International Conference on Estuaries and Coasts
November 9-11, 2003, Hangzhou, China

NUMERICAL INVESTIGATIONS ON EFFECTS OF THE RECLAMATION PROJECT ON HENGSHA EAST BEACH IN THE YANGTZE ESTUARY DEEPWATER CHANNEL

Dingman QI
Scientific Research Institute of the Ministry of Communications, Estuarine & Coastal Science Research Center, Shanghai 201201, China; Corresponding author Phone: 68909900*243; Fax: 68905318; Eamil: Qidm@sina.com

Yan ZHANG
Shanghai University, Shanghai Institute of Applied Mathematics & Mechanics, Shanghai 200072, China

Abstract: The effects of the Reclamation Project on the Hengsha East Beach in the Yangtze Estuary Deepwater Channel have been numerically simulated with an improved ECOM model. The results indicate that the project only has influences on the tide levels of the Baozhen, Liuxiao in the North Channel, and the Hengsha, Beicaozhong, Niupijiao in the North Passage, while the change in magnitude is within 5 cm. So it won't have much impact on the flood control of the Yantze Estuary. The Reclamation Project makes increase in the resistance of the flow in the North Passage as the project blocks off part of the flood tide flow which formerly enters the North Passage through Hengsha East Beach, and this will result in the decrease of the tide velocities in the North Passage. The project won't produce distinct effects on the splitflow ration between the South Channel and the North Channel as well as on that between the South Passage and the North Passage, which means it won't make negative effects on the Yangtze Estuary Deepwater Channel Regulation. Meanwhile, the Reclamation Project makes the high beach stable, and eliminate the current along the bank that is at the outboard of the North Jetty in the reclamation region, so the project will make positive effects on the stability of the North Jetty. And the conclusion can be obtained that the Reclamation Project on Hengsha East Beach is fit for the sediment treatment in the Yangtze Estuary Deepwater Channel Regulation as well as the river bed evolvement.

Key words: Reclamation, Numerical Simulation, Deepwater Channel Regulation

1. INTRODUCTION

Along with the economic development in Shanghai, the area of cultivated land is decreasing day by day. Reclamation is one of the effective ways to countervail the decrease of tilth and alleviate conflict in land use.

For more than 40 years investigation, it has been determined to carry out the regulation project of Yangtze Estuary Deepwater Channel in the North Passage of the South Channel. Beside the dredging project, 2 jetties and 19 spur-dikes will be constructed in the North Passage. The water depth of the Yangtze Estuary will increase from 7.0m to 12.5m, and the width of the channel in the riverbed is 350 to 400 meters. The total dredging quantity will be 200 million cubic meters. Taking into consideration of the environment impact and the soil utilization, the dredged silt can be deposited in Hengsha East Beach, which will benefit both the need in land usage and the dredged silt disposal of the Yangtze Estuary Deepwater Channel Regulation Project. And this paper makes investigation on the environmental impact

of the Reclamation Project in Hengsha East Beach on the Yangtze River Estuary Deepwater Channel and the ambient water body.

2. NUMERICAL SIMULATION

2.1 FEATURES OF THE MODEL

ECOM, which is developed from POM (Princeton Ocean Model), is one of the widely used sea models in home and abroad. The ECOM adopts the statics and Boussinesq approximation based sea equations, orthogonal curvature grid, Arakawa C variable pattern, free surface, and the vertical turbulent viscosity and diffusion coefficients are solved with the turbulence closure model of 2.5 orders. The main features of ECOM include:

1. The orthogonal curvature grids can well simulate the complex shoreline;
2. The semi-implicit method is of good stability;
3. The dry-and-wet moving boundary technique can precisely simulate the emergence and submerge process of the tideland.

2.2 SIMULATION DOMAIN AND GRID

The simulation region of the Yangtze Estuary model is from the Tiansheng Port in the west to the 40m contour line of the out sea in the east, while the north boundary is at the north side of Lianxing Port and the south boundary is to the Luchao Harbor in Nanhui. The maritime space of the Yangtze Estuary with the South branch, the North branch, the South Channel, the North Channel, the South Passage and the North Passage are involved in the domain. The length from the east to the west is about 240km while the width from the south to the north is 120km. The model adopts the orthogonal curvature grids, and the project section in the North Passage is refined. The total number of the grid is 260×203, and the minimum space span is about 35m. The grids in the numerical simulation are shown in Fig.1.

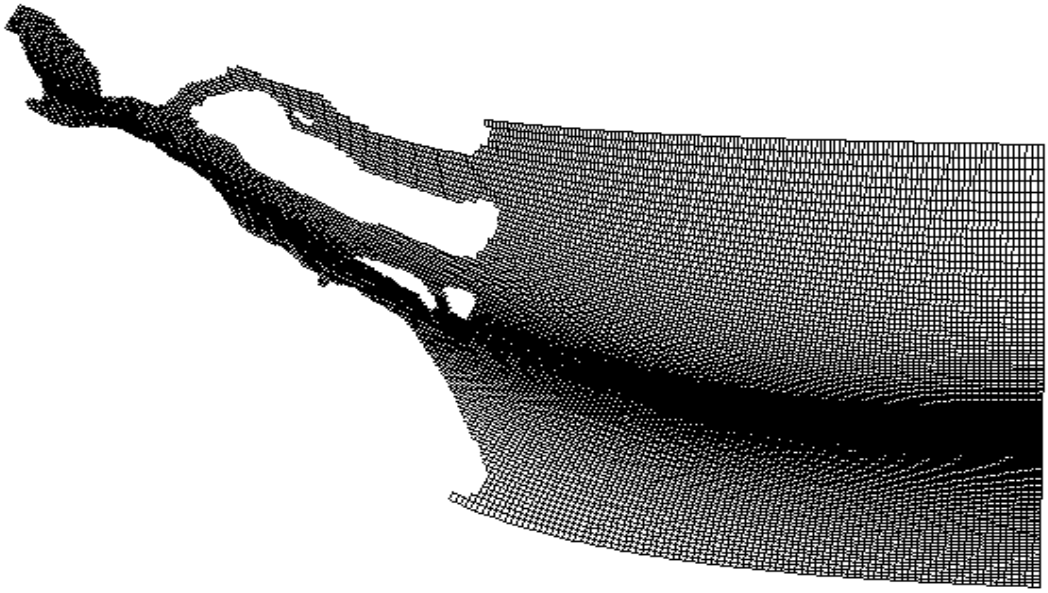

Fig. 1 The Model domain and grid

2.3 CALIBRATION AND VALIDATION OF THE SIMULATION MODEL

The calibration data is the hydrological data of the Yangtze Estuary Deepwater Channel Regulation in Feb. 1998. The validation data is the hydrological data of the Yangtze Estuary Deepwater Channel Regulation in Apr. 2000. And the 10 stations are distributed in the North Branch, the South Branch, the North Passage, and the South Passage. Fig.2 is the tidal level

comparisons of the 10 stations, and Fig .3 is the velocity comparison of 8 sampling point. It can be obtained from the figures that the simulation results confirm to the measurement data.

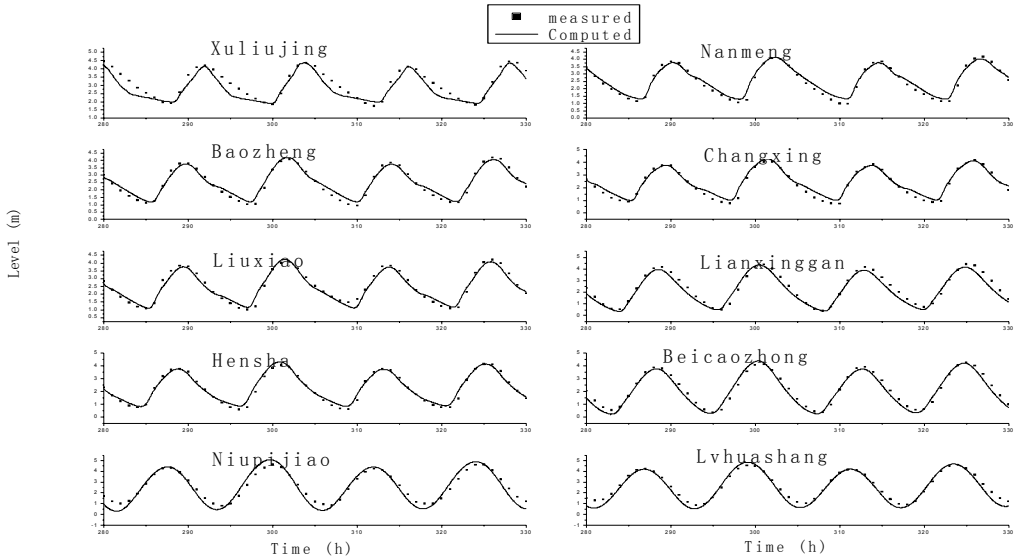

Fig. 2 Comparsion of predicted and measured tidal level

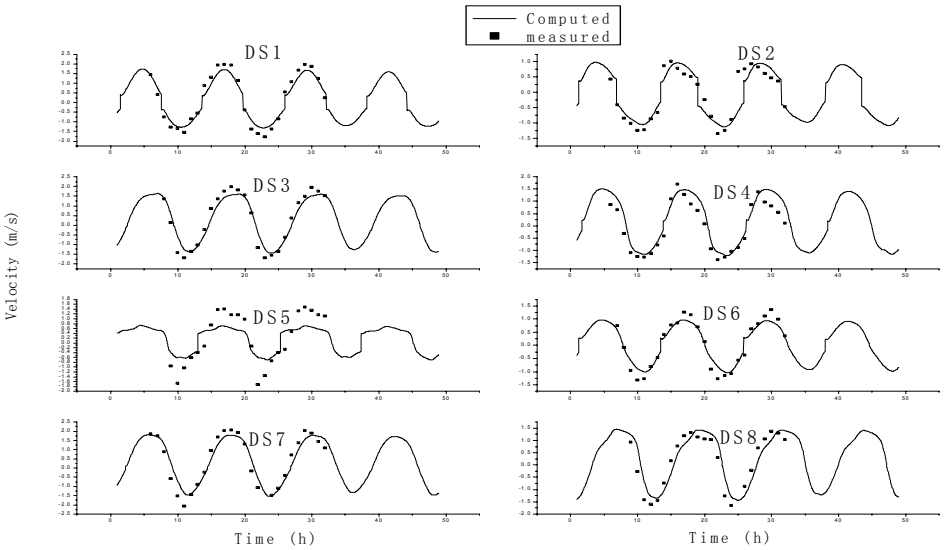

Fig. 3 Comparsion of predicted and measured velocity

3. ANALYSIS OF THE SIMULATION RESULTS

The Reclamation Project will be carried out after the Yangtze Estuary Deepwater Channel Regulation. The plan of the Yangtze Estuary Deepwater Channel Regulation is adopted as the basic plan in order to study the influence of the Reclamation Project on Yangtze Estuary Deepwater Channel. During the numerical simulation, there are 4 observation points in the North Channel, 4 in the South Passage and the North Passage respectively, and 2 in the upstream and downstream of the Hengsha Channel. And the tide fluxes of the Hengsha Channel, the South Channel, the North Channel, the South Passage, the North Passage are also involved in the calculation. Fig.4 is the observation points distribution, and plan1 and plan2 of the reclamation are also included, and the height of the dam is 4m. Simultaneity another 8087m length jetty is built at N23+000 for protecting the beach. The height of 0+000–4+000 jetty is1.5m，4+000–8+087jettty is 1.0m.

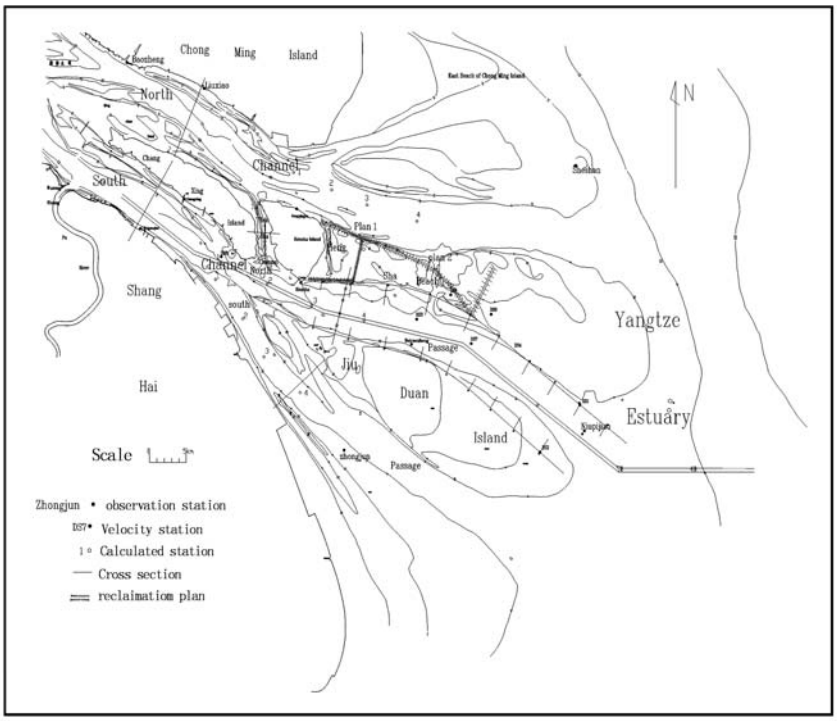

Fig. 4 Reclamation plan, observation station and Cross Section

3.1 VARIETY OF THE TIDE LEVEL

The effect of the Reclamation Project on the flood control of the Yangtze Estuary can be reflected by the effect of the Reclamation Project on the tide levels of observation stations. Table 1 is the tide levels of different plans. It indicates that the high tide levels of Baozhen and Liuxiao will decrease and the low tide levels will increase after the Reclamation Project. For plan1, the high tide level and the low tide level at the Hengsha station will increase. For plan2, the high tide level and the low tide level at the Hengsha station will also increase but the tide levels at other stations are of little variety. It can be inferred from the numerical simulation that the Reclamation Project has little influence on the tide level, and the influential region is confined to the high tide levels of the Baozheng, Liuxiao in the North Channel and the Hengsha, Beicaozhong, Niupijiao in the North Passage while the extent is up to 5cm. And the Reclamation Project has no effect on the Zhongjun, Jiuduandong and Wusong that are relatively far from the project.

3.2 TIDE VELOCITY

The tide velocities of the North Passage, South Passage and Hengsha Channel observation station are obtained to investigate the effect of the Reclamation Project on the tide velocities of the ambient water area in the North Passage, South Passage and the North Channel. And the tide velocities of different observation stations are shown in Table 2 to Table 4. It can be inferred that the change of tide velocities in the navigation channel is relatively small while the velocities in the North Channel will decrease due to the reclamation. For plan2, in particular, the large area reclamation will block off part of the flood tide that formerly run through the east Hengsha Bench into the North Channel, and the ebb tide resistance of the North Channel will increase. As a result, the velocities of ebb and flow will decrease with a extent up to 7cm/s. It is noticeable that both the ebb tide velocity and the flood tide velocity of the observation stations in Hengsha channel increase. And the reason is that the blocked flood tide current will run back to the North Channel, and the ebb tide resistance of the North Channel will increase during the ebb tide and the ebb tide current will increase.

Table 1 Tidal levels of different plans(unit:m)

station / plan	Changxing		Baozhen		Liuxiao	
	High tide	Low tide	High tide	Low tide	High tide	Low tide
Basic plan	4.33	0.8484	4.279	0.976	4.361	0.9366
Plan 1	4.353	0.8646	4.263	0.9973	4.322	0.9601
Plan 2	4.354	0.8672	4.265	1.014	4.327	0.9776
station / plan	Hengsha		Beichaozhong		Niupijiao	
	High tide	Low tide	High tide	Low tide	High tide	Low tide
Basic plan	4.266	0.896	4.332	0.739	4.376	-0.202
Plan 1	4.307	0.9109	4.321	0.7504	4.393	-0.2068
Plan 2	4.311	0.9088	4.369	0.746	4.374	-0.2076
station / plan	Wusong		Zhongjun		Jiuduandong	
	High tide	Low tide	High tide	Low tide	High tide	Low tide
Basic plan	4.314	0.864	4.413	0.1953	4.435	0.0021
Plan 1	4.316	0.881	4.414	0.1966	4.437	0.0014
Plan 2	4.316	0.8847	4.414	0.1956	4.436	-0.0004

Table 2 Ebb tide velocities of different plans (unit:m/s)

	North Passage				South Passage				North Channel			
	1	2	3	4	1	2	3	4	1	2	3	4
Basic plan	1.15	1.16	1.47	1.83	1.76	1.64	1.80	1.53	1.59	1.74	1.76	1.9
Plan 1	1.14	1.17	1.47	1.84	1.76	1.65	1.81	1.53	1.56	1.69	1.69	1.81
Plan 2	1.14	1.18	1.49	1.85	1.77	1.64	1.81	1.53	1.56	1.69	1.68	1.87

Table 3 Flood tide velocities of different plans (unit:m/s)

	North Passage				South Passage				North Channel			
	1	2	3	4	1	2	3	4	1	2	3	4
Basic plan	1.46	1.5	1.44	1.67	1.43	1.36	1.38	1.4	1.72	1.8	1.65	1.63
Plan 1	1.45	1.5	1.53	1.64	1.45	1.38	1.39	1.39	1.68	1.76	1.59	1.53
Plan 2	1.45	1.52	1.43	1.74	1.47	1.38	1.41	1.4	1.67	1.76	1.54	1.59

Table 4 Ebb tide velocities of different plans at the Hengsha channel (unit:m/s)

	Flood tide velocity		Ebb tide velocity	
	1	2	1	2
Basic plan	0.61	0.91	0.39	0.57
Plan 1	0.62	0.93	0.43	0.62
Plan 2	0.67	0.99	0.45	0.64

3.3 TIDE FLUX OF HENGSHA CHANNEL

The tide fluxes of Hengsha observation stations are obtained to study the flux of ebb tide and flood tide. The fluxes are shown in Table5. It can be inferred that the ebb tide flux and flood flux of the Hengsha Channel will increase after the reclamation. For plan1, the increase of ebb tide flux is 4.7% and the increase of flood tide flux is 23.5%. For plan2, the increase of ebb tide flux is 17.1% and the increase of flood tide flux is 34.1%. And the reason for the increase is that the blocked flood current, which formerly go through the East Hengsha Beach into the North Channel, will run back into the North Channel through the Hengsha Channel and the ebb tide current resistance in the North Channel will increase.

Table 5 Tide fluxes of different plans at Hengsha observation station（m^3/s）

	Basic plan	Plan 1		Plan 2	
Ebb tide	8.56E7	8.96E7	4.7%	1.02E8	17.1%
Flood tide	1.32E8	1.63E8	23.5%	1.77E8	34.1%

3.4 SPLITFLOW RATIONS OF THE NORTH CHANNEL AND SOUTH CHANNEL, AND THE NORTH PASSAGE AND SOUTH PASSAGE

The influences of the Reclamation Project on the Yangtze Estuary Deepwater Channel Regulation can be reflected by the effect of the Reclamation Project on the splitflow ration of the North Channel and South Channel, and the North Passage and South Passage. Table6 is the tide fluxes of the North Channel, South Channel, the North Passage and South Passage in different plans. Table7 is percentage of flood flux and ebb flux of different plan. It can be learned that the flood tide flux of the North Channel will decrease while that of the South Channel will increase. As for the ebb tide flux, the North Channel is the same, and the South Channel has a little decrease. The flood tide fluxes of the South Passage and North Passage will increase slightly because of the reclamation. The ebb tide flux of the South Passage will decrease slightly while that of the South Passage has no variety. The reclamation prevents part of the flood tide current from entering the North Channel, so the splitflow ration of the North Channel will decrease while that of the North Passage will increase, and the variety amplitude is within 1.5%. And it can be concluded that the Reclamation Project has little influence on the splitflow rations of the North Channel and South Channel, and the North Passage and South Passage.

Table 6 Tide fluxes of North Channel, South Channel, North Passage, South Passage of different plans(Unit m^3/s)

	Ebb tide				Flood tide			
	North Channel	South Channel	North Passage	South Passage	North Channel	South Channel	North Passage	South Passage
Basic plan	1.72E9	1.61E9	9.01E8	1.03E9	1.33E9	1.27E9	8.96E8	7.42E8
Plan 1	1.72E9	1.58E9	8.59E8	1.04E9	1.3E9	1.29E9	9.23E8	7.48E8
Plan 2	1.72E9	1.57E9	8.51E8	1.03E9	1.29E9	1.29E9	9.13E8	7.56E8

Table7 Percentage of flood flux and ebb flux of different plans

	Ebb tide				Flood tide			
	North Channel	South Channel	North Passage	South Passage	North Channel	South Channel	North Passage	South Passage
Basic plan	51.65	48.35	46.63	53.37	51.15	48.85	54.70	45.30
Plan 1	52.12	47.88	45.23	54.77	50.19	49.81	55.24	44.76
Plan 2	52.28	47.72	45.24	54.76	50.00	50.00	54.70	45.30

4. CONCLUSION

The effects of the Reclamation Project in the Hengsha East Beach on the Yangtze Estuary Deepwater Channel have been numerically simulated with improved ECOM model. The main conclusions are as follows:

1. The Reclamation Project only has influence on the tide levels of Baozheng, Liuxiao in the North Channel and the Hengsha, Beicaozhong section, Niupijiao in the North Passage, while the extent is up to 5cm. So the Reclamation Project has no negative effect on the flood control in the Yangtze Estuary.

2. The Reclamation Project blocks off part of the flood tide that formerly which formerly run through the east Hengsha Bench into the North Channel, and the ebb tide resistance of the North Channel also increases. So the velocities of ebb and flow in the North Channel will decrease, while the extent is up to 7cm/s.

3. The blocked flood current, which formerly go through the East Hengsha Beach into the North Channel, will run back into the North Channel through the Hengsha Channel, and the ebb tide current resistance in the North Channel will increase. So the ebb tide flux running through the Hengsha Channel into the North Passage will increase, and the Reclamation Project makes increase in the tide fluxes and the tide velicities.

4. The Reclamation Project has little influence on the splitflow rations of the North Channel and South Channel as well as on that of the North Passage and South Passage. So the Reclamation Project in Hengsha East Beach conforms to both the evolvement trend of the riverbed and the requirement of the dredged slurry disposal in the Yangtze Estuary Deepwater Channel Regulation, and it won't make negative effects on the Project of the Yangtze Estuary Deepwater Channel Regulation. The Reclamation Project stabilizes the high beach, and eliminates the current along the bank at the outside of the North Jetty, so the project will make positive effects on the stability of the North Jetty.

It can be concluded that the Reclamation Project in Hengsha East Beach conforms to the evolvement trend of the riverbed, the requirement of the dredged slurry disposal in the Yangtze Estuary Deepwater Channel Regulation, and has little influence on the Yangtze Estuary Deepwater Channel Regulation. And the Reclamation Project is reasonable and feasible.

ACKNOWLEDGEMENT

This paper is based on work supported by the National Natural Science Foundation of China (No. 40231017) and the open Foundation of State Key Lab. of Estuarine & Coastal Research, East China Normal University

REFERENCES

Liu, Hua and He, Yousheng. 1999. A review on 3-D Mathematical modeling of Hydrodynamic Flow in estuarine and coastal waters. *Journal of Ocean Engineering*, No.2. (in Chinese)

Liu, Hua et al. 1999. A 2-D vertical mathematical model of morphological processes of a trench. *J. of Hydrodynamics*, No.2.

Dou, Xiping et al. 1999. Mathematical modeling of full sediment transport in the Yangtze estuary. *Journal of Nanjing Hydraulics Research Institute*, No.6.

Guan, Weibing et al. 1999. Numerical simulation of sediment transport in the Yangtze estuary and Hangzhou Bay under Effects of Strong winds and waves. Internal reports of IIHR. (in Chinese)