RELATION OF STRESS TO STRAIN FOR A CRUSHED LIMESTONE BASE MATERIAL

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ABRIDGMENT

•A TRULY rational system for the design of flexible pavements must include realistic physical equations—or computer-oriented procedures—from which traffic-induced stresses and deformations can be estimated. The first step in the derivation of such equations or procedures is to find, from laboratory and in situ testing, a set of basic relations between stress and strain from which one can predict, with acceptable accuracy, the deformations of flexible pavement materials subjected to any given state of stress. Many investigations have been devoted to a search for these basic relations within the laboratory. This is a report of one such investigation.

The physical data were acquired by a newly developed optical displacement tracker (Fig. 1). The instrument, commercially available from Martin Tracker Corporation, made it possible to measure the dynamic displacement vector at selected points on the periphery of a cylindrical triaxial test specimen of water-bound crushed limestone during rapid loading (Fig. 2). Except for brief infrequent intervals devoted to the acquisition of displacement data for selected combinations of lateral and vertical loadings, a 6-in. diameter by 8-in. high test specimen was subjected to a constant lateral pressure of 20 psi and a repetitive vertical pressure of 34 psi. The latter was applied and released within 0.2 sec and was repeated every 2 sec. A total of 2.5 million vertical load applications was made during the testing program.

The displacement data taken at points in the central region of the surface of the specimen—where the stresses were assumed to be reasonably uniform at any given instant—were converted to axial and circumferential strain components. The strain components were analyzed with respect to their relation to the applied pressures (Fig. 3). These strain data are believed to represent more reliably the deformation of triaxially loaded specimens than data obtained by any other method known to the authors. The measurement methods and the techniques used to develop strains are fully described in another paper (1). Table 1 gives values of resilient moduli determined for several typical conditions of loading.

Various stress-strain hypotheses proposed by other investigators were tried in an attempt to fit the observed stress-strain behavior. All were rejected. In general it was found that for brief periods of testing at a fixed confining pressure, a specimen appears to behave like an anisotropic elastic material. However, as the confining pressure is changed or the repetition of load is continued for a period of time, a specimen's pseudo anisotropic elastic constants vary. The writers were unable to formulate a rational mathematical hypothesis that would account for the variations due to both of these factors.

Based on measured axial and circumferential strains of crushed limestone specimens having moisutre contents near optimum, the following conclusions were apparent:

1. Laboratory specimens are anisotropic (that is, their stiffness in the axial direction is quite different from that in the radial direction);
2. The effect of changes in the rate of loading, within the range of about 200 to 600 psi per second, is small and probably insignificant;

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Figure 1. Optical displacement tracker (center), loading apparatus (right), and recorder (left).

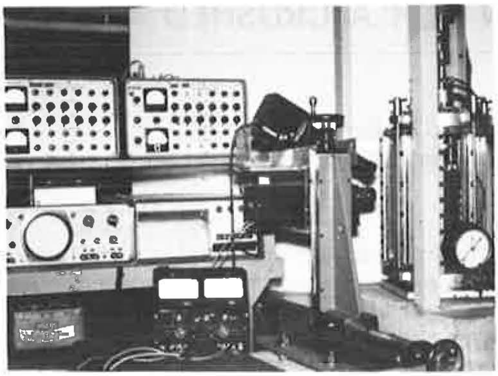


Figure 2. Triaxial test specimen with optical targets attached and ready for testing.

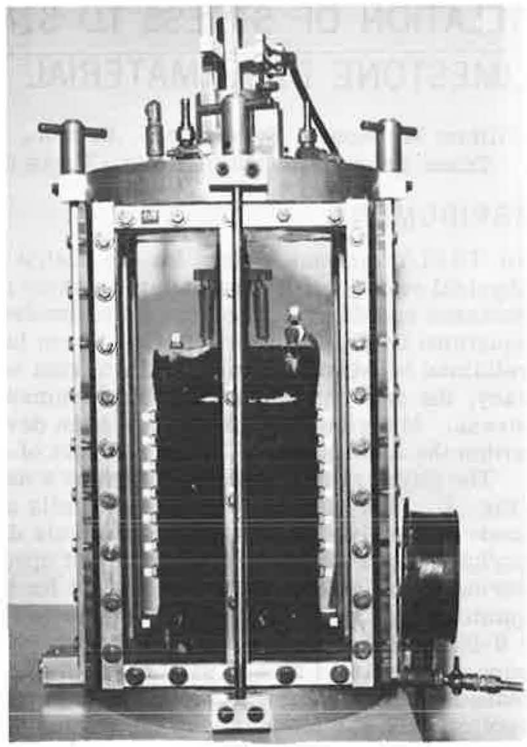
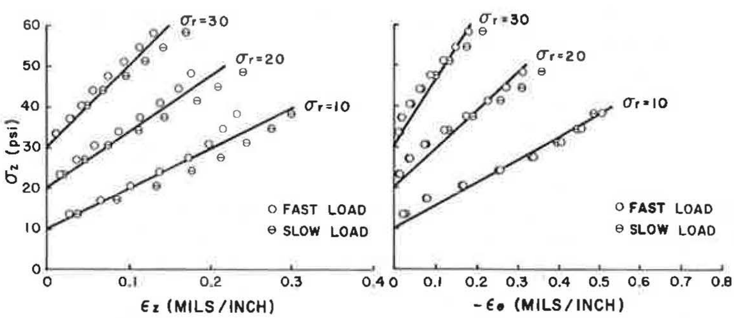


Table 1. Resilient modulus for lateral pressures of 10 and 30 psi.

Test	Average Number of Load Applications (millions)	Resilient Modulus 10 psi	Resilient Modulus 30 psi
1-6	0.06	70,600	160,200
7-12	0.27	98,500	199,700
13-18	0.77	170,600	342,400
19-24	2.49	332,900	503,000

Figure 3. Typical stress-strain data for tests 7-12.



3. The stress-strain relations for laboratory specimens are significantly affected by their stress history; and

4. The axial strains observed were extremely small, resulting in resilient moduli much greater than reported by other investigators (however, they are believed to be correct for the test conditions).

REFERENCE

1. Moore, W. M., Swift, G., and Milberger, L. J. Deformation Measuring System for Repetitively Loaded, Large-Diameter Specimens of Granular Material. Highway Research Record 301, 1970, pp. 28-39.