The Challenges of Mining Old, Shallow, Small Coal Pillars

by

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The coal reserves in the mainstay of South African coal production, the Witbank coal field, are nearing depletion. Very few, if any, medium to large mines can still be opened there to replace the defunct ones. The current mines are having to scratch around to find the remaining pockets of coal in order to extend their lives.

The coal that is left, is often that which was not mined in the past due to adverse ground conditions, low quality or low mining heights that prohibited using the equipment that was available. One such source of coal is that which is contained in small pillars in the old mines that were never intended for secondary mining. Several operators now consider mining those reserves and it is proving to be challenging from a rock engineering viewpoint.

View of a pillar that had undergone severe scaling over time. The original pillar edges can still be seen in the marks on the roof. If scaling had not taken place, the person in the background would have been inside the pillar.

Because these pillars tend to be small by virtue of the shallow depth, there are limited options when designing the sequence of cuts and also the sizes of the remnants (snooks) that are to be left in situ. Snooks very often have to be left as protection during the actual process of mining a pillar. They therefore have to be large enough to remain stable while
there are still unmined pillars close to them, but they have to be small enough to fail once mining has progressed to the next line of pillars.

In usual practice, where pillars are designed for secondary mining, the design process starts off with the snook sizes (determined by modeling or by local experience) and then the development pillars are planned such that they accommodate the snooks. In the case of the old pillars, they are what they are and the secondary mining sequence has to be designed around that.

Example of a roof bolt in an old part of a mine. Although it is still there, it is clearly not functional.

At shallow depth, the snook sizes are much more critical than at greater depth. In order to fail, they have to be much smaller and then small deviations in size can have serious consequences with regard to stability. If they are just too small, they can fail too soon, exposing operating crews to the possibility of roof collapse. If they are just too large, they could easily be too strong and prevent overburden failure. At greater depth, where snooks are larger, the same deviations in size have less serious consequences as the tolerances are wider.

If the overburden doesn’t fail, it raises the possibility of overload on the remaining pillars, although this is usually not too serious an issue at shallow depth. What is often more serious, is the possibility of a sudden collapse of a large area which can cause substantial damage and injury due to the accompanying wind blast.
What often happens in practice is that the snook sizes are calculated, but underground, larger snooks are left. This is completely understandable, as the safety of operators at the coalface is of prime importance and one is prone to err on the conservative side. Overburden failure then does not occur and to prevent undue load buildup on the pillars yet to be mined, two or sometimes three lines of pillars are not mined but left in situ as stopper lines. The cycle is then repeated.

While this method results in at least some coal being mined, there is a price to be paid in terms of lost reserves, but more importantly, it creates a situation where regional instability can occur if the now highly loaded stopper line pillars were to fail. This has fortunately not happened and no instance of current mining is known where it is expected to happen, but it is a matter that needs to be attended to, diligently and constantly.

Example of an area where the snooks are very small, with almost negligible strength, but where the overburden has not failed, presumably due to the panel being too narrow.

The process of mining the small pillars starts with a risk analysis, during which roof conditions are assessed underground and areas in need of re-support are identified. In fact, most areas need to be re-supported and only in isolated cases areas where no re-support is required, are identified. Pillar conditions are likewise noted – joint surveys are performed and the new road widths are measured. Over time, pillars scale and in some cases the size reduction of the pillars is significant.

The current pillar sizes are then used to calculate current safety factors. The most important step, however, is modeling the actual lay-outs with the real pillar sizes and then simulating a global secondary mining situation. The loads on the solid pillars are determined to evaluate the likelihood of a pillar run. LaModel is often used for this purpose and has proved to be a very handy tool for this type of evaluation.
The overburden behavior must also be considered, usually in a separate process as LaModel cannot handle a discontinuous overburden and the programs that can, are expensive and require expert operation. Here, the detailed geology is very important as the composition and thickness of the overburden layers are central to the evaluation process. This is where the next restriction comes in: in virgin mining, panel width can be chosen to suit the overburden characteristics, i.e. a panel can be made wide enough to ensure failure for the given geology. In the mining of old pillars, the panel width is a given.

Old boreholes were very often not logged in sufficient detail to determine the critical parameters. One particular case some years ago comes to mind – the log only recognised three lithological units: soil, rock and coal. Even newer boreholes are often lacking in their descriptions. The transition from one unit to another is often not described. For instance, there can be a number of successive sandstone layers with discriminating descriptors like pinkish gray, grayish pink, etc, but the all important mode of transition (grading into.... or sharp contact, whatever it may be) was simply not noted. Should the layers be treated as a single thick one or as several thinner ones?

If all the lights are still green at this stage, pillars are modeled at large scale to determine the exact cutting sequence of a pillar and the very important snook sizes. This is a time consuming process, as the properties of the snooks of varying sizes have to be recalculated and built into the model for each variation until a satisfactory set of sizes are found. Modeling usually entails using a linear elastic constitutive model for large pillars like inter panel barriers, that are known from experience not to fail. A strain softening model is then used for the snooks, and as the post failure modulus is a function of the pillar width-to-height ratio, care has to be taken to make the necessary adjustment each time a new snook size is modeled.

Then come the practical considerations like the positions where the machine operators are likely to be for the chosen mining sequence. The miner, for instance, has to have a clear escape route in the event of something unexpected happening and he has to be able to see where the continuous miner is cutting. He also has to have a clear view of the mined out area and be under supported roof all the time.

If any red lights appear at any point in this sequence, the design process starts over or the project is abandoned. Everything must be in harmony, from the sizes of the snooks to the width of the cutting drum on the continuous miner and the position where the miner and cable handlers will be and where they will move.

When all of this has been done, the safety procedures drawn up, standard practices developed, crews trained, etc, comes reality. This is where one finds that the snooks are larger than intended (they are seldom smaller), the overburden does not fail, etc. Then the situation has to be remodeled and reconsidered. If necessary, some aspects can be slightly adapted, like changing the angle of attack of a continuous miner into a pillar to give the miner a clearer view. Sometimes more drastic action is required, like increasing the number of stopper lines or decreasing the distance between stopper lines. In some cases, projects simply have to be abandoned.

Of crucial importance, however, is the close link the rock engineer has to forge with his production colleagues on mines where the small pillars are mined. He has to be underground often, he has to respond immediately and he has to think on his feet. If a problem arises, it
has to be solved and the solution implemented immediately. The one thing a secondary mining operation cannot tolerate, no matter what the depth or other circumstances, is a stop-start advance rate. Everything has to be as consistent and gentle as possible – the ground needs to be seduced, not raped.

A small pillar in the process of being mined. There is very little room for error due to the small size of the pillar, the snook can easily be too large or too small.