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MOISTURE-MOVEMENT CHARACTERISTICS OF A SILTY LOAM SOIL STABILIZED WITH SODIUM CHLORIDE

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ABSTRACT

Erodibility, permeability, water absorption, swelling behaviour and drying rate are the major moisture-movement characteristics of a soil. An attempt was made to study these characteristics of a silty loam soiltreated with sodium chloride. It was found that erodibility, permeability, water absorption and the rate of loss of moisture decreased while the swell increased with an increase in salt content.

INTRODUCTION

The construction of a road network is one of the most effective ways of promoting the economic development of a country. Traffic intensity in developing countries is too low to justify expenditure on higher-grade road construction. Recent increases in the cost of traditional construction materials have emphasized the need to explore the potential of indigenous materials for for low-cost road construction.

Soil stabilization is a method of processing available materials for the construction of low-cost roads. The stabilizers usually used are cement, lime and bituminous materials which are very expensive in most of the developing countries. The field experiences reported in literature show that sodium chloride has good stabilizing properties to justify its economic use in most of the tropical and subtropical developing countries of Asia and Africa.

The stability of a pavement can only be maintained if its surface and foundation remain in a relatively dry condition. It is therefore very important to investigate the moisture-movement characteristics (i. e. erodibility, perme-

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ability, water absorption, swelling behaviour and drying rate) of a pavement material.

The object of this study was to investigate the moisture-movement characteristics of a silty loam soil stabilized with sodium chloride.

MATERIALS AND EQUIPMENT

The materials used in this investigation were sodium chloride (rock salt) and silty loam soil from Selby (UK) which resembled the soil from the University of Agriculture, Faisalabad.

To determine the erodibility of salt-stabilized and natural soils, a rainfall simulator of the drop former type was used (Chaudhry and Singh, 1983). The permeability of silty loam soil was expected to be very low. The equipment used for determining the coefficient of permeability was a variable head permeameter. The other tests performed were the measurement of drying rates, water absorption and swell of the natural and salt treated soils. The equipment used for these tests is very common and is described in B. S. 1924 (1976).

EXPERIMENTAL PROCEDURE

The soil specimens were prepared in constant volume moulds for different treatment levels (0.5, 1.0, 1.5 and 2.0 per cent salt contents). They were cured at 30 °C and 54 per cent relative humidity for 28 days. The cured specimens were then soaked in water for four days in order to keep the degree of saturation constant on all treatment levels. The permeability test was conducted in the laboratory on these soaked specimens at 20 °C and three specimens were tested for each treatment level.

The measurement of drying rates, water absorption and swell are very common tests performed in the laboratory and their procedures are described in B.S. 1924 (1976) and in most of the texts, thus no description is required here.

The procedure for the determination of erodibility is described by Chaudhry and Singh (1983).

RESULTS AND DISCUSSION

Figure 1 shows the relationship between the amount of erosion (kg/m^2/hour) and salt content (%). It is obvious that the treated soil is less erodible than the natural one at 0.5 and 1.0 per cent salt contents. The reason is an increase in dry density and crystallization of sodium chloride (caused by dry-curing) at the surface of the specimen, which cements it into a dense hard crust. It is also obvious from Figure 1 that the addition of salt at higher salt contents (i. e. 1.5 and 2.0 per cent) is not very effective in reducing erosion as compared to lower salt contents (i. e. 0.5 and 1.0 per cent). The reason is the flocculation behaviour of clay (present in soil) at that salt content resulting in a decrease in the dry density.

The results of permeability tests (shown in Figure 2) indicate that permeability is decreased with an increase in salt content. This decrease is the result of cation-exchange which takes place in the soil water system, caused by the addition of sodium chloride. The calcium present in the soil is washed out and the soil exhibits the properties of sodium clay, resulting in a decrease in the permeability of the soil. The increase in dry density and the hard crust produced by crystallization of sodium chloride after dry-curing are also responsible for this decrease.

The results of water absorption (expressed as a percentage of the total weight of the specimens) are shown in Figure 3. The values of water absorption (%) and soil permeability (mm/sec) decrease gradually with the increase in salt content. The decrease becomes very small when the salt content increases from 1.5 to 2.0 per cent. The explanation lies in the decrease of dry density at 2.0 per cent salt content which is one of the factors causing the decrease of water absorption. The factors (discussed already) causing the decrease in the permeability of treated soil also hold good for the decrease in water absorption.

The results of swelling behaviour of natural and treated soils are shown in Figure 4, which indicate that the swell increases with the increase in salt

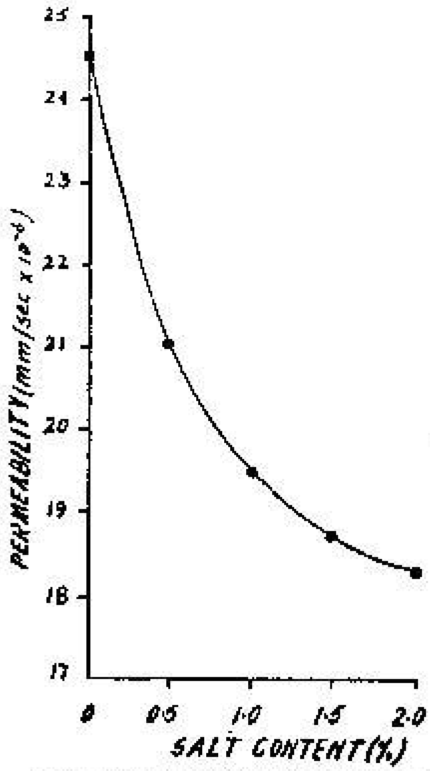

FIG.2. PERMEABILITY-SALT CONTENT RELATIONSHIP

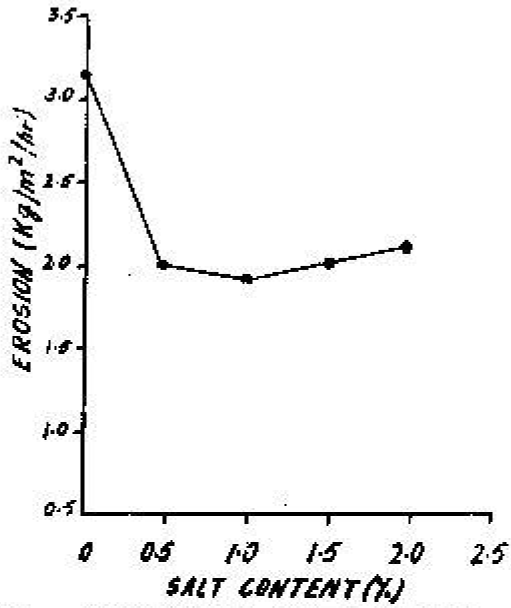

FIG.1. EROSION-SALT CONTENT RELATIONSHIP

CURING PERIOD = 28 DAYS
SOAKING PERIOD = 4 DAYS

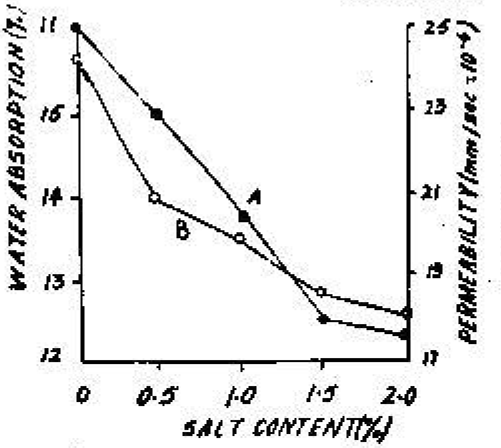

FIG.3. RELATIONSHIPS BETWEEN
(A) SALT CONTENT AND WATER ABSORPTION.
(B) SALT CONTENT AND PERMEABILITY.

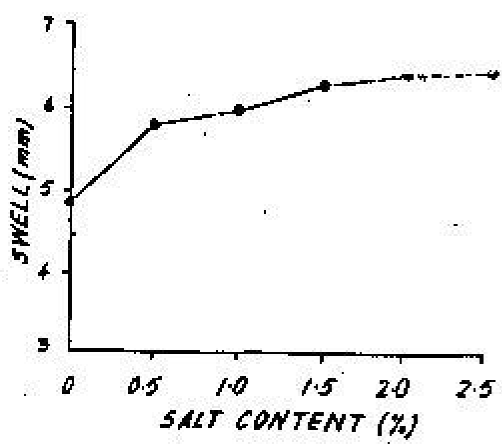

FIG.4. SWELL-SALT CONTENT RELATIONSHIP

content. The soil specimen swells when its volume increases because a force of repulsion separates the clay particles as the moisture content of the specimen rises on soaking. The amount of swell depends upon the nature of the clay minerals, their arrangement or orientation in the soil, and the physico-chemical properties (i. e. valency of exchangeable cations, pore-water salt concentration and cementing bond between clay particles). As a result of the cation-exchange described already, the monovalent exchangeable sodium cations cause greater swell than divalent calcium cations.

The results show that, in general, the drying rate is rapid in natural soil specimens as compared to treated ones owing to the ability of sodium chloride to lower the vapour pressure of the water in which it is dissolved. This decrease in vapour pressure (the tendency of a substance to pass from the liquid or solid into the gaseous state) results in a decrease in the drying rate. Surface tension also affects the rate of evaporation in such a manner that a solution possessing high surface tension tends to vaporize less rapidly than the one having low surface tension. The sodium chloride present in soil-water mixtures causes an increase in the surface tension of water, thereby decreasing the moisture evaporation rate. This property of moisture retention is valuable in reducing the compactive effort and retaining the moisture content at high temperatures so as to reduce cracking of the pavement.

CONCLUSIONS

The erodibility of soil treated with upto 1 per cent salt, measured after a curing period of 28 days, decreases. Higher salt contents are not beneficial. A decrease in the permeability and water absorption is observed with an increase in salt content. The results of the swelling behaviour of the soil indicate that the swell increases slightly with an increase in salt content. The loss and the rate of loss of moisture is reduced in salt-treated soil.

The main conclusion drawn from these tests is that saline soil can be used to construct low cost pavements in the rural areas.

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