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# An evaluation of yielding timber props as a support system in rockburst conditions*

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## Written contribution by J.F. Curtis†

The paper is an interesting exercise in the application of mathematics to a theoretical situation presumed to occur underground. However, some of the assumptions on which the calculations are based are unlikely to occur in any actual mining situation.

*Assumptions made in the paper*

Objections to these assumptions are noted *seriatim.*

(1) 'it is assumed that any loading-rate effect will be small and can be ignored' (p. 3).
A loading rate of the order of 50 kN—12 per cent of the maximum load—is customary to prevent the props being dislodged by the blast.

(2) 'it is unlikely that all the props will be installed with their full stroke available, but for the purpose of this analysis, it is assumed that this is the case' (p. 3).
A more reasonable assumption would be that, with the most careful selection of prop length and the most rigid control of stope width, the available stroke length would on average be reduced by the order of 70 mm on installation—20 per cent of full stroke.

(3) 'each support unit supports a block of 3,3 $m^2$ bounded by vertical fractures with zero cohesion that are parallel and at right-angles to the stope face respectively' (p. 5).
Joughin and Jager[1] have shown this to be an unwarranted assumption in respect of the positioning, the direction, and the dip of the fractures present in a stope in rockburst conditions. If, as assumed, there was 'zero cohesion' between such blocks, the removal of a hydraulic prop in row 3 supporting such a block would ensure that it fell out before a profile prop could be installed in the same position.

(4) 'the height of each of these blocks is 3,0 m, the volume of each block is 9,9 $m^3$, the mass of each block is 27 225 kg' (p. 5).
The concept of individual props being affected by discrete blocks of known and uniform dimensions of relatively low ground velocities (less than or equal to 2,16 m/s) acting in line with the axis of the prop is one that lends itself to neat mathematical calculations. It does not, however, bear much similarity to the actual conditions that are exposed underground in excavations where rockbursts occur.
Ortlepp and co-workers[2] concluded that 'the impulse of the shockwave can cause the displacement of the rock surface to reach very high velocities (in excess of 30 m/s) even though the total movement is only a few millimetres'.
Hodgson *et al.*[3], in respect of one such event, noted that 'from an examination of the damaged props it was deduced that the rate of closure in the area must have been greater than 6 m/s.'

*Conclusions of the paper*

The conclusions of the Roberts paper are unremarkable. (a) and (b) could have, and presumably were, based on observations in a laboratory. Conclusion (c), which recommends that 'direct evidence of the failure of these support systems after rockbursts should be sought in the field' is a worthy one. Regrettably, the author did not avail himself of the wealth of such evidence already available in the many papers on the subject that have been published during the past 60 years. Most of these papers, as might be expected, have appeared in *Papers and Discussions: Association of Mine Managers of South Africa;* others in the *Journal* of this Institute; a comprehensive survey[4] of such papers was published in 1981, with discussion continuing until 1984.

*References*


1. JOUGHIN, N.C., and JAGER, A.J. Fracture of rock at stope faces in South African gold mines. *Rockbursts, prediction and control.* London, Institution of Mining and Metallurgy, 1983. pp. 53–66.
2. ORTLEPP, W.D., MORE O'FERRAL, R.C., and WILSON, J.W. Support methods in tunnels. *Pap. Discuss. Assoc. Mine Mgrs S. Afr.,* 1972–1973. pp. 167–98.
3. HODGSON, K., *et al.* Rapid-yielding hydraulic props as stope support in deep gold mines. *Pap. Discuss. Assoc. Mine Mgrs S. Afr.,* 1972–1973. pp. 279–334.
4. CURTIS, J.F. Rockburst phenomena in the gold mines of the Witwatersrand: A review. *Trans. Instn Min. Metall. (Sect A. Min. Indus.),* vol. 90. 1981. pp. A163–A213.


## Author's reply

Mr Curtis's main objections to my paper are with respect to certain assumptions made in the paper and these are answered below. The numbering refers to that in Mr Curtis's contribution.

*Assumptions made in the paper*

(1) The term *loading rate* appears not to have been understood by Mr Curtis. The loading-rate effect is the way that the deformation rate (for example the stope-closure rate) changes the force–deformation curve of

* This paper was published in the January issue of this *Journal* (vol. 91, no. 1. Jan. 1991. pp. 1–7).

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a support unit. It is particularly noticeable in timber that the force increases 7 per cent for every tenfold increase in the deformation rate. To illustrate this point, the force–deformation curves for two different loading rates are shown in Fig. 2 of the paper. For steel or hydraulic props, this effect is insignificant.

(2) If the analysis outlined in the paper had been undertaken with the full stroke reduced by 20 per cent, the amount of energy that the props could absorb would have been reduced by 20 per cent, but the calculations would still have illustrated the main point of the analysis, namely that *the props have a decreasing ability to absorb energy as stope closure acts on them.* It would also have shown that the support system will fail closer to the stope face.

(3), (4)
It is acknowledged that the specific geometry of the blocks that were assumed to make up the hangingwall does not accurately simulate the well-known underground fracture patterns. However, the object of the analysis was to illustrate the trend that, with higher stope-closure rates, these stope-support systems become increasingly vulnerable to lower ground velocities. A different geometry could have been chosen, and it would have shown the same result. What Hodgson *et al.*[1] observed was just such an example, where the props were damaged because they were not able to absorb the energy associated with the ground velocity or rate of stope closure. In this regard, it is very unlikely that any support system, except perhaps backfill, would be able to control stope closure during ground velocities of 6 m/s, the velocity estimated by Hodgson to have acted on the hydraulic props installed in the stope that he was monitoring. Moreover, it should be pointed out that work sponsored by the mining industry and done by the Rock Engineering Division[2] has shown that 80 per cent of rockbursts are accompanied by closure rates of less than 3 m/s. The rapid-yield props currently in use in mines are normally able to respond to ground movements of only up to 2 m/s. Thus, the rock-engineering staff are at present working with manufacturers and the industry on the development of an improved rapid-yield hydraulic prop with the capability of closing at 3 m/s.

*Conclusions of the paper*

I believe that the conclusions of the paper are significant: the fact that normal stope closure is constantly decreasing the ability of the support system to do work if a rockburst occurs is surely of significance. This must lead to a careful consideration of the choice of support system in rockburst-prone stopes, and to the redesign of support units such as yielding timber props so that they have a larger yield range and, consequently, an increased ability to absorb energy. I would also encourage rock-engineering personnel to seek direct evidence of the failure of these support systems in the way described in the paper on their particular mines.

This paper was originally conceived as the result of underground observations over a considerable number of years in stopes supported by yielding timber props. It became obvious that, at high rates of stope closure, yielding-timber-prop support systems, such as profile props, would have a reduced ability to absorb rockburst energy compared with a similar situation in which the stope closure rates were lower. These ideas were certainly not formulated in the laboratory.

The paper used data obtained from underground measurements at various sites throughout the industry. The closure rates quoted, for example, were given a realistic upper limit. Similarly, the force–deformation behaviour of yielding timber props was determined underground for typical stope-closure rates.

The only laboratory-determined force–deformation curve was that determined for the force–deformation behaviour of profile props at a deformation rate of 1 m/s, and this was essentially a check on the force–deformation curves obtained underground and adjusted for the higher deformation rate of 1 m/s.

*References*

1. Hodgson, K., *et al.* Rapid-yielding hydraulic props as stope supports in deep gold mines. *Pap. Discuss. Assoc. Mine Mgrs S. Afr.*, 1972–1973. pp. 279–334.
2. Jager, A.J. Chamber of Mines Research Organization, personal communication.

# Book news

The following are available from Metal Bulletin Books Ltd, Park House, Park Terrace, Worcester Park, Surrey KT4 7HY, England.

- *World aluminium—a Metal Bulletin databook.* 2nd ed. 1990. £71.50 surface, £76.50 airmail.

This is a compendium of information listing salient details of companies mining bauxite and producing alumina, primary aluminium, secondary ingot, master alloys, and semi-fabricated products; aluminium trading companies; and a memoranda section listing associations, brand names, and other useful information. It is a user-friendly international reference book for aluminium buyers, traders, and producers.

- *Iron and steel works of the world.* 10th ed. 1991. £134.00 surface, £146.00 airmail.

For almost fifty years, thousands of companies have relied upon this directory as a databank on the world's iron and steel producers, re-rollers, tube makers, iron-powder producers, strip coaters, and makers of cold-rolled sections.

# Corrigendum

The following error in the *Journal* has been notified: in the issue of May 1991 (p. 158), Mr Paul McKelvey received a Cullinan Design Award on behalf of New Concept Mining, and not New Consort Mining as printed.