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The article concentrates on the stability of nourished beaches—not on the stability of profiles above and below the water table. All cases mentioned, apparently the result of dumpings of material on the beach itself, may be extended to the very nearshore bottom of the profile.

From experience it is well known that beach dumping is always followed by "slumping" of the fill slope causing rapid shoreline recession. This adjustment occurs because the slope angle deviates too much from the natural stable profile geometry.

That coarser materials give steeper slopes is elementary soil mechanics. It is equally elementary that less compacted (not trucked fill) erodes more rapidly than more compacted hydraulic fills. Therefore, also that "spring fills" are more stable than "fall fills." Higher waves cause more rapid "slumping" and losses than smaller waves. Tranversal as well as longshore drifts increase with wave height as well as with increase of slope angle (Brunn, 1989, Vol. 2, Chapters 7-8). An "early storm," therefore, is always bad for the stability of a beach fill. It is well known from theory and practice that steep slopes are less stable than more gentle slopes (e.g. Sanchez-Arcilla, 1990). From this it follows that "wider fills" (higher density) stabilize better than "narrow fills" because the wider fills have more material to stabilize the offshore bottom "foundation" for the beach fill, thereby approaching the natural profile.

That a long fill is more stable than a short fill is obvious, but length beyond a certain limit is not important. The Dutch manual by Rijkswaterstaat (1987) presents a one-line theory which shows that the initial beach fill may have to cover an area 2-3 times larger than the beach area to be protected. Rapid beach erosion by longshore drift is most often caused by gradients in the longshore transport energy, i.e. when the shoreline curves oceanward it usually increasing breaker angles.

The importance of the article lies in its statements on the apparent less importance of the grain size, and consequently its criticism of conventional design criteria using grain sizes by conventional methods for evaluation of stabilities.

Accepting the results of the paper one may consider the following points: Starting with the steepest slopes, e.g. as found in a mound breakwater, stability and wave height are linearly related as $D \sim H$ (wave height). But a mound breakwater is a very narrow fill draining rapidly, contrary to a beach fill.

The well known diagram relating $H_s/L_o$ to $W\pi/gT$ (Darlymple, 1985) where $H_s$ is wave height at breaking, $L_o$ is deepwater wave length, $w$ is fall velocity of grains, $g$ is the acceleration of gravity, and $T$ is the wave period, shows a separation line between erosion and deposition as $H_s \sim W \sim D$ where $D$ is grain size.
Consequently if D increases twice (e.g. 0.2 – 0.4 mm) $H_n$ only increases 2 or 40%. Vellinga (1986) verified the $H/T_w$ relation in his tests on scales for erosion profiles for dunes, beach and nearshore. Results confirmed a $H \sim w \sim D$ relation, or $H \sim D^{2/3}$. So did Sanchez-Arcilla (1990).

If the almost horizontal offshore bottom is considered for threshold stability (Bruun, 1987, 1988), $H \sim D^{3/2}$, or for twice the grain size, an increase of $H_n$ about 20%. In either case the wave period is kept constant.

The natural beach slope in a “static” condition was given by Sunamura (1975) as $\tan \beta = 0.10 g^{0.5} D^{0.5} T/H_b$ which demonstrates the $D/H_b$ relationship of a rather weak (square root) relation $D$ versus $H_b$ (breaker height). It should still be remembered that during storms and high tides, areas of the beach with a larger median grain size responds more quickly to a new equilibrium condition than areas with finer sands. The “slumping” takes less time for coarse and more time for finer materials.

So the importance of grain size is certainly there, but it may be relatively modest and could actually momentarily be overshadowed by other factors. The tests by Larson and Kraus (1989) show a relatively steep decrease in eroded volume as grain size increases through the range 0.2 mm to 0.4 mm, with a gentle decrease thereafter. This behavior follows from the property of empirically determined functional dependence of the wave energy dissipation needed to generate an equilibrium profile of given grain size.

Factors other than those relating grain size as normally defined to stability may be important. Bruun (1990), referring to actual observations, notes that “specific surface” = surface of grain/weight of grain (Smith, 1990 in press) seems to describe mobility or stability of grains on a beach better than material according to normal definitions of grain sizes. That means: flat grains of any kind should be avoided in a beach fill and grain size analyses should include consideration to specific surface. So the observations of the article are supported.

The rapid erosion of some beach fills is a known fact. The Australians, the Danes and the U.S. Army Corps of Engineers (Wilmington District), all undertake profile nourishment (Bruun, 1989, Vol. 2, Chapter 10), by which the profile is not only nourished on the beach, but at least in one additional section of the profile, e.g. from 3-5 m depth or from 5-8 m depth, or both. The experience with such procedures have been satisfactory. Bruun (1989, Vol. 2, Chapter 10) mentions numerical models developed for movement of sand in a profile nourished offshore by the U.S. Army Corps of Engineers), with special reference to split-hull dumping.

Christiansen (1977) writes: “At beaches with a long term natural equalized sand balance, profilings could help to diminish the annual sand losses rapidly.” He refers to experiences on the German North Sea Coast.

Table 1 explains the profile nourishment procedure.

With the conventional procedure, $2/3 \times m^3$ placed on the beach is lost rapidly to the offshore bottom due to storms and high tides and to longshore drift which depends upon the slope angle in the first power or perhaps to the square foot of the slope (Bruun, 1989, Vol. 2, Chapter 7). This phenomena does not take place with profile nourishment, which behaves as a normal profile. In such profiles grain sizes could vary with depth, (Bruun, 1987, 1988, 1989). To this a very important parameter the price may be added. Based on actual experiences, the unit price for offshore beach dumping in Australia is about $1 US/cu. yd. (1990). The unit prices for profile dumping by over-the-bow methods in Australia and Denmark are $US1.7 to 1.8/cu. yd. Beach dumping is 2.4 to $US2.7 cu. yd. In the United States, unit prices for beach fills vary from $4 to $7/cu. yd. The difference is amazing. Thus, profile nourishment not only gives a more stable profile from the beginning, but gives a much better price depending on the equipment that is used.

In this respect the paper gives indirectly some guidance for future operations—by equipment which includes hopper, split-hull, pump-out as well as over-the-bow pumping procedures. Unfortunately such combined equipment is hardly available in the United States (1990). We need more wide-bodied, hopper, shallow water dredges. For obvious reasons environmentalists prefer the gentle profile for the massive beach nourishment procedure.

That monitoring should be much more comprehensive and include parameters which are not yet on the market is fully agreed upon by the writer.
**Table 1. Conventional versus profile nourishment.**

<table>
<thead>
<tr>
<th>Nourishment Area in Elevations</th>
<th>Conventional Procedures</th>
<th>Profile Procedure</th>
<th>Quantity X</th>
</tr>
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<tr>
<td>Exposed Locations</td>
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<td>End</td>
<td>Initial</td>
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<td></td>
<td>3</td>
<td>3</td>
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</table>

**LITERATURE CITED**


BRUUN, P., 1980. Gravel beaches on Hilton Head Island, South Carolina—Relation between 'specific surface' (surface divided by weight of grain) and the location of gravel pieces in the uprush zone *Journal of Coastal Research*, 6(4).


