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The Capillarity of Mica-Rich Base-Course Aggregates

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In regions of temperate climate, the destructive influence of frost is the main contributor to damage of a road structure. Commonly, the frost susceptibility of base-course aggregates is often ignored in road construction. However, a number of studies on aggregates for construction purposes, and field observations of road failures, indicate a negative influence of mica-rich rock aggregates (used in unbound applications) on the service life of road construction. The scope of the current work investigates the capillary properties of unbound base-course aggregates with varying free mica grains. The materials studied in this research are commercially available road construction aggregates, and originate from different regions of Sweden. The mineral composition of the samples has been determined by polarizing microscopy using a point-count method. The parameter characterizing the capillarity was measured using the test for determining capillary rise (VVMB24). The results show that there is a direct correlation between mica content of the aggregates and water suction by capillary forces. Therefore, mica-rich materials susceptible to frost heave, thus confirming the tendency for frost damage of unbound aggregates.

Keywords aggregates, base-course, capillarity, free mica grains

1. Introduction

A number of studies on aggregates for construction purposes and field observations of road failures, especially those caused by seasonal fluctuations of temperature, have revealed a negative influence of mica-rich base-course aggregates on the service life of road construction (Ref 1-5).

The presence of water within a road construction is one of the major factors influencing its stability (Ref 1, 6, 7). Formation of ice lenses in unbound aggregates can occur when additional water is drawn into porous spaces by capillary action. Capillarity, permeability, grain size distribution, specific surface area, and mineral content are the key factors influencing moisture migration in the road construction causing the growth of ice lenses and frost heave (Ref 8).

The capillary rise, a unit of measurement for capillarity, depends on pore size. The previous investigations have shown that capillary rise increases with decreasing pore size, which in turn depends on grain size and grain distribution. The high frost susceptibility of fine material has been pointed out (Ref 9, 10). However, the influence of the mineral composition of the fines has been generally ignored (Ref 1).

The present work focuses on the capillary water suction capacity of the base-course, consisting of crushed aggregates with different free mica content in the fine fraction. The aggregates have been selected according to actual standards for commercially used base-course materials. Grain size distribution and degree of compaction in the capillarimeter were kept as constant as possible for all samples in order to obtain reliable data, which hopefully show the relationship between mica content and capillary rise. The capillarity determination test VVMB24 (Ref 11) was conducted. The experimental results showed an increase in capillarity rise with increasing amount of free mica particles leading to the conclusion that mica-rich aggregates are capable of transporting and absorbing higher amounts of water compared with aggregates of low mica content. This ability to absorb water can cause significant frost heave, damaging road constructions, and should be taken into account in requirements for road materials.

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2. Materials and Methods

The rock materials selected represent commercial base-course aggregates obtained from material producers throughout Sweden. The rock aggregate samples were chosen on the basis of free mica content in the fine fraction.

The content of free mica grains for the analyzed narrow grain size fractions (0.125-0.25, 0.25-0.5, and 0.5-1.0 mm) is given in Table 1. The composition of the samples (Table 1) was determined through point counting of grain mounts (Ref 12) using a polarizing microscope.

The specimens were dried and sieved (Ref 13) into grain size fractions <0.063, 0.063-0.125, 0.125-0.25, 0.25-0.5, 0.5-1.0, and 1.0-2.0 mm. The fractions >2 mm were discarded. The collected size fractions were proportioned and mixed to achieve required particle size distribution for standard base-course aggregates in accordance with road technical specifications of Swedish Road Administration (Ref 14), see Fig. 1.

The capillarity test procedures were carried out according to VVMB24 (Ref 11), using a capillarimeter m/50 with digital manometer (Fig. 2). The test was based on the principle described in Ref. 9. The capillarity rise was determined by measuring the maximum underpressure that can be applied on one side of the water-soaked sample without the occurrence of air breakthrough.

Table 1 Content of free mica (particle %) for respective samples and fine fractions

	0.125-0.25 mm	0.25-0.5 mm	0.5-1.0 mm	Mica content in thin section	Description
Sample 1	81	71	51	Biotite 10% Muscovite 20%	Medium grained, mica-rich gneiss
Sample 2	56	46	40	Biotite 20.3% Chlorite 2.8% Muscovite 3.2%	Fine grained, schistose-biotite-rich semipelite
Sample 3	40	29	20	Biotite 0-37% Chlorite 1.2% Muscovite 6.6%	Fine grained, schistose-biotite-rich semipelite
Sample 4	19	19	7	Biotite 5.6% Chlorite 0.6% Muscovite 2.5%	Fine to medium grained, red weakly foliated granite
Sample 5 (reference)	0.9	0.5	0.4	Biotite 0.6% Chlorite 0.9%	Fine grained quartzite

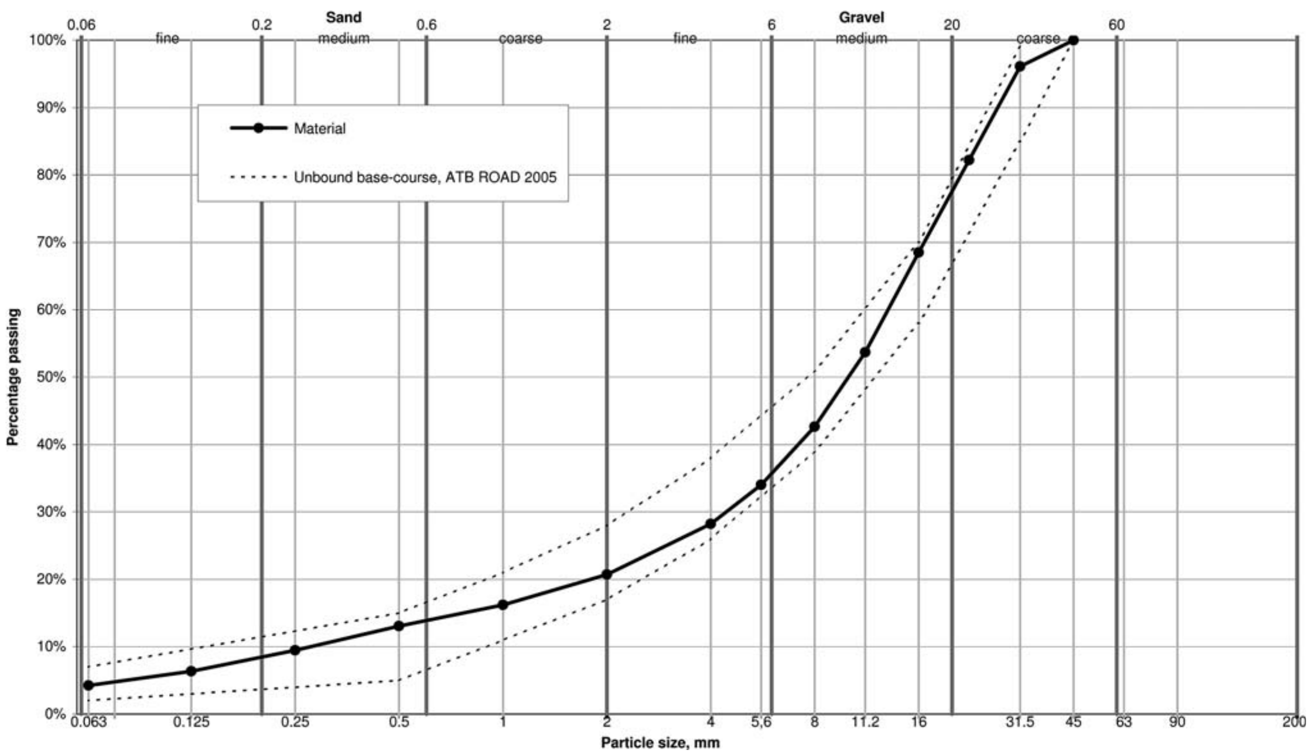

Fig. 1 Particle size distribution for the samples. Material 0-2 mm was used for capillarity test

To investigate the effect of water soaking on capillarity, one set of samples was saturated and stored in sealed plastic containers for 10 days prior to the test.

3. Results

The results of the capillarity test are presented as relationships in terms of capillary rise and mica content in Fig. 3 and 4.

The test results revealed a strong correlation between capillarity rise and the content of mica. The values for capillary rise increased with an increase in mica content.

However, sample 1 (with the highest value of free mica (51-81%)) showed a lower capillary rise than sample 2 (40-56%). This can be explained by the possible deviation in mica particle grain size and may be related to a different mineral composition of the samples.

Figure 4 indicates a strong relationship in terms of capillary rise and mica content. In addition, the results did not reveal any connection between capillarity and the effect of long-term water-soaking. It confirmed that capillarity rise was influenced mainly by the mineralogy of the samples.

4. Discussion and Conclusions

Results of the current research revealed an expected relationship between content of free mica particles and capillary

Fig. 2 Capillarimeter m/50 with digital manometer

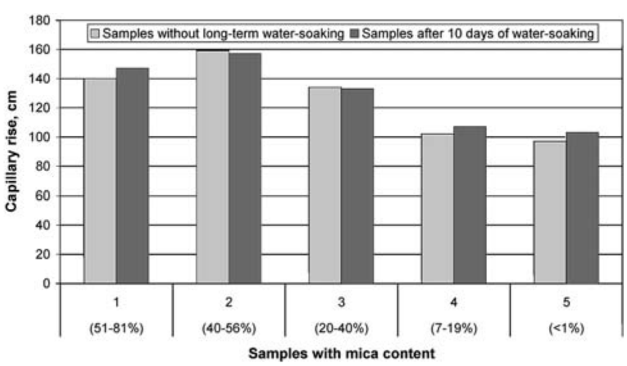

Fig. 3 Results of the capillarity test of base-course aggregates with varying mica content. The mica content decreases successively from sample 1 to sample 5

suction. An increase in free mica content of the aggregates leads to an increase in the ability of the road material to transport water from the surrounding water sources to base layers by capillary action. As a result, an accumulation of water in unbound layers enhances the frost action and, consequently, leads to deterioration of the road construction.

The results highlight the negative influence of mica-rich aggregates and concur with generally similar studies.

The capillarity rise test also confirmed the importance of factors such as compaction degree and grain size of the rock

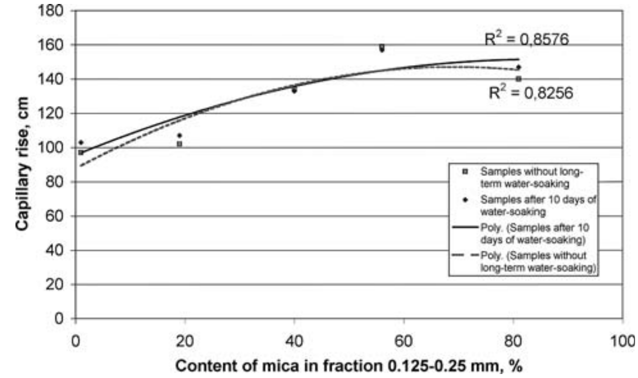

Fig. 4 Relationship between capillary rise and free mica content in the 0.125-0.25 mm fraction. Trendlines are polynomial, third order

material. Gradation, degree of compaction, and grain size should be kept as even as possible for all materials. Small deviations in these parameters can lead to high scatter in capillary rise values.

The aim of the project presented was to establish the influence of mica on the capillarity of the aggregates. However, micas can occur with secondary minerals of large specific surface area (e.g., chlorites and clay minerals) and their possible influence should be studied in the future. Mineralogy of fines appears to be one of the more important parameters in the assessment of critical stability characteristics (e.g., frost susceptibility) of base-course aggregates.

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