MECHANICAL CHARACTERIZATION OF ELASTIC-PLASTIC WORK-HARDENING SOILS

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SYNOPSIS - Laboratory investigations were conducted to determine experimentally soil response under a variety of stress paths for both static and cyclic loading conditions. The results are compared with predictions by various theoretical models presently employed for static loading conditions (1, 2). This paper considers one such model and its application to test results on Ottawa Sand and Grundite.

PROPOSED MODEL - The proposed model is shown in Fig. 1. The yield function combines ideal plasticity and strain hardening. The ideally plastic portion of the yield surface is the Drucker-Prager line, given by

$$f_1 = \sqrt{J_2} - \alpha J_1 + k = 0 \qquad (1)$$

X and L in Fig. 1 define the center and right of the ellipse respectively. J_1 and J_2 are the first and second stress invariants respectively and α and k are material constants. Strain-hardening is represented by a family of ellipses each of which corresponds to a single value of total plastic volumetric strain, ε_{ii}^{P}, introduced during straining of the test specimen. The equation of each elliptical yielding cap is

$$f_2\ (J_1,\ \sqrt{J_2},\ \varepsilon_{ii}^{P}) = 0 \qquad (2)$$

Incremental plastic strains are calculated using the associated flow rules.

$$\varepsilon_{ij}^{P} = \beta \frac{\partial f}{\partial \sigma_{ij}} \qquad (3)$$

β is a non-negative function which for rate independence has to be homogeneous of order one in stress tensor σ_{ij}. In the proposed formulation, the strain hardening is assumed irreversible, in line with the classical theory of plasticity for work-hardening materials, and L is evaluated from isotropic consolidation tests.

STRESS-STRAIN CURVES - Using Eq. (3), theoretical stress-strain curves have been developed for Ottawa sand of various initial densities for both static and cyclic loading conditions and compared with laboratory response under a variety of stress paths. In addition, experimental results have been compared with predictions from finite element analysis. Figures 2, 3, and 4 are typical examples showing comparison between experimental results and theoretical predictions. Excellent agreement is indicated.

CONCLUSIONS - a) Proposed model can effectively predict the response of a soil to diverse stress paths for both static and cyclic loading conditions. b) Assumptions associated with the stability postulate hold. c) Work-hardening is anisotropic.

REFERENCES

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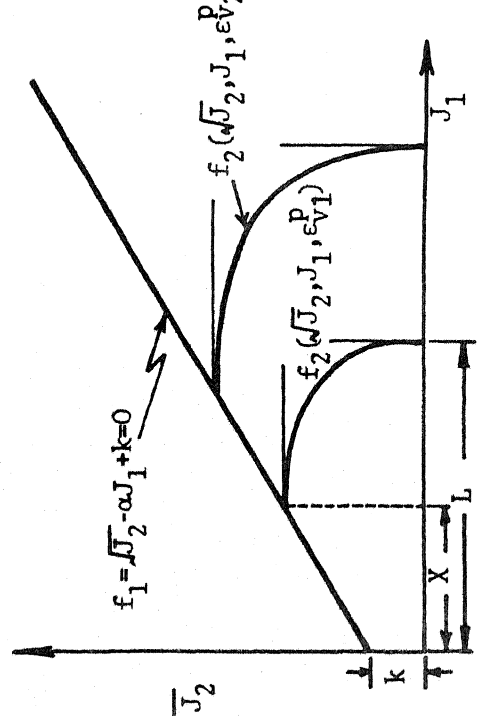

FIGURE 1 - PROPOSED MODEL

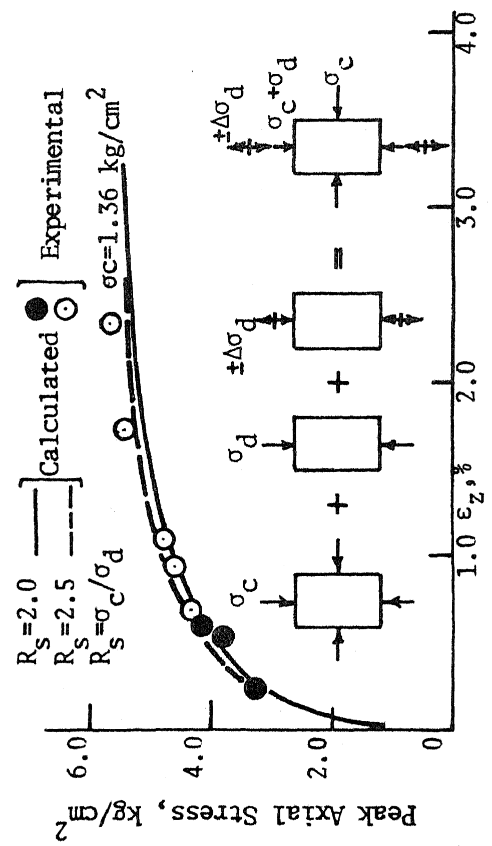

FIGURE 2 - STRESS-STRAIN CURVE FOR OTTAWA SAND

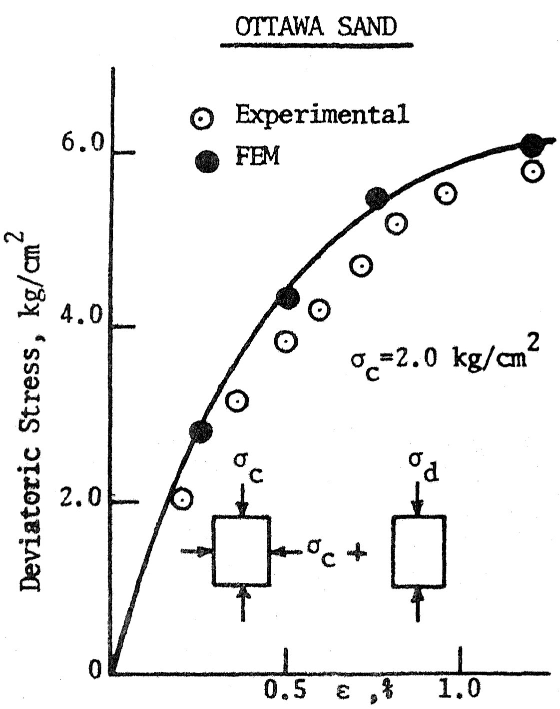

FIGURE 3 - STRESS-STRAIN CURVE

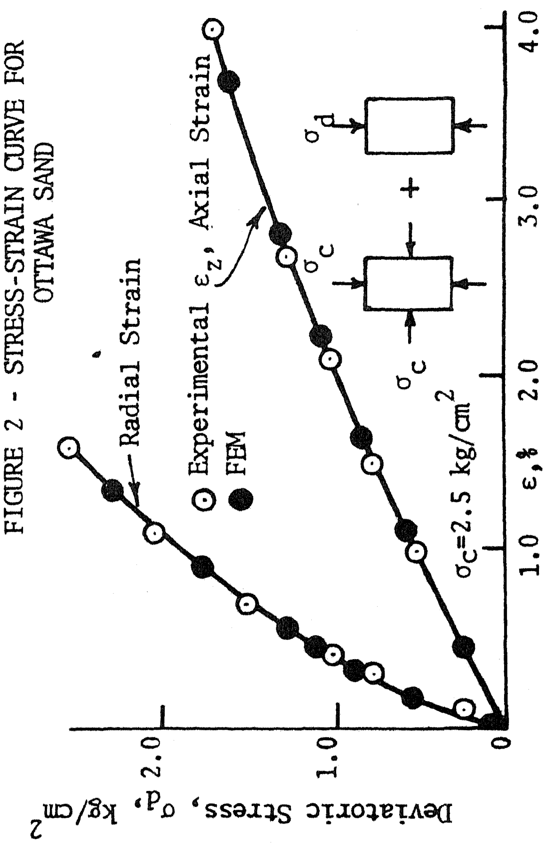

FIGURE 4 - STRESS-STRAIN CURVE FOR GRUNDITE