MORPHODYNAMIC RESPONSE OF BEACH–SURF ZONE SYSTEM

The interaction of beach-surf zone morphological features with the nearshore environmental forces leads to various beach processes. The most prominent among these processes is the seasonal and cyclic erosion – accretion. This cycle is normally presented in its simplest form as 'storm/normal profiles'. But in practice beach cycle is more complex than the simple model normally used. The complexities involved in the cycle are of great significance, for accurate beach modelling. The present chapter discusses the complex processes along the microtidal and moderate-to-high energy beach under study.

6.1 Beach Erosion

It is evident from the earlier discussions that beach erosion can occur under both increasing and decreasing wave energy conditions. Similarly it is also observed that both reflective and dissipative beaches can get eroded.

A slight increase in wave energy is sufficient to initiate erosion on a non-barred (see section 5.6.1) profile. The surf zone corresponding to this profile is devoid of any three-dimensional morphologies and waves directly act on a highly reflective beach face with $\Theta_b$ less than 2.5. Prior to the onset of southwest monsoon, there is a gradual increase in the incident wave energy. Nearshore wave height ($H_b$) and wave steepness become larger than 1 m and 0.02, but do not exceed 2 m and 0.04 respectively during this occasion.

The erosion under these conditions on a highly reflective beach is partially due to the lack of a subaqueous
storage of sand (entire active sand is stored subaerially), which leads to beach instability under increasing wave conditions. It is also due to the fact that reflective conditions are conducive to the growth of resonant subharmonic edge waves under rising wave energy (Guza and Davis, 1974). Growth of subharmonic edge waves on reflective beaches to amplitudes greater than those of incident waves under rising long period swells on steep beaches causes accentuated run-up (Short, 1979). This can cause beach face scarping (overtopping can also cause initial breaching of the berm). Erosion along this beach is initiated in this fashion. It is to be noted that this erosion occurs under moderate incident wave energy conditions. Since subharmonic edge waves are easily excited by long period and low-steepness swells (Guza and Davis, 1974), this form of erosion requires the least energy to get induced. Thus a highly reflective beach is most susceptible to erosion during rising wave energy though this beach represents a fully rebuilt condition.

The initial phase of erosion increases the beach face slope and sometimes produces a low scarp ( < 0.5 m). The onset of monsoon produces a sudden burst of incident wave energy. Wave steepness increases to 0.04 to 0.07 and wave height is now 2 to 4 m. The peak energy of the spectra shows a shift to high frequency. Breakers are plunging and breaker heights as high as 6 m occur. These high and steep waves unleash tremendous energy directly onto the beach. The beach face is partially dissipative with 10 < \( \theta_b \) < 20 allowing more energy to dissipate on the beach face. This causes severe beach cut and results in the formation of a barred profile under rising wave energy which is characterised by a longshore bar in the surf zone. Once formed, the longshore bar acts as an effective filter for wave heights. High energy waves no longer break on the beach face. They break at the partially dissipative seaward side of the bar.
Thus the available incident wave energy on the beach face decreases and the pace of beach erosion too decreases considerably even under high energy conditions. Thus the beach with a longshore bar is least sensitive to erosion and appreciable wave energy is required to induce further beach erosion.

The presence of the bar results in a segmentation of the beach-surf zone showing significant cross-shore variation in the surf scaling parameter with the beach face and the offshore side of the bar becoming partially reflective while the surf zone becoming highly dissipative. On a highly dissipative surf zone infragravity oscillations are more prominent than run up and surf zone flows (Wright et al., 1979). These become destructive only under very high wave energy conditions. Also, the large surf scaling parameter of the inshore causes an increase in the eddy viscosity and this along with the presence of larger breaker heights cause pronounced wave set-up at the shore (Wright, 1980). Growth of set up and infragravity oscillations under high energy conditions can allow the bores of partially dissipated waves to penetrate to the backshore and cause backshore erosion (Short and Hesp, 1982). The most probable mode of erosion of a highly dissipative, longshore barred beach along this coast seems to be under the influence of surf zone infragravity oscillations rather than incident wave energy. This can occur only under very high incident wave energy conditions.

The mode of erosion described till now takes place under increasing wave energy conditions and is almost uniform throughout the coast. Beach erosion can also take place under decreasing wave energy conditions. But this is not uniform all along the beach and is restricted to certain specified locations. This erosion is associated with breaks
in the southwest monsoon when the incident wave energy decreases from a peak and when it interacts with a longshore barred profile.

Immediately following the fall in wave energy, the longshore bar develops a crescentic morphology and giant cusps develop along the shoreline within two or three days. These changes in morphology do not depend on any absolute values of wave height or steepness. Simply a decrease in wave energy (fall in both height and steepness are observed) from the peak is sufficient. Severe erosion is experienced at the giant cusp embayments. Strong rip currents have been observed in these embayments. Embayment scouring is most probably due to scouring by rip currents. If the break in monsoon continues for a long period the cusp horns widen due to deposition under low energy conditions. This widening results in the alongshore shifting of rip currents. The site of embayment erosion too shifts alongshore and becomes narrow but with severe erosion. A marginal increase in wave energy enhances the erosion in the embayments without destroying the giant cusps. But a return to high energy conditions initially causes severe erosion but finally destroys the whole cuspated system.

Though localised, this type of erosion is more severe than the earlier described modes. The scarp in the embayments sometimes reaches a height of 2 m and cuts well into the backshore. This occurs under decreasing wave energy during a high energy situation, when no erosion is normally expected. Embayment erosion which can even damage coastal protective structures (Dolan, 1971) is of severe consequence along comparatively narrow and thickly populated beaches like the one studied here. Failure of beach nourishment programmes due to giant cusp formation and resulting embayment erosion have also been reported (Nummedal et al., 1984).
6.2 Beach Accretion

Accretion generally occurs under decreasing wave energy conditions. Along this coast it happens during breaks in the southwest monsoon and during post-southwest monsoonal season. Beach accretion during monsoon breaks is in the form of giant cusp horns. Cusp horns grow laterally as the monsoon breaks prolong. The exact mechanism behind this type of deposition is not clear. Accretion at the cusp horns takes place well before the welding of the bar onto the beach face. The nearshore wave steepness is usually less than 0.04. The breakers are a mixture of plunging and spilling types with significant cross-shore variation in £. The wave heights are usually <3 m. The spectra are wide and more energy is on the high frequency side. Accretion starts immediately following a decreasing trend from a peak wave energy, i.e. well before the conditions become moderate or low. Accretion continues under moderate energy conditions which follow.

Breaks in the southwest monsoon usually do not continue long enough to cause the welding onto the beach face of the crescentic bar horns and these giant cusp-crescentic bar systems are usually destroyed by high energy waves. Beach accretion during post-monsoon season is the result of onshore migration and welding onto the beach face of nearshore bars under moderate energy - low steepness waves. The welding onto the beach face results in the formation of a low berm. Beach cusps develop on this low berm. The berm grows vertically and cusp troughs get filled up gradually. These processes take place when wave steepness is between 0.03 and 0.02 and wave heights are mostly less than 2 m. The breakers transform from plunging to collapsing and surging as the
berm grows vertically. The surf scaling parameter and surf zone width also decreases while the beach face slope increases.

It is clear that beach accretion occurs both under decreasing and moderate wave energy and steepness conditions. During the southwest monsoon breaks under decreasing wave conditions accretion starts at the crescentic features. The vertical growth of the beach and berm crest takes place under post-southwest monsoon moderate conditions. Hence beach rebuilding actually starts well before the post-southwest monsoon welding of the bars onto the beach face.

Giant cusps that form during monsoon breaks appear just after the development of crescentic bar as more or less a mirror image. But the small scale beach cusps formed during post monsoon accretion are not related to the surf zone crescentic morphology. They appear immediately after the welding of the bar onto the beach face and seem to be related to foreshore sediment deposition (to be discussed later).

Cuspated beaches observed are intermediate stages in the process of beach accretion and they get filled up as the beach acquired a fully accreted equilibrium state.

6.3 Longshore Bar Response to Changing Wave Conditions

It is seen that longshore bar develops as a result of monsoonal erosion and it migrates offshore with an increase in the height of the breakers which are of plunging type. The cross-shore distance of the bar crest from the shoreline is more or less, equal to the distance of this prominent breaker line. The offshore migration of the bar is accompanied by offshore shifting of the breaker position. These
indicate that there is a close relationship between bar formation and the processes in the vicinity of breaker zone.

A breaker zone mechanism suggested by Miller (1976) is trough excavation which causes erosion of a depression by the enhanced stresses at the impact point of breaking waves. Model studies have also shown that the vortex of a plunging breaker extends to the bottom to initiate such a process. During the present observations, it is noted that the plunging breakers dominating during April-May do not cause the formation of longshore bars. It produces a subaqueous terrace. Monsoon waves too produce a subaqueous terrace initially. High breakers acting on this subaqueous terrace excavates a trough to form longshore bar.

It has been shown in the earlier sections that the bar started as linear and later became crescentic. Sufficient data is not available to exactly decide the time and processes involved in the transition. Field estimates point to a better developed crescentic form just after the peak wave energy coinciding with a recovery period. Some evidence for such a transition exists in literature also (Short, 1979).

6.4 Crescentic Bar Development

Bed-form modifications by strong rip currents has been suggested as the reason for the formation of crescentic bars (Short, 1979; Sonu, 1973). According to Holman and Bowen (1982) and Bowen and Inman (1971) drift velocities associated with standing edge waves are responsible for generation of crescentic bars.

Rip currents observed along the present study area before the development of crescentic bars are not space fixed. Hence the possibility of rip currents scouring bed
form is less. But once the giant cusps are formed, rip currents get space fixed at the embayments and scouring of embayments is possible.

If standing edge waves are responsible for the formation of crescentic bars, then the observed wave lengths have to be compatible with those computed using edge wave theory (Chapter 3). Since direct measurements of crescentic bar spacings are difficult, an indirect way of using the giant cusp spacing as equivalent is adopted here. Giant cusps commonly co-exist with crescentic bars forming as a reflection of the bar morphology on the shoreline (Sonu, 1973; Komar, 1976). Studies by Sonu (1973), Wright and Short (1984) and Sallenger et al. (1985) justify this approach.

Bar crest distance from the shoreline as observed here are between 50 to 160 m (Table 5.2). The bar distance corresponding to giant cusp formations during monsoon breaks are between 120 and 160 m. The corresponding standing mode-1 edge wave periods computed using Eq. (3.8) are in the range 80 to 100 s. The beach slope used for this computation is the average slope of the beach face and the inshore. Crescentic bar wavelengths corresponding to these periods, computed using Eqs. (3.3, 3.4 & 3.7), are between 190 and 300 m. The observed giant cusp spacings of 150 - 350 m are broadly comparable with the estimated crescentic bar spacings. It may also be noted that the beach face is partially reflective ($\theta_b < 20$) during this time (Fig.5.1). But for computing $\theta_b$ the amplitude measured just outside the breaker zone has been used. Note that an amplitude measured at the seaward margin of the swash zone is probably more relevant in computing $\theta_b$. The effect of using an inner surf zone amplitude would be to further lower $\theta_b$ making the foreshore even more reflective. High beach reflectivity is very much conducive to the generation of edge waves. This
indicates that the chances of crescentic bar development due to mode-1 standing edge waves are good.

Since the crescentic bars occurring towards the latter half of monsoon do not possess any rhythmic shoreline features, such conclusions are not possible for that season.

6.5 Beach Cusp Formation and Disappearance

Beach cusps are found to occur during beach rebuilding process. Hence an understanding of the morphodynamic processes behind their formation leads to a better understanding of the processes of beach and berm development.

The probable edge wave lengths are computed for subharmonic (edge wave period = twice the incident wave period) and synchronous (edge wave period = incident wave period) edge waves (see Chapter 3). These are compared with the corresponding cusp wave lengths and are given in Table 6.1. These are comparable and points to a relationship between cusp wavelengths and edge wavelengths. Most of the cusp spacings are comparable with the length of synchronous, mode-1 edge wave. It may be noted that those comparable with the length of subharmonic, mode-zero edge waves were observed for cusps formed on a higher berm with a steeper beach face during the final stages of beach reformation.

A partially reflective beach face is present when the longshore bar formed due to monsoonal erosion starts migrating onshore. The breakers are mostly plunging during this period. A low, subtle berm develops seaward of the monsoon berm. Many of the waves break at the longshore bar and then reform in the trough. These waves plunge onto the partially reflective beach face. These breakers are more or less normal to the shoreline. Wright et al. (1979) have observed
Table 6.1 Computed and observed
cusp wavelengths (m).

<table>
<thead>
<tr>
<th>Year</th>
<th>Observed</th>
<th>Computed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>subharmonic</td>
<td>synchronous</td>
</tr>
<tr>
<td></td>
<td>n = 0</td>
<td>n = 1</td>
</tr>
<tr>
<td>1980</td>
<td>36₁</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>38ₜ</td>
<td>29</td>
</tr>
<tr>
<td>1981</td>
<td>40₁</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>58ₜ</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>*33ₜ</td>
<td>31</td>
</tr>
<tr>
<td>1982</td>
<td>38₁</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>43ₜ</td>
<td>26</td>
</tr>
<tr>
<td>1983</td>
<td>35₁</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>*42ₜ</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>*40ₜ</td>
<td>58</td>
</tr>
<tr>
<td>1984</td>
<td>36₁</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>*43ₜ</td>
<td>40</td>
</tr>
</tbody>
</table>

1 - on a low berm; h - on a high berm;
* - comparable with subharmonic edge wave wavelength

that different types of edge waves can occur under these
conditions. These edge waves can cause the formation of
beach cusps on the low berm already formed. Nearshore cur-
rents are then dominated by cell circulation partly due to
the influence of a cuspated shoreline.

Once the beach becomes cuspated the morphology may
interfere with the continued edge wave excitation. Thus the
dge wave amplitude may be reduced by the presence of well
formed cusps (Guza and Bowen, 1981). This along with the
continued accretion of the beach and filling up of the bays,
cause the disappearance of cusps. The shoreline becomes straight and the berm becomes higher. The second set of beach cusps form on this beach with a higher berm and a more reflective beach face. The breakers are plunging, collapsing or surging. A reflective beach face with surging breakers is most conducive to edge wave formation. Thus, edge waves can form under the conditions existing at Valiathura towards the final stages of beach reformation and may initiate the development of beach cusps. During this period the supply of sediments to the beach face is maintained since the beach continues to be in an accretive phase. The waves break very near to the shoreline and they are from a south to southwest direction. The axes of the cusps orient themselves in a direction parallel to wave approach so as to provide least resistance to the incoming swash. Hence the cusp axes are inclined to the shoreline in a south-southwest direction. The longshore currents are not affected by these cusps since they are on a high berm. Currents continue to be northwesterly. Formation of beach cusps when oblique waves dominate goes against the observations of Johnson (1919), Timmermans (1935) and Longuet-Higgins and Parkin (1962) that beach cusp formation is most favourable when waves approach normal to the beach.

The beach remains reflective with collapsing or surging breakers after the disappearance of cusps. Though these conditions are most conducive to edge wave formation, no cusps are observed along the beach. It may be noted that there was a continued supply of sediment to the beach on both occasions of cusp development described earlier. Since the beach has acquired an equilibrium profile by December, excess supply of sediment to the beach ceases by then. Hence no cusps are formed even if edge waves are present along this beach during this period.
6.6 Conceptual Models of Beach Morphodynamic States

The interaction of morphologies and the driving forces leads to a more or less equilibrium condition. Perfect equilibrium conditions are not usually reached in the field due to the frequent changes in the forces. Notwithstanding the frequent variations in the beach and nearshore system, certain beach states can be distinguished at different stages of an erosion - accretion cycle. Each beach state is associated with certain characteristic morphodynamic processes. Based on the observations made, a model comprising of six morphodynamic states in an erosion - accretion cycle is suggested.

The different beach states thus identified are:

- Fully reflective accretional extreme (Beach state I)
- Reflective eroding beach (Beach state II)
- Fully eroded beach (Beach state III)
- Crescentic barred beach with giant cusps (Beach state IV)
- Highly dissipative beach with welded bar (Beach state V)
- Cuspated beach (Beach state VI)

These beach states occur usually in the above sequence along this coast as wave climate changes from fair to rough and back to fair seasons. The evident characteristics of these beach states are described below and summarised in Table 6.2 and Fig.6.1.

6.6.1 Beach state I

This is a fully reflective accretional system with most of its active sediment stored in the subaerial part of the beach. It has a well developed berm with a high berm crest running parallel to the shoreline. The berm crest is
<table>
<thead>
<tr>
<th>Beach state</th>
<th>Shoreline and surf zone morphology</th>
<th>Wave energy, surf scaling parameter, breaker type</th>
<th>Nearshore currents</th>
</tr>
</thead>
<tbody>
<tr>
<td>I (Fully reflective accretional)</td>
<td>'Non-barred profile' type, no alongshore variations in morphology, steep beach face.</td>
<td>Low-to-moderate energy, highly reflective beach face, $c_b &lt; 2.5$, surging and collapsing breakers.</td>
<td>Weak longshore currents.</td>
</tr>
<tr>
<td>II (Reflective eroding)</td>
<td>'Non-barred profile' type uniform small scarp and a subaqueous terrace. No alongshore variations in morphology. Steep beach face.</td>
<td>Increasing from low-to-moderate energy. Reflective to partially reflective beach face, $c_b &lt; 10$, plunging breakers.</td>
<td>Strong longshore currents.</td>
</tr>
<tr>
<td>III (Fully eroded)</td>
<td>'Barred profile under rising wave energy' type. Longshore bar in the surf zone. No alongshore variations in morphology. Moderately steep beach face.</td>
<td>High energy situation cross-shore variation in reflectivity. $c_b &lt; 10$; $c_s &gt; 33; 2.5 &lt; c_{bar} &lt; 33$. Cross-shore variation in breaker type. Plunging and spilling breakers.</td>
<td>Cell circulation with rip currents (not space fixed).</td>
</tr>
<tr>
<td>IV (Crescentic barred with giant cusps)</td>
<td>'Barred profile under decreasing wave energy' type. Crescentic bar in the surf zone, significant alongshore variations in morphology. Shoreline is giant cuspated. Alongshore variation in beach face slope.</td>
<td>Decreasing from high energy. Cross-shore variations in reflectivity $c_b &lt; 10$; $c_s &gt; 33; 2.5 &lt; c_{bar} &lt; 33$ cross-shore variations in breaker type. Plunging and spilling breakers.</td>
<td>Cell circulation with strong rip currents at the embayments.</td>
</tr>
<tr>
<td>V (Highly dissipative with welded bar)</td>
<td>'Welded profile' type. No alongshore variations in morphology. Very gently sloping beach face.</td>
<td>Moderate wave energy $10 &lt; c_b &lt; 20$; $c_s &gt; 33$ Partially dissipative beach face. Highly dissipative inshore spilling and plunging breakers.</td>
<td>Cell circulation/longshore currents.</td>
</tr>
<tr>
<td>VI (Cuspated beach)</td>
<td>'Barred profile under decreasing wave energy' type. Beach cuspatated with normal/oblique axes.</td>
<td>Moderate wave energy $c_b &lt; 20$ Partially dissipative beach face plunging, surging and collapsing breakers.</td>
<td>Cell circulation/longshore currents.</td>
</tr>
</tbody>
</table>
Nearshore currents | Erosion/accretion condition
---|---
Weak longshore currents | Highly sensitive to increasing wave energy. Erosion under rising wave energy. No change under existing or decreasing wave energy
Strong longshore currents | Erosion under rising wave energy. Accretion under decreasing wave energy.
Cell circulation with rip currents (not space fixed) | Least sensitive to increasing wave energy. Highly sensitive to decreasing wave energy.
Cell circulation with strong rip currents at the embayments | Erosion at embayments and deposition at cusp horns.
Cell circulation | Beach cusps form under prevailing or decreasing wave energy (Beach state VI). Increasing wave energy causes beach state III.
Cell circulation/longshore currents | Beach state I develops under decreasing. Increasing wave energy causes Beach state III.
Fig. 6.1 Conceptual model of beach morphodynamic states.
backed by a landward dipping slope. Breakers are exclusively surging or collapsing and the turbulence related to breaking processes is confined to the zone of run-up on the beach face. Low-to-moderate energy conditions and a steep beach face cause a highly reflective beach face ($\theta_b < 2.5$). This state is in dynamical equilibrium and no significant changes occur as long as the existing wave conditions continue or decrease. But it is highly sensitive to increasing incident wave energy and even a marginal increase in incident wave energy causes beach face scouring or scarp development. Components of cell circulation are absent in the nearshore current and only weak longshore currents are present.

The beach shows strong two-dimensionality with no significant alongshore variation in the morphology and it corresponds to the 'non-barred profile type.'

6.6.2 Beach state II

This is a reflective eroding beach and results from the previous state due to a marginal increase in wave energy forming a moderate-to-high energy situation. A uniform small scarp ($< 0.4$ m) may be present, but the beach face will be steeper than that of Beach state I and reflective with $\theta_b < 10$. This is an unstable state and an increase or decrease in the incident wave energy can induce changes in the morphology. Further erosion is mainly due to the incident high energy waves. This state, too, shows strong two-dimensionality without any significant alongshore variation. The profile is closer to a 'non-barred profile' type. A subaqueous terrace seaward of the shoreline is present and most of the breakers plunge seaward of the terrace. Irregularly placed weak rip currents are present along with strong longshore currents.
6.6.3 Beach state III

It is a fully eroded beach. An almost straight shoreline and a well-developed longshore bar are characteristic to this beach state. Continuous action of high energy waves for a few days results in the development of this beach state. The beach face is partially reflective with $\theta_b < 10$. The surf zone is highly dissipative with $\theta_s \gg 33$. The offshore side of the bar is partially reflective with $2.5 < \theta_{bor} < 33$. High waves plunge at the seaward side of the bar while smaller waves spill across the bar. Broken waves reform in the trough and collapse on the beach face. Hence most of the incident wave energy gets dissipated before reaching the shoreline. The direct impact of the incident waves on the shoreline is considerably reduced. The beach becomes least sensitive to increasing wave energy and further erosion takes place only under exceptionally high energy waves. But a fall in wave energy causes significant changes in the morphology. The beach continues to show strong two-dimensionality and the profile corresponds to a 'barred profile under rising wave energy' system. Cell circulation with rip currents dominate the nearshore currents. But these are not space fixed.

6.6.4 Beach state IV

This is a crescentic barred beach with giant cusps. This beach state develops from a fully eroded state under decreasing wave condition. Subaqueous crescentic bar and shoreline rhythmicity in the form of giant cusps are the pronounced features of this beach state. The crescentic bars become dissipative with $\theta_{bor} < 33$ for decreasing breaker heights. Most of these waves spill across the bar and collapse on the partially reflective ($2.5 < \theta_b < 20$) beach face. Beach loses its two dimensionality and significant
Alongshore variations in the morphology occur. Giant cusp embayments are affected by erosion while deposition takes place at the horns. Alongshore migration of giant cusps causes the shifting of the site of erosion and deposition. These changes take place under a decreasing wave energy situation. Rising wave energy initially increases embayment erosion and finally destroys rhythmic features and goes back to Beach state III. Nearshore currents associated with Beach state IV are dominated by cell circulation systems with strong rip currents at the cusp embayments.

6.6.5 Beach state V

This is a highly dissipative beach with a welded bar. Beach face is very gently sloping with $10 < \theta_b < 33$ and the inshore is dissipative with $\theta_s > 33$. Breakers are mostly spilling. This is an accretive state and a continuation or a decrease of the prevailing wave condition leads to the development of beach cusps. An increase in wave energy transforms this beach state into Beach state II or III. The profile corresponds to a welded bar profile type which is by and large two-dimensional. Nearshore is characterised by weak, irregularly spaced cell circulation system.

6.6.6 Beach state VI

Continuation of Beach state V transforms the beach to the cuspated beach state. Axes of the cusps are either normal or oblique to the shoreline with an alongshore spacing of 40 to 60m. Beach face is reflective to partially reflective with $\theta_b < 20$. Breakers are plunging, surging or collapsing. The corresponding profile of this beach state is similar to barred profile under decreasing wave energy type and shows significant alongshore variations. Decrease or continuation of the prevailing wave conditions cause beach
building and Beach state I results. But an occurrence of high energy condition can bring in Beach state II or III. Cell circulation with spatially inconsistent rip current dominate when cusps have oblique axes.

6.7 Summary

Beach erosion under rising wave energy is more or less uniform throughout the coast. Erosion under decreasing wave energy is confined to the embayments which may migrate alongshore. Beach accretion occurs under decreasing and moderate energy conditions. The transformation of longshore bars into crescentic forms and the development of beach cusps can be due to the presence of edge waves. Six beach states with characteristic morphodynamic features are identified in an erosion-accretion cycle. Various beach states react to the same wave conditions differently. It emphasises that the existing beach morphodynamic state is an important factor in determining the erosional or accretive nature of the beach.