CHAPTER 130

LITTORAL DRIFT OF SAND NEAR PORT OF OARAI

by

Kazumasa Mizumura

ABSTRACT

To study the main direction of littoral drift of sand near the Port of Oarai, field observations were made. Through the analyses of the results the following facts were obtained.

(1) The relative changes of foreshore gradients alongshore were correlated with the characteristics of beaches.

(2) By investigating sand grain sizes on the coast the predominant direction of littoral drift of sand could be illustrated.

(3) The direction of littoral drift of sand was almost coincident with the main nearshore currents.

INTRODUCTION

Problems on coastal changes are important and have attracted many engineers. The most reliable work for the shore protection before the construction of ports and harbors is considered to be field observations. Stillmore, the success of hydraulic model tests is also dependent on the data analysis of field observation. To investigate the plan of extension at the Port of Oarai in regard to coastal changes, field observations were done before the start of the plan. Herein, the characteristics of the coast near the Port of Oarai are studied using the results of field observations. Therefore, beach profiles, littoral materials and nearshore currents were measured in July of 1977.

Since the predominant direction of littoral drift of sand was determined, the groin of 400m in length had been constructed in September of 1977.

Associate Professor, Dept. of Civil Engineering, Kanazawa Institute of Technology, Kanazawa, Japan GENERAL

The Port of Oarai is lacated north of Tokyo, Japan and faced to the Pacific Ocean as illustrated in Fig.1. In the south of the port there is a sandy Kashimanada Coast which has an arcuate form and almost 70 km in length. To the east of the port there exist Oarai Headland and Oarai Coast. Contours along the Kashimanada Coast and the Oarai Coast are almost linear and parallel to the shoreline except near Oarai Headland as shown in Fig.1. Because there exist marine ridges in the offshore of Oarai Headland. Therefore, the incident wave energy converges to the headland and shows the shoreline of erosion. In the west of the Port of Oarai some breakwaters remain as represented in Fig.1. This was the old Port of Isohama and tried to construct about 60 years ago. But this was stopped during the construction of breakwaters because of the deposition of much sand. At the present, the sandy beach forms a good bathing place in summer. The arm of the south breakwater is expanded to the south and it causes erosion problems along the segment of the opposite coast to the breakwater. It can be observed that the position of erosions moves down to the south as the south breakwater expands.

WIND AND WAVES

Wind directions and velocities were measured at the position which is located 4.5 km in SE direction of the Port 1973 to 1975. The wind directions from ENE to N are predominant and occupy almost 40 % of the total. Wave conditions offshore were measured at the south point of 9 km from the port. ENE direction is predominant and reaches more than 50 % of the total as shown in Fig.2. The percentage of the periods from 9.0 sec to 13.0 sec attains almost 58 % of all available data as illustrated in Fig.3. Especially, 11 sec and 12 sec are predominant and about 14 %. The percentage of wave height more than 3.0 m is almost 4 % and less than 1.5 m amounts to 75 % as given in Fig.4. It can be seen that the coming wave height is low and seasonal changes are not found.

FORESHORES AND BEACH PROFILES

To study the characteristics of beaches near the port, beach profiles, specially foreshores were surveyed at 8 points as numbered in

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Fig. 1. - Study Area and Port of Oarai



Fig. 2. - Distribution of Wave Directions



Fig. 3. - Distribution of Wave Periods



Fig. 4. - Distribution of Wave Heights

Fig.5. These points correspond to the sampling points of bed materials on the beaches. The beaches in the sheltered zone by the south breakwater are very wide and sand grains are fine there. The slopes are milder than 1/100. The zone between the sheltered zone by the south breakwater and the zone which is not influenced by coastal structures is for simplicity defined as the intermediate zone in this study. The shore in the intermediate zone recedes to the seawall partly and shows the shore of erosion by the existence of the system of small offshore breakwaters and groins for shore protection. The slopes are steeper than 1/30. The southward beaches which are far from the south breakwater have no influence from any coastal structures and are called open beaches. The slopes are about 1/60. The shape of beach profiles on each point are represented in Fig.6.

LITTORAL MATERIALS

Sand was sampled by dredges at 48 points as illustrated in Fig.5 and its physical properties such as specific gravities and size distributions were investigated. The specific gravities are almost constant and equal to 2.65. Fig. 7 represents the relationship between sea bottom slopes and mean diameters of sand grains. This means that very fine sand exists on sea bed with milder slope and vice-versa. The grain diameters in breaking zones are large due to the wave sorting effect. Moreover, Fig. 8 shows "curves of equi-mean diameter" based on the sampled data at 48 points. On the southward beach which does not have any influence from coastal structures, the curves are almost parallel to each other and the shoreline. In the intermediate zone the intervals of the curves become narrow and the curves approach to the shoreline. If imaginary curves were drawn from the south to the north until near the port in parallel condition to the shoreline, it can be understood that the curves in this zone shift more landwards than they are drawn in the south. This suggests that the shifting is caused by sand movement and the predominant direction of littoral drift of sand is landward. In the sheltered zone by the south breakwater the pattern of the curves changes. That is, the curves are not parallel to the shoreline, but almost perpendicular to that. By considering the imaginary curves of the equi-mean diameters previously discussed, the real

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- Sampling Points of Bed Materials
- ⊕ Throwing Points of Fluorescent Sand

Fig. 5. - Map of Field Observations



Fig. 6. - Beach Profiles



Fig. 7. - Relationship between Mean Diameters of Sand Grains and Bottom Slopes



Fig. 8. - Curves of Equi-Mean Diameters

curves drawn in the figure can be recognized to shift seawards. This shows that the shifting is caused by sand movement and the predominant direction of littoral drift of sand is seaward in this zone. The combination of the above two directions of littoral drift of sand gives the direction of that between the two zones. Namely, the transported sand from the offshore in the intermediate zone moves alongshore and deposited in the sheltered zone. The one part of the transported sand moves seawards and deposits in the port. The other part moves alongshore, reaches near the old Port of Isohama and deposits there.

NEARSHORE CURRENTS

The nearshore currents in the breaking zones of 17 points as illustrated in Fig.5 were measured by floats when the wave direction and the wave height were E or ENE and 0.5 m to 0.8 m, respectively. The measured average velocities of nearshore currents are represented in Fig.9. Simple modeling of the measured flow pattern shows the existence of a circulatory current in the lee of the south breakwater. The cause of the circulatory current is explained as follows. The incident waves from the predominant direction ENE are diffracted by the south breakwater and this produces the difference of breaking wave heights along the shore. Moreover, this generates the difference of the mean water level along the shore by the radiation stresses. Therefore, the regular and stationary circular current is induced alongshore from high to low water levels. In the intermediate zone the component of the circulatory current flows landwards and erodes the shore. In the sheltered zone, the component of the circulatory current forms the longshore current and it transports sand alongshore into the port. This fact is also proven by the movement of fluorescent sands as illustrated in Fig.10a and b. The throwing points of the fluorescent sands are located on the beach in the sheltered zone as shown in Fig.5. All sands move definitely alongshore to the port. COMPARISONS OF PAST SURVEYS AND AERIAL PHOTOS

The comparisons of each contour between June of 1977 and December of 1973 are represented in Fig.ll. Solid lines and dotted lines show the contours in June of 1977 and December of 1973, respectively.

Therefore, erosion area is illustrated by the zone of hatching and

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Fig.10a. - Movement of Tracers



Fig.10b. - Movement of Tracers







Fig.12. - Aerial Photo in Dec. of 1969



Fig.13. - Aerial Photo in Jan. of 1975

accretion area is shown dotted in the same figure. As previously discussed severe erosion occures in the intermediate zone, the eroded sand is transported near the old Port of Isohama and forms accretion area.

The maximum advance of the shoreline in the accretion area is almost 120 m in 3.5 natural years. Moreover, aerial photos in December of 1969 and in January of 1975 are shown in Fig.12 and Fig.13, respectively. The comparison illustrates the remarkable accretion phenomena near the old Port of Isohama. Namely, in December of 1969 the shoreline had touched the old breakwaters, but in January of 1975 the shoreline moved more seawards and much sand accumulated around the old breakwaters.

SUMMARY AND CONCLUSIONS

The following conclusions are made for characteristics of the coast near the Port of Oarai under the field observations used in this study. (1) The foreshore gradient on the eroded beach is steep and that on the accreted beach is mild, relatively.

(2) The sizes of sand grains are correlated with the sea bottom slopes.(3) The curves of equi-mean diameter obtained by size distributions of sand grains can indicate the predominant direction of littoral drift of sand.

(4) There exists the circulatory current in the lee of the south breakwater and the direction of this current is coincident with that of littoral drift of sand.