OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

June 20, 1966

To: E. A. Finney, Director
Research Laboratory Division

From: R. C. Mainfort
E. C. Novak, Jr.

Subject: Evaluation of Stamp Sand as a Substitute for Sand Subbase.
Research Project 54 E-14. Research Report No. R-571 (Rev.)

At the request of A. E. Matthews, an Upper Peninsula stamp sand has been evaluated as a substitute for specification Porous Material A. The work was included under that phase of Research Project 54 E-14 concerned with the effects of allowing more than 7-percent minus-200 material in Porous Material Grade A used for sand subbases. About 200 lb of the stamp sand was received in the Soils Laboratory on February 9, 1966, from which two basic samples were tested:

1. Stamp Sand M, representing a mixture of the several samples received, with 10.8-percent passing the 200 sieve.

2. Stamp Sand H, representing the sample found to be highest in minus-200 material, with 13.8-percent passing the 200 sieve.

Also, two artificial laboratory mixtures were prepared containing 18- and 100-percent minus-200 material. These were used to test the sensitivity of the Laboratory's method for obtaining moisture tension curves and are not included as part of the basic study.

In addition to normal identification testing, tests were made to determine permeability, stability, and frost susceptibility of the stamp sands. Results were compared with concurrent values obtained for two sand control samples of different gradation, but both meeting Department specifications for Porous Material A. One of these was coarse with 5.5 percent passing the No. 100 sieve, and the other near the finer end of the specification with 29.5 percent passing the No. 100 sieve. In this report these samples are referred to as "Coarser Porous A" and "Finer Porous A", respectively. Grain size distribution and certain physical characteristics of the basic materials used in this study are shown in Figure 1 and Table 1.

In addition to these tests, a moisture characteristic curve was developed for each material using Test Procedures 29 and 30 as described in the U. S. Department of Agriculture Handbook No. 60[1]. In this test, saturated samples of the soils were placed in a pressure chamber and moisture contents measured as the pressure varied from 0 to 15 psi. As different pressures were applied, different amounts of water were forced from the sample. By converting pressure values to "height of capillary rise" and the moisture content to "percent saturation," the moisture characteristic curves shown in Figure 2 were developed, and from these, relative frost heave pressures were determined. The test results and their significance will be discussed separately.

Grain Size Distribution

As shown in Figure 1, the stamp sand is graded in a manner similar to the Porous Materials A. The gap grading of these samples is necessary in order to obtain an adequately porous mixture. Except for the higher percent passing the No. 200 sieve, the natural stamp sand samples meet specification requirements for Porous Material A.

Permeability

Permeability values for the four basic samples, obtained by using Hazen's approximation formula, show the more coarsely graded Porous A sample to have the higher permeability (Table 1). The stamp sand, containing the lower fines, however, has a permeability almost as high as that of the finer Porous A sample, with values for both natural stamp sands falling within the range of a uniform fine sand, considered to be good, drainable material. This is also shown by the moisture characteristic curves of Figure 2. At 20 in. above the water table, the finer materials have drained back to about 50-percent saturation while the coarser has drained back to about 20-percent saturation. However, at 80 in. or more above the water table all of the natural samples reach approximately equilibrium conditions, losing little additional water with an increase in height above the water table. These tests show that the natural stamp sands should perform almost as well as the porous sands, if placed at a reasonable height above the water table. The 18-percent minus-200 laboratory stamp sand mix was somewhat poorer than the high fines natural material, and as would be expected the 100-percent minus-200 mix was substantially poorer.

Stability

Shear strengths of the 10.8-percent minus-200 stamp sand and the coarser Porous Material A were compared using results obtained from the Hveem Stabilometer. The stamp sand showed higher values of the angle ∅ under both wet and dry conditions of test, showing that satisfactory stability should be obtained with this material.

Frost Susceptibility

Possible frost susceptibilities of the materials were determined using a method reported by the U. S. Army Cold Regions Research and Engineering Laboratory[2] in which it was shown that frost heave pressures developed in soils depend primarily on pore size distribution rather than grain size (although these two are related), and that maximum frost heave pressures developed in soils increase as pore size distribution decreases.

Using moisture characteristic curves for different soils, ranging from sand to silty clay (Fig. 3), they developed the basic curve shown in Figure 4, establishing an empirical relationship between characteristic pore size (located at the knee of the moisture tension curves, as shown for the Research Laboratory's test in Figure 2) and maximum frost heave pressure as determined in the laboratory during freezing tests.

Pore size values determined for Porous A and stamp sand samples were used to establish the relative positions of these materials on the basic curve. Although no limiting value of maximum frost heave pressure has been established to differentiate between satisfactory and unsatisfactory materials, the Porous A and naturally graded stamp sands fall far down on the desirable low frost heave pressure portion of the curve, well below the most coarse material tested by the Cold Regions Laboratory. The sensitivity of this test method is indicated by increase in frost heave pressure as the minus-200 portion of the stamp sand increases. This test, although empirical, does establish the relative maximum frost heave pressures that can be developed in the soils when saturated. Whether a particular soil would reach saturation under field conditions depends on several factors. Through future studies it might be possible to develop a true frost susceptibility curve by taking some of these factors into account. The present results, however, indicate that there should be no detrimental frost action potential in the naturally graded stamp sands.

The soils used in the Army study represent a range of materials, several of which would of course not be considered as porous. It is of interest that a coarse sand used in the Army study (Fig. 3) developed more frost heave pressure than did a finer sand. This is due to the gap grading of the finer sand, as compared to the more densely graded coarser sand, and indicates the need of good gap gradation for satisfactory performance of porous materials. This has been confirmed by Casagrande(3) who found that a uniformly graded soil (gap grading) is susceptible to frost action only when more than 10 percent of its particles, by weight, are finer than 0.02 mm, but that a well graded soil is frost susceptible when as low as 3 percent are finer than 0.02 mm. The stamp sand, as normally found, is gap graded with only about 3 percent finer than 0.02 mm, so in this respect also it should not be frost susceptible.

Based on the Research Laboratory's tests it is concluded that natural stamp sand samples included in this study can be used successfully in place of normally specified Porous Material A.

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References

1. "Diagnosis and Improvement of Saline and Alkali Soils." U. S. Dept. of Agriculture Handbook No. 60, 1954.

2. Hockstra, P., Chamberlain, E., and Frate, T. "Frost Heave Pressures." HRB Record No. 101, pp. 28-38, 1965.

3. Casagrande, A., "Discussion of Frost Heave." HRB Proc., Vol. 11, Pt. 1, pp. 168-72, 1931.

TABLE 1
CHARACTERISTICS OF THE TEST SAMPLES

Property	Porous A Coarser	Porous A Finer	Stamp Sand M	Stamp Sand H
Maximum Density (dry), pcf [(a)]	106.8	112.2	107.9	108.0
Molding Density, pcf	105	110	105	105
Specific Gravity, g per cc	2.68	2.68	2.74	2.74
AASHO Classification	A-3	A-3	A-2-4	A-2-4
Relative Stability ∅ wet [(b)]	34°	-----	35°	-----
Relative Stability ∅ dry [(b)]	34°	-----	37°	-----
Permeability, cm per sec [(c)]	0.032	0.0083	0.005	0.003

(a) Obtained by Harvard Compactor.

(b) Obtained with Hveem Stabilometer.

(c) From Hazen's formula for loose filter sands $R = 100\ D_{10}^2$, where R = coefficient of permeability in cm/sec, and D_{10} = effective size in cm.

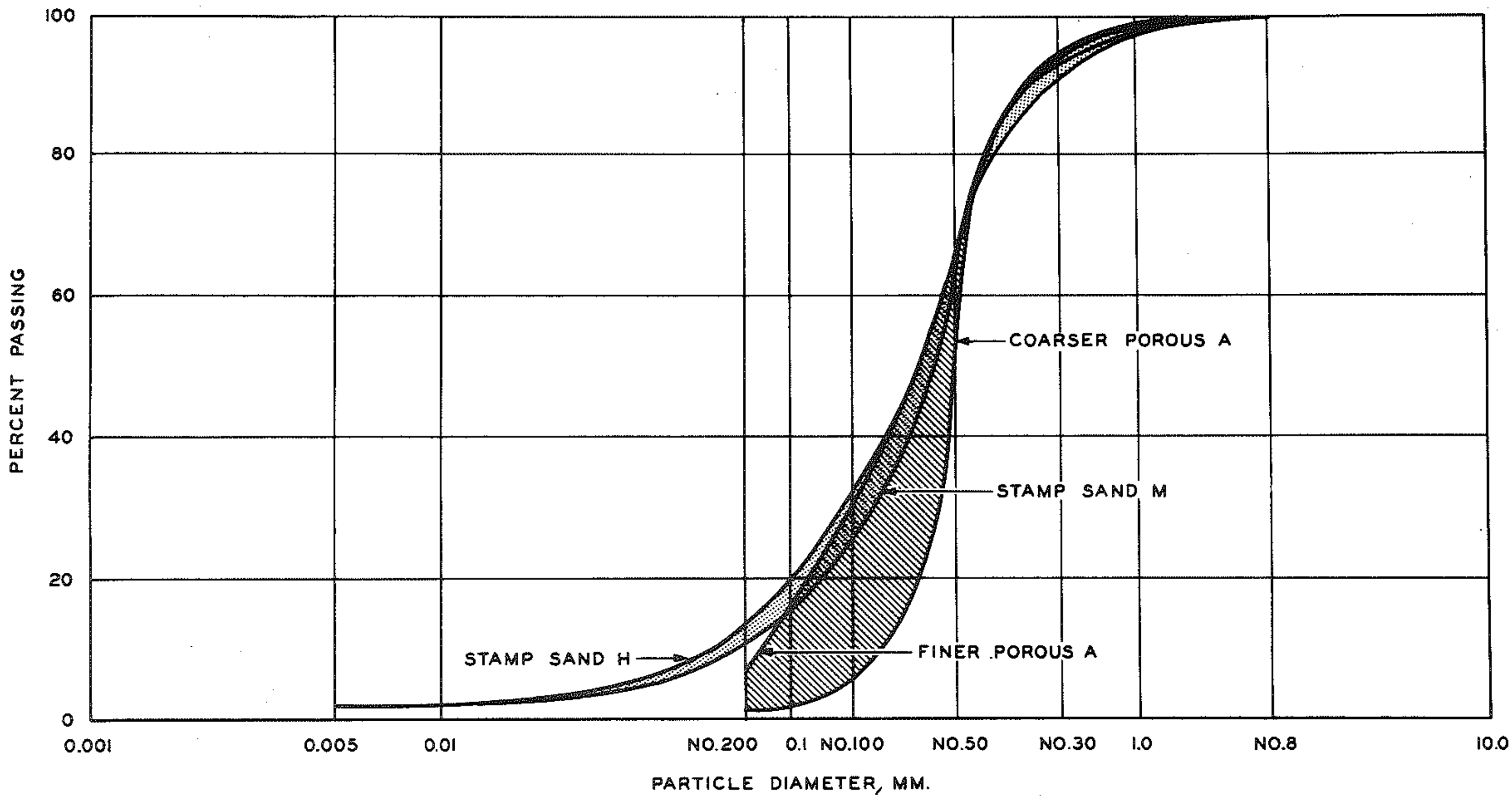

Figure 1. Grain size distribution of the basic test samples.

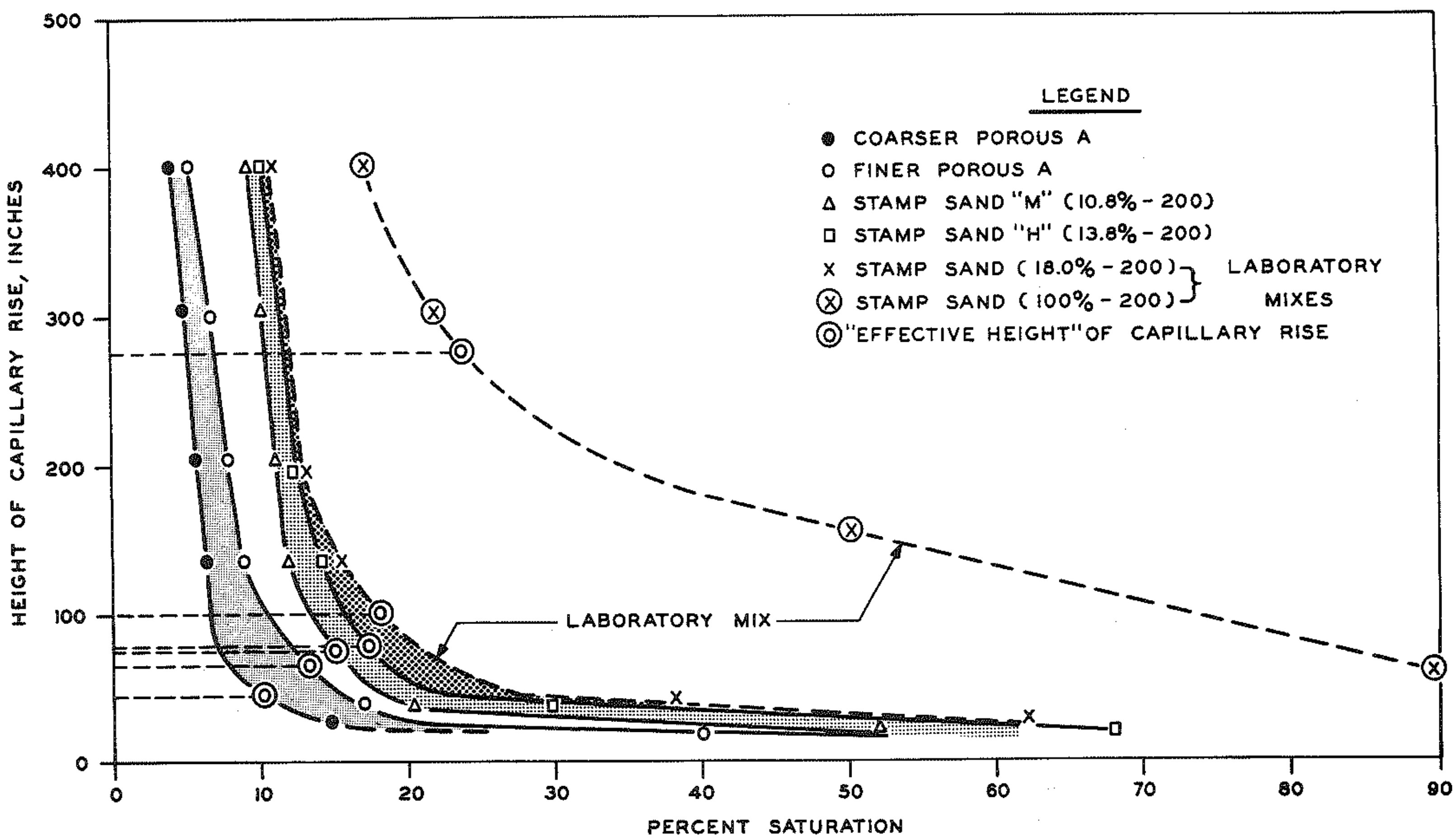

Figure 2. Moisture tension curves for the different soils; each point represents average of four tests.

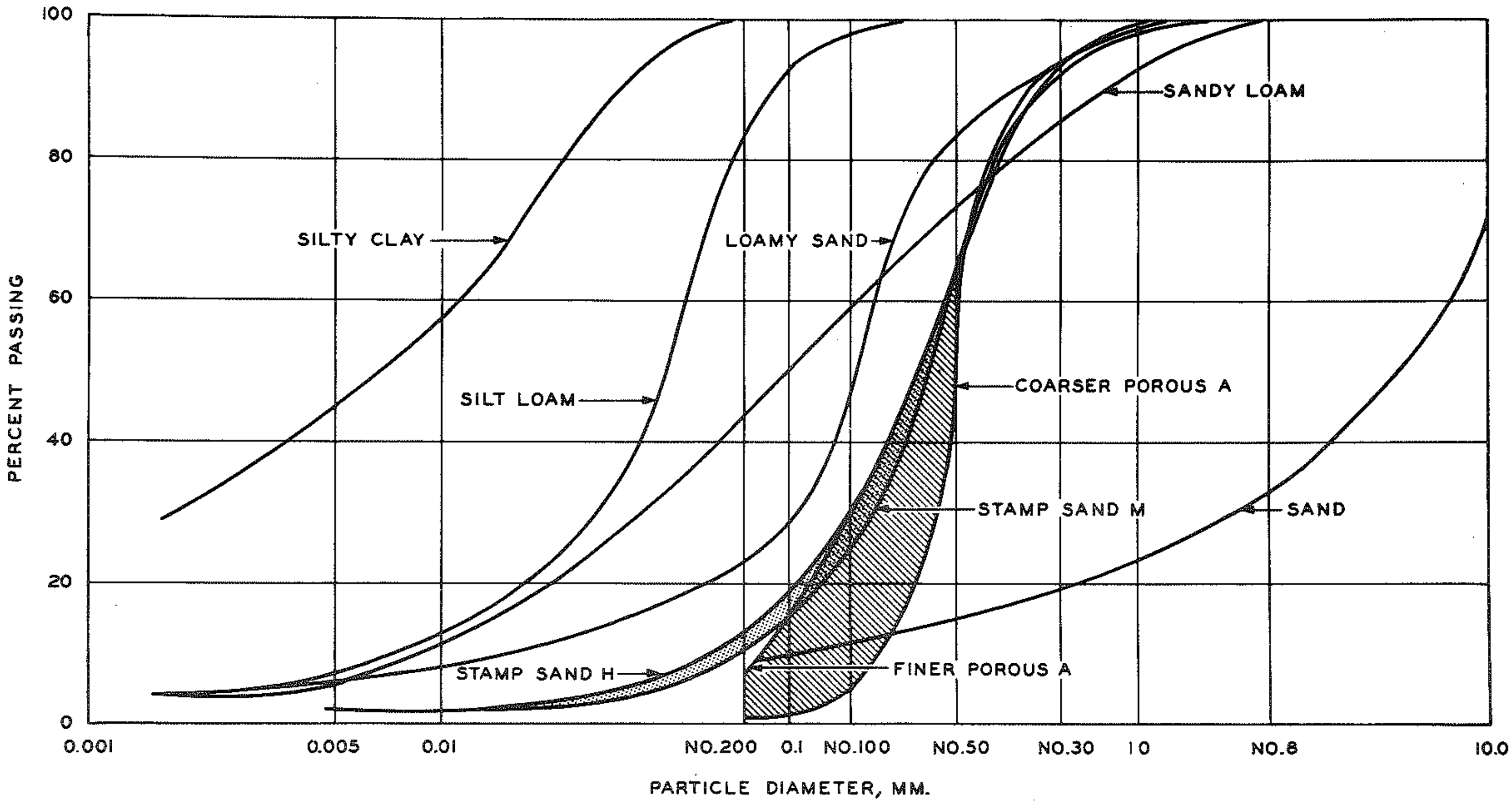

Figure 3. Grain size distribution of test samples compared with those in U. S. Army Cold Regions Research and Engineering Laboratory studies.

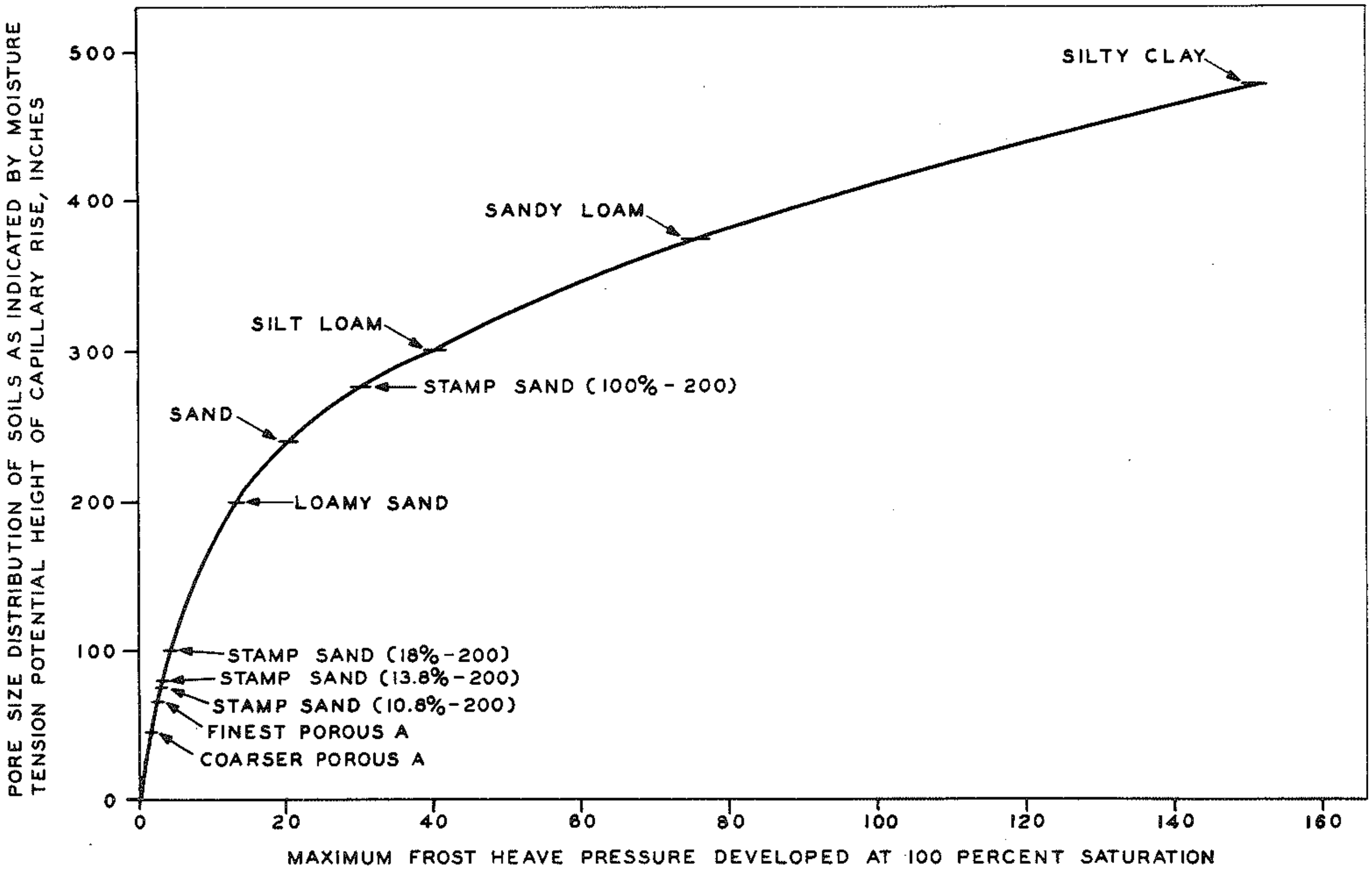

Figure 4. Relationship between pore size distribution of different soils and maximum frost heave pressure developed at saturation. Basic curve developed by U. S. Army Cold Regions Research and Engineering Laboratory.