Danger from the deep

Klemm Bohrtechnik regional sales director, Jörg Müller, talks about how the company's drill rigs are being used in the programme identifying the consequences of mining and war in the Ruhr area of Germany

Intensive mining and the Second World War have left clear traces throughout the Ruhr Region in Germany. Today, however, these are no longer visible in the vast majority of cases – rather, they are hidden underground. Reports of the discovery of unexploded ordnance and sinkholes are commonplace between the Rhine and Ruhr rivers, and the effects of large-scale subsidence are barely recognisable at first sight. For example, areas of Essen's city centre are about 30m deeper today than they were before intensive coal mining began.

In more than 700 years of mining, – including all small mines – there were about 1,300 mines – in the Ruhr area. There were around 280 in both Bochum and Essen alone, plus about 250 in Sprockhövel and about 120 in Dortmund. Until the introduction of the Prussian Mining Law in 1865, mine owners were not obliged to map their mining operations and submit them to the Mining Authority. All mining activities before that time are, therefore, poorly documented or, in some cases not documented at all. In the post-war period, illegal mining also took place in some areas, leaving more undocumented unfilled cavities.

The total number of openings and tunnels in the southern Ruhr region alone is estimated at around 60,000, of which only about 27,000 have been recorded or discovered to date – only a fraction of these have been backfilled and secured. The problem zones with acute dangers due to sinkholes are located in particular where mining was only carried out to a depth of 100m.

As if this were not enough, the bombing by the Allies during World War II also left thousands of unexploded bombs underground, which have remained undiscovered to this day.

UNEXPLODED ORDNANCE

According to a report by the press office of the NRW state government, 1.3 million tons of explosives were dropped on the territory of the Deutsche Reich during World War II. About half of the air raids were concentrated in what is now North Rhine-Westphalia, and a high percentage of these were focused on the cities with their infrastructure and industrial facilities between the Rhine and Ruhr rivers.

Experts assume that about 15% of the bombs were unexploded bombs and therefore up to 100,000t are still hidden undiscovered in the ground throughout Germany at a maximum depth of 8m, depending on the weight, size and subsoil. In North Rhine-Westphalia alone, between 2,000 and 2,500 bombs are discovered and cleared each year. In Essen, which was particularly hard hit, it is assumed that of the 14,000 unexploded ordnance suspected there, only a good half could be found and defused during the war and reconstruction. This means, that there are thousands more lying hidden underground – not counting grenades, hand grenades and mines.

All of the unexploded ordnance, as well as the near-surface mining, pose very special dangers. In the affected areas, special precautions must therefore be taken even before the start of construction work. The owner is responsible for ensuring that a construction site is free of explosive ordnance, and the legal successors of the mining companies – if known or still in existence – are responsible for locating and removing old mining contamination. If no legal successor can be identified, the state of North Rhine-Westphalia takes over.

The Klemm KR 801-3GS drilling rig used to locate UXO and mining caverns in the Ruhr region

PROBING

When evaluations of old documents or aerial photographs reveal suspected explosive ordnance, the first step is usually to probe from the surface using ground penetrating radar, geomagnetic, or electromagnetic systems. Depending on the soil conditions, however, these methods only provide reliable results down to a depth of 3m, or in exceptional cases up to 5m. If no hits are found here, depth probing can be started. A classic method for locating unexploded bombs at depths of up to 15m and above, is geomagnetic depth probing, in which ferromagnetic bodies (iron) are detected at an average radial distance of 0.75m from a borehole. This is also the case on a current construction site of the company GbE Grundbau Essen near Essen's main train station. Two office buildings and a parking garage will soon be built on the approximately one-hectare site on Hachestraße, where the railroad freight terminal used to be located.

Here, the latest generation of a Klemm KR 801-3GS drilling rig is being used to drill 27 boreholes in a specified grid down to 8m below ground level – the ground level at the time of the end of the war in 1945.

The boreholes are drilled using the auger drilling method without flushing. This is because percussive drilling methods with hydraulic drifters or DTH-hammers are generally not permissible here due to the risk of explosion caused by vibrations from any unexploded ordnance that may be present.

The boreholes have a diameter of 120mm, into which a PVC pipe is installed after completion to stabilise the borehole for subsequent travel with the ferromagnetic probe. "As a drilling operator, you have to have a lot of experience here to correctly interpret the invisible processes in the borehole – just based on the rotation and feed behaviour, as well as the resulting noises during drilling," said Timo Hölscher, the drilling operator in charge at GbE.

"Of course, no one wants to risk drilling into unexploded ordnance and thus causing it to explode – but a certain residual risk can never be completely ruled out. The precise and sensitive control of the KR 801-3GS already makes my work considerably easier, and the wireless remote control means that I'm not usually standing right next to the borehole," continued Hölscher.

Once all the boreholes have been completed, the measurement is carried out by lowering the measuring probe (eg a vertical gradiometer) into the plastic pipe. The measurement data obtained in this way is later evaluated by specialist computer operators. Depending on the result, the ground is then either released, or further necessary measures are taken if required.

MINING ACTIVITY

If there are indications of old mining activities, exploratory drilling is carried out immediately, if contamination with explosive ordnance can be ruled out. In this case, boreholes are also drilled in a defined grid using a flushing drilling method. Contrary to explosive ordnance exploration, this can also be carried out using the percussive drilling method, if the subsurface requires it. Hits, or rather tapped cavities, are recognised by the drilling specialists either by the sagging of the drill string or by the drying up of the mud flow. The size, location and course of the cavities are then determined and mapped by further drilling in the vicinity of a hit.

If necessary, a plastic pipe is also inserted into these boreholes, through which the cavity is backfilled with cementitious building materials after the drilling work is completed.

"A few thousand cubic metres of fill material can accumulate on a construction site," said Hölscher. Depending on the intended later use, additional injection boreholes may be drilled to inject grout for further stabilisation of the foundation soil via sleeve pipes.

The construction site on Hachestraße is located in the direct neighbourhood to the shafts of three historic underground coal mines: Secretarius Aak (mined around 1750 to 1805; Vereinigte Hoffnung und Sect. Aak shaft Hoffnung (mining activities from 1805 to 1897); and Vereinigte Hoffnung und Sect. Aak ventilation shaft in the seam Röttgersbank. Already during construction works on Hachestraße in 2013, cavities were discovered that can be assigned to the former minefield of the Vereinigte Hoffnung und Sect. Aak colliery. After exploratory drilling, extensive backfilling work was already necessary at that time. It can therefore be assumed that test drillings will also be carried out at the current construction site as soon as the exploration for explosive ordnance has been completed.

The KR 801-3GS used here defines its own class of especially compact and, at the same time, universally applicable drilling rigs. Mounted on oscillating tracks, the rig is ideal for almost all jobs encountered in special civil engineering – from light to heavy drilling works. Equipped as standard with a power-optimised hydraulic system (Klemm Power Sharing) and the Energy Efficiency Package (Klemm EEP) with adaptive rpm control of the engine and fan, and effective sound insulation hoods, the unit, with its low emission values, is ideally suited for inner-city use. The ergonomic design, easily maintainable, fail-safe machine control with remote diagnostics, remote control operation, and extensive safety features round off the package.

Despite the modern machines and processes available today, the search for, and removal of, the relics of war and mining will remain an eternal task for many generations to come on the Rhine and Ruhr.

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