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LIME TREATMENT OF ONTONAGON CLAY
I 75 at Pine River (Construction Project BI 49025G, C22RN)

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This study is part of Research Project R-58 E-17, being conducted by the Research Laboratory Division to determine the effectiveness of different forms of lime for the improvement of soil characteristics. Previous experiments, conducted by the Department and elsewhere, have indicated that lime can be used successfully as a construction aid to "dry out" wet clays to such an extent that they can support construction equipment and become compactable, without the excessive time for drying and manipulation required under normal construction procedures.

The immediate purpose of this particular investigation was to determine whether a relatively inexpensive waste lime, available in Michigan, could be used to improve a particularly poor construction condition involving very wet plastic clay of low load-supporting value. The field investigation was undertaken in October 1962, when poor weather was to be expected, thereby imposing a further test upon the treatment. The project was constructed under the supervision of the Road Construction Division, with Research Laboratory participation at the request of R. L. Greenman, Assistant Testing and Research Engineer.

The test area forms part of the I 75 freeway construction, located beneath the southbound lane as it approaches the Pine River bridge, south of Rudyard. The soil in this area, classified pedologically as Ontonagon clay, lies about 150 ft deep and once formed part of an Ice Age lake bed. The grain size analysis showed a minus-200 fraction of 97.5 percent, with 35 percent of the material being fine sand and silt. The plasticity index was 21. The material was very sticky and hard to manipulate when wet.

An area approximately 600 ft long by 35 ft wide by 6 in. deep was treated with bagged hydrated calcium lime furnished by the Union Carbide Olefins Co. of Montague, Mich. The supplier also furnished technical assistance throughout the lime application procedures. The initial application rate was 32 tons or about 5 percent lime based on the dry weight of the soil. Later, a second application of 1.5 percent lime was made.

Construction Operations

Before and during construction the weather was very bad. During most of the work there were repeated cycles of three days of rain followed by two days of damp weather and cloudy skies. This left the clay in a very wet condition, covered with pockets of surface water. Figs. 1 and 2, and subsequent figures, show the quagmire-like condition of the test area prior to the lime treatment. To improve this poor condition admittedly was a severe test for any method of stabilization.

Under these conditions, the only practical method of adding the lime was by hand spreading from bags. Fig. 3 shows the spotting of the lime bags to give the required quantity, and Fig. 4 shows the spreading operations. After spreading, the lime was left on the surface for a period of 2 to 3 hr. After this period, the lime was mixed into the soil by means of a small John Deere tractor and an agricultural disc unit (Fig. 5). This was followed by additional mixing with a tractor-driven Seaman Pulvimixer (Fig. 6). However, the consistency of the wet soil made the use of the Pulvimixer very difficult and in some locations it became completely bogged down. Under these construction conditions, therefore, its use was abandoned in favor of the lighter discing equipment. The effective depth of treatment varied considerably throughout the test area. An average of 12 borings, however, showed the depth to average 6 in., with 3 in. the minimum depth.

The treated soil was compacted as well as possible under the adverse conditions. Sheepsfoot rollers could not be used since they punched through the treated layer. Unloaded rubber-tired rollers were finally adopted for the compaction operation. Densities ranged between 83 and 90 percent of T-99 design values based on laboratory tests of the lime treated soil. It was impossible to achieve higher densities due to the high moisture content of the treated soil and the poor support offered by the untreated wet subsoil. No attempt was made to determine the strength of the lime stabilized layer, or the amount of undercut material the stabilized layer might be strong enough to replace.

The addition of lime definitely improved the engineering properties of the soil. In appearance and consistency, the treated soil appeared to have been dried back to its plastic limit or lower. Immediately before treatment the soil was so soft that it could hardly support the weight of a man (Fig. 2). After treatment the soil became crumbly in texture and supported the weight of light equipment without difficulty (Fig. 6). Laboratory tests showed that the lime treatment reduced the plasticity index from 21 to 19. More significantly, however, the plastic limit was in-

Figure 1. Section of the test area with no treatment.

Figure 2. Quagmire-like condition of untreated soil.

Figure 3. Spotting of bagged lime.

Figure 4. Hand distribution of lime.

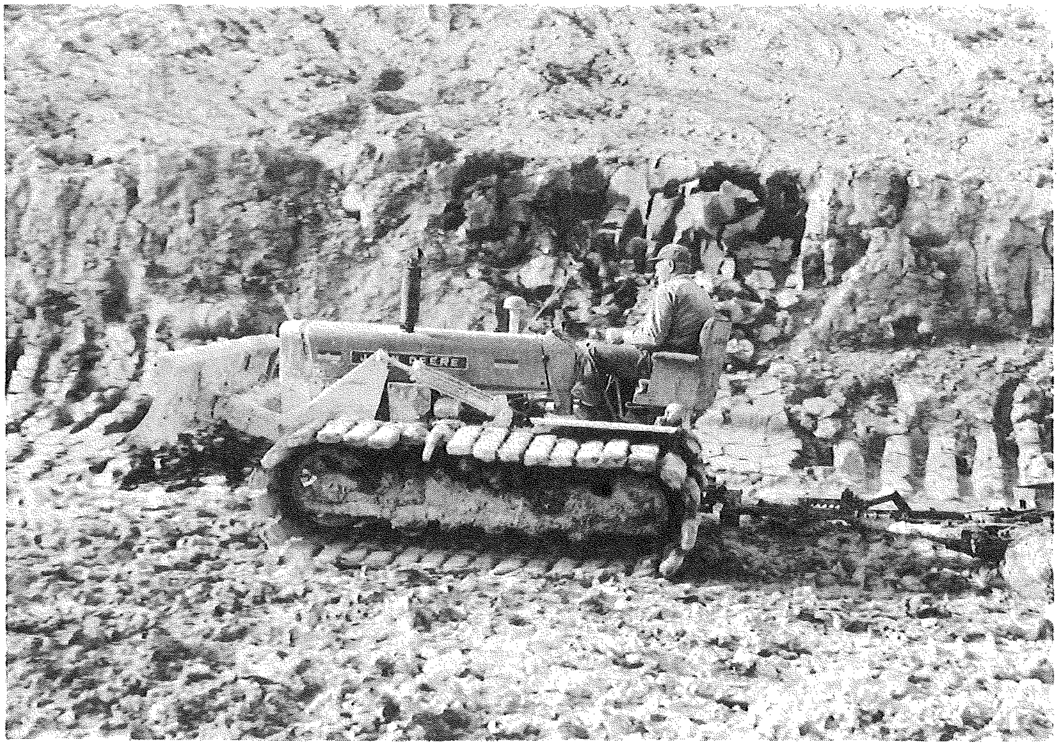

Figure 5. Mixing lime into the soil with tractor and disc.

Figure 6. Further mixing with Seaman Pulvemixer.

creased from 20 to 44 percent with a corresponding increase in the liquid limit from 41 to 63 percent. This explains why the treated material remained firm even at the high field moisture content.

Fig. 7 shows a core of the soil profile extending from the lime-treated surface to a depth of about 18 in. The treated soil (top 6 to 8 in.) appears to be much drier than the untreated subsoil. However, the moisture content of the treated soil was 33 percent as compared to only 30 percent for the wetter-appearing untreated soil. The higher surface moisture in this case probably is due to recent rainfall. The improved texture of the treated soil is obvious even though it is of higher moisture content. This is also shown in Fig. 8 where samples of untreated and lime-treated soils (both at 48-percent moisture content) are side by side. The fact that there can be such a change in properties without change in moisture content indicates that an altered material is formed by the addition of lime to this type of clay.

Fig. 9 shows a general view of treated and untreated areas. Fig. 10 is a closeup of the untreated and treated areas during mixing of the lime. The poor drainage conditions at the test sites are clearly shown in these two photographs, and greatly aggravated the troubles caused by continued rainfall.

As mixing operations continued additional rain fell, bringing the moisture content of the treated soil up to near 50 percent. At this moisture content the equipment again bogged down and the test area was churned up to the condition shown in Fig. 11. Working under these conditions destroyed much of the stability gained during previous operations.

After the rain an additional treatment of 1.5-percent lime was added in an effort to restore the treated area to a more workable condition. The lime was again effective in drying the soil and by the following day the surface could be compacted by light rubber tired rollers. The surface was then shaped by means of a wooden float. Eighteen density tests showed final densities of 83 to 87 percent of T-99 maximum, based on the Research Laboratory's design curve for the lime-treated soil. A general view of the job after compaction is shown in Fig. 12.

Conclusions

Although weather conditions were very adverse during this experiment, certain conclusions are justified as follows:

1. Soil properties were greatly improved by the addition of lime. The soil was altered to such an extent that it was water-resistant and

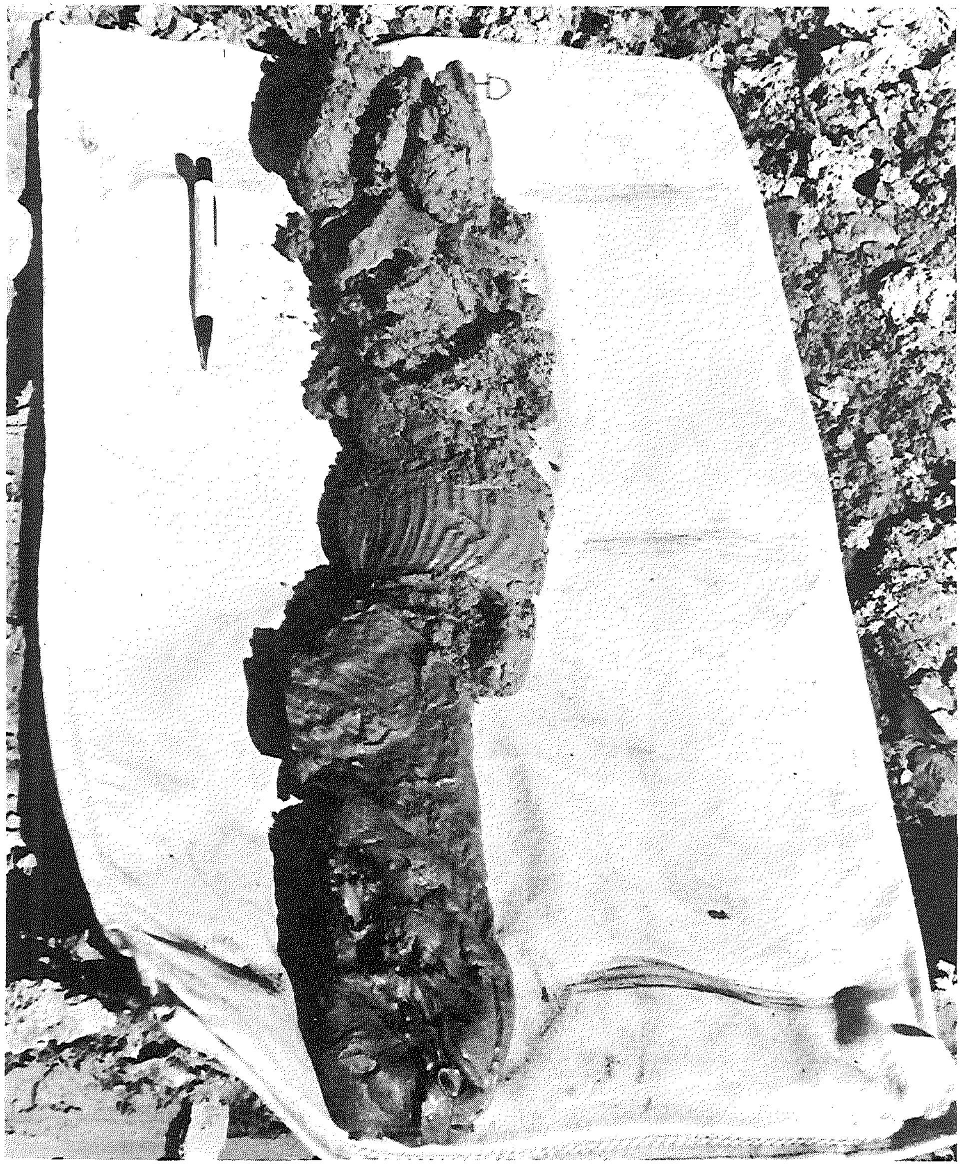

Figure 7. Core taken from treated soil and untreated subsoil.

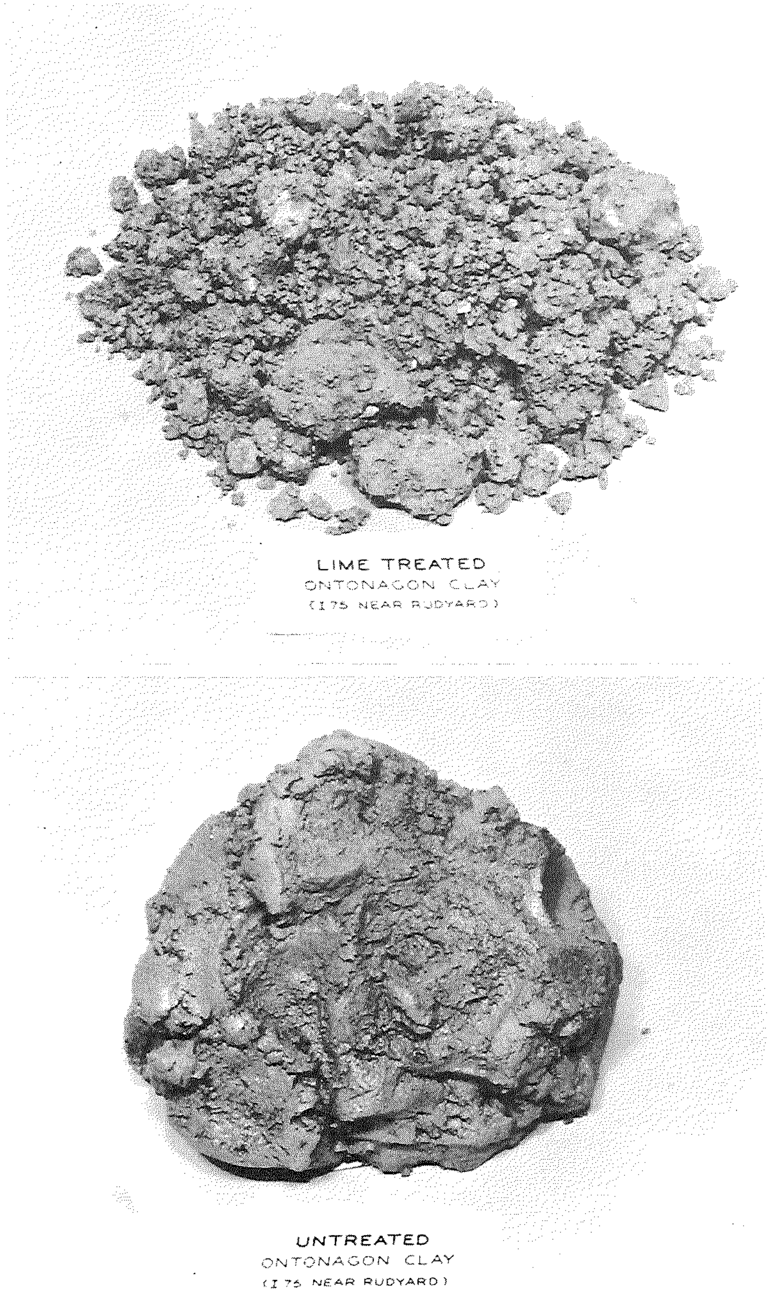

Figure 8. Comparison of texture of treated and untreated soil at 48 percent moisture content.

Figure 9. General view of treated and untreated areas.

Figure 10. Closeup of treated and untreated areas during mixing. Note poor drainage conditions.

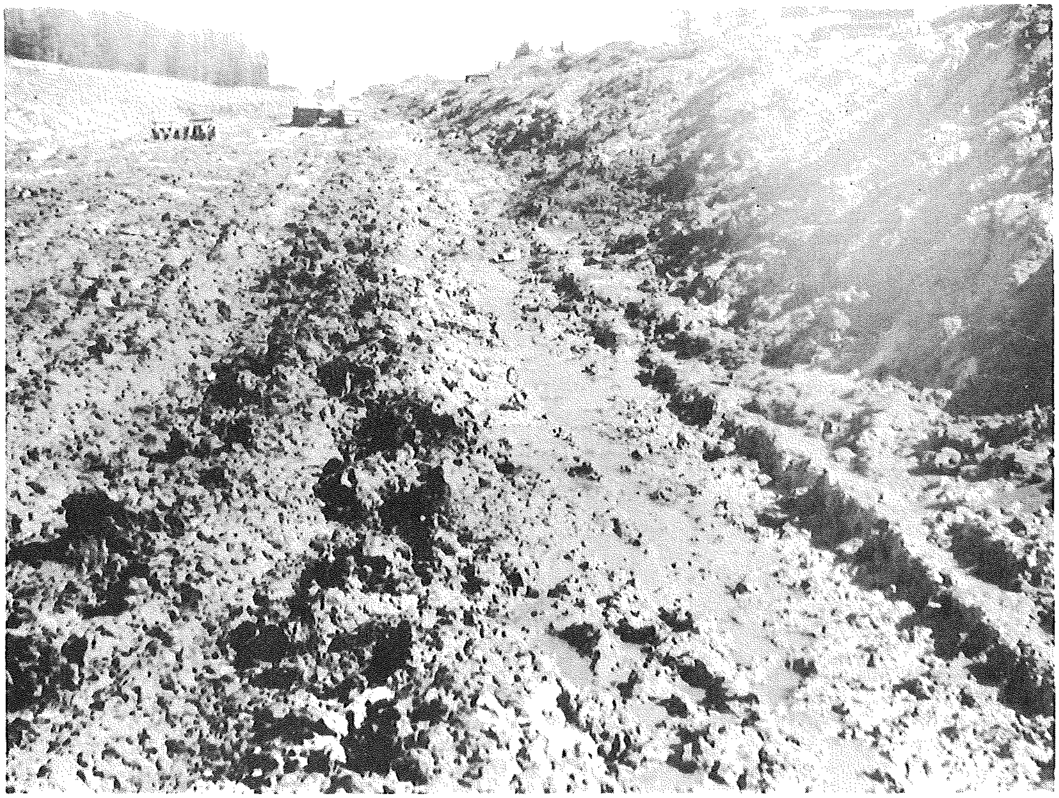

Figure 11. Condition of treated section after manipulation during heavy rain.

Figure 12. General view of the project when nearly completed. The 4-ft sand fill is in place in foreground, with untreated soil at center. Dark area in distance is lime-stabilized.

retained much of its natural dry strength when in a nearly saturated condition. Both the liquid and plastic limits were increased by significant amounts.

2. From a practical standpoint this improvement provided a mat over the untreated soil, of sufficient bearing power to allow small equipment to operate over its surface and to permit compaction of the treated material.

3. The 5-percent treatment was generally satisfactory until additional rain fell during mixing operation. The addition of 1.5 percent more lime restored the surface to its former condition.

4. It is recommended that for future work of this nature that a supply of lime above that required for initial treatment be available during construction for further treatment of any wet area that might develop due to non-uniform application of lime or to higher moisture contents in localized areas.

5. Hand application and the use of light equipment are necessary in the initial application of lime to very wet soils. As the lime reacts, heavier equipment normally can be used. Due to continuing rainfall this could not be done on this project.

6. The continued rainfall caused undrained pockets of water over much of the surface, hampering mixing and subsequent compaction. Under more favorable construction conditions surface water would not be a problem.

7. Although the lime treatment improved the soil considerably, the value of the treated layer was still a function of the underlying subsoil. When, as in this case, the supporting soil is very wet, care should be exercised to see that the treated surface layer is not damaged by subsequent construction and is of sufficient thickness to offer adequate support.

8. Under the adverse temperature and moisture conditions prevailing throughout operations on this particular project, the value gained by the use of the lime treatment was limited. However, the fact that it did react favorably under such conditions indicates that its use might be of much greater value under more normal construction conditions.