III-264 EXPERIMENTAL STUDY AND MODELLING OF THE EFFECTS OF b-VALUE AND INITIAL ANISOTROPY ON THE STRENGTH OF SAND

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INTRODUCTION

The effect of initial anisotropy and the intermediate principal stress on the strength of sand has been studied by several researchers. These studies have demonstrated the importance of the effect of initial anisotropy and b-value. However, most studies concentrated on only one of these factors and there appears to be very little study on their combined effects on the strength of sand.

This paper presents the results of tests conducted on dense sand using a hollow cylindrical apparatus on the effects of b-value and initial anisotropy on the strength of sand. The possibility of modelling the combined effects of these parameters by using two independent functions, one describing the effect of b-value and the other the effect of initial anisotropy, is investigated.

TESTS APPARATUS AND PROCEDURES

A hollow cylindrical apparatus with a 3 cm inner radius, 5 cm outer radius and a height of 19.5 cm was used in this study. The inner and outer pressures were controlled independently within the limits of $0.75 \leq p_i/p_o \leq 1.3$ to minimize stress non-uniformities. Air-pluviated Toyoura sand (D_r = 70~75%) was used as sample. Tests were conducted at drained and stress-controlled conditions, and at constant mean pressure p=1.0 kg/cm².

TEST RESULTS AND DISCUSSIONS

The test results are shown in terms of the stress ratio q/p, b-value and β_σ, where

$$q = \sqrt{\frac{1}{2}[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]} \quad (1)$$

$$p = \frac{1}{3}(\sigma_1 + \sigma_2 + \sigma_3) \quad (2)$$

$$b = \frac{\sigma_2 - \sigma_3}{\sigma_1 - \sigma_3} \quad (3)$$

$$\beta_\sigma = \frac{1}{2}\tan^{-1}\frac{2\sigma_{z\theta}}{(\sigma_z - \sigma_\theta)} \quad (4)$$

β_σ gives the orientation of σ_1 from the normal to the plane of sand deposition.

The effect of b-value on the peak q/p is shown in Fig. 1 for different values of β_σ, while the effect of β_σ on the peak q/p for different b-values is shown in Fig. 2. The results generally agree with previously published results. The peak stress ratio is largest at b = 0 and β_σ = 0 (triaxial compression) and decreases with increasing b-value and β_σ to b = 1 and $\beta_\sigma = 90^o$ (triaxial extension).

The dependence of the peak q/p on both b and β_σ is shown in the three dimensional plot in Fig. 3. With this plot it is now possible to estimate the peak q/p for other combinations of b and β_σ not performed in this research.

MODELLING THE EFFECT OF b-VALUE AND INITIAL ANISOTROPY

The combined effect of b-value and initial anisotropy on the strength of sand is modelled by using a failure surface consisting of a product of two functions in the form

$$\frac{q}{p} = n_f r(\theta)\, s(\beta_\sigma) \quad (5)$$

where $r(\theta)$ is a function describing the effect of b-value and

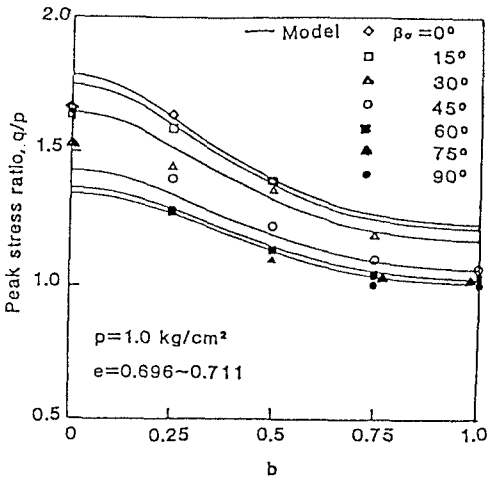

Fig. 1 Effect of b-value on peak stress ratio.

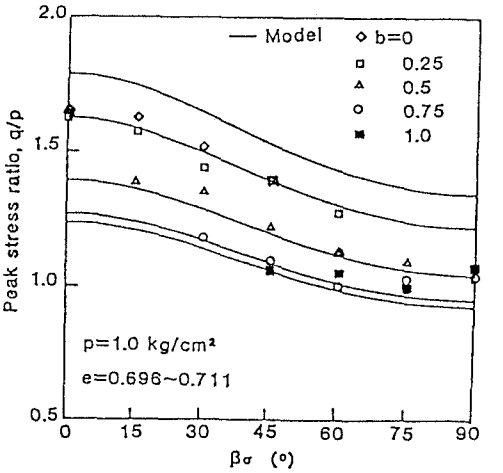

Fig. 2 Effect of β_σ on peak stress ratio.

and $s(\beta_\sigma)$ describes the effect of initial anisotropy. n_f is the peak stress ratio obtained in the conventional triaxial path (b=0 and β_σ=0°). The parameter θ is the third stress invariant related to b-value through the equation

$$\tan\theta = \frac{(2b - 1)}{\sqrt{3}} \qquad (6)$$

The functions $r(\theta)$ and $s(\beta_\sigma)$ must be chosen such that $r(0) = 1$ and $s(0°) = 1$. The effect of b-value is modelled based on the generalization of the Matsuoka-Nakai and Lade's failure criteria. Their failure criteria can be written in the form

$$\frac{1}{r(\theta)} = \cos\left(\frac{1}{3}\arccos\alpha\right) \qquad (7)$$

where $\alpha = K_1 \sin 3\theta$. K_1 is a constant related to the ratio of q/p at b=1 and b=0. The effect of β_σ is modelled by an equation of the form

$$s(\beta_\sigma) = \frac{2K_2}{(1+K_2) - (1-K_2)\cos(2\beta_\sigma)} \qquad (8)$$

K_2 is the ratio of q/p at β_σ = 90° to the q/p at β_σ = 0°.

The constant n_f, K_1 and K_2 are obtained so that Eq. (5) passes through most of the points in Fig. 3. It can be seen in the same figure that the dependency of peak q/p on b and β_σ is adequately modelled by the proposed equations.

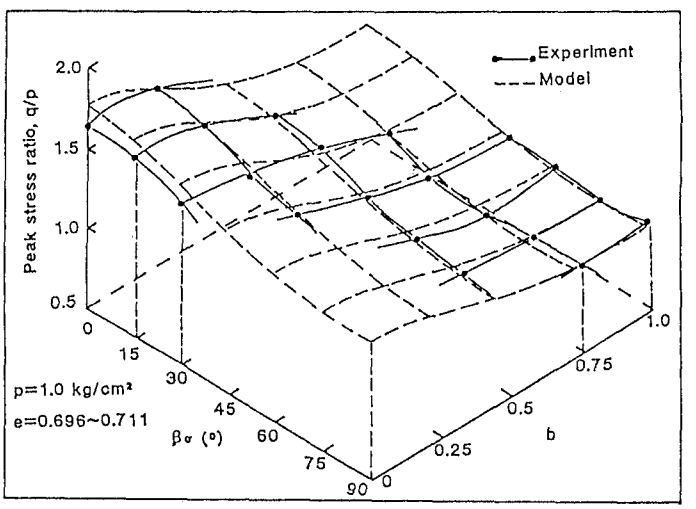

Fig. 3 Peak stress ratio for different b-value and β_σ.

CONCLUSION

The effect of b-value and initial anisotropy on the strength of sand has been shown and the adequacy of the simplifying assumption that their effects can be modelled independently has been demonstrated.