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AN APPROACH OF COASTAL PROTECTION AND DEVELOPMENT IN SEMI-CLOSED BAY

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ABSTRACT: The evolvement of a beach depends on many conditions. Erosion and deposition are the most common phenomena during beach evolvement proceeding, whicn can always be found in the same beach. Sediment transport drived by waves or currents changes with season or tide preod time. The coastal infrastructures have great influences on sediment transport by changing the nature conditions, so it is the most common approch adopted to deal with beach problems. In China, sand beach getting muddy by depositing silt is another beach problem in addition to erosion. With the population of coastal city growing, it is attracting more attention from researchers . This paper demonstrates an approach of coastal shallows and development in a semi-closed bay. The waves, tidal currents and floods are dicussed and the sediment conditions are analyzed. After that, a mud digging and sand beach rebuilding plan is recommanded. In the adduced bay, waves are small and varying with wind forces and directions, tidal currents are weak in the most part of the coastal shallows, floods generally happen during July to Septermber accompanying with sediment input the bay every year. The analyzing method and simulation technology can be used in the similar semi-closed bay and be referenced by other coastal areas.

Keywords: Sand beach, semi-closed bay, approach, plan.

INTRODUCTION

In terms of regional economic development, originally the coastal areas contributed most to economic growth. Ports, electric power plants, near shore industries, etc. are jammed along the shore lines. Coastal beaches are disturbed violently by human activities. Natural beautiful beaches are declining while the population near the shore land is growing. Chinese government has invested a lot to protect some coastal areas. An example plan is introduced here about a semi-closed bay of protection and development.

This bay is named Fangchenggang west bay with open mouth in the south facing the Beibu gulf, located in the southwest of China coastal line, covering approximately 28 square kilometers. Its east coast has been developed into ports area while the north and west one will be developed into habitation areas. The Fangcheng River is the only rive that runs into the west bay at the north-west corner. There are 5 islands, ignoring the tine ones, located in the bay area. There is no people living in these islands, and about 110,000 people live around the bay. There are many kinds of coastal shores around the bay including artificial, sand, mud and some mangrove forest shore. The mud beaches are increasing in the past decade for deposition problems in the bay. A lot is needed to improve the living conditions, among which planning may be the most important at the beginning. The following will detail the plan for the west bay protection and development.

GENERAL INFORMATION

Shore Line History

The Fangchenggang west bay is part of the Fangchenggang bay which is divided by a south-north direction narrow island (Yuman island) into east and west parts (Fig.1). The west bay is a ribbon-shaped inland sea with several islands. The largest two islands both locate in the north part, which guide the flood of the Fangcheng River to pull into three passages from north to south. In the middle of the bay, the three passages join together to extend to the mouth.

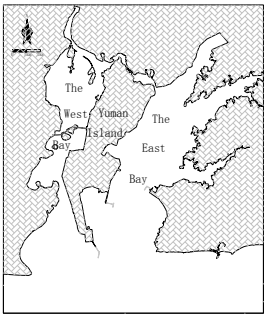

Fig.1 The location of the Fangchenggang west bay

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Before 1960, most of the bay kept natural except some small reclamation works of salt field, agricultures, sea cultures, etc. The islands and troughs have kept steady.

From 1960 to 1980, the shore line has been changed by some unplanned dikes that connected the west shore to the island in the north-west of the bay and narrowed the middle passage of the bay.

After 1980, the shore lines have been changed with the port building, land using, and other human activities.

The south-west shore lines of the Yuman island have been built into ports line and some sea areas have been reclaimed into dock dumps. Yuman island became longer and wider during 1991-2008 and the entrance of the bay has been narrowed to 426m by 1996. A big mount of fish farm facilities have been built in the bay especially in the north parts. Accompanied with the shore line changing and developing, the hydrodynamic of the bay has been getting weak and deposition become accumulated.

Submarine Geomorphology

The study bay is a shallow water area with depth usually less than 15m. The water depths decline from the north to south. There are three trough-shaped valleys derived from the estuary of the Fangcheng River. The west trough was blocked apart from the estuary by a bank during the 1970s while the middle one half was blocked. The east trough is the only main passage of the flood discharge after 1980. So the depth of the east trough is getting deeper while the other two are getting shallower. The three troughs pass by the two islands and joint each other at the middle part of the bay where several smaller islands located. One deeper trough is formed at the south part of the bay and lead to the outlet.

Indicated by submarine topography data of 1980, 2004, 2007 and 2009, the depths under datum for sounding reduction (this is the common water level used in the paper) are usually above 0 m in the north part, even the deepest trough seldom keeps under 0 m to connect the estuary of the Fangcheng River until 2009. The deposition occurred mostly at the tidal interval areas while scour took place in the down part of the troughs. Both the tide and flood currents are not very strong, so scour is relatively slow. Deposition is more clearly than scour although there is no much sediment inputting every year. The deposition layer accumulated nearly to 2 meters at some places during the past 30 years. Usually, the thickness of deposits in the west part is greater than that in the east. The submarine topography in the south part keeps more stable than that in the north. Some sand beaches along the north-west part of the bay have changed into muddy shore because of the deposits.

Climate and Oceanography

The land areas adjacent to the bay lie in a south subtropical oceanic climate. There is rain without snow with the mean monthly temperature varied from 14.2 ℃ to 28.4 ℃. North monsoon prevails in the winter while south monsoon prevails in the summer. From June to September is the rainy season while from November to next March is the dry season. The mean annual precipitation is 2362.6 mm, 71% of which falls in the rainy season and only 6.4% falls in the dry season.

The tidal system in the bay obeys the one in the Beibu gulf which belongs to lunar appulse diurnal tide. It means that only one tidal rise and fall happens in the common day (diurnal tide), except about 6~8 days out of a month two tidal rises and falls occur (semidiurnal tide).

The tidal difference may be greater than 4.5 m in the diurnal tide days while that may be less than 1 m in the semidiurnal tide days. The durations of tidal rise and fall are different between diurnal tide and semidiurnal tide period. The duration of fall is longer in the former and may be approximately same in the later. The tide shape will change from the mouth to the estuary for both marine topography and river discharge reasons. The tide level processes indicate that the duration of fall increasing after the nearing to estuary. The characteristic tidal values are shown in the table 1 according to the records of Fangchenggang tidal station from year 1976~1990.

Table 1 Characteristic tidal values of local station

Items	Values(m)
Highest high water level	5.54
Lowest low water level	-0.29
Mean sea level	2.27
Mean high water level	3.67
Mean low water level	1.12
Maximum tidal range	5.32
Mean tidal range	2.39

The tidal current in the bay is limited by the shore shape and islands. The direction of the tidal current is approximately parallel to the coastal line in the reciprocating flow movement. The velocities of both flood current and ebb current are less than 0.8m/s in the most of the area. Usually, the flood current is weaker than ebb one, current in the troughs is stronger than in the shallows. The velocities in the three north troughs are under 0.30m/s mostly except the estuary and some narrow marine valleys.

The mean annual wind speed is 3.8m/s according to the local station. The maximum wind speed is 26 m/s

happened in typhoon season. Most wind direction varies in N~NNE as shown in Fig.2.

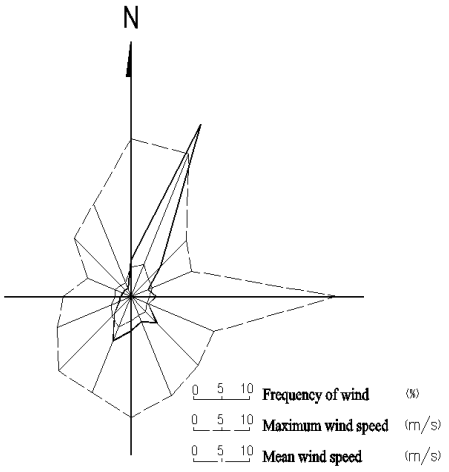

Fig. 2 The frequency of wind at each direction

The waves in the bay are driven by wind especially in the north part water areas for the narrow mouth limited the out sea waves insulating. The wave rose map is shown in Fig.3.

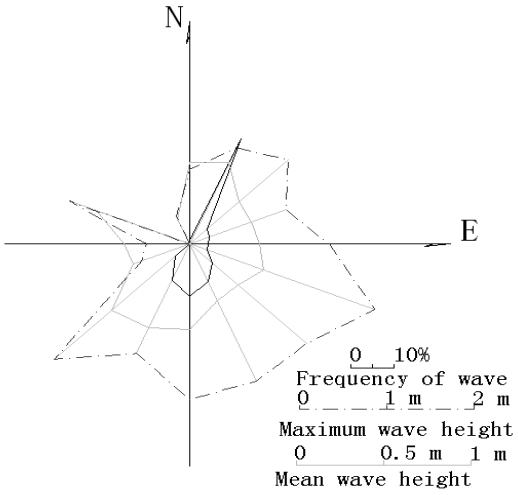

Fig. 3 The wave rose map

SEDIMENT PROBLEMS IN THE BAY

Great changes have taken place in the bay during the past three decades. The west passage was shut at the top of upstream. Depositing along the coast beach has happened for years, which changed some of the sand beach into muddy.

Sea farming developed fast in the past years, especially in the past decade. The piles built in shallows and other sea farming facilities have changed the dynamics of the tidal currents and increased the deposit. The depths of shallows are getting shallower because of the continuous depositing problem.

Reclamation for land or shrimp pool has not been stopped yet. Reclamation reduces the water capacity of the bay which means the current dynamic will getting weak. It will be helpful for sediment depositing, then the capacity of the bay will decline more. So, reclamation forms a bad cycle to the marine environment of the bay.

Another problem coming with the decline of water capacity of the bay is the channel maintaining. The cost has doubled in the past decade for the sediment siltation in the port and channel increasing much more though no new docks built in the bay.

Accompanying the sediment deposit, the resources of tourism, fishery, mangrove forests, marine ecosystem etc. have been affected.

COAST BEACH REBUILT PLAN

The Shore Line Regulation

The government has signed a project to study, design and manage the bay. Shore line regulation is one of important work to do, which focuses on two jobs, one is to recover some of the uncontrolled reclamations and the other is to limit reclamation in the future. The plan of shore line regulation is shown in fig.4. The north island will be shaped slide by getting rid of some shrimp pools and the west tidal passage will be open to the estuary.

Two small artificial islands will be built near the west passage along the coast. These islands will be developed into real estate. Some of the fund of the bay protection project will come from the company to build these islands.

All the muddy beach shore will be built into artificial shore while nature sand shore, rock shore, mangrove forest shore will be kept natural and be protected well.

The Water Area Dredging

The most north parts of the bay area are shoals, which are above low tidal level. There is yellow mud scene without blue sea water. A dredged plan is made to change it. As shown in fig.4, most of the north part area will be dredged to keep water area all the tidal cycle except the islands. There are two depths controlled for dredging, the west passage area is -0.4m under MSL while other places is -0.8 m. The low water level in the dredged area is 0.25 m higher than the Fangcheng station given earlier. So, it means the depth will be deeper than 1.5 m in most days.

The sand and mud dredged out will be used to fill the islands in this bay and the remainder will be transported to the out sea for reclamation.

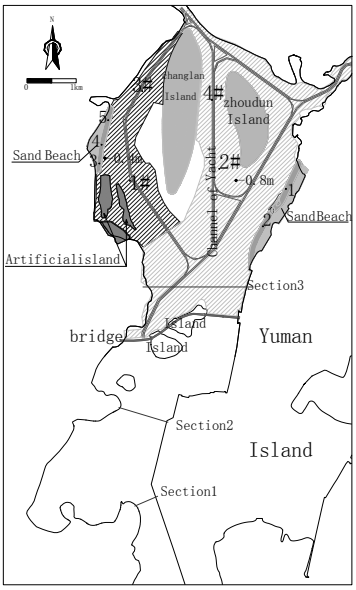

Fig. 4 Coast beach rebuilt plan

Channel of Yacht Dredging

The bay area is beautiful because of the mangrove forest, islands, blue water, green trees along the shore, rich marine species and etc. The yacht channel will be developed later for the scene. The bottom of it will be dredged to -2.1 m as shown in fig.4.

The channels are set around the two big islands, extending south direction to the middle of the bay, east direction to another bay.

The yacht system will improve the tourism resources and conditions of the inhabitants.

Sand Beach Rebuilt

Decades ago, there were beautiful sand beach distributed along the coast of both sides. Especially the west coast had white sand beach where is covered by dark muddy now.

To improve tourism resources and inhabitant conditions, two artificial sand beaches are planned to rebuild along the west and east coast as shown in fig.4.

RESEARCH RESULT

A series of studies have been made to support the bay plan about developing and protecting introduced as follows.

Tidal Currents Simulation

The submarine topograph in the north part of the bay is changed by the plan. A mathematical model is established to simulate the tidal currents movements in the bay.

The Water Level Processes

Tidal processes at the north part will change accordingly. Several sample points shown in fig.6 are set to analyze the water level processes before and after the project. The tidal levels are shown in fig.5. It is clear that low levels drop down while the high levels keep same approximately. The duration of ebb tide is shortened after the project.

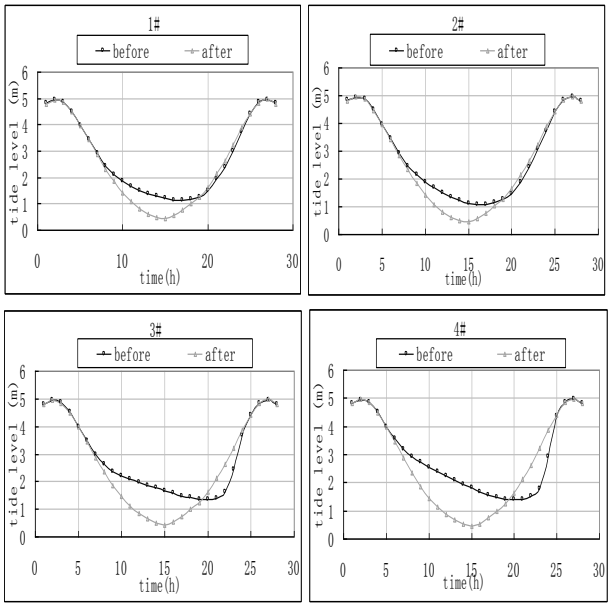

Fig. 5 Water level processed before and after the project

The Tide Capacity Analyzing

Characteristic sections shown in fig.4 are set to analyze the discharge volume changing which is displaced in table 2. Both of the flood and ebb tide capacity are increased.

Table 2 tidal influx and its changing(unite: $\times 10^8 m^3$)

Section		Section1	Section2	Section3
Before the construction		1.0783	0.9121	0.6673
After the construction	Variation	0.1732	0.1763	0.1433
	Rate of change	16.1%	19.3%	21.5%

The Tide Velocity Analyzing

Several sample points shown in fig.6 are set to analyze the velocities of flood and ebb tide. According to table 3, both artificial sand beaches encounter no strong currents. The sand beaches will keep stable for the velocities being seldom greater than sediment incipient velocity. Silting problem will not be violent for there being little sediment coming with flood from river.

Table 3 the analysis of character velocity (unite:m/s)

condition	point location	flood strength flow velocity	ebb strength flow velocity
average annual discharge	1	0.09	0.09
	2	0.06	0.08
	3	0.05	0.04
	4	0.03	0.04
	5	0.03	0.04
the flow of average flood period	1	0.09	0.10
	2	0.05	0.10
	3	0.03	0.02
	4	0.03	0.05
	5	0.02	0.03
the flow of 20 years flood	1	0.10	0.11
	2	0.06	0.14
	3	0.01	0.01
	4	0.02	0.02
	5	0.02	0.01

Wave and Sediment Estimate

The out sea waves seldom enter the north part of the bay. The effective waves are usually driven by the local winds. The wave heights related to each direction of wind and water depth are calculated by formula based on water depth, wind velocity, and wind distance. The capacity of sediment transportation is estimated respectively to different beach sites. The results are displayed in table 4.

Table 4 incipient velocity of grades sediment and depth

depth of water (m)	sediment grain size(mm)					
	0.075	0.25	0.5	0.8	1	2
0.5	0.309	0.286	0.333	0.384	0.413	0.525
1	0.346	0.317	0.368	0.424	0.456	0.578
2	0.394	0.354	0.407	0.468	0.503	0.637
3	0.430	0.379	0.433	0.496	0.533	0.675
4	0.461	0.399	0.453	0.518	0.556	0.703
5	0.489	0.416	0.469	0.535	0.574	0.726
6	0.514	0.432	0.483	0.550	0.590	0.745

DISCUSSION

The study bay is a semi-closed bay with weak tidal currents, little waves, small sediment input capacity which mean the sediment on the bed is less moveable. Although the nature conditions are suitable for coast infrastructures building, a wrong dike may change a beautiful white sand beach into a dark bad small muddy place in three decades. Coast area is rich of natural sources. Each infrastructures plan should be carefully studied before building.

Hydraulic dynamics and sediment transportation have been studied for this plan to develop and protect the bay. The human activities may increase, because the tourism resources and inhabitant conditions will be improved by this plan. So, the protection plan of the environment and ecosystem of the bay should be carefully arranged during the later stage.

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