CHAPTER 60

AN OFFSHORE BEACH NOURISHMENT SCHEME

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Abstract

The University of Florida has conducted a series of tests to evaluate the effectiveness of beach nourishment from offshore sources by a specially designed drag scraper The field work, over a nine-month study period, included hydrographic surveys, fluorescent sand tracing, and a sand sampling program for two scraper sites at Jupiter Island, Florida

The conclusions provide information as to the effect of the borrow pits and the dredged sand on the beach characteristics, the mechanisms of the filling of the pits, and the efficiency of the drag scraper

Introduction

As beach erosion becomes more of a critical problem, extensive sources of sand are necessary for the artificial replenishing or rebuilding of beaches At Jupiter Island, on the east coast of Florida, where erosion has been quite severe due mainly to a large inlet to the north, onshore sources of nourishment sand were being depleted in a beach rehabilitation program begun in 1957, and it became necessary to find another readily available source

In 1963, Dickerson, Inc of Stuart, Florida began nourishing the beaches with a specially designed Sauerman drag scraper (See Gee, 1963) The scraper consists of a three-drum hoist powered by a 260 horsepower engine, which pulls a bottomless, three cubic yard capacity bucket over a wedge-shaped offshore borrow area, demarcated by two anchored buoys The buoys are 850 feet offshore and about 500 feet apart, floating between them is a mooring float which guides the scraper bucket over the borrow area The scraper is able to make over 300 round-trips of the bucket per day, placing the recovered sand at the base of the winding machine See photographs 1 to 4

During 1967 and 1968, the Department of Coastal and Oceanographic Engineering (DCOE) conducted a field study of the two borrow areas (denoted Areas I and II) at which the drag scraper operated The purpose of the study was (1) to determine if the scraper was a viable method of beach nourishment, (2) to determine if spoil placed on the beach returned directly to the borrow area, and (3) to estimate the efficiency of the scraping operation

During the first part of the summer of 1967, from May until the end of June, the scraper was at Area I, then it was moved two miles south to Area II where it operated until August 4, when it shut down for the season The scraper was contracted to recover 30,000 cubic yards of sand at each site, the total being the estimated annual erosion at the developed section of Jupiter Island (Coastal Engineering Staff, 1957) The unit cost of the sand was 50¢ per cubic yard

Environmental Data

At both locations, the shoreline is straight and the beach is narrow The offshore profile is shallow The dune lines have been protected by sloping energy absorbing seawalls, and adjustable groins had been placed on the beach in 1963

Waves in the summer at Jupiter Island approach from the southeast and are generally small, as large ocean swell are blocked by the Bahama Islands from reaching shore During the winter, however, the wave climate becomes very severe and predominantly comes from the northeast In 1967, the seasonal shift between the summer and winter wave climate occurred on September 4, with the onset of a period of northeast storms

The littoral drift follows the wave direction It is mild and from the south in the summer, and more intense and from the north in the winter The net quantity of littoral drift passing Jupiter Island inside the 18' contour has been estimated by the Corps of Engineers as 230,000 cubic yards per year Its direction is north to south

Offshore Effects

At both areas, when the scraper began operation, pits were dug about 175 feet offshore in about 9 feet of water These lengthened in the offshore direction into oval depressions 500-600 feet long and 300 feet wide, as scraping continued, until maximum recorded depths of 14 and 17 feet were reached at each area

During the scraping operation, the summer littoral current moved large quantities of suspended sand, kicked up by the fast-moving scraper bucket, northward, resulting in the formation of a bar on the north side of the borrow pit This "shoulder" bar became quite large at both sites as scraping continued, covering an area about two-thirds the area of the borrow pit, and a height of 3 feet above the bottom See figure 1

At Area I, after the scraper was stopped and moved to Area II, the offshore borrow pit began to change shape slowly under the action of waves and currents The elevation contours of the pit became more rounded, and the bottom of it shoaled about one foot during the first two months The shoulder bar, during this time, was moved shoreward, by wave action concentrated on it by refraction at the hole, and filled the trough that had previously separated it from the beach

Soon after the scraper was shut down for the season at Area II, the wave climate changed Northeast storms during early September brought about the seasonal littoral drift reversal and the larger winter waves This more severe wave climate caused rapid shoaling of the borrow pits Calculated shoaling rates for the bottom of the borrow pits from August 31 to September 22 were 22 foot per day at Area II and 1 foot per day at Area I, which was a much shallower pit by this time These fill rates are much higher than rates calculated for borrow pits examined by Watts (1963)

The high fill rate at Area II produced a migration of the borrow pit As seen in Figure 3, the pit had moved southward A simple experiment in a movable bed hydraulic model showed that a hole in a sand bed, under the action of a unidirectional current, was filled from the upstream side, while sand was eroded from the downstream side--the net result being filling of the hole, coupled with translation downstream

The shoulder bar, at Area II, was moved both shoreward and into the borrow pit, by the northeast waves, the shoulder bar here was a more important factor in the filling of the borrow pit than at Area I, due to the intensity of the littoral current See figure 2

At Area II, 1000 pounds of fluorescent tracer were placed in the spoil pile on the beach in front of the scraper, 20 days after scraping was discontinued The purpose of the test was to estimate the return of dredging spoil to the borrow pit Sand samples taken in the borrow pit subsequently showed some tracer being incorporated offshore into the filling borrow pit However, this recovered tracer was very fine grained, and did not represent a direct return of all the spoil to the borrow pit, but rather the natural action of beach sorting The fill material, including the tracer, had a median diameter of 13 mm and was well sorted, whereas the natural beach sand and the tracer had a median diameter of 29 mm Watts (1963), too, has observed fine grained material in filling borrow pits The sources of the fill material in the pits are longshore current and wave transported material, the shoulder bar, particularly at Area II, and the transversally transported fine-grained dredge material, moved offshore by natural beach sorting processes

By the following summer, both pits had filled entirely and the bottom topography was similar to that of the previous summer

Beach Effects

During scraper operation, the dry beaches at both areas grew, as the spoil pile was dispersed by wave action and due to the natural onshore movement of sand during the summer The Mean Sea Level (MSL) contour moved seaward an average at each station of 5 feet at Area I and 34 feet at Area II However, by the next summer, June 28, beach surveys showed significant erosion had occurred during the winter, after the scraper was shut down, with an average net loss after the whole year of 20 feet and 42 feet at the beaches

Stability

No major beach stability problems were observed, however, they may be created if the drag scraper operates too near shore If the borrow pit is dredged very deep, slumping of the foreshore can occur, with the dredged sand returning directly to the borrow pit Also, as pointed out by Rector (1966), sand moved offshore by steep waves during storms, will fill the borrow pit and be lost to the beach, as this material will not be returned to the beach by natural action when the wave climate becomes less severe For Jupiter Island, where winter and summer bars exist, it was recommended that the scraper recover sand from an area offshore of the normal location of the winter bars, thus ensuring there would be no sand lost from the beach by natural processes

An additional stability problem may arise if the offshore sand is much finer than the natural beach sand This would also be the case if the scraper returned to the same place for additional spoil The fine sand would probably be quickly removed from the beach by wave action

As mentioned previously, the incidental deposition of the shoulder bar by the drag scraper provides a stabilizing effect When the longshore current changed to southward, the deposited sand was moved on to the beach and into the pit, thus removing some of the aforementioned hazard of normal beach sand being lost to the pit during storms

Efficiency

The present scraper design was observed in the field by DCOE personnel to be unable to carry its full capacity due to its design Volume estimates of the beach spoil pile and the offshore borrow pit and shoreline monitoring showed that the scraper did not move the quantity of sand necessary to match or exceed the annual erosion

Conclusions

The drag scraper technique is a viable method of beach nourishment, provided it recovers sand in a quantity to balance or exceed the annual amount of erosion

Only the fine grained dredge material returns to the borrow pit under normal operation Primary sources of pit fill material are the littoral drift and the shoulder bar, built by suspended sand

Beach stability is ensured if the scraper dredges sand compatible with the natural beach sand and from an area at a sufficient distance from the shore

Acknowledgements

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References

1 Coastal Engineering Staff, Coastal Engineering Investigation at Jupiter Island, Technical Progress Report No 5, Florida Engineering and Industrial Experiment Station, March, 1957

2 Gee, Herbert C , Beach Nourishment from Offshore Sourcea, ASCE Journal of Waterways and Harbors, Vol 91, No WW3, August, 1965 Discussion by R L Rector, No WW2, Vol 92, May, 1966

3 Watts, George M , Behavior of Offshore Borrow Zones in Beach Fill Operations, Int Assoc for Hydraulic Research Congress, London, 1963

Photograph 1. Winch System for the Sauerman Drag Scraper

Photograph 2. Drag Scraper Bucket and Spoil Pile

Photograph 3. Drag Scraper in Action. Note the large amount of suspended sand in borrow area.

Photograph 4. Aerial View of Drag Scraper

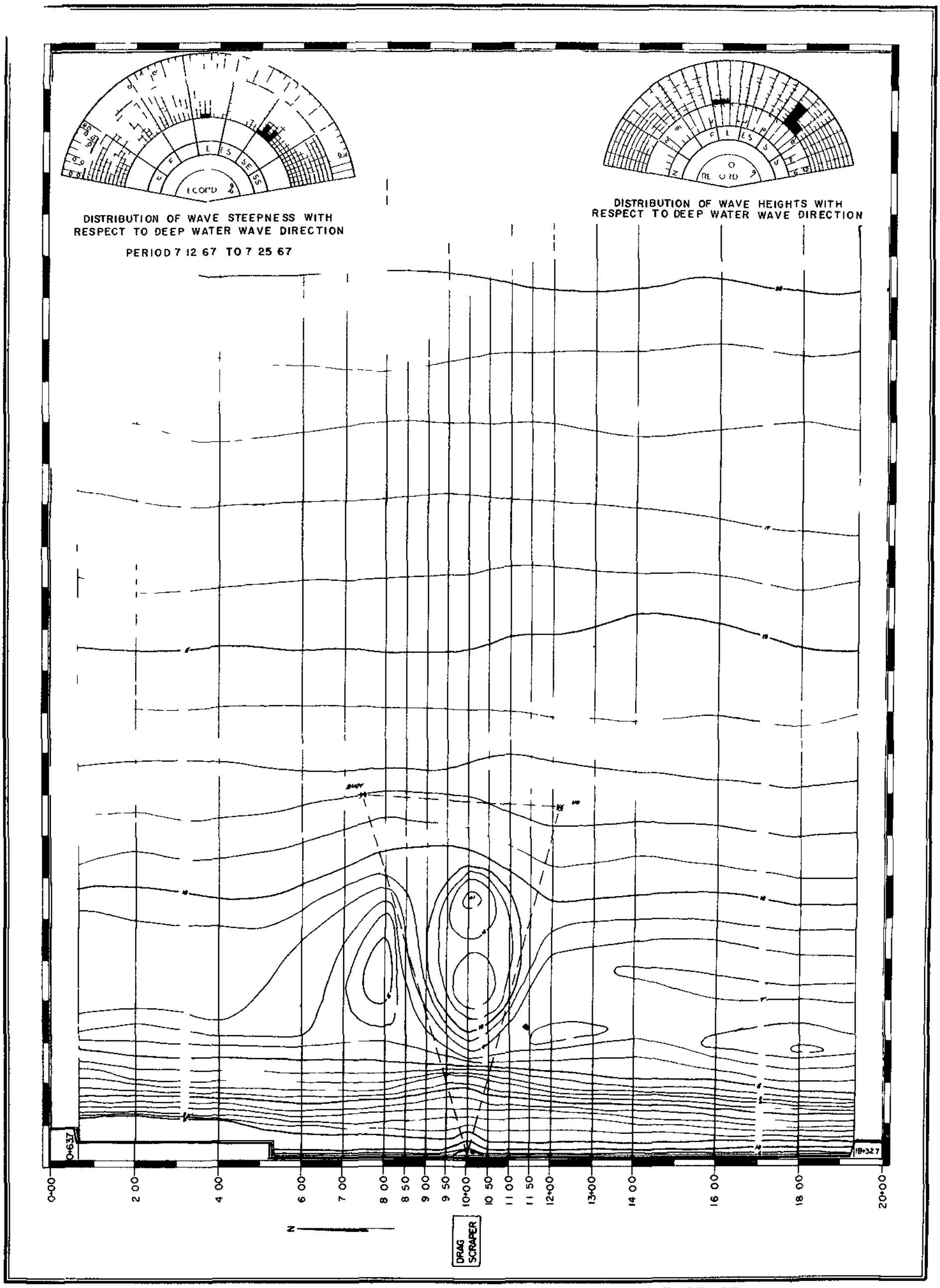

Figure 1 Hydrographic Survey, Area II No 3,7-25-67

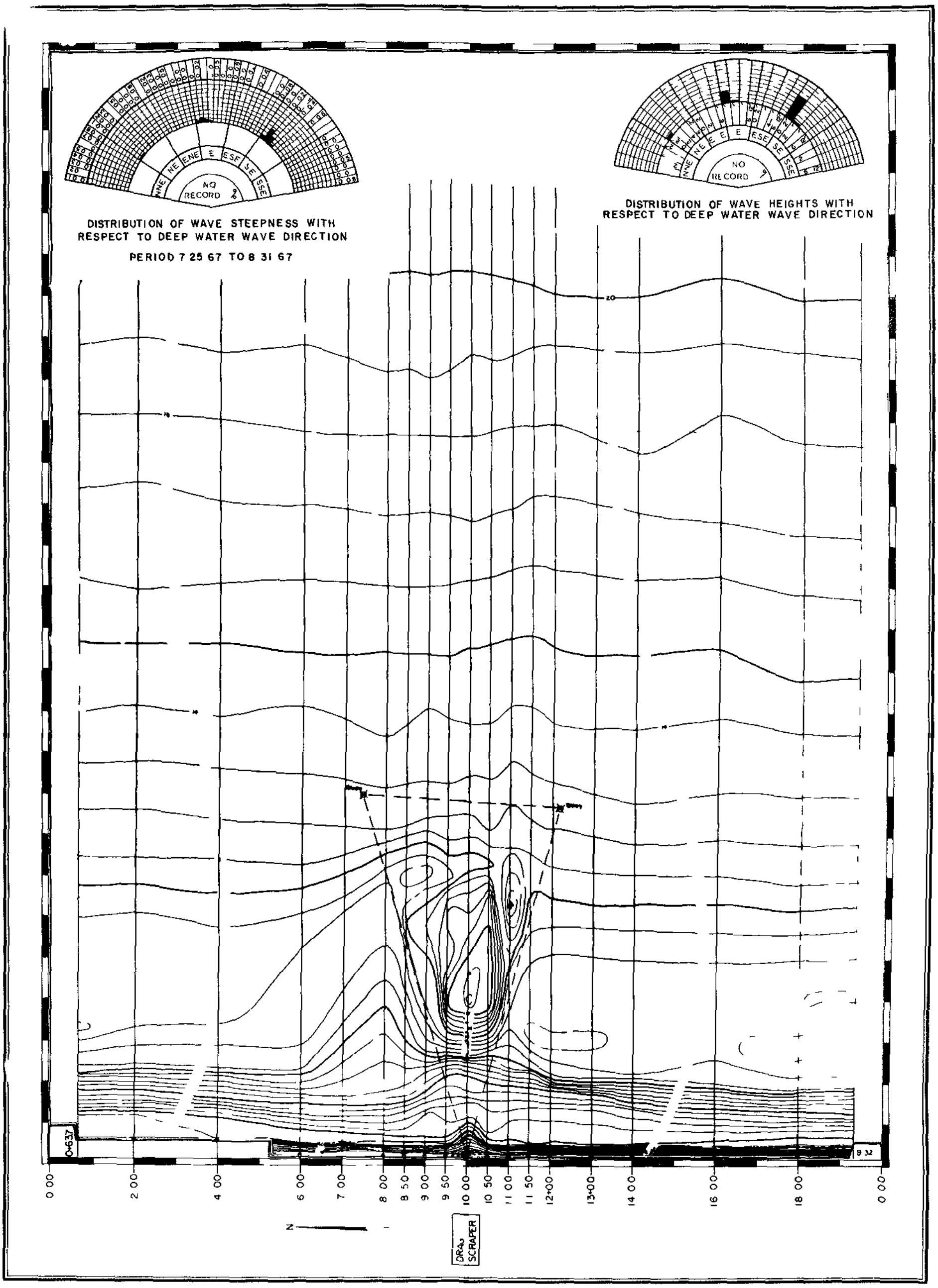

Figure 2 Hydrographic Survey, Area II No 4,8-31-67

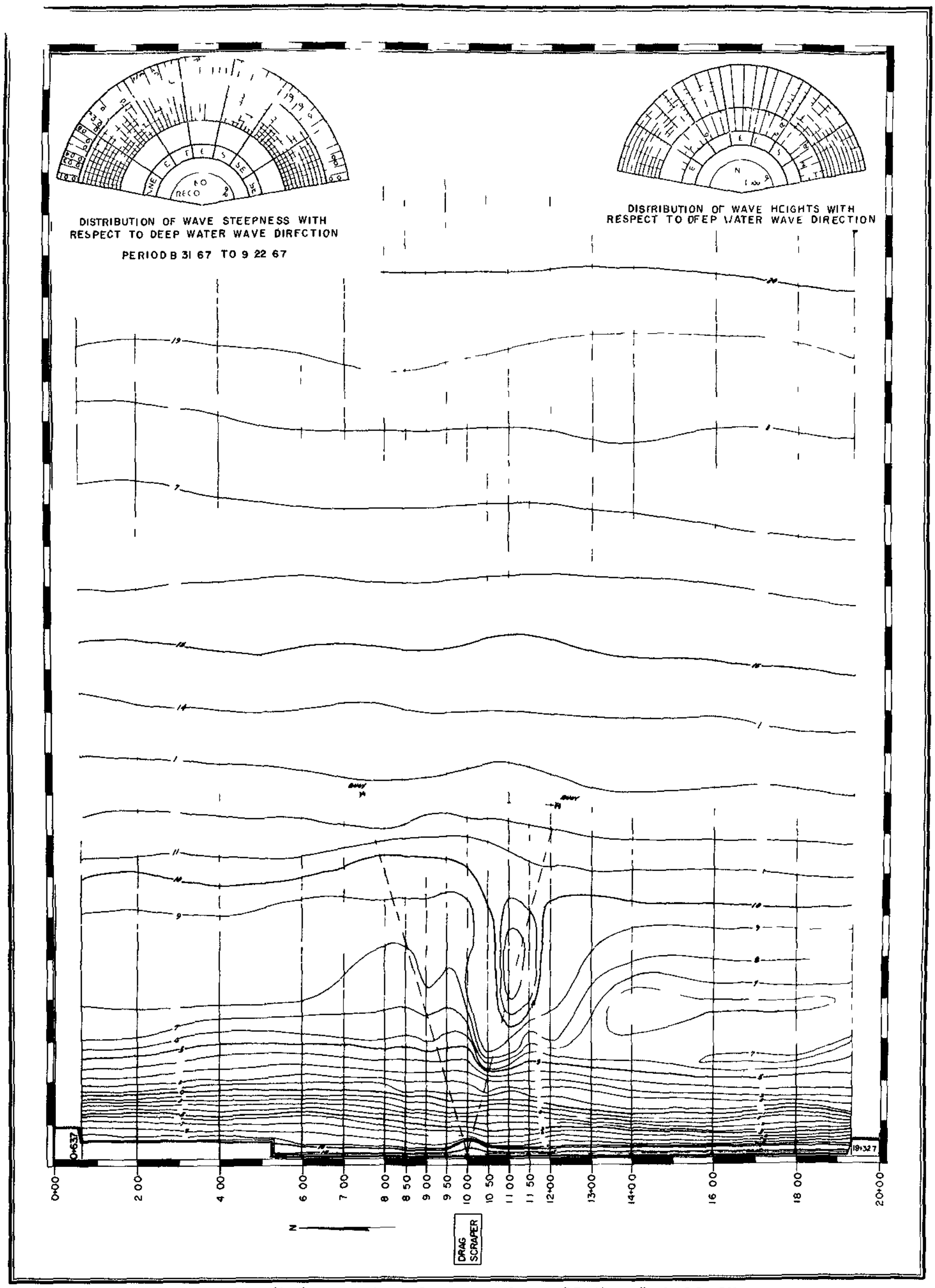

Figure 3 Hydrographic Survey, Area II No 5,9-22-67