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Effects of agglomerate size on California bearing ratio of lime treated lateritic soils

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Abstract

Lateritic soil with high liquid-limits is commonly used for roadbed construction. However lateritic soil has properties that are sensitive to moisture, and therefore a common method of treating the soil is by adding lime to it. However, it is difficult to mix lime with lateritic soil homogeneously in the field as lateritic soil is prone to agglomeration. Therefore, agglomeration size is important and in this study, soil agglomerates are tested for their California bearing ratio (CBR). Lime ($Ca(OH)_2$) is added to one of the groups of soil samples and the other group is left untreated. The results show that soil that has been treated with lime both hardens and softens, which is related to the agglomerate size, whereas the untreated soil just hardens. The agglomerate size that corresponds to the maximum CBR value is not consistent with that of maximum dry density. Moreover, the CBR values of soil that has been treated with lime are higher than those of the untreated soil for an agglomerate size that ranges from 0.5 mm to 2 cm. Beyond this range, the addition of lime does not improve the lateritic soil. Compaction status and water intrusion are two important influential factors on CBR values. Therefore, it is necessary to take further measures to prevent moisture infiltration and migration of water.

Keywords: Limed treated soil; Aggregate size; Lateritic soil; California bearing ratio

1. Introduction

Lateritic soils are widely found worldwide, especially in humid tropical and subtropical zones. They are a type of highly weathered material, rich in secondary iron oxides and/or aluminum (Gidigasu, 1972). Their geotechnical properties range from inferior to excellent. Sometimes, lateritic soils perform well when used in roads, airport subgrades, and dam foundations, as they are compatible with gravel components (da Silva, 1967; Hirashima, 1951; Little, 1967). However, lateritic fine grained soils may be unsuitable as engineering filling materials due to high water content and their moisture sensitivity. In Hunan, a Province located in the central part of China, there is an abundance of lateritic fine grained soil which has been used to build over 30 highway routes in the most recent decade. Consequently, there have been many challenges. In summary, the challenges include: (a) poor compaction due to high

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moisture content; (b) sensitivity to fluctuations in moisture, where strength may be significantly reduced with a slight increases in water content; and (c) serious agglomeration and difficulty in compaction in the field. Due to the above reasons, lateritic soil should not be used when more suitable materials are available unless only laterite is found near the highway routes, and no other suitable filling materials can replace it. If laterite is used for availability and economic reasons, its properties can be improved using additives. The addition of lime or cement is a common method that addresses some problems of lateritic soil. Many researchers have carried out experiments that add lime or cement to soil in laboratory experiments (see Ola, 1977; Akoto, 1986; Osula, 1991; Bell, 1996), and the tested specimens could be homogeneously and easily mixed with soil particles less than 5 mm. The testing results also demonstrated that these are good stabilizers. However, aggregated laterite is difficult to separate in the field, see Fig. 1. Although aggregated laterite could be crushed into pieces using machinery, this may increase engineering costs and prolong construction time. It is not a viable method for a developing country where these two factors are an important consideration. In this research, aggregated soils have been subjected to compaction using a rotary tiller, and agglomerated soil with larger particle size has been tested in laboratories. However, lime or cement applied to aggregated soils in the field may only be a surface treatment. Compaction is ineffective due to inhomogeneous mixing, and thus many researchers believe that this method is not effective in the field. Currently, a few studies have quantified the effects of soil aggregate size on geotechnical properties (Cai et al., 2005; Carminati et al., 2008; Tang et al., 2011), but the diameter of the samples used in their experiments is less than 1 cm. Comparatively, most researchers have focused on the effects of aggregation on tillage and soil erosion (Oztas and Fayetorbay, 2003; Reuss et al., 2001; Murungu et al., 2003; Barthès and Roose, 2002).

The samples used in the trial experiments to determine axial stress and direct shear strength are small, and the maximum particle size may pass through a 5 mm sieve. An evaluation of the agglomerate effect cannot be carried out using small samples. The California bearing ratio (CBR) test allows evaluation of the maximum solid particle size up to 4 cm. Besides that, the CBR is a primary method to evaluate filling materials for road engineering. In this paper, the intention is to determine a suitable agglomerate size of aggregate soil for use in the field to maintain a long term performance.

2. Experimental program

2.1. Materials

Lateritic soil was collected from a highway in Hunan Province, China, located at a section between the cutting and filling area, see Fig. 2. The lateritic soil was brick-red, fine and smooth. The samples were air dried instead of oven dried to avoid the disturbance of their intrinsic bonds. The crushed materials were passed through a 40 mm sieve and used in a standard compaction test to obtain the optimum water content (OWC) and maximum dry density. The consistency and specific gravity properties of the lateritic soil samples were determined by passing the samples through 0.5 and 5 mm sieves, respectively. The basic properties of the samples were tested in accordance with the Test Methods of Soils for Highway Engineering (JTG E40, 2007), which was modified with reference to the ASTM, and the results are shown in Table 1. The chemical compositions of the lateritic soil samples are shown in Table 2.

The liquid limits of the lateritic soil samples are greater than 50%, and thus categorized as high liquid limit clay.

Figure 1. Soil agglomerate size.

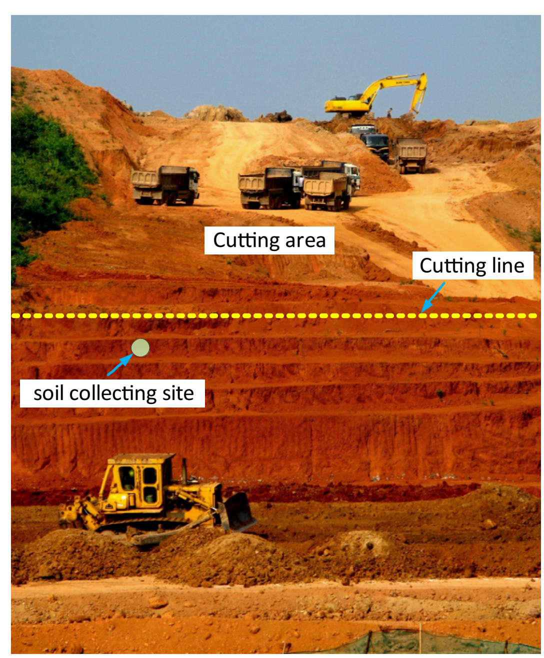

Figure 2. Soil collection site.