A Study of an Old Lime-Stabilized Gravel Base

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The life expectancy of any construction material is of interest to all engineers because of its importance in design procedures and cost analysis of structures. In the stabilizing of unsatisfactory materials in order that they may serve as a satisfactory base for highway construction, the life expectancy is of unusual interest to all engineers because these procedures will permit utilization of unsatisfactory materials at usually a considerable saving in total cost. This report covers the utilization of waste lime in stabilizing an unsatisfactory gravel base material. The lime not only provided a satisfactory stabilized base, but also proved economical to use. Now, 15 years after the base was constructed, cores have been taken and tested to determine the durability and life expectancy of this stabilized gravel. The paper gives both the results of tests on these cores and the original laboratory tests on the stabilized gravel.

●ONE of the earliest sections of lime-stabilized roads in Texas was in Williamson County, approximately 4 mi east of Round Rock, Texas. It extended from the McNutt Creek bridge, 2,168 ft west. The original base consisted of a limestone gravel with a plastic clay binder. The base material had 37 percent passing the number 40 sieve, with a liquid limit of 36 and a plasticity index of 18. Underneath the base material was a clay gravel and plastic black clay overlying the Austin chalk. The topography coupled with the porous clay gravel subgrade permitted water to seep into the base, causing it to become saturated and resulting in breaking up the pavement, making it difficult and expensive to maintain. Therefore, it was decided to use this section for experimental lime stabilization.

Waste lime was available at a very low price. This material had accumulated over a period of years from the mechanical rejections at the hydrator of the lime plant. It contained 80 to 100 percent moisture, and approximately 75 percent calcium hydroxide based on dry weight. Often large "clinkers" of partly burned limestone were found in the lime. They had a "pasty mass" of partly burned lime on the surface, and uncalcined limestone in the center (Fig. 4). These "clinkers" caused weakened areas that often resulted in the specimens breaking during the coring operation, or lowering the compressive strength.

The treatment consisted of scarifying the old gravel base to a depth of 6 in., adding 3 percent of waste lime (based on dry weight), and then mixing with a maintainer and compacting the material in two courses of 3 in. each. During the compacting operations, the material was sprinkled and rolled, first with pneumatic-wheel rollers and later finished with a three-wheel roller. The stabilized base was moist cured for a period of 4 days, then allowed to dry for 3 days prior to sealing with a triple asphalt surface treatment. Later a 2-in. asphalt concrete surface was applied. Prior to scarifying the existing base, an attempt was made to blade off the old asphalt surface. However, this was not completely successful as the scarified base contained considerable quantities of fragments of the old asphalt surfacing (Fig. 3). These particles acted similarly to the uncalcined limestone in that often they made coring difficult, and reduced the unconfined compressive strength.

Tests on the stabilized base material showed that the added lime had not changed the liquid limit in that it remained at 36. However, the plasticity index was reduced to five, and the linear shrinkage from 10 to 3.8 percent. A quantity of the stabilized base material was taken to the laboratory and used to make test specimens. It was placed in the molds with a compactive effort equivalent to twice the standard proctor value, moist cured by being placed in the saturated atmosphere for 7 days. The specimens were then dried at 140 F in a forced draft oven for one day and capillary wetted by being placed in a capillary tank 1/2 in. above the water level on porous stones, and permitted to absorb water through the porous stones. At the age of approximately 20 days they were tested in unconfined compression with the rate of strain of 0.15 in. per min. The average height of the specimens was 5.66 in., and they were 6 in. in diameter. All specimens were capped before testing. Stress-strain curves for the maximum and minimum strength specimens are shown in Figure 6. Also at this time, similar specimens made with the untreated gravel were tested and a typical stress-strain curve for this material is also shown in Figure 6.

To check the behavior of this lime-stabilized base, it was decided that cores should be taken from time to time for strength tests. The first series of cores were obtained when the stabilized base was 2 years old. These cores were taken with a ceramic coring device which used a thin brass slotted cutting barrel and carborundum abrasive. The operation was very slow and tedious, often taking well over 2 hr to cut a single core, and many times the specimens were broken during the coring operation. If any pieces of uncalcined limestone from the waste lime or asphalt surfacing materials were encountered, the cores broke in these areas. If there were any weakened planes in the specimen, it also broke. Thus, the ceramic coring operation made it difficult and time consuming to obtain the specimens. If attempts were made to core the base at any place except where perfect conditions prevail and the strongest base materal was available, it was impossible to obtain a core. While the cores taken with the ceramic apparatus gave an indication of the behavior of the base, it only gave the strongest portion of the base and no indication of any weaker areas. The same apparatus was used to take cores when the stabilized base was 7 yr old,

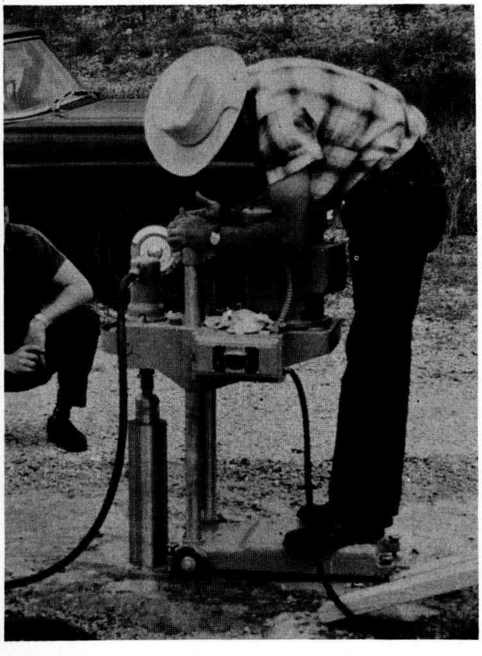

Figure 1.

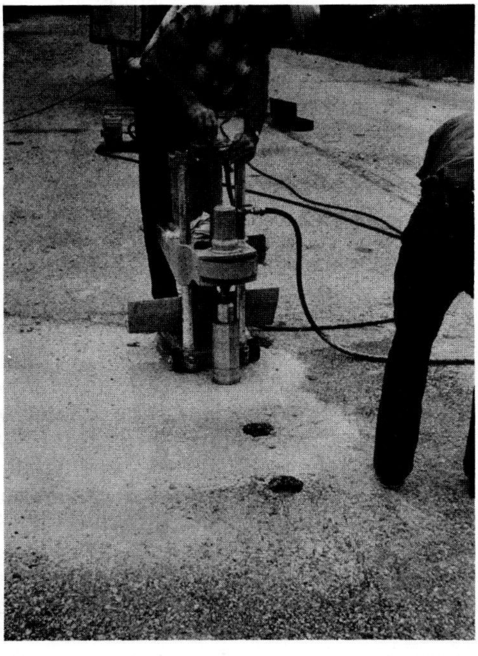

Figure 2.

and again it was possible to core only the strongest material. In Figure 7, there is a stress-strain curve for one of the 7-yr cores. Comparing this with the cores obtained later, it may readily be seen that only maximum conditions prevail.

Specimens taken from the stabilized base when it was 14 yr old were made by a Kor-it drill, using a 4-in. diamond bit and 3-horsepower electric motor. The new equipment proved highly satisfactory and cores were able to be cut through the base in approximately 5 min. Also, cores were obtained in areas of lower strength material so that an indication of the range of strength of the base could be obtained. Figures 1 and 2 show the core drill in operation. The operator soon learned to control both the amount of water and rate of feed on the drill to obtain satisfactory cores in a minimum period of time. Figure 3 shows a series of these cores with the bituminous topping, and also, the broken up bituminous material that had been mixed in the base during the scarifying operation. Figure 4 shows one of the cores cut through a "clinker" from the waste lime.

The ends of the cores were trimmed and they were capped prior to testing as shown in Figure 5. Stress-strain curves for the 14-yr old specimens are shown in Figure 6. The curves for the highest strength and the lowest strength specimen at this age are shown in this curve. Other stress-strain curves were quite similar and fell between the ones shown. At the time the 14-yr old compressive strength cores were prepared, specimens approximately 2 in. in height and 4 in. in diameter were prepared for testing in the cohesiometer.

Figure 7 shows the unconfined strengths of specimens taken from this base material from time to time. The original specimens were tested when they were approximately 20 days old and range in strength from 190 to 368 psi, the average being 276 psi. At the age of 14 yr, the minimum value had increased to 300 psi, and the maximum value to approximately 600 psi with the average being 480 psi. As explained previously, it is believed that only maximum strength specimens were obtained with the ceramic coring apparatus, and the 2- and 7-yr strengths are thus indicated on this curve. Inasmuch as it was impossible to obtain any cores from other than the highest strength areas, there was nothing to indicate the average and minimum strengths at these ages. Therefore, the dash curves are used for the average and minimum strength values. Also on this curve are shown the strengths of the untreated gravel, which was tested in the same manner as the lime-stabilized material.

The results of the cohesiometer tests are shown in Figure 8. The cohesiometer values are given in grams/inch of width corrected to a 3-in. height. To compare

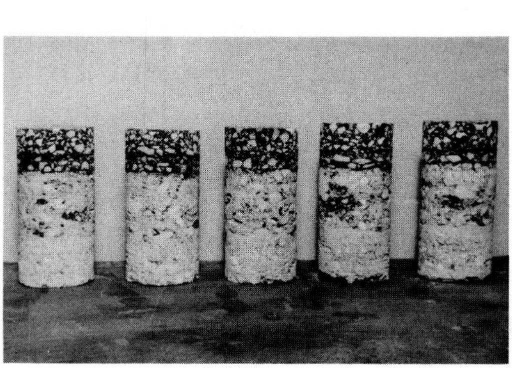

Figure 3.

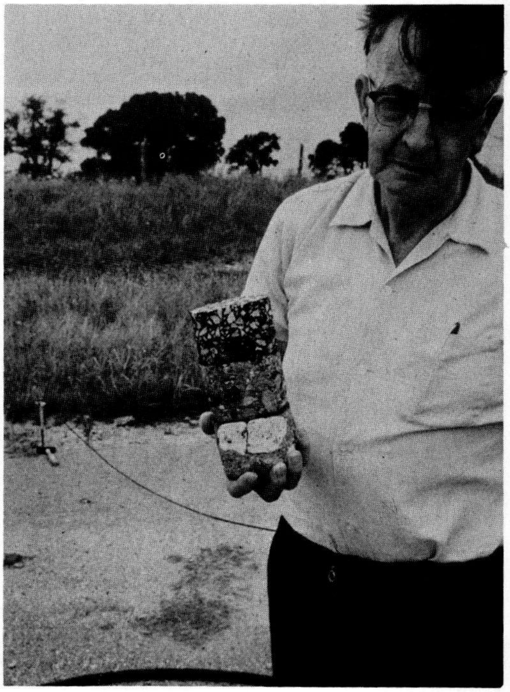

Figure 4.

the cohesiometer strengths, these values are plotted on a chart prepared by F. N. Hveem and R. M. Carmany (1). This chart also shows results of laboratory specimens of lime-treated clay gravel using 5 percent lime (2). After the specimens had been broken in the cohesiometer, they were pushed back together and a rubber band placed around the perimeter. The specimens were then placed back in the moist room and left for slightly more than 4 months, when they were again placed in the cohesiometer and broken in the same area of the original break. The specimens were carefully lined up so that the maximum stress would be at the line of the original break. By some process of autogenetic healing, the specimens developed a considerable strength in the period of recurring. The results of these breaks are also shown in Figure 8. Although no attempt is made to explain the recovery of strength in these specimens, they are reported here as a point of interest.

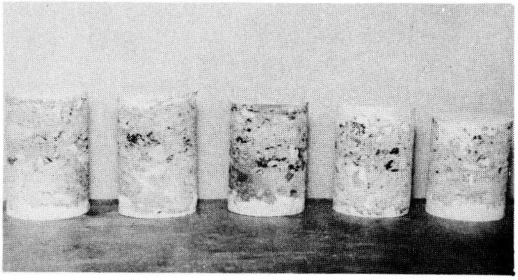

Figure 5.

This section of roadway with the lime-stabilized base has remained in excellent condition during its more than 14 yr of existence with little or no maintenance required, whereas prior to the stabilization, almost continuous maintenance was necessary to keep the road in passable condition. Therefore, it can be concluded that the use of the waste lime was not only economical but highly satisfactory.

In 1947, lime stabilization was used on a section of North Main Street in Taylor, Texas. Here again a clay gravel used as a base material had given trouble and caused a continuous maintenance problem. This base was treated with 3 percent commercial lime in a manner similar to the previously described section. When it was 13 yr old, the cores were taken and unconfined compression tests were made, the results being indicated in Figure 7. It may be seen that the strength of this core was approximately equal to the maximum value obtained from the waste lime material. It was noted that an exceptionally fine core was obtained from North Main Street in Taylor, Texas, and

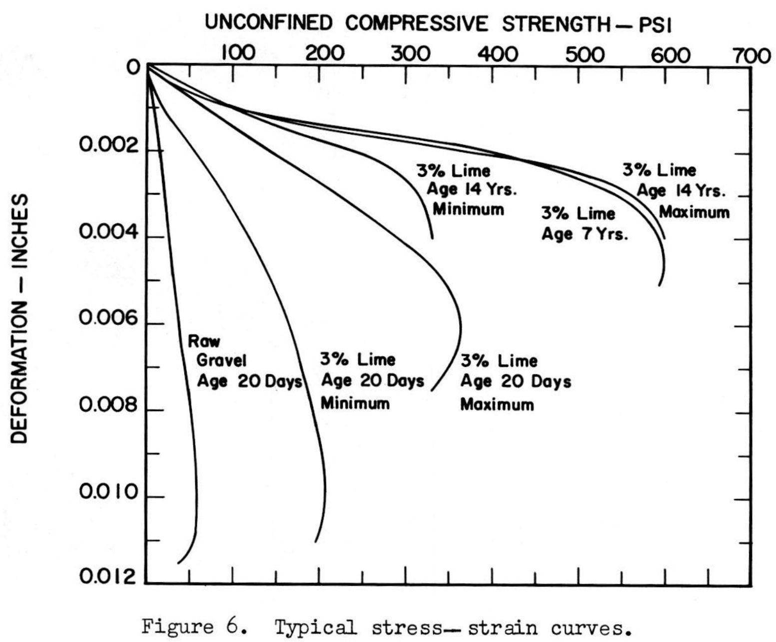

Figure 6. Typical stress— strain curves.

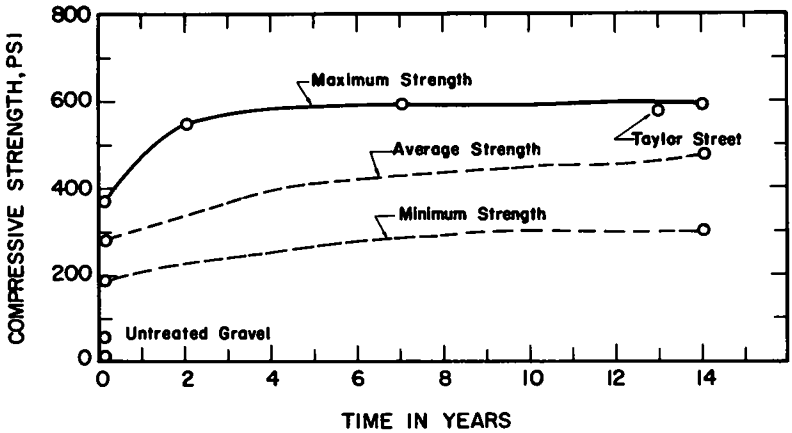

Figure 7. Unconfined compressive strengths.

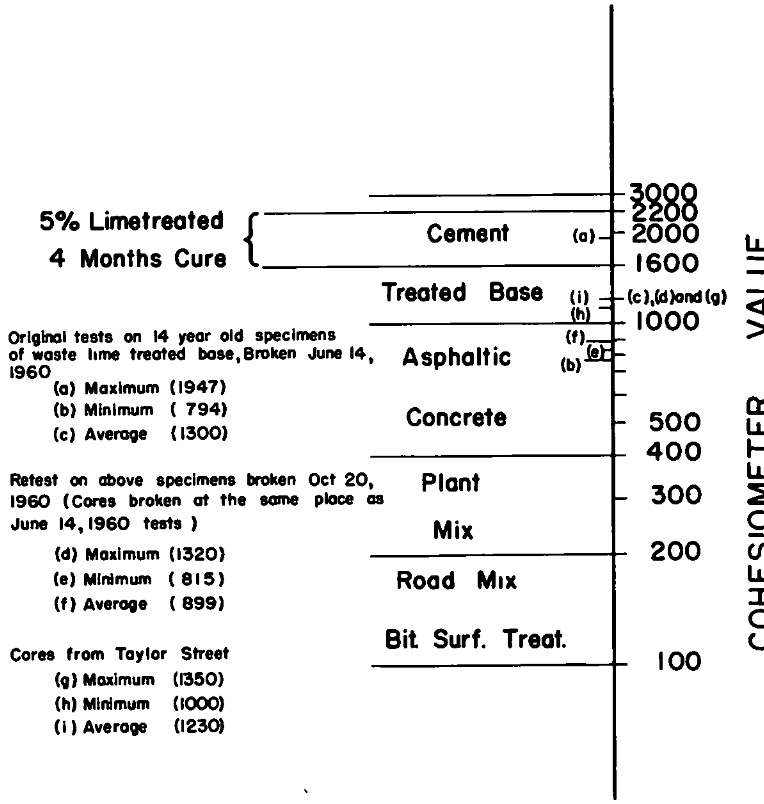

Figure 8.

it would be expected that it would give near the maximum value. Also, from this core, cohesiometer specimens were prepared and tested, similar to those from the previous section. The results are also shown in Figure 8. A rather unusual condition prevailed with these cohesiometer specimens in that after being broken they were also pushed back together and the sections held by rubber bands, and cured in the moist room for approximately 4 months; but when they were again tested in the same area, there was no regain in strength, and the specimens broke with little or no load.

The tests from the specimens from Taylor Street show that the waste lime was apparently almost as good as commercial lime. However, there was some difficulty with the "clinkers" in the waste lime which was particularly troublesome when these "clinkers" occurred within the cores cut from the base.

The success of lime stabilization on these projects as well as others throughout the state has resulted in the Texas Highway Department using more and more lime as a stabilizing agent in clay gravels and clay soils. During 1959, more than 120,000 tons of lime were used in stabilization work in the state, and the 1960 figures will exceed 160,000 tons, although the total number of contracts will probably be in the order of 30 percent less than the 1959 contracts.

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2. Dawson, R. F., "Special Factors in Lime Stabilization." HRB Bull. 129, pp. 103-110 (1956).