Engineering

UPDATE©

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ESTABLISHING MINE SUBSIDENCE RISK

The assessment of the risk of mine subsidence related damage above underground coal mines is the most critical and driving factor for land development. Only about 50% of the undermined sites investigated for mine subsidence by MEA were found to have significant risk. Half of these required only partial mine grouting to reduce them to low risk. The risk of land development above coal mining is established by:

1. The integrity of the mine structure against failure;
2. The nature and magnitude of the subsidence; based on past events; and
3. The tolerance of the proposed structure(s) to the estimated subsidence movements.

Therefore, the investigation and evaluation of the mine's integrity becomes a controlling factor in establishing the risk.

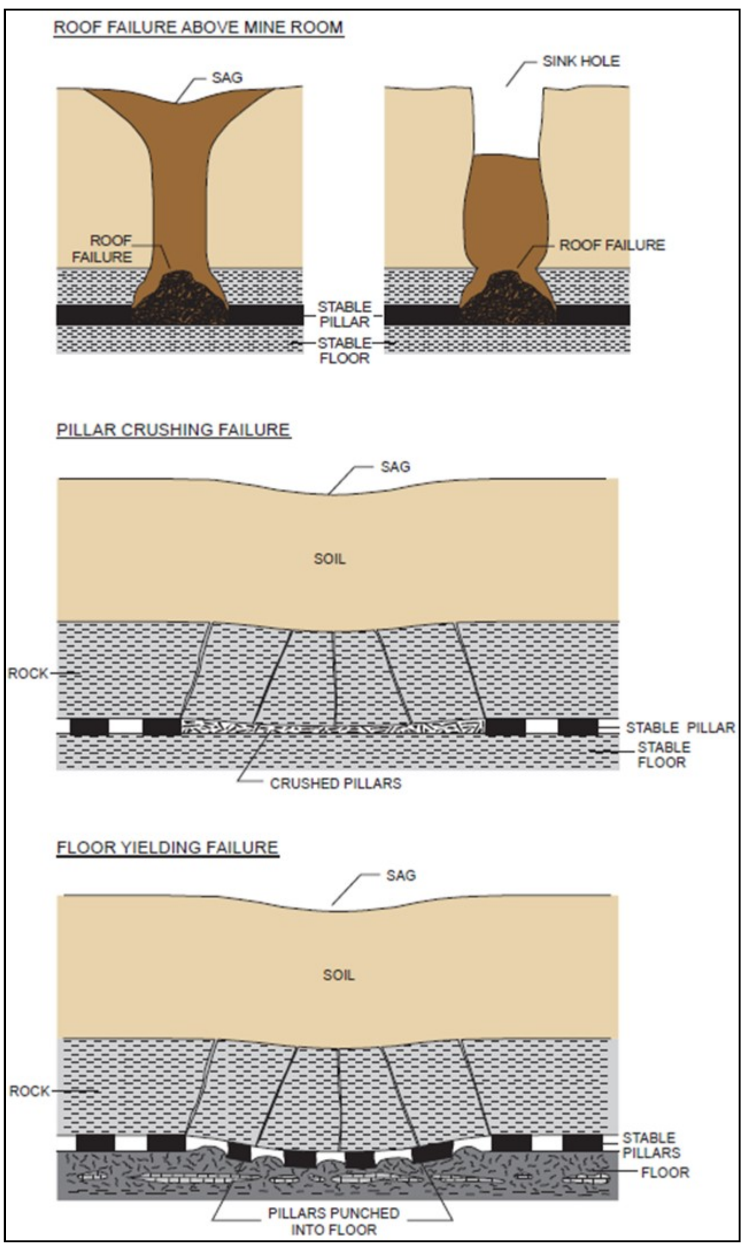

FIGURE 1 PRIMARY MODES OF MINE FAILURE

The evaluation of the integrity of the mine structure must consider the various ways underground old works can collapse resulting in surface subsidence. Although there are exceptions, a mine stability investigation should consider that:

1. The rock roof above the mine can fail;
2. The coal pillars can crush over time; or
3. The coal pillars can sink into the floor over time.

An illustration of these types of mine failures is shown in Figure 1.

The greater the experience and knowledge of the investigative engineer, the more accurate and certain he is of his assessment of the mine's integrity. In other words, it is easy and safe for the investigative engineer who is less confident, and who has less knowledge, training, and experience, to conclude that significant risk exists and that the mine should be stabilized.

From the numerous investigations and engineering analyses of old mine works that MEA has performed, we have found that the risk of mine subsidence can range from very low to high. This is because the geologic and mining conditions vary from site to site. MEA has found a number of such project sites that have very low to low risk of mine failure and subsidence when the support coal was determined to be adequate from a stability standpoint, given the surrounding geologic conditions or where the mine was found to be already collapsed. Obviously higher risks are present where analyses indicate the rock geology is too weak to support the mine over time.

For large project sites, the integrity of the mine structure can vary across the site. Examples of MEA investigated project sites where there was a significant variation in the mine stability have involved the presence of added coal support over a portion of the project, or where the roof or floor geology had changed from weak to resistant.

This latter point is illustrated in Figure 2. Therefore, MEA found that on some undermined sites it was only necessary to stabilize the portion of the mine workings which had been determined to have unacceptable risk instead of the common practice of grouting the entire mine workings under a proposed structure. This realized significant savings to the owner on stabilization costs.

Where possible, a cost-effective option can be to design the proposed structure(s) for the potential subsidence movements. The assessment of whether less expensive surface mitigation as compared to mine stabilization can be done involves the consideration and integration of a number of areas of engineering from mining to geotechnical to structural to architectural. This becomes evident when realizing the important factors that must be assessed:

- Mine stability and nature of existing mine conditions;
- Specific nature of the subsidence ground movement and the foundation loading;
- Structural response of the foundation;
- Structural and architectural response of the structure(s); as well as
- Ground and structural mitigation.

The greater the integration and understanding of these factors combined with ingenuity, the more efficient and the least conservative the design rendered. For example, where the potential subsidence was determined to be limited, no mine grouting was deemed necessary and MEA assisted in the subsidence-resistant design of the foundation and superstructure.

At the request of the owner, MEA has reviewed subsidence engineering investigations by other engineers which have resulted in different outcomes. For example, the engineer's findings determined that the mine roof had insufficient capacity and thus assigned the site an upper medium risk. MEA found the mine roof presented little risk of subsidence. Another example involved the understanding of the mine maps, which can play a critical role in establishing the risk. In multiple seam mining, understanding the mine maps can be complex. MEA found that the maps were incorrectly assigned to the wrong coal seams by the geotechnical engineer.

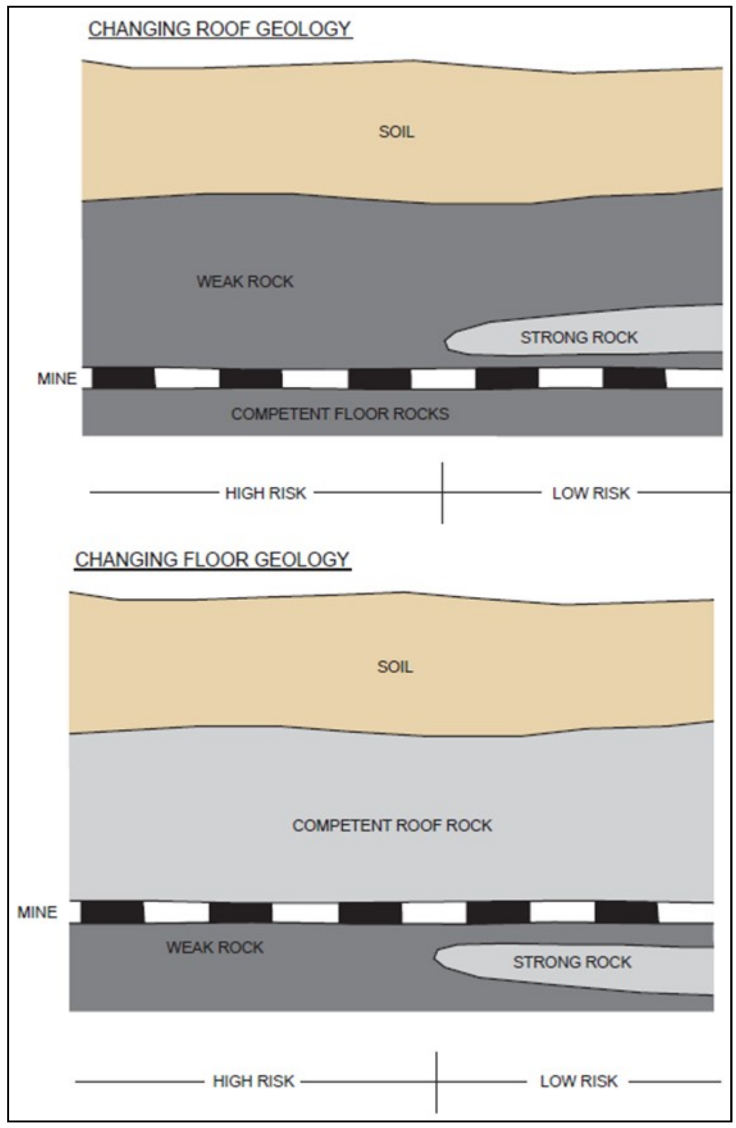

FIGURE 2 ACTUAL EXAMPLES OF VARYING SURFACE SUBSIDENCE RISK ACROSS A PROJECT SITE DUE TO CHANGING GEOLOGY

In summary, the assessed level of risk of subsidence damage is the controlling factor in determining what mitigation measures, if any, should be taken. This in turn determines the development costs. The accuracy of the risk assessment, however, depends on the investigative engineer selected to determine the risk. The quality and appropriateness of the conclusions drawn by the selected engineer can vary considerably because of the highly specialized nature of the subsidence engineering.

Other Engineering UPDATES of Interest:

UPDATE 1: Successful Deep Mine Backfilling to Mitigate Mine Subsidence

UPDATE 2: Mitigation of Mine Subsidence Risk to a Prison Complex

UPDATE 3: Successful Field Test of Steel Strap Repair

ABOUT MEA: Marino Engineering Associates, Inc. focuses on engineering research, practice and expert evaluations and is licensed in 25 states in the U.S. Our projects primarily have an emphasis on Geotechnical Engineering, however, we also have significant experience in projects involving transportation, subsidence engineering, laboratory testing, training, and geophysical exploration. Gennaro G. Marino, Ph.D., P.E., D.GE is president and principal engineer of Marino Engineering Associates, Inc., and has been a licensed professional engineer since 1984. To obtain additional information on MEA, one can also visit our website at www.meacorporation.com.

FOR MORE INFORMATION: There is a significant amount of additional information that is available on the above subject. For more information, please contact MEA at the address listed below.

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