

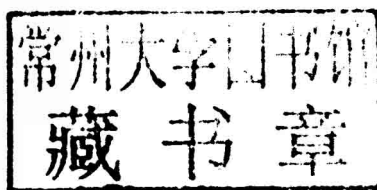
# The Return Period of Siltation on a Silt-sandy Beach

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China Communications Press

## 图书在版编目 (CIP) 数据

粉砂质海岸航道淤积重现期 = The Return Period  
of Siltation on a Silt-sandy Beach: 英文 / 侯志强,  
孙晓明著. —北京: 人民交通出版社, 2014. 5  
ISBN 978-7-114-11379-6

I. ①粉… II. ①侯… ②孙… III. ①淤泥质海岸 -  
淤积 - 重现期 - 研究 - 英文 IV. ①P737.12

中国版本图书馆 CIP 数据核字(2014)第 079713 号

**Book Name:** The Return Period of Siltation on a Silt-sandy Beach

**Author:** Hou Zhi-qiang, Sun Xiao-ming

**Editor in Charge:** Han Ya-nan, Zhao Rui-qin

**Publisher:** China Communications Press

**Address of the Press:** 3 Waiguan Xiejie Street, Andingmen Wai, Chaoyang District, Beijing 10011

**Website:** <http://www.chinasybook.com>

**Sales Telephone:** (010)59757973

**Chief Distributor:** Beijing Federated East Printing Company Limited

**Page Size:** 720 × 960 1/16 of a sheet

**Sheets:** 6

**Edition:** First edition, May, 2014

**Impression:** First impression, May, 2014

**Book No.:** ISBN 978-7-114-11379-6

**Price:** RMB 38.00

(The Press can replace books with printing or binding defects.)

## Preface

Silt-sandy beach is a special kind of coast between the muddy beach and sandy beach, sediment movement is very active. After the construction of coastal engineering, strong siltation and suddenly siltation in windy days become the disaster factors of port, therefore to some constructed silt-sandy ports, some engineering measures of breakwater extension have to be used for improvement, to some silt-sandy ports under construction or planned to be built, the scale of breakwater have to be considered in the engineering design stage to prevent possible suddenly siltation. However, in determining the breakwater scale, it is related to the problem of prevention standard of breakwater, therefore, the concept of the return period of the suddenly siltation is put forward. This book is based on the project background, relying on the project practice of Huanghua harbour, statistical characteristics of suddenly siltation are researched in theory, and propose the scientific method of calculating the return period of the suddenly siltation on a silt-sandy beach, can be used for engineering design.

The book analyses the natural conditions, the sediment environment, sediment hydraulic characteristics of the research area by a large amount of measured data, and studies the characteristics of suddenly siltation, and points out that the gale process is a random variable, and formulates the process that "the certain wind situation causes the certain wave situation, and the certain wave situation causes the certain siltation and the corresponding sediment movement, and the certain sediment movement causes the certain siltation under the wave and the flowing power". Points out that it is a deterministic process from the wind to the channel siltation. So the sedimentation is random, the randomness of the wind causes of the random siltation. And then, the book includes three contents: random probability of wind and statistical characteristics; the certain relationship between wind and channel siltation; the probability distribution and statistical characteristics of suddenly siltation. And it is established that the certain process of the return period of the suddenly siltation.

In this book the concept of "effective wind energy" is presented, and the probability statistical characteristics of wind energy is analyzed. Through the analysis of all kinds of probabilistic linear, it is pointed out that wind and suddenly siltation obey Pearson type III curve and logarithmic normal distribution curve.

The theoretical and conceptual model that Suddenly Siltation is calculated by the wind situation on a silt-sandy beach is developed, and verified by the data on-the-spot of Huanghua. It is pointed out that the relationship between siltation and wind energy is linear.

In Huanghua harbour as an example, probability curve of suddenly siltation has been defined, and the analysis method of suddenly siltation forecast probability is summarized on the silt-sandy beach, and discusses how to determine the siltation remediation standard of silt-sandy coast.

In the process of writing this book, Professor Cao Zude, Professor Zhao Liping and Professor Yang Hua gave a lot of help, to express sincere thanks.

Because of the limited level of the author, and the understanding of the silt-sandy channel is a gradually deepening process, there may be a fallacy and inappropriate in this book, please give me your criticism.

March 2012, TangGu

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# Chapter 1 Introduction

## 1.1 The importance and significance

Silt-sandy coast is a special kind of coast between the muddy coast and sandy coast, sediment movement is very active. Under the effect of the wave and tide, silt is easy to start and to deposit, and silt transport patterns is very complex. After the construction of coastal engineering, strong siltation and suddenly siltation in the local area become the disaster factors in engineering construction.

A large number of silt-sandy coast are scattered in distribution from the Yangtze River to Liaoning province of Yalu River in the north coast, such as Liaodong, Eastern Hebei, Northern Hebei, Shandong, Jiangsu and other places. These areas are relatively backward areas relative to economically developed coastal areas in China. Therefore, development of the coastal port construction has become one of the key factors in the development of the economy of these areas. Along with the rapid development of national economy and the deepening of reform and opening up in recent years, the desire of port construction in these areas is also more and more strong, and some have been implemented, but unfortunately, in the existing silt-sandy port, the sediment problem is severe: since 2001, Huanghua harbour basically completed so far, in heavy weather conditions, the siltation is serious in channel, the Suddenly Siltation amount can reach  $1,000,000 - 3,000,000\text{m}^3$ , October 10 - 13, 2003, the suddenly siltation amount is as high as  $9,700,000\text{m}^3$ . So the country had to invest heavily in building renovation project to improve channel siltation. In Dongying harbour since 1997 the channel dredging, although the channel is covered, the deposition is very serious. The channel of Weifang harbour is in the use of estuarine natural deep trough, but the deep groove is very unstable, so the maintenance of channel depth is very difficult. In Jingtang Harbour, although there are dual embankment protection, but not covered section of dike head, the deposition come into being. In Binzhou harbour, the siltation range is wide, and the construction has halted now.

At present, on the silt-sandy coast the development and construction of port and coastal





engineering show the following situation, the local people's desire of port construction is eager, and scientific research and design staff are scared to talk about "silt", and authorities hesitate about investment decisions, and builders are back to listen to "silt". The main causes of the above situation is: mechanism of silty sand movement is not clear, basic hydraulic characteristics of silt has not been understood, the complex migration patterns and sedimentation characteristics of silty sand has not been grasped, the basic rules of silting can not be grasped, the principle and mechanism of deposition reduction measures are not clear.

Sediment movement of silt-sandy coast is far more complex than the muddy coast and sandy coast, silty sand is the biggest difficulty in coastal engineering, the research is not enough in-depth, it is currently interdisciplinary borderline front edge subject, and is the key problem of the coastal engineering to be solved urgently. Both sediment hydraulic characteristics, sediment transport patterns, sedimentation, and the mechanism of deposition reduction are unique, subject to special experimental study.

This research is a frontier topic of engineering sediment based on the sediment on the silt-sandy coast, based on actual engineering research (Huanghua harbour, Weifang harbour and so on), is one of engineering project focuses on silt-sandy coast harbour siltation—"statistical characteristics of sediment siltation and the calculating method of return period".

This research has a broad prospect in engineering applications, such as: Huanghua harbour will have the concept of "Suddenly Siltation return period" into engineering practice, made the remediation standards of remediation engineering I in Huanghua: "in the situation of equivalent of the annual maximum Suddenly Siltation return period of 10 years, can guarantee 35,000 tons collier not to be hindered the full departure, after the maintenance dredging, can meet 50,000 ton collier full departure."

And based on the established remediation standards I, the formation of the first phase of renovation project, completed in September 2005. Up to now, the fact is that the effect is remarkable; the ongoing Weifang Sendamei million tons wharf Breakwater Project also launched a Suddenly Siltation return period analysis, and as a basis to preliminary design the breakwater. The above facts show that, to carry out the research of "the statistical properties of sediment siltation in silt-sandy coast waterway and return period" is the key problem to be solved urgently in silt-sandy coast engineering, is great practical significance.

## **1.2 Research status**

Suddenly Siltation occurs mostly in silt-sandy coast waterway, this book will study Sud-



denly Siltation of the waterway based on the particular type of silt-sandy beach. Therefore, firstly review the research history of silt-sandy coast.

### 1. Internal present situation of sandy of silt-sandy coast sediment

Silt-sandy coast exist widely in Chinese yellow, Bohai coast, is a special coast, its formation associated with the Yellow River, the Yangtze River sediment and local wave, tide and ocean dynamic interaction.

Our sediment researchers has done a lot of researches on sediment movement characteristics of silt-sandy coast and practical application.

Tianjin research institute for water transport engineering, M. O. T carry out the research of sediment movement and port construction of silt-sandy coast firstly. At present, have experts and scholars of Tianjin research institute for water transport engineering, M. O. T of more than 80% published research results' authors. In the early 90's in the last century, Tianjin harbour and Waterway Engineering Research Institute of Ministry of transportation had starting and migration test of silt and fine sand in the wave flow launder, but only as a sand hydraulic characteristic test, and not contacted with the Coast type and engineering application. From the middle of the last century 1990's, Tianjin research institute for water transport engineering, M. O. T had on China's Zhuanghe harbour, Huanghua harbour, Binzhou harbour, Weifang harbour and Dongying to carry out the preliminary work of Engineering sediment, but at that time, the silt-sandy coast did not known, still took the muddy coast sediment theory as the theoretical guidance. Until the end of the nineteenth Century, Binzhou harbour stopped construction, the outer channel in Huanghua harbour in 2000 silted seriously, the particularity of silty sand movement and disaster Suddenly Siltation had been realized gradually, and the concept of silt-sandy coast had been built, and opened the basic research direction of silt-sandy beach, and combining the transversion from rise and fall of the 7 existed silt-sandy harbour, carried out a systematic study. After 5 years of exploration, has obtained the preliminary understanding:

#### (1) The definition and origin of silt-sandy coast

In port engineering, at the end of the last century the word of silt-sandy coast was on the lips, but in the study, there is still no professional words about silt-sandy coast. In the newly revised "seaport hydrology" JTJ 213—98 there are only muddy coast and sandy coast, until 2001, The masterpiece "coastal engineering" by Chinese Academy of Sciences and the Chinese Academy of Engineering Yan Kai's is also no mention of silt-sandy coast, appears the concept only in Appendix B.



About the definition of silt-sandy coast, on the basis of previous research achievements and combining the sediment classification, Cao Zude (2003) suggests that coastal sediment mean median grain diameter  $d_{50} = 0.031 - 0.125 \text{ mm}$  for silt-sandy coast, at the same time, sediment transport characteristics should be analyzed combined with the sand size distribution curve and the clay content.

About the origin of silt-sandy coast so far little research, but according to some data of the existing silt-sandy coast, silt-sandy beach causes have three basic conditions: one is the left abundant sediment, two is the long-term strong action of wave and tide; three is no longer a large number of external sediment intervention. When three conditions exist at the same time, because the hydrodynamic conditions and sediment grain size are different, resulting in different sub-types of silt-sandy coast, such as type tide, type wave and tide, type sludge, type silt sand.

## (2) Basic hydraulic characteristics and sediment transport model

The sediment incipient velocity on Silt-sandy coast is in the lowest parts (Valley) of sediment incipient velocity curve, is smaller than the starting velocity of silty and sandy sediment. under the action of waves, starting velocity is more smaller. In addition, the settling velocity of sediment on silt-sandy beach is bigger than silt sedimentation velocity, because easy to start and settle, the sediment of silt-sandy coast is activity, and the seabed is easy to be scoured and deposition.

Through the study found by Zhao Chongjiu, in the wave and tidal current, sediment migration shape on the silt-sandy coast is very complex, not only have suspended and bed load, and easily formed sediment layer of high concentration on the seabed, it is the transport form between upper suspension and the bedload, with the same migration pattern as suspension, enter the fairway or low-lying place and deposit with bedload phase approximation. We call it the "flow load". Due to the existence of various sediment transport patterns, thus the deposition is aggravating, difficult to calculate and analyze.

(3) The amplitude of channel siltation volume is large, there is certain statistical regularity

Because of sediment easily starting and sinking on silt-sandy coast, the dredged channel are prone to siltation, and great changes of siltation caused by different wind energy level, using of wind energy level to calculate the siltation quantity, the data show it conforms to probability statistics curve distribution, can be used to calculate the siltation quantity in different return period.



#### (4) The new model of channel siltation calculation

According to the sediment on the silt-sandy coast may exist three different migration patterns at the same time, established three models to calculate the channel siltation, were used to calculate the qualitative channel siltation by suspended, bedload and drift formed, and analyzed the volume ratio of the three part siltation.

#### (5) Siltation reduction measures on silt-sandy coast outer channel

Based on the sediment transport patterns of silt-sandy coast and siltation mechanism, combined with the local hydrological conditions, several engineering measures of prevention and reduction are put forward, and on-site tracking test on engineering measures have been adopted in the port of Huanghua, to understand the characteristics of sediment transport, the rules of sediment and siltation reduction effect.

#### (6) New technology to test the sediment erosion on the silt-sandy coast and erosion control measures

The silt is very easy to start, so the scour problem is one of the key problems that must be solved in silt-sandy coast engineering, usually by physical model test. But because of the model scale and the difficulties to choose sand, we have not come to a satisfactory conclusion by erosion test. Combined with the construction requirements of Nantong harbour Yangkou Harbour, we carried out scouring model test, model for normal distribution, power for the wave and current at the same time, prototype sand, using a series of models, the scouring and erosion control engineering experiment, and gained certain experience, in the field, Han Xijun has gained some basic researches.

It must be stressed that, the above conclusion can only reflect the current situation of domestic research. As a result of these studies are preliminary work of construction, some new ideas and a certain level, but the theory is not perfect, the mechanism is clear, the level is not high, need to be further improved and perfected. In January, 2005, the traffic departments have decided to increase the silt-sandy coast section in criterion, at present, Tianjin harbour and Waterway Engineering Research Institute of Ministry of communications is undertaking the work.

### 2. The abroad research status of silt-sandy coast sediment

So far, jargon words about silt-sandy coast have not yet been found abroad, also did not discover the report of silt-sandy coastal construction, that may be abroad without forming silt-sandy coast conditions, or little construction, has not yet formed the concept of silt-sandy coast. As China's aid in the construction of Pakistan's Gwadar Port, according to our pres-



ent classification for silt-sandy coast, but at that time, English, Dutch, Japanese, etc. to participate in the study, consider it to be sandy coast. As Japanese Xiongben harbour, we think it is silty mud coast, but Japan, Lotus, etc. recognize that it belongs to the muddy coast. Therefore, the study of sediment on the silt-sandy coast abroad has not yet formally launched, also has not formed the system.

### 3. Research status of siltation statistical characteristics on silt-sandy beach

From 10 to 13, October, 2003, the northern area of our country experienced a 45 years of the cold wind, the wind cold exactly coinciding with high tides, caused a rare big waves and storm surge process to Bohai Bay, Laizhou Bay, it was this big wave process that caused catastrophic Sudden Siltation to Huanghua harbour, therefore, in December of the same year, the relevant departments of the state decided to take remediation project to renovate outside waterway siltation in Huanghua harbour, ensure national coal transport, then some domestic, international design and scientific research units carry out the research and engineering treatment measures, and finally developed the remediation principles of remediation combined with dredging the port of Huanghua, and set a standard for the regulation of "10 years of wind deposition, ensure the 35,000 ton collier can full clearance, 50,000 ton collier can be loaded by the tide departure." First put forward the concept of the return period of deposition, it is since then that some scholars and scientists began to give more attention to the determination the return period of the suddenly siltation.

The most difficulty to determine the return period of the suddenly siltation is the lack of actual measured data, and sufficient deposition data almost can not be gotten, so we must solve the problem of lack of data. For this problem, Cao Zude, Kong Lingshuang, as the representative to carry out some research, recently Tianjin Harbour and Waterway Engineering Research Institute of Ministry of Communications also carried out the prediction research of suddenly sedimentation in different return period in preliminary design of Weifang Sendamei harbour breakwater. but because of lack of measured data, there are some limitations in formula establishment and parameter determining in the past research work, and failed to form a system to determine different suddenly sedimentation return period and the suddenly sedimentation in different return period. Now Huanghua Harbour as a typical silt-sandy coast port, in the process of the construction, a large number of data has been accumulated. The author has been engaged in the sediment research work of Huanghua harbour since 2001, has experienced the historical changes of the channel siltation after the treatment on Huanghua harbour, mastered a large number of data, and the author himself is the earliest partici-



pation in the research of channel siltation probability statistics, which creates conditions for the smooth development of the study.

### 1.3 Research objective

Study the statistical characteristics of Suddenly Siltation volume on silt-sandy coast and the determination of return period, establish the generalized model for calculation of Suddenly Siltation volume in silt-sandy coast outside waterway, form the initial statistical analysis system for prediction of Suddenly Siltation probability in silt-sandy coast outside waterway.

### 1.4 Research content

Study on statistical characteristics of sediment deposition is a new research topic, the concept of the suddenly siltation return period is brought forward recently by the port industry. However analysis of return period on a random amount, according to the existing statistical theory, must analyze the annual maximum amount of random analysis for many years firstly, establish the statistical frequency curve according to the general practice, the amount of random in a certain return period can be obtained. But analysis of the siltation return period, without a lot of sedimentation data, many ports might not have data, so the lack of data has become the biggest difficulty, to solve this problem, this paper starts from the measured data related to the natural conditions, through the theoretical analysis, establishes the relationship, so as to achieve the extension of the data, the main research contents are as follows:

1. Analysis of meteorological, hydrological, sediment and geomorphology of research area
2. Analysis of siltation of channel
3. Establishment of the relationship among wind, wave and sediment deposition

Closely rely on the measured siltation volume of silt-sandy harbour outer channel (channel of Huanghuaharbour), the relationship among wind causing siltation and wave energy, using long-term measured wind data of the area, search after the siltation corresponding to wind and wave for years. Therefore the research of the following two contents:

(1) Because strong siltation occurred in the process of high wind on the silt-sandy coast, from the dynamic conditions, first of all to analyze the relationship between wind energy and wave energy, establish the energy relation easy use of flat silt-sandy beach;

(2) On the basis of measured deposition data, the relationship between wind energy and sedimentation amount of experience on silt-sandy coast, and then can use (1) estab-



lished relationship, wind energy will be related to the corresponding siltation, this can use the data of wind to extend “historical period” of deposition data.

4. To establish the probability distribution curve of siltation of channel

Analysis of sediment deposition probabilistic statistical characteristics based on the third step, find out the probability distribution curve suitable to describe the distribution of Suddenly. In the given probability distribution, Siltation volume in corresponding return period can be gotten.



## Chapter 2 The conditions of research area and problem of sediment

This study will rely on the port engineering construction of Huanghua harbour and the renovation project of the outer channel, the following is a brief for the project.

### 2.1 Project situation

The Huanghua harbour in Hebei province is on the edge of the Bohai sea, about 90km east of Cangzhou city, east longitude  $117^{\circ}53'$ , north latitude  $38^{\circ}18'$ , at the junction of two provinces, Hebei and Shandong, north of the intersection of Zhang Wei New River and Xuanhui River, 60n mile away from the Tianjin Harbour, east about 149n mile away from Shandong Longkou harbour, and it is the second major channel to the sea China's for the coal transportation from West to East, railway Shuo (state) Huang (Hua) through the port. Position shown in figure 2.1.

Huanghua harbour construction began in 1997, the overall layout consists of two north-south breakwater surrounding port, the water area of  $6,600,000\text{m}^2$ ; the north embankment length of 5,782m, the full-length of South Bank of 5,030m, head of breakwater is in natural water depth  $-2.5\text{m}$  (hereinafter, the local theoretical datum), the crest elevation is  $+4.5\text{m}$ . The channel to  $35^{\circ}-215^{\circ}$  (hereinafter, the included angle to the North), straight, vertical fathom line.

In January, 2002 the first phase of the project was completed: 2 special berths for 50,000 tons and 1 special berth for 35,000 tons for coal exports, quay depth of  $-13.7\text{m}$ , channel width of 140m, channel depth of  $-11.5\text{m}$ .

In 2003 as the effects of the channel siltation the line was forced to be changed, 3km from the waterways to the east of  $4.5^{\circ}$ , channel deflection, the basic scale (width, depth) was invariant.

In October 2004 Project 2 was completed: to build 2 berths of level 50,000 tons and 1 berth of 100,000 tons for coal exports, quay depth of  $-14.7\text{m}$ , the channel width invariant, channel depth of  $-12.3\text{m}$ . But because of the strong wind deposition, before December 2005, the depth of channel has not reached the design standards.

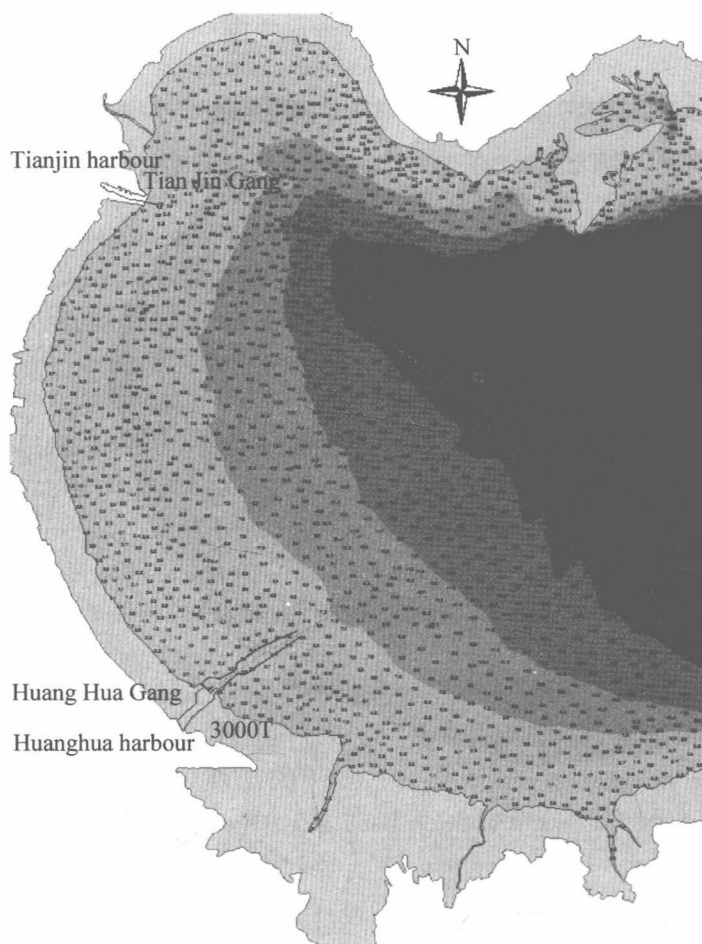


Fig. 2.1 Schematic diagram of Huanghua harbour location

In May 2004 renovation project construction in outer channel of Huanghua harbour began, two sand block breakwater, south and north, was built, breakwater head at  $-6.0\text{m}$  depth, the cover channel length of  $10.5\text{km}$ . In September 2005 renovation project completed. In 2006 the channel was expanded to  $170\text{m}$ , the depth of dredging to  $-13.0\text{m}$ , at present, channel situation is stable.

## 2.2 Sedimentation

At the beginning of construction of Huanghua harbour, sediment deposition problem followed the formation, according to the Huanghua harbour renovation construction division, the