of 9.28 m was observed in 1981, which also ranks first along the entire coast of China. The mean tidal ranges in the other two large tidal channels, Xi Yang and Xiaomiao Hong

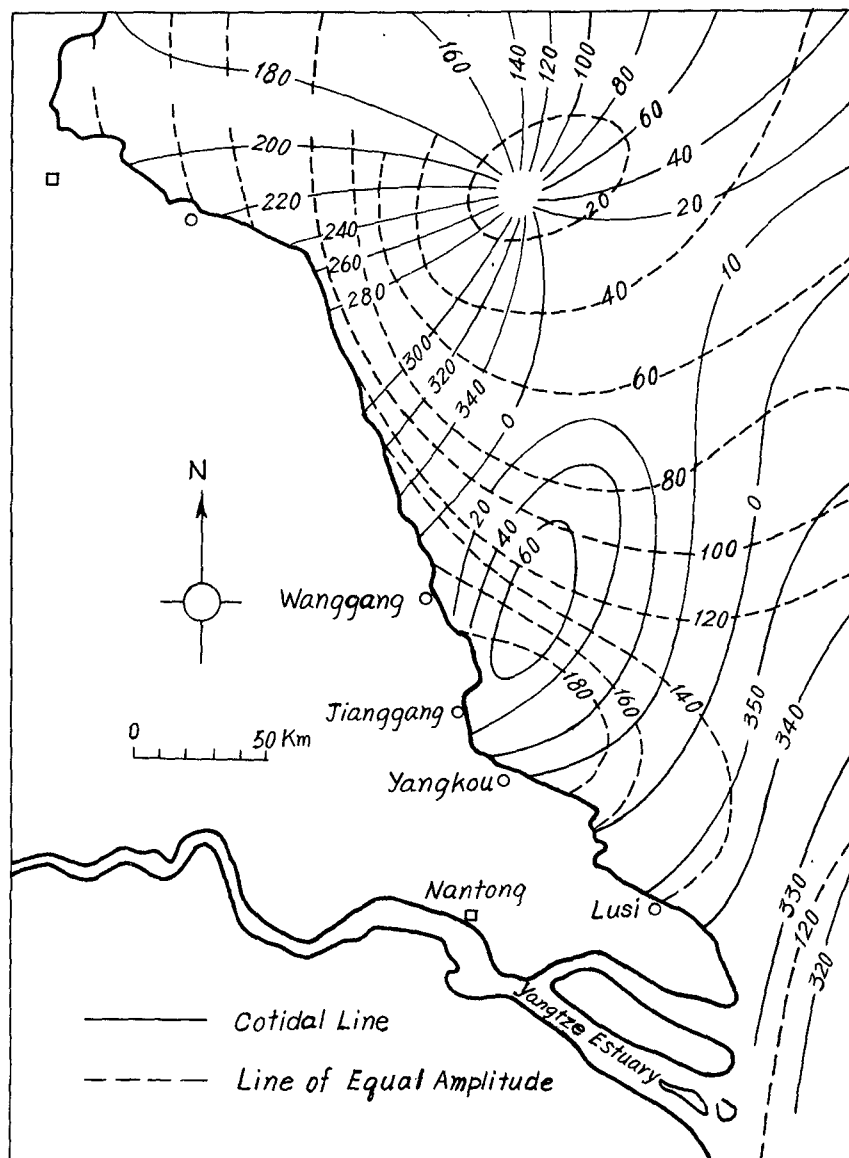


Fig.2. M_2 Constituent in Harmonic Analysis

are respectively **2.64** at Wanggang and **3.68** m at Lusi, with a max. of **5.46** m and **6.87** m respectively (Fig.3). The tidal current in this region is also strong. In Huangsa Yang and Xi Yang, the flood current velocity is higher than that of ebb tide, attaining a max. of **2.5** m/s and **2.0** m/s respectively, while in Xiaomiao Hong the ebb current is stronger, having a max. of over **1.5**m/s.

Waves exercise also significant influence on the Radial Sandbanks. Waves generated by prevailing wind come from NEE and the storm waves come mostly from NW and N. Under the action of waves and currents the Abandoned Yellow River delta is continually under erosion and large amount of the eroded materials are transported to the Radial Sandbanks. The sediments from the Yangtze River, which amounts to ca. 500×10^6 t yearly, are also partly transported to the Radial Sandbanks by flood tides, particularly during the flood season of the Yangtze.

Investigation shows that in the summer the dominant sediment transport is landwards from the sea through the tidal inlets, converging in the vicinity of Jianggang, and in the winter the sediment flow is spreading seawards and to the Yangtze Estuary. It has been found that the littoral drift in the Xi Yang tidal channel is directed southwards, in the Huangsa Yang it is westwards and in the Xiaomiao Hong eastwards. The sediment concentration in the winter is **1.5** to **2** times higher than that in the summer, and it increases from the sea landwards, a max. concentration of 1.2 kg/m^3 has been observed in the vicinity of Jianggang. The sediments are composed mainly of fine sand, sandy silt and silt. The mean sediment diameter of the sediments on the sandbanks ranges from **0.125~0.5** mm, in the tidal channels it is **0.07~0.18** mm and on tidal flats, **0.03~0.09** mm.

As a rough estimate, the yearly sediment transport into the area of Radial Sandbanks is 109×10^6 t from the north, 203×10^6 t from the east and 36×10^6 t from the west, totalling 348×10^6 t, and sediments flowing out of this area is 102×10^6 t. Thus there is a net sediment inflow of 246×10^6 t, and the area of the Radial Sandbanks is continually increasing. Nevertheless, the change is rather slow, as can be also seen by comparing the topographic maps of **1964** and **1979**, as well as from the satellite pictures. It has also been found that the entire Radial Sandbanks including the tidal inlets are relatively stable, and in

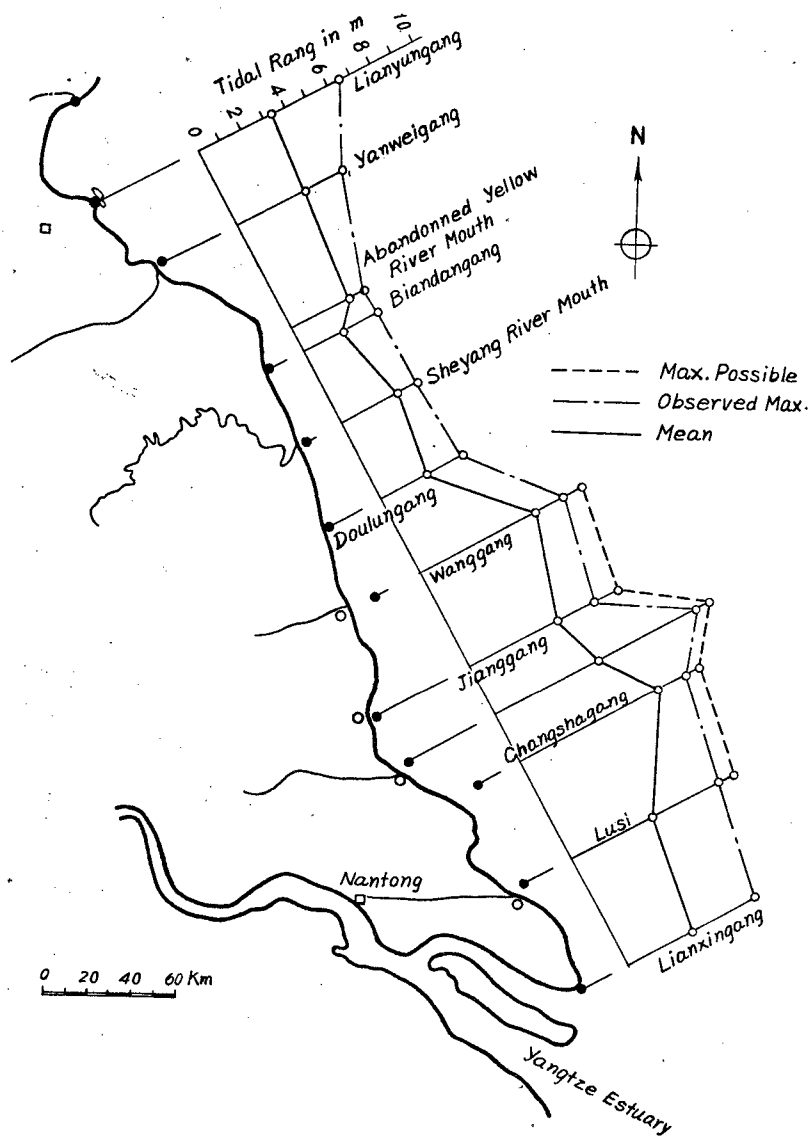


Fig. 3 Tidal Range Along Jiangsu Coast

the above mentioned three tidal inlets deepwater channels underwent little change. Only at the ends of these channels erosion and accretion occurred frequently and this is sometimes aggravated by wanton reclamation of the adjacent tidal flats.

Selection of Port Sites

A comprehensive investigation had been carried out since early 1980's along the coast of Jiangsu Province, which includes the field survey, laboratory work and theoretical study. One of the main problems to be solved was the stability of the tidal inlets. It has been found that the inlets are relatively stable due to the existence of the strong tidal action. For instance, at Wanggang the depth contours of -5 m and -10 m had been moving seaward at a rate of 100 m and 68 m per year from 1979 to 1990, respectively, but the depth contour of -12 m had been kept basically unchanged. Meanwhile the Xi Yang tidal inlet was enlarged to correspond with the increased tidal discharge, the inlet became deeper and the shore slope turned steeper.

As compared with port on open sea coast or in an estuary, port located inside a tidal inlet has neither the problem of protection against storm waves, which usually needs the building of costly breakwaters, nor the bar forming at the mouth of the estuarine channels, which as a rule gives hindrance to navigation. So the three large tidal inlets of the Radial Sandbanks provide favorable conditions for port development. In these tidal inlets the water areas are well sheltered, the sediment concentration is low and channels are relatively stable. The drawbacks are, however, the large tidal range and wide tidal flat, which bring inconvenience to navigation and difficulties in port layout. Therefore these should be taken into full consideration in the development of ports inside such tidal inlets.

In the selection of deepwater port site along the coast of Jiangsu, we have to bear in mind that the Yangtze River, which flows through the Jiangsu Province and is an important waterway for sea-going traffic, can only allow vessels of under 25,000 t to pass the estuarine channel due to the bar forming at the mouth, and it is a very difficult task to increase its water depth. Hence it is necessary to explore deepwater port sites along the open coast. Moreover, coastal harbours have the

advantage of more direct access to the hinterland of North Jiangsu than ports in the Yangtze Estuary, since for the former there is a network of inland waterways facilitating the connection with the hinterland. In view of the fact that Jiangsu Province is badly short of energy resources, the import of coal and the development of petroleum industry have become of ever increasing importance in the economic construction. For this purpose the creation of deepwater port along the coast with berths of **50,000 to 100,000 t** and over is needed. It has been planned to build deepwater ports in all the above mentioned three large tidal inlets, namely Huangsha Yang, Xi Yang and Xiaomiao Hong, taking due consideration into the rational geographical distribution of ports. We have then in the south a port group with Port Yangkou in the Huangsha Yang tidal inlet, Port Lusi in the Xiaomiao Hong tidal inlet and Port Nantong in the Yangtze Estuary as the major ports; in the middle a port group with Port Wanggang in the Xi Yang tidal inlet as the major port; and in the north a port group with Port Lianyungang as the major port, as shown in Fig.1. The Port Lianyungang is an existing port built in the thirties. It has been rehabilitated, extended and modernized since the founding of the People's Republic, and is now one of the major ports of China, capable of berthing vessels of **50,000 t**.

Except port Nantong and Port Liangyungang all the above mentioned ports are situated in the tidal inlets of the Radial Sandbanks. It is rather unique to built deepwater port under such conditions. In the following a typical example is given for the layout of the Port Yangkou in the Huangsa Yang tidal inlet.

Preliminary Layout of Port Yangkou

Full use is made of the Huangsa Yang tidal channel in the layout of the Port Yangkou. The water depth of this tidal channel varies from **10 m to 30 m** with channel width of **0.7 km to 2 km**. The channel ends at Yangkou, the selected port site. Here a well sheltered water area is available for port development. The port will mainly serve for oil and coal transportation and to some extent container and general cargo traffic. The layout is shown in Fig.4. As can be seen from the figure, there is **20 m** deepwater area of **2.4 km²** at a distance of about **10 km** from the coastline and within this area we find an area **700 m × 2000 m** where the water

depth is 22 m. This can be used to berth the 100,000 t tankers which requires a water depth of 21.5 m. Underwater pipeline will be used to deliver the oil to the oil depot on the bank. It has also been contemplated to provide berths for supertankers of 200,000 t in the future at the location 20 km to the east of Yangkou, called Changsa, where the tidal inlet Lansha Yang joins Huangsha Yang. Here 25 m deepwater area of 4.7 km² is available for mooring such supertankers, only that the under water pipeline will be longer, i.e. >16 km.

For coal import, 10,000 t berths will be provided at the -10 m water area and navigation channel should be built for coal transfer. The coal will be transferred by barges of 100 t to 300 t or by highways to the neighboring areas. Container berths will be located at the deepwater area west of the tanker berths, with a connecting trestle leading to the container terminal or transferred by shipment. Trestle for berthing ships of 3,000 t is also provided west of Yangkou for general cargo handling.

Serving as an approach channel to the sea, the Huangsa Yang tidal inlet has a length of 50 km from Port Yangkou to -20m depth in the sea. In order to create a navigable channel for 100,000 t tankers it is estimated that the amount of dredging would be 260,000 m³. If the berthing of supertankers of 200,000 t were contemplated, the tidal inlet Lansha Yang - Huangsha Yang should be used as approach channel to the berthing area Changsha, which has a length of about 30 km, and the amount of dredging would be 1,000,000 m³ to 3,000,000 m³.

5. Conclusions

Sea port construction is essential to the economic development of the Jiangsu Province and opening to the outside. The aforementioned three port groups along the Jiangsu coast all have good connection with the hinterland. The intercontinental railway connecting Port Lianyungang to Rotterdam, the waterways of the Huai River system and Yangtze River system, together with the Grand Canal and other waterways and highway systems, form a transportation network very convenient to the gathering, distribution and transfer of cargo. The utilization of tidal inlets of the Radial Sandbanks for port construction is technically possible and economically feasible as the preliminary

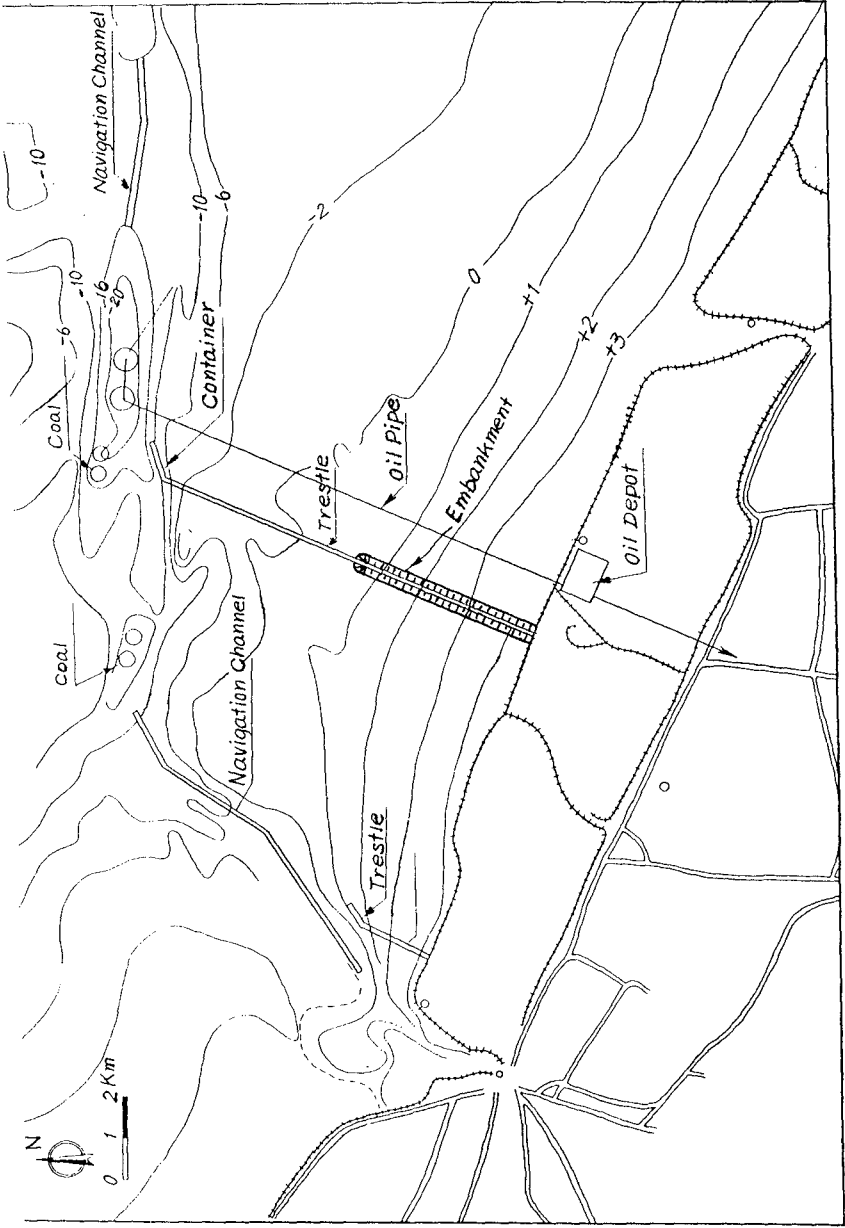


Fig. 4. Layout of Port Yangkou

study of the morphological and hydrological features of this region and the economic assessment have shown. Numerical modelling has been undertaken to study the channel condition of the Huangsha Yang tidal channel. It was found that the channel would be relatively stable and the tidal currents are favorable to maintenance of a stable channel.

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