CHAPTER 91

TRACKED VEHICLE FOR CONTINUOUS NEARSHORE PROFILES

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INTRODUCTION

The measurement of nearshore profiles has been the traditional method for evaluating on- and offshore transport of beach sand by waves. The measurement on that portion of the beach face which is dry at low tide presents no particular problems and can be effectively accomplished with conventional rod and level surveying techniques. Once the measurement location moves into the wet part of the foreshore, however, the problems rapidly incease. In general, it requires an extremely dedicated rod man to remain on position in breakers larger than a meter, although measurements in breakers up to 2 meters in height have been accomplished on a nonroutine basis. When waves exceed this height, or when the water depth exceeds the ability of a man to stand and hold the rod, this method must be abandoned. In deeper water, and well outside the surf zone, a boat and fathometer approach is normally employed with considerable loss in vertical and horizontal accuracy. In particular, the vertical resolution is decreased by the uncertainties in knowledge of the instantaneous sea level because of the combination of tides, waves and storm surge. If the tides are large and the waves small, it is possible to achieve an overlap between the boat survey and the shore survey. When the wave height exceeds the ability of the boat to operate, this method also must be abandoned. Although larger boats can operate in larger waves, they are generally also restricted to deeper water.

The result of all of the restrictions described above is that profiles can be measured with reasonable accuracy only during periods of low waves. Unfortunately, the episodes of greatest interest are the rapid cutting back of the beach face and the accompanying offshore bar building which occur during times of high waves. The technology to measure the storm waves has been available for many years. The ability to correlate wave parameters with offshore transport rates requires the ability to make accurate profiles from the dry beach through and beyond the breaker line under storm wave conditions. This paper describes a vehicle that was developed to meet this need.

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PROFILER VEHICLE

The approach selected to obtain storm wave profiles was to use a remotely controlled tracked vehicle capable of traversing to a sufficient distance offshore to pass well beyond the breaker line. Design limits were set at 450 meters maximum offshore excursion and 10 meters maximum operating depth.

The basic vehicle is a small tractor originally used for light construction work. The 7.5 horsepower internal combustion engine was replaced by an electric motor of the same power which is powered from an umbilical cable. The motor is run totally immersed in the reservoir of hydraulic fluid to protect it from sea water. This reservoir is maintained at ambient pressure by a large flexible diaphragm. The electric motor drives the hydraulic pump in the tractor which in turn powers the tracks through a hydraulic motor driving through a transmission and mechanical clutches and brakes on each tread. The manual controls for steering the tractor were replaced by hydraulic rams controlled by solenoid valves.

The profiler is shown in Figure 1. The mechanism above the tractor provides for cable tension control when the profiler is returning to shore. The simplest maneuver is for the profiler to be stopped at the end of the profile and then returned on the same line. Eliminating turns avoids any concern with running over the cable in the case where strong longshore currents may exist and also provides for a second realization of the profile. Since the cable drag over the bottom is large, it dominates the tension at the land end so that the winch operator cannot tell if the cable is slack at the profiler from measuring tension on shore. A cable tension measuring system is provided utilizing a hydraulic cylinder and a pressure measuring transducer as the load sensing element. This tension is displayed onshore on a meter and is used to adjust the winch takeup speed. The cable, which contains 16 conductors, is jacketed in plastic and uses Kevlar strength members to reduce weight. Its diameter is 2.5 cm and its length is 450 meters.

SUPPORT EQUIPMENT

The profiler is transported on a military surplus ten-wheel-drive truck capable of traversing sandy beaches. This truck also mounts a 75KVA diesel powered generator which delivers 220 v, 3 phase power to the electric motor and 110V current to the instruments and controls. Two aluminum ramp sections are stored below the truck bed and are used to load and unload the profiler. Also mounted on the truck bed is a winch powered by a 3HP variable speed direct current

PROFILER DESCENDING FROM
TRANSPORT VEHICLE
PRIOR TO BEACH SURVEY.
THE PROFILER WILL BE
TURNED THROUGH 180° BEFORE
BEGINNING A RUN.

FIGURE 1

motor which is used to unwind and wind the umbilical cable. The truck and other support equipment is shown in Figure 2.

INSTRUMENTATION

Consideration was given initially to using a stadia rod on the profiler so that conventional surveying methods could be extended into deeper water. However, it was decided that the poor visibility associated with flying spray from heavy wave breaking, plus the great distance offshore, would make optical tracking very difficult. Therefore, the decision was made to utilize onboard instruments that would not require any penetration of the surface.

Horizontal position as well as vertical profiles are obtained from the on-board instrumentation. A two-axis vertical gyroscope, a flux gate compass, and an odometer for each tread are sampled once per second. These data are multiplexed, converted to serial format, and transmitted by cable to the beach. The on-board instruments are contained in a waterproof enclosure.

The shielded cable used for data transmission is jacketed together with the power cable. All conductors of both cables are connected to slip rings to allow rotation of the winch. Double rings are provided for data conductors. At the stationary slip rings, the power conductors leading to the diesel generator and control box branch away from the data lines.

The serial multiplexed data are transmitted asynchronously over a single line. On the beach, it is immediately recorded on a digital cassette tape recorder. An electronic monitor box decodes the data, either as it is recorded, or from tape recorder playback. Any channel can be selected for binary display on LED panel lights. The control box used for vehicle control and data recording is shown in Figure 3.

Motions of the profiler are calculated relative to its starting position, which is a fixed point on the beach of known position. Distance traveled along the path is obtained from the odometers, assuming a constant, empirically determined slippage rate. At each observation, the odometer and compass azimuth readings form the magnitude and direction of a displacement vector. Horizontal position is updated by adding this vector to the previous position fix.

Vertical excursions are tracked in the same manner. The two-axis vertical gyro measures pitch and roll. The sine pitch angle is integrated with respect to odometer output to obtain profiles. Roll

THE TRANSPORT VEHICLE FOR THE PROFILER
IS A TEN-WHEEL DRIVE TRUCK.
A DIESEL POWERED GENERATOR AND A
VARIABLE SPEED WINCH MAKE THE SYSTEM
COMPLETELY SELF-CONTAINED.

FIGURE 2

THE PROFILER CONTROL CONSOLE
CONTAINS TRACTOR DIRECTIONAL CONTROLS,
A PLOTTER FOR POSITION VISUALIZATION,
THE DATA RECORDER AND INSTRUMENT
STATUS CHECKOUT EQUIPMENT.

FIGURE 3

angle is not used in position calculations but is valuable for construction of topography between transects.

$$x(t) = \sum_{i=1}^{t} l_i \cos \Theta_i \cos \phi_i$$

$$y(t) = \sum_{i=1}^{t} l_i \sin \Theta_i \cos \phi_i$$

$$z(t) = \sum_{i=1}^{t} l_i \sin \phi_i$$

l_i = distance traveled in i^{th} observation period

Θ = azimuth

ϕ = pitch

Since the profiles will ideally be measured along a straight line, the course is plotted in printer-plot style with a compact thermal printer. A commercial programmable calculator has been modified so that data can be entered remotely. An interface circuit is used to bypass the buttons. Program steps required to calculate and plot the course are stored on a magnetic card. Each time the tractor moves a fixed distance, its new position is approximated from the reported azimuth and plotted. Although the plotted position is not exact, it indicates to the operator when course corrections are necessary. The control console is shown in Figure 3.

After the beach experiment is over, the cassette tape is played back through an interface circuit, into an IBM 1800 computer. This interface, like the decoder box on the beach, converts the data back to parallel form and generates synchronization pulses as external interrupt. Computation of courses and profiles and interpolation of topography is done after the data are transferred.

PERFORMANCE

Initial evaluations have been performed on the handling characteristics and profile measurement capabilities at Scripps Beach, California. Figure 4 shows the profiler entering the ocean on a calibration run. In order to provide verification of the actual profile traversed, a mast was added temporarily to support a standard surveyor's stadia rod. A base line was set up on the beach with a surveyor's level on the profile range line and a transit for measuring angles at the other end of the base line. The tractor was stopped at approximately 5 m intervals to allow recording of the position and elevation. Observations have shown that no track slippage occurs, even on steep and soft beach slopes. Further, no vertical elevation changes occur even when the tractor remains stopped for long periods under breakers greater than one meter in height as illustrated in Figure 5 and Figure 6.

The results of one of the calibration runs at Scripps Beach is shown in Figure 7. The agreement between the measured and computed profiles is excellent, with a maximum error of only a few centimeters. The actual slope measurement record is also depicted to illustrate how the apparently noisy slope signal integrates to a smooth profile.

Figure 8 shows the profiler returning on a calibration run.

ACKNOWLEDGEMENTS

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THE PROFILER
ENTERING THE SURF ZONE
ON A CALIBRATION TRIAL.
THE STADIA ROD IS MOUNTED FOR CALIBRATION
PURPOSES ONLY AND IS NOT NORMALLY USED
WITH THE PROFILER.

FIGURE 4

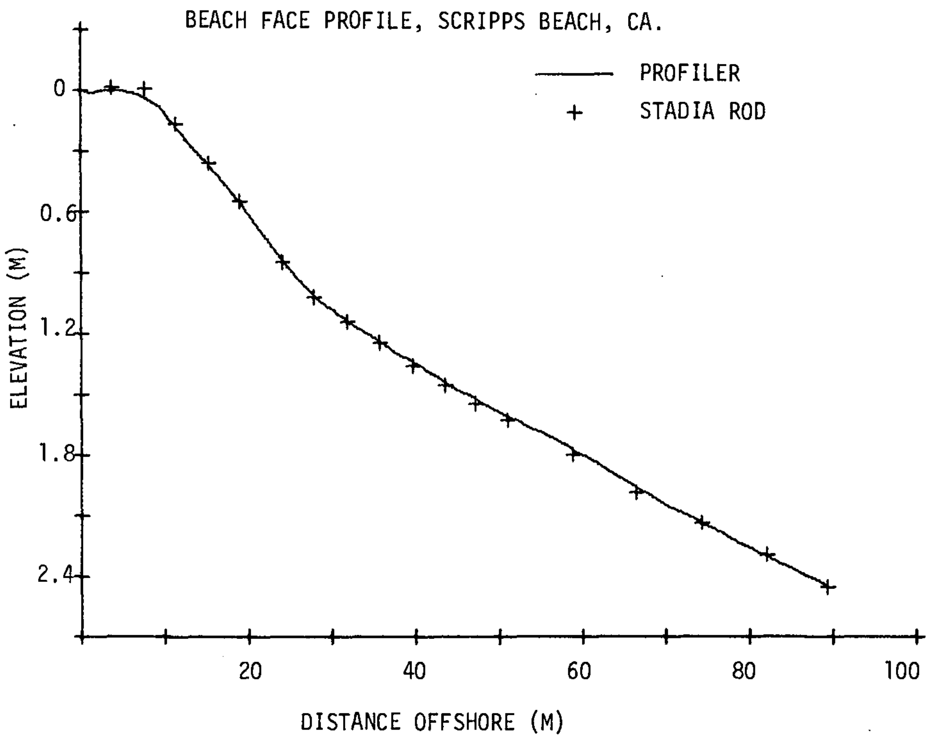
THE PROFILER
TRAVERSING THE BREAKER ZONE

FIGURE 5

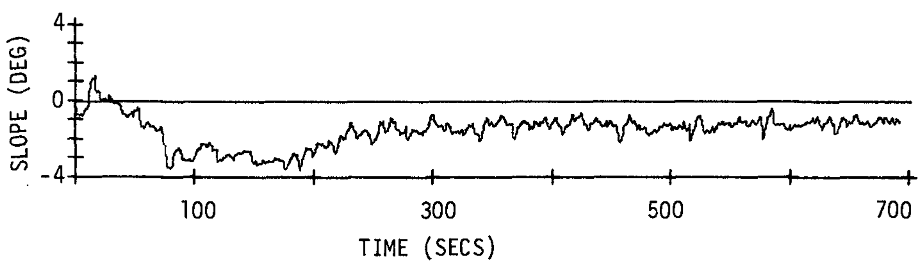
AN UNDERWATER VIEW
AT A DEPTH OF APPROXIMATELY 2 M.

FIGURE 6

FIGURE 7



COMPARISON OF BEACH PROFILE MEASURED WITH STADIA ROD AND LEVEL WITH THAT OBTAINED FROM INTEGRATING THE PROFILER RECORD BELOW.



RECORD OF SLOPE OBTAINED FROM PROFILER INSTRUMENTATION. RECORD DURATION CORRESPONDS WITH DISTANCE TRAVERSED IN TOP FIGURE.

THE PROFILER
COMPLETING A RETURN RUN AT SCRIPPS BEACH

FIGURE 8