CHAPTER 186

An experimental study on beach transformation due to waves under the operation of coastal drain system

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ABSTRACT

The performance of a coastal drain system was investigated experimentally. When the drain pipe was buried in the seaward area of a shoreline, the system was most effective. When the discharge is large, the drain system could accumulate a large amount of sediments on a beach face even under erosive wave conditions without drainage. The flow toward shore induced by drainage seemed to play an important role.

INTRODUCTION

The coastal drain system has been publicized to be a new effective soft approach to coastal erosion control and beach restoration that has no impact on human activity and the environment (Parks,1989; Vesterby,1991). However, there seemed to have been negative view on the performance of it e.g. Bruun(1989). Moreover, this system does not seem to have enough physical basis which enables us to design optimum system.

The purpose of this study is to investigate experimentally the function, performance and optimum location to install of a coastal drain system.

The results showed that this system has a potential ability to accumulate a large amount of sediments on a beach even under storm wave conditions and it protects the landward area of the drain pipe at the worst.

The reason the system work has been explained by relating effects of drain to the net sediments carried due to runup-down wash processes of waves on a beachface. Our experimental results showed, however, that the flow toward the shore generated by drain in surf zone carried suspended sediment and migrated a bar toward the beachface and seemed to play the most important role.

EXPERIMENTS

A series of experiments was carried out using a wave basin of 26.7m long, 14m wide and 1.2m deep (Figure 1) to take a survey of the performance of coastal drain system by comparing the beach profile of drained part with the one of part where

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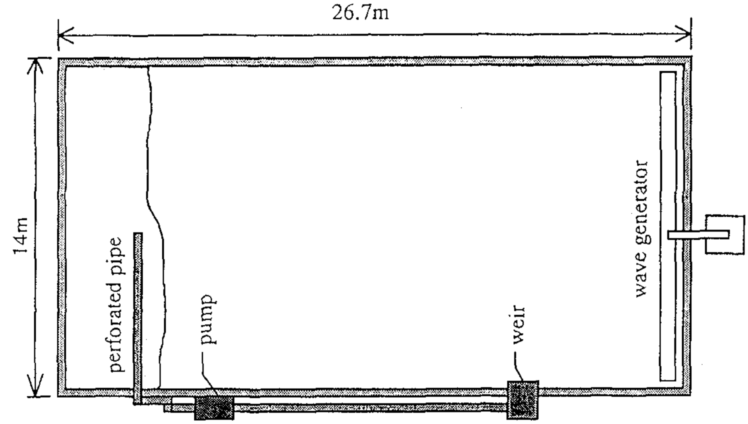

Figure 1. Experimental Setup

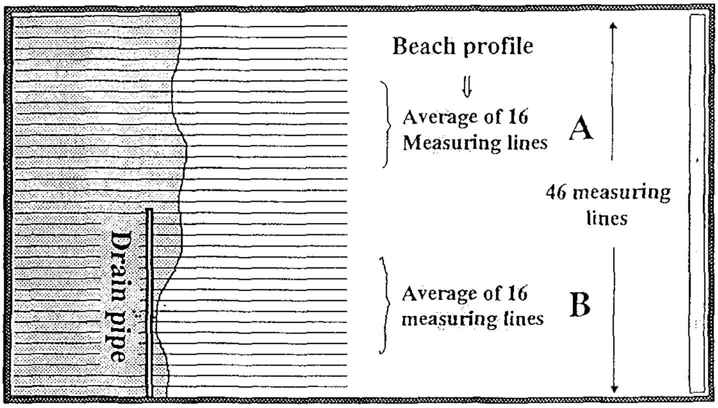

Figure 2. Measuring lines

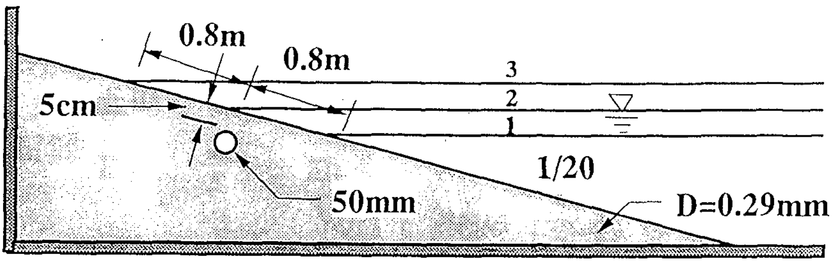

Figure 3. Cross section of the beach.

the system was not installed. The beach profile of each side was obtained as the mean profile of 16 measuring lines perpendicular to the initial shoreline(Figure 2).

A drain pipe of 7m long was installed under the beachface of the left half of the beach parallel to the shoreline. The diameter of the pipe was 50mm. Filter sheet of 10mm thickness was bound round the pipe. Then, the pipe was buried under the beach face of 1/20 slope. The initial covering was 50mm (Figure 3).

The dependence of the performance on location of the system was investigated to find optimum location to install by changing the relative location of the drain pipe from landward to seaward of the shoreline. Water depth was changed to change the relative location of the system from the shoreline instead of changing the location of the system itself.

The experimental conditions are shown in Table 1. According to the classified laboratory beach profiles by Sunamura and Horikawa, runs 2,3 and 6 are expected to produce erosive beach profiles of Type I and runs 4 and 5 were expected to produce accretive profiles of Type III(Figure 4).

Table 1 Experimental conditions

Run No.	Wave Period	Wave Height	C	Type	Location
1	2.0sec	10cm	7.3	II	1
2	1.0	10	11.6	I	1
3	1.0	10	11.6	I	2
4	2.0	5	3.7	III	2
5	2.0	5	3.7	III	3
6	1.0	10	11.6	I	3

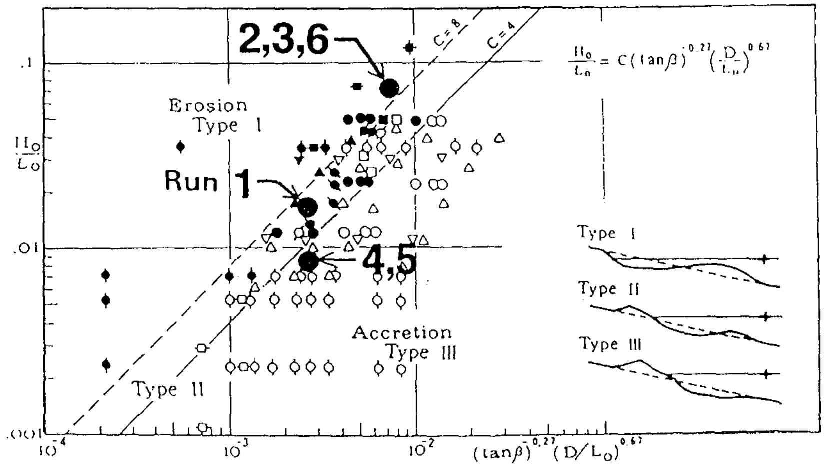

Figure 4. Classified laboratory beach profiles(Sunamura and Horikawa,1974)

The pump used was 2.2kw and the discharge was 0.33l/sec/m when the covering was 50mm. This discharge was equivalent to about 4 percent of flux that balances with the mass transport of the wave, $E/\rho C$ (E: wave energy density; ρ: density; C: wave celerity). The velocity of water infiltrated into the bottom was about 2 percent of the settling velocity of the bottom sediments (d_{50}=0.29mm).

As the discharge of the drain system for the experiments mentioned above was relatively small and invariable, we used a small wave flume of 13m long, 0.4m wide and 0.4m deep to investigate the dependence of the performance of a coastal drain system on discharge(Figure 5). Discharge of the drain system installed in the flume was variable by changing the engine speed and larger(maximum discharge was 1.6 l/sec/m).

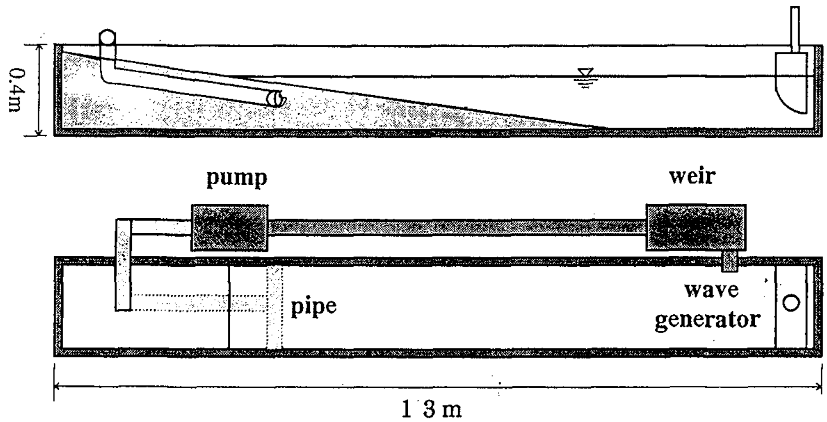

Figure 5 Experimental set-up

RESULTS AND DISCUSSION

Figure 6 is one of the experimental results under accretive wave conditions. The ordinate ,Δd, is the net change of the bottom level from the initial beach profile (Figure 7). Black circles in the figure denote the relative location of drain pipe from the shoreline(left vertical dashed line; another vertical dashed line indicates the wave breaking point). The profiles of upper part of the beach face could not be obtained by the surveys after 18 and 24 hours wave action because the berms of drained side developed too high to measure using our profiler. These results showed that the drain system enhanced accretion.

Figure 8 is one of the results under erosive wave conditions. The profiles of drained side after 18,24 and 36 hours wave action show accretion on beach face in spite of the erosion in the rest side. This accretion ceased and turned into erosion as the erosion in the inshore region proceeded. However, the drainage reduced the erosion. Figure 9 shows the difference of shoreline change with time between the drained

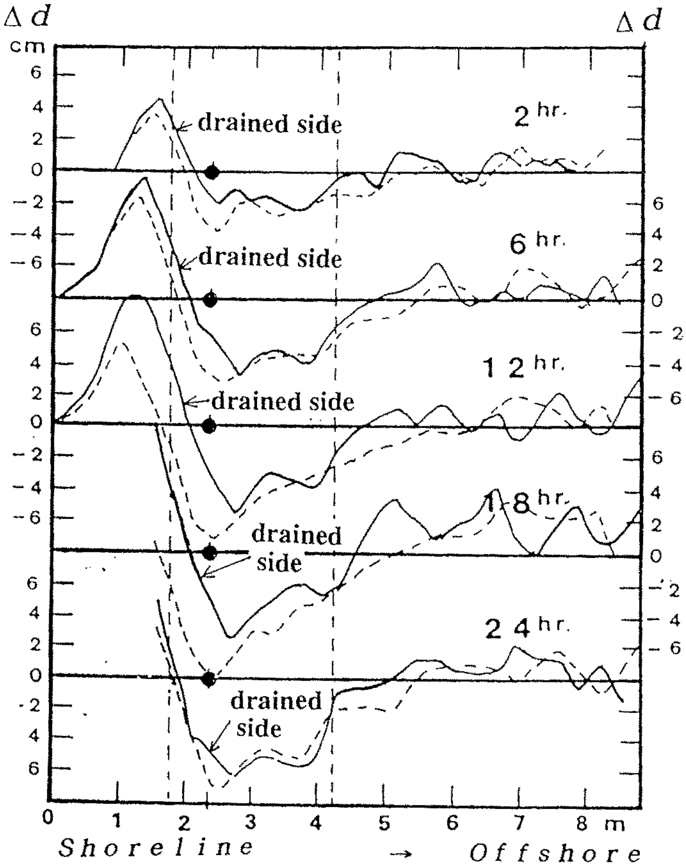

Figure 6 Result under accretive wave condition

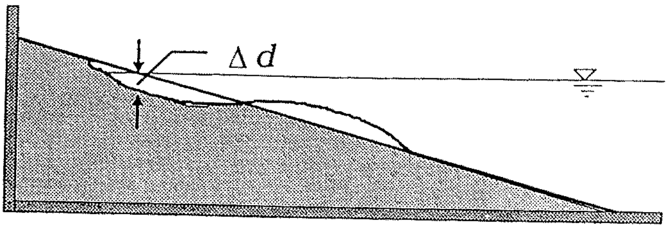

Figure 7 Difinition of Δd

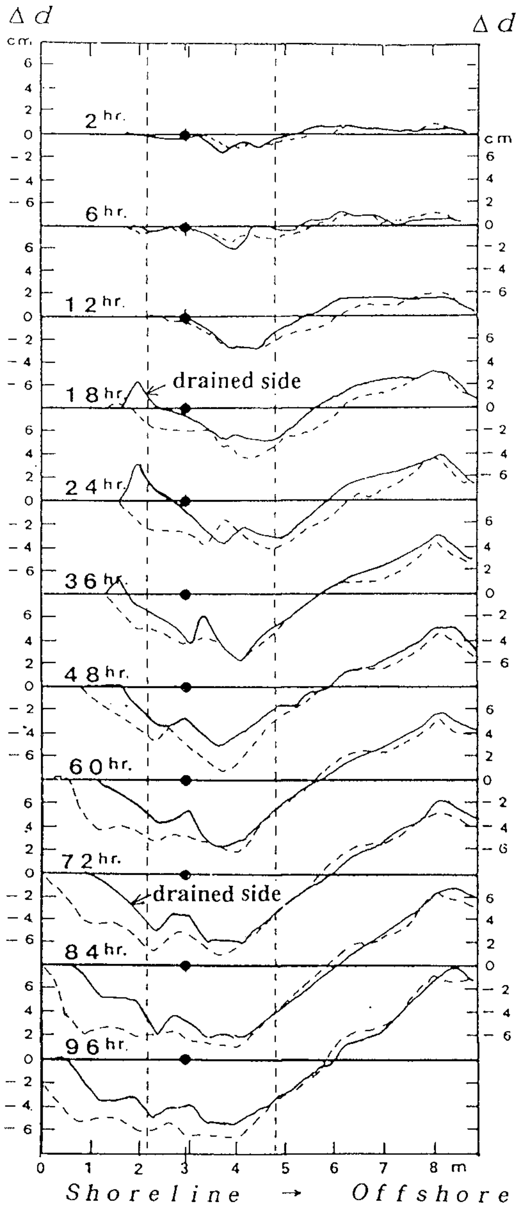

Figure 8 Result under erosive wave condition

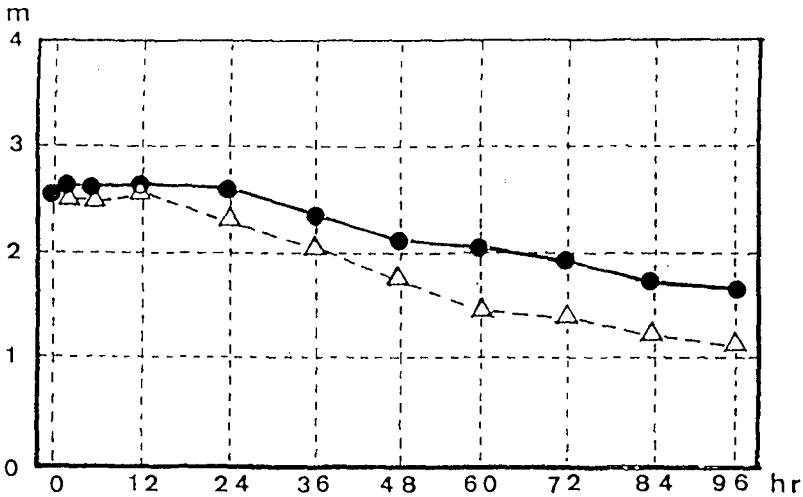

Figure 9 Changes of shoreline

side(full line) and the rest(dashed line). The ordinate is the distance of shoreline from a reference point on the back shore. This figure shows the retrogression speed of the became smaller by drainage.

These experimental results confirmed that a coastal drain system advances accretion of sediments on the beach face under accretive wave conditions and retards beach erosion under erosive wave conditions even if the discharge is not so large.

Effect of location of the drain pipe

Next, we consider the dependence of performance of a coastal drain system on the location of the drain pipe.

Figure 10 shows the comparisons of beach changes between drained side and the rest due to twelve hours accretive wave action. The best results were obtained when the drain pipe was installed in the seaward of the shoreline.

Figure 11 is a result of twelve hours erosive wave action. In this figure, there was no discernible difference between the two beach profiles. However, the difference became discernible after twenty-four hours wave action(Figure 12). This result also shows that seaward of a shoreline is the best to install. As we quitted the experiment for the case of landward installation after eighteen hours elapsed, results of two locations were depicted in Figure 12. Examination of the result after eighteen hours wave action did not affect the above conclusion.

When the system was installed at a shoreline or somewhere landward of beach face, we were impressed to see visually the infiltration of runup waves into the beach and sheet-like sediments left and piled up on a berm for accretive wave conditions. For erosive wave conditions, however, the erosion of inshore zone was retarded most for the cases of seaward installation.

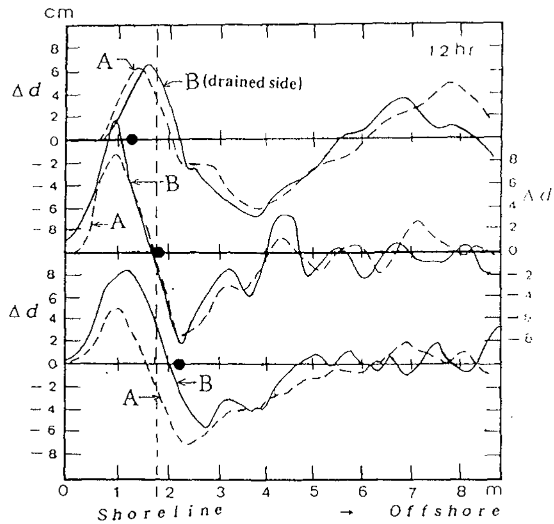

Figure 10 Comparison of beach change among three locations of drain pipe after 12 hours accretive wave action

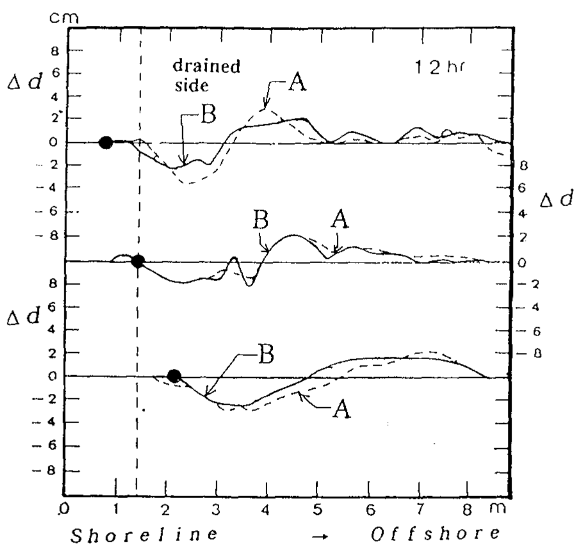

Figure 11 Comparison of beach change among three locations of drain pipe after 12 hours wave action

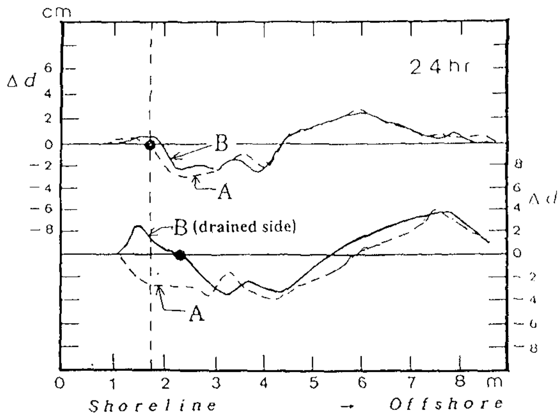

Figure 12 Comparison of beach change among two locations of drain pipe after 24 hours wave action

Effect of discharge

As the discharge of the drain system for the experiments mentioned so far could not be changed, we used a small wave flume to investigate the dependence of the performance on discharge. Discharge of the drain system installed in the flume was controllable by changing the engine speed and the maximum discharge was 1.6l/sec/m. As the discharge increases, the system becomes effective even for storm wave conditions. Figure 13 is an example of such cases. Figure 13 (a) shows the change of beach profile when the drain system was not operated. Just seaside part from the shoreline and offshore part were eroded and sediments from both parts formed a bar. When the discharge was 0.4 l/sec/m, there was no erosion of the part just seaside of the shoreline(b). For the case of 0.7 l/sec/m discharge, accretion of sediments in the inshore area resulted on a large scale after two hours' wave action. Observations of the sediment motion showed that a large amount of suspended sediments of the offshore zone moved toward the shore and a bar which was formed at the same location as the cases (a) and (b) in early stage grew and migrated to the shore with time.

The function of a coastal drain system has been regarded as the reduction of sediments which are carried away by backwash than are brought to the beach face by uprush. It is because drainage lowers the water table and intensifies downward percolation of wave runup which lessens water runs down than runs up.

However, our results revealed the idea that, when a shoreward flow induced by the drain system overcame the wave induced flow component to offshore like undertows, the system became effective even under erosive wave conditions without the coastal drain system. In any case, the shoreward flow seemed to play an important part when a drain pipe is buried in seaside area of a shoreline.

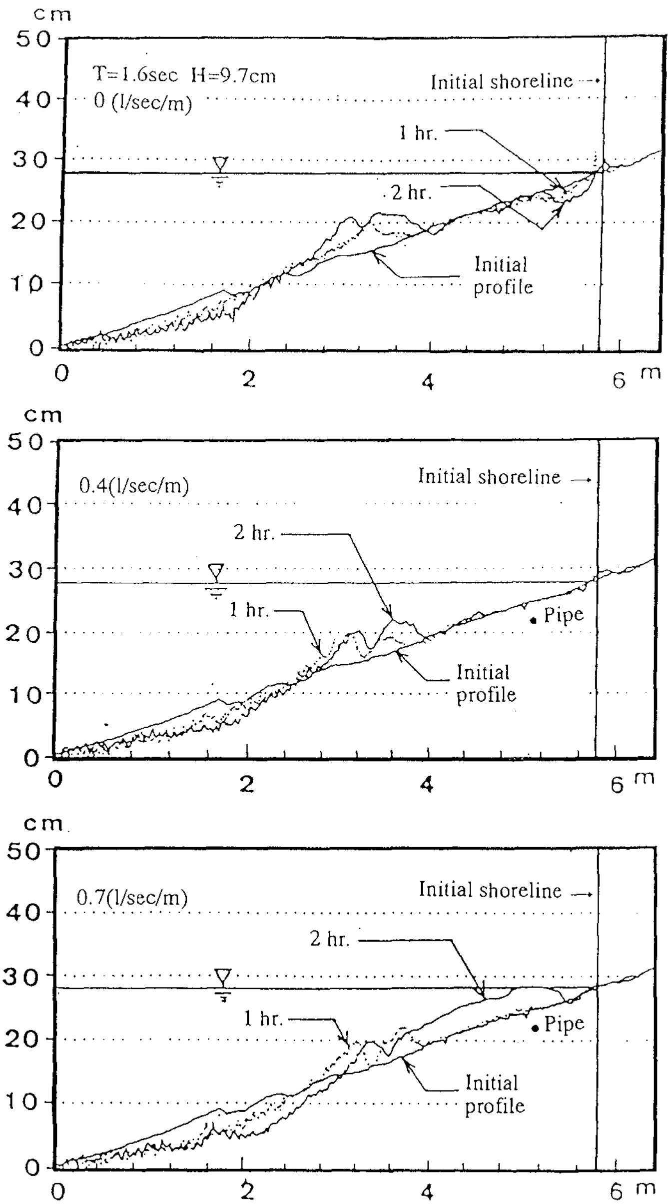

Figure 13 Changes of beach profile with discharge

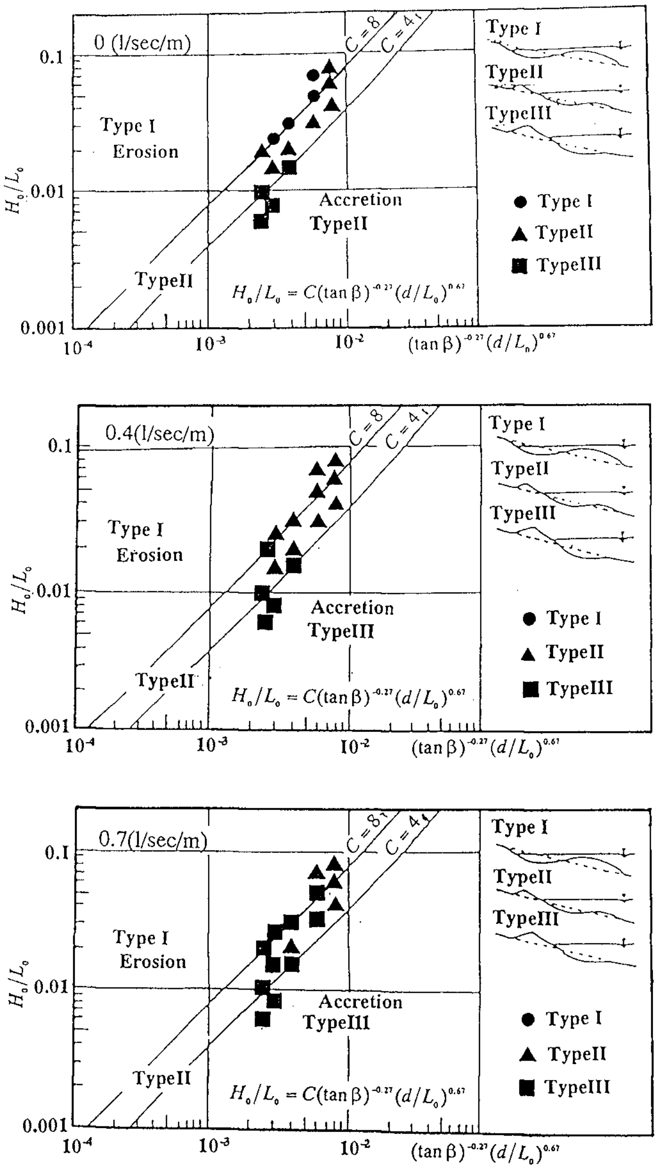

Figure 14 Change of beach type with discharge

Figure 14 shows the change of classified beach profiles with discharge. We can see that some of Type I profiles changed into Type III as the discharge increased. This shows that the coastal drain system has a potential ability to coastal erosion control.

CONCLUSION

The performance , function and optimum location to install of a coastal drain system was investigated experimentally.

From the experimental results, it was confirmed that a coastal drain system advances accretion of sediments on the beachface for accretive wave conditions and retards beach erosion for erosive wave conditions.

Comparisons of the performance among three installation locations showed that seaward area of a shoreline was most appropriate for the installation.

As the discharge increases, the system becomes effective even for storm wave conditions.

The flow toward shore induced by drainage in the surf zone carried suspended sediments and migrated a bar toward the beach face and seemed to play the most important role.

ACKNOWLEDGMENTS

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