Coastal Engineering Technical Note

SUMMARY OF SEAWALL AND BEACH INTERACTION AT NORTHERN MONTEREY BAY, CALIFORNIA

PURPOSE: To summarize results of recent field studies on the effects of coastal armoring on beaches along northern Monterey Bay, California.

BACKGROUND: Engineers and scientists are studying seawalls, revetments and bulkheads to define the effects of coastal armoring on beaches. Seawalls, revetments and bulkheads are structures built to protect a coastal community against wave attack and flooding during severe storms, since there are few other structural alternatives available to provide the same degree of protection. Throughout the remainder of this document seawalls, revetments and bulkheads will be grouped together and referred to simply as seawalls. The failure of some seawalls and rapid erosion of the foreshore in the vicinity of some seawalls has prompted controversy as to whether seawalls protect or damage natural beaches. Coastal planners and managers become increasingly reluctant to consider these structures for their coastal defense applications. Both North Carolina and Maine have legislation prohibiting the construction of seawalls.. In other states such as Texas, Florida, and Massachusetts, construction of seawalls or other types of hard structures along the coastline is severely restricted.

Kraus (1987,1988) conducted extensive literature reviews and concluded that "beaches with and without seawalls exhibit similar behavior and variation with regard to short-term erosion and recovery associated with storms and post-storm wave conditions." He further pointed out that "seawalls are relatively innocuous with regard to cross-shore sediment transport processes and only have potential to damage neighboring beaches if longshore processes are interrupted." Accordingly, a "properly" designed and engineered seawall should not cause or accelerate beach erosion provided a sediment supply exists.

Structures improperly designed and sited can adversely impact beaches adjacent to and/or in front of structures. These potential impacts are (1) accelerating or enhancing beach erosion in the form of either lowering the beach profile or causing toe scour during wave attack and (2) causing downdrift flanking and updrift accretion. On a receding beach, hard structures interfere with nearshore sediment processes if the shoreline retreats to the proximity of the structures. In this case, corrective measures such as beach nourishment can be effective to mitigate the structure/beach interactions.

Structural impacts on beaches can be minimized or avoided through comprehensive analyses of site-specific wave climate and coastal processes along with sound engineering judgement and design practice. To develop effective functional design guidance, the research Work Unit, "Engineering

US Army Engineer Waterways Experiment Station, Coastal Engineering Research Center
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

Performance of Coastal Structures," in the Coastal Structures Evaluation and Design Program at the Coastal Engineering Research Center sponsored a long-term field monitoring study of seawall-beach processes at four locations along the northern coast of Monterey Bay in California. This ongoing field study, initiated in 1986, is being conducted by Dr. Gary B. Griggs of the University of California at Santa Cruz. The study involves measurements of beach profiles in front of seawalls and comparisons with profiles measured at adjacent unstructured or control beaches. This note summarizes the significant findings to date. Detailed discussions of the study results are presented in Tait and Griggs (1990), Griggs, Tait, and Scott (1990), and Griggs and Tait (1988).

MONITORING SITES: According to Griggs and Tait (1988), the coastline along northern Monterey Bay is backed by cliffs cut into Tertiary sedimentary rocks which range in height from 5 to 30 m. The interior of the bay, which extends from New Brighton Beach on the north to Monterey on the south, is considered an "equilibrium" coastline (Griggs and Jones 1985). It has a smooth arcuate shape and is flanked by a continuous wide sandy beach which is often 50 to 100 m in width during the summer months. During severe winters, however, waves will erode the beach and, on occasion, reach the base of the cliff. In contrast to the interior of the bay, the northern margin, from Santa Cruz to New Brighton Beach, is also backed by steep cliffs, but consists of a series of pocket beaches of varying length. One of the four monitoring sites, Corcoran Beach, is situated along one of these pocket beaches, with the other sites (North Beach Drive, South Beach Drive and South Aptos Seascape) being along the inner bay (Figure 1).

These sites differ from sites on the Atlantic or Gulf barrier island coastlines where many of the observations concerning impacts of seawalls on beaches have been made. Three of the four sites monitored in this study are along equilibrium/stable shorelines with no net erosion or accretion. Littoral drift in the area is relatively high and beaches are well supplied with sand. Conversely, on the Atlantic shoreline, the barrier islands generally migrate landward and many areas exhibit severe erosion rates. In addition, typical storm and wave conditions associated with impacts of seawalls for the Gulf and the Atlantic are associated with hurricanes, occurring less frequently and of greater severity than typical winter storm conditions which affect this region of the California coastline (Griggs, Tait 1988).

The average diurnal tide range of the study area is 5.3 ft, and the extreme range is 9.0 ft. Waves in the region are relatively moderate. According to Griggs and Tait (1988) deepwater wave heights of 21 ft were measured offshore of Monterey Bay during the severe winter storms of 1978 and 1983. In the same time period, wave heights ranged from 5 to 10 ft one mile off Santa Cruz. Wave conditions during the study period were relatively mild. Measurements at the Santa Cruz Small Craft Harbor gage (Figure 1) revealed that on only 11 days did wave heights exceeded a height of 5 ft between October 1986 and October 1987.

Figure 1 shows the four monitoring sites in northern Monterey Bay. Site No. 1 at Corcoran Lagoon is immediately south of Santa Cruz. The riprap wall structure, approximately 820 ft long (Figure 2), is situated on a relatively narrow beach and stacked directly against coastal bluffs. Rocks were randomly placed without core and bedding layers at a slope of 1 (vertical) : 1.6

(horizontal). The crest elevation varies from 33 to 36 ft mean lower low water (MLLW) and the toe is at approximately 11 ft MLLW. Two different walls meet at Site No. 2, North Beach Drive (Figure 3). Upcoast is an 800-ft long rubble mound type structure with core stone and filter fabrics. The crest ranges from 12 to 15 ft MLLW. Immediately downcoast is a 650 ft wooden bulkhead with curved concrete cap and crest of 16.6 ft MLLW. Site No. 3, South Beach Drive, is a 410-ft long rubble mound wall (Figure 4) randomly placed without core stone and filter fabrics. Mound crest is at 16.6 ft MLLW. Site No. 4 at South Aptos Seascape (Figure 5) is a 980 ft curved concrete seawall of 21 ft MLLW crest with stone toe protection. Except at Site No.1, the beaches are all of relatively moderate width with gentle offshore slopes.

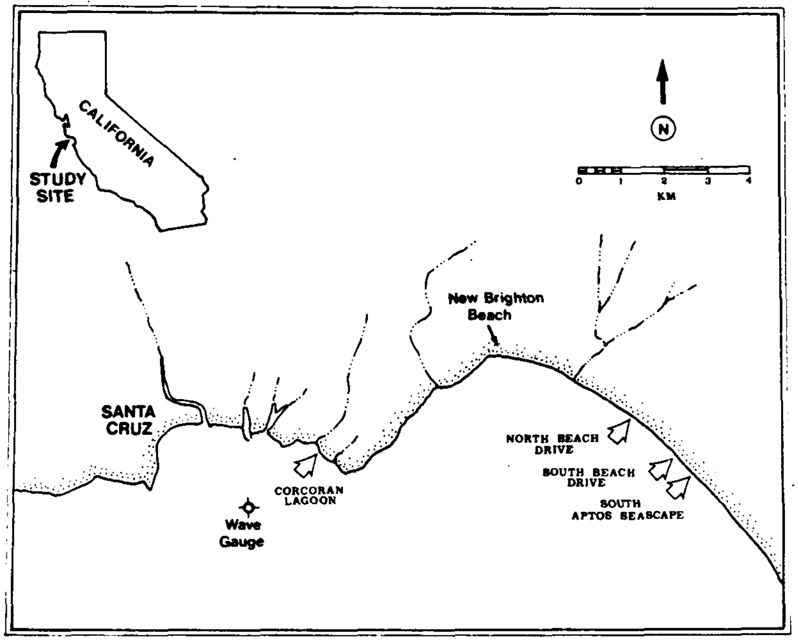


Figure 1. Locations of Monitoring Sites

SIGNIFICANT FINDINGS: All changes in beach profiles were temporary or seasonal, and develop during the transition between summer swell and winter storm conditions. Regarding cross-shore transport, no long-term differences were observed between armored shorelines and unarmored control areas. In some instances longshore transport appeared to be affected and signs of sediment deprivation were observed downdrift of the structure. The following are the conclusions by Griggs, et al (1990a) and Griggs (1990b) derived from a 4-year field monitoring study at the coast along northern Monterey Bay.

a. With the arrival of winter waves, the loss of the summer berms occurred sooner in front of all monitored seawalls than in front of the adjacent unstructured beaches.

b. The berm may or may not be removed sooner in front of an impermeable vertical wall when abutted by a sloping permeable wall.

c. After the winter profile has been established, there is no significant or consistent difference between the beach face fronting permeable structures and impermeable walls.

Figure 2. Monitoring Site No. 1 at Corcoran Lagoon

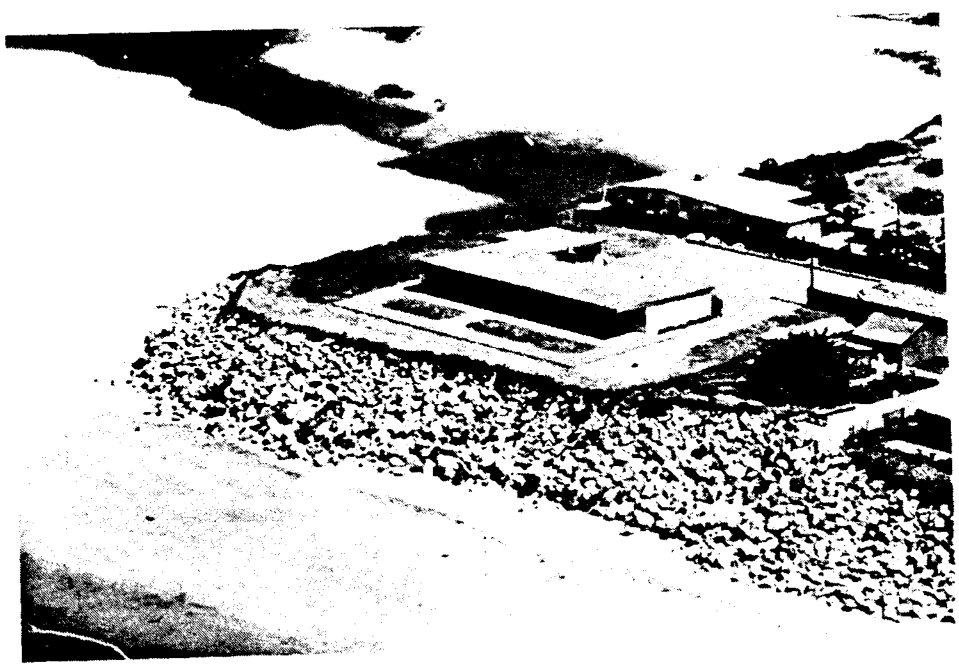


Figure 3. Monitoring Site No. 2 at North Beach Drive

Figure 4. Monitoring Site No. 3 at South Beach Drive

Figure 5. Monitoring Site No. 4 at South Aptos Seascape

d. Once the berm on the adjacent unstructured beaches has retreated landward of the seawalls, there is no significant difference in winter beach profiles seaward of seawalls or revetments relative to adjacent unprotected beaches.

e. Increased berm retreat and beach scour occurs up to 500 ft downcoast from seawalls due to a combination of wave reflection and groin effects.

f. Late spring/summer berm rebuilding takes place in a uniform manner alongshore with no obvious difference between seawall-backed or adjacent control beaches.

g. A trough was never observed in front of any walls during the monitoring period.

h. Longshore troughs oblique to the shoreline often develop in the surf zone at downcoast ends of seawalls in response to rip current development during the winter months.

i. Dean's hypothetical profile (Dean, 1986), based on the excess sand removed from in front of a seawall which would have scoured from the area landward if the seawall had not been constructed, did not occur. Figure 6 shows Dean' hypothetical profile. Figure 7 shows mean profiles which represent all of the mean profiles for an entire season of surveying at the Aptos Seascape Site, upcoast, at the seawall, and downcoast sites. An area of localized scour at the seawall area is not present on these profiles.

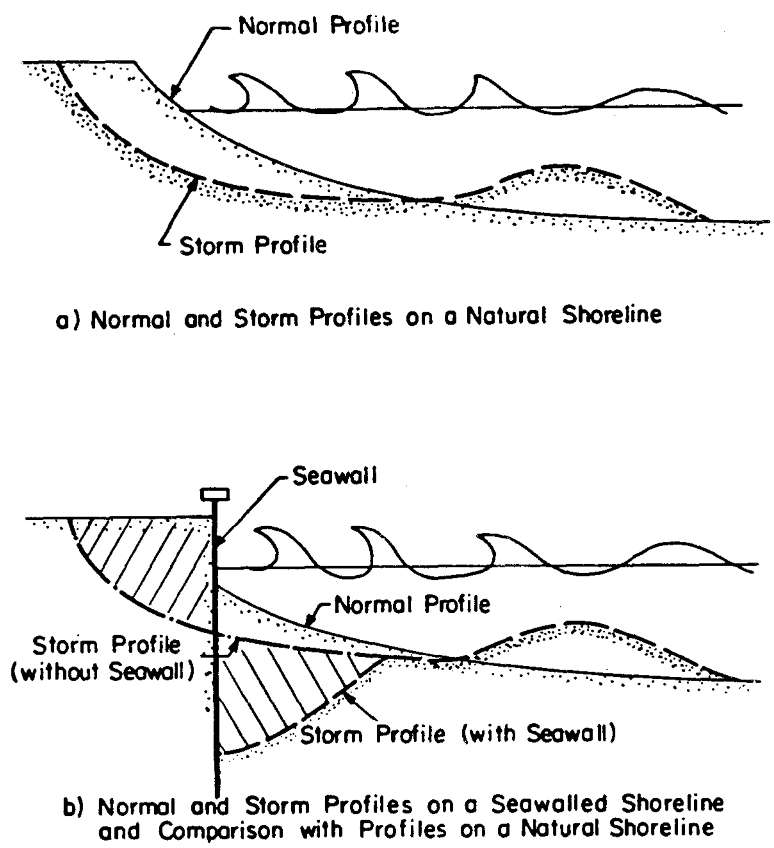
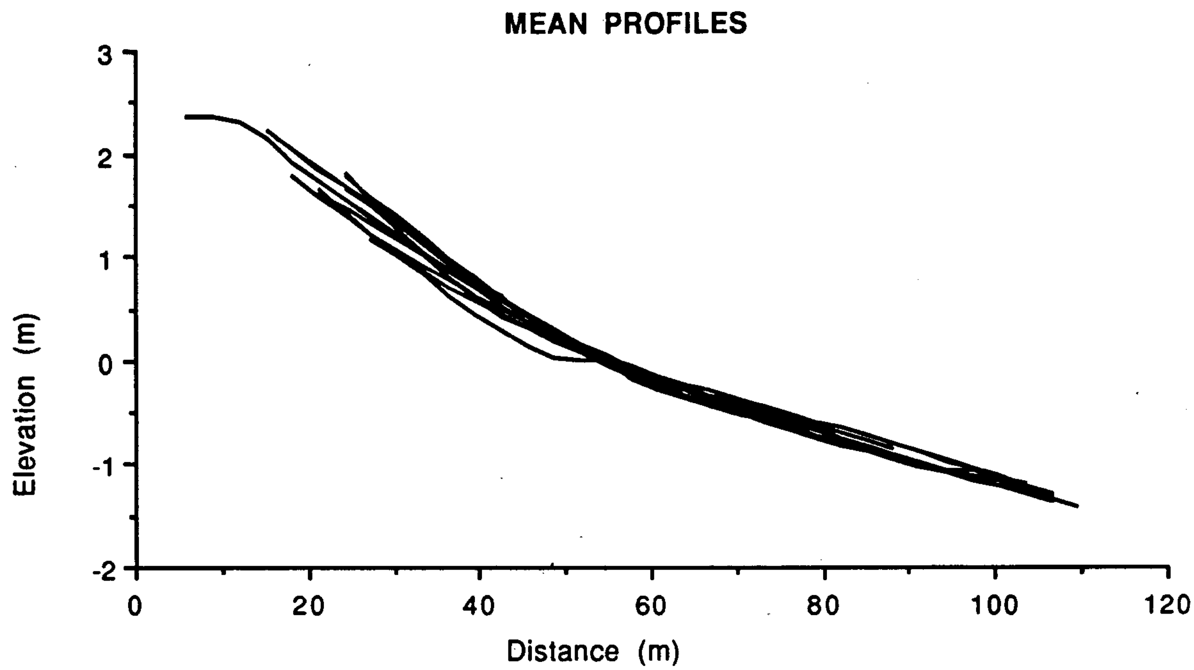


Figure 6 Dean's Hypothetical Profile predicts additional scour immediately in front of a seawall due to storms.



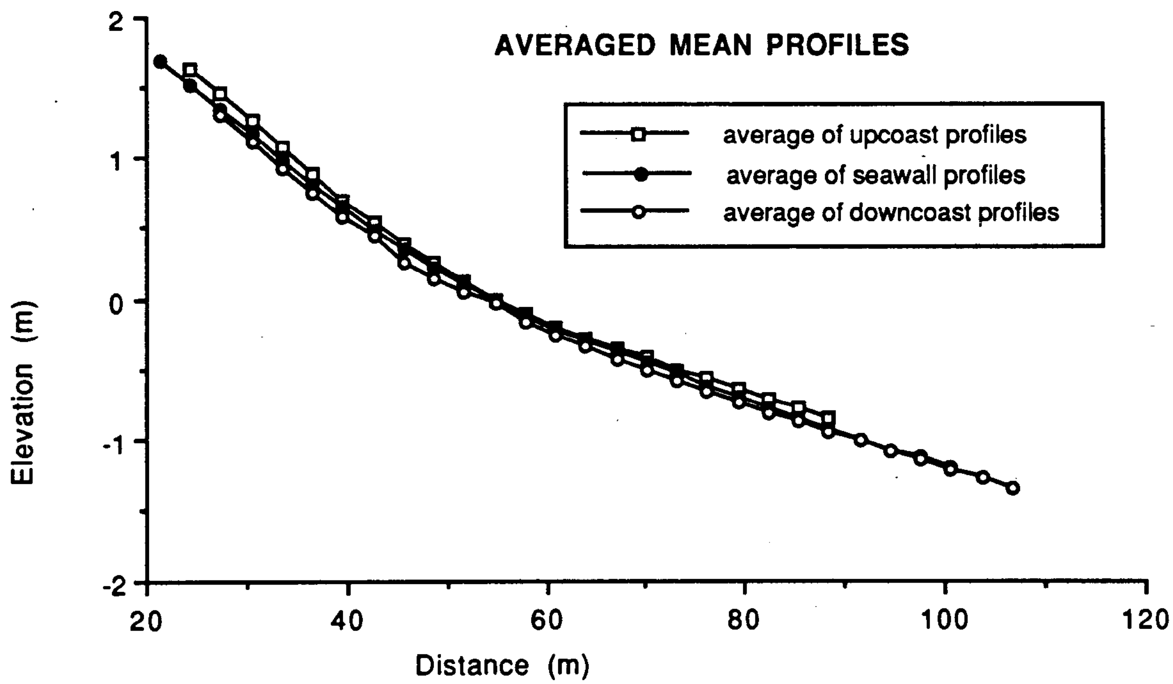


Figure 7. The upper graph shows all of the mean profiles, matched at mean low water. The lower graph shows the mean profiles of each of the averaged beach sections.

ADDITIONAL INFORMATION: A similar Corps sponsored field monitoring/study was initiated in 1989 at Sandbridge Beach, Virginia and is being conducted by Dr. David R. Basco of Old Dominion University. For additional information about the seawall effects studies at both east and west coast locations contact Ms. Cheryl E. Burke at (601) 634-4029 or Mr. Greg Williams at (601) 634-2089.

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