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STUDY ON THE INFLUENCE OF SEA RECLAMATION PROJECT IN TIANJIN ON THE SURROUNDING SEDIMENT ENVIRONMENT

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Abstract: In order to make full use of coastal resources and provide conditions for the strategic transfer of Tianjin industry to the east actively, Tanggu District of Tianjin has decided to carry out sea reclamation on the south beach of the Haihe Estuary. How will the reclamation project after its completion affect the flood discharge of the Haihe Estuary and the Tianjin Port nearby is the concern in the layout and planning. In this paper, based on the related field measured data of hydrology, sediment, and others, a comprehensive analysis is carried out by multi-means of mathematical model, test analysis, etc. The study results are put forward and a scientific basis is provided for the project implementation.

Key words: Sea reclamation; Sediment, Hydrology; The Haihe estuary; Coastline

1. THE GENERAL DEVELOPMENT CONDITIONS OF THE BEACH

The Western Coast of the Bohai Gulf is typical muddy plain coast. The coastal zone is broad and flat and the morphology is single. The beach strand is situated the long and narrow intertidal zone between land and sea, which is the important component of the coastal zone. It is general recognized the beach area from the coastline to the theoretical bathy-metrical datum plane, which is located between zero contour lines and bared at low tide. The Western Coast of the Bohai Bay is one of the best-developed beaches in our country.

Haihe estuary—Duliujian estuary is situated the middle of the Western Coast of the Bohai Bay. The beach direction is NE－SW, and the topography is flat and broad, height above sea level 0-3.5 ms, Width 3000-5300, the slope lowers 0.71%－1.28%. The beach is in the intertidal zone, different from the land and shallow sea hydrodynamic characteristics. It's drown on the high tide and been beach area on low tide. Because of the difference of hydrodynamic ways, intensity, time, the beach area has obvious zonation nature in topography, material make up on this beach. From bank to sea, the beach can be divided in interior deposition zone on spring tide, erosion zone on medium tide, exterior deposition zone on low tide, Table 2 provide its characteristic.

The beach strand is the most active area of hydrodynamic, and the variation of erosion and deposition at present. Because the artificial breakwaters were general built in coast district, modern coastlines are in relative stable state. However, because of the difference in topography, hydrodynamic and the amount of sediment inflow, the variation of erosion and deposition on the different beach is obvious disparity. Comparing with sea charts that published in 1983 and 1958, according to the changing range of the zero depth contour, the beach can be divided three a kind of beach dynamic types: the erosion-receding type beach, comparative stable type beach and deposition-soaring type beach. (Table 3)

Table 2 the characteristic of beach zonation from Haihe Estuary to Duliujian Estuary

Beach zonation		The zonation of tidal zone	Width (m)		Gradiend rate(‰)	Material component	Topography characteristic
Interior deposition zone	Crack zone	Climax tide zone	0−1200	0−100	0.25−1.57	Silt, clay silt, fine sand, silty clay	The topography is flat and the estuary crack is developed.
	Transition zone			0−1100	0.72−1.40		
Erosion zone		Medium tide zone	40−856		0.98−1.31	Slit	The erosion scarp is developed well.
Exterior deposition zone		Low tide zone	2624−3500		0.80−1.04	Fine sand, slit, clay silt	It is flat and broad, and sand ripple is tiny.

Table 3 The characteristic of beach dynamic types from Haihe Estuary to Duliujian Estuary

Dynamic types	The area of distribution	Beach width (m)			Gradiend rate(‰)	The beach dynamic at present(1958−1983)
		Interior deposition zone	Erosion zone	Exterior deposition zone		
The erosion-receding type beach	Dao gouzi —Lvju River	0−450	40−500	2600−2700	1.2−1.25	zero depth contour erosion-receded 200−800m, erosion-receded rate is 8−32m/year, parts of the erosion zone is up to the beach bank.
		3000−3600				
Comparative stable type beach	Lvju River —Gao shaling	400−850	300−500	2600−2700	1.10−1.20	The deference of the zero depth contours is little.
		3500−3600				
Deposition-soaring type beach	Haihe Estuary—Dao gouzi	200−1200	120−850	2700−3500	0.50−0.90	The zero depth contour transgression to sea for 200−600m in Gao shaling −Du liujian estuary, and the transgression rate is 8−24 m every year. Crack zone of thetwo estuaries have been developed.
		3000−5300				
	Gao shaling —Du liujian	700−1000	40−800	2600−3000		

2. THE NATURAL STATE OF SEA AREA OF THE PROJECT

2.1 THE CHARACTERISTIC OF TIDAL CURRENT

By the analysis to the spring, medium, neap tide direction data of surveyed in July 1997 and August 2002, there are the following characteristics on the direction movement:

(1) The distribution of tidal current on plane

According to the statistics analysis of the data surveyed, the tidal current in the sea area belongs to reversing tidal current basically, and the tidal current direction is different for the changing of depth and topography. At the Haihe estuary, because the rise, ebb tidal current is restrained by the training dike, and the rise tidal current direction is NW (Point to the estuary). The ebb tidal current direction is SE (Point to the sea) and the flow direction is centralized. However, the flow direction of rise, ebb tidal current in the south is very deferent from that in the estuary. The rise tidal current direction is WSW and the ebb tidal current direction is NNE −E and the flow direction is disperse. In other words, the rise tidal current is leaving to the Haihe estuary and the area of port and the ebb tidal current is flowing to the Haihe estuary and the area of port, so the flow is moving by the shore. At the point of 5 m depth, the depth is deepen and the tidal current is not influenced of the project and beach, so the tidal current belongs to characteristic of sea and the rise, ebb tidal current direction is centralized. The rise tidal current direction is NW and the ebb tidal current direction is SE, so it is perpendicular movement between onshore and offshore.

(2) The vertical distribution of tidal current velocity

According to the distribution of vertical velocity at –2.5 depth contour of different sea area and tide types, the first floor velocity is the minimum and the middle-level velocity is maximum both in rise tide and in ebbing tide. The first floor velocity is 0.13−0.24m/s in average, and the influence of tide types are very obvious. According to the distribution of vertical velocity, it is not influenced of the estuary runoff. It said that the estuary is characteristic of sea for the building of the Haihe barrier.

(3) The feature value of the tidal current

Both spring and neap tide, the tidal current velocity of the rise tide is always bigger than that of the ebbing tide. The velocity of rise tide is 1.5−0.29m/s in average, and that of ebbing tide is 0.14−0.27m/s. Moreover, the velocity in deepwater is bigger than that in shallow water and the velocity of spring tide is bigger than that of neap tide. It shows that the tide type acts different roles on the beach sediment movement. However, according to the values, the sea area belongs to weak current area for the little tidal current velocity and the erosion to the beach is not very strong.

2.2 SEDIMENT CONCENTRATION

According to the survey data made in July 1999 and August 2002, the sediment concentration of this sea area is low and the value is lower than 0.1 kg/m^3 in summer. The causes of the low sediment concentration mainly show the two questions. The first one, the two times hydrology are operated in this sea area in summer. The wind and wave is weak in this season and the function the sediment is lifted by the wave is rarely little, so the sediment concentration is low relatively. The second one, the current velocity is little relatively in this sea area, so the bed materials cannot be lifted by the tidal current only, and whether spring tide or neap tide is the same. In strong wind weather, the sediment concentration survey is very difficult, so the empiric formula was presented to reckon the sediment concentration in different wind class by the force of wind, when the question of Tianjin Port sediment.

$$S = \frac{4.25}{h} \lg(\frac{W}{3.4})$$

where

S —is the average sediment concentration in different wind classes（kg/m^3）;

h —is the water depth（m）;

W —is the average wind velocity in different wind classes（m/s）.

Through calculating the sediment concentration suddenly increases by more than ten times when the wind acts on the sea area is above 6 classes. As a result, the sediment concentration is resulted from the strong wind. In other words, the strong wind and waves erode the beach (the unfavorable direction is NE−E) and a lot of silt suspend in the water, then the sediment is carried and deposition by the rise tide, ebbing tidal current.

2.3 WAVES

According to the statistics survey data of a whole year, the waves characteristic of the sea area is the following:

(1) Wave types

The waves of the sea area are made of pure wind and wave, mixed wave, and pure surge are little. The frequency of the pure wind and wave is 74.2%, and that of pure surge, mixed wave are 0.9%, 24.9%. The frequency of the mixed wave (V/F) that is mainly made of surge occupies 23.8%, and that are mainly made of wind and wave is 1.1%. It shows that the powerful wind is the dominant cause of the waves, and the wind and wave are the dominant wave.

(2) The distribution of the wave direction

According to the statistics wave data of one year, the dominant wave direction are E with a frequency of 18% in the sea area. As regards the waves that wave height is above 1.0 m, the wave direction is mainly E, SE, NW, SW, SSE and ESE, but the waves that wave height is from 1.0−1.9 m are E, NW, NNW, N, NE, ENE. The direction of waves that wave height is above 2.0 m is mainly E, ENE, NE and N. As regards the direction of the coastline, the powerful wave direction is onshore wave that have strong erosion function, so it is the unfavorable wave direction of this sea area.

(3) The distribution of the wave height

According to the statistics the frequency of $H_{1/10}$ that wave height is below 1.0 m is 87.6%, but that wave height is above 1.0 m is 12.4% that the frequencies that wave height is above 2.0m and 3.0 m are 1.9% and 0.4% respectively. It shows that the waves of this sea area belong to weak wave area. The wind wave is strongest in spring and inferior in autumn, and that is weak in summer but the typhoon can have some effects occasionally.

(4) The seasonal variation of the waves

Wind wave are dominant part of waves in this sea area, and the variation characteristic is relative to the variation of the wind field. The season variation of the wind field is obvious so that the season variation of the waves is also obvious.

Spring (from March to May), because of the remaining of the high pressure above the sea the wind wave direction is mainly NE-E, and the waves in this direction is strongest, which direction of the waves that wave height is above 2.0 m is also NE-E so that it is regards strong wind season.

Summer (from June to August), which the southeaster flourishes but the force of wind is weak and the frequencies of wind are low so that the waves are not strong, is weak wind season.

Autumn (from September to November) is transition season, which flourishes southwester and the gale direction is partial north and for the influence of the cold wave, the big dimension waves are from NW-E and NW is the dominant direction.

Winter (from December to February), for the Mongolia high pressure controlling, flourishes northwest and the velocity of wind is high and the frequency is multifarious which direction is stable. For these factors the wave direction is mainly NW in this season, and frequent powerful wave is consistent. But because the monsoon direction is always onshore and offshore, it act on beach weakly.

(5) The range of waves crushing

Because this sea area topography is flat that Gradiend rate is from 1/1000−1/2000, there is not obvious crush zone and the breaking depth is relevant to the wave height. For the different of wave height that spreading from open sea, the breaking depth is different too. At the low tide, the breaking depth of waves that wave height is above 2.0 m is between–2.5 m and ±0 m depth contour, and the breaking depth of waves that wave height is below 2.0 m is from ±0 m depth contour to bank. At the high tide, the breaking depth is pushed to the bank, which depth is from ±0 m to +2.5 m , and the waves that height is below 2.0 m will break near the bank. According to the breaking depth, both big wave and small wave can affect the beach in variant degree when they break.

2.4 BED MATERIALS DISTRIBUTION

The analysis of bed materials in this sea area bases on the sampling analysis result in July 1996 and in august 2002 which was the sampling in ±0 m contour and-2 m contour. According the analysis of the silt particle size, the bed materials in this sea area have the following distribution characteristic:

(1) The distribution of particle size

The silt particle size can be analysis by the NSY-Z particle size instrument made in Hohai University. The analysis results show that the bed materials which are between±0 m contour to -2 m contour are mainly the fine particle size silt, and the median particle size is between 0.00 mm to 0.019 mm and the average median particle is 0.0098 mm. The frequencies of the particle size are: sand is 9.2% in average, silt sand and clay is 52.3% and 38.5% respectively. It is clear that the bed materials belong to clay silt(YT) that is very easy to be lift and drift.

(2) The sorting degree of the bed materials

The sorting coefficient Qdϕ reflects the sorting degree of sludge. The norm is defined that the sorting degree marks five classes. The analysis result shows that the sorting degree marks only three classes by the data (Table 3), which are good sorting (0.6−1.4), medium sorting (1.4−2.2) and poor (2.2−3.0). In the case of sorting coefficient, the sorting coefficient of this area is between 1.30−2.64 which belongs to medium sorting. It declares that this area is under influence of the estuary flood.

(3) The characteristic of the bed materials section variation

According to vertical section, the grain in the estuary section is fine, and the grain is rough at two sides, which is relative to that waves crush the beach at two sides and the sediment is gathered and deposition in the tank by the tidal current. According to cross section, the particle size is rough at the ±0 m contour depth and it will be gradual finer outside the sea. The cause is that waves erode the beach and the finer sediment move outside the sea with the ebb tide. In general, the bed materials have thick direction that takes gradually.

2.5 THE HYDRODYNAMIC OF SEDIMENT

The hydrodynamic of sediment mainly includes the competent velocity, nonsilting velocity and settling velocity of sediment, etc. Every feature value is defined by the annular water trough experiment.

(1) The competent velocity

The definition of the fine grain competent velocity is determinate by the process that the sediment is from resting state to moving. The sediment on the bed is resting state in the beginning and then the sediment begins to suspend, while the flow intensity is to an extreme value. This extreme value is named the competent velocity and it is also called scouring velocity in project. For the mucilaginous fine grain, the competent velocity is just the stirring-up velocity. That is to say as long as sediment under certain current condition leave bed it can suspend in the water body directly.

The competent velocity is one of the hydrodynamics of sediment, and it is an important parameter that reflects the sediment movement. Because it marks starting point of the beginning of bed erosion, it is significant in regulation works. According to the annular water trough experiment data of Tianjin Port, the competent velocity of this sea area is 0.20m/s, and the competent velocity of d_{50} is 0.4 m/s. According to the survey tidal current velocity data, no matter spring and neap tide, the velocity all is lower than the value, which is said that the effect of tidal current is weak.

(2) The nonsilting velocity

The nonsilting velocity is corresponding to the velocity of the carrying saturate sediment concentration water. In the actual process, when the water velocity augments, the sediment will move and suspend from the bed and the sediment concentration will be higher. On the contrary, the suspension sediment will sink down to the bed, and the sediment concentration of the water will be lower, so the nonsilting velocity is the logo of beginning of deposition. Through the experiment, the nonsilting velocity is 0.56 m/s.

(3)Settling velocity of sediment

It is a complex problem that the flocculation settling velocity of fine grain that is relative to the particle size, sediment concentration, salt concentration, the flow velocity, depth and so on. Especially the flowing settling velocity of sediment, there is not a very appropriate theoretical formula, so the sediment concentration in different time can be obtained in order to ascertain the settling velocity of sediment in different time. The variant features of the flowing settling velocity of sediment are the following: firstly, the lower the flow velocity, the higher the settling velocity of sediment. On the contrary, the higher the flow velocity, the lower the settling velocity of sediment. The flow velocity is inverse ratio to the settling velocity of sediment. Secondly, the higher the sediment concentration, the higher the settling velocity of sediment, otherwise, the lower the sediment concentration, the lower the settling velocity of sediment. It is to say that the sediment concentration is in direct proportion to the settling velocity of sediment.

According to the velocity of this sea area, its average velocity is 0.2 m/s, so the hydrodynamic cannot lift the sediment of the bed. Only if the strong wind and wave conditions, the sediment can be suspended, and the suspended sediment move to the estuary and course of river with the rise tidal current. When the wind and wave becomes weaker, the sediment deposits so that the course of river begins to be deposited. It can be move to the open sea with the ebbing tidal current and deposit.

2.6 EVOLUTION OF THE BEACH

The elementary characteristic of this sector project sea area is accumulation topography, and the bed materials are made of clay silt, silty clay and so on. The epoch of the forming is new, and the majority is formed, developed, evolved and finalize among 5000−6000 year. The main topography types have the characteristics that the obvious arcuate zone is distributed. The gradiend rate of beach is flat [i： $1/1000-1/2000$], and the intertidal zone is wide. Before the 1958, Haihe estuary had not built the tide-block sluice, so this district was the estuary littoral area, and the river dynamic force and marine dynamic force work at the same time. After built the floodgate in 1958, then this district had already turned into coast district in fact, and marine power played a leading role. “Wave lift sand and the tidal current carry sand” is the main power factor of forming the topography under water. Compared with two pieces of depth of water of 1992 and 2000, at the sea area to the south of Tianjin Port south breakwater, namely the project district of this sector of sea area, the obvious topographical change has taken place within eight years.

(1) From the variant of the ±0 m, -2 m and-5 m depth contour, during the short eight years, three depth contours have eroding in various degree, and they have move to the bank with 90 m every year in average. It proves that there is insufficient sediment from outside, and the wave function to erode seashore is obvious, which causes the depth contours to be backwards.

(2) The isobaths outside the estuary has draw back by a relatively large margin too. According to general state of estuary, because the runoff discharge and carry a large amount of sediment, which make the estuary get shallow and the isobaths move to outside. However, the Haihe estuary is just opposite, it proves that there is no sediment from Haihe River during these years, and the dredging constantly every year in the estuary causes the sediment that is lifted by waves is moved to the river and dredged to blow away, then the sediment is moved to the open sea with the tidal current. In the condition of no sediment supplement from outside, the isobaths were backwards.

3. TWO DIMENSION TIDAL CURRENT NUMERICAL SIMULATION CALCULATION AND ANALYSIS

Two dimension tidal current numerical simulation that is in a fit system of plane coordinates is adopted in this paper, and this model can simulate complicated current and sediment movement better. Main characteristic of this model is to adopt square curve girds, and use the calculation form of solving the turblence transport standard SIMPLAEC. It has good unit physicalness conservation, abolishing grids little and stable.

3.1 BUILDING UP THE MODEL

The methods of the square curve girds are multiple, in this paper, according to mechanism of potential flow and flow orthogonal intersection the square curve girds are divided. The curve net The grids produced according to this method can not only keep the grids orthogonal intersection, but also control the density of the grids. Its transformational equations are:

$$h_2^2 x_{\xi\xi} + h_1^2 x_{\eta\eta} + J(x_\xi P + x_\eta Q) = 0$$
$$h_2^2 y_{\xi\xi} + h_1^2 y_{\eta\eta} + J(y_\xi P + y_\eta Q) = 0$$

where

(ξ, η) is transformational plane coordinates

(x, y) is physical plane coordinates

h_1, h_2 is the Lehmann coefficient of the square curve coordinates $h_1 = \sqrt{x_\xi^2 + y_\xi^2}, h_{12} = \sqrt{x_\eta^2 + y_\eta^2}, J = h_1 h_1, P = -\frac{1}{h_1}\frac{\partial(\ln k)}{\partial \xi}, Q = -\frac{1}{h_2}\frac{\partial(\ln k)}{\partial \eta}, K = \sqrt{h_1/h_2}$ Above-mentioned equation groups are one group nonlinear equations, and they can be solved by adopting the finite deformation commonly used and TDMA. The coordinates system is formed by the sticking coordinates, which can control grids density and grids direction in a flexible way. It is a corresponding one matrix grids system at (ξ, η) plane, and it gives convenience for the procedure establishment and raising commonality of procedure.

In fitting system of coordinates, the two dimension current and suspended sediment motion equation can be showed the following unified form:

$$\frac{\partial(h_2 H_{u\varphi})}{\partial \varepsilon} + \frac{\partial(h_1 H_{v\varphi})}{\partial \eta} = \frac{\partial}{\partial \varepsilon}(\Gamma_\varphi H \frac{h_2}{h_1}\frac{\partial \varphi}{\partial \eta}) + \frac{\partial}{\partial \eta}(\Gamma_\varphi H \frac{h_1}{h_2}\frac{\partial \varphi}{\partial \eta}) + S_\varphi$$

The main difference of all aspects reflects on source item S_φ. Source item is the function of variable, and it can be showed the unified form $S_\varphi = S_{p\varphi} + S_c, (S_p \le 0)$ (after negative slope is linearized).

3.2 THE ANALYSIS OF THE PROJECT SCHEME FLOW FIELD CHANGING AND INFLUENCE

Through calculation, the main characteristic of the changing caused by the first-phase project is the entrance of Haihe estuary is extended outside, the current velocity is obviously strengthened in the north of the project, and the angle reduced between the ebb tide flow and the north training line of Haihe estuary. The extension of the draught of Haihe estuary reduce the sediment with rise tide, and cut off the high concentration sediment in southern side entry, which has obvious results to reduce deposition in draught. The increase of current velocity of north side of the project can also reduce further deposition of this place. Ebb tide current complies with south breakwater southern side dark trough, and it can strengthen discharge capacity. It is obvious first-phase project has positive influence to reduce deposition and increase discharge capacity. The impact on Haihe estuary of the long-term planning project keeps the same with first-phase project.

3.3 THE INFLUENCE OF THE PROJECT SCHEME TO HAIHE ESTUARY DISCHARGE

Whether the project scheme has influence to discharge of the draught of Haihe estuary, is mainly based on the variant of the high tide level. If the high tide level is redounded, it will reduce the discharge amount. The high tide level value at downstream of the barrier is 4.43 m before the project, 2−3, July 1999, and the first-phase project and under planning, it is still 4.43 m. It is obvious that recalamation besides the planning regulation line will be unfavorable influence to the discharge of Haihe estuary.

3.4 IMPACT OF THE PROJECT ON TIANJIN PORT

The recalamation locate in south to the south training line of Haihe estuary, and at - 2.0 m depth contour, Tianjin Port is apart from this project position for 2.5 km. From the qualitative aspect, the project will not has unfavorable influence to the incoming flow and incoming sediment of Tianjin Port entrance. From the point of sediment source, it has advantages to reduce the deposition of Tianjin Port.

In order to check the influence to adjacent area after the project, we choose several calculated points value of before the project and after the project to compare. The rise and ebb tide velocity has not variant and it is proved that the project has unfavorable influence to the adjacent hydrology sediment.

4. THE ANALYSIS OF RECALAMATION INFLUENCE TO THE ADJACENT AREA

4.1 HYDROLOGY CONDITION ANALYSIS

According to statistic results above-mentioned, the tidal current motive power in this project area is relatively weak, and the average velocity is about 0.16m/s. According to hydrodynamic characteristic experiment, the competent velocity of bed materials in this district is: 0.2 m/s; the competent velocity of d_{50} is 0.4 m/s; the competent velocity the whole grades is 0.56 m/s. It is clear that the average current velocities of spring and neap tide are lower than the critical competent velocity. That is to say the bed materials of this sector beach can not be eroded by single power of tidal current only, so the sediment concentration is very low about 0.06 kg/m^3 on average and the tidal current can only play a role sediment transport.

From the tidal current field of survey in this district, at the Haihe estuary, the rise tidal direction point to the river, and that is to say sediment with the tidal current can enter directly and deposit in the downstream of Haihe barrier; ebb tidal current carry the sediment to the open sea. The rise tidal direction in about of Lvju river is to lean towards the south, so the rise tidal current carry mainly the sediment to transport to the southern side; on the contrary, the sediment is transported by ebb tidal current to the northern side. This proves the sediment with the tidal current is definite influence to Haihe estuary.

According to the above analysis the tidal current of this district can not suspend the bed materials, but from change of the beach, the topographies take place phenomenon of erosion from –5 m depth contour to the bank and the beach was eroded and receded about 90 ms every year from the year of 1992 to 2000. This is mainly due to function of waves. It can be seen by analysis result from waves, waves that wave height is higher 1.0 m are account for 12.4% of the whole year. The direction of the waves is mainly NE-E, and they mainly centralize the season of spring and autumn, and the direction of waves is mainly onshore waves. The attenuation of strong onshore waves transportation is little from deep water to the bank, so the erosion to the beach is relatively strong. Raising the bed materials under erosion of the big waves, because of the particle being fine, they are easy to suspend in water with the tidal current moving. So the strong wind and wave is to cause the main factor of deposition of Tianjin Port and Haihe estuary.

4.2 ENCLOSES IMPACT ON RIVER MOUTH OF SEA OF PROJECT OF SEA ANALYSIS

(1) General situation of Haihe estuary

According to the depth cross sections of in the downstream of Haihe barrier from the year from 1983 to 1997, the sea area which is down from Haihe barrier 9.2 km, and from south breakwater in the range 2 km, except that the sea area from the Haihe barrier for 5.6km was eroded and other sections are still in the state of depositing. The annual deposition amount is about 500,000 m^3. The change of depth in eroded section suffered the function of erosion and deposition above-mentioned. The river-mouth bar also changed constantly, and its change characteristic is: from the year1959 to 1975 the water depth of the bar climax was rose from –1.8 m to +0.4 m, and the climax point moved from 10 km (the distance is to Haihe barrier) to 5.5 km, and the change is violent relatively in front three years among them, then that is gradually slowdown after this. By the year from 1975 to 1995, the change of river-mouth bar is stabille already, namely the bar climax rose from +0.4 m to +0.8 m only, and the climax point only moved from 5.5 km (the distance is to Haihe barrier) to 5 km.

Since 1973, for guarantying Haihe River passing the flood period security, the Committee of Haihe River took the measure of dredging and desilting before flood period in the river to the Haihe barrier for 2 km and disconnected to dredging four years until 1980, and the total desilting amount was 1,610,000 m^3; from the year 1981 to 1993, dredging was going on every year, and dredging was made above the barrier floodgate for four years only, the desilting amount was 640,000 m^3 totally, which accounts for 10% of total amount; the total desilting amount reached 5,840,000 m^3, about 500,000 m^3 every year totally under the barrier. However, in order to make Haihe estuary releasing floodwater ability be up to 400m^3/s, the desilting amount is about to 2 million m^3 altogether in 1997, and the length of desilting extended to 3.2km down to the barrier too. According to calculation in the current situation, the annual back-silting quantity of the river is about 800,000-1,500,000 m^3. The height of the shallow beach in estuary is also increasing constantly.

(2) The analysis of the influence after the project

The finishing the 20 km^2 reclamation project recently make the estuary extend about 3 km outwards, and the area of the beach protection is 20 km^2. It is estimated the erosion thickness of this section beach is about 0.7 m from 1992 to 2000, and it is 0.09 m every year; Its quantity is 1,800,000 m^3 annual in average. The part of 1,800,000 m^3 silt entered the river rise and deposited with the rise and ebb tidal current, and another part of them drifted to the open sea. If this section is reclamated, the silt entered the river will be reduced, which is very favorable for lighten deposit to the river.

On the other hand according to the result of model calculation, because this item construction of project make the estuary contract narrowly, the velocity increase, current centralize. It reduces the probability of subsiding of sediment with tidal current, and it will be favorable to the depth of river below the barrier too.

The main reason to reduce deposit of river below the barrier is in no natural calamity weather (namely the discharge of great flood), the sediment source of the deposit in river below barrier is from the sediment nearly bank and enters with the rise and ebb tidal current. Before reclamation, the high sediment concentration water body nearly bank can enter the river directly, and after reclamation, the sediment concentration of the water body nearly bank is reduced, so the sediment of entering the river corresponding is reduced. Because the sediment concentration vertical distribution of water body nearly bank is presented high inside and low outside, and namely the sediment concentration nearly banks is the highest, then it is reduced gradually with constant increase of the depth of water outwards. No matter heavy and little wind waves, it follows the law of distribution. When the range of reclamation extend to the open sea constantly, it is doubtless that the estuary will extend constantly outwards and enter the low sediment concentration, which make the sediment concentration of entering to the river reduce and the deposit of the river will be reduced naturally too.

(3) The question of building the quay in the estuary

If the quay is built in the north side of the reclamation project, there are the following three questions mainly in the near future in this paper:

Firstly, the front of quay cannot exceed the south training line of the estuary designed by the water conservancy department water conservancy. Whether the marginal or excavated-in port is feasible.

Secondly, it may be relatively heavy that the deposit in the basin. The depth of the current river is relatively shallow, and the water areas are relatively large. There is a large amount of silty mud, and the floating fluid mud layer is relatively thick. After the depth of the basin being excavated for – 7 m to -13.5 m, under the function of density flow and gravity flow density current, there will be amount of fluid mud entering the basin and channel from shallow places, and the maintenance of depth will be difficult. It is relatively difficult. It will be very heavy of the deposit in the near future, and the question of port benefit should be also considered.

Thirdly, because of the excavation of the basin and channel, the part of sediment flowing into the river below the barrier is intercepted, so it will be favorable as to maintain the depth of river below the barrier. The Tianjin Port is an example, on the initial stage of opening the port, there are only No.1, No.2 quays in the whole port, and the basin deposited seriously so that maintenance of the depth is very difficult. With building of the port constantly, the deep-water berths were increased constantly, and the No.1, No.2, No.3, No.4 basins were built up in succession, so the deposit in the port changed too. Because of every basin of interception, it made deposit of No.1 quay and No.2 quay reduce year by year, and they do not deposit basically under the current situations. It is obvious that if the port will be built in north. In the point of sediment, the deposit of basin will be serious relatively in the near future, but the deposit of river below the barrier will be lightened, and it will be help to improve the ability of discharge of flood.

4.3 ANALYSIS OF THE IMPACT ON TIANJIN PORT OF THE RECLAMATION PROJECT

(1) The general deposit situation of Tianjin Port

Tianjin Port is border closely on Haihe estuary, and the south jetty of the port reachs - 1.0 m depth contour. Before the barrier of Haihe estuary was built in 1958, the materials deposited in the port and the channel is mainly stem from the sediment of Haihe River discharging, and the deposit is serious in the port. After building the barrier, the main sediment source is blocked, and the sediment concentration of the sea area is reduced year by year, in the case of the Sediment concentration of the entrance:

The 1950s 0.75 kg/m^3; The 1960s 0.44 kg/m^3; The 1980s 0.29 kg/m^3; The 1990s 0.20 kg/m^3.

The sediment concentration is reduced obviously year by year, so the depositing intensity and siltation volume of the port and channel is reduced year by year. The source of sediment influencing the deposit of port now is mainly to stem from the beach on both sides. The main deposit period is in the strong wind and wave season in spring and autumn. In order to reduce sediment deposit of port further, Tianjin Port plan to extend the south training line, the north training line to - 2.5 m depth contour in the future.

(2) The analysis of the influence after the reclamation

After the project building, though the estuary is extended, the distance is still 5 km from the entrance of Tianjin Port. Firstly, the change of current velocity can not influence the entrance; secondly, there is no influence of the sediment in the estuary; thirdly, because the protecting of the project reduces the wave erosion to the bank, and it improved the sediment environmental state of the sea area further. Generally, no matter in the point of current or sediment, the reclamation near the bank will have no adverse effect to Tianjin Port, on the contrary, it will improve the sediment environment of this area and plays a positive role to reduce deposit in channel.

5. CONCLUSIONS

In sum, the preliminary conclusions are obtained to the influence of reclamation, and they are following:

(1) The function of tidal current in this sea area is relatively weak, so the single tidal current movement cannot lift the sediment but play a role in transporting the sediment.

(2) Wave is the main dynamic factor to erode the beach. The direction of NE−E is the unfavorable wave direction, which is strongest to the beach. "Wave raising sediment and tidal current transporting sediment" is the main characteristic of the sediment movement in this sea area.

(3) The phenomenon of the beach being eroded is obvious, which retreated from –5 m depth contour to± 0 m depth contour and the distance was about to 90 m every year from 1992 to 2000. Firstly, it proves the sediment of this district from outside is insufficient; Secondly, it proves this district sediment concentration is stem from shallow shoal mainly.

(4) After the reclamation project, the flow velocity of river is increased obviously, which is favorable to improve the sediment-carrying capacity of current and to lighten the deposit of the river.

(5) After both recent project and long-term project is implemented, which plays a protecting beaches role. It is helpful to reduce the sediment concentration of water body of this sea area, and it can reduce about 0.5−2 M m^3 every year.

(6) Both recent project and long-term project will not be negative effect to the deposit of the river below the barrier of Haihe estuary and Tianjin Port channel, on the contrary, it will be favorable to reduce the deposit of these places. In the point of sediment, the reclamation project is feasible.

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