

Shoreline Deformations in Relation to Shore Protection Structures along Kerala Coast

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Received 18 May 1979; revised received 12 September 1979

Impact of some shore protection structures on beaches and the neighbouring zones along the Kerala coast has been examined in relation to their physical set up and environmental processes. The studies show that although some of these structures help in stabilising the beaches at certain locations, others are responsible for severe erosion. Further, some of the beaches free from artificial structures and are generally stable, are observed to experience erosion during some years. The role of mudbanks in causing such deformation in the shoreline has been discussed. The modifications brought about by these mudbanks on the wave characteristics and the resulting changes in the beach morphologies have been discussed.

Shoreline along the Kerala coast is oriented in a NNW-SSE direction (Fig. 1). The beaches are of barrier type, backed by lagoon systems. The constituent sediments are mainly sands and occupy a parallel narrow zone close to the shore beyond which clastic sediments (muds) prevail. A conspicuous feature along the central part of the coast is the irregular occurrence of mudbanks¹ in the nearshore regions.

Considerable stretches of this shoreline particularly in the vicinity of Fort Cochin and south, up to Manaccadum are reported to undergo severe erosion^{2,3}. Shore protection structures such as seawalls and groynes have been constructed as and when the erosion reached alarming proportions.

In this paper, the nature and modification of the environmental processes and analyses of the effect and impact of the existing shore structures (built prior to 1966-1967) are presented.

Description of Area

Beaches at Narakkal and Manasserry were situated within seawall and groyne assemblies while Elankunnappuzha and Saudi were in their vicinity up to 1966 (Fig. 1). During 1966, seawalls were extended to the latter locations. The sea bottom on the northern side of the Cochin Harbour Channel presents gentle offshore slopes and waves generally break offshore during the calm season. However, during the SW monsoon and at high water, wave activity is felt in the inshore regions. South of the channel the slopes are relatively steep.

The beach at Punnappra was free from artificial structures. A mud bank existed in the offshore reaches during 1965. Purakkad had a physical set up similar to Elankunnappuzha and Saudi (prior to 1966).

Morphological variations at these locations are shown in Figs 2 to 4. At Narakkal, the beach showed nearly stable conditions during the period of study (Fig. 2). The beach experienced continuous erosion at Elankunnappuzha. After the extension of seawall in 1966 the beach remained more or less stable (Fig. 2).

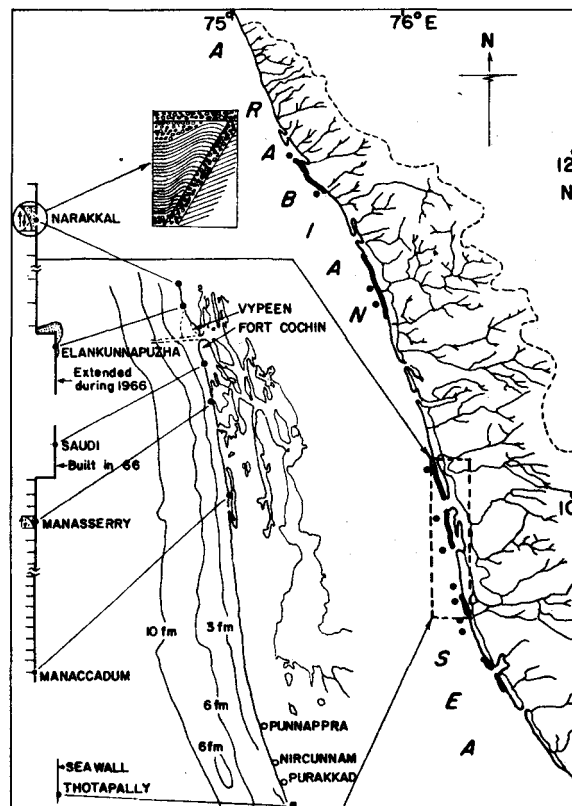


Fig. 1—Part of the shoreline along Kerala coast where studies are carried out

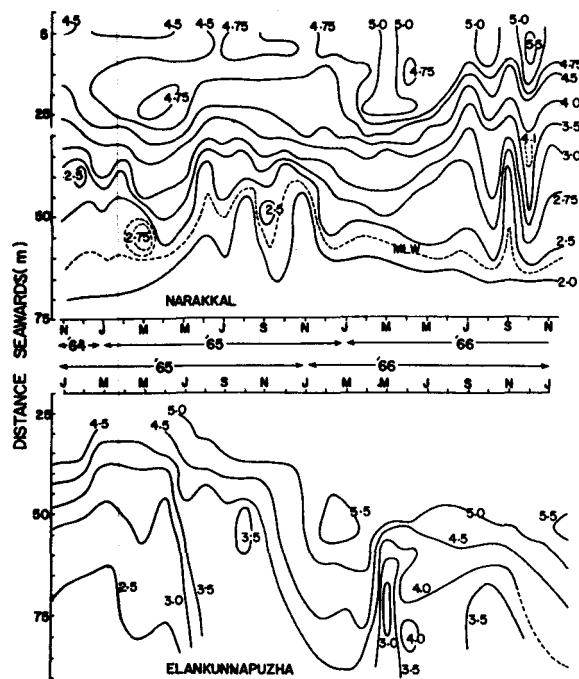


Fig. 2—Variation of beach topography with time at Narakkal and Elankunnappuzha

Fairly stable conditions with mild foreshore slopes were observed during 1964-1965 at Saudi. However, after the construction of the seawall in 1966, the steepness of the foreshore increased followed by a decrease in its width (Fig. 3). The beach at Manasserry experienced continuous erosion inspite of the protection provided by the seawall and groyne assembly (Fig. 3). At Punnappra, the beach initially showed progradation and later (after 1966) it experienced erosion of an appreciable magnitude (Fig. 4). The Purakkad beach was stable initially. However, it experienced erosion from about April 1966, possibly as a delayed effect of the construction of seawall about 0.5 km south (Fig. 4).

Results and Discussion

For understanding the behaviour of the beaches under study, a detailed investigation of the physical processes governing the sediment transport both under natural and artificial conditions is essential^{4,5}. Studies on wave refraction near Cochin harbour indicate divergence of wave energy followed by convergence on either side of Fort Cochin beach associated with waves, whose directions vary between SSW and WNW⁶⁻⁸.

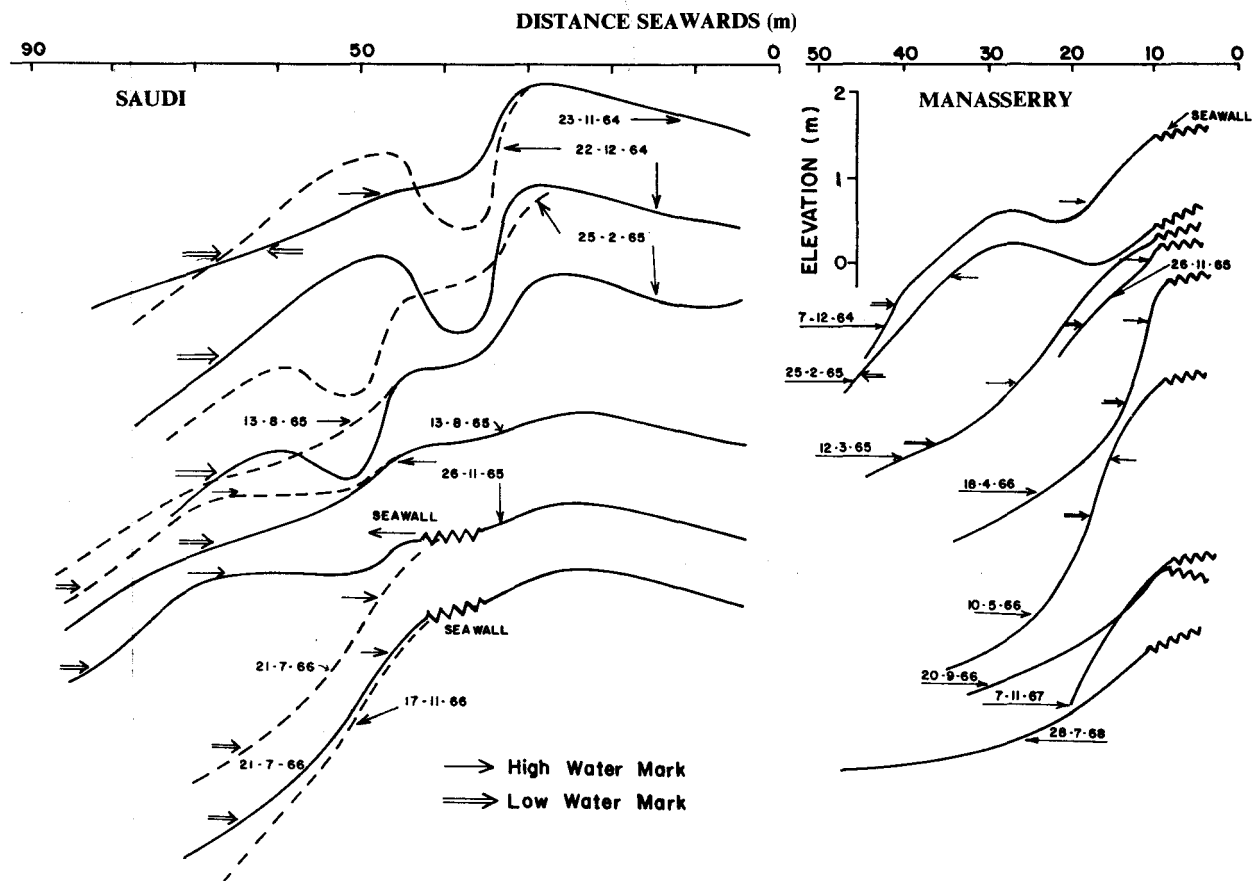


Fig. 3—Typical beach profiles at Saudi and Manasserry

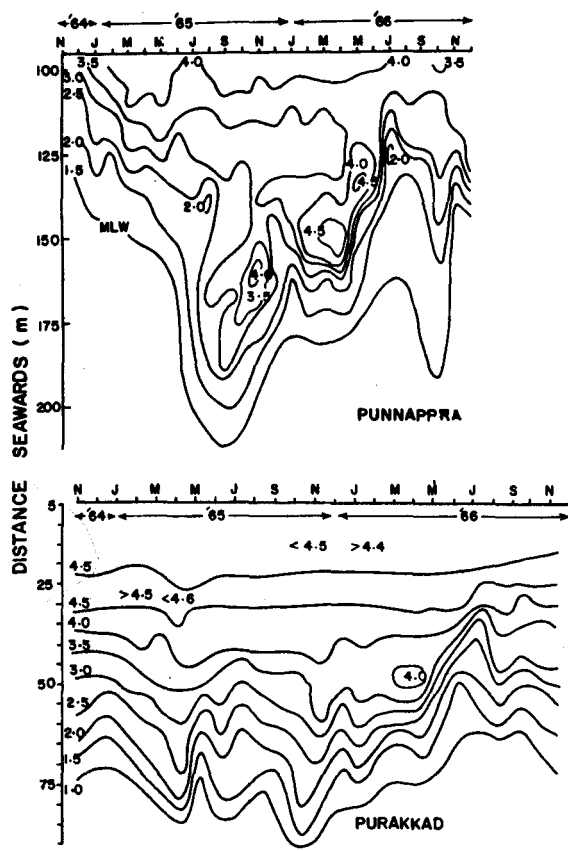


Fig. 4—Variation of beach topography with time at Punnappra (variations are shown from 100 m from the reference point) and Purakkad

The zones of converging and diverging wave energies are found to shift with changes in the wave period.

The Narakkal beach had been known to be eroding for a long time¹. Studies⁶ indicated a zone of converging wave energy leading to erosion of this stretch. After the construction of seawall and groyne assembly, the beach remained nearly stable with erosion of considerable magnitude during the monsoon months, and accretion of similar magnitude during the fair weather period. The month to month variations in the beach profiles appear to be mainly due to the onshore and offshore transports.

Manasserry presents marked difference in the nature and variation of the beach profiles from those at Narakkal even though they are only about 16 km apart. The proximity of these locations does not permit large variations in the wind and wave climates. The beach topography at Manasserry shows steep slopes, particularly during April and November, followed by flat inshore slopes with steps. Fig. 3 shows continuously decreasing width of the beach and lowering of its elevation leading to relatively low volumes of beach sediments indicating an unstable equilibrium as compared to the beach at Narakkal. The steepness in

the foreshore and the steplike feature in the inshore regions at Manasserry lead to reflection of waves approaching the shoreline particularly during high water. The interaction of these reflected waves with the incoming waves lead to the development of short crested waves which give a glossy appearance to the sea in the nearshore regions. During the monsoon the wave set up is considerable⁹ and the run up on the beach face contributes to scouring of the sediments from the upper reaches. This process leads to the sinking of the seawall. In addition, the alongshore flows alternating in direction with the changing wave field associated with seasonal changes in winds, contribute to deposition of material on the northern or southern side of the compartment (between the groynes and the seawall) in the form of upcoast deposition and downcoast erosion. Thus, the impact of the shore protection structures on the stability of this beach needs reassessment.

The beaches at Elankunnappuzha and Purakkad, experienced erosion after shore protection works were initiated. Continuous erosion (contour of 4.5 m in Fig. 2) at Elankunnappuzha, during 1965, necessitated the extension of seawall from its northern side. Thereafter, the beach profiles indicated initial progradation of the beach and later cyclic variations with minor losses or gains.

While the construction of seawall at Elankunnappuzha seems to have helped in building up a beach there, the same does not hold good for Saudi located 10 km south. At Saudi, the beach profiles (Fig. 3) show cyclic changes prior to the construction of seawall whereafter the beach presented eroding tendencies. The marked differences in the behaviour of the beaches at Elankunnappuzha and Saudi could be explained as follows: In the presence of a seawall, the reflection of incoming waves and their interaction with the approaching waves result in diamond patterned short-crested waves. These are further altered by refraction and prevailing currents and they get propagated in various directions. Under the influence of such short crested waves, zones of erosion occur at the location where these waves enter while zones of accretion form at the zones of exit¹⁰ (Fig. 5). At the intersection of the reflected wave orthogonals (broken line, Fig. 5) caustics develop leading to shadow zones. Deposition of the sediments occur in the shadow zone while in the immediate vicinity of the seawall, there is erosion. Elankunnappuzha and Saudi are represented by A and b respectively in Fig. 5. The waves after modification appear to approach the shore for a greater length of time in a year, between W and NNW directions in the region off Elankunnappuzha and between SW and NNW off Saudi. The presence of groynes and seawall on the northern side of

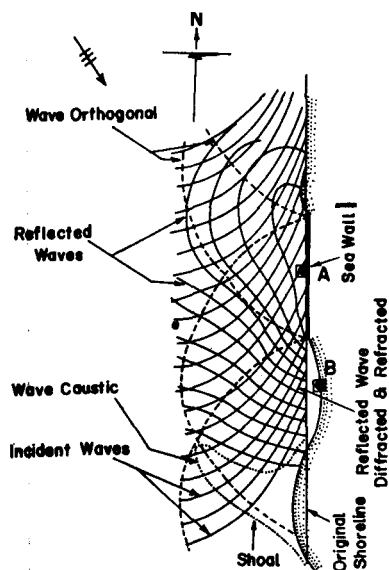


Fig. 5—Interaction of incident and reflected waves from a seawall (schematic)

Elankunnappuzha restricts the passage of sediments. The alongshore flows, however, contributed to scouring on the leeside of the seawall and groynes resulting in higher rates of erosion (20 to 30 m/year) at Elankunnappuzha. After the construction of seawall at Saudi, the reflection of waves from the seawall, contributed to scouring of sediments which resulted in the formation of steep foreshore slopes (Fig. 3).

Conditions at Purakkad are similar to those at Elankunnappuzha. Referring to Fig. 5, Purakkad could be placed at A but with a change in the direction of wave approach (here the waves appear to approach the shore between WSW and W directions). Considerable reduction in the beach width (Fig. 4) had taken place due to scouring of sediments from the beach. In the downdrift zone of caustics relatively calm conditions prevail. This feature was recorded on many occasions, particularly during the SW monsoon season, when low and long period swells approached the coast. In the proximity of the seawall south of Purakkad, the inshore regions were steep compared to those further offshore¹¹. These features suggest that while erosion could be checked by the construction of a seawall, significant changes such as steep slopes in the nearshore bathymetry and erosion are possible.

The wave refraction and direction functions⁸ at Punnappra, reveal weak alternating alongshore flows. This has been corroborated by the float tests⁹. These indicate that the onshore and offshore flows assume greater importance in causing the observed variations in the area. However, it is doubtful whether these weak onshore and offshore flows could result in the large increase in the beach width and the volume of the sediment as revealed by the time-height contour

patterns at Punnappra between June to September, 1965. The beach had been nearly stable with a tendency for considerable progradation during the initial stages of this study. During 1965, a mudbank was reported in the nearshore regions and it is possible that the progradation of the beach is closely related to the location of the mudbank. In the presence of a mudbank the wave heights decay in an exponential manner and the resulting dissipation of wave energy exceeds by far the energy loss due to bottom friction¹³. As long as the bottom sediments remain undisturbed, these deposits act as rigid systems. During the SW monsoon months the waves break offshore close to the outer periphery of the mudbank. The resulting higher concentrations of the sediments in suspension increase the apparent viscosity of the water. The silt-laden fresh water discharges through river run-off adds to these suspended sediments. The resulting increases in viscosity reduces the increased wave intensity during the SW monsoon¹². The development of shear stresses in the boundary layer adds to further attenuation of wave energy in the shallow areas. Thus, these waves, after breaking, impart their momentum to the surrounding fluid¹⁴ and as a consequence, regeneration of waves of lesser amplitudes takes place. The incident waves and the changes that occur in the presence of a mudbank are shown in Fig. 6. Punnappra may be located in the central part of the shadow zone in this figure. Due to the refraction of waves in the mudbank region, the waves approach the coast at an angle on either side of the mudbank producing littoral currents directed towards the shadow zone from either side. This favours accumulation of sediments in the

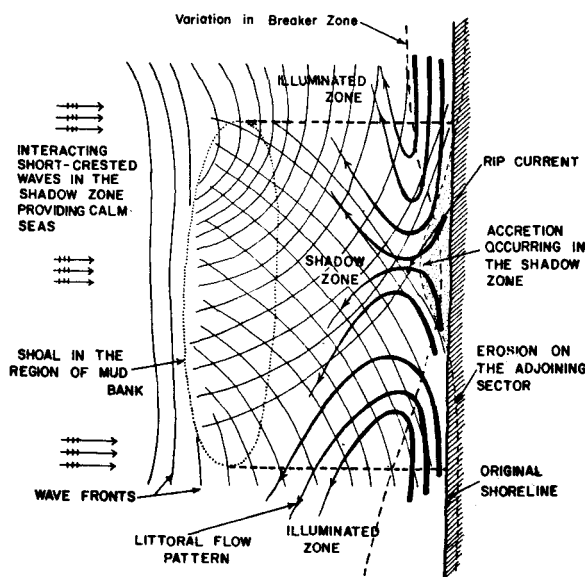


Fig. 6—Effect of shoal in the nearshore regions on the adjoining shoreline (schematic)

shadow zone, and in turn gives rise to changes in the slopes of the inshore regions and the type of wave breaking. The opposing littoral currents in the shadow zone (Fig. 6) leads to offshore flows. The section of the beach located near the shadow zone thus continues to grow at the expense of the adjoining sectors. The offshore flows transport fine sediments in suspension offshore to depths of about 30 m by the bottom surge¹⁵. During the field surveys in 1965-1966 converging flows at Punnappra beach were observed. The anomalous growth of the beach as evidenced by the seaward extension of the elevation contours (Fig. 4), especially from June to September 1965, is clearly the result of mudbank formation.

Thus, any shore protection structure of a permanent nature should take into consideration the natural environmental process variables as well as the transient nature of the mudbanks. Permanent remedial measures can be undertaken only at those places where the causes for erosion are due entirely to the environmental process variables. At places where the deformation of the beach is primarily due to formation of a mudbank (which is of transient nature) the remedial measure should also be transient (such as a mobile breakwater) which can be removed after the purpose is served.

Acknowledgement

The authors are thankful to Dr S.Z. Qasim, Director, for his interest and encouragement.

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