Engineering

UPDATE©

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From Research to Practice

In engineering practice, there are three essential components to design. They are: 1. input data or knowledge; 2. prediction methodology; and 3. comfort margin or factor of safety. The manner in which each of these components is addressed determines the ultimate cost of the project.

The comfort margin is the amount or level in which something is built greater than the exact predicted integrity required for the structure. The comfort margin is therefore determined by the level of risk of failure (or service level) one is willing to assume and how accurate the prediction. The level of risk or service level is commonly defined by the owner in terms of expected performance. Costs can play an important role here. For example, the greater the integrity of design, the greater the construction costs, but often times the maintenance expense is incrementally reduced. In other words, "pay now or pay later".

The accuracy of the zero risk design, however, is solely dependent upon the input data and the prediction methodology. Obtaining greater accuracy can require a significant effort and consequently result in greater design cost. Great cost savings in the ultimate construction of the project are still realized here when conservative input or model assumptions can be eliminated with known data or more representative modeling. Conversely, engineering that costs a dollar to save a penny is wasteful and not beneficial to the project. And the answer to how much effort should be spent on data acquisition and prediction methodology? As an old professor of mine would say to such questions: "That's where engineering judgement comes in".

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MITIGATION OF MINE SUBSIDENCE RISK TO A PRISON COMPLEX

Readers of our mine backfilling project (see Issue 1 of Engineering UPDATE) had a number of questions regarding the site evaluation process. Consequently, this UPDATE discusses the process that was undertaken to mitigate the effects of mine subsidence on the proposed prison structures above old abandoned underground workings. The site for the proposed prison complex purchased by the state of Indiana was located in west-central Indiana and was undermined by an old abandoned room-and-pillar mine. This site was chosen because of its relatively low cost (as a result of being undermined), significant acreage, politically advantageous location, and possible other reasons. The original plan consisted of one phase of construction.

Based on a study of the mine map and subsurface verification of the extent of mining, it was determined that all prison buildings and important structures could be placed above solid coal to the north. The subsurface verification program consisted of drilling a number of holes and performing crosshole electromagnetic surveys. One masonry building, however, was located near mine works that still contained significant mine voids. The subsurface investigation identified the only viable ground movements to be associated with this structure were the milder reaches of the draw zone in lieu of costly design for the various more severe subsidence scenarios. The subsidence potential was estimated based on empirical data and the building was designed accordingly to be mine subsidence resistant.

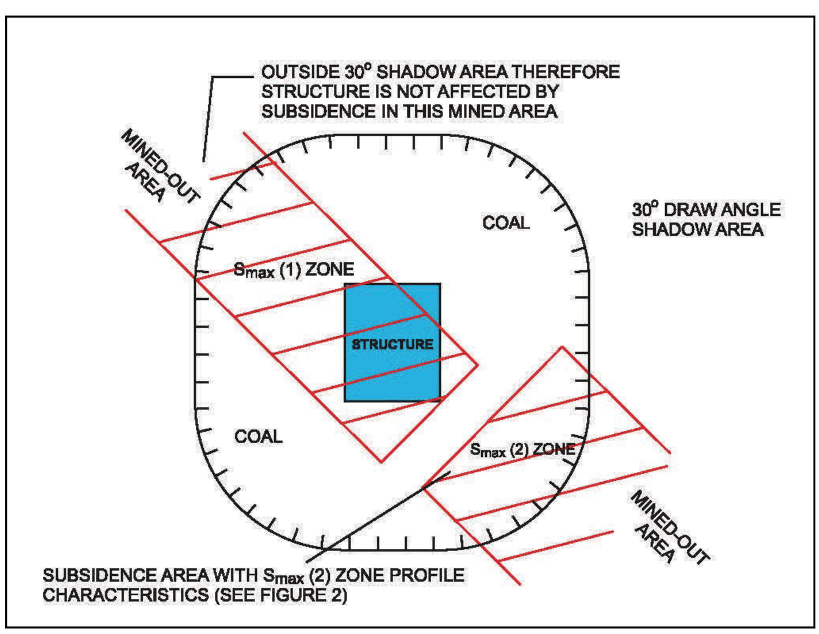

FIGURE 1 EXAMPLE OF SUBSIDENCE RISK MAP FOR A STRUCTURE

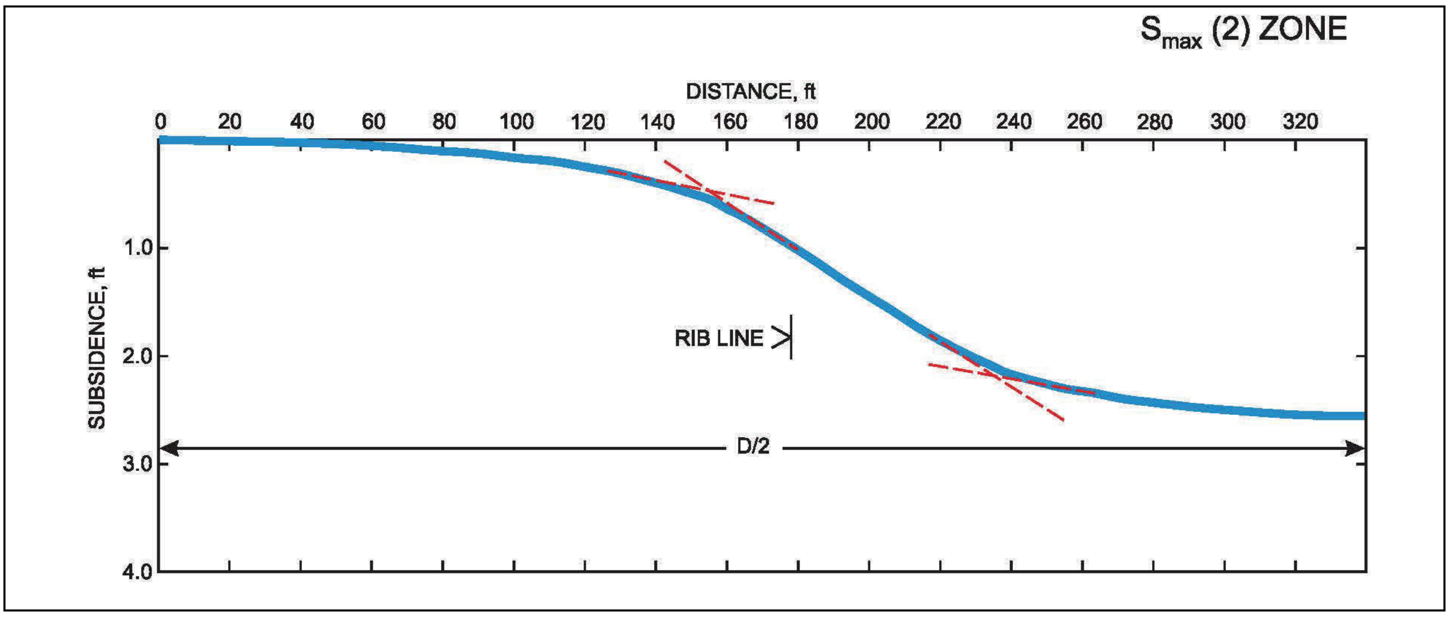

FIGURE 2 EXAMPLE OF ESTIMATED SUBSIDENCE PROFILE FOR S_{MAX}(2) ZONE WITH A 30° DRAW ANGLE (SEE FIGURE 1)

Because the land had already been purchased and the ability to use the newly constructed facilities, the State of Indiana decided to construct a Phase II prison complex adjacent to and just south of the Phase I complex (see Figure 1, Issue 1). This complex would be directly above the underground workings. The first stage of design was to minimize by positioning the exposure of significant structures to subjacent mining, assuming the mine map was sufficiently accurate. Consequently, an extensive subsurface investigation program similar in nature to Phase I was then undertaken mainly to:

1. Ascertain whether or not mine areas where buildings would be located were already collapsed and thus only nominal, if any, subsidence could occur in the future; and

2. Verify the presence of solid coal areas within the mine as indicated on the mine map.

Based on all the information gathered, subsidence profiles were developed from an empirical database of subsidence events in the Illinois Coal Basin. For each important structure that could be potentially affected by future subsidence movement, preliminary subsidence resistant designs were completed using the expected level of potential subsidence movement. Figures 1 and 2 illustrate an example of the subsidence risk maps provided for each structure. The estimated costs to make each structure subsidence resistant were found to be significant.

As an alternative to providing each exposed building with subsidence resistant construction, the possibility of mine backfilling was explored. Structure locations were moved somewhat to obtain the most surface support that could be obtained for the area of mine backfilled. As a result, three mine areas were identified for backfilling. The estimated cost for the backfilling was found to be by far the most cost-effective solution for the structures where little damage could be tolerated. Furthermore, the mine backfilling solution resulted in nominal risk of any surface subsidence above the areas backfilled.

Other Engineering UPDATES of Interest:

UPDATE 6: Subsidence Mitigation by Combining Foundation Treatment with Deep Mine Grouting

UPDATE 30: Risk Based Analysis Results in Efficient Mine Stabilization

UPDATE 14: Establishing Mine Subsidence Risk

ABOUT MEA: Marino Engineering Associates, Inc. focuses on engineering research, practice and expert evaluations and is licensed in 24 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 Dr. Marino at the address listed below.

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