CONE FACTORS IN SAND

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SYNOPSIS: The mapping of cone penetration resistance to a state index for a sand, such as relative density, is an important aspect of the CPT. A sound theoretical basis for such a mapping is provided by cavity expansion theory. Collins et al. (1992) have presented a cavity expansion solution based on the state parameter and critical state parameters for several sands, for which there are also large calibration chamber test data. A comparison of this cavity expansion solution with the experimental data suggests a systematic mismatch for sands in a denser (more dilatant) state. The absence of plastic hardening in the cavity expansion model is postulated to be the most significant factor contributing to the mismatch between theory and experiment.

1. INTRODUCTION

Sands are difficult materials to sample in anything like an undisturbed condition and accordingly the engineering of sands has come to depend on in situ testing, and penetration tests in particular. All in situ tests, however, present an inverse boundary value problem as in situ tests measure a material response to a loading rather than a material property. Soil behaviour cannot be simply read from the data but must be interpreted from the measurements using theory and/or calibration tests.

Although a few early theoretical studies (eg Vesic, 1972) provided some basis for understanding the CPT in sand, the very idealized mohr-colomb constitutive model is a poor choice for analysing the CPT and leads to arbitrary influences such as "compressibility" being invoked to explain departures between data and theory. Most interpretation today is actually based on large calibration chamber (CC) testing in which CPT response is measured under controlled conditions to develop a mapping between response and some combination of sand density and stress. But, there is no unique mapping applicable to all sands, so that one either has to test the particular sand in a calibration chamber or develop a proper understanding of the factors involved in the mapping of the CPT. The importance of developing this understanding cannot be understated and is easiest understood by example. Hilton Mines sand at 60% relative density produces the same CPT resistance as Monterey sand at 40% relative density all other factors being equal (see Figure 4 of Robertson & Campanella, 1983). In many circumstances a 40% relative density will be regarded as inadequate while 60% could well be acceptable. The engineering decision about suitability of a sand for a specific purpose then hinges on nuances attached to unquantified factors, not the CPT data itself.

Because few projects can support calibration chamber testing, it becomes essential to understand the nature of the CPT response and how sand properties can be recovered from a CPT for any chosen sand.

be deduced from CPT data in sand. For this reason most CPT data are interpreted in terms of one parameter alone, commonly relative density but sometimes peak friction angle.

Relative density is an almost universally used state index for sand. However, it is easy to show with a modest laboratory test program that relative density is misleading. When dealing with sands with a few per cent silt, one sand/silt mixture at 40% relative density can dilate while another mixture at 60% relative density can be contractive. In addition there is the deficiency that dilatancy can be suppressed by mean stress (Been & Jefferies, 1985 &