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LETTERS TO THE EDITOR

NUMERICAL PREDICTION OF COLLAPSE LOADS USING FINITE ELEMENT METHODS

by S. W. Sloan and M. F. Randolph, *Int. j. numer. anal. methods geomech.*, **6**, 47–76 (1982)

The Authors are to be congratulated on their contribution to the theoretical understanding of collapse predictions using Finite Elements, especially in axisymmetry.

I too have considered the axisymmetric collapse problem, but using eight-noded isoparametric elements with reduced (2-point) integration. This technique, as acknowledged by the Authors, may improve the performance of lower order elements but at the expense of relaxing the requirement of zero volume change throughout the element. This latter point has not, in my experience, posed a threat to the accuracy of a finite element analysis provided collapse loads only were the aim of the calculations. Indeed, the errors inherent in any finite element analysis due to spatial discretization have been of more concern in the search for 'accuracy'.

Zienkiewicz *et al.*,[1] using reduced integration, showed that a flow rule which predicted plastic volume changes ranging from incompressibility to fully associated Mohr–Coulomb made little difference to the computed collapse load in relatively unconfined plane strain problems. Similarly, the elastic properties assigned to a material within the failure surface have little influence on collapse loads although Poisson's ratio has a stiffening effect as it approaches one half due to the elastic incompressibility.[2]

Naturally, volume change, or the tendency for it, has a dramatic effect on collapse loads in a truly coupled soil/fluid undrained analysis in which effective stresses and thus shear strength respond immediately to changes in pore pressure.[3]

Returning to the axisymmetric problem, collapse predictions have been made using a visco-plastic algorithm with eight-noded elements and reduced integration. Using the mesh of Figure 1, the stress/displacement response of Figure 2 was obtained and this compared well with the Authors' computed results using fully integrated cubic strain triangles and with Shield's[4] exact solution where

$$q_{\mathrm{ULT}} = 5{\cdot}69\, C_{\mathrm{u}} \qquad (1)$$

Further results are shown in Figure 3 where solutions of Cox *et al.*[5] for frictional weightless soils are compared with finite element calculations, again using reduced integration. Once more, the results compare very favourably.

Further numerical experiments must clearly be performed before firm conclusions can be established regarding the advantages of reduced integration apart from the obvious economies. Mounting evidence, however, indicates that simple elements, with reduced integration, are

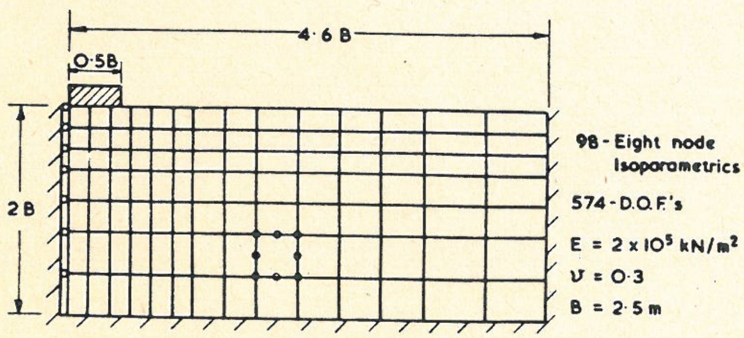

Figure 1. Mesh used for axisymmetric analyses

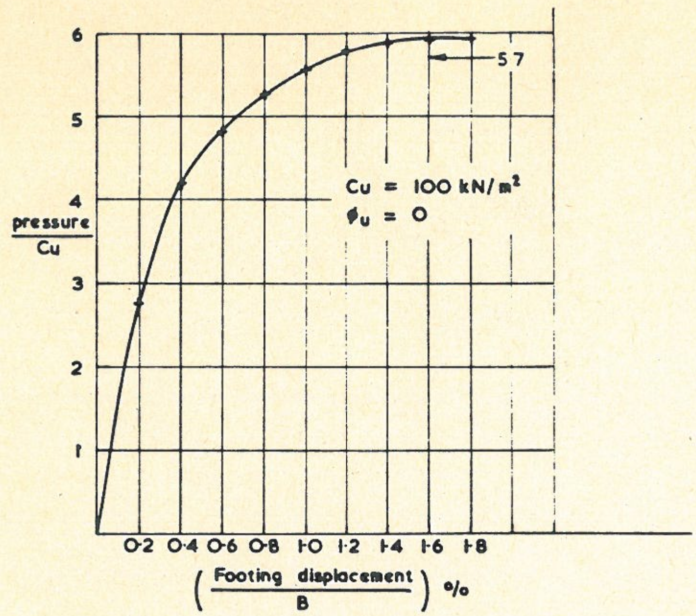

Figure 2. Bearing capacity of a rigid circular footing using reduced integration

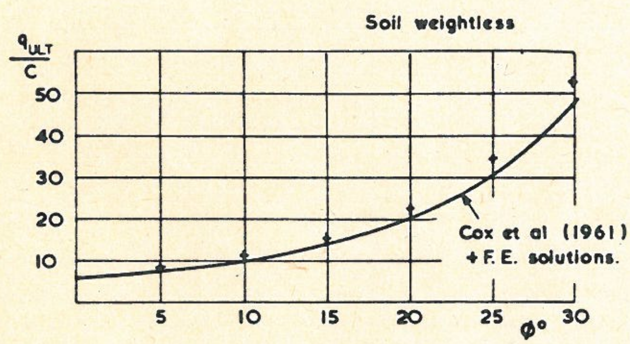

Figure 3. Comparison of finite element solutions using reduced integration with analytical values

able to predict collapse loads in soil mechanics over a wide range of boundary value problems and soil types with some confidence.

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