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CHARACTERISATION OF WEATHERING GRADES IN GRANITE USING STANDARD TESTS ON AGGREGATES[1]

by

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(1 table)

RESUME.- Les essais standards de mesure de qualité des granulats utilisés dans les bétons et en technique routière sont en accord avec les indices micropétrographiques pour séparer les granulats de granite sains et altérés provenant d'une même source dans le Sud-Ouest de l'Angleterre.

ABSTRACT.- Standard tests for the soundness of aggregates for use in concrete and as roadstone agree with micropetrographic indices in discriminating between sound and unsound granite aggregate from a single source in South-west England.

INTRODUCTION

A suite of weathered granites from Hingston Down in East Cornwall, England has been characterised by selected classification and engineering tests and micropetrographic indices (IRFAN & DEARMAN, 1978 a,b; 1979). The geological setting has been described (DEARMAN, BAYNES & IRFAN, 1976) as have the problems associated with the determination of a practical weathering grade zonal scheme in the context of large-scale quarrying for concrete and roadstone aggregates.

Offcuts left over from the preparation of test cylinders and the coarse fragments by point load testing were crushed in a Fritsch Pulverisette laboratory jaw crusher to provide the 1/2 in. - 3/8 in. (125-95 mm) fraction needed to carry out selected standard tests on aggregate (British Standard 812, 1973, American Society for Testing and Materials, 1967).

TEST METHODS

Only brief descriptions of the tests are given here; for full details the appropriate standards should be consulted.

Aggregate impact test

The sample is water-saturated and blotted to remove surface water just before the test. The number of blows is limited to a number which will yield between 5 and 20 percent fines; the modified aggregate impact value (AIV_{mod}) is obtained by multiplying the percentage fines by 15 and dividing the product by the number of blows.

The modified test has the advantage of discriminating between different weak aggregates which would pack too tightly in the cylinder under standard test conditions (HOSKING & TUBEY, 1969).

Magnesium sulphate soundness test

The ASTM test procedure (C88-69) is used. Approximately 330 gm of aggregate was immersed in saturated magnesium sulphate solution for 18 hrs, and then dried at 105°C for 6 hrs. The percentage loss in weight after 5 cycles, recorded as weight passing 5/16 in. (ASTM) sieve is recorded as the soundness value. Two specimens per sample were tested and the average value determined.

Flakiness index

This is the percentage by weight of particles in an aggregate in which the least dimension (thickness) is less than three-fifths of their mean dimension.

Elongation index

In an aggregate this is the percentage by weight of particles whose greatest dimension (length) is greater than $1^4/5$ times their mean dimension.

Aggregate abrasion value

A sample comprising about 35 1/2 - 3/8 in. chippings is abraded by 25-36 grade silica sand on a standard grinding lap. The aggregate abrasion value is the percentage loss in weight of the sample.

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CHARACTERISTICS OF THE WEATHERING GRADES

Testing has been confined to samples of the rock material available from different mass weathering grades. Grade I and II, with subdivisions IIi-iv, are conventionally characterised with the grade II boundaries based on staining of joint surfaces, IIi; less than 50 o/o penetration of discoloration, IIii; more than 50 but less than 100 o/o discoloration, IIiii; complete discoloration, IIiv. Conversion to grades III and IV is accompanied by a marked weakening of the material in the rock cores, the grades being characterised by soil development inwards from discontinuities with 50 o/o soil marking the grade III-IV boundary. Although test cylinders could be cored with extreme care from some grade V material, it was too friable to yield aggregate for testing.

Micropetrographical characterisation

Quantitative measurements using thin rock slices (MERWE, 1968) were used to determine the micropetrographical index I_p, which is the ratio of volumes of sound to unsound constituents in the rock. Unsound constituents include all alteration products, voids and open or infilled microcracks. The total microcrack intensity, I_{ft}, is the number of microcracks counted on linear traverses across the slice expressed as No/10mm. Both indices may be regarded as a quantitative weathering index.

DISCUSSION AND CONCLUSIONS

Results of the standard tests, together with values of micropetrographical indices, are given in Table 1. For all strength tests, the first major increase in the test values takes place at the transition from partially to completely stained granite present in mass weathering grades IIiii and IIiv respectively. An even more striking change occurs with the transition from completely stained to weakened granite in mass weathering grades IIiv and III.

In practice, the rock grades quarried for aggregate production include mass weathering grades I and IIii-iii; all other types are either removed as waste or overburden or are left unquarried (DEARMAN, BAYNES & IRFAN, 1976). With the exception of a rather arbitrarily chosen limit for bulk density (HIGGINBOTTOM, 1976), acceptance values for other standard tests including the aggregate impact test (Table 1) are higher (indicating lower quality) than the practical quarrying cut-off grade.

Shape indices

Two major factors influencing the aggregate shape in crushed rock aggregates are the petrographical character of the rock and the type of crusher and reduction ratio (RAMSAY, 1965). The shape and surface texture of the aggregates are influenced by the petrography of the rock material including mineral composition, grain size, degree of interlocking of mineral grains and also microfractures and alteration in the rock. Crushing method can often exert more influence on the shape than the petrography and alteration state of the rock material. Fine-grained rocks tend to produce a high proportion of flaky and elongate fragments. The aggregate impact value, used as a standard method of assessing many road aggregates, is a function of the flakiness and elongation indices; when the indices increase the aggregate impact value also increases (DHIR, RAMSAY & BALFOUR, 1971). Shape indices are also important to the durability and strength of concrete and also to the skidding resistance value when the aggregates are used in a flexible road construction.

Elongation values obtained for fine-grained Hingston Down granite are very much lower than the values obtained by RAMSAY (1956) for granites. This is due to the fine-grained nature of the granite studied. There is a decrease in I_E value with increased weathering and this is particularly apparent in the grade IIiv material (Table 1). Flakiness index values are lower in the least weathered granite, but the increase is not regular. This is probably the result of factors other than the petrography and alteration state of the granite, and is most probably influenced by crusher type and reduction ratio.

Low grade aggregates

The usefulness of the modified aggregate impact value in discriminating unsatisfactory aggregates is shown by the great increase in AIV_{mod} from 16 to 49, whereas the standard aggregate impact value AIV only increases from 14 to 24 with transition from mass weathering grade IIiv to III. The magnesium sulphate soundness test picks out the same transition even more strongly.

Aggregate derived from Grade III weakened granite would generally be considered as low-grade. HOSKING & TUBEY (1969) have reviewed the use of low-grade aggregates in road making and conclude that, for unsurfaced roads, for bases on more lightly trafficked roads and for sub-bases, the test limit for the modified aggregate impact value should be a maximum of 40. The problem of unsound aggragates relates to the problem of apparently sound aggregates which rapidly decompose

Table 1.- The results of impact and weatherability tests on aggregates from different weathering stages characterised in terms of petrographical indices.

	Mass weathering grade	Aggregate impact value AIV %	Aggregate impact value modified AIV_{mod} %	Aggregate abrasion value AAV %	Flakiness index I_F	Elongation index I_E	Magnesium sulphate soundness value %	Micropetro-graphical index I_p	Total microcrack intensity I_{FT} No/10mm
FRESH GRANITE	I	6	7	3.5	11	20	0.05	15	3
PARTIALLY STAINED GRANITE	IIi-iii	8	10	4.7	7	20	0.08	6-9	9-11
COMPLETELY STAINED GRANITE	IIiv	14	16	8.0	18	14	0.23	4-6	23-27
WEAKENED GRANITE	III-IV	24	49	17.1	14	13	33.4	3.5-4	25-33
GRANITIC SOIL	V	nd	nd	nd	nd	nd	nd	nd	nd

nd: not determinable

in use. This lack of discrimination by mechanical testing has led to the development of weathering simulation tests such as the sodium sulphate and magnesium sulphate soundness tests. Discussion of the sodium sulphate test (ibid. p. 10) emphasizes the poor reproducibility and the length of time taken for the test; at Newcastle the magnesium sulphate test has been adopted as a standard because it crystallises as only one hydrate and hence has potentially better reproducibility. The test is carried out according to the ASTM conditions.

Petrographical indices

The micropetrographical index and total microcrack intensity clearly discriminate between the various weathering grades and may be used to determine relative quality indices. Of the two petrographical tests, the total microcrack intensity determination most clearly discriminates between partially stained granite, grade IIiii, and completely stained granite, grade IIiv, and may be recommended for diagnostic purposes.

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