

GEOTECHNICAL ENGINEERING

Protecting infrastructure from dolomite-related subsidence and sinkholes



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When infrastructural developments are underlain by dolomitic ground, there is an increased risk of subsidence and sinkholes; this demands the early involvement of geotechnical professionals by developers, ideally during a project's design stages.



Dolomitic ground beneath infrastructure developments increases the risk of subsidence and sinkholes



South African National Standards (SANS) 1936 require a detailed assessment of geological stability before any development on dolomitic ground commences. Dolomite is a common feature of the geological landscape in many parts of South Africa, particularly in Gauteng and the Northern Cape. There are particular concerns related to mining activities, as the extensive dewatering conducted by mines has tended to increase risk levels.

Groundwater commonly fills cavities within dolomite rock, exerting hydrostatic pressure that helps to stabilise these voids. When groundwater is removed during dewatering, this pressure is reduced, making the ground more prone to internal erosion and the migration of cavities to the surface. Dewatering can also result in desaturation of weak horizons present in the profile, triggering their consolidation and causing surface sinkholes and subsidence.

EVOLUTION OF STANDARDS

Risk related to dolomite is not limited to mining areas; it is equally prevalent

where the presence of water concentrations leads to internal erosion within the ground profile. Developments in areas of Gauteng that are underlain by dolomite – such as Soweto, West Rand, East Rand and Centurion – have been plagued by sinkholes and subsidence, leading to significant damage and potential risk to life.

Accidents caused by sinkholes have already claimed many lives. A three-storey crusher plant at West Driefontein Mine fell into a sinkhole in December 1962, killing all 29 employees in the building. Just a couple of years later, a Carletonville family of five and their live-in domestic worker were killed when their home was swallowed by a 100 m wide sinkhole.

In response to these disasters, South Africa introduced stringent regulations and standards to manage the risks associated with infrastructure and development on dolomitic ground. These have evolved over the years and now include SANS 1936, which provides guidelines for geotechnical investigations, risk assessment and mitigation measures.

MEASURES TO MANAGE RISK

Risks associated with dolomite are not confined to South Africa. Regions of the Democratic Republic of Congo (DRC) and parts of the Northern Cape face similar challenges due to the widespread presence of dolomite rock. Rapid infrastructure development in mining provinces like the DRC Katanga Copperbelt underscores the importance of effective risk management strategies.

To ensure the safety of human life and prevent damage to infrastructure, the best starting point is a thorough dolomite stability investigation of the area where developments are planned. Preventative measures include a dolomite risk management strategy, conducted in line with the regulated SANS standards. This proactive approach mitigates the risk of causal factors and ensures that infrastructure design meets the demands of the prevailing ground conditions.

Gravity surveys are among the techniques available to identify anomalies in the subsurface, indicating voids or weak zones. The findings of these geophysical surveys can then inform a more detailed drilling programme. Percussion or rotary core drilling can reveal the site in more detail and inform a fuller understanding of site conditions. This approach allows



Without a detailed inspection and intervention, continued subsidence can lead to sinkholes

the investigation team to identify potential hazards early, and to guide the development of tailored solutions.

TAILINGS DAMS

Mining infrastructure such as tailings dams – or tailings storage facilities (TSFs) – are particularly vulnerable in the context of dolomitic ground, as they contain large volumes of water. These concentrations of water – either in the pipes delivering tailings product or even in the separation of water in the dam itself – can cause problems by leaking into the substrate. Sinkholes can form directly underneath the tailings dam, leading to structural instability, groundwater contamination or, in severe cases, dam wall failure.

A critical area for investigation before construction commences is the foundations of the embankments and basin of a tailings dam. Tailings dam liners are effective to a degree, but have limitations and cannot fully mitigate the risks posed by unstable dolomitic ground. If a sinkhole initiates in the basin of the facility, there is only so much strain that the liner can accommodate before it ruptures, and water and tailings start seeping into the groundwater.

There are also consequential risks beyond the TSF itself, as any sort of failure could affect mine workers, surrounding communities, and mine infrastructure. An example may be a nearby ventilation shaft system, which could be damaged by subsidence in the TSF. This occurred in South Africa in 1974, when the Bafokeng failure killed 13 people underground.

Dolomite-related incidents also have the potential to cause considerable damage to infrastructure in urban areas. Subsidence in roads and parking lots, for

example, can be caused by a water leak that accelerates ground instability in the underlying rock. Resolving these issues can be costly and time-consuming. The source of the leak needs to be found, and extensive earthworks and compacting of ground is often required to achieve a normal surface. If a detailed inspection is not carried out in these cases, the subsidence could become steadily worse, potentially leading to a sinkhole and risk to public safety.

IMPORTANCE OF MULTIDISCIPLINARY TEAMS

Geotechnical investigations in dolomitic areas are most effectively conducted by multidisciplinary teams, with collaboration between engineering geologists and geotechnical engineers. The main role of the engineering geologists is to characterise the karst conditions on the site, while the engineers design the solutions and mitigating measures that help prevent failures and safeguard the structures.

Geophysicists are also important, as they facilitate the ground characterisation phase with gravity or resistivity surveys, ensuring a detailed understanding of subsurface conditions. Competent interpretation of geophysical data streamlines the accurate identification of anomalies during the early stages of a project. This in turn helps with the design of targeted interventions, saving time and costs in the long run.

Another vital discipline to the dolomite site investigation team is geohydrology. Groundwater is at risk of pollution, but also contributes to the stability of the ground, so the risk of sinkhole formation and subsidence is reduced if the underground dolomitic cavities are filled with water. □