Expanded Shale as an Admixture In Lime Stabilization

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The pozzuolanic action between lime and volcanic ash or flyash has long been known. It is also known that other materials when combined with lime will produce a similar action, but the investigation of these other combinations has been limited. This paper gives the results of the use of dust from expanded shale aggregate as an admixture in lime stabilization. The effect of expanded shale and the unburned raw material on the compressive strength of the mixtures is given as well as a limited amount of data on the variation of the quantities of the expanded shale dust. In general, the results show considerable increase in the strength of the lime stabilized mixtures for two different aggregates, one aggregate having a high clay content and the other being a sandy gravel.

● THE POZZUOLANIC ACTION between lime, volcanic ash, flyash and some other materials has long been known. The use of artificial materials in combination with lime is also quite old, although not nearly as old as the use of the natural volcanic materials. India has long used burned clay as a pozzuolanic material. Reports of early use of burned clay in Egypt have also been found, although complete references are limited. Mortar composed of lime and burned clay was used extensively in the construction of the Asyut Barrage completed in 1902 across the Nile River as reported by George Henry Stephens (1). He describes in detail the test of lime and clay mortars in which was found considerable increase in strength with the addition of burned clay to the lime mixtures. The soft-burned clays gave greater strengths than the hard- and very hard-burned clays. Although no reason was given for the greater strength obtained with the soft-burned clays, the writer believes that it might be possible that the softer clays were actually ground much finer than the harder materials thus producing much greater action. "The burnt clay after grinding was passed through a sieve having 400 meshes per square inch." This, of course, would be a No. 20 sieve and therefore a rather coarse grind.

McDowell found that the addition of small quantities of dust from expanded shale aggregate also had beneficial effects on lime stabilized soil mixtures. This paper is a report of the investigation of the use of expanded shale dust as an admixture in lime soil stabilization.

MATERIALS

Lime was freshly burned, hydrated lime obtained from the Austin White Lime Company and was sealed in tight containers prior to use.

Expanded shale was dust passed through a 200-mesh sieve, obtained from pulverizing light weight concrete aggregates that had been made from burning shale materials.

Two different aggregates were used in these investigations. One was the WASHO gravel which had a liquid limit of 24, a plasticity index of 4, a shrinkage ratio of 1.71 and a grading as shown in Figure 1. This material had only a small percentage of the clay sizes. The second aggregate was Post Oak gravel from near Austin, Texas which had a liquid limit of 53 and a plasticity index of 33. It can be seen (Fig. 1) that the Post Oak gravel all passed the ¼-in. sieve, and although the percentage of clay was not high, most of the clay fraction was smaller than 0.001 mm in diameter.

Figure 2 shows the moisture density relationship of the Post Oak gravel as obtained naturally and the effect of the addition of lime and shale to the mixtures. These density tests were made with the Harvard miniature compaction apparatus.

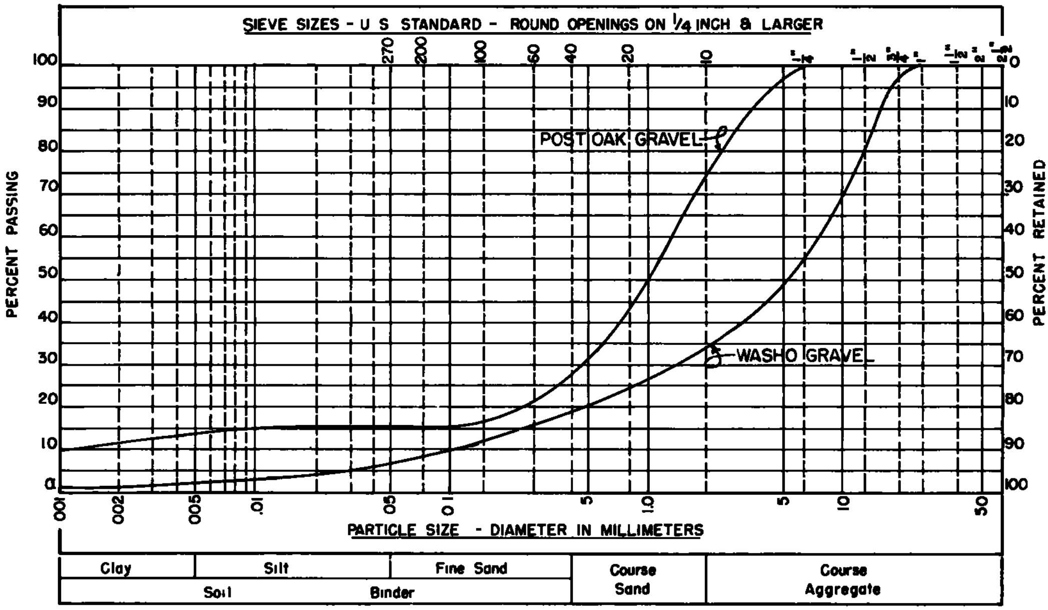

Figure 1. Grain size accumulation curve, Post Oak and Washo gravels.

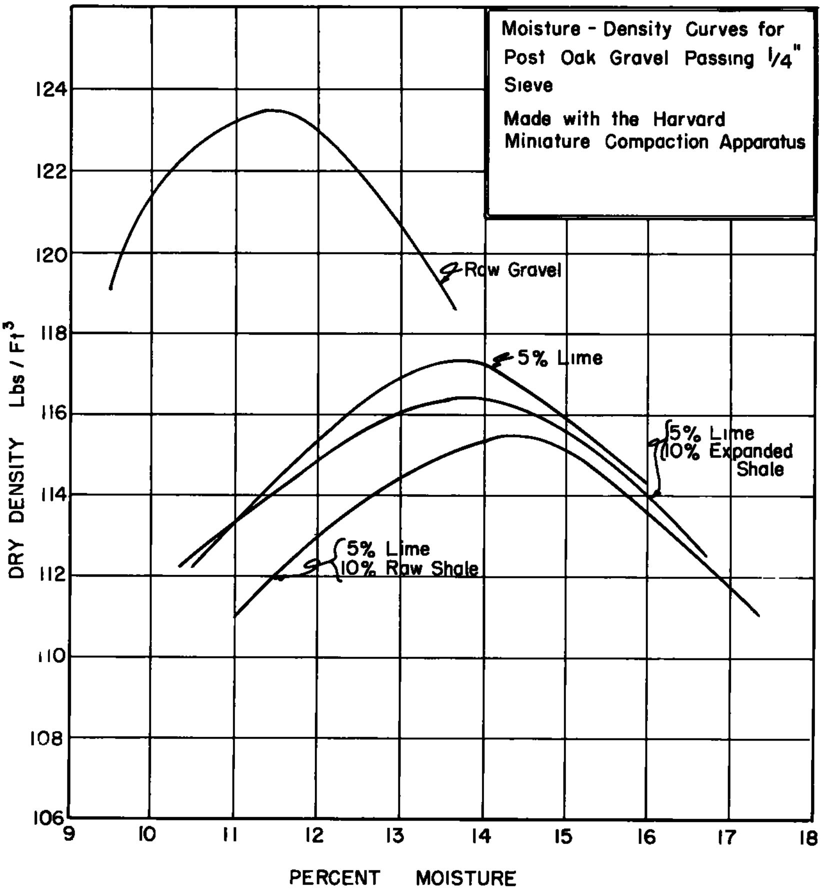

Figure 2.

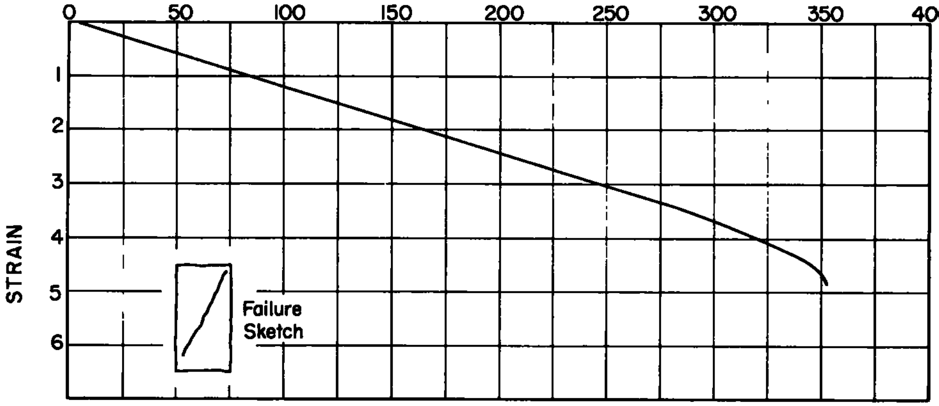

Figure 3. Typical stress strain curve, Post Oak gravel, 5 percent lime and 10 percent expanded shale. Age 28 days.

In determining the percentage of lime and shale, the total aggregate was taken as 100 percent, and the percentages of this figure were added to the aggregate in making the final mixture.

TESTING METHODS

In order to have a comparatively simple test that could be quickly made and yet give a satisfactory indication of the action of the expanded shale, it was decided to use the unconfined compression test. A few flexure tests were also made on small beams.

The unconfined specimens varied considerably in size, many of them being 2-in. by

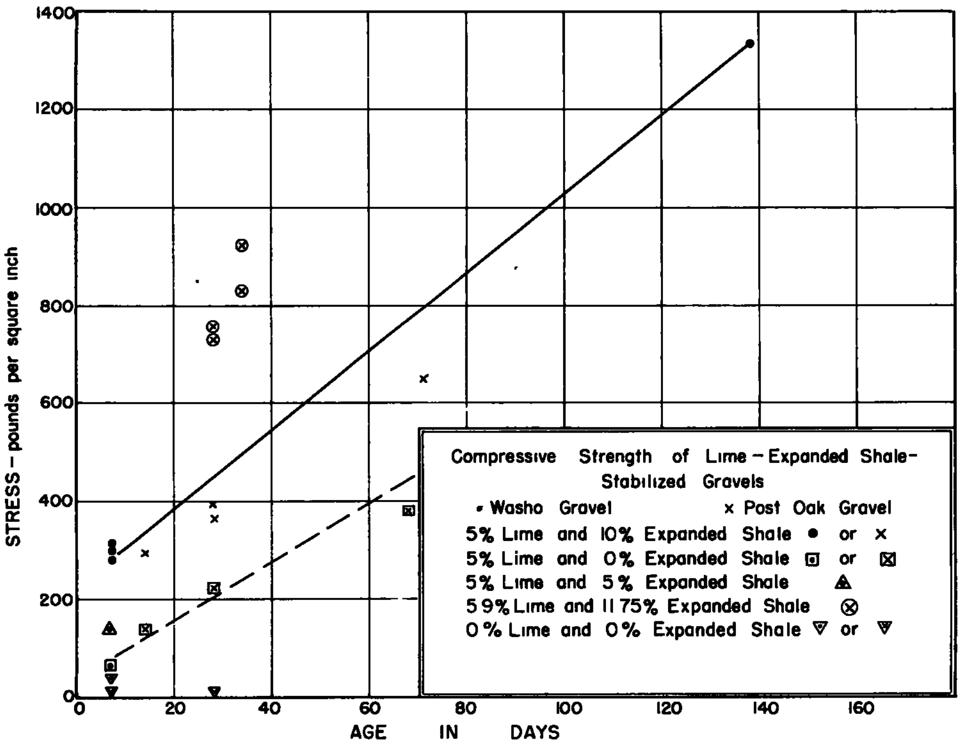

Figure 4.

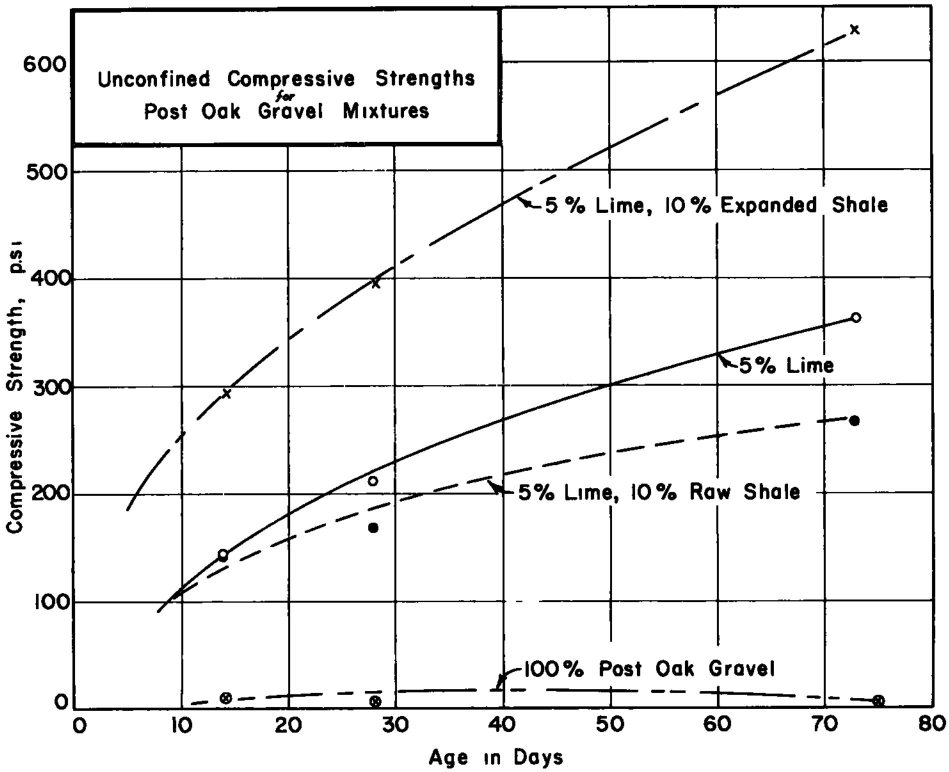

Figure 5.

4-in. cylinders made with material passing in a ¼-in. sieve. Others were 4-in. by 8-in. cylinders, and 6-in. by 8-in. cylinders were used with the coarse WASHO gravel. The specimens were compacted to the standard Proctor density and cured under moist conditions prior to testing. Testing was done in a constant-strain testing device at a rate that required approximately 5 minutes to cause failure. Specimens were capped with plaster of Paris prior to testing and protected with Saran-wrap to prevent the loss of moisture.

Figure 3 is a typical stress-strain curve for the 2-in. by 4-in. specimens. Most of the breaks occurred rather suddenly, and the specimen shattered with little or no bulging, thus simulating a brittle material.

Flexural strength tests were made on small beams cut from cured cylinders. These beams were approximately 1.33 in. wide, 1.1 in. high and 2.8 in. long and were tested with mid-point loadings.

RESULTS OF TESTS

The flexural strength tests were limited; all were made after a considerable curing period. All of these specimens were made with WASHO gravel and contained 8 percent lime and 10 percent expanded shale. The following results were obtained:

Curing Time in Days	Flexural Strength psi
229	533.9
487	550.9
487	343.2

Although there is some variation in the strengths obtained, the tests do indicate that the material has considerable flexural strength.

Figure 4 shows the results of a number of compressive strength tests. The solid dots are results obtained with the WASHO gravel and the x's result from specimens made with the Post Oak gravel. For combinations of 5 percent lime and 10 percent expanded shale, it can be seen that the Post Oak gravel gave values only slightly lower than the WASHO gravel, and there is considerable increase in strength with age and also with the addition of expanded shale. In one set of specimens made with Post Oak gravel, the percentages of materials were determined as a percent of the total mixture and not as a percentage of the aggregate. When these values were reduced to percentages of the aggregate, it was found that actually 5.9 percent lime and 11.75 percent expanded shale were used, thus giving considerably higher strengths. These points are indicated with x's inside the circles. One specimen was made with 5 percent lime and 5 percent expanded shale which gave lower values than the 10 percent expanded shale mixtures. Also the specimens with 5 percent lime and 0 percent expanded shale were lower than when the expanded shale was used. These values are given with dots and x's inside the squares. When no lime or lime and shale was used, very low values were obtained, as indicated by the inverted triangles.

In order to check the effect of burning on the shale, one series of tests was made in which a raw shale was used. This material is one that will expand on burning, but in these tests was merely pulverized by passing through a 200-mesh sieve. Figure 5 gives the results of these tests showing that the raw shale actually reduced the strength below that of the specimens with lime but no shale admixture. The expanded shale dust causes a considerable increase in strength over the other mixtures while the raw gravel specimens gave very low strengths.

CONCLUSIONS

Although the addition of lime to these gravels was quite beneficial as compared to the raw soils, the addition of 10 percent expanded shale dust to the lime mixtures gave added strength to the specimens. In some cases, the increase in strength was as much as 100 percent above the straight lime stabilized soil. The addition of more than 10 percent of the expanded shale indicates somewhat higher strengths than the 10 percent expanded shale mixtures. Other tests now under way indicate that the optimum amount of expanded shale ranges from about 7.5 percent to 12.5 percent.

The addition of raw shale reduces the strength of the lime-gravel mixtures as this material is merely adding more clay to the gravel.

Flexural strength tests indicate that considerable bending strength may be obtained from mixtures stabilized with lime-expanded shale admixtures.

ACKNOWLEDGMENTS

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REFERENCE

1. Stephens, George Henry, "Barrage Across the Nile at Asyut," Proceedings of the Institution of the Civil Engineers, Vol. CLVIII of minutes, Paper No. 3462, 1904.