THE IMPORTANCE OF SOME ENVIRONMENTAL FACTORS ON THE EVALUATION OF CEMENT STABILIZED ARID ZONE SOILS

INFLUENCE DE CERTAINS FACTEURS SPECIFIQUES DU MILIEU ARIDE SUR LE COMPORTEMENT DE SOLS TRAITES AU CIMENT.

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Abstract

The effects of desiccation on the compressive strength of both soaked and unsoaked cement stabilized arid zone soils (sandy loam, silty loam and clay/clay loam), were investigated. The pre-drying of the stabilized clay/clay loam soils resulted in total strength loss on soaking, whereas the sandy loam soils still possess significant compressive strength which are however much lower than those obtained in the standard soaking test (i.e. without pre-drying). At higher cement contents (> 10%), the calcareous silty loam soils showed slight increases in strength when pre-dried before soaking. Although the addition of 8% cement to most soils is capable of achieving the minimum compressive strength (1,720 KN/m²), and the maximum permissible strength reduction (20%) on soaking, possible desiccation of the stabilized soils under arid conditions could lead to unacceptable strength reductions when subjected to subsequent increase in moisture content. The results of this study highlight the importance of the use of various criteria, especially those simulating environmental conditions, in the evaluation of cement stabilized arid zone soils.

Résumé

Les effets de la dessication sur la résistance à la compression de sols de zones arides traités au ciment (saturés et non saturés) ont été étudiés (limons sableux, limons, argiles limoneuses, argiles). Le pré-séchage des argiles ou argiles limoneuses traitées a conduit à une perte complète de résistance à l'imbibition, alors que les limons sableux traités conservent une résistance à la compression non négligeable, bien que beaucoup plus basse que celle obtenue lors de l'essai d'imbibition standard (i.e. sans pré-séchage). Si l'on augmente les teneurs en ciment (> 10%), les limons calcaires ont présenté une légère augmentation de résistance quand ils ont été pré-séchés avant imbibition. Bien que le traitement à 8% de ciment suffise pour la plupart des sols à atteindre la résistance à la compression minimale (1,720 KN/m²) ainsi que la chute de résistance maximale permise après imbibition (20%), il faut noter qu'une dessication possible des sols stabilisés dans des conditions arides pourrait conduire à des chutes de résistance inacceptables lorsqu'ils sont soumis ultérieurement à une augmentation de teneur en eau. Les résultats de cette étude mettent en évidence l'importance de la prise en compte de paramètres très variés et en particulier de ceux qui permettent de simuler les conditions réelles de l'environnement lors de l'utilisation de sols stabilisés au ciment dans les régions arides.

Introduction

The use of Portland cement in the stabilization of inferior soils has been widely successful in various geotechnical projects such as roads, runways, embankments, dams and shallow foundations. The choice of any particular stabilizing agent depends partly on the nature on the civil engineering structure to be built and partly on the geological and physicochemical properties of the soils involved. In the construction of roads and runway pavements, the actual decision on the most appropriate stabilizing agent and the exact quantity required, is usually based on the unconfined compressive strength of the compacted stabilized soil, after curing for seven days under constant moisture content conditions. Many authorities (e.g. British Standards) often stipulate a minimum 7 - day compressive strength of 1,720 KN/m² (250 lbsq in) for stabilized road pavements. However, the field performance of the stabilized structure not only depends on the strength, but also on the environmental conditions (especially climatic) of the area where the structure is located. Some researchers (e.g. Croft 1968) favour the use of the strength reduction on soaking as a more practical and realistic criterion in the determination of the suitability of any soil for cement stabilization. This is in view of the increasing evidence that there appears to be little relation between strength specification and the performance of a pavement in the field.

In arid regions, evaporation is usually well in excess of rainfall and consequently, the soils are often invariably in a perpetual state of high undersaturation. Under such conditions, desiccation becomes such an important environmental factor that it cannot be ignored in the design of the structure. In arid regions, it is more likely for a completed pavement or structure to lose, rather than gain, moisture content. This is mainly due to the high rate of evaporation and the low amount of rainfall. However, the occasional storms in the arid region may result in a temporary increase of moisture content. Even then, what appears to be an increase in the design moisture content of the structure actually involves a partially dried pavement with a field moisture content which is significantly lower than the design value. But the standard soaking test is normally performed on samples kept at constant moisture content, which assumes that no moisture was lost either during or after construction. This assumption is in most cases, not true in arid zone regions. For the standard soaking test to be of any practical significance in arid zone regions, the desiccation factor must be incorporated in the test. The aim of this paper, therefore, is to examine the probable
effects of desiccation on both the soaked and unsoaked compressive strength of some cement stabilized arid zone engineering soils. Such an investigation should lead to a more accurate evaluation of the quality of cement stabilized arid zone soils.

Environmental setting and nature of the soils

The soils used for this study occur at Fowlers Gap Arid Zone Research Station in northwestern New South Wales, Australia (fig. 1). The station is located approximately on latitude 31°S and longitude 141°40’E, in the Australian semi-arid region. The area is underlain by a sequence of Precambrian metasediments (phyllitic shales, schistose quartzite and dolomite) which are unconformably overlain by Late Devonian Sandstones and Cainozoic unconsolidated sediments. The general landscape consists of gently undulating surfaces which are underlain by the phyllitic shales, and prominent schistose quartzite ridges.

The majority of the soils have been described in pedological terms as Desert Loams (Stace et al., 1968). The detailed engineering—geological properties of the soils have been discussed by the author (Akpokodje, 1982). The soils generally show a strong association with land-forms but may not necessarily bear any direct genetic relationship to the underlying bedrock. Like other arid zone soils, most of the soils are characterized by an appreciable accumulation of soluble salts, gypsum and carbonates in the subsoil. Both carbonate and gypsum content may be as high as 30% (from semi-quantitative XRD analyses).

The climate of the area is semi-arid (Bell, 1973), with hot summers (October-March) and mild winters (April-September). The average daily maximum temperature range during the summer is 26-38°C whereas the average daily minimum range for the winter period is 3-10°C (fig. 2). The mean annual rainfall is low (241 mm annually), and highly variable both in distribution and intensity. The rate of evaporation is high and usually more than ten times that of rainfall. This is mainly responsible for the highly unsaturated nature of the soils.

Methods of investigation

The laboratory tests carried out on the soils included particle size analyses, Atterberg limits and compaction, whereas those on the soil-cement mixtures comprised the unconfined compression test, and standard and "pre-dried" soaking tests (durability test). The geotechnical index property tests were carried out according to the procedures recommended by both the Australian Standards (AS 1289; 1977) and the American Society for Testing and Materials (ASTM, 1979). The particle size distribution was determined by both dry sieving and hydrometer methods, after washing the whole soil sample through ASTM sieve No. 200 (0.074 mm). The stabilization tests were performed using the soil fractions passing ASTM Sieve No. 4 (4.75 mm), and Portland cement type A. Cylindrical specimens (36 mm diameter by 76 mm length) were prepared at the optimum moisture contents and maximum dry densities (Standard Proctor) of the soil-cement mixtures (Tabl. I). This was done by compacting a mixture of the pre-determined weights of cement and the oven-dried soil, with a specific volume of water, into a cylindrical sampling tube of known volume. All the soil-cement mixtures were wax cured at approximately 100% relative humidity.

In order to simulate the dry conditions of the region, an additional soaking test was performed on samples that