Extract from MDG 1005 Manual on Pillar Extraction in Underground Coal

Roof weight loading is re-distributed during the extraction of coal. The loading onto ribs increases as the active goaf area approaches as described in Figure 12 and Figure 13 extract 1.2.4 (Impact of Mining Excavations).

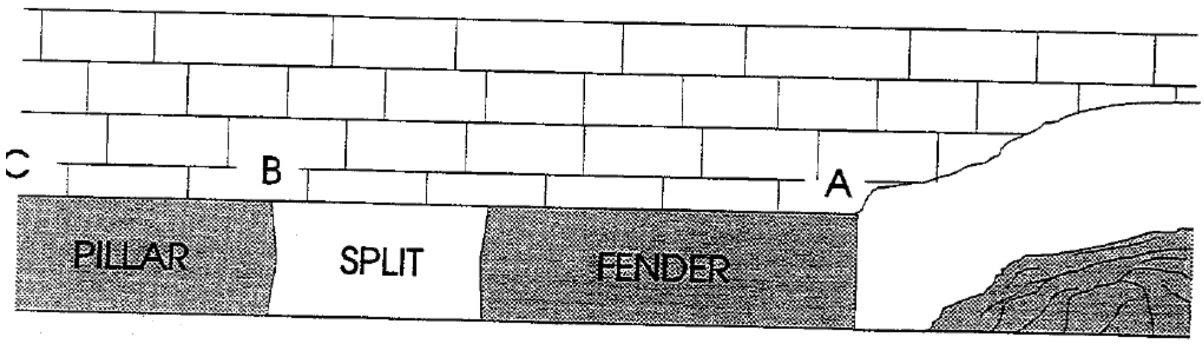

Figure 7.1a

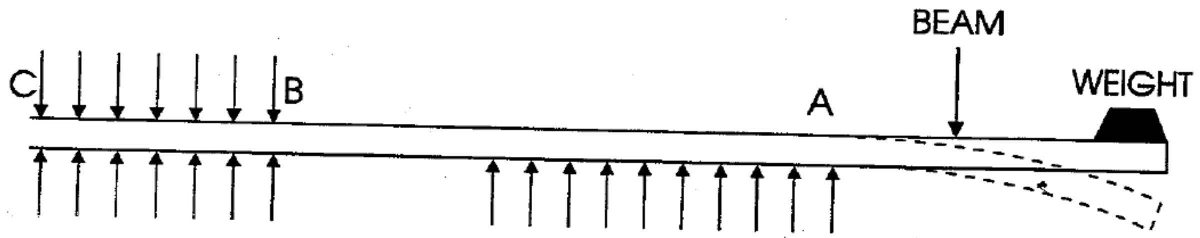

Figure 12 Extract from MDG 1005 Figure 7.1a Beam loading in active goaf area

1.2.4 IMPACT OF MINING EXCAVATIONS

Prior to mining, a rock mass is in a state of equilibrium; that is, stresses are equal and opposite (or balanced), in all directions.

The effect of any excavation whether it be a notch in the surface (a foundation trench, or open-cut mine strip), or an underground excavation, is to remove material which was providing balancing stresses around the boundary of that excavation.

Therefore, upon mining, the balancing stresses are removed causing the boundary to move inwards. The movement of that boundary continues in a form dictated by the stiffness of the surrounding material, until such time as a new state of stress equilibrium has been reached. Refer to Figure 1.7. This ground movement generates changes in the direction and magnitude of the pre-mining stresses in all the surrounding rock mass. As a result of these induced stresses, the material will either be capable of sustaining the increased stress level and hence deform accordingly, then reach a new equilibrium, or it will fail, if strained beyond its capacity.

Figure 13 Extract 1.2.4 Impact of Mining Excavations MDG 1005

The right hand side pocket appears to have been initially cut in the wrong location and it would appear that Mr Jones corrected the pocket location by widening the area of the pocket cut out. Section 1.2.8 of MDG 1005 describes the effect of excavation width.

1.2.8 <u>EFFECT OF EXCAVATION WIDTH</u>

Excavation shape plays a major part in determining the distribution of stresses around an excavation. A mine roadway, and an extraction panel are both essentially rectangular excavations, with width being the only major, and dominant variable.

In general, the wider an excavation is, the greater the level of mining induced tension that exists in the roof (and floor) strata, normal to the excavation boundary. Refer to Figure 1.11. These induced tensile stresses reduce pre-mining compressive stresses, giving rise to large zones of rock at very low confining stress which exhibit low compressive strength. This leads to greater propensity for failure to occur, particularly when discontinuities are present.

Increasing width also leads to increasing abutment stresses on adjacent pillars or solid coal on either side of the excavation. It is these regions which have to carry the vertical load which was previously carried by the coal in the excavation. This redistribution of stresses through the overlying strata is the cause of overlying goaf failure, aided by the low confining stresses set up by the roof. Therefore increasing excavation width leads to a propensity to form extensive overburden failure - as is deliberately engineered in a longwall or pillar extraction section, as goaf failure.

Figure 14 Extract 1.2.8 Effect of Excavation Width MDG 1005.

The floor adjacent to the location of the rib spall had been cut by Mr Jones during the process of cutting the first right hand pocket. Pillar width to height ratios are altered with an increase in cutting height–the width to height ratio can increase loading factors on the rib sides. Section 1.2.9 of MDG 1005 provides information on the effect of pillar width and height.

1.2.9 EFFECT OF PILLAR WIDTH AND HEIGHT

The role of pillars in controlling the underground geotechnical environment is often grossly under-estimated. Pillars - whether they be barrier, development/chain, yield pillars or fenders - are the key load bearing elements of an underground coal mine. A later section addresses pillar design as such; this section is intended to simply highlight the importance of the geometric factors of width and height, for any type of pillar.

A pillar of coal should be regarded as a block of material, or column, loaded vertically from either end, with a varying degree of horizontal constraint applied at each end also. The horizontal constraint may vary from zero to the full value of resultant horizontal stress in the adjacent strata. Depending on the interface between roof/floor and the coal pillar, that horizontal constraint will be distributed into the coal pillar also, providing a degree of confinement to the coal in the pillar, as shown on Figure 1.12.

The extent to which the horizontal constraint can confine elements of the coal pillar, and particularly achieve overlapping constraint from roof and floor, is clearly a function of both the width (w) and the height (h) of the pillar.

Similarly, the vertical stress profile across the width of the pillar is such that in the centre of the pillar there is a lower applied vertical stress and higher horizontal confining stress than there is on the pillar edges. This results in a much stronger, confined 'core' of material in the pillar centre, which carries the majority of the load, while the pillar edges are subject to more uniaxial loading and possible failure, but still provide essential constraint to the pillar core. Refer to Figure 1.13a and 1.13b. (It is for this reason that apparently yielding or fractured pillar ribsides should not be continually cleaned away from pillars, as they are fulfilling a vital pillar core constraint role, even when in a broken state).

Therefore the ratio of pillar width (w) to height (h) is a critical one in pillar design.

Width: Height Ratio (w/h) is the main geometrical consideration in determining a pillar's strength, hence stability, not simply width, as is all too often the case. w/h Ratios of 10 or above are generally regarded as indestructible pillars, although coal properties, surrounding strata and the loading environment must always be carefully examined.

It is worth noting that, for a given pillar height, as the width is progressively reduced, it is the pillar core which reduces in width first, while the 'yield' zones on either side of the core remain roughly constant in width. There comes a point when the core becomes too narrow to sustain load, and eventually for narrower pillars, the core disappears altogether and the two yield zones intersect, resulting in a fully yielding pillar.

It is imperative to recognise the role of roof and floor strata stiffness, relative to the coal pillar. If the floor, for instance, is a very low stiffness claystone, then even the best engineered pillar geometry will not prevent the pillar from punching into the floor under any reasonable pillar loading. The pillar coal itself may not fail, but the floor may, and the consequences in terms of control and support of overlying strata could be just as serious as if the coal pillar itself had failed.

Figure 15 Extract of 1.2.9 Effect of Pillar Width and Height MDG 1005

It is noted that two of the Breaker Line Supports at the time of the incident were positioned further back for the right hand pocket. It is likely that when the Breaker Line Support was trammed into position, for the first of two attempts at breaking away into the right hand pocket, Mr Jones subsequently widened the right hand pocket. The two Breaker Line Supports were left in position and not brought closer to the continuous miner. The exposure of the roof area between the two Breaker Line Supports and the continuous miner would have induced further loading onto the rib sides and the immediate area of mining. Figure 7.2a of MDG 1005 (see Figure 16) provides information concerning the area of control of the roof due to the positioning of the two BLSs in relation to the solid coal and the stable fender during pillar extraction.

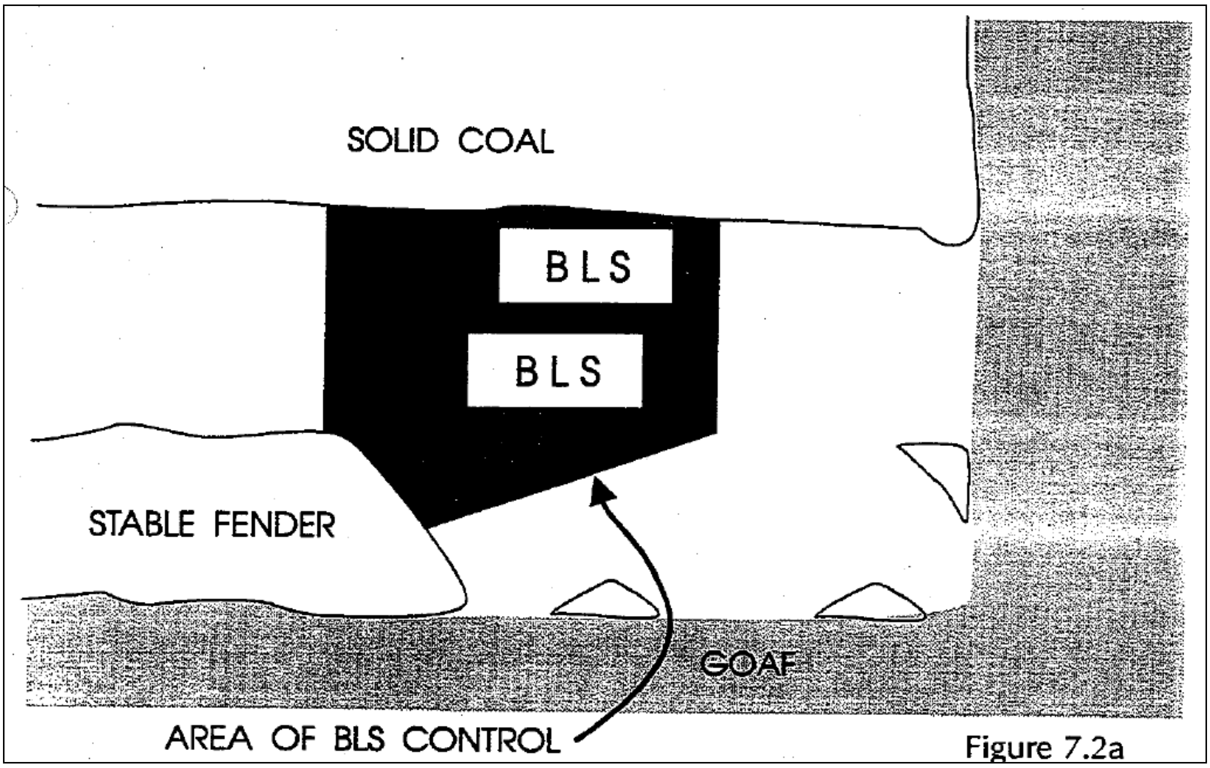

Figure 16 Extract from MDG 1005 Figure 7.2a Area of BLS control for full extraction of the fender

The left hand side pocket was driven in the wrong location as it was approximately 2.5 metres inbye of the design location. It should be noted that post incident rib bolts were observed at 6 cut-through and it can not be determined how far back towards 5 cut-through that the rib bolts extended. It is clear from measurements taken at the incident site that the rib spall that fell was 4.8 metres in length and had not been bolted. It is apparent that if the left hand pocket had been placed in the correct location then the length of unsupported rib that fell would have been considerably reduced by the action of the continuous miner cutting into the rib.