Singularities of Geotechnical Properties of Complex Soils in Seismic Regions

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Abstract: Volcanic activity results in a wide range of soil types with very unusual characteristics, the most remarkable of which are volcanic ash clays containing the clay minerals allophane and imogolite. In addition to these soils, volcanic activity often produces the special environmental conditions that result in the formation of diatomaceous soils, namely, water rich in dissolved silica. These soils consist of individual particles containing intraparticle voids filled with water, resulting in a very unique porous particle morphology that is quite different than stereotypical sedimentary soils. This paper presents a series of careful laboratory tests on samples of both materials found in Chile. These tests demonstrate that soils weathered from volcanic ash develop yield pressures that are similar to the preconsolidation pressure of sedimentary soils. This type of soil also shows a dramatic change in properties due to drying. In addition, diatomaceous soils and those containing allophane have very low densities, in spite of which they develop remarkably high shear strength. The need for their properties to be properly understood and taken into account in geotechnical design, especially seismic design, is emphasized, since the location of these soils generally coincides with earthquake activity, which, like volcanic activity, arises from tectonic plate interaction.

CE Database subject headings: Soil dynamics; Microstructure; Volcanic ash; Seismic effects; Clays.

Introduction

Plate tectonics are recognized as the main cause of earthquakes around the world, and they should similarly be recognized as the main source of volcanic activity. For example, along the so-called circum-Pacific belt, there is clear correspondence between the presence of volcanoes and seismic activity. Volcanic activity generates a specific spectrum of soil deposits, all of which have distinctive characteristics, the most remarkable of which are volcanic ash deposits containing the clay mineral allophane. In addition, areas influenced by volcanic activity often have the specific environmental conditions favorable to the formation of diatomaceous soil deposits, namely, water rich in dissolved silica. In contrast to common sedimentary soils, volcanic ash clays and diatomaceous soils consist of porous individual particles of unusual shape, making possible a particle morphology that is quite unique. In describing their microscopic features, it is important to be clear about the terminology used here; the term fabric refers to the arrangement of particles, particle groups, and pore spaces in a soil, while the term structure refers to the combined effects of fabric, composition, and interparticle forces. With this understanding, soil structure reflects all facets of the soil composition, namely, history, present state, and environment (Mitchell and Soga 2005). Individual forms of particle interaction, particle assemblages defining units that interact with other units, and pore spaces within and between these units are part of the microfabric component of the soil structure (Collins and McGown 1974). As a consequence of this, the intraparticle voids existing in volcanic ash clays and diatoms are likely to be associated with very unusual microfabric.

With sedimentary soils, it can be shown that soil fabric is mainly controlled by the environmental characteristics existing during the deposition of soil particles, or genesis of the soil, and subsequent loading, whereas soil structure is only developed with time and it is controlled by both particle mineralogy and geological processes. In this context, the weathering process, through solution and reprecipitation that creates a more porous material and the formation of clay and other secondary minerals, is one of the most important geological influences in the creation of the soil structure. Soils produced directly by such weathering can, therefore, be expected to show quite different behavior than common sedimentary soils (Zhang et al. 2004). Additionally, weathering may produce bonds between particles and induce the formation of new units or aggregates. At the same time, it is recognized that the development of aggregates also takes place in sedimentary soils, where the interaggregate and intraaggregate pore spaces have been identified as the two common types of pore spaces for describing clayey sedimentary soils (Delage and Lefebvre 1984). In the case of volcanic ash, the weathering process leads to both a complex structure and unusual particle morphology, with the result that the soil shows very unique and very interesting behavior. With the above factors in mind, this paper gives an account of the properties of two soil groups having very distinctive geotechnical properties arising from the volcanic environment associated with their formation, namely, volcanic ash clays and diatomaceous soils.

Overview of Volcanic Ash Soils

Volcanic ash is normally made up of significant quantities of volcanic glass, which is likely to be one of the minerals most rapidly

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Note. Discussion open until December 1, 2008. Separate discussions must be submitted for individual papers. To extend the closing date by one month, a written request must be filed with the ASCE Managing Editor. The manuscript for this paper was submitted for review and possible publication on July 26, 2005; approved on August 24, 2007. This paper is part of the ***Journal of Geotechnical and Geoenvironmental Engineering***, Vol. 134, No. 7, July 1, 2008. ©ASCE, ISSN 1090-0241/2008/7-982–991/$25.00.