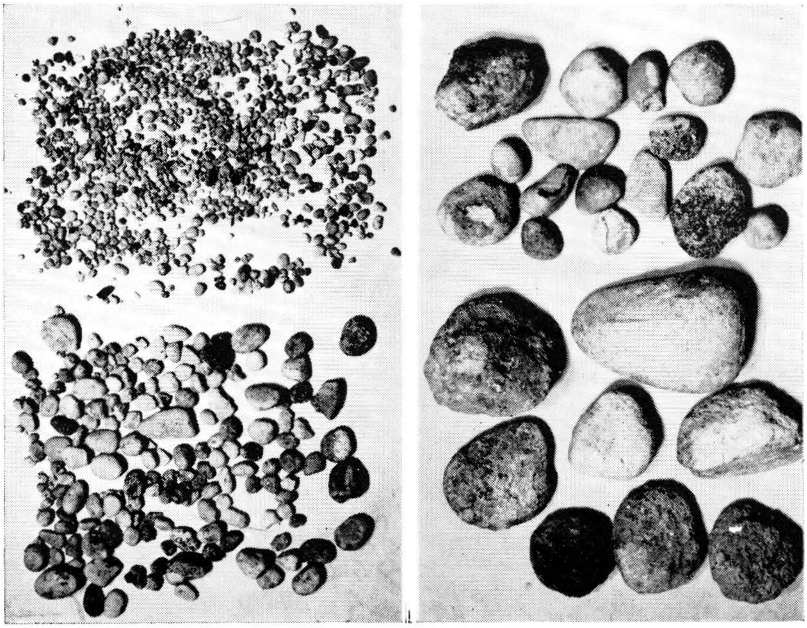
SUMMARY REPORT 99-1(S)

THE USE OF PARTICULATE THEORY IN THE SIMULATION OF STRESS-STRAIN CHARACTERISTICS OF GRANULAR MATERIALS

SUMMARY REPORT
of
Research Report Number 99-1
Study 2-8-65-99



Cooperative Research Program of the
Texas Transportation Institute and the Texas Highway Department
In Cooperation with the
U. S. Department of Commerce, Bureau of Public Roads

August, 1966

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College Station, Texas

The Use of Particulate Theory In the Simulation of Stress-Strain Characteristics of Granular Materials

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It is a common practice in designing pavements to use elasticity theory to calculate traffic induced stresses and then modify these based on experience. But tests indicate that certain portions of the flexible pavement system, notably the granular layers, are not linearly elastic. This indicates that the classical methods for evaluating stresses in soils need revision.

The use of Hookean relationships for the mass of discrete particles does not hold as it does for many other materials of construction, a fact which again discloses that another method of analysis is needed for use in soil work.

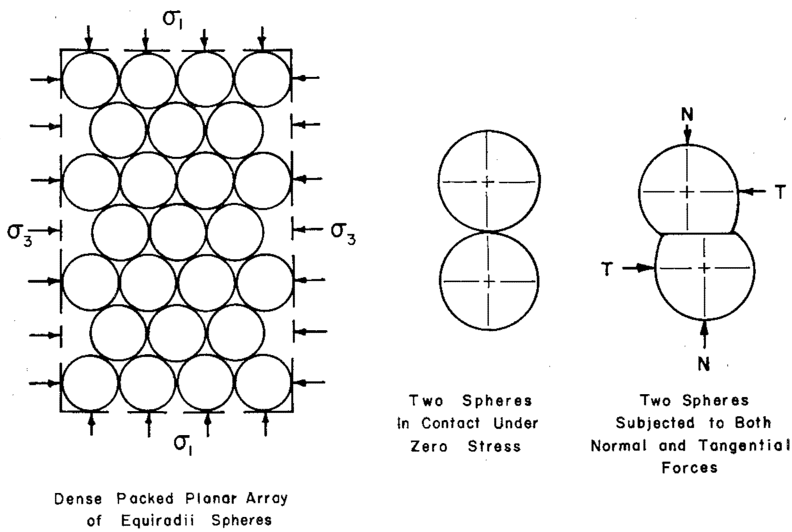
The Texas Highway Department, in conjunction with the Bureau of Public Roads, sponsored a study to investigate the feasibility of using the relatively new field of particulate mechanics in computing the stresses and corresponding strains in granular soils. This report summarizes the findings associated with the application of particulate theory to three separate arrays of equiradii spheres.

Particulate mechanics considers the forces and deformations at contact points between individual particles (in this instance equiradii spheres). The deformation equations can be developed for a given array provided the geometry of the array is known. Using these equations, the strain within the array can be calculated if the particle parameters (coefficient of friction, modulus of elasticity, and Poisson's ratio) are known.

Summary of Investigations

A theoretical analysis was conducted of the strains occurring in three different sphere arrays. First, a two dimensional loose[1]

[1]A loose array indicates one in which each sphere is in contact with six other spheres.



Spheres used to simulate a granular material in triaxial compression.

array was subjected to one dimensional compression;[2] second a two dimensional dense[3] array was subjected to triaxial[4] compression; and third, a three dimensional loose array was subjected to both triaxial and one dimensional compression. The deformation equations for each of the above arrays were developed and a study was made of the effects of varying the particle parameters. The strains predicted by these equations were then compared to those obtained by the repetitive stressing of a cherty limestone gravel.

The reverse S-shape curvature of the stress-strain curve which was evident in repetitive triaxial tests did not develop in either of the two theoretical triaxial cases. However, it did evolve in both of the one dimensional compression cases. This seems to indicate that repetitive triaxial test results are more nearly approximated by one dimensional compression theory than by triaxial compression theory for the soil tested.

The shape of the stress-strain curve for the three dimensional loose array subjected to one dimensional compression compared

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[2]One dimensional compression refers to the application of a vertical stress while restraining radial motion. The effect is to increase the radial stress also.

[3]A dense array is one in which each sphere is in contact with 12 other spheres.

[4]Triaxial compression indicates constant radial stress and increasing vertical stress. Thus, the array may expand radially.

remarkably well with those obtained from variable confining pressure tests.[5] Again, the real curves resembled curves from one dimensional compression theory.

For all arrays and loading conditions studied, the theoretical stress-strain curves exhibited a tendency for the secant modulus to increase with increase in lateral pressure, a tendency frequently observed in the triaxial testing of granular materials.

In summary, particulate theory for one dimensional loading predicted stress-strain curves somewhat similar in shape to those observed in triaxial testing. For all arrays and loadings studied it predicted an increase in modulus with increase in lateral pressure, a tendency that is consistent with experimental findings. However, extension of the theory to more complex arrays appears to be necessary if acceptable agreement with experimental results is to be achieved.

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[5]Variable confining pressure tests are conducted by increasing the confining pressure as the vertical pressure increases. Usually it is increased at some constant ratio of vertical to confining stress.