THE EFFECT OF COMPACTION AND ADDITION OF LIME ON A LATOSOL

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ABSTRACT

Micromorphology has been used to study the stabilisation of clayey material from oxic B horizons of ferrallitic soils for purposes of civil engineering constructions.

The material in its natural state and after compaction in the moist state with and without the addition of 5% hydrated lime was examined with the optical and scanning electron microscope.

The mechanical behaviour was examined using the classical methods of soil mechanics (Proctor tests and measurements of shrink-swell, California bearing ratio, and permeability and capillarity).

The addition of 5% lime completely modified the effects of the physical treatments (mixing, wetting, compacting). When these treatments are applied to the natural soil material the microstructure is destroyed but the mineral constituents remain intact. When the treatments are applied after addition of 5% lime, there is a 'fossilisation' of structures of pedological origin but at the same time a partial attack on the mineral constituents and neoformation of calcium aluminosilicates.

INTRODUCTION

Micromorphology was used to study the behaviour of material from an oxic B horizon (Soil Survey Staff, 1975) (clayey latosolic B horizon, Comissao de Solos, 1960). Examinations were made of samples with and without the addition of 5% hydrated lime added as a stabiliser.

Study using optical and scanning electron microscopes was made of both natural undisturbed materials (Fig. 1a and d) and of samples subjected to the Proctor test at an 'optimal Proctor moisture' (27 to 30% water for the material studied) with the addition of lime (Figs. 1c, 2a, c, d and e) and without the addition of lime (Figs. 1b to e and 2b). Thin sections were all vertically oriented,

10

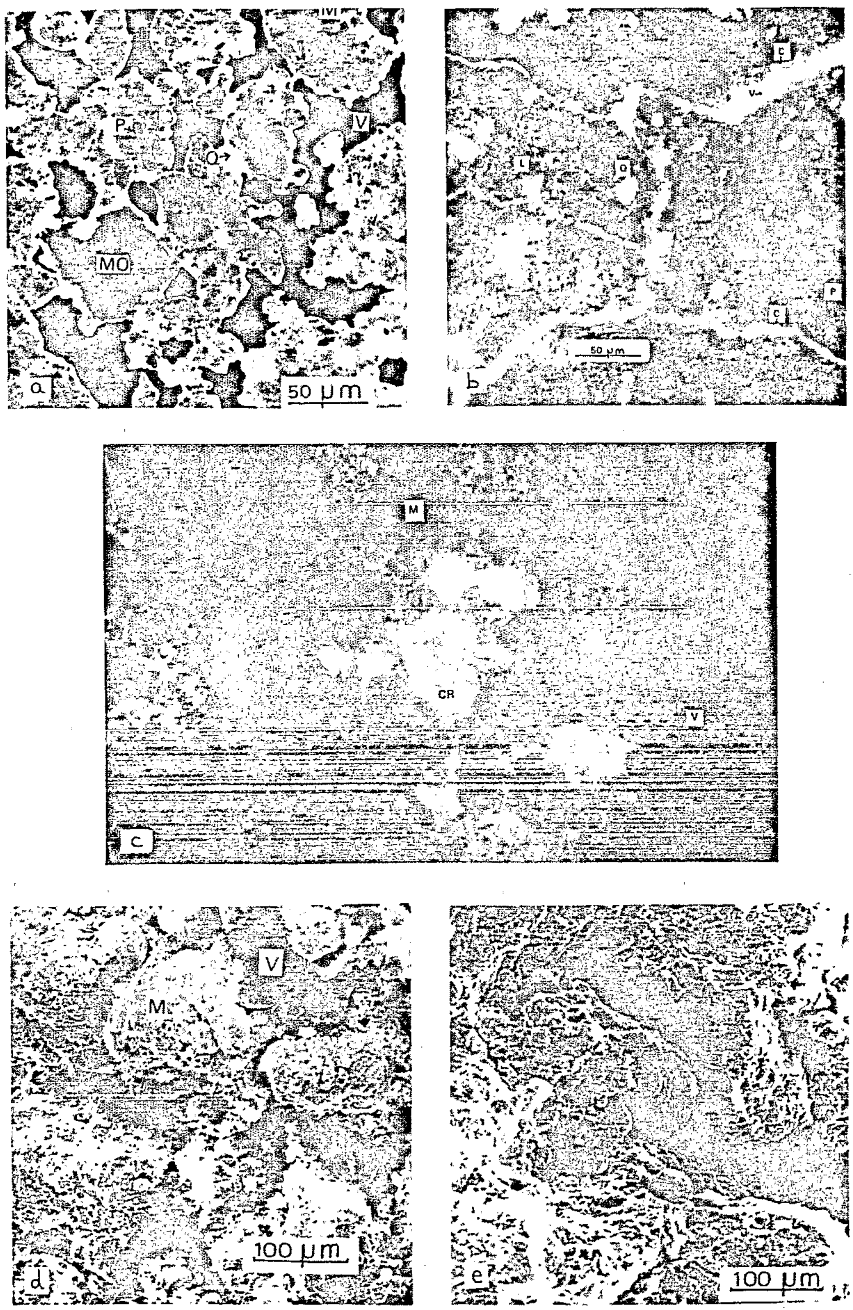

Fig. 1.

parallel to the compacting axes. The mechanical behaviour was studied by classical methods of soil mechanics: Proctor test, shrink-swell test, Califormia Bearing Ratio (CBR), permeability and capillarity tests. Only the results of the first two are presented here (Figs. 3 and 4).

COMPACTION OF UNLIMED SOIL MATERIAL

Compaction caused modification of the fabric at different levels of organisation but no change in the nature of the constituents:

- The initially argillasepic plasmic fabric is modified on compaction, with development of plasmic separations, stress cutans and fine plane fissures perpendicular to the compacting axis.
- The related distribution (Stoops and Jongerius, 1975) characterised initially by a micropedal arrangement (porphy-enaulic related distribution pattern) changes due to aggregate coalescence into a continuous material of porphyric type.
- The natural porosity consisting of a network of packing voids is replaced by a series of sub-parallel meta-joint planes along which there may be slickensides
- A micropedal, very porous structure breaking under finger pressure into a granular/single grain structure is converted to a continuous structure divided into

Fig. 1(a) Natural material. Porous framework formed by continuous assembly of micropeds. Plasma is dominant and skeleton grains are rare, mainly opaque minerals and some quartz. Interconnected packing voids. SRDP agglutinic. XPL; (b) Compacted material, continuous structure divided into lamellae by stress cutans and fissure voids perpendicular to the compacting axis. PPL; (c) Compacted material after lime addition. Conservation of the porous framework. Crystallisation of calcium aluminous silicate in the packing voids. XPL; (d) SEM micrograph of natural material. Porous framework formed by micropeds. Interconnected packing voids; (e) Compacted material. Microped coalescence. Joint plane formation.

Symbol key: C - cutan; CR - calcium aluminous silicate; L - lamellae; M - micropeds; MO - opaque minerals; P - plasma; Q - quartz; V - voids

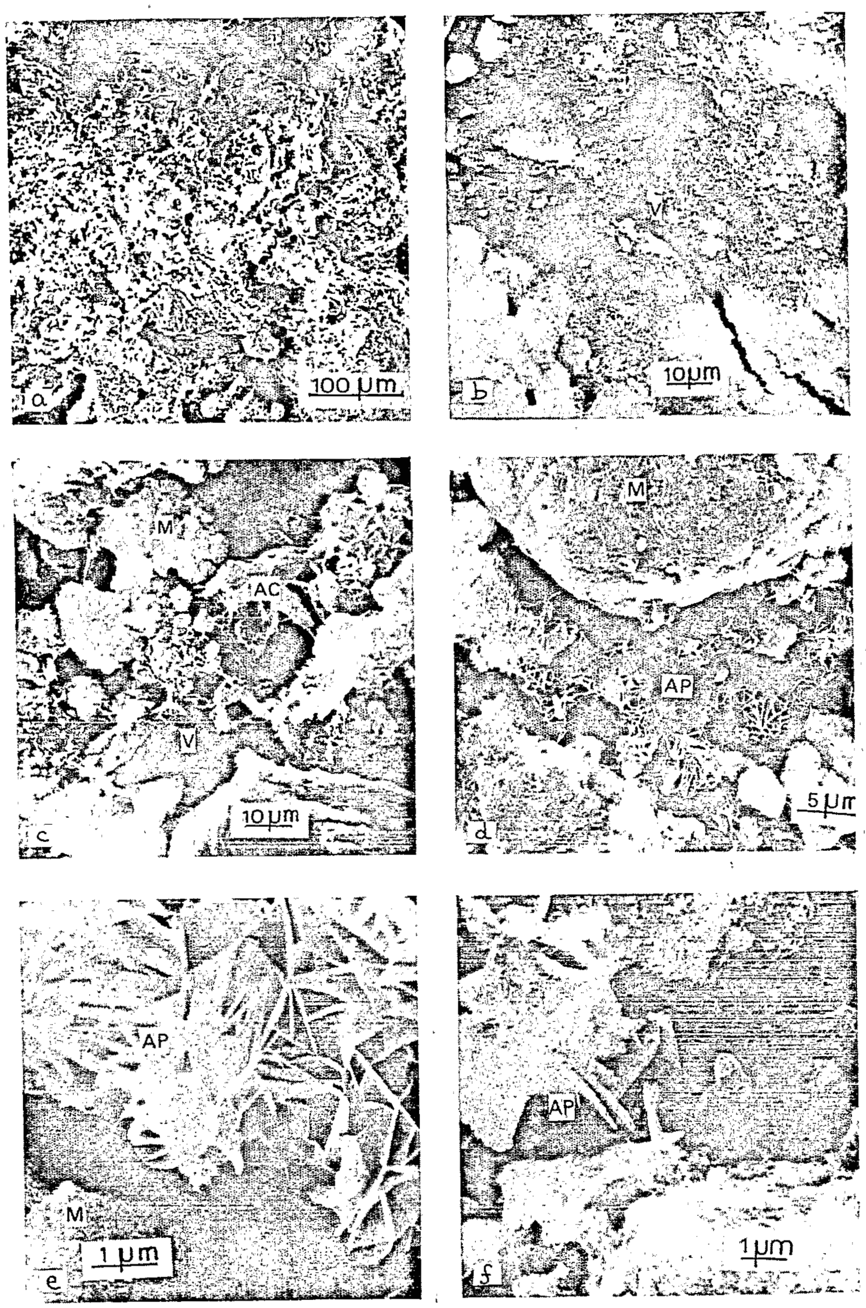

Fig.2.

fine lamellae.

In its natural condition, the soil is very stable provided no mechanical stress is applied. However, after the application of force (Proctor normal force), the material becomes strongly compacted and its bearing index increases (CBR = 10%) but at the same time becomes sensitive to water action reflecting the clayey nature of its constituents. In response to forces of internal or external origin, the lamellae may become dislocated by slipping over one another.

THE EFFECT OF LIME ON COMPACTION

The inherited soil fabric is better preserved when soils to which lime has been added are compacted than when the soil contains no added lime. In addition, in the limed soil there is neoformation of calcium aluminous silicate from the dissolution products of the soil constituents (Al, Si) and added calcium.

The plasmic fabric and related distribution pattern of the original ferrallitic soil are resistant to compaction if lime is added. The micropeds which characterise the original structure become 'fossilised' by calcium aluminous silicate crystals forming on their surfaces and within interpedal voids. The peds thus become enmeshed in crystallaria formed after liming.

The material after the addition of lime is much more resistant to water action and its bearing capacity increases by a factor of five.

Fig. 2 (a) SEM micrograph of compacted material after lime addition. Conservation of micropeds. Surface aspect very broken. (b) Compacted material. Planar microvoids roughly perpendicular to the compacting axis; (c) Compacted material after lime addition. Conservation of micropeds separated by assembly of polycrystalline particles. Interconnected mesovoids; (d) Compacted material after lime addition. Micropeds and framework formed by assembly of polycrystalline particles and micropeds; (e) Detail of (d). Assembly of polycrystalline particles and micropeds; (f) Material of experimental road. Crystallaria of calcium aluminous silicates in voids.

Symbol key: AC - polycrystalline particles; AP - polycrystalline particles; M - micropeds; V - voids

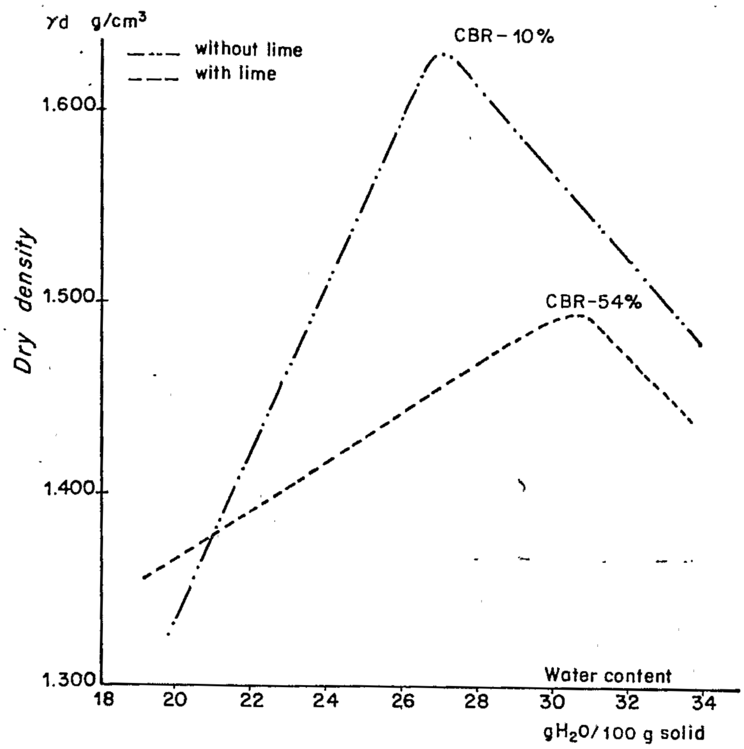

Fig.3. Effect of lime addition on the Proctor curve. Note flattening of curve, material is less compacted and the maximum Proctor is displaced toward a level of greater moisture.

CONCLUSION

A better knowledge of the mechanisms responsible for the stabilisation of latosols by the addition of lime is of ultimate value in improving this approach for civil engineering constructions. The introduction of a reactant totally changes the effects of compaction in a wet state. Compaction of material without added lime destroys the original microstructure but does not modify the mineral constituents. By contrast, in material containing 5% lime there is fossilisation of the pedological organisation.

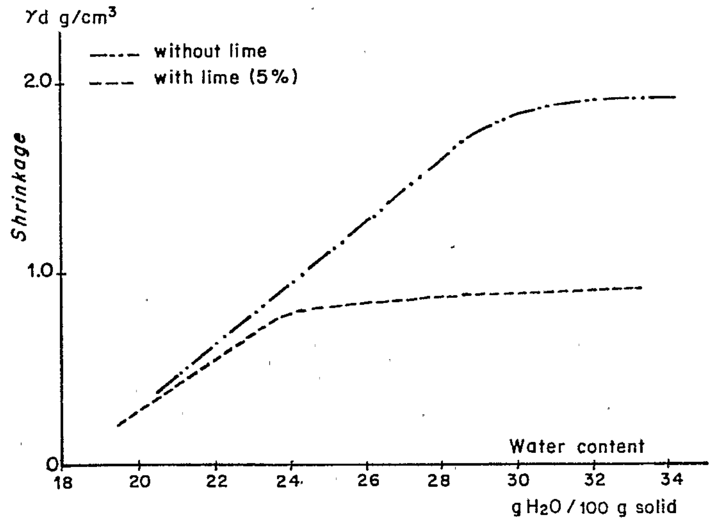

Fig.4. Effect of lime addition on the shrinkage after compaction at different moistures; with lime addition there is little further shrinkage above a moisture level of 24%.

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10