

Influences of Penetrometer Tip Geometry on Bearing Strength Estimates

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ABSTRACT

The use of easily deployable penetrometers, for obtaining bearing strength estimates of seabed sediments, has been under investigation for a number of years. The motivation, in most cases, has been to develop a rapid method of obtaining suitable data for estimating the depth of burial of naval mines when they strike the seafloor, immediately after being deployed, but such instruments would be of general use for obtaining bearing strength profiles in the upper metre or so of the seafloor. Previous experiments have found that the measured bearing strength decreases as the diameter of a penetrometer increases. This effect is not currently understood, but in this paper it is shown, with the help of some new experiments, that with the right penetrometer design it is possible to obtain bearing strength profiles which can be validly used for mine burial prediction. Finally a particular penetrometer configuration is recommended.

INTRODUCTION

Many nations have wide areas of continental shelf for which seabed sediment data are required for purposes such as natural resources investigations, ecological zone mapping and defensive mine counter-measures. Because knowledge is often required on quite fine scales over considerable areas, remote sensing methods, particularly acoustic, are being investigated. The potential benefit of acoustic seabed classification systems is that they would be able to determine seabed characteristics continuously with a ship under way, as against the conventional approach of stopping at regular intervals to obtain bottom samples. Without some ground truthing, however, it is still difficult to relate sediment properties to acoustic returns, and this is particularly true for sediment bearing strength, which is the main sediment property controlling mine burial on impact (Satkowiak, 1988; Chu et al., 2000). Instead, to obtain sediment strength values quickly and easily, a number of free-fall penetrometers have been developed (e.g., Beard, 1975 and 1984; Crook et al., 1995), and these have been tested side by side in a number of trials (Hurst et al., 1996; Poekert et al., 1996; Lott et al., 1996; Tooma et al., 1996, Mulhearn et al., 1998 and 1999).

The last series of trials, which took place in Sydney Harbour (Mulhearn et al., 1999), found that, as penetrometer diameter increased, the measured bearing strength values decreased, as had been found in previous trials, but they appeared to decrease towards values which agreed with those obtained with more conventional apparatus (i.e. a vane-shear device). However, more data were still required to verify this. It had previously been found that bearing strength values obtained with a vane-shear device provided good predictions of mine burial on impact using the IMPACT 25 model (Mulhearn, 1993; Hurst, 1992).

The past trials had also found that larger-diameter penetrometers slowed down, before they impacted the seabed, when they were within a distance of order one diameter above the seabed. This is probably due to a build-up of pressure in the narrow space

between penetrometer and seabed. In the trials reported here, various sizes and shapes of penetrometer tips were tested to see which would minimise this deceleration and if it was significant for the range of tip diameters tested. More importantly, bearing strength values were obtained with a range of tip diameters to determine more clearly how bearing strength values varied with tip diameter and if values plateaued out as diameter increased.

EQUIPMENT AND PROCEDURES

Work was carried out from a 12.2-m (40-ft) workboat, AWB 440, at various locations in Sydney Harbour, as shown in Fig. 1 and listed in Table 1. Representative sediment data are listed in Appendix 1, and more can be obtained from the author. Differential GPS navigation was used. The DGPS reference station was a MX9250 Leica. Navigation accuracy is estimated as ± 5 m. The STING (Seabed Terminal Impact Naval Gauge) penetrometer, used for all these tests, was purchased by the Royal Australian Navy from JASCO Research Ltd of Victoria, British Columbia,

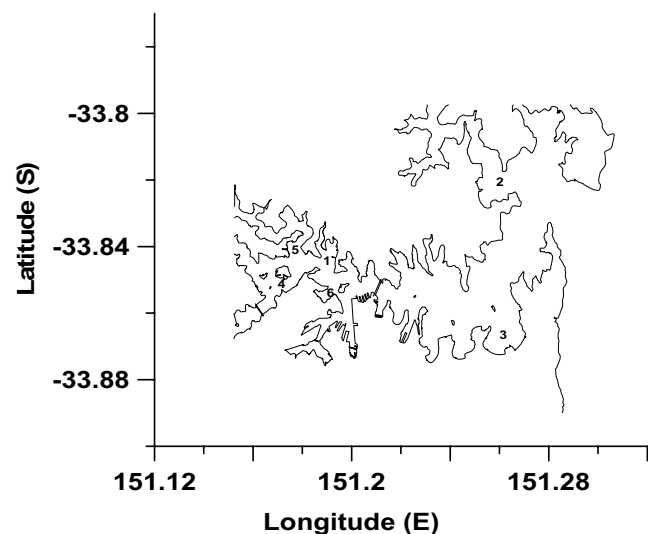


Fig. 1 Station positions in Sydney Harbour

Received October 15, 2002; revised manuscript received by the editors November 24, 2002. The original version was submitted directly to the Journal.

KEY WORDS: Penetrometers, seabed, geotechnics, route surveys, mine counter measures.