Beach & Bank Protection Works and Water & Soil Resources Sustainable Development In the Yangtze River Estuary

Ji Yongxing[1]***, Liu Shuiqin***[2] and ***Mo Aoquan***[1]

[1]Shanghai Water Conservancy Engineering Design & Research Institute
Zhongning Rd. 99, Shanghai, 200063, P.R.C.
E-mail: jiyx@public8.sta.net.cn
[2]Resource and Environment College, East China Normal University
North Zhongshan Rd. 3663, Shanghai, 200062, P.R.C.

Abstract: The paper analyses water & sand transportation and tidal flat scour-and-fill development tendency. According to scour-and-fill stability, the paper presents several protection methods for different failure factor at different eroding shore to prevent water and soil loss and control the estuary development trend; and accretion promotion and reclamation at properly occasion to keep the water & soil resources sustainable development. At last, the paper suggests that water & soil resources and sustainable development at he Yangtze River Estuary must be sufficiently considered in accretion promotion and reclamation by analysis of the positive and impassive effects on resources, environment and ecological environment.
Keywords: the Yangtze River Estuary, beach & bank protection, water & soil resources, sustainable development

1 Introduction

The sand from upstream deposited at the estuary and the beach is the material base of bottomland of our country. The Yangtze River Estuary has plenty of sand sources. (Fig.1) There are 4.68×10^8t sands every year transported by water from upstream to the Estuary, 50per deposit and silt at the Yangtze River Estuary, which is extensive and abundant beach resource [1]. It is important for Shanghai and Jiangsu's economic development and people's life quality. But the beach of the Yangtze River Estuary is scoured and denuded seriously by ebb-and-flow double direction power, Coriolis's power, wind wave erosion, and etc. The sands of the beach are running off with flow badly. In order to protect people lives and property, keep the sea-route and shore stable, protect beach and resource, keep the water & soil resources sustainable development, the beach & bank protection works should be done.

Beach & bank protection has two fashions. One is direct protection, and the other is indirect protection. The direct protection is to build spur dikes and parallel dikes at the scour reach to provoke current and protect wave. The indirection protection is to use biogenic method and engineering for accretion promotion first, then reclamation. But anyway, engineering or no-engineering factors will affect the beach the scouring-and-filling in the Yangtze River Estuary. So, protecting the water & soil resources should be raised while presenting beach & bank protection works in order to keep the water & soil resources sustainable development, thereby keep the beach resource rational exploitation and the human habitat, ecological balance, environmental protection and economic advance sustainable development.

2 Scouring-and-filling beach zone distribution and alteration in the Yangtze River Estuary

2.1 Beach zone distribution in the Yangtze River Estuary

The Yangtze River Estuary belongs to land-and-sea facies tidal estuary. Because of many islands in the estuary and runoff flux from upstream, the ebb-and-flow current is separated by two strong power. There are 4.68×10^8t sands every year transported by water from upstream to the Yangtze River Estuary, 50% of it deposit and silt at the Yangtze River Estuary. Therefor, series of islands and regularity multi-branches come into being. The bottom matter of the beach in the Yangtze River Estuary belongs to soft

facies deposit sediment. The deposit sediment around Chongming Island is fine particle sand, and most of it is argillaceous silt. The most around Changxing and Hengsha Island is argillaceous silt sand and silt. There are several soil types at the east of Hengsha Island and Jiuduan Island in different hydrodynamic zone. Some is fine yarn, some is sandy silt, and some is sandy clay. The higher is the beach elevation, the finer is the bottom matter. Contrarily is coarser. The region of beach morphologic in the Yangtze River Estuary is divided clearly. Above of the neap high water grows sea three-edge grass, and the below is bare beach. Above of the spring high water grows hunch reed.

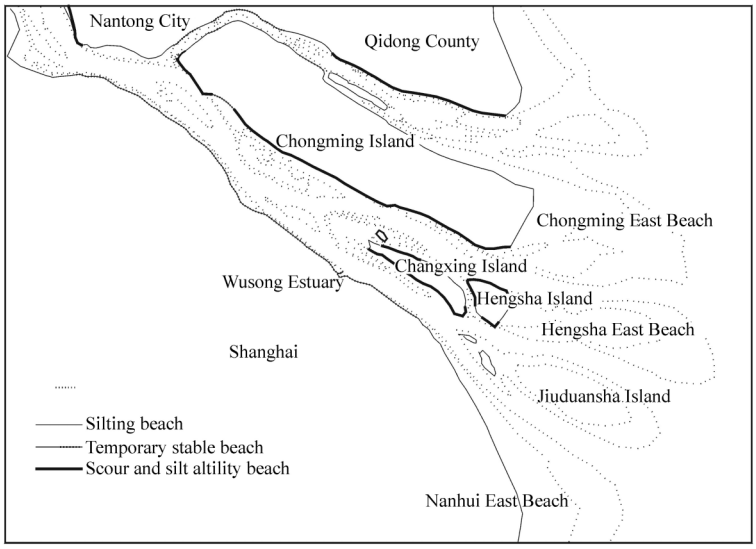

Fig.1 Tidal beach resources distribution and scour-and-fill zone location in the Yangtze River Estuary

Chongming Island, Changxing Island, and Hengsha Island are all shoals consist of sands from the Yangtze River upstream. The area of Chongming Island is 1,110.58km^2, and the coastline is 209.73km long. The East Beach of Chongming Island is extensive international swampy land. The maximum width is 13km. The changxing Island and Hengsha Island are alluvial island. The changxing Island is 87.86km^2 and coastline is 59.10km long. The Hengsha Island is 49.26km^2 and coastline is 30.25km long. The Jiuduansha Island is another alluvial sandbar followed by Chongming Island, Changxing Island and Hengsha Island and is a new sandbar littoral wetland. Anomalistic year, the Dongfeng Sandbar, Qingcao Sandbar [2], Huanggua Sandbar, Hengsha East Beach, and etc come out one by one in the Yangtze River Estuary. Therefor, The international over size estuary wetland has been assuring source. The beach resource in Shanghai churchyard is 98,429.2ha. Thereinto the marginal bank is 68,807.7ha (up of 0m bathymetric is 60,090.0ha and up of 3.5m bathymetric is 8,784.4ha) and aquatic bank is 29,612.5ha. Specific areas list as follows Table 1[3].

Table 1 The distribution of tidal beach resources along the Shanghai coastline/myriad mu

Place name	Marginal bank		Aquatic bank	
	Up of 0m	Up of 3.5m	Place name	Area
South bank of the Y.R.E	37.76	2.07	Huangguasha Island	4.15
North bank of Q.E	7.97	1.15	Up of Biandan Bar	2.79
Chongming Island	36.45	9.45	Down of Biandan Bar	2.26
Changxing Island	3.08	0.32	Jiuduan Island	10.71
Hengsha Island	4.83	0.08	None-name bar	24.50

2.2 The distribution and alteration of scour-and-fill beach zone in the Yangtze River Estuary

Affected by ebb-and-flow, Coriolis's power, wind wave erosion, and etc., the beach in the Yangtze River Estuary scour-and-fill differently. The scour-and-fill zone includes scouring zone, scouring-and-filling alternation zone, stable zone and filling zone. The filling beach coastline in Shanghai churchyard which is 210km long lies in Nahui East Beach, north beach of Chongming Island, Chongming East Beach and Hengsha East Beach. The stable beach coastline that is 85.9km long lies in up-and-down Wusong Estuary at the south branch of the Yangtze River Estuary. The scour-and-fill beach coastline which is 175.6km long lies in Xinjian Estuary, the south beach of Chongming Island and Changxing Island, the north beach of Hengsha Island, the tidal bore reach at the north branch of the Yangtze River Estuary, and etc. Figure 1.

According to river evolution and the Yangtze River Estuary regulation planning, the North Branch is more atrophic. Especially, the north beach of Chongming Island [4] and Chongming Island East Beach are mainly soil resource for Shanghai accretion and reclamation recently. Nanhui East Beach is one of Shanghai accretion and reclamation recently too. Pudong international airport reclamation [7,8], Nanhui East Beach reclamation and Luchao Estuary reclamation all have been done.

The unstable beaches include north of Chongtou, Xianjian Estuary, Qidong County beach, north of Chongming Island and Changxing Island, and etc. Different unstable beaches have different failure reasons. The north of Chongming Island beach is washed off by surge. And the Xinjian Estuary reach beach is washed off by radial flow from upstream. The seashore at Qidong County, the south beach of Chongming Island and Changing Island are scoured because by Out-bar and inner stream [5,9]. The high beach out of the Yangtze River Estuary is mainly destroyed by wind wave, for example, Tuanjiesha Beach and south east beach of Hengsha Island retrograde approximately 50m per year.

3 Beach and bank protection works in the Yangtze River Estuary

Based of reach development and beach failure reason at different location, the protection includes direct and indirect protection. The direct protection means to build spur dike, parallel dike and protective ridge at scouring and scour-and-fill reach. And it is the main beach and bank protection works and an important measure for protecting water and soil loss. The indirect protection means beach accretion promotion and reclamation, planting vegetable or building accretion promotion dam to extend beach and develop wetland or land. But generally, the beach and bank protection works means the direct protection.

3.1 Beach and bank protection

Because the beach failure reasons (reach development, hydrodynamic condition and wind wave etc.) is different at different reach, the protection works is different. For example, at the reach where the current is along shore and the speed is quick, such as e at the south beach of Chongming Island and Changxing Island, it is a main fashion to build spur-dike to provoke current off the beach and protect groin basin non-scoured. At the reach where is erode by wind wave, parallel dike and protective ridge is very useful. The difference between parallel dike and protective ridge is that parallel dike body is bigger than protective ridge and its top elevation locates average high tide level, about 3.5m—4.5m.The protective ridge is smaller, and it top elevation locates average tide level, about 2.5m—3.0m. The parallel dike and protective ridge is very useful for protecting beach from wind wave. On the other hand, the parallel dike and protective ridge can accrete and promote the beach. The sand comes into the dike basin following the flood current, and deposits when tide ebbs. The beach elevation rises and the depth in front of the dike decreases. Therefor, it can protect the beach and protect the bank.

Along the Jiangsu Province and Shanghai coastline, there are plenty of spur dikes, parallel dikes and protective ridges to protect beach and bank safety. By the end of 1999, There are 442 bars spur dikes, parallel dikes is 60.18km long and protective ridge is 64.08km in Shanghai coastline. (347 bars spur dikes, 20.68km long parallel dikes and 59.6km long protective ridges in the Yangtze River Estuary.)

Table 2 Beach protection works along the Shanghai coastline

Place name	Spur dike /bar		Parallel dike	protective ridge
	Construct	Sludge/washout	/km	/km
Chongming Island	183	21/6	5,410	28,045
Changxing Island	73	7/18	958	20,670
Hengsha Island	24	–/2	2,388	6,843
Baoshan Borough mainland	44	—	154	—
Pudong Borough mainland	23	—	11,769	4,043

3.2 Beach accretion promotion and reclamation

Beach accretion promotion and reclamation at the filling reach beach is an indirect and an positive mode. Some research data indicates that the reclamation land is 62% of Shanghai territorial land from liberation of P.R.C. to 2000 years [10]. From 1953 to 2000, the reclamation land area is about 84,042ha in the Shanghai inland (Fig.2). The reclamation land distributes at Nahui East Beach, north beach of Chongming Island, Chongming East Beach and north beach of Qiantang Estuary. After beach accretion promotion or reclamation, the hydrodynamic conditions in front of the bank or the vegetables beach is weakened, then the sand deposits and the beach develops. The bank safety and the beach development are one path of keeping the wetland and soil resource sustainable development. According to statistic data, the coastline at east of Nanhui extends 1.2km in 20 year and average silting rate is 57m/a. Since 1997, large scale beach accretion promotion have been done in the Yangtze River Estuary, and reclamation will finish by the end of 2005. In the due time, the coastline will extend 4.0km.

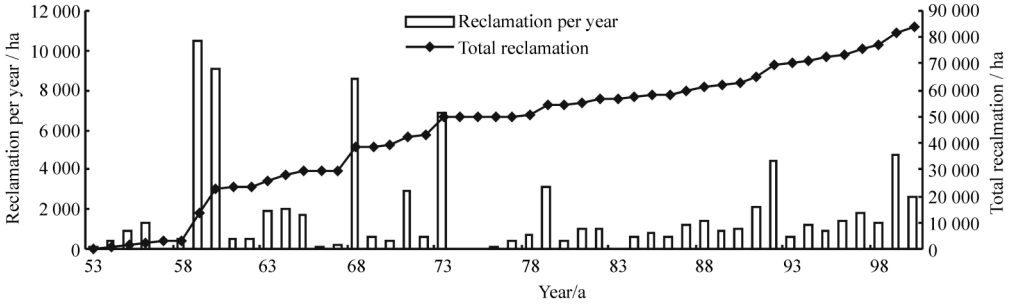

Fig.2 Reclamation land area in the Shanghai inland since 1953

4 Beach and bank protection effect analysis and sustainable development

Everything has two aspects. Beach and bank protection has positive effect and negative effect Accretion promotion and reclamation can supply land for city development, and on the other hand, it may break ecological condition and ecological balance of wetland. But, the beach and band protection is good to keeping water-and-soil sustainable development and ecological balance in the Yangtze River Estuary.

4.1 Beach and bank protection positive effect

(1) Preventing water loss and soil erosion

It is very useful for the beach and bank protection works to prevent the beach from erosion. Based on the underwater topography, from 1985 to 1990, the 2.0m contour line nearing Tuanjiesha at south east of the Chongming Island backed off 300m—500m, average 60m—100m very year. After reclamation, but no protection, the 0m contour line backed off 300m—480m from 1991 to 2000, the –5.0m contour line backed off 400m—660m. The maximum retrograde width is 520m from 1990 to 2001, average 50m very year. Others, at the outer-bar and inner-stream beach, the stream is approaching to bank and the bank

is cliffier because of power current [5]. Therefor, the beach and bank protection is very useful for protecting water loss and soil erosion and keeping the water and soil resource.

(2) Ensuring the embankment safety

Dynamic forces such as runoff, tidal current and wind wave, the beach and bank in the Yangtze River Estuary go through with silting, scouring and slumping process. In allusion to river development and water regime, beach and bank protection works had been done around the Yangtze River Estuary coastline in 1970's. It very useful for keeping the beach stable and controlling dikes breach. The beach elevation is important to embankment safety. Once the beach scours deep, the depth in front of the beach increases. So the wave action boosts up and the resistance to embankment overturning depress. Therefor, Putting the beach and bank protection works in practice is very advantaged to ensuring embankment safety and protecting human being and property.

(3) Stable the balance of the Yangtze River Estuary

The beach and bank protection is very useful to estuary regulation. The spur dike can be protecting beach and bank, and on the hand, it can be provoking current and ameliorating hydrodynamic condition. For example, the Xuliujing node being form controls the Yantze River Estuary developing anomaly [12]; the beach protection at Shitousha beach of Changxing Island from 1950's to 1960's restrains the Shitousha beach back off; the beach protection at north west of Hengsha Island controls Hengsha Island moving. All of them show that the beach and bank protection is very useful to estuary regulation.

(4) Supplying wetland for animal and plant living

Islands and islets wetland is important element of estuary wetland and is a belt of seawater, freshwater and land transition. And it's main region for estuary seashore resource developing and using. The islands and islets wetland is also subject investigated for natural protection and global change [13]. The Chongming Island, Hengsha Island and Jiuduansha Island are important habitat and feeding zone on the migratory bird flight way. The beach and bank protection not only prevent beach scour and ensure the embankment safety, but also promote beach accretion and supply more wetland for animal and plant living.

(5) Supplying environment wetland

There is plenty of algae and aquatic propagation besides plenty of microbe. And it comes into being environment purified nature bio-membrane of the Yangtze River Estuary. The environment purified nature bio-membrane composed of tidal beach and bank can purify low-polluted seawater directly and improve environmental sanitation. The beach accretion and promotion supply more living space for animals and plants. And at the same time it supplies more nature bio-membrane for environment purified either.

4.2 Beach and bank protection negative effect

The beach and bank protection works may affect hydrodynamic condition of the peripheral water area. When the hydraulic and sediment conditions of upstream changes, the protection works may be destroyed. If the protection works are layout according to hydraulic and sediment condition and bed development analysis result, it can improve hydraulic condition.

The beach and bank protection works may engross part of wetland. And so the aquatic organism besides the seashell has to move to another handy environment living. But the protection works prevent beach from scouring and promote beach accretion, so the wetland area may be enlarged. Therefor, The effect of beach and bank protection on environmental condition is feebly and provisory.

4.3 Beach resource rational exploitation and sustainable utilization

The beach resource sustainable development is defined as keeping nature, economy and social developing persistently, coordinately, effectively and roundly during exploitation process. The Yangtze River Estuary beach resource should be developed according to beach location, nature resource, environmental condition, developing actuality and social needs and according to national economy position of the Jiangsu and Shanghai province. We should create advantaged condition and optimize ecological environment to realize beach resource development aim that is protect during the developing

and develop during the protecting. So, the resource developing of Yangtze River Estuary is connected to economy development, ecology establish and sustainable development. The resource development must be consistent with the Yangtze River Estuary regulation, waterway regulation, port construction, soil resource programming and wetland protection. The development should put short development and remote programming together, put using and protecting together, follow the order of nature, and keep the resource developing sustainable.

The beach and bank protection is more preponderant than the reclamation on resource sustainable development and ecological balance, so it provides guarantee for the resource sustainable development and using in the Yangtze River Estuary.

5 Conclusion

The Yangtze River Estuary regulation is a systematic engineering. On the one hand, people do beach and bank protections or construct ports at the scour reaches. And on the other hand, they plant vegetables at silting area to protect wetland or do promotion works and reclamation project to gain more soil resources. The rational exploitation-and-using and sustainable development of beach resources is very important for the human habitat, ecological balance, environmental protection and economic advance. In order to keep the wetland resources sustainable development in the Yangtze River estuary, we suggest that the reclamation land improvement should be less than or equal to sediment accumulation rate. And on the other hand, we should do beach and bank protections works to protect beach scouring and keep water and soil resources sustainable development.

Conference

[1] Reclamation Special Committee of China Hydraulic Engineering Society, Nov. 2000. Reclamation Works of China. Beijing: China Hydraulic and Hydroelectric Publishing Company.(Chinese).

[2] Lu Yongjin, Chen Mefa, Ji Yongxing, etc. Sep. 1998. 2D Hydrodynamic Models Using in Shanghai Water Conservancy Engineering. Journal of Hydrodynamics, vol. **13**(3): p.61-65. (Chinese).

[3] Shanghai Water Conservancy Bureau. Dec. 1997. Shanghai Water Conservancy Records. (Ver. 1) Shanghai: Shanghai Social Science Publishing Company. (Chinese).

[4] Ji Yongxing, Lu Yongjin, Mo Aoquan. Nov. 2000. Hydrodynamic Models Research for Reclamation Works at Chongming Island in the Yangtze River Estuary (Ⅱ). 14th China Hydrodynamic Committee Colloquium. Beijing: Ocean Publishing Company (China). (Chinese).

[5] Ji Yongxing, Lu Yongjin, Mo Aoquan. Mar. 2000. Beach and Bank Protection Works at Outer-bar and Inner-stream Reach in the Yangtze River Estuary. Bulletin of Soil and Water Conservation, vol. **21**(1): p.15-18. (Chinese).

[6] Zhang Wei, Xu Jinhuan, Li Guochen. Jun. 1999. Analysis of Bore Propagation and Calculation of Bore Speed. Hydro-Science and Engineering, vol. **80**(2): p23-30. (Chinese).

[7] Ji Yongxing, Lu Yongjin, Yao Huasheng. Dec. 2000. Hydrodynamic Model Study for Beach Reclamation Closure of Shanghai Pudong International Airport. Advance in Science and Technology of Water Resources, vol. **20**(6): p.36-38. (Chinese).

[8] Pudong International Airport Engineering Headquarters. 1998. Pudong International Airport sustainable development Research and Experience. Shanghai: Tongji University Publishing Company. (Chinese).

[9] Liu Shuiqin, Ji Yongxing, Lu Yongjin. Nov. 2000. Numerical Simulation and Genetic Analysis for Outer-bar and Inner-stream Reach in the Yangtze River Estuary. Bed Development and silt Prevention and Cure. Xinjiang: Xinjiang People's Publishing Company, p.6-12. (Chinese).

[10] Chen Manrong, Hang Xiaofei, Liu Shuiqin. Dec. 2000. The Effects of Reclamation and Sustainable Development on the Coastal Zone in Shanghai, China Soft Science, vol. **120**(12): p.115-120. (Chinese).

[11] Chen Jieyu.1988. Effects of reclamation in the Yangtze River Estuary Regulation. Shanghai: Shanghai Social Science Publishing Company. (Chinese).

[12] Yuan Xingzhong, Lu Jianjian, Jan. 2001. Studies on Zoobenthos Resources in the Islands of the Changjiang Estuary. Journal of Natural Resources, vol. **16**(1): p.35-41. (Chinese).

[13] Sun Pingyue, Lu Jianjian, Jul. 1998. Sustainable Utilization of Biological Resources on the Wetland in the Yangtze Estuary (Changjiang Estuary). Resources and Environment in the Yangtze Basin. vol. **7** (4): 330-336. (Chinese).

[14] Yu Yamin. Sep. 2000. Investigation and Protection of Biological Resources on the Wetland in the Yangtze Estuary. Journal of Capital Normal University. vol. **21**(3): p.81-87. (Chinese).