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Enrichment of Fine Mica Originating From Rock Aggregate Production and Its Influence on the Mechanical Properties of Bituminous Mixtures

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Analyses of mica-bearing, crushed granitoid rocks revealed a significant enrichment of free mica in the fine fraction. Qualitative tests of bituminous mixtures with an increasing content of free mica in the fine fraction suggested a considerable deterioration of the mechanical properties of the asphalt mass. The negative influence of fine mica on the mechanical properties of the asphalt mixtures was most likely caused by the ability of mica to adsorb bitumen and to create zones of weakness. This phenomenon seemed to be linked to a preferred orientation (foliation) of the mica particles that was connected to the compaction of asphalt masses during the construction of the surface course. The threshold content at which the fine mica negatively influenced the quality of the bituminous mixtures was estimated to be 30-35 vol.%.

Keywords foliation, free mica particles, granites, mechanical tests of asphalt mixtures, quality of bituminous mixtures

1. Introduction

The quality of an asphalt mixture can be influenced only by the properties of the aggregates and by the properties of the bitumen. So far, the influences of the mineral composition of the rock aggregate fine fraction on the mechanical properties of an asphalt mixture have received little attention. According to Ruud,[1] the fine fraction (0-4 mm) of asphalt mixtures significantly influences the wearing strength of the surface course. Mesch and Pettersson[2] studied the influence of free mica on the mechanical properties of bituminous mixtures. Their results indicated a diminishing tensile strength and increasing Tröger abrasion, with an increasing amount of free mica. On the other hand, Eppensteiner et al.[3] did not find any connection between the quality of the bituminous mixtures and the composition of the fine fraction.

The first aim of the current study was to investigate the enrichment of free mica particles in the fine fraction, which originated from granite materials with different contents of mica. The second aim was to evaluate the influence of free mica particles on the mechanical properties of the asphalt mixtures that are generally used for the wearing course.

2. Enrichment of Free Mica in the Fine Fraction: Results From the Production of Rock Aggregates Originating From Mica-Containing Granites

The main task of the first part of the study was to estimate the amount of mica in the fine fraction originating from granites with known mica content. For this purpose, five samples of granitoid rocks were selected with a mica content between 5.6 and 33 vol.%.

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2.1 Experimental Methods

The samples were crushed by a laboratory crusher, and fractions of 2.0-0.25, 0.25-0.074, and <0.074 mm were selected by sieving. The mica content of the original samples and the mica content of selected fractions were estimated using polarizing microscopy and the point-count method for thin sections.

Table 1 Aggregate fractions of the bituminous mixture tested

	Fractions, mm								
Variable	0.075	0.125	0.25	0.5	1	2	4	8	16
Cumulative wt.%	9	11	16	24	33	42	60	80	100

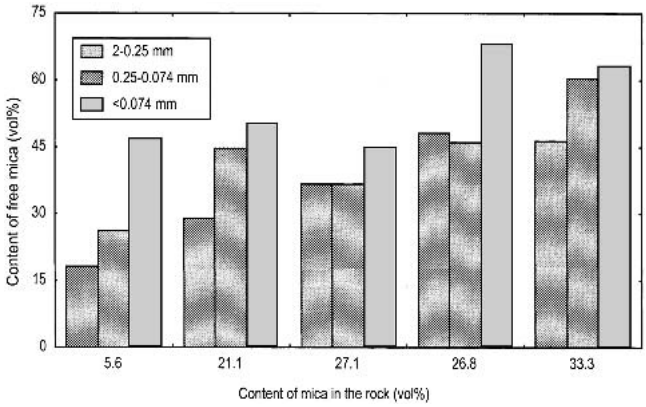

Fig. 1 The content of free mica in fine fractions originating from granites

2.2 Results

The investigation revealed the following results:

1) In fractions between 2 and 0.25 mm, mica particles occurred partly as particles bound to rock fragments and partly as free particles. In fractions <0.25 mm, only free mica particles were recognized.
2) The content of free mica increased with a decreasing particle size in the finest fraction that originated from mica-bearing rocks. The results are presented in Fig. 1 and sug-

Table 2 Variation of bulk density, void ratio, Marshall stability, Marshall flow value, tensile strength, and fracture extension in relation to variations of the fine mica content

Mica content, wt.%	Bulk density, g/cm^3	Void ratio, vol.%	Marshall stability, kN	Marshall flow value, mm	Tensile strength, kPa	Fracture extension, mm
0	2.370	0.6	10.1	3.2	2400	2.6
2.5	2.325	1.5	7.4	3.2	1850	2.9
5.0	2.127	10.1	2.0	4.6	900	5.4
7.5	2.058	13.2	1.4	6.2	625	5.6

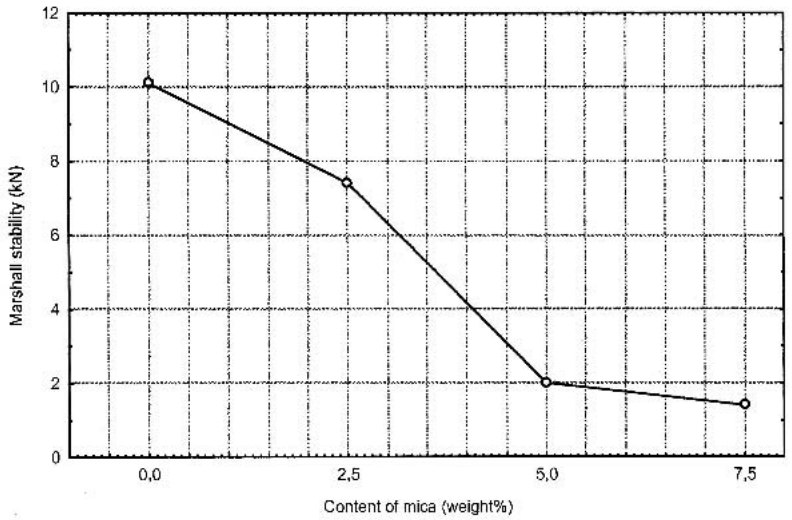

Fig. 2 Relationship between an increasing content of mica and Marshall stability

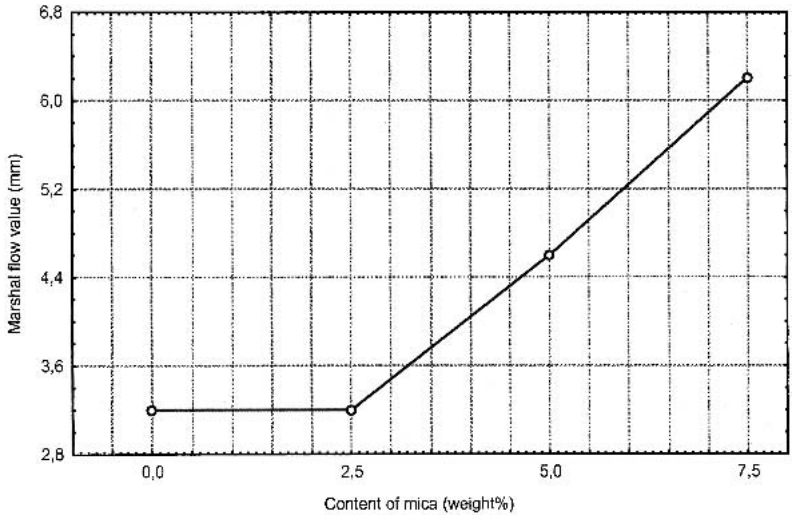

Fig. 3 Relationship between an increasing content of mica and Marshall flow value

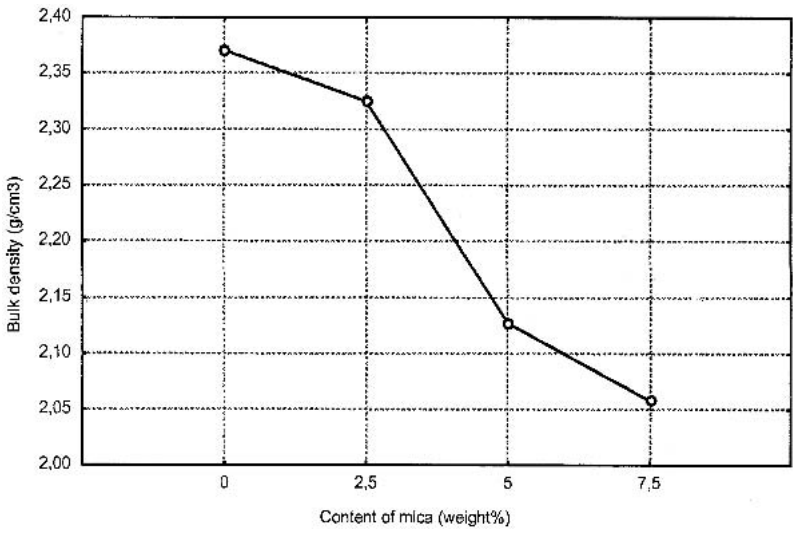

Fig. 4 Relationship between an increasing content of mica and bulk density

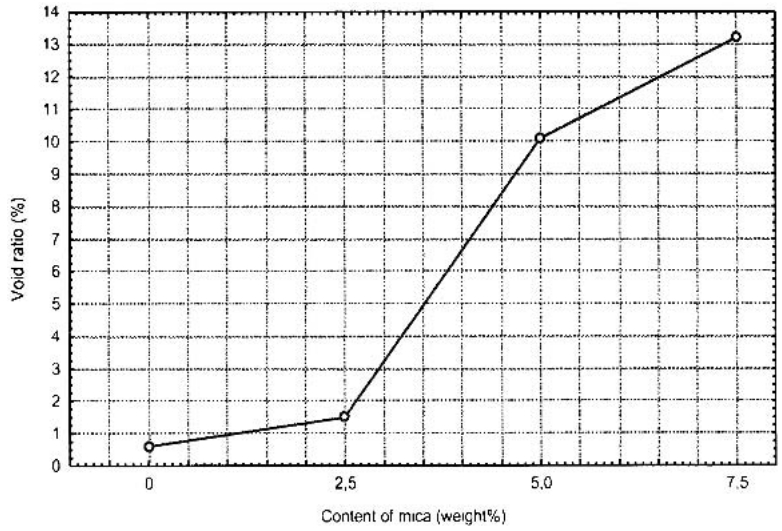

Fig. 5 Relationship between an increasing content of mica and the void ratio

gest that the mica enrichment in the size fractions of 2-0.25 mm corresponded to between 8 and 21.2 vol.%, while in fractions of 0.25-0.074 and <0.074 mm, the content of mica increased to between 9.5 and 34.6 vol.% and 17.8 and 41.4 vol.%, respectively.

3. Content of Mica in Aggregate Fine Fractions and Its Influence on the Mechanical Properties of Bituminous Mixtures

The influence of the mineralogical composition of the fines on the mechanical properties of bituminous mixtures is relatively unknown. Mesch and Pettersson[2] found that a small addition of mica to fines produced from granites caused a qualitative deterioration of the asphalt pavement. The aim of the second part of the study was to evaluate the influence of the fine mica content on the physical properties of an asphalt mixture.

3.1 Experimental Methods

For this study, quartzite was chosen as the test material due to a lack of mica. Crushed rock material consisting of pure quartzite was collected and sorted. The content of aggregates in the asphalt mixture that was tested is presented in Table 1. Fine-grained mica (muscovite) was added to fractions of 0-4 mm, proportionally, so that the form of the curve representing the size distribution would not be changed. The amount of mica added corresponded to 2.5, 5.0, and 7.5 wt.%.

Laboratory samples with a mica content of 0, 2.5, 5.0, and 7.5 wt.% were prepared according to the Marshall method.[4]

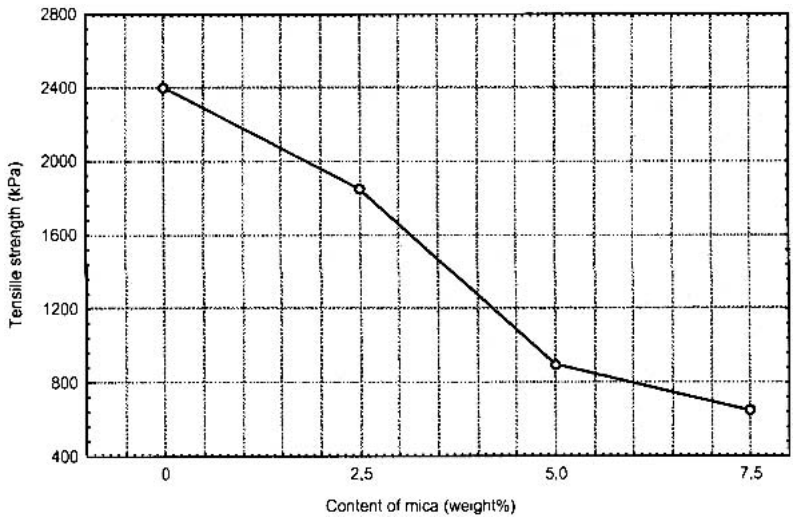

Fig. 6 Relationship between an increasing content of mica and tensile strength

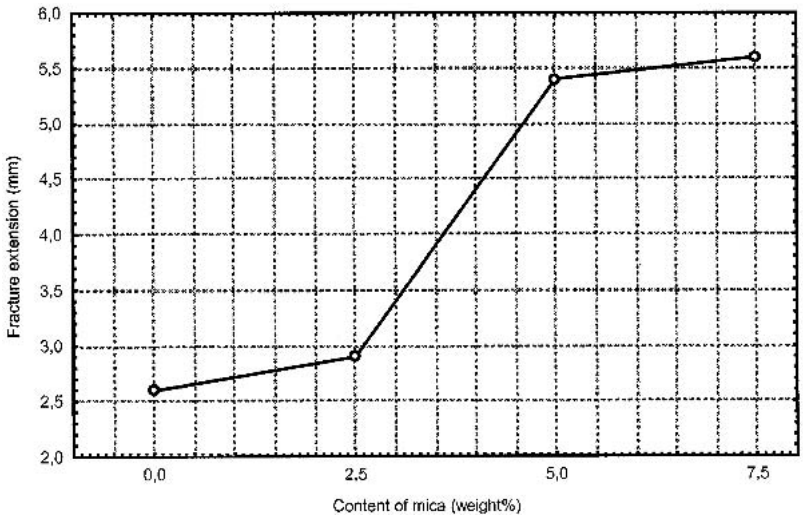

Fig. 7 Relation between an increasing content of mica and fracture extension

The binder content was estimated to be 6.3-6.4 wt.%. The samples were examined with respect to Marshall stability, Marshall flow value, bulk density, void ratio, tensile strength, and fracture extension. The orientation of the mica particles in the bituminous mixture was studied in thin sections using a polarizing microscope.

3.2 Results

The results of this investigation are presented in Table 2 and Fig. 2-7. The results of the tests performed revealed significant alterations of the mechanical properties of the asphalt mixture corresponding to the increasing content of mica. The values for Marshall stability, bulk density, and tensile strength decreased, while the values for void ratio, flow value, and fracture extension increased. All of these factors stressed the negative influence of free mica on the quality of bituminous mixtures. Microscopic studies of the thin sections that originated from asphalt samples revealed a pronounced preferred orientation of the mica particles around the coarse aggregates (Fig. 8).

4. Discussion and Practical Applications of the Results

The results of this study point out the following aspects:

- The crushing of rocks containing mica causes a significant enrichment of mica in the fine fraction. This phenomenon is partly dependent on the original particle size of the mica in the host rock, and partly dependent on the ability of the mica to form small particles during the crushing. This in turn seems to be related to the physical properties of mica, such as hardness and cleavage.

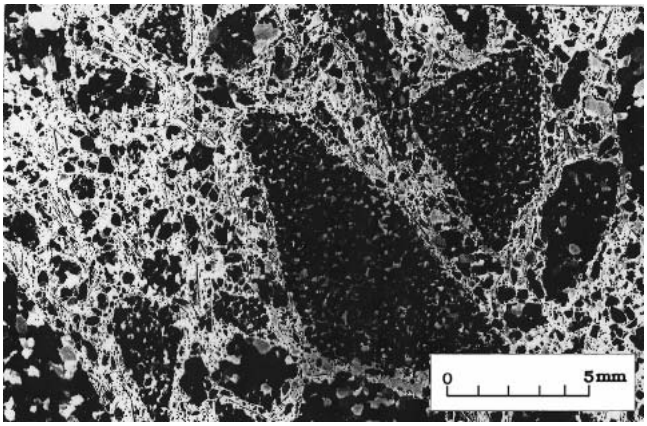

Fig. 8 Thin section showing the preferred orientation of the mica particles (black lines)

- The negative effects of a high content of mica in fines may occur especially when the "cubification" method of crushing is used, probably because this method pulverizes the soft parts of the rock.
- To avoid the problems connected with the enrichment of mica in fines, the mica-rich fraction may be changed to a mica-poor fraction. Such a change in fines may be appropriate in bituminous mixtures,[5] and in road bases in regions with a temperate climate.[6] The reason for the change is related to the ability of mica to adsorb and keep liquid such as bitumen and water.
- The current study stressed the importance of free micas due to their influence on the quality of bituminous mixtures. Even small additions (i.e., 2.5, 5.0, and 7.5 wt.%) of mica to fines caused significant deterioration of the quality of the asphalt mixture. The critical point for the mica content in fines appeared to be 2.5 wt.% (Fig. 2-7). This amount corresponds to 30-35 vol.% of free mica particles when estimated by the point-count method.
- The microscopic studies of mica-containing asphalt mixtures indicated that the deterioration of the quality of asphalt pavements also might be related to a preferred orientation of mica particles (foliation) around the coarse aggregate fragments. It is most likely that this phenomenon has its origin in the compaction of asphalt mixtures that is connected to the production of the bounded surface course.

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