THE RELATIONSHIP OF MOISTURE AND MACROPOROSITY TO THE HARDNESS OF LLOYD CLAY

It has been shown for at least two soils, Greenville fine sandy loam and Decatur clay, that soil macroporosity has more effect on soil hardness than moisture content within the moisture range between field capacity and air dryness.

From field data using a hammer soil core sampler, measuring field moisture and macroporosity with the tension table and drying oven and recording the number of hammer blows required to cut each sample as a measure of soil hardness, equations relating the three variables were derived. They were of the general form

\[ M = C - m \log (\Theta H) \]

where \( M \) = soil macroporosity percent
\( \Theta \) = soil moisture percentage
\( H \) = soil hardness
\( m \) and \( C \) are constants.

It has been found subsequently that this same general relationship will apply where a hammer driven probe type penetrometer is used to measure soil hardness. For the particular probe used

\[ H = 3.45 \cdot h \]

where \( H \) was the hardness as determined by the sampler and \( h \) the penetrometer measurement for the same soil depth layer. Thus, 3.45 \( h \) was substituted for \( H \) in the empirical formula derived from previous field data to estimate soil macroporosity space. These values agreed very well with the tension table determined measurements where averages of several determinations were taken for each soil tillage treatment.

An effort was made to apply this method of estimating macroporosity to another soil, Lloyd clay, which is higher in clay content than either the Greenville or Decatur studied previously. As before various functions of \( \Theta \) and \( H \) were tested in relation to \( M \). The best simple function found was \( \log (\Theta H) \). However, the general formula \( M = C - m \log (\Theta H) \) wasn't entirely satisfactory, although the simple function, \( \log (\Theta H) \), was highly significant, the values when plotted were scattered somewhat along the line relating \( M \) and \( \log (\Theta H) \).

An alternate and more satisfactory method of estimating \( M \) from \( \Theta \) and \( H \) was derived. The measurements were made at roughly three different moisture conditions, dry, near the average of 14.6%; moist, near the average of 21.4%, and wet, near the average of 27.5%. The relationship \( M = C - m \log H \) derived from these groups is shown in figure 1. Each point represents the average value found with four soil cores in each of several soil treatments. Note that the intersections of the lines vary between \( \log H = 0.3 \) and 0.8. It was assumed that if the sampling had been adequate to represent each group the intersection of all lines for various values of \( \Theta \) would be close to the point \( \log H = 0.4 \). The relationships between \( \Theta \) and the X-axis intercepts were plotted from the experimental values, assuming all lines for \( \Theta \) would pass through \( \log H = 0.4 \) and the approximate values of \( C \) and \( M \) were determined at \( \Theta \) values between 5 and 30%.

The curves thus estimated for the various values of \( \Theta \), relating \( M \) and \( \log H \), or \( M \) and \( \log h \), are shown in figure 2. Note that at very high extrapolated values of \( M \), moist soils appear to be more "firm" than dry soils. This is quite reasonable from observations with loose, aggregated soils. The bearing capacity of dry sands or loose soil aggregates increases with the addition of moisture due to the adhesive and surface tension forces involved. It is also noteworthy that with the Lloyd clay studied, in the range of ordinary values of \( H \), moisture changes affect hardness less in the dry than in the wet range.


---

Notes