THE MANAGEMENT OF ARTIFICIAL BEACHES

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Abstract - An artificial beach that prevents storm waves from attacking the base of a cliff can be used as a means of coastal protection in preference to sea walls or boulder ramparts, providing it persists for a sufficient period to be cost-effective. To achieve this, it is necessary to understand the processes that erode emplaced beach material and disperse it offshore and alongshore. Monitoring of artificial beaches has generally been restricted to the emplaced sector, to decide when renourishment is necessary, but a wider approach to the management of artificial beaches should include mapping of changes in adjacent areas into which emplaced sand moves and assessments of whether it is beneficial or otherwise in these areas. Examples will be given from artificial beaches on the shores of Port Phillip Bay, Australia.

Key-words - Australia, artificial beaches, coastal management, coastal monitoring.

Résumé - On sait que la création de plages artificielles est un bon moyen de lutte contre l'érosion marine, à condition toutefois que le coût élevé de l'opération soit compensé par une “durée de vie” suffisamment longue. A partir de l'exemple de Port Phillip Bay en Australie, où près de vingt plages ont fait l'objet d'opérations de rechargement, l'auteur montre que la gestion des plages artificielles, contrairement à ce qui est généralement réalisé, doit dépasser l'aire stricte de rechargement et faire l'objet d'un suivi très attentif étendu à la fois à des profondeurs importantes comme à des zones adjacentes suffisamment larges.

Mots-clés - Australie, plages artificielles, gestion du littoral, suivi de l'évolution littorale.

Introduction

The chief response to the modern global prevalence of beach erosion (Bird 1985) has been the construction of sea walls, boulder ramparts, and other structures designed to halt recession of the coastline. The outcome has very often been further reduction of beaches and lowering of foreshores in front of such structures, which are then undermined by storm wave attack. The response to this has generally been further engineering, with coastal management agencies bearing the costs of the replacement, reinforcement, and extension of sea walls or other protective structures. An alternative is to emplace and maintain artificial beaches as a means of absorbing wave energy and protecting the coastline from further erosion.

There are now artificial beaches in many parts of the world (Schwartz and Bird 1990), notably in the United States, Europe, Australia, and the Black Sea coast of the Soviet Union. On the shores of Port Phillip Bay in south-eastern Australia, for example, some 20 beaches have been artificially renourished in recent years. Port Phillip Bay is a marine embayment with a coastline 256 km long, and about 20 km (7.8 %) of its coastline is now fringed by artificial beaches (Bird 1990). The work had been carried out by the Port of Melbourne Authority at a total cost of about $A5 million [$US 4 million].

On the north-east coast of Port Phillip Bay (Fig. 1) most of the beaches were emplaced on sectors where sea walls had been built to halt coastline recession, and the natural beaches fronting them had then diminished (Fig. 2). Complaints about beach
depletion led to artificial renourishment of beaches in front of sea walls, using sand trucked in from inland quarries or dredged from the sea floor and pumped onshore. Initially, these beaches were shaped into a terrace a metre above calm sea level at high spring tide and 20 to 30 metres wide. Typically, storm waves have cut back the seaward margin of the emplaced terrace, some of the removed sand (generally the finer fraction) being carried alongshore. On most of the beaches at least half of the sand volume remained in place after a period seven years, but in several cases secondary nourishment has been necessary to maintain these beaches.

In 1984 an artificial beach was used for the first time to protect a sector of retreating cliffs at Quiet Corner, Black Rock, on the north-east coast of Port Phillip Bay, where no sea wall or protective structure had been built (Fig. 3). It has proved successful in halting cliff recession for the ensuing seven years, and indicates that artificial beaches can be used as a means of stabilising coastlines. An artificial beach that prevents storm waves from attacking the base of a cliff is a suitable means of coastal protection, in preference to sea walls or boulder ramparts, providing it persists for a sufficient period to be cost-effective. The costs of emplacing and maintaining artificial beaches on the coast of Port Phillip Bay have proved to be less than the costs of repairing damaged sea walls on sectors where the beach has disappeared.

In order to manage such artificial beaches effectively it is necessary to understand the processes that erode the emplaced beach material and disperse it offshore and alongshore. Monitoring of artificial beaches has generally been restricted
Fig. 3 - Changes on the coast south of Quiet Corner, Black Rock, where a previously stable bluff was undercut by wave attack to form a receding cliff when the protective beach diminished, and erosion was subsequently halted by emplacing an artificial beach.

Fig. 2 - Conversion of retreating cliffs to stabilised bluffs by means of a sea wall can result in the subsequent removal of the adjacent beach by reflected waves.
to the emplaced sector, to decide when further nourishment is necessary to maintain the beach, but a wider approach to the management of artificial beaches should include mapping of changes in adjacent areas, and a geomorphological analysis to explain why these changes are taking place. The point can be illustrated with reference to the artificial beach emplaced to halt cliff recession near Quiet Corner, south of Black Rock.

The artificial beach at Quiet Corner

Until the late nineteen-thirties the cliffed coastline at Black Rock, Port Phillip Bay (Figs. 1, A and 4), had been receding several metres per year, and was threatening to undermine Beach Road, the coastal highway. A sea wall was built to halt this erosion, and when it was completed in 1939 the cliffs were graded and vegetated as a stable slope. Thereafter, the beach that had fronted the receding cliffs gradually dwindled.

The sea wall came to an end just south of the headland known as Quiet Corner where in 1939 the receding cliffs gave place to stable, vegetated bluffs (Fig. 1, B). However, as the Black Rock beach diminished, the beach that bordered these bluffs beyond the limit of the 1939 wall was also depleted, and by the nineteen-seventies storm waves were undercutting these bluffs, so that basal erosion was again threatening to undermine a segment of Beach Road (Fig. 5, A).

A proposal to extend the sea wall to halt this cliffing was opposed by local residents, who argued in favour of an artificial beach as a protective formation which would also restore scenic and recreational values to this sector. This was agreed, and in mid-1984 an artificial beach terrace 100 metres long, 25 metres wide, and a metre above high spring tide level, was built by pumping in about 5300 cubic metres of coarse shelly
Fig. 6 - An air oblique view south-eastwards over the artificial beach near Quiet Corner. Photo: Port of Melbourne Authority.

Fig. 7 - Changes on beach profiles south of Quiet Corner between 1984 and 1989, when substantial amounts of sand moved south-eastwards from the artificial beach.
sand from a sea floor borrow area three kilometres south at a cost of $A46,000 (Fig. 5, B and Fig. 6).

Fig. 5 - The coastline south of Quiet Corner, A - in 1980 after sea wall construction had been followed by beach depletion, B - in 1984, when an artificial beach was emplaced, C - in 1989, when the artificial beach had been cut back by wave erosion, a sand bar had formed offshore, and sand had drifted south-east to Quiet Corner. Wave roses indicate seasonal variations in wave approach on this sector.

Changes on artificial beaches such as this can be monitored by regular mapping, supported by data from sequential air photographs, and by means of repeated surveys along transverse profiles from the back of the beach out on to the nearshore sea floor. Successive profile surveys showed that the beach terrace emplaced south of Quiet Corner was cut back by storm waves: by February 1986 some of the finer sand had been withdrawn from the beach and deposited as a sand bar that has persisted in the nearshore zone, its crest moving shoreward in calmer weather and seaward after storms. However, it is evident from the profiles (Fig. 7) that the volume of sand lost from the artificial beach here greatly exceeded the volume deposited in the nearshore bar, and further surveys showed that sand has also been carried alongshore (Fig. 5, C).

On this coastline the beaches occupy compartments between rocky headlands (Fig. 1), and show a dominance of northward drifting in the summer half-year (November to April in the Southern Hemisphere) and southward drifting in the winter half-year (May to October). This is illustrated on Black Rock Beach (Fig. 4), and is correlated with a slight seasonal variation in the proportions of southerly and westerly wind action, as shown by the summer and the winter wave roses in Fig. 4. The regime
of seasonal beach drifting varies with the orientation of the beaches. On Black Rock Beach, which faces south-west, the northward and southward seasonal drifting is balanced, but where the aspect is more westerly there is a gradual loss northward around intervening rocky headlands, and where the aspect is more southerly there are losses southward (Bird 1991). Quiet Corner beach, having a more southerly orientation than Black Rock Beach, has responded only to a small extent to the northward drifting typical of this coastline in summer, with minor migration of its boundary towards Quiet Corner (X on Fig. 5, C). This part of the beach faces almost due south, and has therefore been less affected by the large component of southerly summer wind and wave action than Black Rock Beach, which faces south-west. The refraction of southerly waves over and around the nearshore sandstone reefs has also created a wave pattern that has impeded drifting towards Quiet Corner.

By contrast, there has been strong south-eastward drifting of beach sand each winter along the shore, behind the rocky platform to and beyond Banksia Point (Fig. 5, C). This is illustrated in the transverse beach profiles (Fig. 7): A-E showed substantial losses, F and G smaller gains. Between November 1984 and November 1989 the artificial beach lost about 2336 cubic metres of sand (about 44 % volume), of which 1941 cubic metres was added to the beach south to Banksia Point. This strong south-eastward drifting was the outcome of the greater proportion of westerly winds in winter (Fig. 5, B), producing strong waves that arrived obliquely to the beach and swept sand towards Banksia Point, where the beach is now much wider and higher than it was in 1984.

**Sandringham Beach**

Similar problems have arisen a few kilometres to the north, where Sandringham beach (Fig. 1, C) occupies the coast between Picnic Point and Red Bluff (Fig. 8).
Apart from two minor sea walls and the dumping of rubble debris to blanket the cliff north of Red Bluff there has been little modification of this sector, and the beach in front of generally vegetated bluffs showed the same northward drifting in summer and southward drifting in winter as on Black Rock Beach. However, in recent years the Sandringham beach has gradually diminished, and in late summer and early winter it has been so low and narrow in the souther part (south from Royal Avenue: Fig. 8) that storm waves have attacked and undercut the vegetated bluffs, forming receding cliffs of slumping sandy clay. As these are cut back, there is a risk that another segment of Beach Road, which here runs close to the top of the bluffs, will be undermined.

In consequence, Sandringham municipality has asked the Port of Melbourne Authority to emplace an artificial beach here as a means of halting cliff recession. As on the coast south of Quiet Corner, local people would prefer such a beach, providing amenity and recreational opportunity, to a sea wall or rocky boulders at the base of the eroding cliff. Aware of the changes that have occurred on the other beaches, the Port of Melbourne Authority indicated the risk that an artificial beach on this 600 metre sector, with an orientation similar to that of Hampton Beach, would lose sand northward in summer towards Picnic Point, and round into Sandringham Harbour. To reduce this risk, the Authority made a condition that an anchor groyne first be built opposite Royal Avenue to retain the artificial beach in front of the eroding cliff sector (Fig. 8). Such a groyne will impede the loss of sand northwards, each summer, and enable a 25 metre wide artificial beach to be held in a position where it can continue to protect the base of the bluffs from storm wave erosion. There is a possibility that sand will accumulate each winter alongside Red Bluff, and that some of this will escape southwards past this headland into the next bay, but this is not expected to be a major problem, because the orientation of the beach is more like Hampton Beach, where northward drifting has predominated, than Quiet Corner Beach, where south-eastward drifting has been dominant.

Construction of the groyne was completed in September 1990 as a prelude to the emplacement of about 35,000 cubic metres of sand to form a protective beach, which is expected to bring to a halt the recession of these cliffs.

Conclusion

Artificial beaches can be used to protect eroding coastlines, as an alternative to sea walls and boulder ramparts, but their management requires an understanding of geomorphological processes. On coastlines where longshore drifting of beach sand is prominent the patterns and regimes of longshore drifting, and their variations with coastal aspect. Case studies of artificial beach projects, based on repeated monitoring, can influence the design of on-going beach nourishment projects, and provide a basis for management of restored beaches.

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References