## ACKNOWLEDGMENTS

The author wishes to thank Frank Hawthorne and the other commissioners of Comanche County for permission to core and sample their county road; Mayor Bailey and the citizens of Indiahoma for authorizing the Portland Cement Association to core and sample their street; Atlas-Truck Concrete, Inc., Duncan, for supplying the concrete and assisting in repairing the cored holes; and Shepherd Engineering and Testing Company, Norman, Oklahoma, for conducting the field and laboratory investigations.

## REFERENCE

1. C. R. Reid. "Concrete Pavement Subgrade Design, Construction, Control." *HRB Proc.*, Vol. 19, 1939, pp. 541–551.

*Publication of this paper sponsored by Committee on Soil-Portland Cement Stabilization.*

# Flexural Fatigue Strength of Lime-Laterite Soil Mixtures

P. G. BHATTACHARYA AND B. B. PANDEY

**Laterite soils, which are the products of tropical or subtropical weathering, have been stabilized with lime to evaluate the dynamic modulus and the flexural fatigue strengths of the lime-soil mixtures. Tests have been carried out on four types of laterite soils compacted at three dry density ranges—light, medium, and heavy. Least-squares regression analysis was used to establish relationships between stress ratio and the logarithm of the number of stress cycles to failure. Heavily compacted lime-soil specimens were found to have considerably higher dynamic modulus and fatigue life than those having standard Proctor compaction. Increased values of dynamic flexural modulus and strength at the higher dry density favor the use of lime-laterite soil as a road base.**

Highway pavements need good quality paving materials with adequate strength and durability characteristics. With petroleum prices rising sharply, bitumen is no longer a cheap material, particularly in India, and therefore asphalt-bound pavement layers cannot be considered economical road bases now. Highway activities, on the other hand, have increased manyfold and as a result quality paving materials have become scarce and costly. Under the circumstances, utilization of locally available indigenous materials may provide a solution to reduce construction costs if the characteristics of the in situ soils, otherwise unsuitable, are modified by appropriate treatment. This study is an attempt to evaluate the suitability of lime-treated laterite loams available in India.

Laterites are apparently very complex and controversial materials that defy any satisfactory geological, chemical, or pedological definition (*1*, p. 5). Essentially, they are products of tropical or subtropical weathering that includes all stages from parent rock to the surface and in which iron or aluminum content or both are higher and silicon content is lower than in merely kaolinized parent rock (*2*, pp. 1–10). Though they frequently occur in the humid tropical areas of South America, Africa, India, Indonesia, and Australia (*3*), there is an absence of adequate engineering data for highway and runway construction.

Areas of laterite soil occur in coastal India and the adjoining interior. The present study area at Kharagpur is on the east coast. These reddish-brown fine-grained laterite soils are evaluated for their suitability as a lime-bound base. Tests were carried out on four laterite soils treated with an optimum lime content of 5 percent.

The changes that take place on addition of lime to certain laterite soils are rapid amelioration effects and strength development due to hydration and increased degree of crystallinity of the reaction products formed during the first 5 to 7 days (*4*). The strength of a stabilized soil has been quantitatively assessed by unconfined and confined compressive strength tests (*5*; *6*, p. 290; *7–9*) and also by the split tensile strength test (*10*). But the shear and compressive strengths of lime-soil mixtures are not the limiting factors in their application as subbase or base-course materials (*11*). The lime-soil

P. G. Bhattacharya, B. E. College, Shibpur, Howrah, India. B. B. Pandey, Indian Institute of Technology, Kharagpur 721 302, India.

TABLE 1 LATERITE SOIL PROPERTIES

| Property | Soil A | B | C | D |
|---|---|---|---|---|
| Gravel (>2 mm) (%) | 1.02 | 0.78 | 0.75 | 0.40 |
| Sand (2–0.075 mm) (%) | 42.89 | 47.52 | 43.87 | 35.70 |
| Silt (0.075–0.005 mm) (%) | 47.40 | 46.22 | 48.54 | 54.00 |
| Clay (<0.005 mm) (%) | 8.69 | 5.48 | 6.84 | 9.90 |
| Liquid limit (%) | 30.95 | 23.60 | 23.50 | 38.63 |
| Plasticity index (%) | 12.58 | 10.35 | 10.54 | 18.07 |
| Standard Proctor maximum dry density (kg/m$^3$) | 1926 | 1945 | 1910 | 1900 |
| Optimum moisture content (Proctor) (%) | 12.78 | 11.50 | 12.50 | 13.50 |
| Modified AASHTO maximum dry density (kg/m$^3$) | 2080 | 2085 | 2040 | 2015 |
| Optimum moisture content (modified AASHTO) | 10.23 | 9.50 | 10.50 | 12.00 |
| AASHTO classification | A–6(5) | A–4(3) | A–4(4) | A–6(9) |
| Textural classification | Loam | Loam | Loam | Silty loam |
| Unified classification | CL | CL | CL | CL |

layer in a pavement is subjected to repeated flexural stresses, and therefore its flexural strength and fatigue responses are more important considerations. Published fatigue data for lime-treated soil in general and lime-laterite soil mixtures in particular are limited. Swanson and Thompson (*11*) conducted a flexural fatigue study of selected lime-soil mixtures with the primary objective of evaluating the general flexural fatigue response of the materials and determining whether the fatigue response would limit the use of these materials in subbase and base-course applications.

## PURPOSE AND SCOPE

The main purpose of this investigation was to determine the dynamic and flexural fatigue response of lime-laterite soil mixtures at three levels (low, medium, and heavy) of compaction. The standard Proctor and modified AASHTO compactions are designated as low and heavy compaction, respectively, and the mean of the two is defined as medium compaction. Simply supported beam specimens of nominal size 50 mm high, 64 mm wide, and 254 mm long were tested under symmetrical third-point loading in a fatigue-testing apparatus developed in the laboratory (*12*) for the specific purpose of applying pulsating loads on lime-soil beams and similar materials. The study was limited to laterite soils described as loam and silty loam belonging to the CL group of the Unified Soil Classification System and to the A-4 to A-6 groups of the AASHTO classification.

## TEST MATERIALS

### Soils

Four laterite soils, air-dried and passing the 4.75-mm sieve, were designated A, B, C, and D; the samples were from the well-developed mottled zone found in and around Kharagpur, India. The soils were all reddish brown, blocky, and sticky, with iron nodules fairly well distributed. Soils A, B, and C were collected from scrub jungle and D from a paddy cultivation area. The soils ranged from loams to silty loams, with particle sizes smaller than 0.075 mm varying from nearly 52 to 64 percent and plasticity index (PI) values ranging from 10 to 18. Addition of 5 percent lime by weight of air-dried soil reduced the PI values of the lime-soil mixtures to about 40 to 50 percent of those of the untreated soils. Tables 1 and 2 give the properties of the laterite soils and the lime-laterite soil mixtures.

TABLE 2 LIME-LATERITE SOIL MIXTURE PROPERTIES

| Property | Soil A | B | C | D |
|---|---|---|---|---|
| Lime treatment (%) | 5 | 5 | 5 | 5 |
| Liquid limit (%) | 30.45 | 23.00 | — | 33.80 |
| Plasticity index (%) | 7.25 | 6.30 | — | 7.73 |
| Standard Proctor maximum dry density[a] (kg/m$^3$) | 1884 | 1878 | 1875 | 1870 |
| Optimum moisture content (OMC) (Proctor)[b] (%) | 14.96 | 13.78 | 13.95 | 14.63 |
| Modified AASHTO maximum dry density[c] (kg/m$^3$) | 2035 | 2030 | 2000 | 1980 |
| Optimum moisture content (modified AASHTO)[d] (%) | 11.97 | 10.60 | 12.00 | 13.20 |

[a]Mean = 1877 kg/m$^3$.
[b]Mean = 14.33 percent.
[c]Mean = 2011 kg/m$^3$.
[d]Mean = 11.94 percent.

### Lime

Commercial-grade quick lime, slaked, dried, and sieved through a 0.075-mm sieve, was used throughout the testing program. The mean calcium oxide content of the hydrated lime was nearly 64 percent.

## SPECIMEN PREPARATION

Each batch of soil was weighed and mixed with the required amount of lime. The compaction water was then added and the mixture was again hand mixed until it appeared to be uniform with an even distribution of moisture. The mean amount of compaction water needed to achieve maximum dry density for the lime-laterite soil mixtures was 14.33 and 11.94 percent for standard Proctor and modified AASHTO compaction, respectively. Dry densities of 1880, 1940, and 2000 kg/m$^3$ represented light, medium, and heavy compactions. The soil-lime mixture was compacted in a steel mold in three layers, each layer being subjected to 15 tamping blows of a standard Proctor hammer. The soil was then compressed to a given volume by a hydraulic jack. Next the sample was extruded from the mold and weighed. Side dimensions were measured for volume calculations, and the dry density was calculated considering the actual moisture content and the weight of the specimen.

Beam samples, after extrusion from the mold, were placed inside polyethylene bags to prevent escape of moisture from within and cured in a temperature-regulated oven at 50 ± 1°C for 3 days. In a separate study (*12*) it was found that 3 days of oven curing at 50°C is equivalent to 41 days of moist curing at the mean summer temperature of 30.50°C having a maturity of 1245 degree-days above a 0°C datum.

## STRENGTH EVALUATION OF LIME-LATERITE SOIL MIXTURES

Static compression test studies were conducted in which 64 oven-cured cylindrical specimens 50.8 mm in diameter and 101.6 mm high were tested under unconfined compression to examine the variation of strength with dry density and lime content of the specimens. Lime content of 5 percent was found to be the optimum for the stabilization of laterite Soil A, because the rate of strength gain for higher lime contents was not significantly high (*13*, *14*, pp. 37–41). The least-squares regression line for the lime-soil mixture with 5 percent lime content was found to be

$$\sigma_u = -15.3158 + 9.4342 \times 10^{-3}\,\gamma_d \qquad R^2 = 0.84 \qquad (1)$$

where

$\sigma_u$ = unconfined compression strength (MPa),
$\gamma_d$ = dry density (kg/m$^3$), and
$R^2$ = coefficient of determination.

In order to assess the applicability of the foregoing equation to other lime-treated laterite soils in the area, cylindrical samples of Soils B, C, and D of the same size and treated with 5 percent lime were tested under identical conditions. The predicted and observed unconfined compressive strength values of all 22 samples of Soils B, C, and D, along with 32 samples of Soil A, were observed to compare favorably with respect to the 1:1 correlation line, indicating that laterite Soils A, B, C, and D treated with lime would develop comparatively equal strengths. The coefficient of determination between the predicted strength values from Equation 1 and the observed values for Soils B, C, and D was found to be 0.87.

## STATIC FLEXURAL STRENGTH STUDIES

The stress ratio in the flexural fatigue test is the ratio of the applied flexural stress ($\sigma_f$) on the beam specimen to its modulus of rupture. It is therefore necessary to predict the static flexural strength of the beams for analysis of fatigue test results. Beam specimens of different densities were tested under third-point loading at a rate of 1.25 mm/min until failure. The test results yielded the following regression equation:

$$MR = -7.0361 + 4.3 \times 10^{-3}\,\gamma_d \qquad R^2 = 0.89 \qquad (2)$$

where *MR* is the modulus of rupture in megapascals.

## EXPERIMENTAL INVESTIGATION

Figure 1 is a representative diagram of the experimental setup for the fatigue testing machine. The rate of loading is 110 cycles/min with a cycle length of 0.54 sec and the distribution of loading to unloading time adjusted to 1:1. Load and deflection of the beams were recorded on a two-channel electronic recorder. The load cell and the linear variable differential transformer were calibrated before use for the purpose.

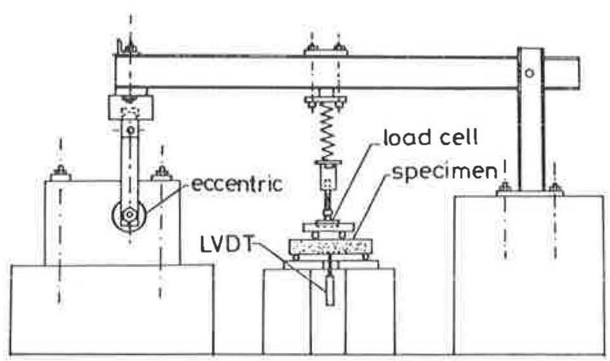


**FIGURE 1 Fatigue-testing experimental setup.**

Three types of beams, depending on the compaction (light, medium, or heavy), were tested under repeated flexure to study the fatigue characteristics of the material. The stress ratio varied from 0.41 to 0.68 for lightly compacted beams, from 0.47 to 0.71 for medium-compacted beams, and from 0.31 to 0.72 for heavily compacted beams. Once the dry density of the specimen had been determined, the modulus of rupture was calculated by using Equation 2, and the stress ratio was calculated by noting the applied load on the specimen obtained from

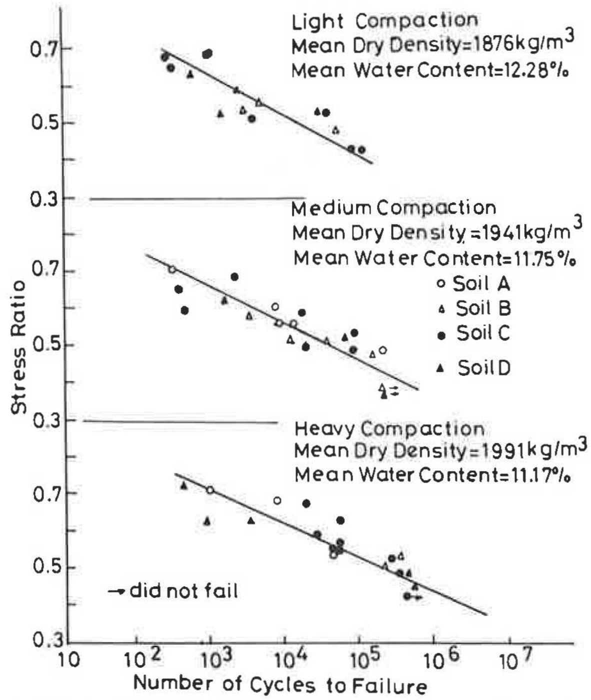


**FIGURE 2 Relationship between stress ratio and fatigue life for lime-laterite soil mixtures.**

the recorder. The results of the tests are shown in Figure 2. The least-squares regression lines for different dry densities are as follows:

Light compaction:

$$S = 0.96 - 0.114 \log N_f \qquad R^2 = 0.76 \tag{3}$$

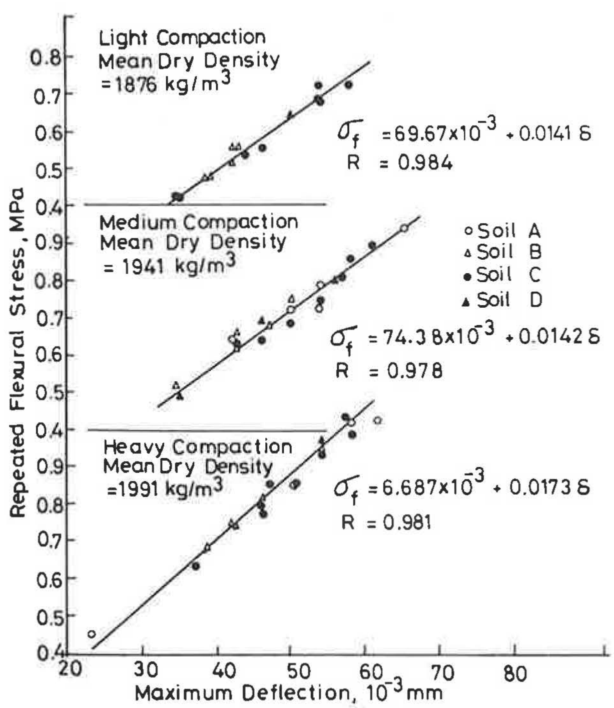


**FIGURE 3 Relationship between repeated flexural stress and deflection for lime-laterite soil mixtures.**

Medium compaction:

$$S = 0.95 - 0.099 \log N_f \qquad R^2 = 0.77 \tag{4}$$

Heavy compaction:

$$S = 0.982 - 0.090 \log N_f \qquad R^2 = 0.79 \tag{5}$$

where $S$ is the stress ratio and $N_f$ is number of cycles to fracture.

The applied flexural stresses have been plotted in Figure 3 against the central deflections of beams subjected to third-point loading. The scatter is very small and the coefficients of determination for linear regression for all compactive efforts are around 0.97. The lime-laterite soil beams thus display linear elastic behavior right up to the rupture stage under the cyclic loading, because deflections and loads remain constant till the specimens suddenly fail.

## DYNAMIC MODULUS AND DRY DENSITY

Fifty-four beams with dry densities ranging from light to heavy were tested under repeated flexure, and for each beam the dynamic flexural modulus was calculated according to the following equation:

$$E_{DF} = 23WL^3/1296\delta I \tag{6}$$

where

| | | |
|---|---|---|
| $E_D$ | = | flexural dynamic modulus, |
| $W$ | = | load applied, |
| $L$ | = | simply supported span (225 mm), |
| $I$ | = | moment of inertia of the beam, and |
| $\delta$ | = | central deflection. |

$E_{DF}$-values have been plotted against dry density in Figure 4

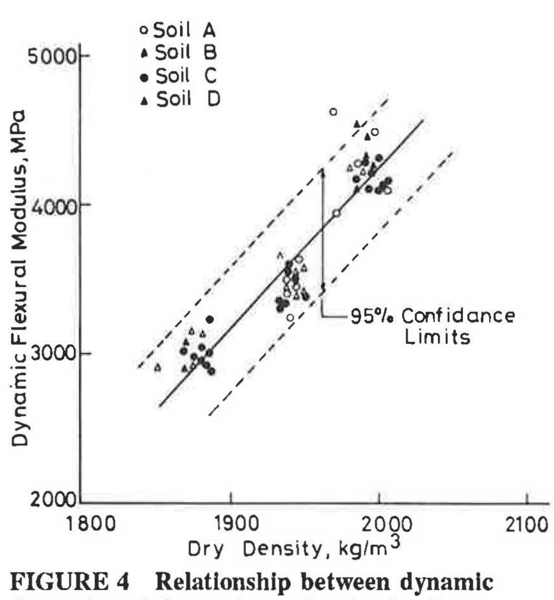


**FIGURE 4 Relationship between dynamic flexural modulus and dry density for lime-laterite soil mixtures.**

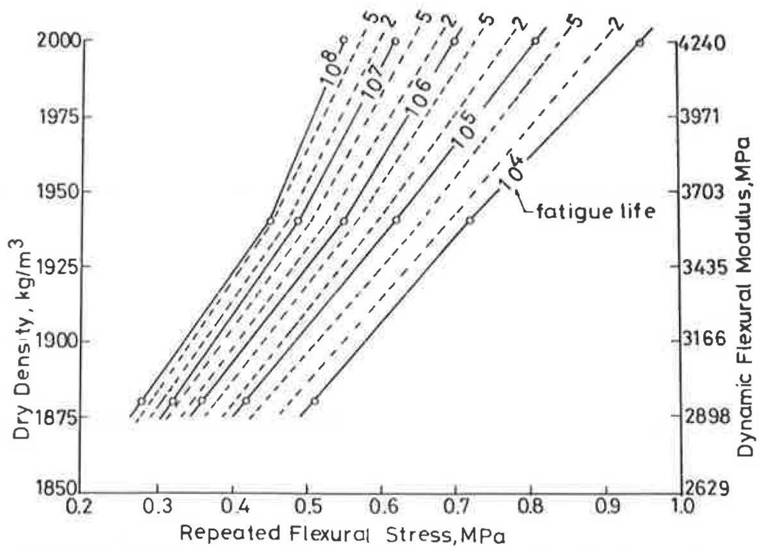


**FIGURE 5 Variation of fatigue life with dry density, dynamic flexural modulus, and flexural stress for lime-laterite soil mixtures.**

and the following equation relating $E_{DF}$ in megapascals and $\gamma_d$ in kilograms per cubic meter was obtained:

$$E_{DF} = -17.234 + 10.734 \times 10^{-3}\gamma_d \qquad R^2 = 0.84 \tag{7}$$

Using Equations 2 and 7, the relationship between $MR$ and $E_{DF}$ (in megapascals) was found to be

$$E_{DF} = 330 + 2496MR \tag{8}$$

The major findings of the investigation are combined in Figures 5 and 6, which show the relationships among various parameters that are important for design of pavements having lime-laterite soil layers.

## PRACTICAL APPLICATION

The fatigue data presented in the paper can be applied to the design of pavements having lime-stabilized laterite soil. The design method essentially consists of two steps.

The first step is to select a thickness of pavement to prevent fatigue failure in the lime-soil layer. The tensile stresses computed in the lime-soil layer by elastic-layer analysis are increased by 50 percent (*15*, pp. 409–416) to account for increased stresses resulting from loading at the transverse crack that may develop after construction because of shrinkage and temperature changes.

The second step is to ascertain that the combination of load and thermal stresses will not crack the stabilized layer (*15*).

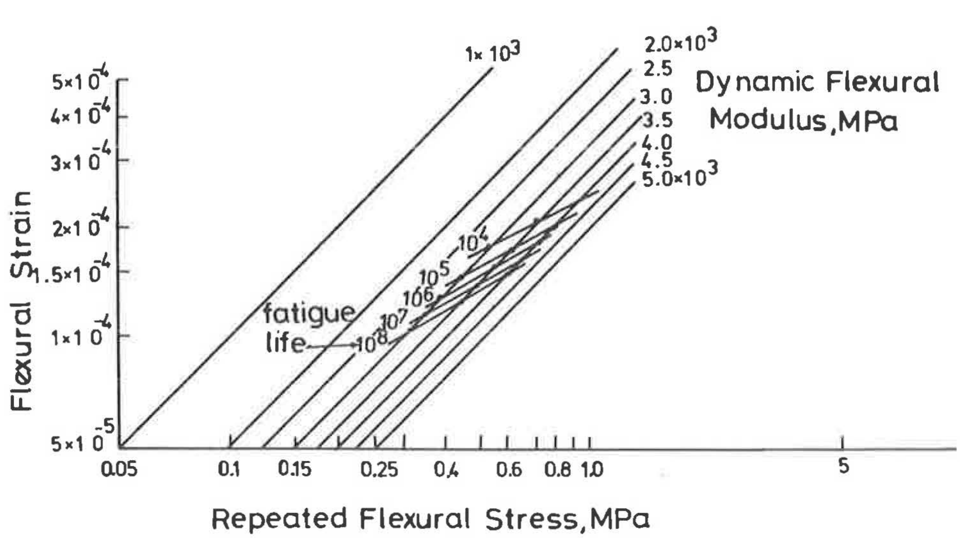


**FIGURE 6 Relationship among flexural stress, strain, dynamic modulus, and fatigue life.**

The design of a pavement consisting of lime-stabilized base with a thin bituminous wearing surface has been determined (*12*) for the Kharagpur region by assuming an axle load spectrum identical to that of the left-hand traffic lane of the northbound carriageway of Trunk Road Al at Alcombury Hill in England (*16*, p. 52). Assuming the traffic growth to be 5 percent, it was found that a 45-cm lime-bound laterite soil base at modified AASHTO compaction with a thin bituminous surfacing has a life of about 20 years.

## DISCUSSION OF RESULTS

The physicochemical properties of laterite soils are responsible for the strength values for the lime-soil mixture, which are different from those reported by others (*11*, *17*), though there is a similarity in the trend of the results.

The plots of $S$ versus log $N_f$, $\sigma_f$ versus $\delta$, and $E_{DF}$ versus $\gamma_d$ have yielded linear relationships with coefficients of determination varying from 0.74 to 0.97. The slopes of the fatigue lines in Figure 2 are higher for lightly compacted soil, indicating that fatigue damage takes place at faster rates when the dry density is low. An examination of Table 3 reveals that heavily compacted lime-laterite material will withstand flexural stresses almost twice the values sustained by the lightly compacted beams for the same number of repetitions.

**TABLE 3 REPEATED FLEXURAL STRESSES AT DIFFERENT DRY DENSITIES AND AT SELECTED FATIGUE LIFE**

| Compaction | Dry Density ($\gamma_d$)(kg/m$^3$) | Dynamic Flexural Modulus ($E_{DF}$)(MPa) | Fatigue Life ($N_f$) | Repeated Flexural Stress ($\sigma_f$)(MPa) |
|---|---|---|---|---|
| Light | 1880 | 2952 | | 0.51 |
| Medium | 1940 | 3596 | $10^4$ | 0.72 |
| Heavy | 2000 | 4240 | | 0.95 |
| Light | 1880 | 2952 | | 0.42 |
| Medium | 1940 | 3596 | $10^5$ | 0.62 |
| Heavy | 2000 | 4240 | | 0.81 |
| Light | 1880 | 2952 | | 0.36 |
| Medium | 1940 | 3596 | $10^6$ | 0.55 |
| Heavy | 2000 | 4240 | | 0.70 |
| Light | 1880 | 2952 | | 0.32 |
| Medium | 1940 | 3596 | $10^7$ | 0.49 |
| Heavy | 2000 | 4240 | | 0.62 |
| Light | 1880 | 2952 | | 0.28 |
| Medium | 1940 | 3596 | $10^8$ | 0.45 |
| Heavy | 2000 | 4240 | | 0.56 |

Study of Figure 3 reveals that the stress-deflection relationship is strikingly linear for all the compactions and the material behavior is linearly elastic. The lightly compacted beams undergo deflections that are nearly one-and-one-half times the deflection of the heavily compacted beam at various applied stresses. The dynamic modulus, a major parameter for pavement design, can be estimated from the values of dry density spread over the three dry density ranges. The dynamic modulus at heavy compaction is one-and-one-half times that at light compaction.

Fatigue response curves relating flexural stress, dry density, dynamic modulus, and flexural strain have been developed for $N_f$ varying from $10^4$ to $10^8$ repetitions to cover a wide range of traffic movement; these curves are shown in Figures 5 and 6. They show the effects of various parameters on fatigue lives of the lime-soil mixture.

## CONCLUSIONS

1. Good correlation exists between the flexural fatigue life and stress ratio and between dry density and dynamic flexural modulus for two stabilized laterite soils. The relationships are all linear and statistically significant.
2. Lime-laterite soil mixtures behave like linear-elastic brittle materials under pulsating loads. Hence, a lime-laterite soil layer may be considered a linearly elastic material in the stress analysis of pavements.
3. The fatigue resistance of lime-laterite soils is increased to a considerable extent at the higher dry density. Heavily compacted materials can be subjected to almost twice the flexural stresses as compared with the lightly compacted beams for the same number of repetitions to failure.
4. The dynamic flexural modulus of heavily compacted lime-soil mixtures is nearly 1.5 times that of the lightly compacted ones and the values of the moduli at light, medium, and heavy compaction are, respectively, 2952, 3596, and 4240 MPa.

## REFERENCES

1. M. D. Gidigasu. *Lateral Soil Engineering*. Elsevier Scientific Publishing Company, New York, 1976.
2. W. Schellmann. "Considerations on the Definition and Classification of Laterites." *Proc., International Seminar on Laterisation Processes*, Trivandrum, India, 1979.
3. J. K. Nixon and B. O. Skipp. "Airfield Construction on Overseas Soils, 5: Laterites." *Proc., Institution of Civil Engineers*, Vol. 8, 1957, pp. 253–292.
4. J. G. Cabrera and C. A. Nwakanma. "Pozzolanic Activity and Mechanism of Reaction of Red Tropical Soil-Lime Systems." In *Transportation Research Record 702*, TRB, National Research Council, Washington, D. C., 1979, pp. 199–207.
5. M. A. Jan and R. D. Walker. "Effect of Lime, Moisture, and Compaction on a Clay Soil." In *Highway Research Record 29*, HRB, National Research Council, Washington, D. C., 1963, pp. 1–12.
6. *Laterite and Laterite Soils and Other Problem Soils of Africa*. Report AID/C8D-2164. U. S. Aid for International Development, Washington, D. C., 1971.
7. J. G. Laguros. "Lime-Stabilized Soil Properties and the Beam Action Hypothesis." In *Highway Research Record 92*, HRB, National Research Council, Washington, D. C., 1965, pp. 12–20.
8. J. W. H. Wang, M. Mateos, and D. T. Davidson. "Comparative Effects of Hydraulic, Calcitic and Dolomatic Limes and Cement in Soil Stabilization." In *Highway Research Record 29*, HRB, National Research Council, Washington, D. C., 1963, pp. 42–54.
9. M. R. Thompson. "Shear Strength and Elastic Properties of Lime-

Soil Mixtures." In *Highway Research Record 139*, HRB, National Research Council, Washington, D. C., 1966, pp. 1–14.
10. M. R. Thompson. "Split Tensile Strength of Lime Stabilized Soils." In *Highway Research Record 92*, HRB, National Research Council, Washington, D. C., 1965, pp. 69–80.
11. T. E. Swanson and M. R. Thompson. "Flexural Fatigue Strength of Lime-Soil Mixtures." In *Highway Research Record 198*, HRB, National Research Council, Washington, D. C., 1967, pp. 9–18.
12. P. G. Bhattacharya. *Static and Flexural Fatigue Strength of Lime-Laterite Soil—Plain and Fibre Reinforced.* Ph.D. thesis. Indian Institute of Technology, Kharagpur, India, July 1984.
13. P. G. Bhattacharya and B. B. Pandey. "Study of Strength and Curing of Lime-Stabilized Soil—Plain and Fiber Reinforced." *Indian Roads Congress, Highway Research Board Bulletin 24*, 1984, pp. 1–26.
14. P. G. Bhattacharya and B. B. Pandey. "Effect of Density on Strength and Modulus of Plain and Fiber Reinforced Lime-Laterite Soil Mixtures under Static and Repeated Load." Presented at Indian Geotechnical Conference, Calcutta, 1984.
15. J. K. Mitchell and C. L. Monismith. "A Thickness Design Procedure for Pavements with Cement Stabilized Bases and Thin Asphalt Surfacings." *Proc., 4th International Conference on Structural Design of Asphalt Pavements*, University of Michigan, Ann Arbor, 1977.
16. D. Croney. *The Design and Performance of Road Pavements.* Her Majesty's Stationery Office, London, 1977.
17. L. W. Locket and R. K. Moore. "Lime-Soil Mixture Design Consideration for Soils of Southeastern United States." In *Transportation Research Record 839*, TRB, National Research Council, Washington, D. C., 1982, pp. 20–25.

*Publication of this paper sponsored by Committee on Lime and Lime-Fly Ash Stabilization.*

# Experimental Aspects of Mercury Intrusion Porosimetry

DOUGLAS N. WINSLOW

**Several frequently ignored aspects of mercury intrusion porosimetry are discussed. The importance of knowing the correct contact angle between the mercury and the solid is emphasized. It is also suggested that mercury intrusion be considered in some instances when a specific surface measurement is desired. Also, a method for handling inhomogeneous samples is discussed. Finally, a possibly instructive use for the hysteresis found on depressurization is explored.**

Mercury intrusion has become the predominant experimental technique for determining pore-size distributions. This is because modern instrumentation allows one to measure rapidly pores with sizes ranging over about six orders of magnitude. Much of the experimental technique and data reduction has become routine, and ASTM standard methods are beginning to appear (ASTM D 4284-83 and D 4404-84).

Nevertheless, certain experimental aspects have not received the attention that the author believes they deserve. It is the intent of this paper to discuss several of these aspects. It is assumed that the reader is familiar with the fundamentals behind the phenomenon of mercury intrusion and with the basis of the experimental technique. A general reference for experimental technique is *Surface and Colloid Science* (*1*, Vol. 13, Ch. 6).

School of Civil Engineering, Purdue University, West Lafayette, Ind. 47907.

## CORRECT CONTACT ANGLE

It is necessary to know the applicable contact angle in order to accurately convert the pressures that are recorded during an intrusion experiment into their corresponding pore sizes. In some cases, the exact value of this angle is not particularly important. If tests are being conducted merely to determine whether or not a piece of porous material has the same pore structure as a companion piece of the same material, any angle will serve. Indeed, under such circumstances, one can make the comparison by using the pressure-intrusion data without bothering to convert the pressures into pore sizes.

However, when the aim is to correlate pore sizes with some other property of a material, a wrong impression may be obtained if the pores sizes are incorrectly calculated. Another case in which accurate angles are needed is in the comparison of the pore structures of different materials. This is because the contact angle is a function of the surface properties of both the