

CHAPTER 96

Experimental study on on-offshore sediment transport of Accretive Beach

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1. INTRODUCTION

In treating coastal processes, sediment transport is usually divided into along-shore and on-offshore components. It is believed that the on-offshore component has a prominent connection with short-term profile changes, observed during storm wave climates. Obviously its shift of sand plays a very vital role in shoreline migration. In other words, the beach profile has great bearing on coastal phenomena related to on-offshore sediment transport. As we know, there have been many studies on this kind of sediment transport rate, and considerable amount of knowledge on this problem has been accumulated so far. Yet it seems that we are still far from a reliable formula to estimate the beach profile changes. The reason why is due to the complexity of mechanics of sediment transport. Therefore, the aim of this study is to examine experimentally the mechanism between on-offshore sediment transport and the deformation processes of two-dimensional beach profile. Then, a predictive model of the temporal and spatial distribution of net on-offshore sediment transport based on two-dimensional beach profiles and an equation of continuity of sediment transport is proposed. Various parameters of net on-offshore sediment transport in this model are discussed also.

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2. THE CONTINUITY EQUATION OF SEDIMENT TRANSPORT

The evaluation of net sediment transport in this study was on the the basis of continuity equation of sediment transport, assume the transport mode of sediment was just bed-load and there is no suspended sediment occurred. Therefore a coarser sand of 0.57^{mm} ϕ was used as a bed material in order to satisfy this theoretical consideration. Usually, sediment transport rate was measured directly by a sand trap during the last few decades. But due to such apparatus would cause severe disturbance to the fluid motion and the sediment movement. Instead the net rates of sediment transport were estimated by the continuity equation from the beach deformation data comparing with the initial profile. Attempt to find temporal and spatial the relationship between the net transport rate and wave condition were then made. Suppose a beach profile changes as given in Figure 1. By virtue of the conservation of bed material amount, the local net transport rate $q(x,t)$ per unit width is related to the bed elevation $h(x,t)$ measured from a certain datum as :

$$\frac{\partial h}{\partial t} = \frac{1}{1-\epsilon} \frac{\partial q}{\partial x} \dots\dots\dots(1)$$

in which ϵ is the sediment porosity. Therefore the effective net transport rate $Q(x)$ averaged over a time duration Δt of wave action is evaluated from the bed elevation change $\Delta h(x)$ by

$$Q = \frac{\bar{q}}{1-\epsilon} = \int_{X_R}^{X'} \frac{\Delta h}{\Delta t} X' \dots\dots(2)$$

where X' is positively seaward and X_R means shoreward limit of beach deformation. Parameter definition is shown as Figure 2.

3. EXPERIMENTAL PROCEDURES

Experiments were carried out in a two-dimensional wave tank, 1 m wide, 1 m deep, 80 m long with a glass wall on one side of 30 m length at the end of tank. Figure 3 shows the general arrangement of the test equipment.

The experiments were performed using monochromatic waves generated by a flap-type wave maker installed at another end of the tank.

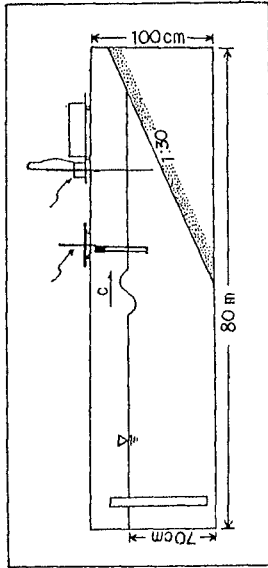


Fig. 3 General arrangement of test equipment

Table-1 Experimental Conditions

| | T (sec) | i H ₁ (cm) | H _s /L _s |
|----|---------|-----------------------|--------------------------------|
| A1 | 1.2 | 8.4 | 0.039 |
| A2 | 1.2 | 6.7 | 0.031 |
| A3 | 1.2 | 5.1 | 0.024 |
| B1 | 1.5 | 12.4 | 0.038 |
| B2 | 1.5 | 8.3 | 0.026 |
| B3 | 1.5 | 6.1 | 0.019 |
| C1 | 2.0 | 12.1 | 0.021 |
| C2 | 2.0 | 8.4 | 0.015 |
| C3 | 2.0 | 6.3 | 0.011 |

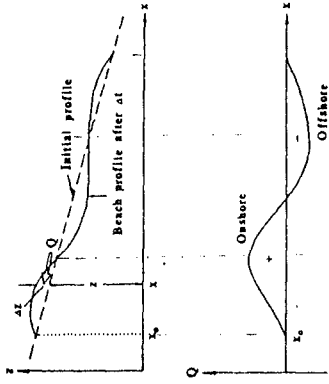


Fig. 1 Evaluation of net sediment transport rate

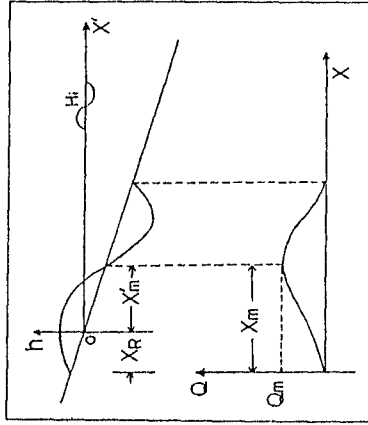


Fig. 2 Coordinate system and notation

The incident wave height was measured by a capacitance type wave gage placed just offshore from the toe of the model beach. In order to make simply the experiments, tests were limited to a uniform initial beach profile of 1/30 and one coarse sand of 0.57^{mm} ϕ was used as a bed material mentioned above. Beach profile changes were measured by an electronic profile sensor to record the continuous profile data for every two hours within the testing duration of 18 ~ 20 hrs totally. Then, the temporal and spatial net rate of on-offshore sediment transport was evaluated from the beach profile changes.

Table 1 is a list of experimental cases. Various kinds of wave conditions were investigated for this test. Both the breaker height and local wave heights were also measured by a capacitance type wave gage mounted on a carriage capable of moving with constant speed along the centerline of the tank at the locations of 50 cm interval along the model beach in the middle of wave action. The horizontal distance from a base line on the model beach to the breaking position and the limited shoreward position of run-up were measured by ruler attached on grass wall.

4. EXPERIMENTAL RESULTS & DISCUSSION

Figure 4 (a)~(i) show the beach profiles at the end of wave action for all the cases listed in Table 1. It should be noted that profile changes are belong to the accretive type i.e. a shoreline progresses and no sand deposition takes place offshore. (Sunamura and Horikawa, 1974). The locations of breaking points are indicated by arrow symbols; dot line arrows for the initial stage and solid line arrows for the final stage. Experimental results indicate that the locations of breaking point progress shoreward as the accumulated time of wave increased, i.e. the breaker zone become narrowed gradually as shown in Fig 5 (a) ~ (h) and its breaker type changed gradually also from spilling one to plunging breaker. Results also indicate that the maximum sediment transport rate take place arround the breaking point. Figure 6 (a) ~ (b) show some examples of the spatial and temporal distribution of the effective non-dimensional net transport rate Q/Q_m evaluated from beach profiles mentioned above. It's seen that the

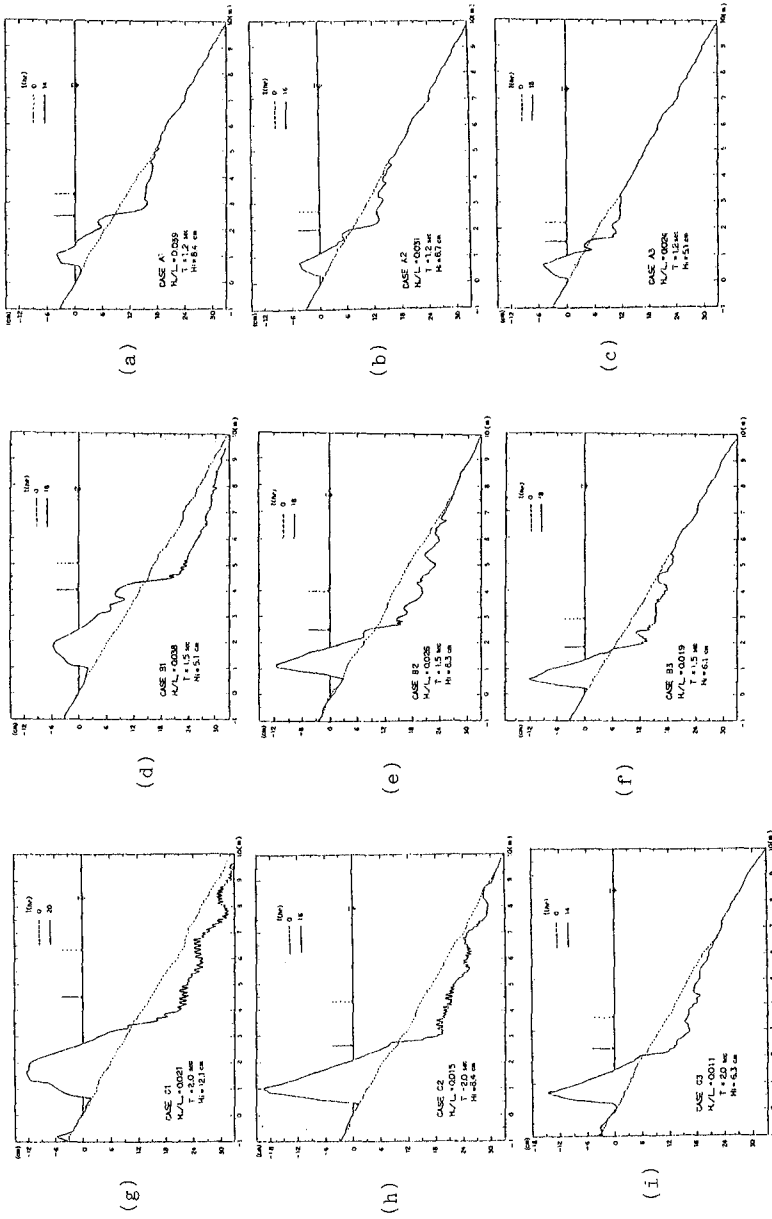


Fig.4 Beach profile after wave action

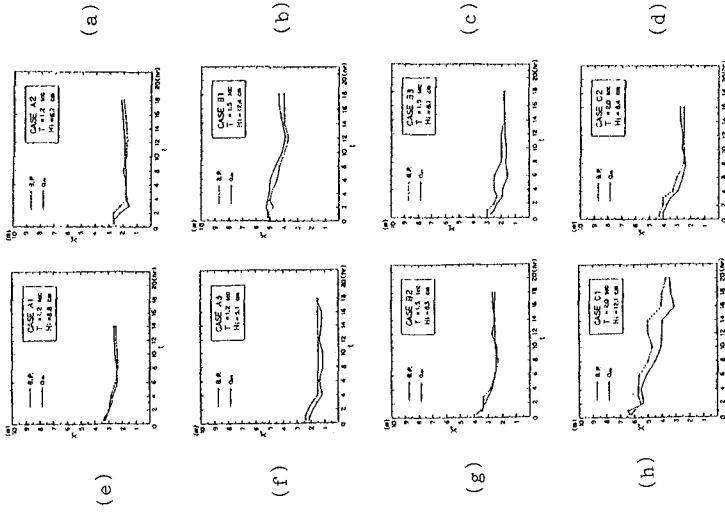


Fig.5 Spatial and temporal relationship between B.P. and Q_m

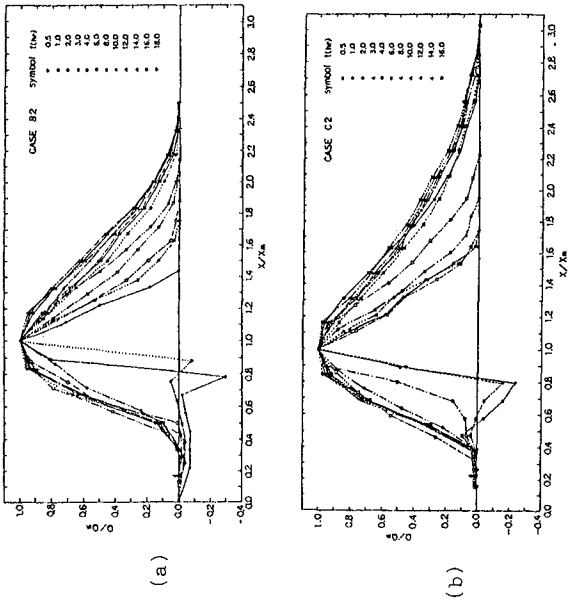


Fig.6 Spatial and temporal distribution of Q/Q_m

dimensionless distribution curves of sediment transport rate tend to steady after $t/T = 1.44 \times 10^4$, in which t is accumulated time of wave action and T is the incident wave period. Based on these data of each case an optimum curve was obtained to represent its characteristics as shown in Figure 7 (a)~(c). Then, a dimensionless sediment transport rate shown as Figure 8 for accretive beach were analyzed and relationship of parameters were shown also as figures 9~13. These experimental formuluses were established as follows:

$$Q/Q_m = AM\bar{X}^{M-1} e^{-A\bar{X}} \quad ; \bar{X} > 1 \dots\dots\dots(3)$$

$$Q/Q_m = C_6 \bar{X}^6 + C_5 \bar{X}^5 + C_4 \bar{X}^4 + C_3 \bar{X}^3 + C_2 \bar{X}^2 + C_1 \bar{X} + C_0 \quad ; \bar{X} < 1$$

and

$$C_6 = 32.31, C_5 = -87.96, C_4 = 79.23, C_3 = -25.38$$

$$C_2 = 2.81, C_1 = 0.01, C_0 = 0.00$$

$$A = 15.16 (H_o/L_o) + 0.89 \dots\dots\dots(4)$$

$$M = 13.55 (H_o/L_o) + 2.52$$

in which

$$\bar{X} = X/X_m$$

$$Q_m/Q_o = 478.6 (t/T)^{-0.64} ; t/T \geq 1.44 \times 10^4 \dots\dots\dots(5)$$

$$Q_o/W_{odso} = 0.16 Ns^{1.51} \dots\dots\dots(6)$$

$$Ns = H/T / \sqrt{(s-1)gdso} \dots\dots\dots(7)$$

$$X_m/H_o = 141.3 (t/T)^{-0.16} ; t/T \geq 1.44 \times 10^4 \dots\dots\dots(8)$$

$$x_R/H_o = 0.771 (H_o/L_o)^{-0.537} \dots\dots\dots(9)$$

Where

Q, Q_m = local and maximum accumulated sediment transport rate

X, X_m = corresponding position of local maximum accumulated

sediment transport rate

C_n = constant

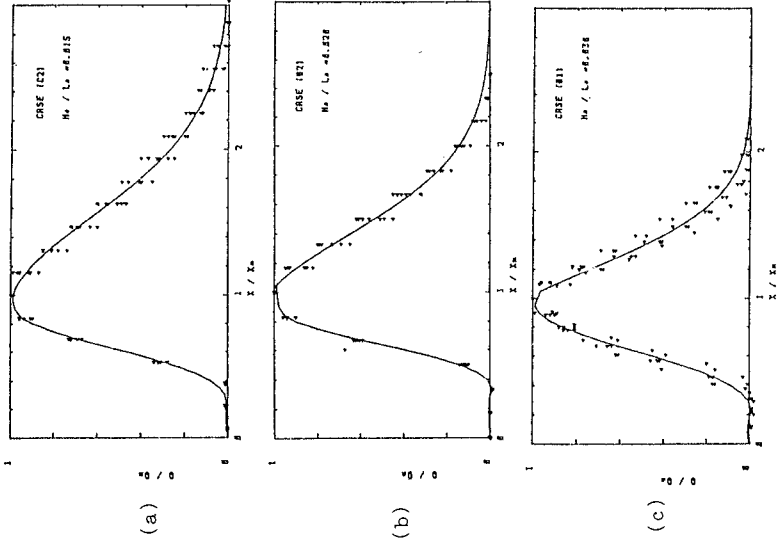


Fig. 7 Optimum curve between Q/Q_m and X/X_m

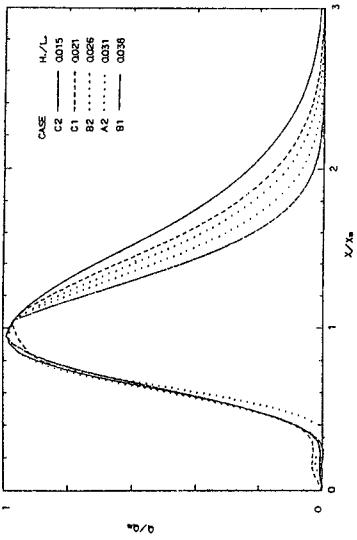


Fig. 8 Spatial distribution of non-dimensional Q/Q_m

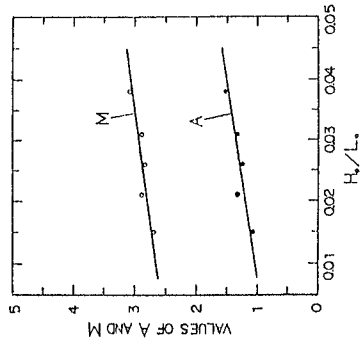


Fig. 9 Relationship between H_0/L_0 and A, M

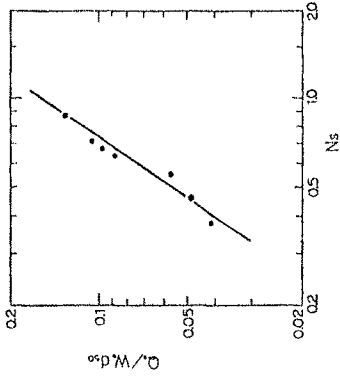


Fig.12 Relationship between $Q_o/W_o d_{50}$ and N_s

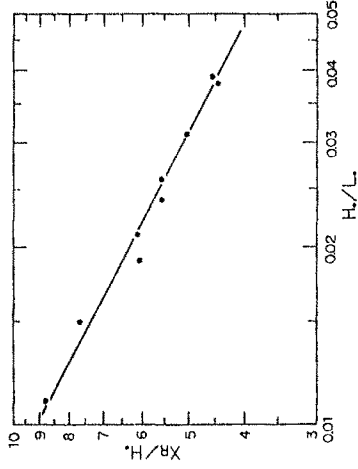


Fig.13 Relationship between X_r/H_o and H_o/L_o

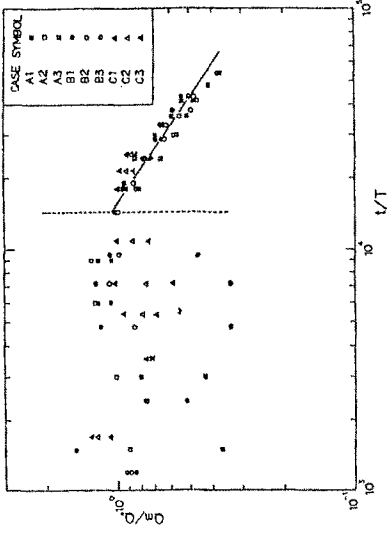


Fig.10 Relationship between Q_m/Q_o and t/T

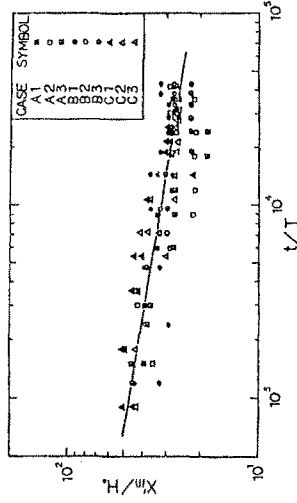


Fig.11 Relationship between X_{fm}/H_o and t/T

N_s = dimensionless parameter

5. APPLICATION OF THE NUMERICAL MODEL

Based on These experimental formuluses mentioned above, then, a numerical model of two-dimensional accretive beach profile changes is presented. Figure 14 (a)~(c) are the examples of the comparison between this predictive numerical model and experimental results; solid line represents the numerical computational values and dot line represents the experimental results after 20 hours of wave action. Results indicate that the numerical model could be used to describe adequately on-offshore beach profile changes for the accretive beach.

6. CONCLUSIONS

The main conclusions of this study are summarized as follows:

(1) Experimental results indicate that final beach profile changes after 14 ~ 20 hrs wave action respectively for all the cases are belong to the accretive type, i.e. a shoreline will progresses seaward and no sand deposition takes place offshore and predominant mode of sediment transport is the bed-load.

(2) When the time of wave action was increased, the breaker zone width will become narrower and narrower and its breaker type will change gradually also from spilling one to plunging breaker.

(3) Results indicate that the position of maximum sediment transport rate will take place around the breaking point.

(4) On-offshore sediment transport rate is the function of N_s and t/T , and could be expressed as equation (3) to equation (9). When the accumulated time of wave action are greater than $t/T = 1.44 \times 10^4$, its normalized non-dimensional spatial distribution of sediment transport rate could tend to be steady.

(5) Based on the experimental results, a predictive numerical model is presented and shown that this model could be used to describe adequately the on-offshore beach profile changes for accretive beach.

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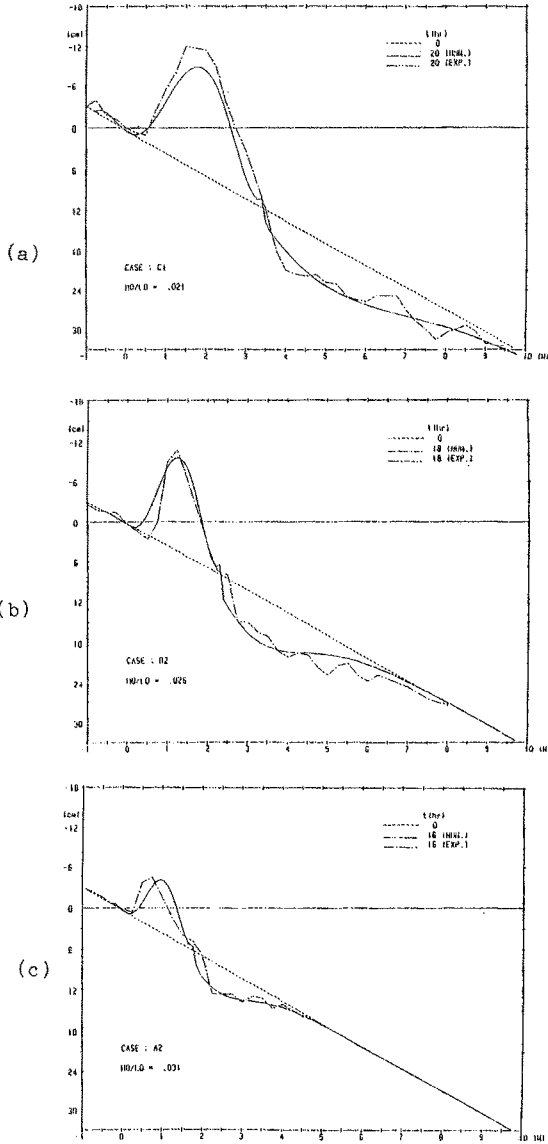


Fig.14 Comparison between numerical model and experimental results

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