# Beach accretion with erosive waves : "Beachbuilding"
## *Accrétion sur les plages avec vagues érosives : "la technique de construction de plage"*

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**Abstract** : A new method of beach preservation, the *Beachbuilder Technique*, proposes to harness the energy of normally erosive waves to produce beach accretion. A "flow control sheet" located in the surf zone directs the flow of swash and backwash causing net transport of sediment onto the beach. Beach and surf zone profiles created by the wave-tank tests show that the technique leads to accretion on this beach, during every test run with erosive waves. The successful wave tank results should reproduce on actual beaches ; rapid accretion on real beaches can be expected from the scaled wave-tank results. It is anticipated that by use of this new technique, costs of beach preservation would be cut by as much as 66 %. Furthermore, rapid beach accretion, quick reaction, high mobility, good durability, and provision of employment for making the installations are major benefits to be derived.
***Keywords*** : *Erosion - Waves - Accretion - Nourishment - Beach*

**Résumé** : Une nouvelle méthode de protection de plages, la *Technique de Construction de Plage*, est proposée. Un "drap de contrôle d'écoulement" placé dans la zone des brisants dirige le clapotis et le remous et provoque un transport de sédiment vers la plage. Les profils de plage et de brisants créés par des tests conduits en bassins montrent que la technique produit une accumulation sur la plage pendant chaque test avec vagues érosives. Les résultats favorables obtenus dans les réservoirs devraient se répéter sur les vraies plages ; on peut s'attendre à des dépôts rapides sur les plages à l'échelle des bassins. L'emploi de la méthode réduirait des deux tiers le coût de la préservation des plages. D'autres avantages à prévoir sont une alimentation naturelle rapide, une réaction rapide, une grande mobilité, une bonne "longévité", et la création d'emplois lors de l'installation du système.
***Mots-clés*** : *Érosion - Vagues - Accrétion - Alimentation - Plage*

Worldwide expenditures of well over USD 1 500 million per year are made to restore beaches and shorelines and to prevent future damage (Houston, 1995). While sandy beaches are dynamic and meant to erode, the use of attractive and expansive beaches is in great demand, to such extent that they are vital to the economic survival of some communities. Travel and tourism may well be the largest industry in the world with beaches a preferential destination. In the U.S., for instance, 85 % of tourist revenues are spent in coastal states. Billions of dollars worth of beach homes and coastal infrastructures cannot be abandoned (Houston, 1995).

Past attempts at saving the shoreline usually involved installation of solid structures such as seawalls and revetments, expensive aesthetically unappealing yet generally ineffective. Beach nourishment acts as a buffer against wave attack and coastal flooding, and provides a recreational beach (Charlier, 1989 ; Davison *et al.*, 1992).

## I - BEACH NOURISHMENT

Renourishment is not problems free. The sand that is used must be compatible with the native *viz.* original sand. If too fine or soft it will be rapidly lost. Locating a source for suitable sand is not always easy and it must be sufficiently accessible to prevent excessive cost. Occasionally a certain type of dredge is needed.

Nourishment lasts, on average, about three to ten years depending on the site and on the severity and number of storms occurring during the period (Weggel, 1995). Beach nourishment does not remove the cause of erosion, though might attenuate it, and temporarily protects upland development from waves and flooding (*ibid*). There is no existing method for actually preventing beach erosion.

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## II - BUILDING

Methods intended to prevent beach erosion attempt to decrease the effectiveness of erosive waves by dissipating their energy with the use of obstructions such as concrete blocks, boulders, tires, etc..., placed in the surf zone. This approach has rarely, if ever, proven successful in preventing erosion of a beach. The swash, in-flow of the surf onto the beach, has much greater energy than the backwash, seaward return flow down the beach. Could not the superior energy of the flow toward the beach be employed to move more sand particles to than are moved away from the beach ? Erosion might be prevented, or at least slowed if, instead of trying to dissipate the energy of the in-flowing surf, it were utilised to produce a net transport of dislodged and suspended sand particles toward and onto the beach.

The *Beachbuilder technique* has this objective. The hypothetical operation of this technique is schematically illustrated in Fig. 1. Tethered in the surf zone is a flow-control sheet (FCS) consisting of an elastomer-coated industrial fabric having a lifting-foil-shaped buoyand seaward edge and a weighted shoreward edge. The break and plunge of steep erosive waves dislodge and suspend sand from the surf zone bottom. Transporting bed-load and suspended sand particles, the ensuing turbulent surf in-flow lifts the buoyant seaward edge of the FCS, and rushes beneath it with uninhibited energy, scouring the bottom surface and transporting dislodged sand particles toward and onto the beach. Upon completion of the surf in-flow, the FCS is no longer lifted. Due to its weight it sinks weighted shoreward edge first to rest upon the bottom. The ensuing out-flow, backwash, must pass above it without disturbing the underlying bottom surface or any momentarily trapped sand particles. With each wave, the FCS ***acts like a check valve***, moving increments of sand toward and onto the beach.

By directing surf in-flow to pass in contact with the bottom surface, the full wave energy is used to transport dislodged sand particles to the beach. The normal seaward transport of sand is reduced as the backwash out-flow is prevented from dislodging and carrying away sand particles under the flow-control sheet. Admittedly simplistic, this possibly effective novel approach was investigated in wave-tank tests.

## III - WAVE TANK TEST

The test apparatus is designed to successfully withstand water velocity of about 10 m/sec (30 ft/sec). The rugged elastomer-coated industrial fabric FCS is tethered to anchors by braided nylon ropes attached at 4 ft (1,22 m) intervals along its seaward and shoreward edges. Each anchor has a holding force of > 1 000 lb (> 453 kg).

At the depth where the FCS is tethered, water velocities are less than about 30 % of the velocity at the top of the breaking wave. If the plunge following the wave break should impact upon the top of the FCS, pressing it onto the bottom sand, it would not tear nor stress. Durability however can only be established by actual use.

## IV - WAVE TANK TEST RESULTS

Wave tank tests were conducted to investigate the effect of erosive waves upon a beach when the FCS of the *Beachbuilder Technique* was in place in the surf zone. Detailed test objectives included determination of the effects of FCS size, configuration, and location for various initial beach profiles. Beach profiles were recorded before and after each test run to determine the amount of accretion or erosion, and other profile changes resulting from erosive waves action.

More than 500 test runs were made to investigate various conditions, with several FCS configurations. The test runs were usually of 15 minutes duration. A 1/10 beach slope was most frequently employed. Some test runs were started on a beach whose profile was formed by a preceding test ; others started on a beach having a so-called "normal" profile, formed by the erosive wave and surf action when no FCS was present. The latter procedure allows to more realistically determine the effect of the FCS on a normally formed or eroded beach. Profiles formed by test runs with a FCS in place differ greatly from the runs with no FCS present. Each FCS run produced an additional net buildup above the length of the original starting profile. Three runs led to a total net building of approximately 59 $cm^2$ (9,15 $in^2$), in contrast to a 16 $cm^2$ (2,48 $in^2$) buildup after three runs of the same duration with no FCS. Relative to the original starting profile, the total net buildup remaining after the "FCS runs" was 3,7 times as great as the total net buildup remaining after the three "no-FCS runs" of equal duration. Trends of the last runs of each series indicated that the "no-FCS runs" were eroding the beach, while the "with-FCS runs" were continuing to build it up.

Though the FCS configuration used in this series of tests and its location were neither optimal, these tests showed that in a thin flexible sheet FCS located over the bottom surface of the surf zone produces a profile buildup under conditions that cause erosion when the FCS is absent. Model tests in a wave tank can closely reproduce actual beach and surf-zone profiles formed by erosive wave conditions if the wave-tank and full-scale conditions are appropriately related by key scaling parameters. This was demonstrated, for example, by Kriebel, Dally and Dean (1986) who concluded that : «*The model scaling law based on Froude's similarity, and using sediment fall velocity as the controlling parameter, was found* ***to reproduce beach profile evolution quite well*** *under erosive conditions*». These same model scaling laws can be applied to scale up the wave-tank conditions to define the full-scale conditions where reproduction of the wave-tank results can be expected.

Hughes and Fowler (1990) conducted laboratory wave-tank test to determine whether they could reproduce the profile formed by a full-scale wave tank. They concluded : «*Two-dimensional flume tests* ***successfully reproduced profile evolution*** *observed in prototype-scale wave flume tests conducted in Germany under both regular and irregular wave conditions*». The model scaling laws mentioned above require scaling hydrodynamic properties according to the accepted Froude criteria. Values for wave and beach conditions projected by scaling up the successful wave-tank conditions are within a range typical of values for actual, real world, erosive conditions. Considering the similitude zones, there is quite an extensive range of conditions where reproduction of the accretion-producing, erosion-preventing performance of the wave tank test results can be expected.

## V - ESTIMATED COSTS COMPARISON

The USD 80,53 cost per foot span of beach (roughly USD/m 240) is approximately 1/3 of USD 250 per ft (about USD/m 750) which we have considered as the average cost of conventional renourishment. The actual average renourishment cost was USD 375 per ft (± USD/m 1 128) for 56 projects reported in the Army Corps of Engineers "Shoreline Protection & Beach Erosion Control Study". The average cost for Initial Beach Restoration was USD 663 per ft (± USD/m 2 000). The USD/ft 80,53 is about 1/4 and 1/8, respectively for these latter two actual average costs.

Life-cycle costs are also low. The apparatus is expected to last for at least five years. If an installation remains in place for five years the annual lifecycle cost is one fifth of the total installation cost, or USD 80,53 ÷ 5 or USD 16,10 per ft (± USD/m 50). The cost of removing and reinstalling the apparatus, including new anchors, etc... is approximately one third of the total cost of the initial installation. If the apparatus is installed to build up the beach each winter, and removed each summer to permit unencumbered recreational use of the beach, the five-year cost would be :

5-yr. cost = 80,53 x (1 + 4 x 1/3) = USD 187,90 per ft. (± USD/m 564).

The annual life-cycle cost would be one fifth of this, or USD 37,58 per ft (± USD/m 115). As a comparison with conventional renourishment, assume renourishment is performed every five years at a cost of USD 375 per ft (± USD/m 1 128), the average cost given in the above-mentioned report. In this case the annual life-cycle cost would be USD 375/5 = USD 75 per year or twice as much as the preceding case with the *Beachbuilder Technique*. However, there are strong arguments in favour of beach nourishment and pending actual beach tests, such nourishment remains a very valid solution where beaches must be maintained (Charlier and De Meyer, 1995 ; Davison *et al.*, 1992 ; Houston, 1995 ; Weggel, 1995).

## Conclusion

Generally beach replenishement has been attempted by erecting hard structures or by artificial nourishment. The first approach created problems for areas downstream, the second, particularly with the so-called profile or berm feeding approach, has met with success because it "follows nature's processes". The literature has included in recent years other alternatives such as dewatering for instance. Still another system is described here.

It is proposed to use nature's "destructive" actions to build the beach : in other words to harness the energy of normally erosive waves to bring about beach accretion. In the surf zone a "flow-control sheet" directs the swash and backwash flow so that a net transport of sediment is carried onto the beach. In view of the economic problems encountered the world over by receding shorelines such "mechanism" would be a bonanza, particularly with the cost of the system considerably below that of more commonly used methods.

The problem is that it has proven utterly difficult to convince coastal zone managers to "try something untried". Yet, tank tests have shown that apparently this approach works. Beach and surf zones profiles created in wave-tank tests evidence that the technique produces accretion on the "beach" during every test run with erosive waves. Successful wave-tank results will be reproduced on actual beaches, if one is to give credence to a good number of papers published in the past.

On tidal beaches rapid accretion is predicted, but additional benefits lie within the realm of the possible including quick reaction, high mobility, good durability, and, from a socio-economic point of view creation of employment opportunities setting-up the installations, but also monitoring them afterwards.

The break and plunge of steep erosive waves dislodges sand from the surf zone bottom and then keeps it in suspension. The ensuing turbulent surf in-flow, transporting bed-load and suspended sand particles, lifts the buoyant seaward edge of the flow-control sheet, and rushes beneath it with uninhibited energy, scouring the bottom surface and transferring the dislodged sand particles toward and eventually onto the beach. Once the in-flow completed, the flow-control sheet is no longer lifted, but sinks by its own weight, shoreward edge first, to then rest upon the bottom. The out-flow then passes above it without disturbing the underlying bottom's surface, nor any momentarily trapped sand particles. The sheet thus acts, with each passing wave, like a check-valve, moving increments of sand toward and onto the beach.

By directing surf in-flow to pass in contact with the bottom surface, the full wave energy is used to transport dislodged sand particles. The normal seaward transport of sand is reduced by preventing sand particles underneath the flow-control sheet to be picked-up and carried away. It is self-evident that tank observations are not always repeated under actual conditions, but they frequently are. The results obtained in the tanks, however, are of such encouraging nature that it is hoped an opportunity will arise for a pilot study. Economic conditions have precluded launching those that had been already contemplated in California, Texas, Florida, Mexico and Spain. Yet, the fact that authorities in those areas considered "giving it a try", militates in favour of a try-out.

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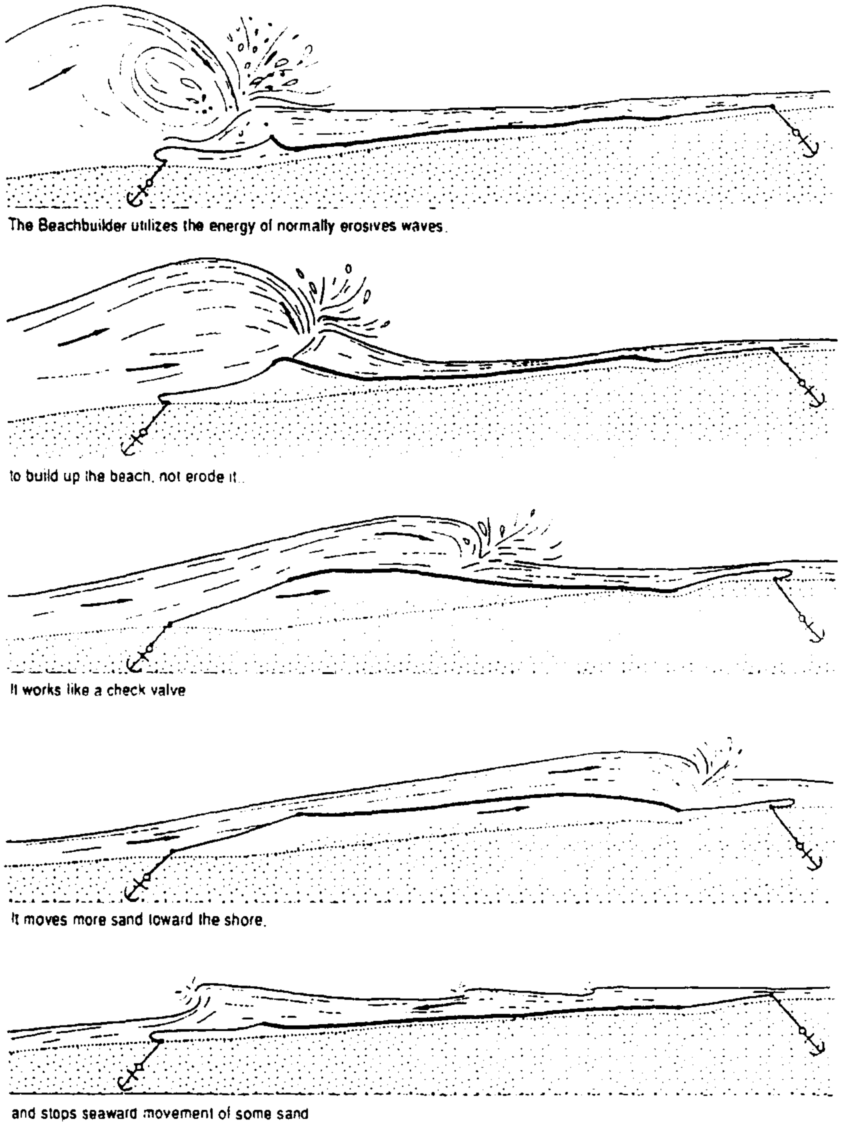
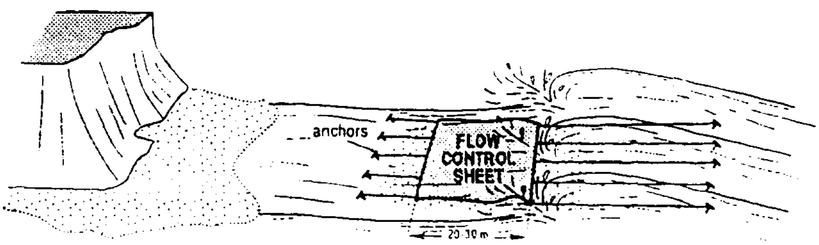



**Fig. 1A - Schematic operation of the Beachbuilder technique**




| COMPONENT | | DESCRIPTION |
|---|---|---|
| | **Flow-control sheet** : Elastomer-coated Nylon fabric<br>Seaward edge buoyant & foil shaped<br>Shoreward edge weighted | |
| | **Anchors** : "Duckbill", flat-plate resistance type<br>Holding force 1 000+1b each | |
| | **Tether Lines** : Braided Nylon rope, 5/16" - 3/8" diam | |

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**Fig. 1B - Schematic of deployment**

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