Trans. Inst. Indian Geographers
Vol. 30, No. 1, 2008

Effect of Construction of Protection Wall on Beach – Dune Morphology of Shrivardhan Bay Mouth Spit, Konkan Coast, Maharashtra

Subhamita Chaudhuri, Anargha Wakhare and Ajay Kamble

Abstract

Sea walls are barrier to wave impact and can alter swash and backwash velocities, modify the beach slope and have significant impact on sediment budget. The morphological changes that have been brought about in the beach-dune morphology of the Shrivardhan bay mouth spit by the construction of the protection wall have been monitored and documented in this article. The direct or indirect effects of the wall on the position of the high tide line of the beach have also been assessed. Periodic theodolite surveys and photography were carried out to detect short-term changes from 1998 to 2002. Wave refraction diagram was prepared to detect the relation between wave refraction pattern and the zones of erosion. Field observations revealed that the wall had a definite influence on beach elevation, development of runnel and low tide bar. Observation redistribution of material over the beach, of contemporary course of events show that, the protected portion of the beach first starts to gain elevation with accelerated sand accumulation at the base of the wall. If there is subsequent seaward shift of the high tide line the zone comes under the purview of wind deposition and the beach assumes an accretionary nature. The unprotected southern part of the beach, downdrift of the wall experienced active erosion, as a major proportion of the wave energy was expended where the wall terminates.

Introduction

The coastal zone is a 'dynamic system', affected by offshore bathymetry, the wave energy, the input and output of sand, tidal influx, the long-shore drift, the action of onshore wind and the fresh water input from the streams draining into the coast. In an un-interfered coast all these processes are in a state of delicate yet dynamic state of balance. But in reality very few stretches of today's coastline have been able to escape anthropogenic interventions. Man has always felt it necessary to modify the coastline either directly or indirectly. Such modifications are often of considerable scale leading to serious environmental problems mostly through changing the rate and zone of erosion and sedimentation. Changes in the rate of erosion and sedimentation caused by natural events require sufficient time before the change can become perceptible. As against these, the human induced changes are often more dramatic and their effect can be felt within a relatively short span of time. Any coastal engineering structure, however small or large interrupts the natural equilibrium and brings about some sort of modification, may be on the rate and direction of sediment movement, the morphology of the beach or the angle of wave approach.

The construction of beach protection wall is one common example of such an engineering structure. Sea walls are barrier to wave impact and have been the most traditional method of coastal defence. Sea walls can alter swash and backwash velocities, modify the beach slope, have significant impact on sediment budget and lead to beach disequilibrium. Problems may reach considerable proportions if wave fronts and sea walls are misaligned. In such cases, the reflected wave energy causes increased rate of erosion in the down-drift part of the wall, thus merely transferring the original problem laterally (French, 1997). In fact it is often said that engineers build seawalls to protect the land, not the beach (Viles and Spencer, 1995).

Objective

In this paper an attempt has been made to monitor and document the morphological changes that have been brought about in the beach-dune morphology of the Shrivardhan bay mouth spit by the construction of the protection wall. It further tries to assess the direct or indirect effects of the wall on the position of the high tide line of the beach.

Regional setting

Throughout the Konkan Coast of India, one can find almost a regular sequence of bays and headlands. Shrivardhan bay is one such small bay, which together with its catchment area lies roughly between 18°0'N to 18°5'N latitude and 73°0'E to 73°7'E longitude. The catchment area of the bay is about 90 sq. km, out of which the bay itself covers only about 9 sq km. The bay is backed by basaltic ridges on all the three sides. The 20 m contour line, which closely borders the bay in the northern and southern parts, progressively moves away from the present margin of the bay towards the east. A number of streams, mostly non-perennial, drain into the bay. The water inside the bay remains restricted in two narrow arms during low tide, but during high tide the water spreads almost over the entire bay area, with a small portion of the central island remaining above water (Fig 1).

The most significant characteristic of the bay is the development of a very prominent bay mouth bar, which extends from north to south. The Shrivardhan settlement has developed on this bar. This so-called bay mouth bar can well be termed as a 'spit' since it has not blocked the mouth of the bay entirely. The western margin of the Bay mouth spit acts as the present beach, which is backed by a dune line. The dune and the beach act as the storehouse for the sediment and due to active erosion of the dune huge amount of sand gets released which eventually moves into the bay with the incoming tide.

Methodology

a) Periodic theodolite surveys to detect short-term changes (c. 2-3 years) have been carried out for three consecutive years (1999, 2000 and 2001). This survey was essential to monitor the erosion of the dune face.

b) Periodic photography has been carried out to monitor changes of micro-relief forms. Latest morphological changes along the southern part of the wall have been incorporated from photographs taken in 2005.

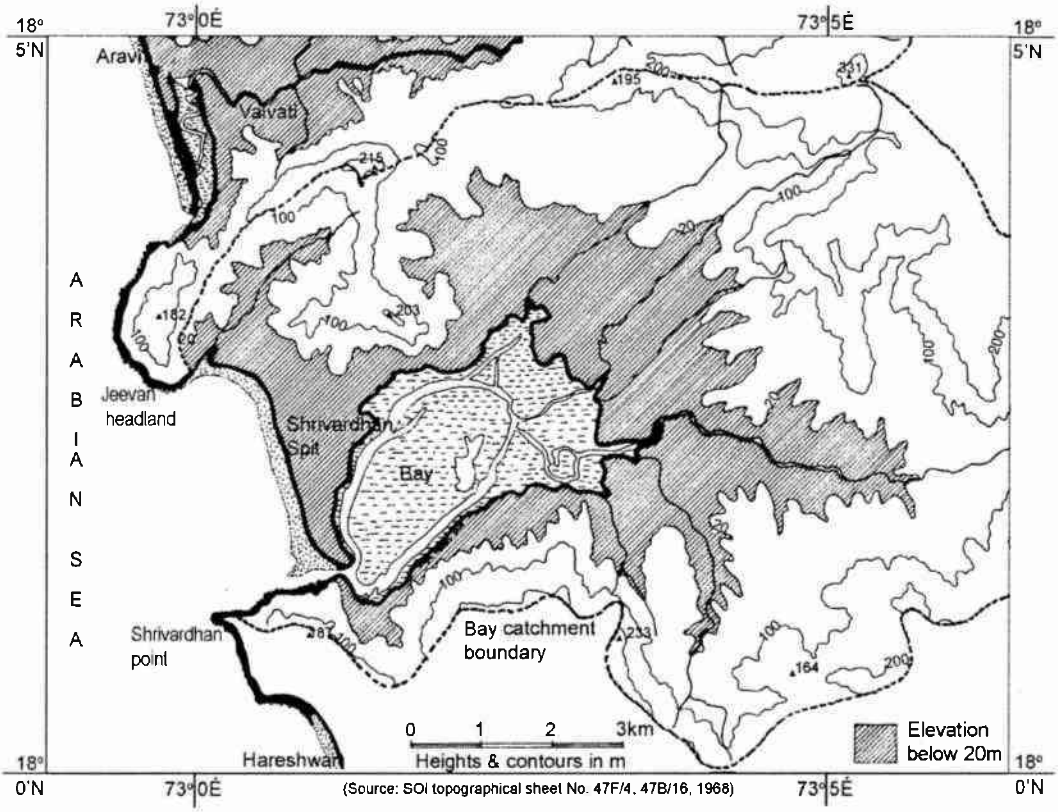

Fig. 1: The study area, located in central Konkan Coast, India.

c) Wave refraction diagram was prepared for the month of July (the peak of Monsoon season) to detect any possible relation between wave refraction pattern and the zones of erosion, and compare the results with field observations. The Monsoonal season has been chosen since, in this part of India, all erosional activities attain maximum vigour during this season.

Observations

In order to understand the effect of the wall in the changing morphology of the beach-dune area it is necessary to give a brief idea about the characteristics of this unit. It has been already mentioned that the most prominent feature in the Shrivardhan Bay area is the development of a very prominent bay-mouth spit. The entire spit area is composed of the following morphological units: (Fig 2):

1. the beach – forming western margin of the spit and extending from northern headland. Extension of the spit southwards is almost closing the mouth of the bay.
2. the dune complex – it backs the beach almost throughout its length, except in its extreme southern portion. The protection wall has been constructed almost throughout the entire length

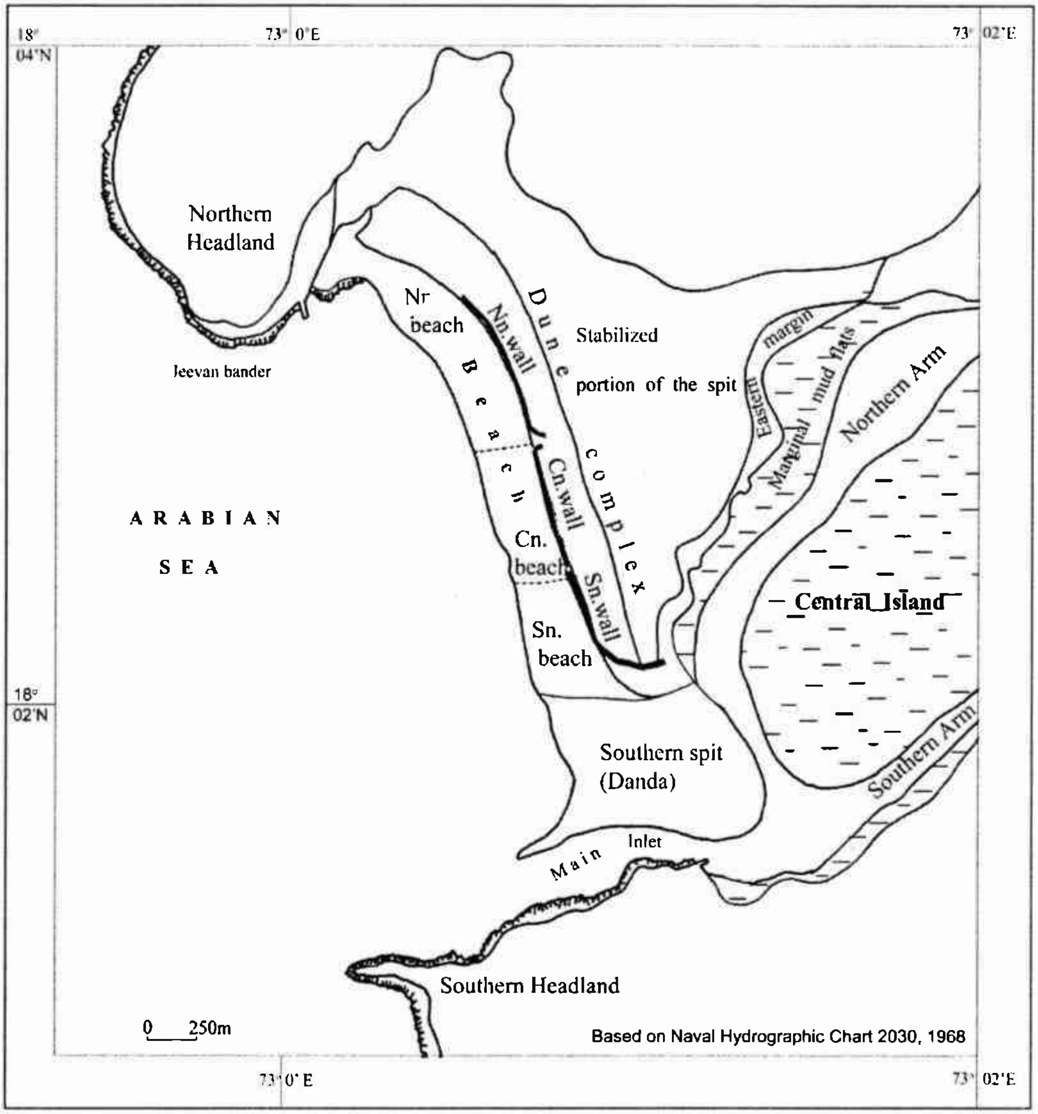

Fig. 2: Morphological Zones of Shrivardhan bay mouth spit.

of the beach. The southern part of the dune was under the process of active erosion until 2002, when the southern wall was not constructed.

3. the southern tip of the spit - locally known as Danda is an extension of the beach, and acts as the actual bay-mouth bar, as far as the present extension of the bay is concerned. It is bordered on its northern limit by the active dune zone. The southern most tip of the spit is yet to get stabilised. During low tide the bay maintains its connection with the sea through one

inlet, situated between the southern margin of the bay-mouth spit and the southern headland. But during high tide, water overrides this part of the spit. Unlike the beach it shows greater influence of tidal currents. The material released from the beach-dune complex gets spread out over this portion of the bar, later to be carried on to the bay by the flood tide.

4. stabilised portion of the spit, the area to the east of the active dunes, is occupied by Shrivardhan Township.
5. eastern margins of the SPIT borders the bay.

The first three morphological units are directly affected by the protection wall, hence in this paper only these three units have been dealt with in detail.

The effect of the wall on the beach-dune morphology

As has been already mentioned, Shrivardhan beach forms the seaward face of the bay-mouth spit, extending for a distance of 3.12 km and is backed all along its length by a fairly extensive dune belt. However, its southern part for a distance of 400 m appears to be the most dynamic part. This may be attributed to the following facts – 1) the movement of water circumventing the spit-end develops multidirectional flow components and hence, the interplay of waves, currents and tide is more complex in the southern part, 2) the southern end of the spit is in the inter-tidal zone, thus it experiences transfer of water and sediment from and to the sea at flood and ebb tidal conditions, 3) the protection wall was abruptly terminated before the southern 400m of the beach and it remained so, up to 2002. All these factors reflect on the beach slope, erosion of the dune face and variations in micro-relief forms. Since the wall has played different roles in different parts of the beach, each unit of the beach has been dealt with separately.

The northern beach

The beach does not have a protection wall for about 300 m from the port of Jeevan Bander situated at the base of the northern headland. In this part, the beach shows slightly steeper slope with rip cells developed during pre-monsoon season. The primary dune belt has mainly plantations of *Pandanus faccicularis*, which is preceded towards the beach by a zone of neo-dune formation. This portion of the beach is not directly affected by the protection wall, which starts further south.

The next 950 m of the northern beach unit shows relatively gentle slope and the berm line is not clearly defined. The beach merges into the dune without any distinct break of slope. The Casuarinas plantation over the dune succeeds a gentle berm and is backed by another line of broad crested dunes, only 2-3 m in height. The dune slope merges gradually with the orchards, cultivated fields and plantation plots towards the inner margin (Fig 3). In this part of the northern beach area one may trace the existence of an old stonewall (at times two lines of them). The protection wall, however crude it may be, was erected on the line of the berm up to which the waves were expected to have their influence. From interviews with local people it was known that the wall was constructed almost 90 years ago. Both these lines of wall at present are required to be traced with effort, than being easily detectable. The seaward relief of these walls has been reduced to the extent of near non-existence and walking from the low tide line towards east seldom makes one realize the existence of walls unless one encounters a partially exposed portion of the same by chance. In fact, the wall itself may have been instrumental in trapping the sand and helping in the rapid accumulation of the material. At present the wall in this part has been totally covered under sand and a dune line with an average elevation of almost 1.5-2.0 m has developed on it. The beach too appears to have accreted at its eastern margin, so that the wall crest now appears almost at the level of the beach. Considering the average height of the wall during construction to be at least 2 m, the amount of increase in beach elevation may be ascertained.

What the authors would like to argue is the fact that these walls at the time of construction must have had sufficient height and seaward relief. The fact that they are now been buried clearly indicates that there has not only been accumulation of sand behind the wall but also raising of the beach elevation. The elevation is raised to the extent that the high tide line has shifted towards the sea, and wind action has gained prominence in this part. This indicates that at present this portion of the beach has changed over from erosional to depositional regime (Plate 1 a).

The central beach

The central beach zone extends for about 700 m. In the central zone the dune has been protected by erecting a crude stonewall, built about 50 to 60 years ago, which is partially buried in some sections. Though the wall has been constructed much later, it has been constructed as a continuation of the northern wall. The total length of the wall is about 600 m. The protected portion of the dune is quite broad, with an average width of 100 m. A casual glance at the dune belt reveals three distinct parts – 1) a slightly elevated yet flat berm, 2) a zone of discrete round-topped mounds with 2-3 m height and 3) a zone of high primary dunes with average elevation ranging between 5-8 m, which remains farthest from the beach. The round-topped mounds appear to be subsequent development at the base of the primary dunes (Fig 3).

The generalised section of the beach and dune across the walled portion shows a more or less gentle beach with slight steepening at the foot of the wall (Fig 3). However, the seaward relief created by the exposed wall is still appreciable and does provide protection to the dune zone from direct wave attack. The approaching waves still break at the base of the wall during high tide. The empty spaces between the wall boulders allow the waters of the approaching waves to penetrate, but at the same time dissipate the wave energy. This leads to deposition of the wave borne material in the inter-boulder spaces and at the base of the wall. Moreover the backwash fails to acquire sufficient velocities to remove the dumped material. The net result of this is greater accumulation of material and rise in the beach elevation.

The presence of the wall also results in the formation of small channelised flow lines, which come out from the base of the wall and extends across the beach. These

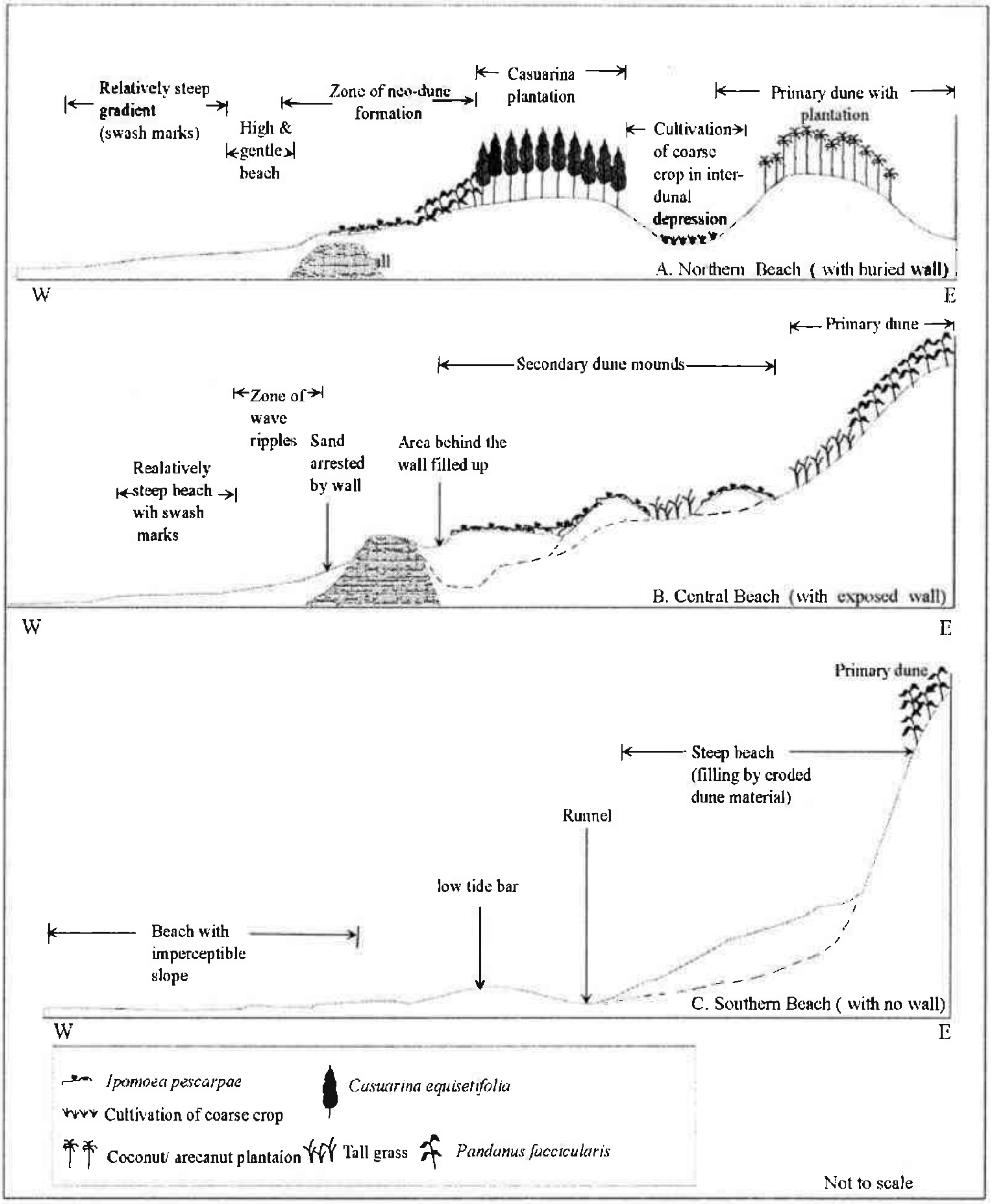

Fig. 3: Generalised profiles of beach-dune complex.

appear as shallow and narrow depressions starting from the base of the wall, and moving in accordance to the beach slope. However, such streams do not continue for long and appears to be getting lost mid-way on the beach. The progressive addition of material by the incoming waves keeps altering the mouths of these so-called streams and they get ultimately choked.

The wall in its landward side is followed by more or less flattish dune surface succeeded by two lines of dune-mounds. The height of the mounds does not exceed 3 m and these are often separated by a stretch of undulating surface usually covered by grass. The flattish dune surface immediately behind the wall may have been formed by subsequent filling of the area between the wall and the first line of dune mounds (Fig 3). This has been inferred from the fact that the landward edge of the wall remains buried under the dune material. Material blown in, by onshore wind may have been deposited behind the wall resulting in quick accretion and gradual merging with the next succeeding dune line. This linear depression behind the wall may be seen in Plate 1.c. The dune creepers acting as trappers and binding agent facilitated dune accumulation. Due to the construction of the wall, the beach-berm boundary cannot be seen. The height of the last line of primary dune rises to about 5m, descending steeply to plantation plots and cultivated fields at its rear.

The southern beach

Out of the three sub-zones of Shrivardhan beach the southern one appears to be most dynamic in terms of alterations that are taking place. If the northern zone is considered as a zone of accretion which is experiencing a seaward shift of high tide line, it is the southern zone which appears to be at the receiving end so far as wave erosion is considered. The central zone largely appears as a zone of transition between the two.

The southern zone roughly extends for a distance of 640 m, before one enters the southern tip of the spit located further beyond. The protection wall of the Central beach used to get abruptly terminated in this zone up to 2001. In 2002 a new wall has been constructed. However, most of the work related to mapping of dune was completed by 2001. The morphological changes in this part of the beach-dune complex has to be explained in two parts – 1) morphological characteristics of the zone before the construction of the new wall and 2) morphological changes after the new wall was constructed in 2002.

1) Condition before construction of the new wall

The protection wall extending from north abruptly terminated in this section leaving about 640m of the southern beach and the paralleling dunes directly exposed to wave attack. In this stretch of the beach, the dune was undergoing active erosion. The rate of erosion was highest in the southernmost part. The width of the dune zone was about 50-70m just after the termination of the wall where at least one line of secondary dune mounds could be traced. At the extreme southern tip of the dune the width was drastically decreased to a mere 15-20 m. Here only the primary dune zone at the eastward margin of the dune belt could be seen which had a vertical ascend of almost

8m from the beach. The primary dune zone had a steep slope with the loose sand just at its angle of repose. The moment the basal portion was removed by wave impact, there was a sudden increase in slope and the dune material readily slumped down. Once this process was initiated the primary dunes were eaten away at an alarming rate. The interdunal area, with low angle of slope and limited elevation were comparatively more resistant to erosion. So long as the interdunal zone or the present day berm was present, the rate of erosion remained within controllable limits. But, once this portion was removed and waves reached up to the base of the primary dune zone, then even the slightest wave impact created havoc.

A section across this part shows a steeper beach slope, terminating at the base of the dune (Fig 3). The steepness of the beach was due to piling up of eroded dune material. This sector of the beach, after the termination of the protection wall showed a wide patch of dark coloured sand, adjoining the dune and berm line. These black sands though very fine, are composed of high concentration of opaques, which has very high specific gravity. Hence, these materials once deposited on the upper most beach portion are not easily dislodged by the withdrawing tide. Part of the eroded material carried by backwash gets deposited near the low tide level in the form of a low tide bar. The depression between the low tide bar and the steep beach sector was occupied by a runnel. This runnel system was located at the western side of the unprotected part of the beach-dune complex and occupied a pivotal role in the sediment movement over this part of the beach. At the onset of flood tide the water first enters through the runnel and the runnel attains the nature of a channelised flow. The bed of the runnel showed very prominent current ripple marks. During ebb when water starts withdrawing the runnel also drain out in accordance with the slope. A major portion of the sand released from erosion of the dune gets distributed over the southern tip of the spit through the runnel. Hence the runnel played a very important role so far as the distribution of water and sediment over the southern spit is concerned (Plate 1b and Plate 1c).

The abrupt terminal portion of the wall can be seen in Plate 2a. Its so-called abrupt termination appears to be abnormal. No one would construct a wall halfway unless there exists some raised portions, may be of a metre or two in the form of a dune mound. So it is more than likely that though the protection wall appeared to have an abrupt termination (till 2001), it must have been constructed till it encountered a dune of sizeable height, which appears to have been eroded in subsequent period. In fact it was observed during field visits, that up to 1997 this portion had dunes of considerable height. As a result of consumption of the frontal dunes – probably protecting the primary dune line as well as interdunal surface, the waves gained considerable area for their spread. The photographs clearly show that the waves reach right up to the base of the surviving portion of the interdunal area. This location is about 200 m south of the terminal portion of the wall in the central beach. It may be clearly seen that the interdunal area has almost been totally consumed and the high tide line has receded back right up to the base of the primary dunes.

The erosion of the dune front is in itself an indication of the landward progression of the high tide line in the southern part of the beach. SOI topographical maps of 1968 and 1925 show that the high water line extended at least 500m further down to the south, almost up to the southern end of the spit. Verbal evidences derived from interviews with local people revealed the same.

Periodic surveys of the southern part of the dune belt were taken up in 1999, 2000 and 2001 to find out the rate of erosion. The superimposition of the three surveyed maps of 1999, 2000 and 2001 showed interesting trends. The maximum rate of erosion is noticed at two places – 1) at the southern end in front of the primary dunes and 2) along the portion of the dune, just after the termination of the protection wall. In 1999 the dune face gently curved inward after the termination of the wall and it showed indications of dune erosion up to the southern tip of the dune line. In 2000 the dune line formed a notch just after the terminal portion of the wall, bending sharply for about 11 m towards the north. The tip of the protection wall also showed signs of deformation, probably due to the dislodgement of the boulders. Almost 150 m south from the wall-end the dune margin had receded almost 8 m inside. Further southward, where the dune attains maximum height, the amount of recession was maximum, going up to 10 m (Fig 4).

From the periodic surveys detailed contour maps were prepared with 0.25 m contour interval. The area occupied by the dune belt and the total volume of the dune between 0.25 m and 8.50 m contour has been calculated with the help of the software Surfer, version 7, for the years 1999, 2000 and 2001. The values obtained have been presented in Table 1.

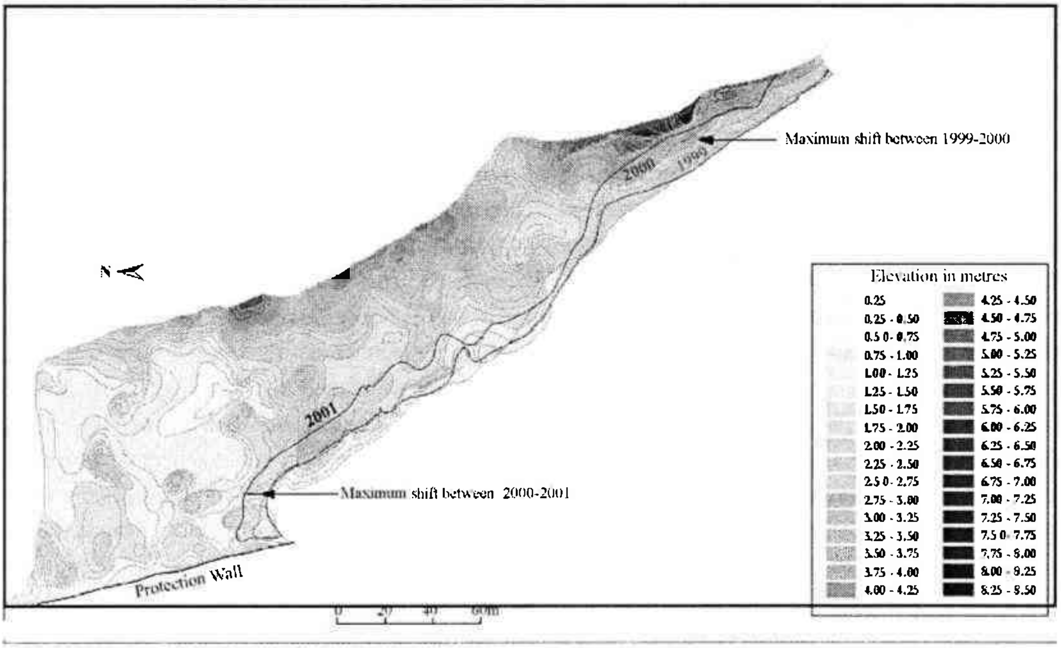

Fig. 4: New wall accumulating sand at its base (2002).

Table 1: Area and the volume of the dune (1999-2001)

Year	Area (m^3)	Volume of sand (m^3)
1999	32626.616	86137.296
2000	32211.918	85221.595
2001	31363.039	83949.699

The results indicate that between the years 1999 and 2001 the dune has reduced 1263.577 m2 in area and it has lost 2187.597 m3 of sand. In view of the high rate of reduction in the dune volume within two years the seriousness if the problem becomes apparent. Presently due to the construction of the new wall this part of the beach has been protected and the primary dunes are no longer subject to wave attack.

2) Condition after construction of the new wall

The severity of the erosion of the dune face led to the construction of a new protection wall in 2002. This wall takes off from the abrupt terminal portion of the previous wall. The present wall extends from this point onwards in north-south direction and circumventing the southern margin of the dune axis it turns eastwards bordering the northern limit of the spit end. In the N-S aligned portion, the wall shows signs of accretion of material (Plate 2b).

The wall profile shows a much gentler slope, and the beach elevation seems to have increased at the wall base. It can be clearly seen that the relative height (drop) of the wall has decreased considerably due to piling up of sand at the base of the wall. At the portion where the new wall changes its alignment from N-S to NW-SE, the high tide water reaches the wall base and signs of wave erosion can be observed.

The eroded face of the dune line, now being protected by the wall has started to show signs of re-stabilization. The near vertical face of the dune has assumed a gentler slope, probably diverting back to its angle of repose. The dune stabilizing creepers (*Ipomoea*) have extended over the freshly developed slope face and giving anchorage to the embryo dunes.

After the construction of the new wall the supply of eroded dune material to the beach was stopped and the low tide bar was eventually obliterated. The runnel was filled up and now the adjoining area is represented by a plain beach without ripple forms. The change in the morphology of the southern beach before and after the construction of the new wall can be seen in Fig 5.

Discussion

From the above observations a few points needs to be discussed in detail. The community of people who owned the plantations behind the high primary dune line must have constructed the walls owing to possible erosional threat in the northern part of the beach. At present the wall is buried under aeolian dunes and the high tide line has shifted towards the sea. This surely indicates a change-over from erosional to depositional regime. What was the cause of such a change-over is difficult to ascertain. It may be noted that the two parallel lines of wall indicate two such phases when the dune was under erosional threat. The older parts of the Shrivardhan settlement is in the stable northern part of the spit, and since

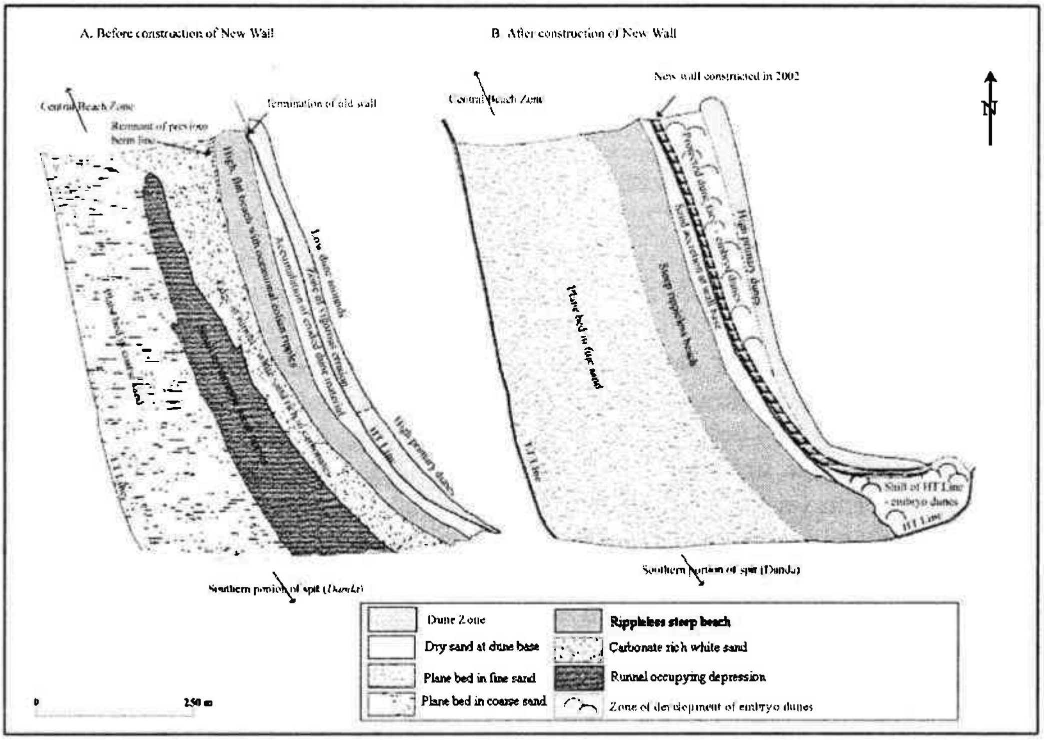

Fig. 5: Geomorphic map of southern beach – before and after construction of new wall.

the wall in the northern beach is almost 90 years old, it is quite probable that the central and southern parts of the spit may not have had any settlements at that time which needed protection. Hence, the local people built the wall only as far as it was necessary to protect their property. Seawalls may be designed for several purposes: to absorb and reflect wave energy, to hold sediment-fill in place and to raise the problem area above flooding elevations (Clark, 1995). In this case the wall was built with lose basaltic boulders which were piled up without any cementing material. Since basalt is the most easily available material in this locality, the choice of the building material is expected. The lose boulders absorbed the wave energy and also trapped sediment in the inter-boulder spaces. This may have initially helped in increasing the beach slope at the wall base. However, the setting-in of the depositional regime cannot be explained by the wall alone. There may have been some changes in the bathymetry, but in the absence of any sounding chart before 1960's such a statement can, at the best be based on assumption. It is a known fact that in many seawalls the reflected wave energy interacts with the incoming wave energy and erosion occurs on the downdrift side of the wall. This results in a temptation to extend the wall downdrift to prevent the new erosion problem. (Viles and Spencer, 1995). Hence it can be assumed that once the northern protection wall was constructed, the part of the central beach just south of it must have experienced erosional threats and that led the people to further extend the wall another 200m or so. The repercussion of the construction of the second wall was felt since the 1990's, when the dune belt backing the southern beach was faced with erosional threats. The plantation owners attempted to stop the erosion at first by adopting soft measures like putting sand-filled gunny bags but such an effort proved futile.

At this juncture it is necessary to mention the pattern of wave refraction in this part of the beach. A relevant portion of the wave refraction diagram of the monsoon season, prepared by the authors has been shown in Fig 6. It can be seen from the diagram that the wave orthogonals are not only converging near the central and southern beach sector, but the orthogonals and the dune line are almost aligned at right angles to each other. In such a set-up it is but expected that this portion of the beach would experience severe erosion. Hence, keeping these conditions in mind it may be stated that keeping this part of the dune belt unprotected for so long has been a wrong decision. By the time the southern beach was provided with the new protection wall in 2002, some 2187.597 m3 of sand was already been eroded within 2 years.

It has been observed that both the northern and the southern beach showed steep beach sector near the high tide line. But the cause of beach steepening is different in these two sections of the beach. The northern beach indicates addition of wave borne sand to the beach to cover up the old wall and in turn increases the beach elevation. In the southern part the steepening of the beach, at the base of the dune (before the construction of new wall in 2002) is an effect of dumping of the eroded dune material and their redistribution. This could be ascertained through granulometric analysis of sediment samples taken from northern and southern beach and the dune zone. It was observed that the frequency plots of the samples taken near the HT line of southern beach had close similarity with the dune samples, unlike that of the northern beach.

With the wall protecting the entire dune belt chances of further erosion of the dune line are weak. Hence, there may be two possibilities – I) the southern portion of the spit (Danda) which lies beyond the protection wall may be attacked by waves causing stripping of the surface leading to reduction in elevation and II) the new wall may accumulate sand at its base resulting in faster rate of spit accretion. From the refraction diagram it can be seen that the extreme southern portion of the protection wall has a W-E orientation, which is almost parallel with the approaching wave orthogonals. Hence it may be assumed that this portion of the wall experience deposition at the wall base. In May 2005, observations proved that the new protection wall at its W-E oriented part was already showing signs of accretion at wall base and substantial increase in beach elevation. The beach has gained elevation in this part to such an extent that the there has been definite southward shift of the high tide line. This could be confirmed because of the formation of aeolian dunes at the base of the wall. The dune biding Ipomoea have already started to spread over these embryo-dunes (Plate 2c).

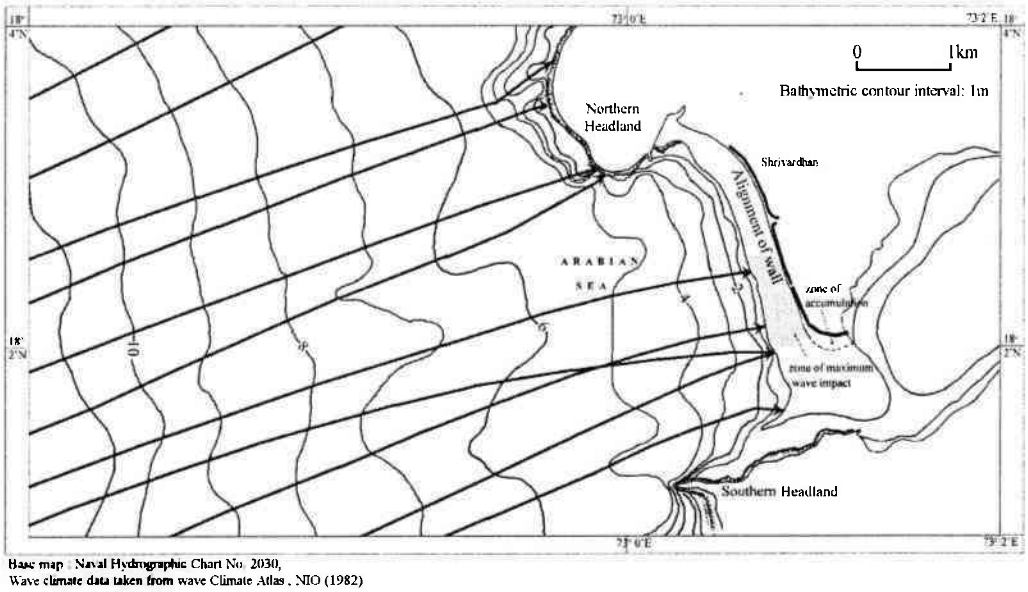

Fig. 6: Wave refraction pattern during Monsoon (dominant wave direction southwest) and the zone of maximum wave impact.

Conclusion

Observation of contemporary course of events shows that, the protected portion of the beach first starts to gain elevation with accelerated sand accumulation at the base of the wall. If there is subsequent seaward shift of the high tide line the zone comes under the purview of wind deposition and the beach assumes an accretionary nature. The unprotected zone down-drift of the wall experiences active erosion, as a major proportion of the wave energy is expended where the wall terminates. Hence the unplanned construction of the sea wall may be held partially responsible for the unprecedented erosion of the southern dune belt. Before the southern wall was extended in 2002, the dune belt had already lost more than 2000m3 of sand within three years. It has been already stated that the southern tip of the spit experiences exchange of material and water between the bay and the sea. So, even if a fraction of this huge volume of sand enters the bay it can have significant impact upon the sedimentary budget of the bay. Comparing the sounding charts of 1668 and 2000, it is seen that there has been definite shallowing and narrowing down of the northern arm and the main inlet. The fishing jetty of Mulgaon situated on the northern arm of the bay has been adversely affected by such increased rate of siltation. Hence, the unplanned construction of the wall can be considered as an indirect cause of bay siltation. The southern beach sector was under erosional regime up to 2001, but at present it is showing definite signs of a depositional environment. This change-over from erosional to depositional regime and the construction of the new wall may be purely coincidental, and the actual cause may be a change in the wave climate altogether. But observing the drastic change just within 3 years from the construction of the new wall it can be stated that the construction must have acted as a triggering event, if not the only one.

Acknowledgement

The authors would like to express deep sense of gratitude to the residents of Shrivardhan, from whom they collected valuable information, which could never be acquired otherwise. The authors are also thankful to the Headmaster, Shrivardhan Government School, Mr. Dashrath Mahkar and Mr. Ravindra Borkar for giving useful information regarding construction of the protection wall – both old and new. Mr. B.V. Pendse needs special mention because it was his excellent narration that gave us an insight into the history of development of the Shrivardhan spit and settlement. The authors would also like to thank the Maharashtra Maritime Board, Mumbai, India for providing the sounding charts of the concerned area. Last but not the least, the authors would like to thank friends and colleagues without whose help the associated field work would not have been possible.

References

Clark, John.R, (1995). Coastal Zone Management Handbook. Lewis Publishers, CRC Press, USA.

French, Peter. W.,(1997). Coastal and Estuarine Management. Routledge, London, New York, pp 80-87.

Viles, Heather., Spencer, Tom., (1995). Coastal Problems. Edward Arnold, London, pp 76-84.

1. **Subhamita Chaudhuri**
(corresponding author)
Lecturer, Jogamaya Devi College,
Kolkata 700033, India
E-mail: suvamita@hotmail.com

2. **Anargha Wakhare**
Lecturer, Nowrosjee Wadia College,
Pune 411001, India
E-mail: amitdhorde@unipune.ernet.in

3. **Ajay Kamble**
Sr. Lecturer, Bhavan's College,
Andheri (W), Mumbai 400058, India
E-mail: ajay_bhavans@rediffmail.com

Plate 1a: Buried portions of old wall – northern beach.

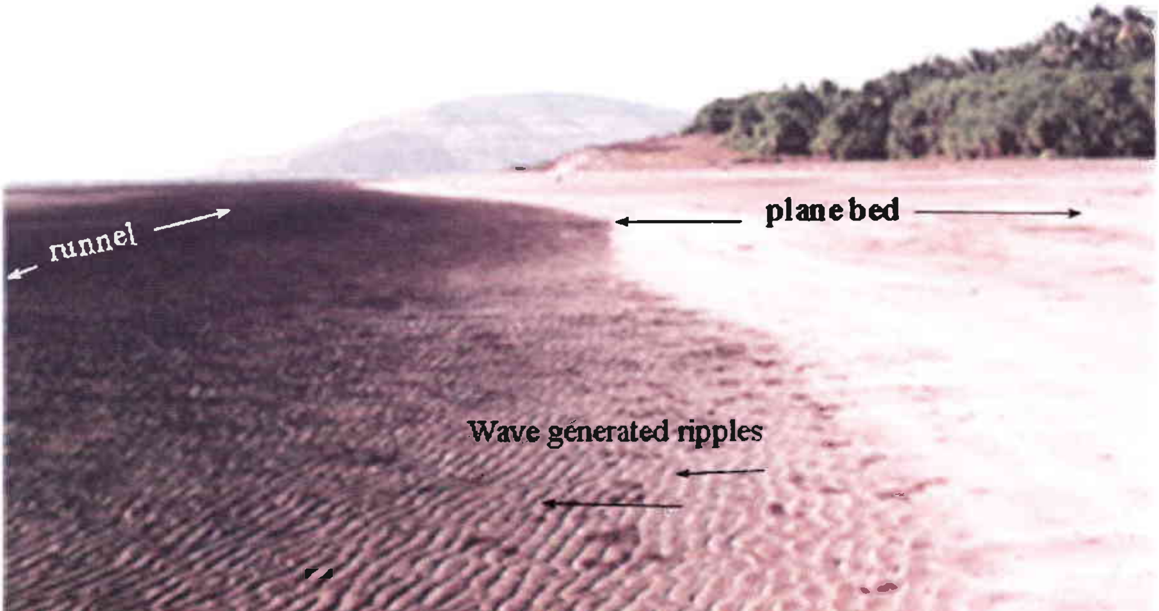

Plate 1b: Runnel development is southern beach (1988); extensive current ripples developed in the bed of the runnel.

Plate 1c: Filling up of the runnel after construction of new wall (2004); current ripples absent, only swash marks seen.

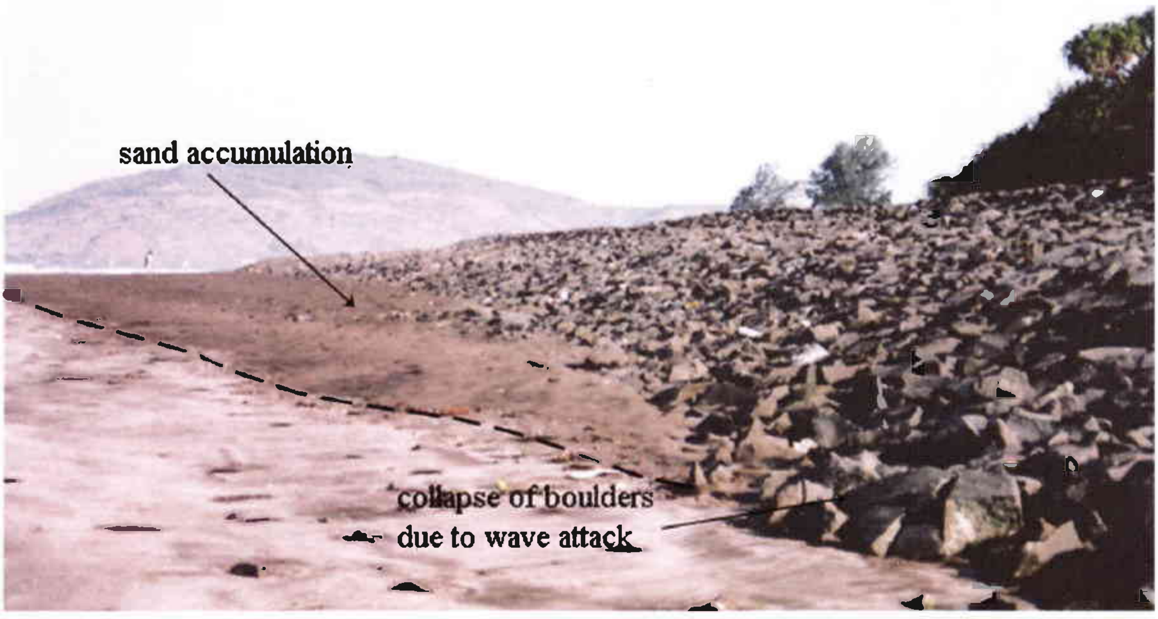

Plate 2a: Sand accumulation at the base of new wall.

Fig 1: Planar profile of Jainta Devi Ki Roa, Floods and erosion of cultivable lands of low terraces are a common feature. Vegetative anti-erosion checks are along the right bank.

Fig 2: Convex profile of Siswan Nadi due to sedimentation. On the left bank low terrace supporting wild vegetation *Eucalyptus* plantation and inhabitation, is heavily eroded.

Plate 2b: Periodic photographs of southern beach from wall termination.
The reduction in dune width is to be noted.

Plate 2c: Development of embryo dunes at the base of the wall – southern beach (2005).