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EXPERIMENTAL STUDY FOR THE EFFECT OF THE CONSTRUCTION OF SEAWALLS ON BEACH PROFILE

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ABSTRACT

Recent years have noticed a great increase in the services needed for the design of major sea defenses and coast protection works to solve coast problems . As an important aspect in the design of shore improvement measures, is the effect resulting on the beach from placing walls or any other defenses in the zone reached by wave and current action.

In this study we have treated experimentaly the effect of one of the protection structures on the morphology of sea bed;this structure is the seawall.

The effect of the seawall position on the profile of seabed before the wall was studied using vertical and inclined walls.Experiments were achieved using different wave steepnesses,different beach slopes ,and different wall positions and inclinations.

The analysis of the results led to some important graphical relations between different dimensionless parameters .The study of these relations showed how each variable is affected by the other variables. It was found that the existance of seawalls causes more deposition of bed material and so more accretion in the nearby region to the seawall. It was also found that the beach profile after obtaining the equilibrium state has approximately the same shape for different cases of beach slope.

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INTRODUCTION :

In coastal engineering, the primary purpose of any protection work is to protect the land from erosion by waves and currents. All protection works have one feature in commen,they separate land and water areas. These structures afford protection only to the land immediately behind them ,and none to adjacent areas upcoast or downcoast.

Among the fundamental problems of coastal engineering are the water movement along a coast,the interaction between moving water, loose beach sand or sea bed materials,and the hydrodynamic forces exerted by waves and currents.

In general measures designed to stabilize the shore fall into two classes: (1) Structures used to retard the longshore transport of littoral drift such as groins and jetties. (2) Structures to prevent waves from reaching a harbor area, or from eroding shore line such as breakwaters,seawalls,bulkheads and revetments.

In this work we study the effect of the position of seawall on the beach profile. The experimental investigation was excuted using both vertical and inclined walls. The experiments were realized in a range of steepness varying from 0.023 to 0.043,and for beach slopes 1:10 and 1:20. Different wall positions and wall inclinations were used during experiments. The resuls were represented by curves relating the different dimensionless parameters, and the analysis showed the effect of each of these parameters on the others. Interesting conclusions are extracted and summarized.

EXPERIMENTAL WORK:

The experiments were carried out at the Suez Canal Authority Research Center at Ismailia at the hydraulics research center laboratory in an existing wave flume.

Flume Description:

The wave flume used during the experiments is of uniform cross-section and have a R.C. bottom supported on R.C. supports raising it 70 cm from laboratory floor. The successive panels forming the sides of the flume are made either from R.C.or from securit glass fixed in steel frames. The total length of the flume is 40.0 ms, and the overall width is 1.80 ms. The maximum admissible depth of water is 50 cm. The wave generating machine, fixed on the wave flume, consists of 9.50 H.P.motor,7.70 H.P.hydrotitan to vary the r.p.m. of the machine ,gear box with reduction ratio of 1:10 ,and two discs rotated by the gear box and connected to the wave making plate. See figures (1) and (2).

The wave generator is capable of generating deep or shallow waves and it was calibrated to secure a successful operation of the flume under the working conditions. The wave characteristics used during the experiments were selected to simulate the boundry conditions occuring along the Egyptian Northern Coasts.

The wave characteristics were measured using a Hellige type wave recorder and electrode system.

The sand used in forming the beach in the model had a mean diameter of 0.33 mm , a dry density of 1.335 kg/cm^3 , a specific weight of 2.673, an angle of internal friction O of 32°,a coefficient of conductivity K of 1.486 cm/sec , a void ratio at

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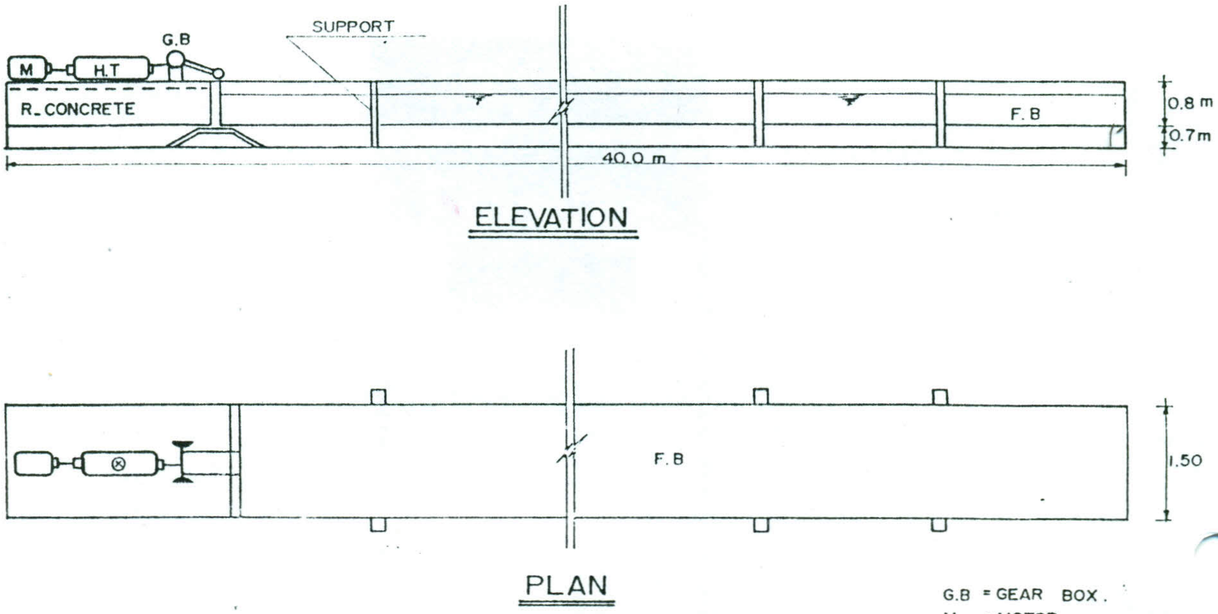

G.B = GEAR BOX.
M = MOTOR.
H.T = HYDROTITAN.
F.B = FLUME BED.

FIGURE (1) WAVE FLUME

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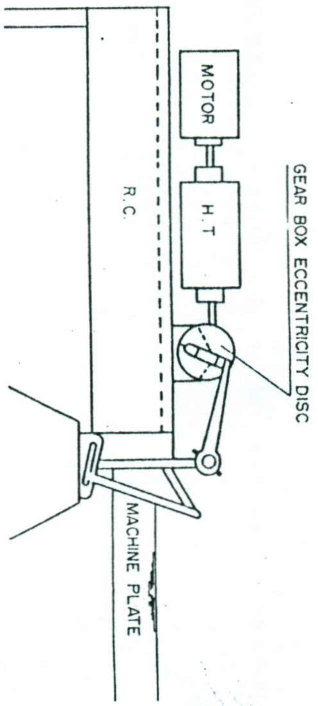


FIGURE (2) SKETCH OF WAVE GENERATING MACHINE.

loose state (e_{max}) of 1.0,and a void ratio at dense state(e_{min}) of 0.555.

Scope of Work:

The experimental program consisted of nine series of tests to study the effect of the construction of sea walls and the change of their positions ,relative to the shore line , on the beach profile.Two series of tests were carried out with no wall and the rest seven were carried out using the sea wall at different positions. Four series of tests were done for a beach slope of 1:20 and the other three were related to slope 1:10.

For each wall position , the wall was used once vertical and then inclined by 45° with the vertical. The effect of 3 different wave steepnesses were studied in each case.

The equilibrium profiles were measured ,photographed, and plotted for each test.

Table (1) describes the experimental program.

Experimental Procedures:

All the runs were carried out with the three steepnesses 0.023, 0.032 and 0.043.The wave steepness 0.023 is the average steepness of the Egyptian coast waves. The other two steepnesses are of relatively steep waves which are typical of storm conditions.

The experimental procedure is explained briefly as follows:

1- The beach profile is formed using the sand to give the required slope.

2- The flume is filled with water to the required depth (d).

3- The wave generator is adjusted to give the required wave characteristics.

Table (1)

Series	Exper-iment	Steep-ness	Place of wall	Inclination of wall	Slope of beach
	OIA	0.043	No wall	No wall	1:20
1	OIB	0.032	No wall	No wall	1:20
	OIC	0.023	No wall	No wall	1:20
	1 II A	0.043	At water line	Vertical	1:20
	1 II B	0.032	At water line	Vertical	1:20
2	1 II C	0.023	At water line	Vertical	1:20
	2 II A	0.043	At water line	45°	1:20
	2 II B	0.032	At water line	45°	1:20
	2 II C	0.023	At water line	45°	1:20
	3 II A	0.043	At L/4 from water line (46 cm)	Vertical	1:20
	3 II B	0.032	At L/4 from water line (46 cm)	Vertical	1:20
3	3 II C	0.023	At L/4 from water line (46 cm)	Vertical	1:20
	4 II A	0.043	At L/4 from water line (46 cm)	45°	1:20
	4 II B	0.032	At L/4 from water line (46 cm)	45°	1:20
	4 II C	0.023	At L/4 from water line (46 cm)	45°	1:20
	5 II A	0.043	At L/1.5 from water line (124 cm)	Vertical	1:20
	5 II B	0.032	At L/1.5 from water line (124 cm)	Vertical	1:20
4	5 II C	0.023	At L/1.5 from water line (124 cm)	Vertical	1:20
	6 II A	0.043	At L/1.5 from water line (124 cm)	45°	1:20
	6 II B	0.032	At L/1.5 from water line (124 cm)	45°	1:20
	6 II C	0.023	At L/1.5 from water line (124 cm)	45°	1:20
	7 II A	0.043	At L/2.5 from water line (74.4 cm)	Vertical	1:20
	7 II B	0.032	At L/2.5 from water line (74.4 cm)	Vertical	1:20
5	7 II C	0.023	At L/2.5 from water line (74.4 cm)	Vertical	1:20

Table (1) Cont'd.

Series	Experiment	Steepness	Place of wall	Inclination of wall	Slope of beach
	8 II A	0.043	At L/2.5 from water line (74.4 cm)	45°	1:20
	8 II B	0.032	At L/2.5 from water line (74.4 cm)	45°	1:20
	8 II C	0.023	At L/2.5 from water line (74.4 cm)	45°	1:20
6	OIA*	0.043	No wall	No wall	1:10
	OIB*	0.032	No wall	No wall	1:10
	OIC*	0.023	No wall	No wall	1:10
7	1 II A*	0.043	At water line	Vertical	1:10
	1 II B*	0.032	At water line	Vertical	1:10
	1 II C*	0.023	At water line	Vertical	1:10
	2 II A*	0.043	At water line	45°	1:10
	2 II B*	0.032	At water line	45°	1:10
	2 II C*	0.023	At water line	45°	1:10
8	3 II A*	0.043	At L/4 from water line (46 cm)	Vertical	1:10
	3 II B*	0.032	At L/4 from water line (46 cm)	Vertical	1:10
	3 II C*	0.023	At L/4 from water line (46 cm)	Vertical	1:10
	4 II A*	0.043	At L/4 from water line	45°	1:10
	4 II B*	0.032	At L/4 from water line	45°	1:10
	4 II C*	0.023	At L/4 from water line	45°	1:10
9	7 II A*	0.043	At L/2.5 from water line (74.4cm)	Vertical	1:10
	7 II B*	0.032	At L/2.5 from water line (74.4cm)	Vertical	1:10
	7 II C*	0.023	At L/2.5 from water line (74.4cm)	Vertical	1:10
	8 II A*	0.043	At L/2.5 from water line (74.4cm)	45°	1:10
	8 II C*	0.032	At L/2.5 from water line (74.4cm)	45°	1:10
	8 II C*	0.023	At L/2.5 from water line (74.4cm)	45°	1:10

4- The wave generator is turned on and records for the wave profiles were taken (from the fairly uniform waves.).

5- Waiting for the equilibrium profile,a mark was traced on the glass every one hour to study the history of the beach profile. When no significant change is recognized for two successive hours ,the wave generator is shut down and equilibrium profile is traced on the glass and then plotted.

6- After each run is terminated sand is remixed to eliminate any effect of sorting resulting from the previous run. Sand is reformed again and the wall is placed or moved to the next required position and/or the wave generator is readjusted for the next run.

7- For the next run , procedures from step no. 4 are repeated.

RESULTS AND ANALYSIS:

In order to explain the relations between different variables measured experimentally,and their effect on each other, the obtained data have been plotted using dimensionless parameters and then technical analysis and comments were introduced.

The variables used are:

d : water depth measured from the still water level,

D : seawater distance measured from the shoreline as a datum ,

r : vertical change in beach profile at any section.

The above variables are put into dimensionless form as follows:

D/d : relative seawall distance, and

r/d : relative change in beach profile.

Also, the wave steepness H/L was added to the above dimensionless terms.

Final beach profiles at equilibrium were shown plotting the relations between relative change in beach profile (r/d) and the relative seawall distance (D/d). These relations are shown by figures from (3) to (7).

The above figures show the relations for each wave steepness (0.023, 0.032 and 0.043) and for the original beach slopes 1:10 and 1:20. For each beach slope, the relations were plotted at different wall positions (at D=0, D=L/4, D=L/2.5, and D=L/1.5). At each wall position a comparison was done for the different cases of wall inclination (vertical and 45°) and also for the case of no wall.

It was noticed that the level of beach profile in case of nowall is always lower than the profile in case of using a seawall, whether the wall is vertical or inclined. This means that the existence of seawalls causes more deposition of bed material and so more accretion in the beach profile in the nearby region to the seawall. This accretion extends seaward from the location of the wall to a certain distance. This distance varies with the relative position of the wall and with the wave characteristics represented by the wave steepness.

The experiments showed that the extent of the accretion zone seaward decreases with the increase of the relative seawall distance.

Figures from (8) to (10) show a comparison between the resulting profiles for the case of 1:10 and the case of 1:20 beach slopes. It was noticed that the beach profile after reaching the equilibrium state, has approximately the same shape in both cases,

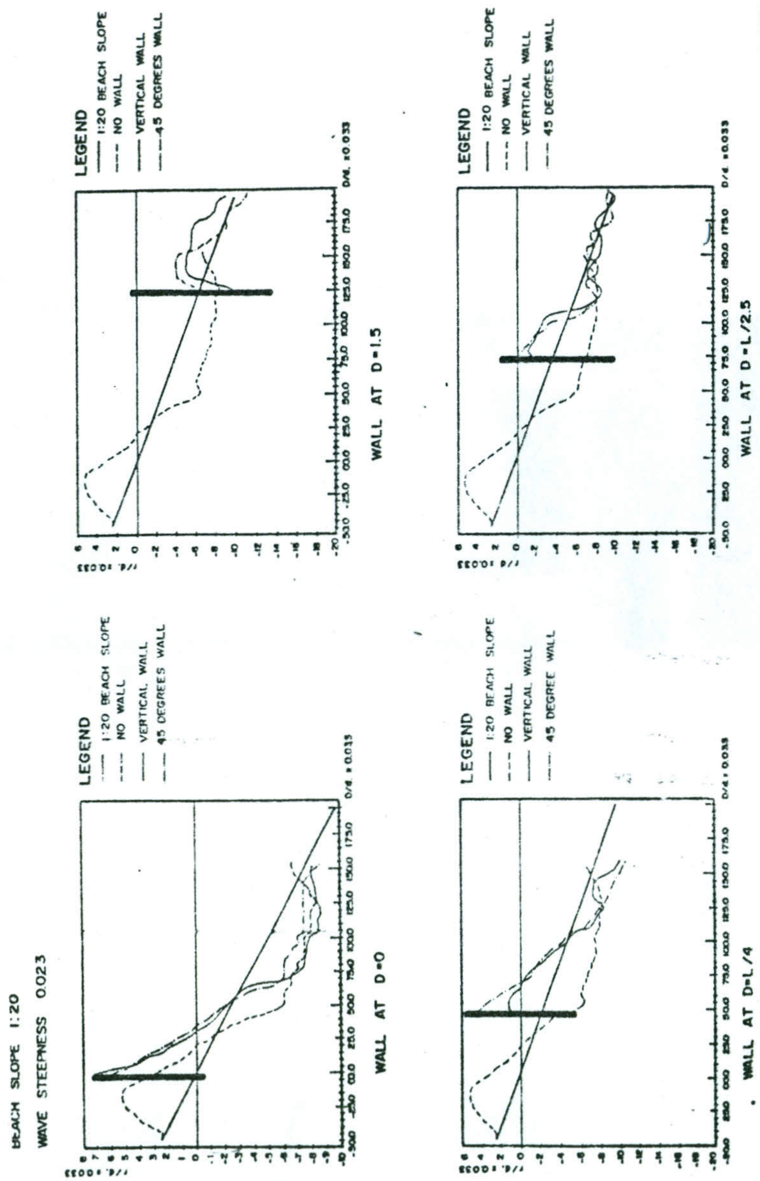


FIGURE (3) RELATION BETWEEN THE RELATIVE SEAWARD D/d AND THE RELATIVE CHANGE IN BED LEVEL r/d for beach slope 1 : 20 & wave steepness 0.023.

BEACH SLOPE 1:20

WAVE STEEPNESS 0.032

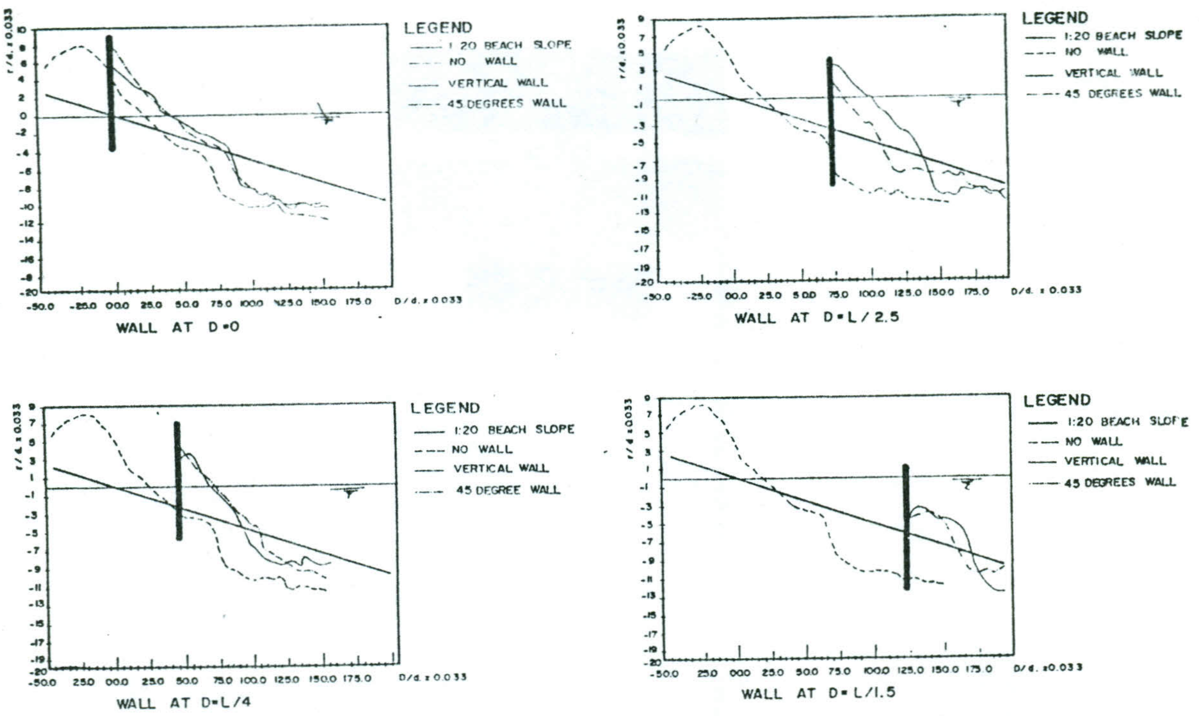


FIGURE (4) RELATION BETWEEN THE RELATIVE SEAWARD D/d AND THE RELATIVE CHANGE IN BED LEVEL r/d for beach slope 1 : 20 & wave steepness 0.032 .

WAVE STEEPNESS 0.043

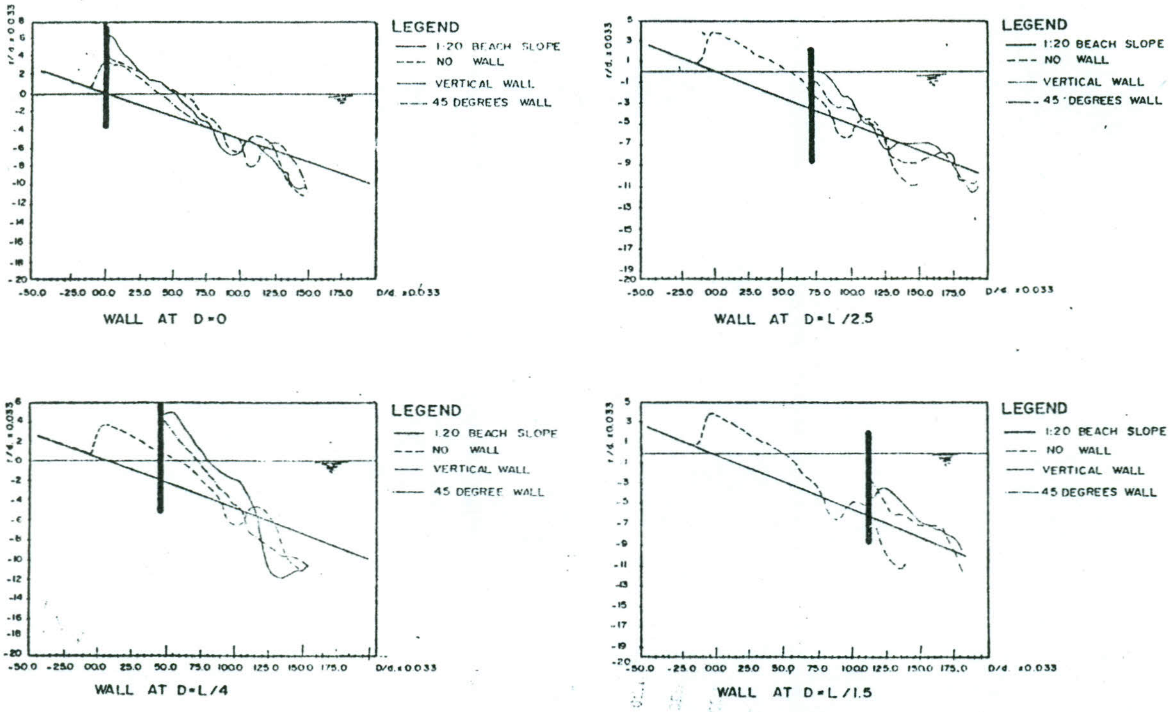


FIGURE (5) RELATION BETWEEN THE RELATIVE SEAWARD D/d AND RELATIVE CHANGE IN BED LEVEL r/d for beach slope 1 : 20 & wave steepness 0.043 .

WAVE STEEPNESS 0.023

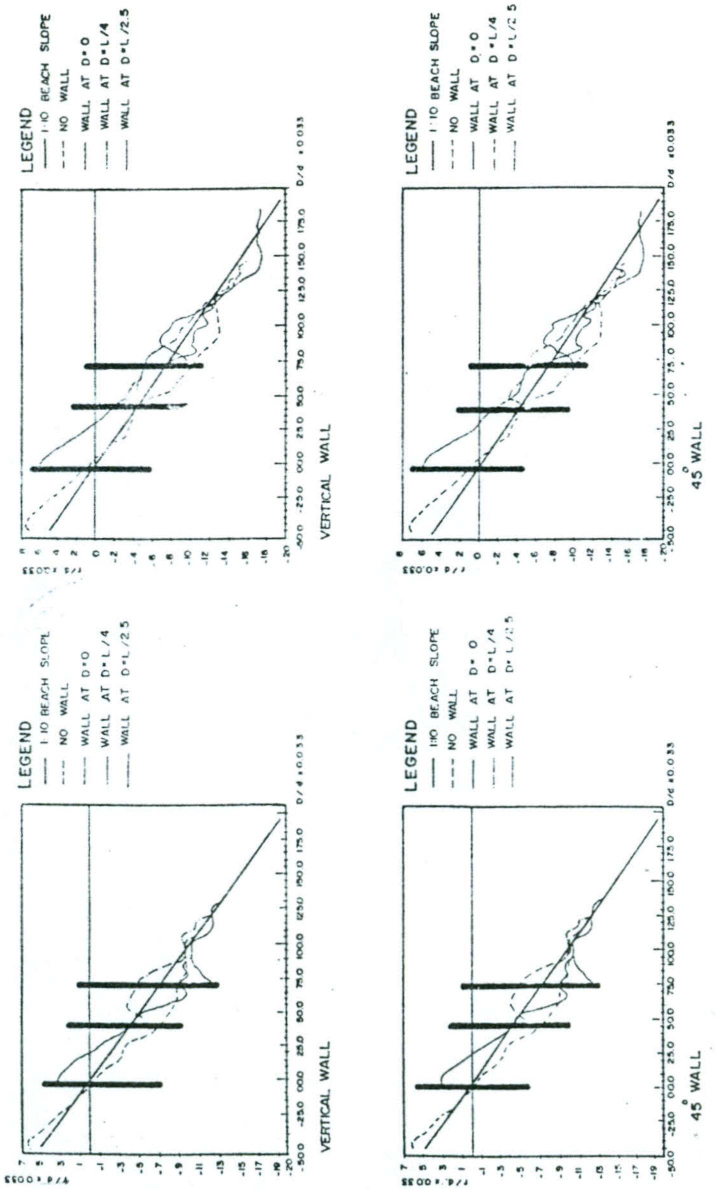
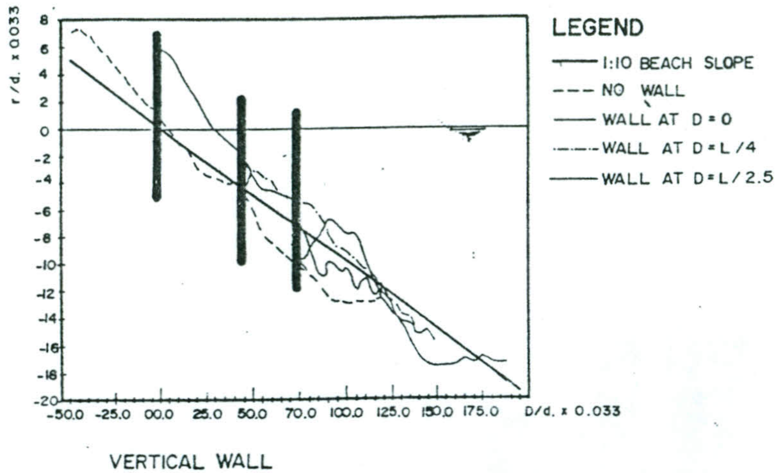


FIGURE (6) RELATION BETWEEN THE RELATIVE SEAWARD D/d AND THE RELATIVE CHANGE IN BED LEVEL r/d for beach slope1: 10 & wave steepness 0.023 .

BEACH SLOPE 1:10

WAVE STEEPNESS 0.043



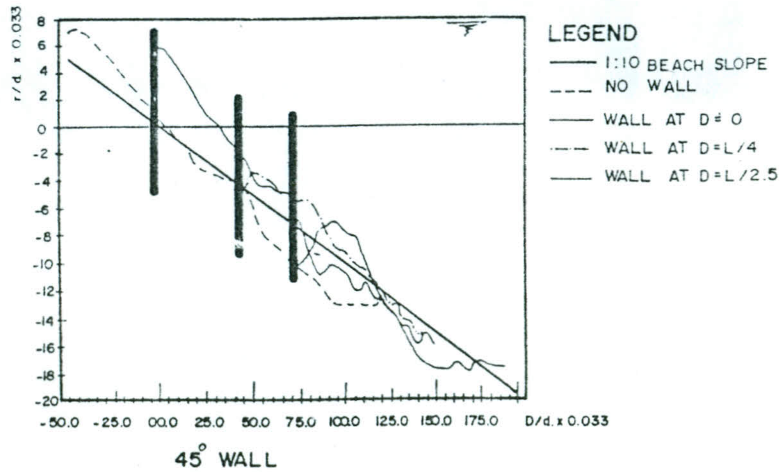


FIGURE (7) RELATION BETWEEN THE RELATIVE SEA WALL DISTANCE SEAWARD D/d AND THE RELATIVE CHANGE IN BED LEVEL r/d

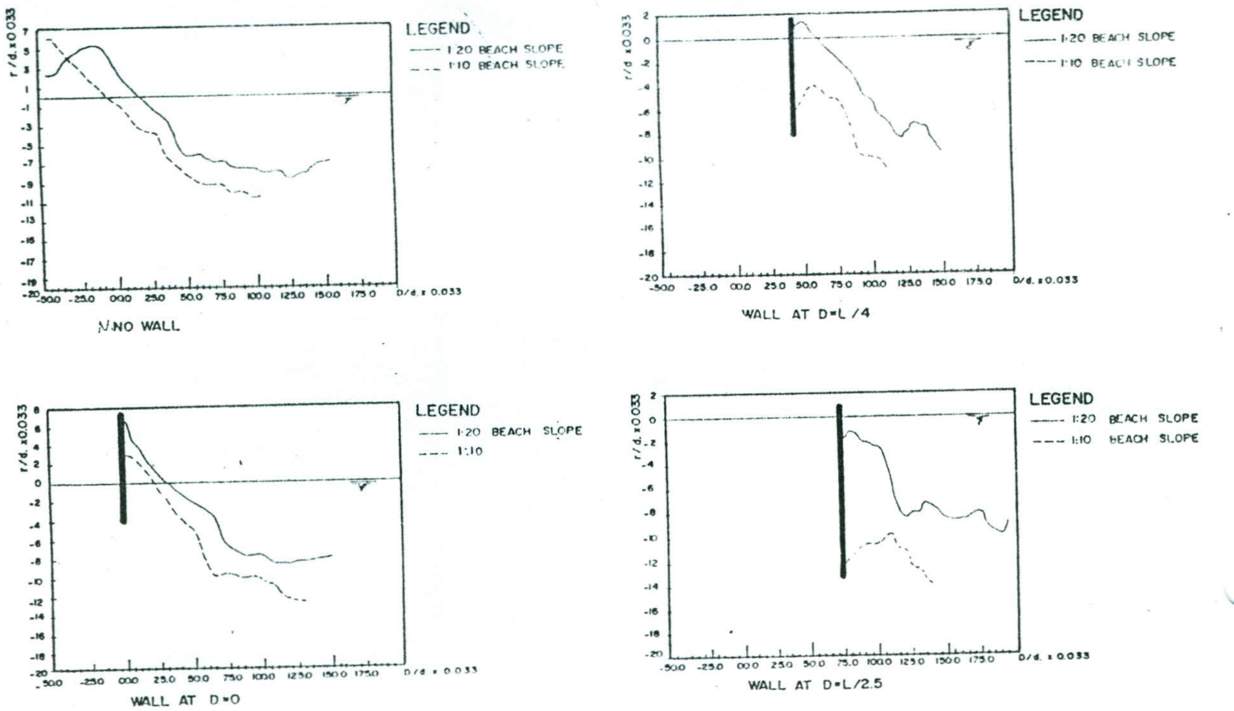
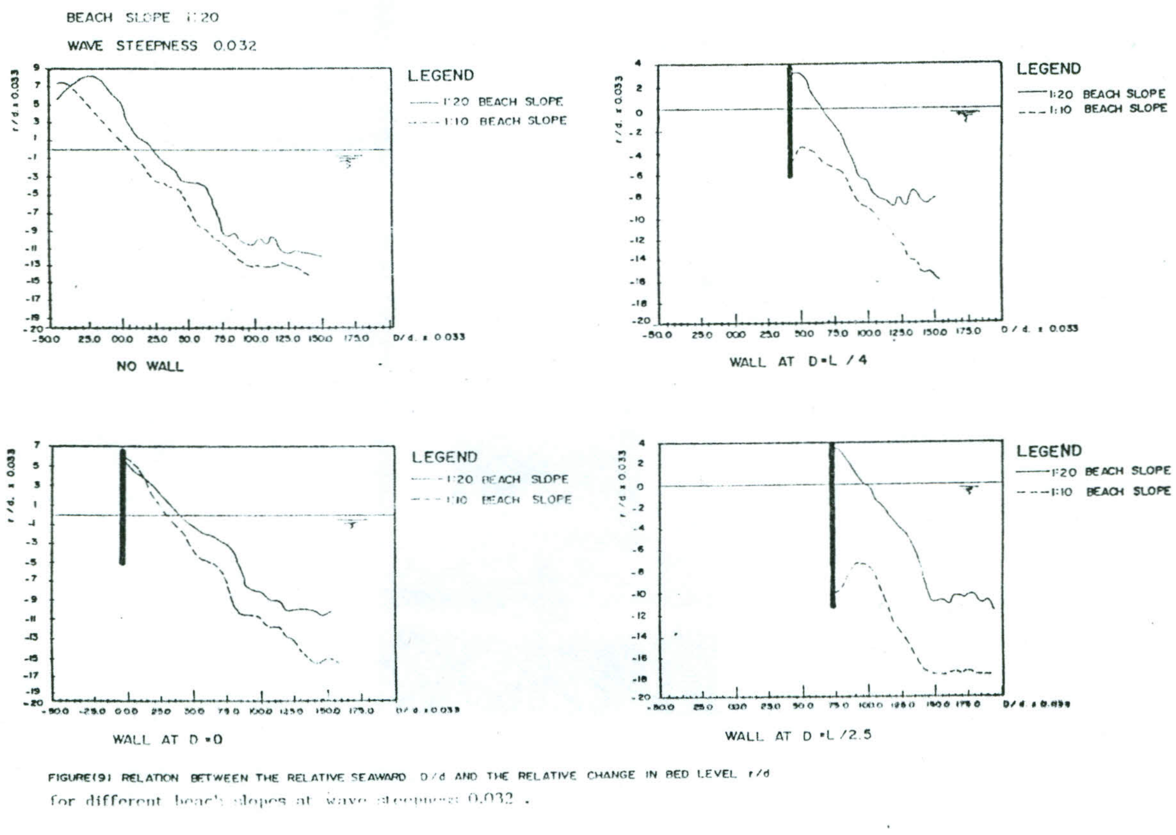


FIGURE (8) RELATION BETWEEN THE RELATIVE SEAWALL DISTANCE SEAWARD D/d AND THE RELATIVE CHANGE IN BED LEVEL r/d
for different beach slopes at w[illegible] steepness 0.023 .



FIGURE(9) RELATION BETWEEN THE RELATIVE SEAWARD D/d AND THE RELATIVE CHANGE IN BED LEVEL r/d
for different beach slopes at wave steepness 0.032 .

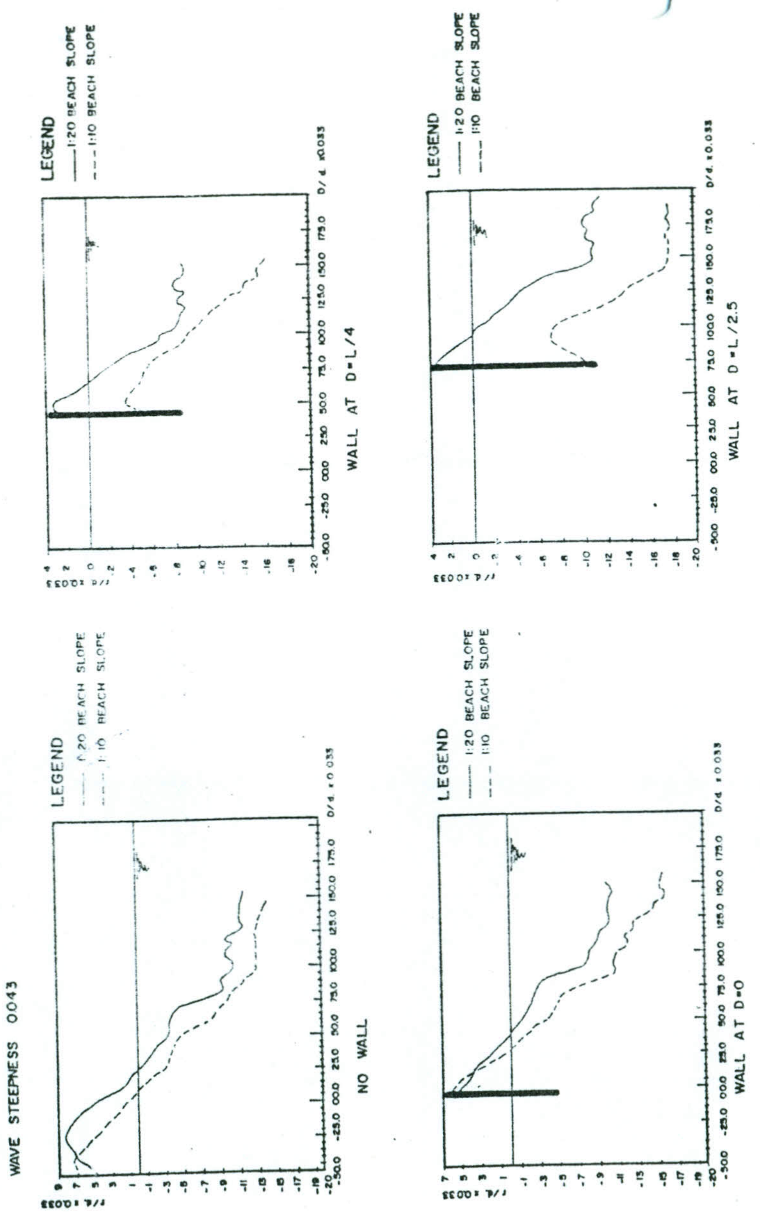


FIGURE (10) RETATION BETWEEN THE RELATIVE SEAWALL DISTANCE SEAWARD D/d AND THE RELATIVE CHANGE IN BED LEVEL r/d.
for different beach slopes at wave steepness 0.043 .

1:10 and 1:20 beach slopes. The distance apart between the two bed slopes, at equilibrium state , is more or less constant regardless to the value of D/d. The slope of the deformed bed tends to be very steep near the shore, and as the distance from the shore increases this slope tends to be flatter.

CONCLUSIONS:

From the above work, and within the range of experiments ,we come to the following conclusions:

(1) The existence of seawalls causes more deposition of bed material and so more accretion on the beach profile in the nearby region to the seawall . This was shown by the formation of a lower equilibrium beach profile in case of nowall than that in case of using a seawall , whether vertical or inclined .

(2) The extent of the accretion zone , seaward the location of seawall,decreases with the increase of the relative seawall distance , measured from the shoreline.

(3) The beach profile,after reaching the equilibrium state, has approximately the same shape for both cases 1:10 and 1:20 beach slopes . The distance apart between the two beach slopes is more or less constant for different values of D/d.

(4) The slope of the deformed bed,seaside the seawall position, tends to be very steep near the shore ; and as the distance from the shore increases this slope to be flatter.

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