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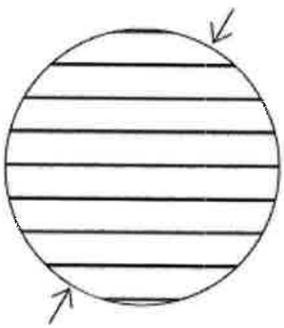

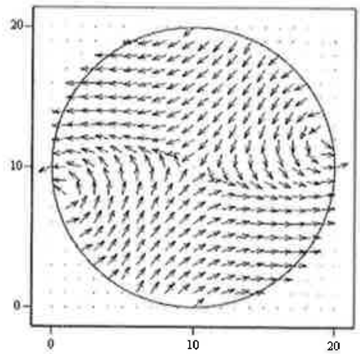

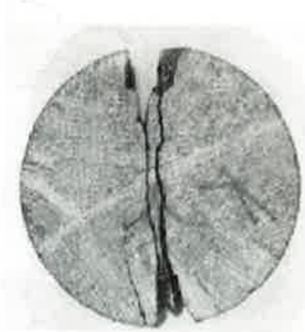

Mechanics of Rock Fragmentation

Static and Dynamic Laboratory Testing Applied to Aggregate Production

BAHMAN BOHLOLI

Department of Geology
CHALMERS UNIVERSITY OF TECHNOLOGY
Göteborg, Sweden, 2001

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5 Conclusions

- Laboratory testing of rock specimens with the Brazilian test showed that there is a relationship between the strength of rock and the amount of fines generated. For a specific type of rock, the higher the tensile strength, the higher was the quantity of generated fines. Accordingly, the amount of fines would be smaller, if we could reduce the strength of rock at the time of failure (or during crushing processes for full-scale). This hypothesis was examined by testing water saturated specimens in laboratory. The reduction of fines for gneiss was about 30 %, and for diabase (dolerite) and diorite, about 20 %.

- Since the Brazilian test results are usually analyzed inappropriately for anisotropic rocks, an analytical solution was obtained for calculating the tensile strength of such rocks. The stress field due to the normal point loads at the periphery was obtained at the disc plane and, more exactly, at the center of the disc. The calculation of the stress and tensile strength of the anisotropic rock sample requires that the principal elastic constants E, E', ν, ν' and G' be known. The assessment of the analytical solution showed that the dimensionless stress field depends on only two intrinsic material parameters (E'/E and b, beside the angle, θ_b, between the direction of the applied force and normal to the plane of transverse isotropy). An approximate formula for the tensile stress at the center of the disc was suggested: it is very close to the exact solution.

- Gneiss specimens were subjected to the Brazilian test, after which they were assessed with the analytical solution, the proposed formula, and the solution for isotropic material. The tensile strength from the analytical solution was nearly the same as for the formula, however it was 10–20 % lower than the values from the isotropic solution. Hence, significant errors in analyzing the Brazilian test results for anisotropic rocks can be avoided by using a solution for anisotropic material.

- The samples of gneiss, cored in a direction normal to the plane of foliation, were tested in diverse directions with the Brazilian and ultrasonic methods to detect possible anisotropy of the plane of foliation. This plane was found to be anisotropic. The ultrasonic measurements indicated the anisotropy coefficient to be some 3 %, while the results from the indirect tensile test gave an anisotropy coefficient of 15 %. Although the anisotroipy coefficient is so small that it may be negligible in practice, it has nevertheless been shown to exist.

- Dynamic laboratory testing of gneiss and diabase with a conventional Hopkinson pressure bar showed that the dynamic tensile strength was about double the static tensile strength from the Brazilian test. The method provides not only tensile but also shear failure in the vicinity of the loading points. Therefore, the instrument was modified to include the pure tensile conditions. The modified apparatus had a strain rate of about 10–15 (s^{-1}). The dynamic uniaxial tensile strength of granite, gneiss and granodiorite was approximately the same as that from the Brazilian test. The modified Hopkinson bar has four advantages over the conventional Hopkinson bar: (i) the failure occurs only in tension, (ii) the failure occurs in the weakest plane, (iii) the test specimen volume is greater, and (iv) the test results are less scattered.

Future work

The current work could be continued with laboratory and full-scale tests. In the laboratory, a systematic study of various types of rock using tests such as the Swedish Impact Value, *Sprödhetstal,* or the Brazilian test can be carried out to improve understanding of the relationship between strength related fines and mineralogy related fines. Full-scale studies on various types of rocks in dry and saturated conditions should be done with one-stage crushing machines. Furthermore, the relationship between the post failure load and the generation of fines.

The analytical solution of the tensile stress at the disc plane could be improved further and equations devised for the stress field in whole disc plane. The model can be verified with more experimental work, for example: (1) to compare the tensile strength of rocks from the analytical solution with the isotropic solution to determine the range of error that arises using the isotropic solution, and (2) to measure the strain field of rock discs and compare it with that of the model.

The modified Hopkinson pressure bar could be adjusted to test larger rock cores. Another possible improvement would be to increase the range of the velocity of the impact bar to enable the study of dynamic rock behavior at higher strain rates.