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Sabrex 3 - Developments underground

J.Paul Tidman, ICI Explosifs Canada

SABREX 3 - DEVELOPMENTS UNDERGROUND

by

Dr. J. Paul Tidman
Principal Scientist

ICI Explosive Group Technical Centre
McMasterville, Quebec J3G 1T9

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ABSTRACT

The SABREX 3 computer blast model has the flexibility to permit evaluation of complex underground blasting geometries. Examples of open stope mining and development rounds are described.

INTRODUCTION

The use of computer blast models has increased steadily since their initial development in the 1970's. The aim has been to increase the efficiency of mineral extraction by improving blast results or by reducing direct blasting costs. This was achieved by the application of a steady stream of new explosive products. The ICI Explosives Group collected their blast modelling experience into one unified program, called SABREX (1). The SABREX program has since been used around the world for blast prediction and examples of the work have been reported in many publications.

Much of the work preceding SABREX was done for open pit metal mines and so there was an emphasis on the geometry of bench blasting and bulk explosives. In fact it was only possible to apply SABREX to limited underground mining methods, those which had regularly-spaced, parallel holes.

The introduction of SABREX and its ability to successfully predict blast results lead to a demand for more features. The result has been SABREX 3, ICI's newest computer blasting model. In this presentation, the input data and program features which are particularly appropriate to underground blasting practice are described.

The result of a blast is the interaction of three regimes which one must either control or characterize. They are the rock, the charge and the blast geometry.

ROCK

From the blasting scientist's point of view, the rock is the most difficult phase of the blast model to define. The rock's mechanical properties determine how much explosive energy is transferred into the rock. The mechanical properties required for SABREX are the stiffness, termed Young's modulus. Values are derived from measurements of the sound velocity in rock samples.

The manner in which the rock reacts to the explosive energy determines in part the blast results. To date, the strengths in compression and tension have been used in SABREX to characterize this property. In addition, the overall rock quality, derived from a description of the joint structure which is a natural part of the rock mass, is used to link the blasting energy to blast results.

There are many more mechanical properties of rock which can be measured and related in some way to blast results. We are engaged in research to identify and include the most significant ones in future SABREX developments.

EXPLOSIVES

The explosive data required for SABREX calculations must be pre-calculated by detonation computer programs and saved in the SABREX database. The performance evaluation of explosive products has been improved with the introduction of ICI's ideal detonation code IDeX and continual improvement of ICI's non-ideal detonation code CPeX.

BLAST GEOMETRY

It is the positioning of holes, their location and the firing times that constitute the blast geometry.

The most significant changes made to SABREX have been the expansion of blast geometries to cover many more mining situations. As mentioned above, most of the proven experience of SABREX had been in open pit metal mines where there was a large array of holes in a regular pattern. The blast geometry previously allowed in SABREX was a set of holes having the same burden, spacing and charge for each and every row of holes.

As part of the improvements to SABREX 3, the effects of different hole burdens, spacings, angles and charge lengths have been included. This has lead us to consider the effects of 1) diverging holes, 2) discontinuous or decked charges and 3) variation of blast results over the depth of a blast. The added flexibility of blast geometry in SABREX 3 enables us to model two important underground blast geometries, open stoping and development rounds.

OPEN STOPING

Open stoping as modelled in SABREX 3 treats a set of holes drilled down from the same drill drift in a series of rings (figure 1). There is an open slot and an undercut associated with the stope (figure 2). The blast design features allow each hole in the ring to be individually angled and charged. Currently the charge in each hole can consist of two different explosives and an inert deck.

The blast predictions from an open stope blast include the fragmentation, damage and heave. These results are found using the same algorithms as the open pit option in SABREX. The fragmentation for the overall stope as well as in the top, middle and bottom thirds of the stope are calculated (figure 3).

While the open stope holes are described by their dip below the horizontal and appear as downholes, for the fragmentation and damage predictions they could represent any set of holes in a full ring blast. With a little care, the fragmentation around a full ring can be evaluated and the poorest sectors identified and improved.

DEVELOPMENT ROUNDS

The development or tunnel round is one of the most complicated geometries in the blasting catalogue (figure 4). The cut holes rely on the reflected shock from the nearby relief holes in a burn cut. However the cut's success ultimately depends on it's ability to clear the cut. This is a 3-dimensional heave problem and beyond SABREX's current capabilities.

In a wedge cut, the fan holes may be considered as a bench blast with each hole defining a new face for the next. The fragmentation from such a blast can be predicted with SABREX but the total volume of rock in the cut compared with the total blast volume is small.

Beyond the cut, the development blast may be viewed as a set of four bench blasts, one for each side of the tunnel. A cross-section from the cut to any wall (figure 5) suggests a blast design in which burden, spacing and charge vary from row to row. This can be described within the open pit geometry of SABREX 3. With this perspective, the effect of production and wall-control hole charges on damage and fragmentation can be readily evaluated (figure 6).

CONCLUSION

The SABREX 3 computer blast model uses fundamental principals to describe the blasting process. These calculations can be applied to underground as well as surface mining geometries.

There are two caveats to any modelling exercise using SABREX or any other blast model. The first is that the products used in the blast (explosives and accessories) fire in the normal and expected manner. A blast optimized by computer cannot account for a misfire. The second caveat is that the blast design is set by the blasting engineer, not the computer. The SABREX program is a tool to be used by engineers to quickly evaluate their ideas and options.

ACKNOWLEDGEMENTS

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SABREX and subsequent feedback have directed the program's improvements.

REFERENCES

1. Kirby, I.J., Harries, G.H. and Tidman, J.P.; ICI's Computer Blasting Model SABREX - Basic Principals and Capabilities, Proceedings of the 13th Conference on Explosives and Blasting Technique, Society of Explosives Engineers, Feb. 1987.

Figure 1. Open Stope Side View

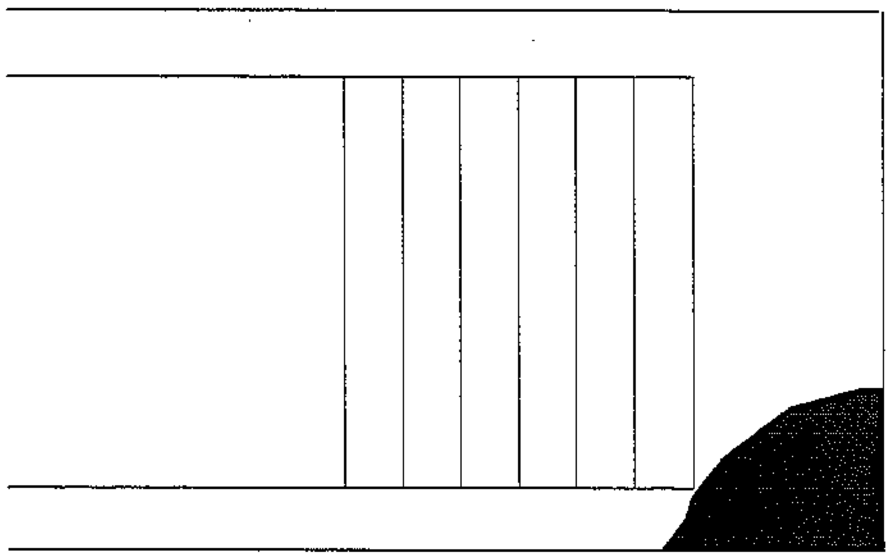
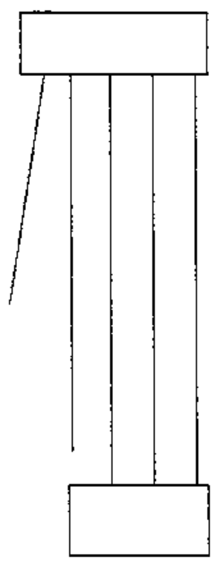
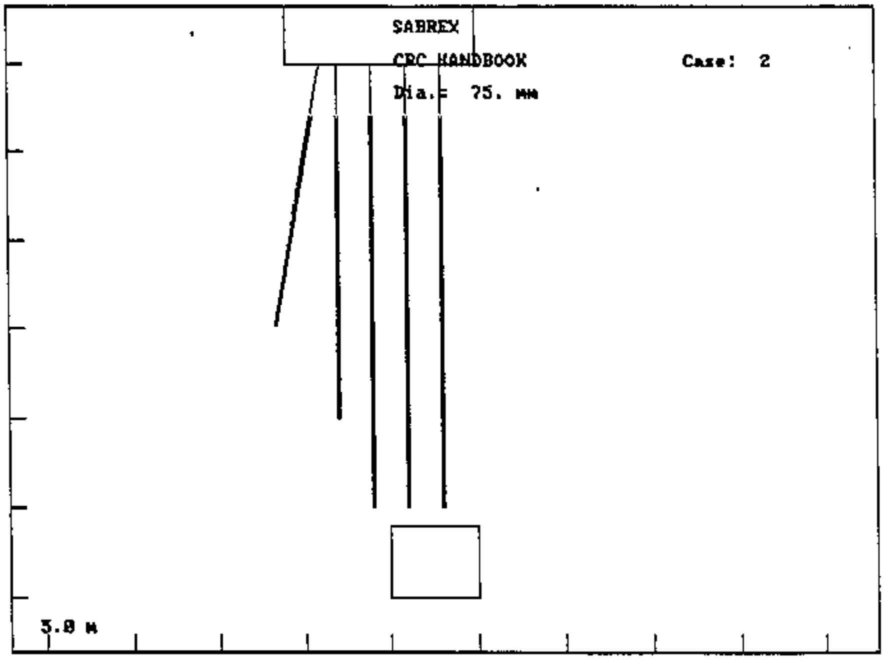
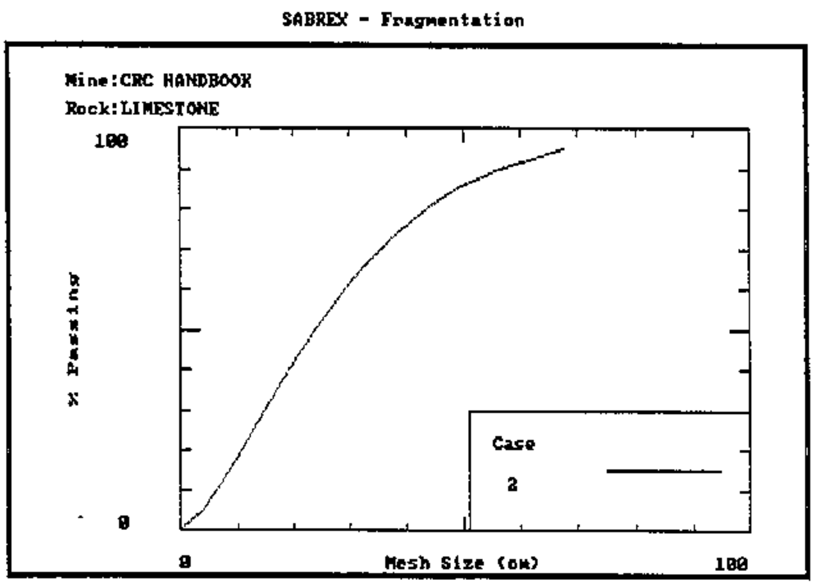


Figure 2. Open Stope End View







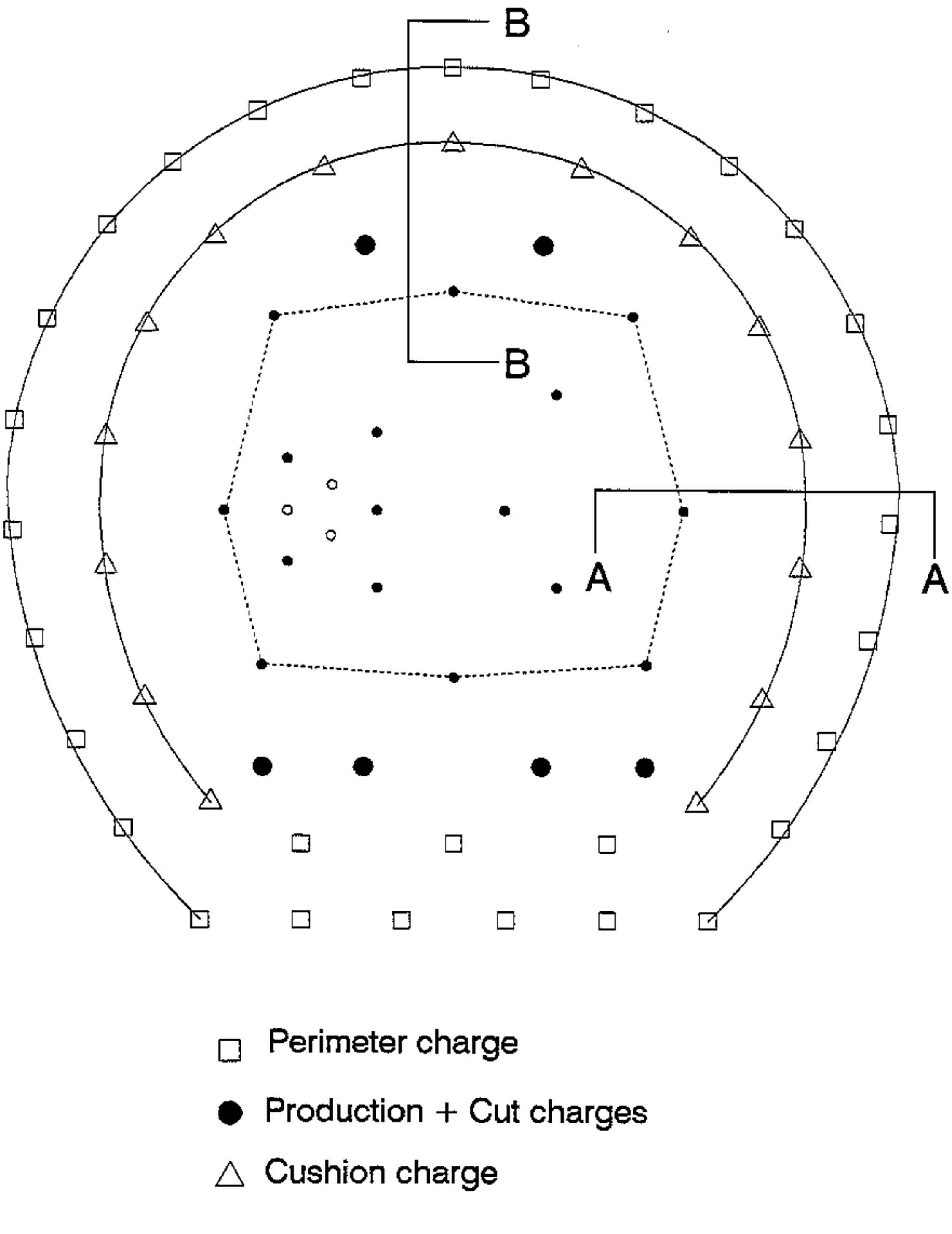
Case: 2

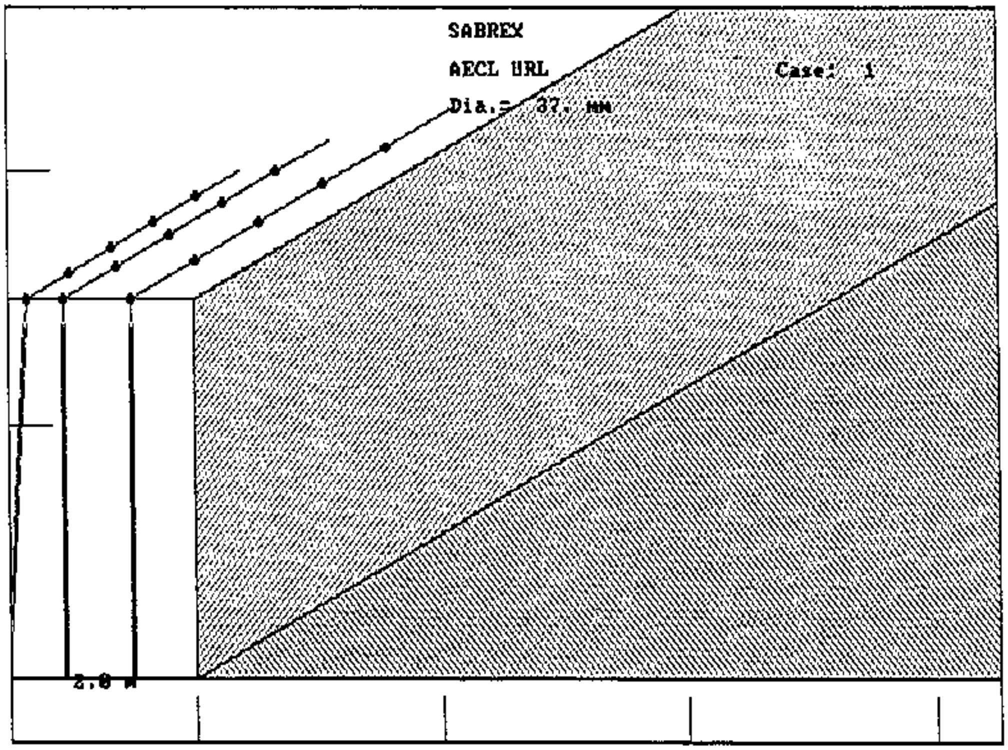
Bottom of Stope Frag.	<BSF>:	100.
Mid-stope Frag.	<MSF>:	100.
Top of Stope	<TSF>:	100.
Overall Fragmentation	<OF>:	100.
Heave Factor	<HEF>:	100.

90 % passing	56. cm.
80 % passing	44. cm.
70 % passing	36. cm.
60 % passing	29. cm.
50 % passing	24. cm.
40 % passing	19. cm.
30 % passing	15. cm.
20 % passing	11. cm.
10 % passing	6. cm.

Figure 3: Design and fragmentation of an open stope blast by SABREX 3

Figure 4. Development round, 3.3 m by 3.5 m.





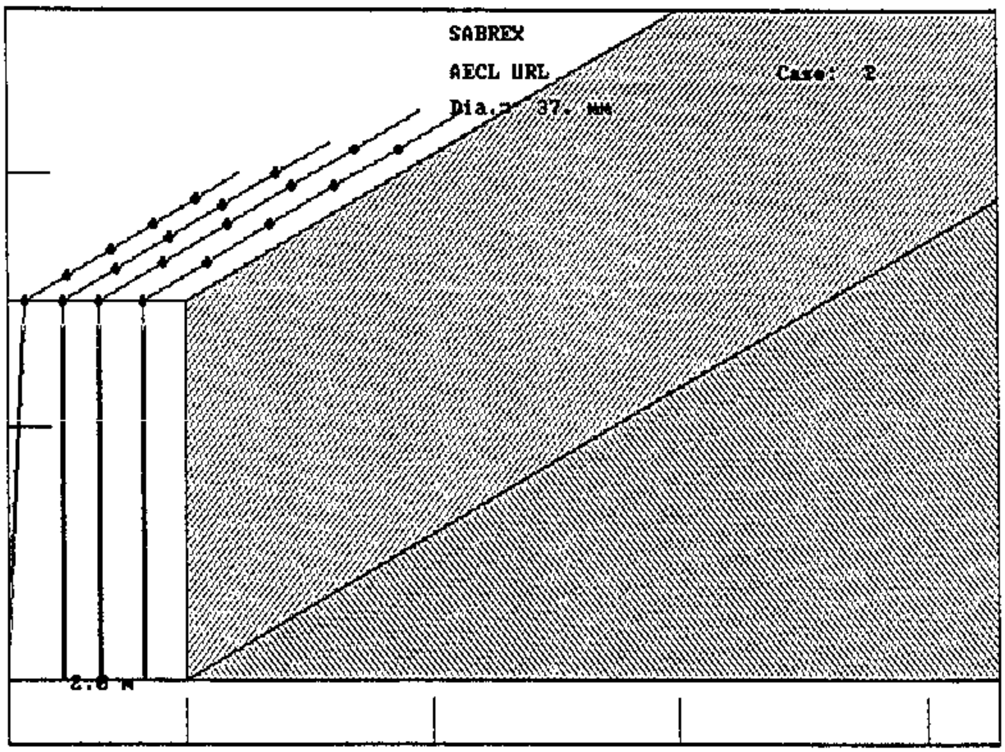


Figure 5: Cross-sections A-A and B-B of Figure 4.

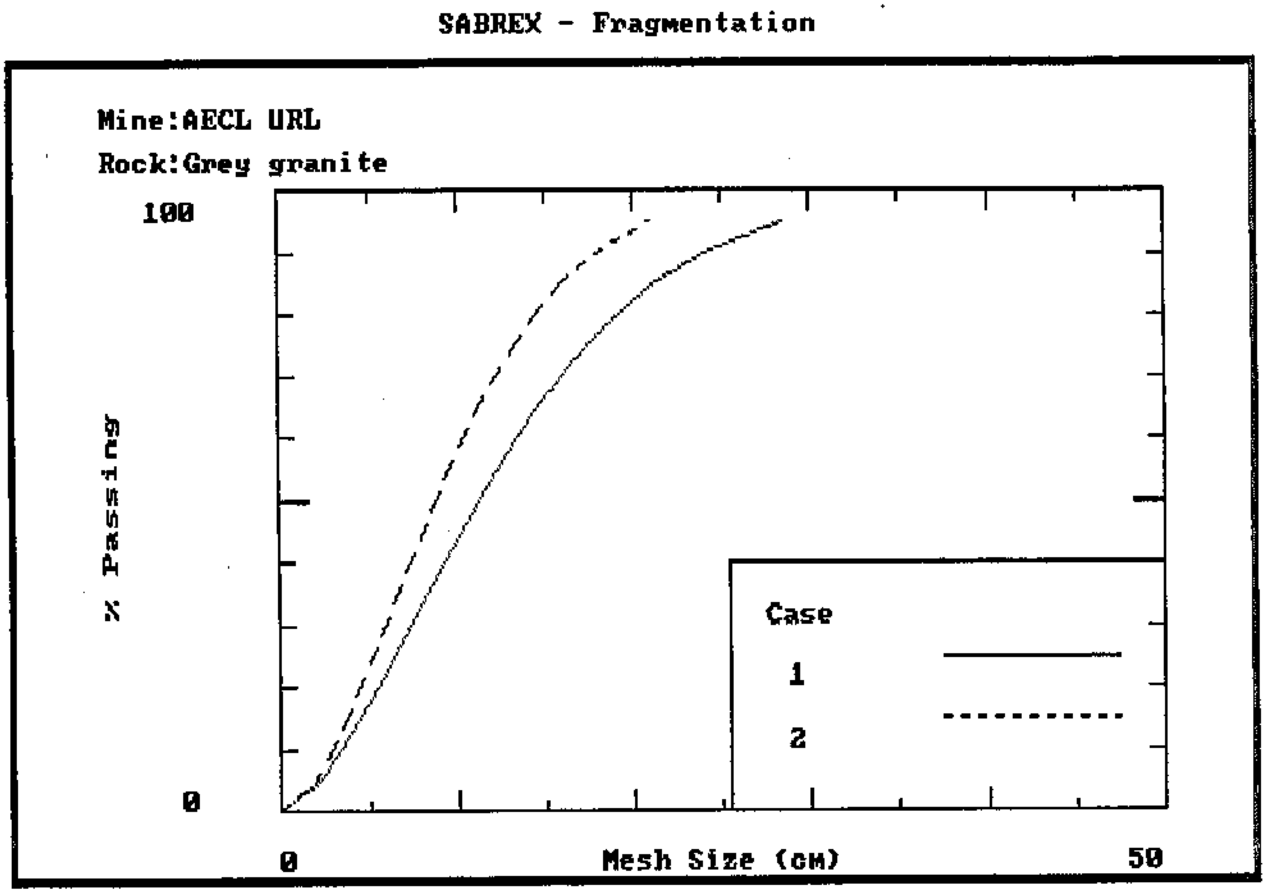


Figure 6: A comparison of fragmentation at top and side of blast in Figure 4.