Special Factors in Lime Stabilization

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This paper discusses the results of Hveem cohesiometer values on lime-soil specimens ranging in age from zero up to four months'curing. The specimens were prepared under two different compactive efforts and with various percentages of lime. Modifications made for the clamping plates of the Hveem cohesiometer, in an attempt to secure more uniform results, are also described.

IN cooperation with the National Lime Association, the Bureau of Engineering Research f The University of Texas is conducting some investigations in regard to lime stabiliation. Certain unusual features, which are reported in this paper, have been noted in onnection with the investigation.

Because of the rather wide use of the Hveem cohesiometer it was decided to use this levice in testing lime-stabilized clay gravel. The soil used was the red clay gravel rom Austin, Texas, known locally as "Post Oak" gravel because of its general occurence in the river terraces where a large number of Post Oak trees grew. In the past his gravel was used as a base material on many streets in the city of Austin. Because f the active clay content, however, it has caused considerable trouble in the breaking p of the pavements during the wet seasons. Figure 1 shows a grain-size accumulation urve of the Post Oak gravel. The deposits vary extensively, both between the different leposits and within each deposit, some of them having considerably more gravel and ess clay than indicated in Figure 1 and others having even less gravel and more clay han that indicated in the figure.

The clay is quite active and will exhibit large volume changes reflecting changes in noisture content. This fact is especially apparent to the writer; for his home is located n the Post Oak gravel and, after long periods of dry weather, the windows and doors of is house become stuck and can be opened only with difficulty. After a period of rainy veather these doors are free again, but after a long period of wet weather other sections f the doors or windows will stick because of the continued movement of the foundation. The liquid limit of the material passing the No. 40 sieve ranges from 50 to 65 percent nd the plasticity index ranges from about 25 to 40 percent. Figure 2 gives the liquid imit, plastic limit and plasticity index of material used in these tests as well as the efect of the addition of lime. It will be noted that the added lime has little effect on the iquid limit although, with higher percentages, there is a tendency for the liquid limit to ncrease slightly. On the other hand, even a small percentage of lime reduces the plasic limit materially, thus reducing the plasticity index. Figure 3 shows the effect of ime on the density of the Post Oak gravel. It will be further noted that the addition of ime tended to "fluff" the soil, thereby reducing the dry density and the optimum moisure content.

The Hveem cohesiometer was constructed as outlined in a report[1] by F. N. Hveem nd R. M. Carmany. Figure 4 shows the cohesiometer as originally constructed, while Figure 5 shows the machine with a broken specimen.

Figure 6 gives the effect of various percentages of lime on the cohesiometer values. The 6-inch diameter specimens were compacted with two different compactive efforts: amely, 6.63 ft.-lb. per cu. in., and 13.26 ft.-lb. per cu. in. These compactive efforts vere used in order to compare the results with those of certain other tests that had been nade on the lime-stabilized soil but which have not been reported in this paper.

The compacted cylinders were placed under a one-psi. all-around pressure and pernitted to saturate by capillarity through a porous stone. This action took place in a noist room at 70 degree temperature. Specimens were tested immediately on removal rom the moist room.

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[1] "The Factors Underlying the Rational Design of Pavements," Proceedings of the Twenty-Eighth Annual Meeting, Highway Research Board, 1948, pp. 101-136.

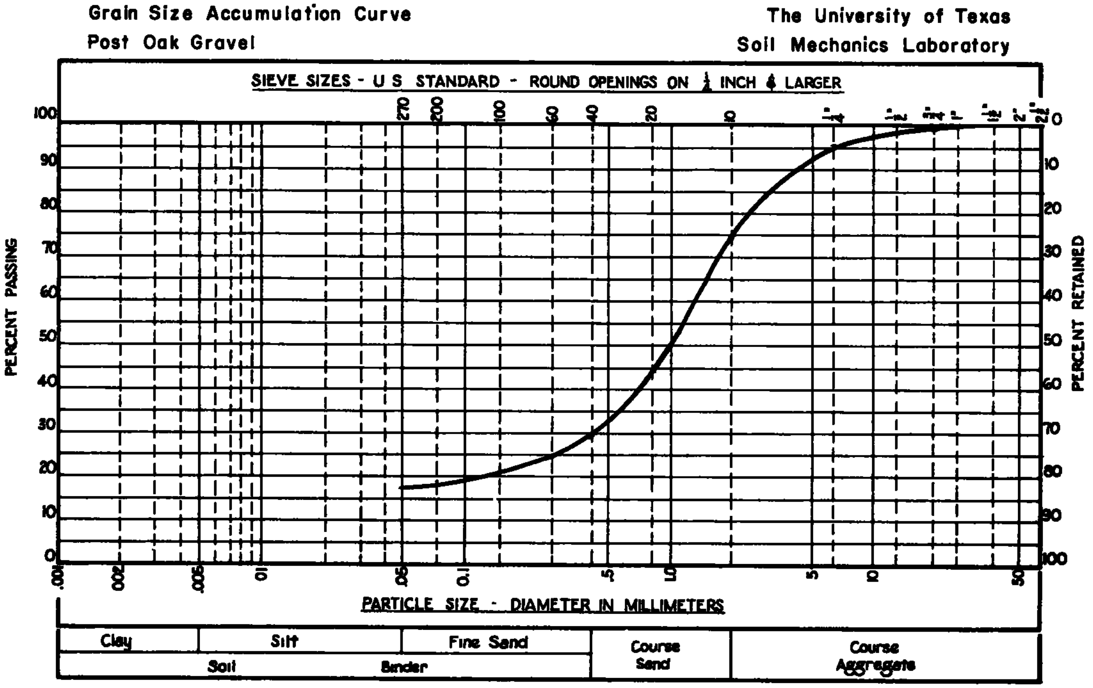

Figure 1.

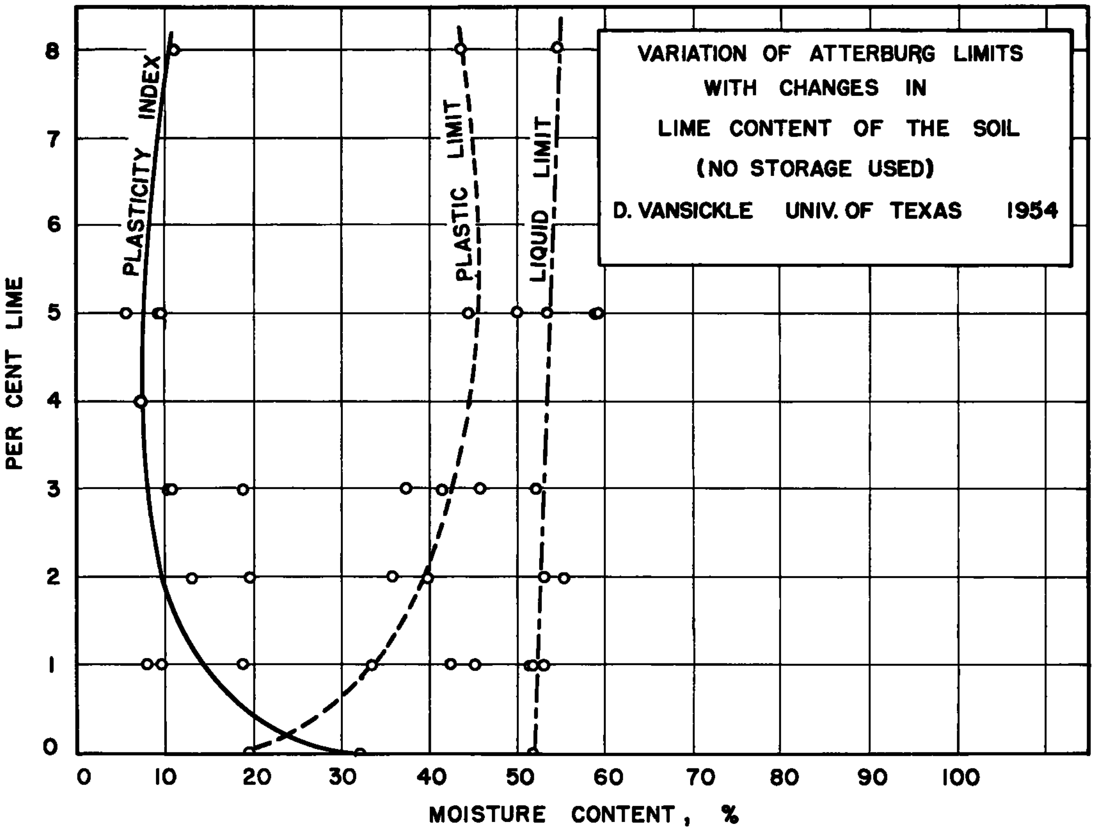

Figure 2.

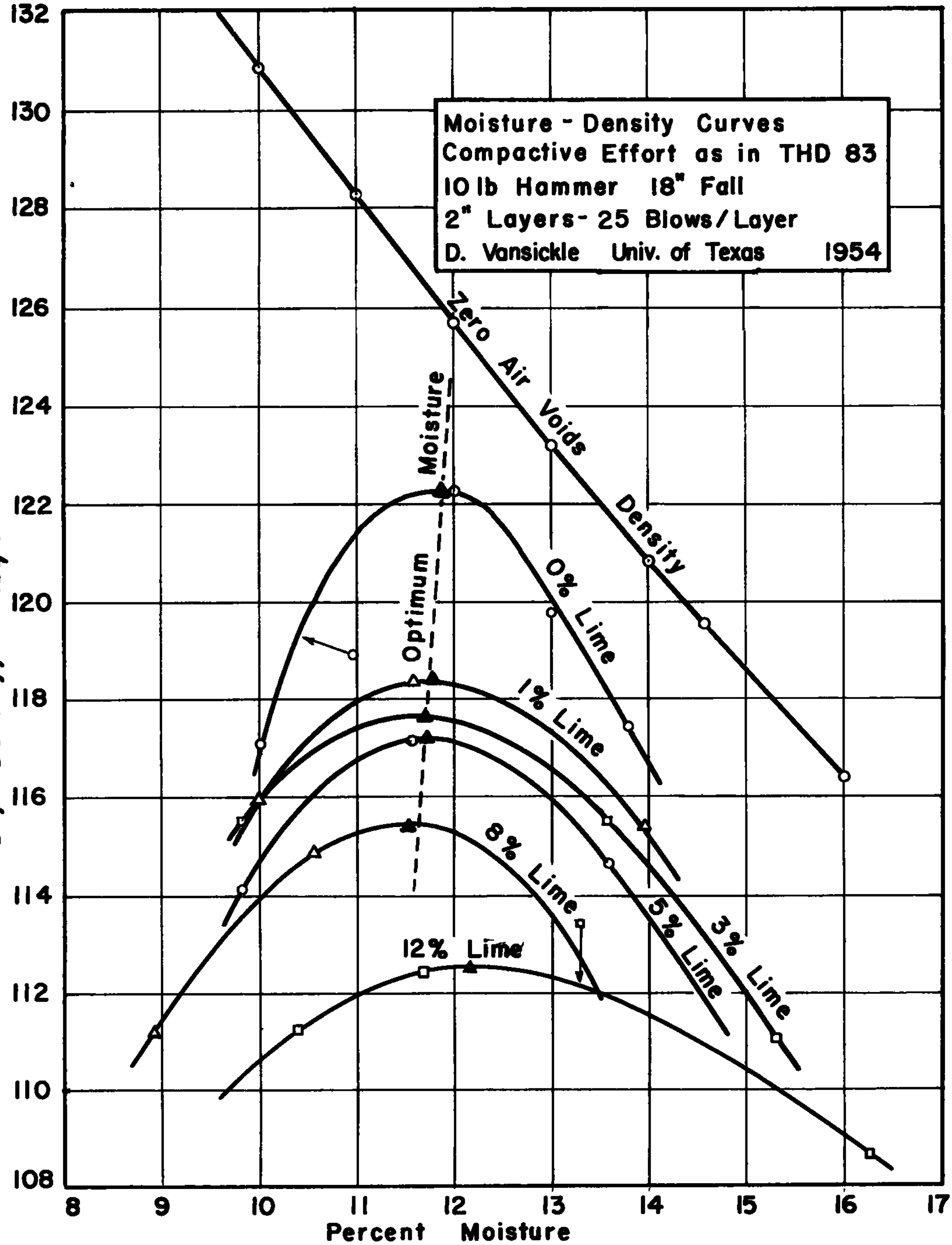

Figure 3.

The effective age of curing on the lime-stabilized soil becomes quite apparent from Figure 6, in which it is shown that this material does not gain in strength until it has had an opportunity to cure for a considerable period of time. Also in Figure 6, the writer wishes to call special attention to the rather wide variation, particularly with the lime content of 5 percent, in the results of the specimen which had been cured for four months. Certain revisions, which will be described later, were made in the cohesiometer in an attempt to reduce this spread in the results. From Figure 6 it may be further noted

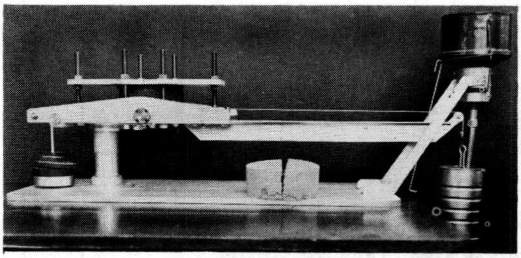

Figure 4.

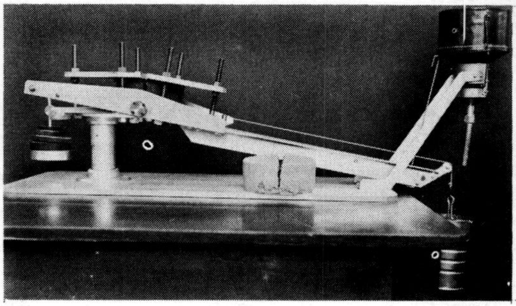

Figure 5.

that the optimum lime content for the Post Oak gravel is 5 percent and percentages of lime above this tend to reduce the strength of the stabilized mixture.

Figure 7 shows the effect of curing on the lime-stabilized soil with a compactive effort of 6.63 ft.-lb. per cu. in. Here it becomes obvious that, after some irregularities during the early curing periods, the strength of the stabilized mixture increased quite rapidly; and at the end of four months no indication was given that the ultimate strength of the mixture had even been approached.

Figure 8 illustrates the effect of age on the material compacted at a higher compactive effort: namely, 13.26 ft.-lb. per cu. in. This data is only for a short curing period of 28 days. While the curve shows an increase between 7 and 28 days, there is a tendency to level off between 18 and 28 days. However, it should be remembered that (Figure 7) there was considerable irregularity in the strengths up to 30 days — from that point on the increase in strength was quite rapid and on a straight line relationship. Therefore it might be expected that, under longer curing periods, these curves would

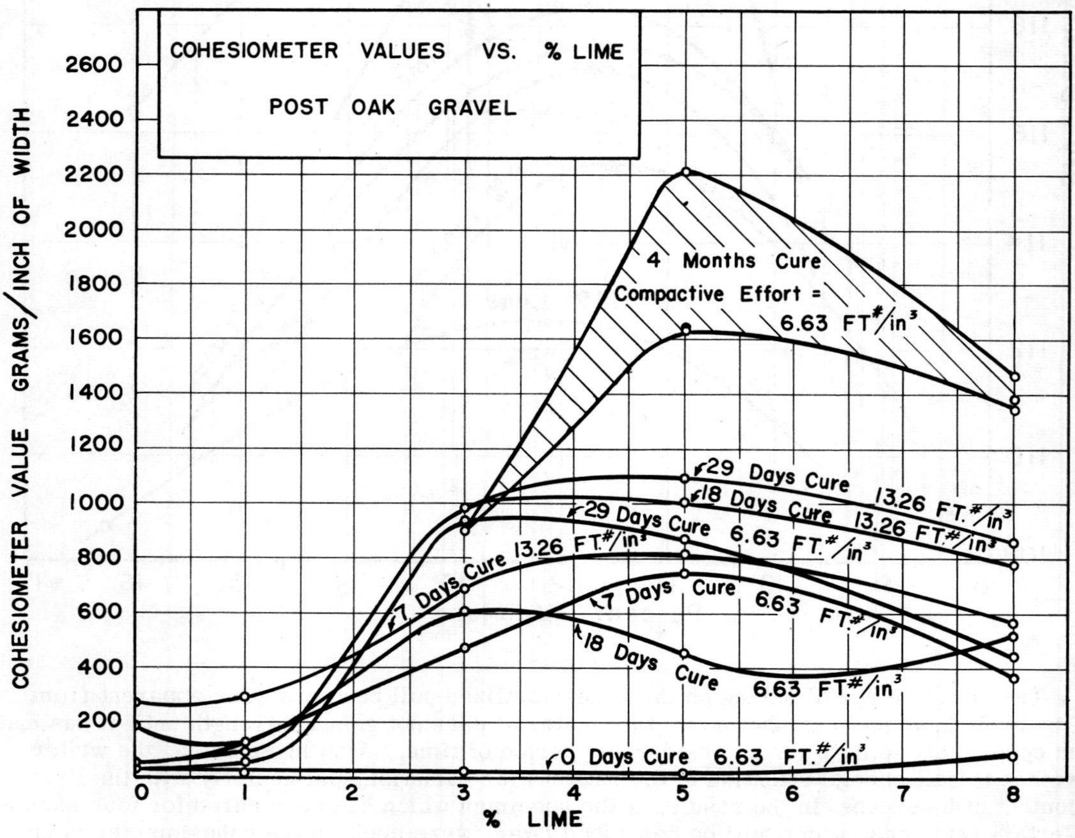

Figure 6.

go up at an even more rapid rate than indicated by the slope of the curves from Figure 8. Data to extend these curves are not available at the present time, but will be at some future data.

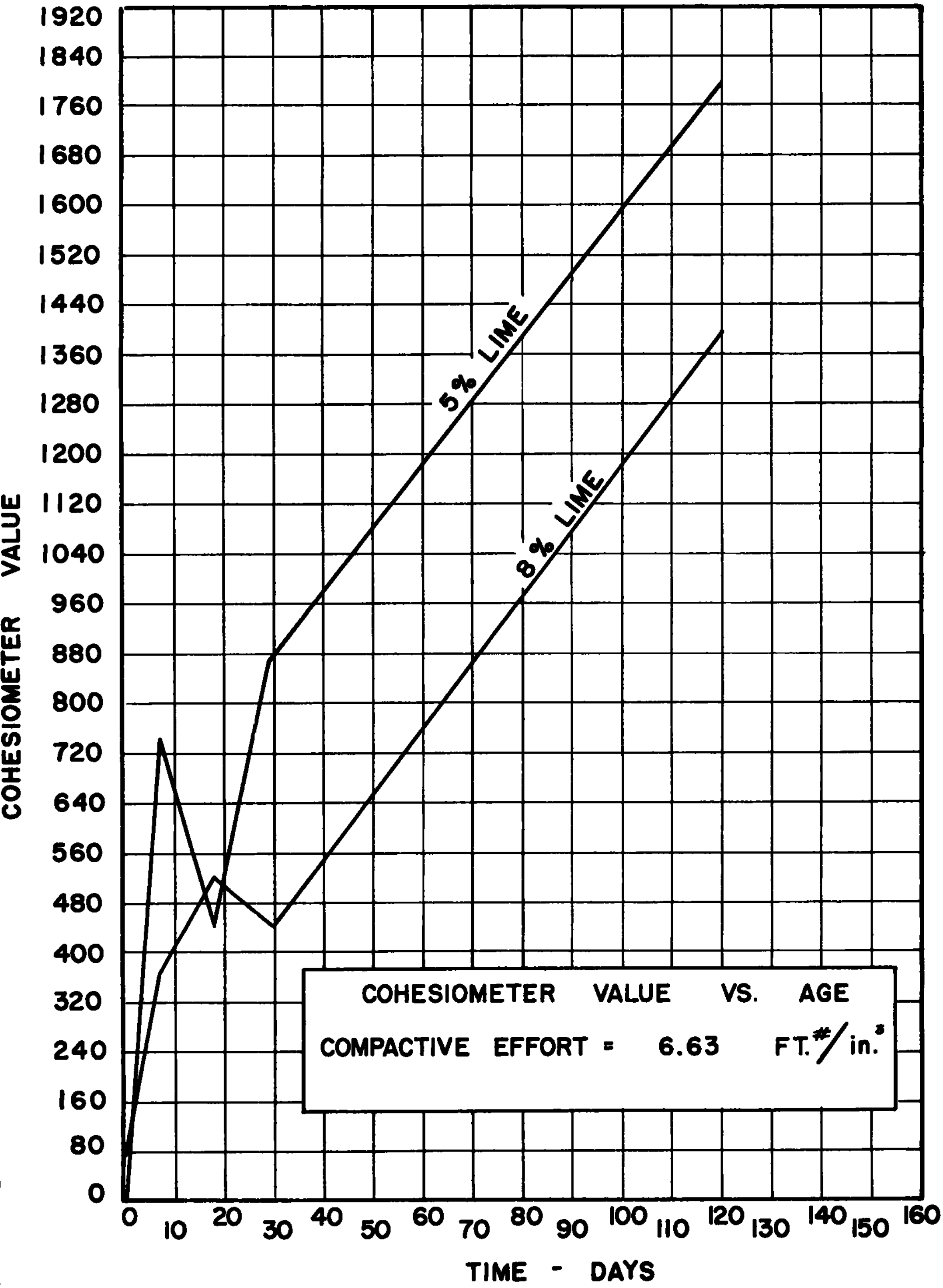

Figure 7.

In order to show the comparative strength of lime-stabilized gravel with that of other materials the data obtained from the 5 percent lime-stabilized Post Oak gravel with four month's curing was plotted on a portion of Figure 40 (p. 133) in the report by Hveem and Carmany already cited. Figure 9 shows that, when properly aged, the lime-stabilized soil has strength comparable to that of the cement-treated bases.

Tests for accelerated tensile strength, such as the cohesiometer test, have traditionally been unrealistic for lime stabilization in the construction field unless some un-

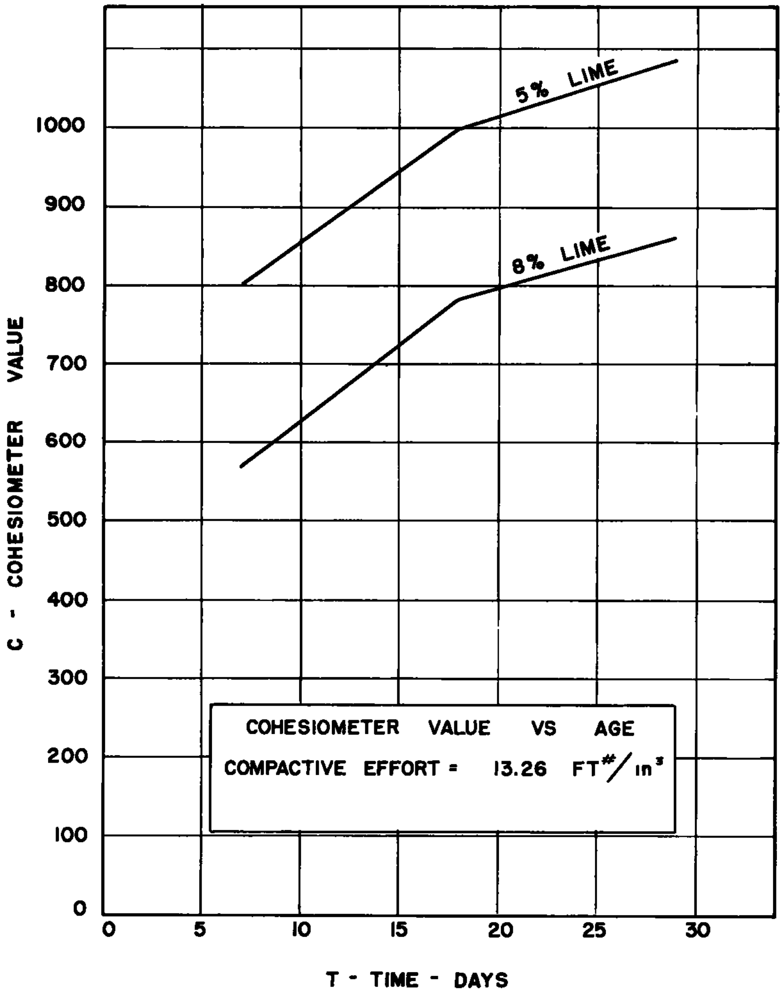

Figure 8.

usually long periods were used. While the results obtained here show a considerable increase in strength up to a period of four months, they also indicate that the strength increase would be expected to continue far beyond this period; and it might well be expected that curing periods of six months to a year or even longer would give much higher strength than those currently indicated. The increase in strength with age is due to the fact that lime gains in strength through pozzolanic action and that carbonation takes place slowly.

In Figure 6 attention was called to rather widespread cohesiometer values for the four-month's cured specimens with 5 percent lime. It was felt that these results might be due at least partially to the cohesiometer. The upper plates of the cohesiometer are held on the soil specimen by nuts which are tightened against these plates. If unequal pressures are applied to the various nuts, eccentric stresses will be induced in the specimen. In order to eliminate this condition a torque wrench was used to apply uni-

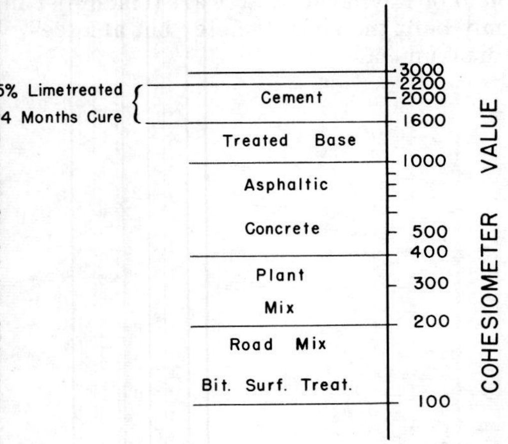

Figure 9.

form pressure. However, this proved time-consuming and required numerous adjustments of the nuts because, when one was tightened, the others on the same plate had to be retightened in order to bring them

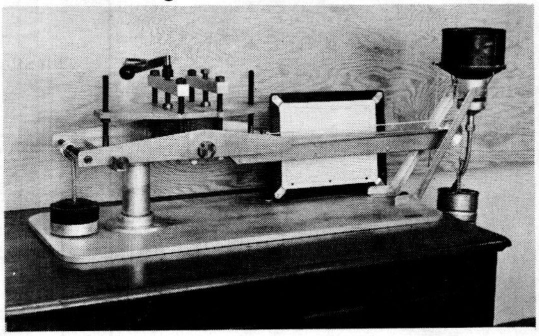

Figure 10.

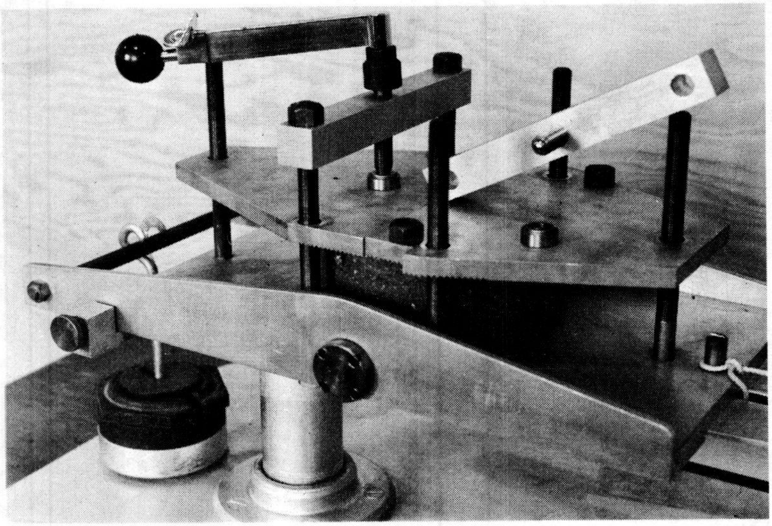

Figure 11.

to the desired tension. After attempting to use a torque wrench, a yoke was devised with a single stud bolt on each plate which would apply a uniform pressure.

Figure 10 shows the cohesiometer with a loading yoke and Figure 11 shows the detail construction of the loading yoke. Pressures are applied to the plates through stud bolts, the ends of which contain steel balls which rest on sealed radial bearings. The bearings are left entirely free so that they will center under the stud bolts. The stud bolts are then tightened with a torque wrench using 10 inch-ounces of pressure to tighten each bolt. This device has only recently been constructed and at present sufficient data have not been obtained to determine whether or not the change has produced any greater uniformity of results. Indications are that there will be a considerable reduction in the spread of the various test specimens.

While the information in this paper is directed solely toward tensile strength measurements of lime soil mixtures, it is recognized that these are not the only criteria for measuring the beneficial characteristics obtained from lime stabilization. Accordingly, it is not the intention of this paper to recommend that the cohesiometer test become a standard testing procedure for lime — at least, not until supplementary tests have been made and other factors investigated.

The writer wishes to acknowledge the assistance and cooperation of the National Lime

Association, the fine laboratory work of Donald R. Van Sickle and W. E. Strohm, Jr. (Research Assistants on the project), and the help of Raymond H. Stewart (Machinist in the Bureau of Engineering Research) who not only built the cohesiometer but also designed and built the described revisions of the instrument.