Engineering
UPDATE©
MARINO ENGINEERING ASSOCIATES, INC. • Issue 34

RISK INVESTIGATION OF KARST ON SINKHOLE/SUBSIDENCE PRONE LANDS

The term karst is defined as the effects of groundwater dissolution of rock over time. This occurs in both evaporite and carbonate rock formations, however, this Update article focuses on the latter. The carbonate rock, which is most affected by acidic groundwater dissolution over geologic time is limestone, but also includes dolomitic rocks and marble. As a result of the dissolutioning from concentrated groundwater seepage along fractures is the formation of voids and associated cavity collapse features. The extent and nature of these resulting collapse features, which have occurred from long ago to present time, mainly depend on geologic, geohydrologic, and geotechnical conditions. Consequently, when performing a subsidence risk analysis, the better the understanding of these conditions, the more reliable and cost-effective the approach to a construction site can be .

The vast majority of the surface subsidence results from shallow bedrock karst features (aka epikarsts). The more typical karst-subsidence scenarios are illustrated in Figure 1. Once the voids in the bedrock have formed, the downward raveling or piping (washing) of the soil cover can be induced by groundwater seepage. Downward seepage results from significant precipitation, or the lowering of the groundwater table. This results in groundwater flowing laterally and up or down through voided fractures. From the soil piping or raveling into the solution features below, a depression forms on the ground surface. These subsidence events form into sinkholes (or pits), or sags (dish-shaped depressions). The surface expression from epikarsts depends on if the soil cover acts as a cohesive (e.g. clay) or cohesionless (e.g. sand) material.

With a cohesive cover, as soil is washed down into the bedrock void, a soil arch forms and over time becomes larger as it progresses upwards toward the ground surface. See Figure 1. As the arch approaches the ground surface, it collapses causing a sinkhole to form. This phenomenon is called a cover collapse. For risk analysis, it is critical to identify the susceptibility of the site to cover collapse. Such events in epikarsts can abruptly occur with little warning, resulting in typically up to 30 ft. diameter sinkholes of considerable depth, thus undermining building foundations, creating hazards, and potentially draining detention/retention ponds.

Where the subsidence from karst results in a sag (aka doline), the hazard and damage potential can be considerably less. These events are called cover subsidence, and are typically gradual and occur over extended periods of time, and allows for one to avoid hazardous conditions with periodic site inspections. Consequently, karst terrain prone to the development of cover

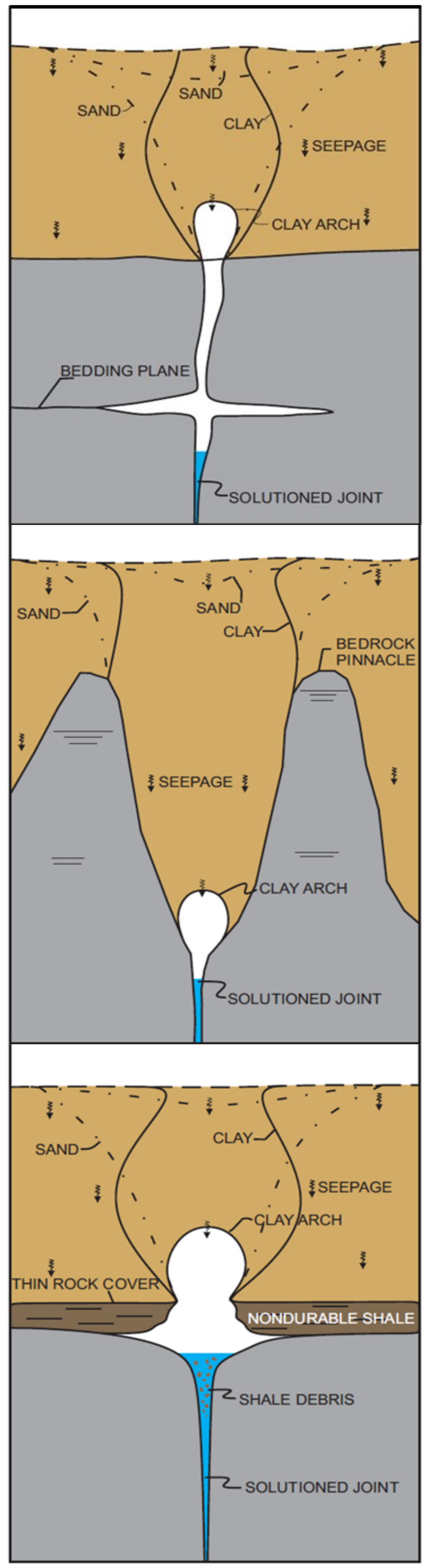

FIGURE 1 TYPICAL KARST SUBSIDENCE SCENARIOS

subsidence is typically of much less concern, and although associated ground distortions can become severe over time, they can take more than the expected lifetime of the site facilities to develop.

Deep seated cavity collapse results in catastrophic subsidence events, but they are very infrequent. Such a collapse can be associated with a significant change in the groundwater table. An example is shown in Figure 2. These dramatic events usually make the news. However, the potential for such an event is often not investigated, due to the costs and because they are unlikely to occur.

FIGURE 2: LARGE SINKHOLE FROM A LIMESTONE CAVERN COLLAPSE (COURTESY OF UNIVERSITY OF MISSOURI, 2012)

Site investigation of a construction site for subsidence potential from karst conditions is one of the more difficult challenges due to the multi-variable site factors and the complex/erratic nature of the geologic/geotechnical conditions. For example, merely drilling borings can result in missing critical subsurface subsidence-prone features which are literally 10 ft. away. Consequently, because of the more extraordinary site exploration challenges and the number of risk-related factors, the most cost-effective investigation and mitigation approaches depend on the understanding of the site and the experience and training of the investigator.

ABOUT MEA: MEA is a leading expert in subsidence engineering addressing underground mining and karst issues. With over 34 years of experience, MEA's staff has provided services across the full scope of subsidence engineering, including significant work in research, site subsidence studies, mine stability design, failure analyses, prediction of subsidence displacement and damage potential of structures, subsidence damage evaluation, foundation design, repair design, and grout stabilization design and monitoring. Being foremost in this field, MEA staff have authored over 90 publications on related topics and have worked in ore fields and karst across the U.S. and Canada. MEA staff have significant related experience acting as expert witness on a variety of engineering problems. MEA's experience extends to underground mines in limestone, gold, trona, salt, lead/zinc, iron, and coal. MEA is licensed to practice in 24 states.

MEA has also been hired by mining companies and others to provide consulting services on active or new operations for both room-and-pillar and longwall mining in addition to low to high extraction old works. These services are included in those listed above. Because of the amount of coal mining related work MEA has done, it has designed and developed a cross-hole radar to detect mine voids for cases where mining may exist.

Having worked extensively on old mines and both low and high extraction active mines, MEA is uniquely qualified and separates itself from other geotechnical and mining engineering companies across the U.S. MEA also has expertise in a full scope of services in geotechnical and pavement engineering, as well as construction material testing and monitoring.

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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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