

STABILITY AND SAFETY OF ANJUNA BEACH, GOA

G. NARAYANA SWAMY* AND V. V. R. VARADACHARI

National Institute of Oceanography, Dona Paula, Goa-403 004.

ABSTRACT

Studies on the Anjuna beach, Goa, from March to December, 1975, show that it is fairly stable though it undergoes seasonal changes and a series of short-term cuts and fills. The beach appears to be quite safe as the longshore currents are generally weak and the rip currents are very rare. The sweep zone is around 1.5 m in the foreshore of the beach. Investigations on beach volume indicate that sand bypasses Baga promontory and moves northward and gets locked up in the southern part of Anjuna beach during the monsoon period.

INTRODUCTION

The general stability of a beach can be assessed from the profile changes during rough and fair-weather seasons and examining them in the light of oceanographic factors such as waves, tides, littoral currents, breaker characteristics, sediment characteristics, etc. If the beach materials, washed away during the rough-weather season, are redeposited at least quantitatively during the fair-weather season, the beach can be considered to be 'stable' in the dynamic sense; the same cycle being assumed to occur in the following year, and so on. However, several feedback mechanisms, both positive and negative, complicate the situation so that while assessing the general stability of a beach sufficient margin should be allowed for the short-term, long-term, sporadic and solitary events occurring in the beach environment. Still the concept of 'general' stability of a beach holds good and it is of utmost significance as it defines the 'normal' condition as far as the beach is concerned.

Likewise the 'safety' of a beach can be conceived of in a simple manner. For recreational purposes, the safety of a beach is judged by the absence of strong longshore and rip currents, as well as deep cuts and steep slopes in the beach frontage.

The present study has been carried out with a view to identify the behaviour of the Anjuna (south) beach which is a cliff-locked beach with a characteristic setting of great tourist potential (Fig. 1), and to examine its stability and suitability for recreations such as swimming in the nearshore regions. The studies were taken up at the request of the Government of Goa, Daman and Diu, following some reports of drowning of swimmers near this beach.

The beaches of Goa have been the subject of many recent studies. Studies on the various beaches of Goa, viz., Miramar, Colva, Sinquerim and Spring (Swamy, 1976; Swamy and Varadachari, 1978; etc.) have revealed that the beaches of Goa are,

* Present Address : Regional Centre of NIO, "Sea Shell", Seven Bungalows, Versova, Bombay - 400 061

in general, stable. Certain geological and littoral characteristics of the Calangute beach lying south of Anjuna beach have been described by Veerayya (1972) and Murty, Veerayya and Varadachari (1975). Antony (1976) studied the refraction of waves off Calangute with special reference to sediment transport and rip currents. Wave refraction in relation to beach stability along the coast from Cape Ramas (Goa) to Karwar (Karnataka) has been investigated by Gouveia, Joseph and Kurup (1976). None of these studies reports any major imbalance in the beaches of Goa.

AREA OF STUDY

The study area consists of the southern part of Anjuna beach proper (Fig. 1). Anjuna (south) is separated from the main beach by rock outcrops across the beach in the north, and from the southern beaches by a rocky cliff in the south. Where the rocky cliff and the beach meet there is a small bay-like formation with scattered rocks. The Anjuna (south) beach, about 1 km long, is composed of coarse to fine sand. Like the other beaches of the same coast the sediments are moderately to well sorted.

Predominant waves off Goa have been described by Swamy and Varadachari (1978). High waves with average height of about 3 m, and period 5-9 sec are experienced mainly from directions between W and SW during the SW monsoon. These are generated mainly by W and SW winds. During the fair-weather season the waves are generally from directions between W and WNW with significant wave height of less than 1 m (Swamy, Das and Varkey, 1976). Winds of speed of about 15 kmph; and at times reaching 50 kmph, blow onshore during the monsoon period.

Tides in the area of study are semidiurnal and have been observed to have an

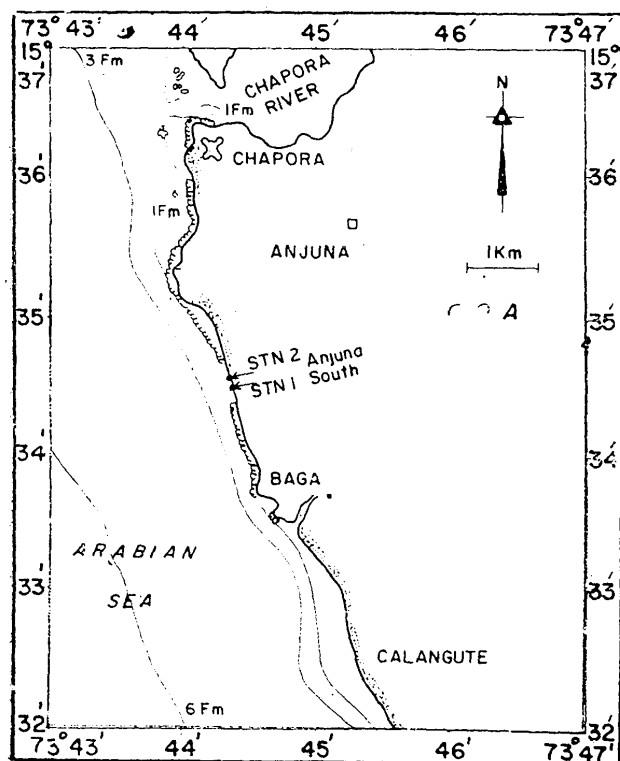


Fig. 1. Location Map.

average range of about 2.3 m during the spring tides. The predicted tide data at Mormugao harbour, Goa, is given in Fig. 2. The figure shows the variation in the Highest High Water (HHW) and the Lowest Low Water (LLW) during the period of observation (Survey of India, 1974).

The width of the foreshore is 15 to 30 m with an average slope of 1/10. The beach exhibits practically no peculiar features apart from occasional scarps of about 0.5 m the backshore. The breaker heights are generally 1 to 2 m during the monsoon period and 0.5 to 1 m during the fair weather season.

METHOD OF STUDY

Beach-profile observations were made at Station 1 in Anjuna (south)

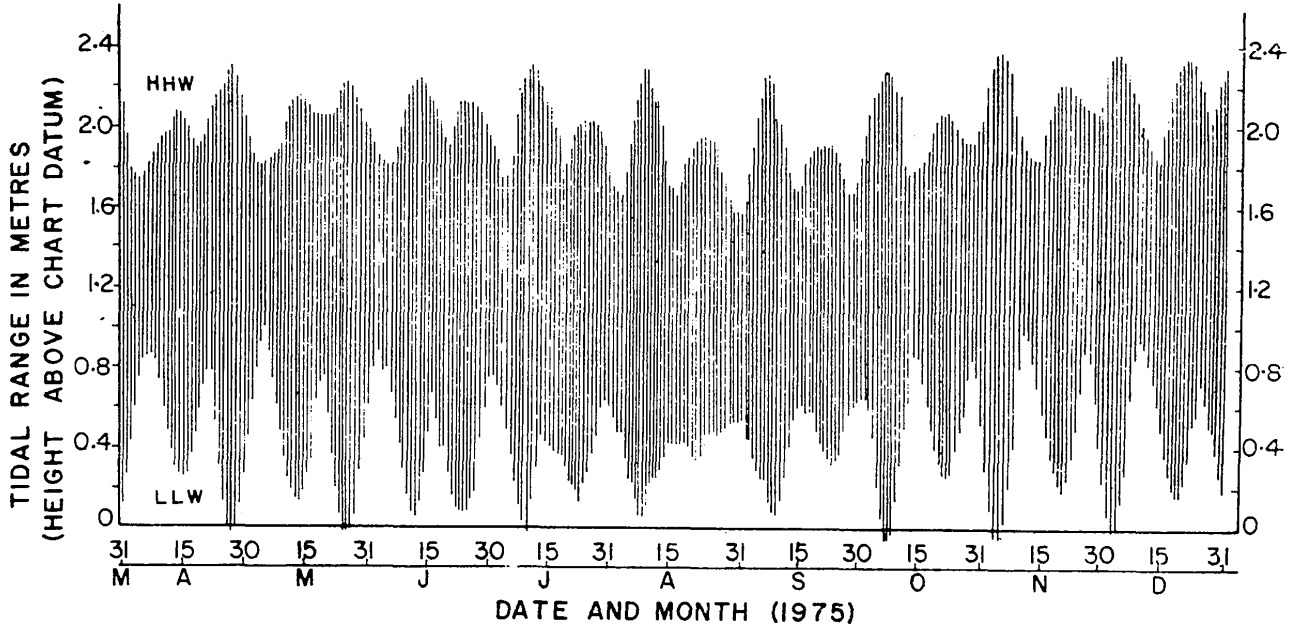


Fig. 2. Predicted tide at Mormugao, Goa, during the period of study. Figure shows the variation in the daily Highest High Water (HHW) and the Lowest Low Water (LLW).

beach from March to December, 1975. The beach configuration in terms of the temporal variation of the beach elevations (above an arbitrary reference level 6 m below the reference point) at points 5, 10, 15, (Ietc) metres seaward from the reference point is presented in Fig. 3. Mean High Water Level (MHWL) and Mean Low Water Level (MLWL) computed from the observed data are marked in the figure. Based on the beach-profile data, the volume of beach material per unit length of the beach above Mean Low Water Level has been computed and the distribution is given in Fig. 4(A), along with the variation in beach width (width of the beach between the reference point and MLWL). The speed and direction of longshore currents have been estimated at Station 1 and at Station 2 hundred metres north of Station 1, using Rhodamine-B dye following the method described by Murty, Veerayya and Varadachari (1975). The current speeds and directions are shown in Fig. 4(B). Occasional measurements of longshore currents have been conducted 100 m south of Station 1 also. All the supplementary observations are summarised in Table I. The sweep-zone of the beach, derived from the beach profile data, is presented in Fig. 5.

RESULTS AND DISCUSSION

The observations covered premonsoon, monsoon (southwest) and post-monsoon periods. It is the adjustment of the beach after the monsoon period against the monsoonal disturbances, relative to the premonsoon condition, that is mainly considered here. During the period of study all the portions of the beach exhibited signs of returning to the premonsoon beach conditions, thereby implying a dynamic stability for this stretch of the beach (Fig. 3 & 4A). The stabilization was attained through a series of cuts and fills. Among these, the fill during May-June, the cut during June-July, and the fill in the foreshore during July-August have been prominent. A comparison of the beach-elevation changes with the changes in the beach volume and beach width is interesting (Figs. 3 and 4A). While it is not clear yet

which of these three parameters is to be reckoned as the key factor for stability evaluation, a close association has been observed between the volume and the width of this 'well-behaved' beach, excluding two instances of fill during May–June and July–August. These two peaks in the volume distribution warrant explanation. The dramatic changes by themselves suggest an extraneous source contributing to these peaks. Murty, Veerayya and Varadachari (1975) and Antony (1976) have indicated that enormous quantity of beach material moves towards north along Sinquerim–Calangute beach during the monsoon season. The net annual drift is also considerable and it moves towards north. It is quite possible that a fraction of the northward-moving material bypasses the Baga promontory and gets locked up in the beach of Anjuna (Fig. 1). Sudden increase in the beach volume without any increase, but a decrease in the beach width seems possible only by mixed type of waves refracted to varying degrees off Anjuna. It may be noted that the longshore currents along the beach during the period of occurrence of the fills have been comparatively weak and inconsistent. The average breaker heights have been relatively small too. When the longshore currents increased to a magnitude of 60 cm s^{-1} throughout the beach (in June–July), equally dramatic cut in the beach was observed without much variation in the beach width (Fig. 4A). This decrease in the beach elevation gave rise to the formation of a freshwater stream across the beach about 50 m north of Station 1 (Table I). In fact, the feature encountered here might be due to the temporary locking up of extraneous beach-material by monsoon waves and circulation cells, when enough supply was available through bypass across Baga promontory from the long stretch of sandy beach (Sinquerim–Calangute) in the south. Furthermore as suggested by Ingle (1966), the average breaker height appears to be the most reliable index of accretion and erosion (Table I); indeed the breaker height is primarily a function of deep-water wave height, wave steepness and beach slope.

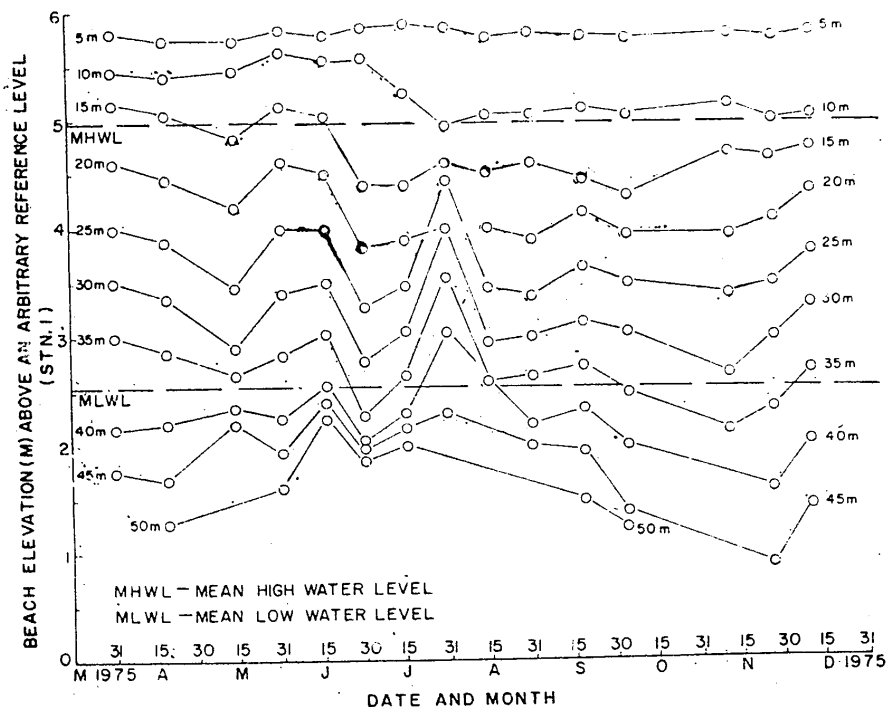


Fig. 3. Changes in beach configuration during the period of observation.

Table I. Supplementary observations.

Date	Time (Hrs)	Tide	Breaker Height (m)	CHARACTERISTICS			Remarks
				Period (Sec.)	Angle*		
					Stn. 1	Stn. 2	
31-3-75	1045	Flood	0.75	9-10	5	—	Nil
19-4-75	1150	Flood	0.75	9-10	0	5	Dye patch stationary at Stn. 1 after southward movement.
14-5-75	1000	Flood	0.5-1.0	6-10	175	175	Black sand and pebbles present. Southerly longshore current curved offshore in the bay.
31-5-75	0930	Low	1.0-1.5	12-14	5	175	Black sand observed.
16-6-75	1220	Flood	1.5-2.0	8-14	0	0	Sand very soft. Black sand and tar depositions present.
30-6-75	1030	Flood	1.5-2.0	8-14	170-175	170-175	Tar balls and black sand present. A stream cut across the beach 50 m north of Stn. 1.
15-7-75	1045	Flood	1.0-1.5	10-14	—	—	Scarp in the backshore. Offshore movement of dye patch in the bay. Tar balls and black sand present.
30-7-75	1050	Flood	0.75-1.0	8-12	—	—	Tar balls and black sand observed. Small scarp in the backshore.
14-8-75	1115	Flood	2.0-2.5	10-12	175	—	Tar balls and black sand depositions. Small scarp in the backshore.
30-8-75	0950	Low	1.0-1.5	8-14	5-10	—	Tar balls and black sand present. Freshwater stream joining the sea north of Stn. 1.
18-9-75	1530	Low	0.5-1.0	8-12	175	5	Black sand deposition present.
4-10-75	1630	Low	0.5	8-10	175	5	Longshore current oscillatory at Stn. 2 after some time.
10-11-75	1145	Flood	0.5	5-9	0	0	Dye patch almost still.
26-11-75	1020	Low	0.5	5-6	0	0	Dye patch still at both the stations.
10-12-75	1125	Low	0.5	5-8	0	0	Dye patch stand still at Stn. 1. Northward trend at Stn. 2.

* Approximate angle, anticlockwise w. r. t. coastline in degrees; '—' indicates varying angle.

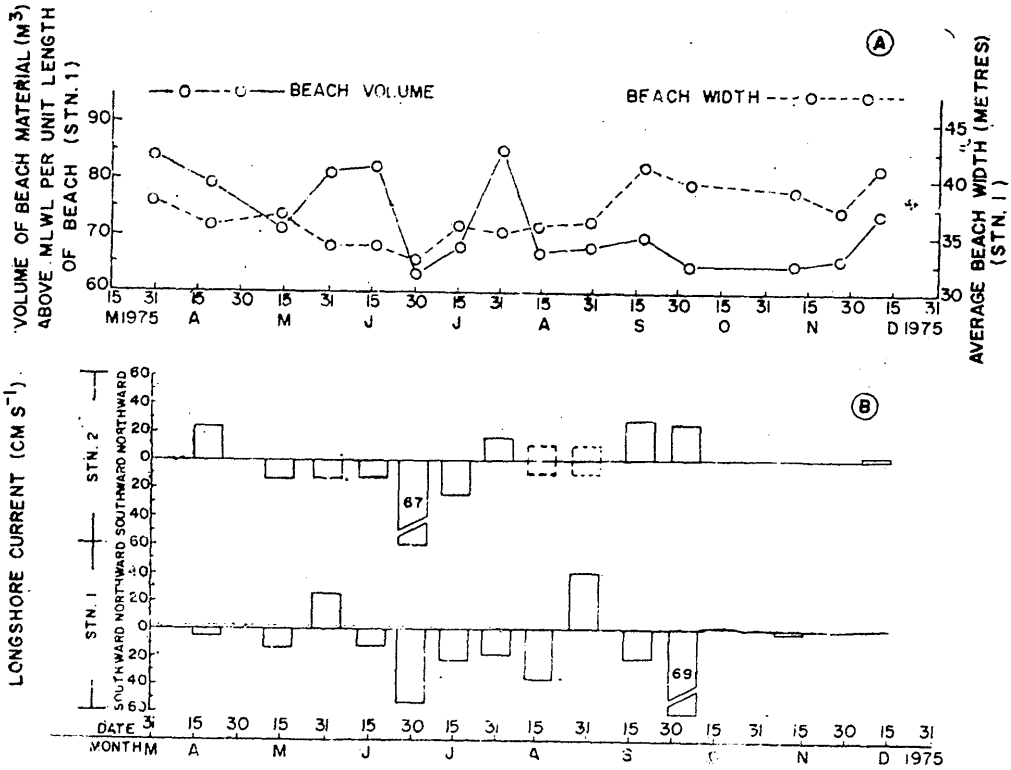


Fig. 4. Temporal changes in (A) Beach volume and beach width at Station 1 and (B) Observed longshore currents at Stations 1 & 2.

Fig. 5 shows the sweep-zone for the Anjuna beach during the period of study. The backshore is subject to a maximum cut of less than 0.5 m whereas the cut in the foreshore is seen to be about 1 to 1.5 m and in the inshore about 2 m. It cannot be expected that this small stretch of beach will show major deviations from these values normally.

The longshore currents off Anjuna beach are also interesting (Fig. 4B). During the SW monsoon, when the directions of predominant waves are from S to WSW,

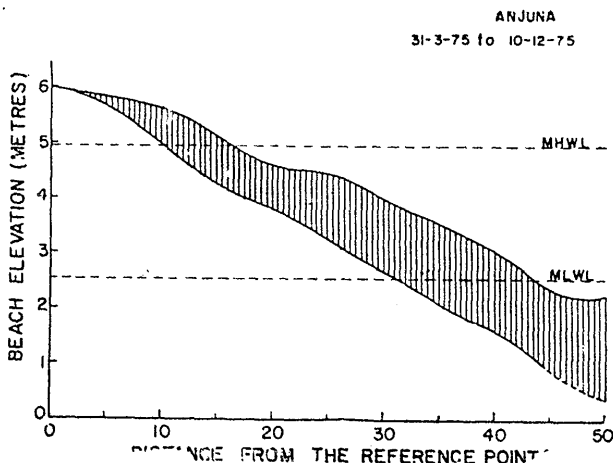


Fig. 5. Sweep-zone of Anjuna beach (Station 1).

longshore currents are expected to be towards the north along this coast (Antony, 1976). Similarly, during the fair-weather season, longshore currents should be southerly as the directions of the predominant waves are from W to WNW. However, waves from W and WSW give rise to opposing currents forming cellular structure in the circulation pattern. Fig. 4B shows that these general features are not applicable in the case of Anjuna beach. During June-July the longshore currents were observed to be strong (20-70 cm s⁻¹).

and directed towards the south, contrary to the general direction in the beaches south of this area. At the two stations of observations, diverging currents noticed during the post-monsoon season (September–October) weakened to almost nil during the fair-weather (November–December). Converging currents forming weak rips were noticed just before the onset of the SW monsoon (June). Rip currents, if any, may be expected to be confined only to the transition months when the offshore wave conditions vary over a wide spectrum. Rip currents in this beach are more a chance than a regular feature.

The inconsistent nature of the longshore currents along this beach may be explained as follows. Anjuna (south) beach is situated in a valley (trough) with hillocks on either side. It is possible that this feature extends into the sea although this is not clear from the bathymetry shown in Fig. 1. The incoming wave energy diverges in the trough region and circulation cells are formed owing to the refraction of waves of different directions and periods. A detailed bathymetric survey and wave refraction analysis may reveal some of the features of the microstructure of convergence and divergence of wave energy and the associated littoral currents in this area.

ACKNOWLEDGEMENT

The authors are grateful to Dr. S. Z. Qasim, Director, National Institute of Oceanography for his keen interest and constant encouragement.

REFERENCES

- Antony, M.K., 1976. Wave refraction studies off Calangute Beach, Goa with special reference to sediment transport and rip currents. *Indian Journal of Marine Sciences*, 5: 1–8.
- Gouveia, A.D., P.S. Joseph and P.G. Kurup, 1976. Wave refraction in relation to beach stability along the coast from Cape Ramas to Karwar. *Mahasagar-Bulletin of the National Institute of Oceanography*, 9: 11–18.
- Ingle Jr., J. C., 1966. The Movement of Beach Sand, *Developments in Sedimentology* (5), Elsevier, Amsterdam, 221 pp.
- Murty, C.S., M. Veerayya and V.V.R. Varadachari, 1975. Littoral and rip currents off Calangute Beach, Goa. *Indian Journal of Marine Sciences*, 4: 1–4.
- Survey of India, 1974. The Indian Tide Tables for the Year 1975. Office of the Geodetic and Research Branch, Dehra Dun, 236 pp.
- Swamy, G. N., 1976. Changes in Miramar–Caranzalem Beach Goa, during the period of shoaling in Aguada Bar. *Mahasagar-Bulletin of the National Institute of Oceanography*, 9: 19–22.
- Swamy, G. N., V.K. Das and M.J. Varkey, 1976. Wave characteristic off Goa for the period November to May. *Mahasagar-Bulletin of the National Institute of Oceanography*, 9: 63–66.
- Swamy, G. N. and V. V. R. Varadachari, 1978. Erosion at Colva, Goa. *Mahasagar-Bulletin of the National Institute of Oceanography*, 11: 11–20.
- Veerayya, M., 1972. Textural characteristics of Calangute beach sediments, Goa Coast. *Indian Journal of Marine Sciences*, 1: 28–44.