

Mammoet brings up tunnel boring machine Bertha

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After a year of meticulous planning, Mammoet liberates a 1,700-metric-ton tunnel cutter in just 16 hours

Mammoet's heavy lifting engineers have lifted out the Cutter Drive Unit (CDU) from tunnel boring machine 'Bertha'. The unit was lifted to the surface, rotated to lie face down and then skidded onto supports ready to be repaired.

Back in December 2013 Bertha stalled 120 feet underground, while boring from South Main Street to the Alaskan Way Viaduct. Seattle Tunnel Partners, designer and builder of the tunnel, found they would need to repair the enormous machine which was buried deep beneath the surface.

To reach the machine and make the repairs it was necessary to create a deep, concrete-lined shaft down to the cutter. Mammoet then lifted the CDU out through the shaft from its underground location. Once raised to the surface, it was rotated and skidded onto a pre-constructed repair support system.

A range of engineering conundrums were overcome during the project. The lifting of the heavy CDU was complex due to its difficult shape and asymmetrical weight distribution.

Weighing 1,700 metric tons and with a diameter of 17.5 meters it is a huge component to lift. The site itself also presented challenges, next to a highway, over a 120-feet-deep pit and in a location with complex soil stability requirements.

To carry out this tricky, precision extraction, a special gantry mounted on a skid system was designed to lift the heavy tunnel cutter. The gantry is supported on twin rows of concrete pillars.

Originally these piles were designed to stabilize the surrounding soil while tunnel boring took place. Using the pillars as solid foundations the gantry was constructed across the wide span. Mammoet's engineers developed the design in just four weeks. Using steel beams from Mammoet's fleet of heavy lifting equipment they constructed a specialized modular tower which could safely support the forces exerted by the weight of the load.

The concrete foundations were not designed to support a load at height and while making calculations for the design of the gantry Mammoet's engineers identified that the uneven loads had potential to create torque in

the concrete piles. They solved this potential problem by devising a hydraulic equalization system to place under the tower.

Comprising 48 hydraulic cylinders, the system was designed to help the gantry withstand wind and tail forces when skidding. Using the principle that fluid in the hydraulic system disperses the weight of the load equally and in all directions, the tower becomes effectively 'self-balancing'. It is the first time a gantry has been developed which is fully supported by hydraulics.

With many surveyors and engineers on site to monitor ground movement and ensure the safe extraction of the CDU, it took around 16 hours to lift. More leveling work took place the following morning. Now that the CDU has been brought to the surface, the remaining repairing and lifting operations are aiming to get Bertha back to work as soon as possible. Once the repairs are completed, the CDU will be maneuvered, with millimeter precision, back down the shaft and reinstalled in the machine ready to complete the Highway 99 tunnel.