Subsidence Comparison

Comparison of finite element model subsidence and reported subsidence over a mine is indicative of model credibility when the computation is based on first principles. However, the usual procedure is through model "calibration" that is done by forcing a match between model output and mine measurements. This procedure is usually one of adjusting input data, mainly strata properties, using "scale factors" to reduce moduli and strengths. Justification is generally based on an argument that points out the presence of joints and so on that are absent in laboratory-size test cylinders. Consequently, field-scale properties should be reduced or "scaled". The argument for model validity based on calibration is obviously circular, but may be useful in certain cases. In this study, the effects of joints on rock properties are computed in a technically sound manner by embedding joints sets into the model mesh and then computing equivalent rock properties that result. No scale factors are required; only properties of joints and intact rock between joints are needed. Joint orientation and spacing are taken into account during the process. In this way, results are based on first principles.

Figure 7 shows computed and reported surface subsidence data in the form of south to north profiles through the center of the mined barrier pillars and through Panels 7-12 to the north and Panels 13-18 to the south of the main entries. Comparisons of reported 2002 and 2003 results, located close to the computed profile, with computed results (P13/18) show the computed maximum subsidence to be close to the reported maximum of the surface subsidence associated with mining Panels 13-18 to the south of the main entries (Fig.5 shows the location of Panel 13; Panels 14-18 are farther south). The reported trough shape is much narrower at the surface than the computed trough shape and perhaps indicates a need for a more complex "caving" model. However, trough shape is not critical to seam level stress, displacement and so on.

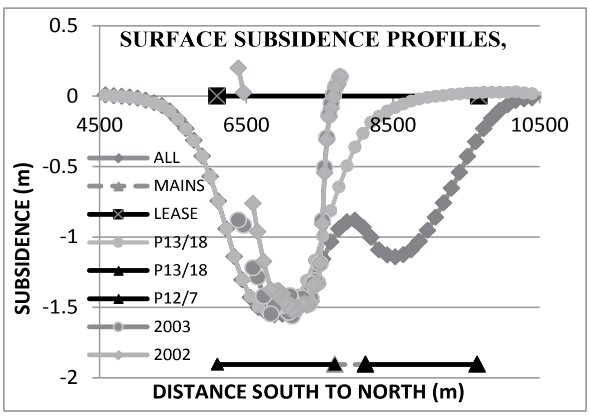

Figure 7. Subsidence profiles. ALL=all mined,=P13/18 mined, 2002, 2003=reported P13-18.

Figure 8 shows surface subsidence in color contour format over the whole mine mesh from the beginning of mining. Evidently maximum subsidence occurs over Panels 13-18 in the lower left of the colored contoured area. This maximum is over 70 percent of mining thickness with a subsidence factor somewhat greater than 0.7.

Yield Zone Evolution

Element yielding occurs at the limit to a purely elastic deformation that is characterized by an element safety factor of one or less in numerical analysis. An element safety factor is simply a ratio of strength to stress. Plots of element safety factor distributions indicate extent of yield zones and inform engineering judgment about safety and stability of a proposed mining plan. Such plots thus summarize much of voluminous computer output in a practical way.

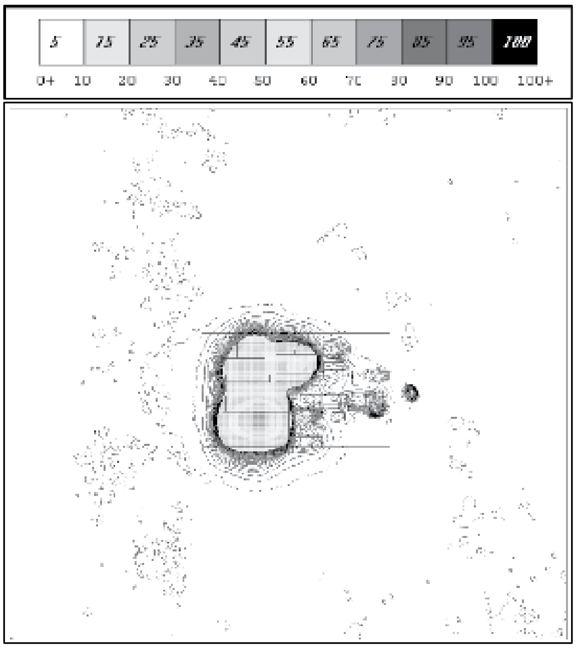

Figure 8. Subsidence over the whole mine model. Color contours are in percent of mining thickness (2.4 m, 8 ft). Edge length is about 16.8 km (55,000 ft). Rectangles are mined panels. The large rectangle approximates the mining lease.

Figure 9 shows in various views element safety factor distributions in the "big" mesh after historical mining followed by barrier pillar mining in 2007. This mesh contains over 13 million elements and nodes. Grey elements are excavated and thus are "air". These results indicate the main entries and pillars are in a "hot" zone of red elements where the safety factor is 1.6, although a core of yellow elements is present where the safety factor is 2.7 as seen in the color scale at the top of the figure. The black box in Figure 9(d) outlines the "small" mesh (Figure 7). The "small" mesh contains about 10 million elements and