RISING TO NEW HEIGHTS WITH GUIDED BORING

An artist's impression of how the new One Za'abeel building will look

Since the construction of the Dubai World Trade Centre in 1979, Dubai has become the most innovative city to showcase modern architectural marvels in the world. Scheduled to open in December 2023, Dubai is set to open another record-breaking Middle East icon, One Za'abeel which will become the world's longest occupied cantilevered building, and the newest addition to Dubai's breathtaking skyline.

One Za'abeel is a symbol of ambition, innovation, and the pioneering spirit of Dubai. Consisting of two towers standing at 304 m and 241 m in height, the buildings straddle a six-lane bridge and are 'linked' by an impressive 225 m long cantilevered building near the top to achieve Guiness Book of World Record accolades. Trenchless technology is not commonly associated as a key attribute in the construction of such iconic structures, however the developer, Ithra Dubai, required the finesse of multiple Akkerman Guided Boring Machines to assist construction of this world record breaking structure. >

The One Za'abeel construction site

Enabling construction to grow up

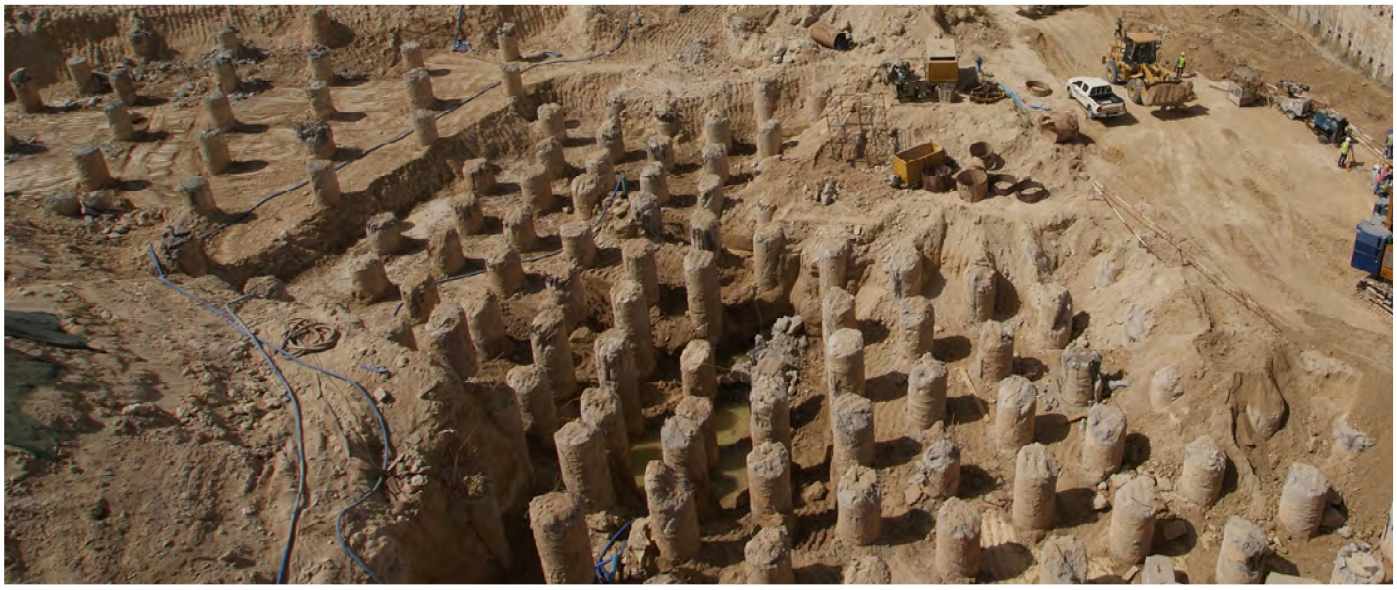
As with most underground construction, notoriety is often lost without visibility. One Za'abeel is just as impressive below ground as the visible architecture above. Designed to a depth of 38.5 m below ground, the basements for each of the towers include 7 individual floors with space for over 2,500 parking spaces, storage units, and maintenance rooms requiring engineering firsts in foundation construction. The two towers and associated basements are connected by two underground tunnels which further complicated foundation construction due to the proximity of the existing highway bridge piers and its foundation.

APCC Piling and Contracting L.L.C. (APCC) was awarded the foundation work for the One Za'abeel Mixed Use Development Project with WSP as the consultant engineering firm. Since the foundation for both tower 1 and tower 2 is near the bridge foundation, the Investment Corporation of Dubai required supportive D-Walls on both sides of the bridge to be 'linked' together with tension cables to minimise any risk of settlement or deviation to existing structures.

Trenchless technology tests – HDD vs. Pilot tube

Nearly two years into the construction phase, site excavation and foundation work slowed as the first layer of D-Walls could not be fortified using the original design method. Initially, a horizontal directional drill (HDD) rig was to install a drill rod for 150 ft (45.7 m) from one D-Wall support to an adjacent D-Wall support at the other side of the bridge. Each pilot required entry and exit through a pre-existing 8 in (200 mm) o.d. x 8 ft (2.4 m) long steel casing that was grouted into the structure. With intention of pulling back 6 in (150 mm) diameter HDPE to house a series of high-tensile strength cables, APCC would then use specialised cable tensioners to solidify the foundation between towers 1 and 2 by putting the series of cables into tension.

Although highly skilled operators and HDD equipment were available, extreme passive interference from the active bridge structure, 11 kV power lines, and other existing utilities on the construction site would not allow an HDD pilot rod installation to within tolerance guidelines. After several attempts, experts were not happy with the results and required an alternative trenchless installation method. The installation of the tension cables required an extremely straight and accurate bore path to ensure the cables would remain in proper tension for the lifespan of the structure. >



Foundation piles at the One Za'abeel site

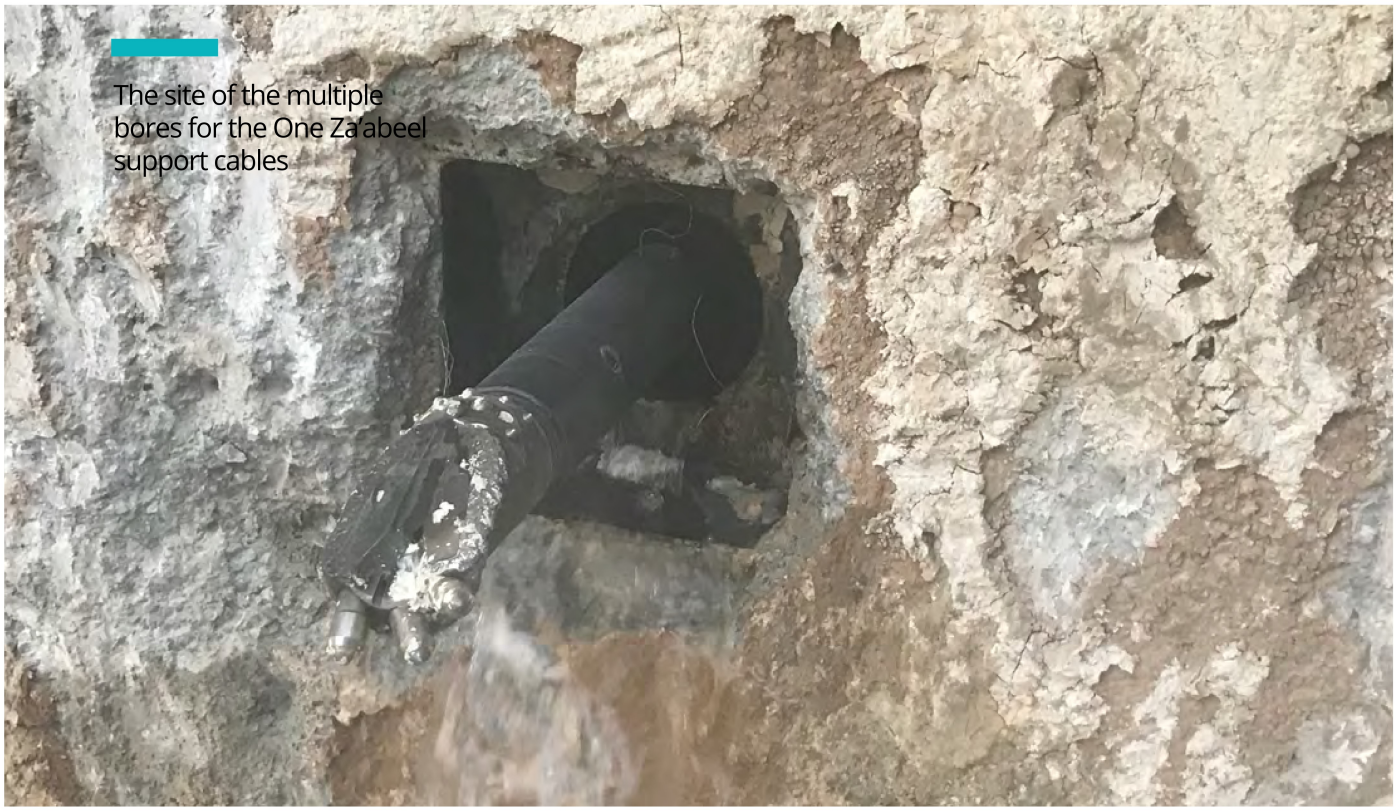
To successfully continue work on the iconic One Za'abeel project, APCC required technology not often utilised in foundation construction. With a background in Civil Engineering and being known as an extreme innovator, Managing Director of APCC Elie M El Moussa reached out to Terranaut Technologies of Kuwait and Akkerman Inc. in the USA for an alternative solution concept.

Due to the high-profile nature of the project, the construction schedule was of the utmost importance. To maintain the schedule, a total of 296 crossings were to be completed at six different elevations within a three-month period. Tension cables on each level needed to be properly installed, inspected, and approved prior to excavation of the next subterranean level. To expedite a proficiency test for approval, Terranaut Technologies mobilised its Akkerman Guided Boring Machine (GBM) system from Kuwait to Dubai, while Akkerman dispatched tooling suitable for the sandstone rock, as well as a technician to assist with the installation. Approximately six days after the initial inquiry by APCC, the first guided pilot tube installation was successfully completed in Dubai and the Pilot Tube Method was approved by the owner and consultant engineering teams.

Pilot tube installation method

To complete the project on schedule, APCC commissioned two additional Akkerman GBM systems to work in concert with the GBM system supplied by Terranaut Technologies. Since the project required the rapid installation and quick mobility of the frame, Akkerman 240A GBM systems were sourced for the project. These units can install a complete pilot tube in one advance sequence and are much lighter to mobilise around the project site than the larger Akkerman 4812A GBM system initially acquired from Terranaut Technologies.

While pilot tube installations have been commonplace in soft, displaceable ground conditions, navigating through hundreds of 150 ft (45.7 m) long crossings in sandstone rock required an alternative solution. Akkerman fitted all GBM systems with a Rock Drill Adapter, which allows conventional pilot tube systems to use steerable rock tooling in conjunction with the line-of-site, theodolite-based GBM guidance system. The combination of these components allowed successful excavation of the sandstone while maintaining an accurate bore path along the entire alignment. Since the guidance system provides instantaneous feedback along the entire alignment and does not require a beacon locator, so interference issues evident in previous HDD trials were non-existent. >



The site of the multiple bores for the One Za'abeel support cables

A completed pilot bore. Below: A bore with the case pipe installed

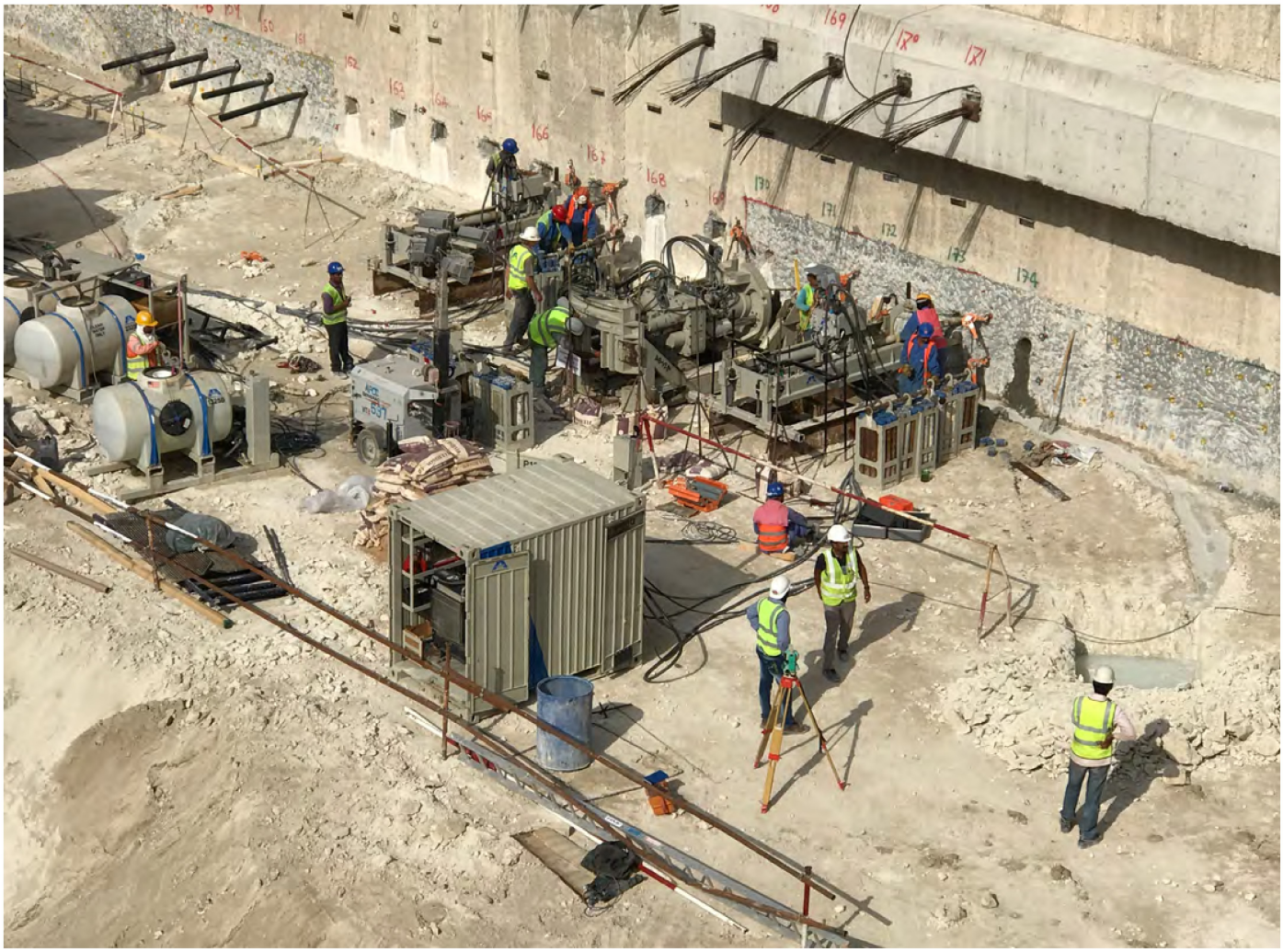
Once the pilot tubes were installed, the steering head was removed at the reception side and replaced with a pull-back tool customised to fit the 6 in (150 mm) diameter HDPE. During both the installation and pull-back sequence of the pilot tube, a bentonite lubrication mixture was pumped through the dual-wall pilot tubes from the launch shaft to minimise forces and move away chips created from the cutting action of the steering head. Unlike in HDD, flowrates are extremely low during the pilot tube process as the overcut diameters are minimal to achieve line and grade tolerances.

Project challenges

Outside of the tight schedule demands, the One Za'abeel project was faced with some extreme challenges that required perseverance, innovation, and execution.

Equipment Setup: With a massive foundation excavation serving as a launch shaft, the team had to be creative on how to set up the equipment both efficiently and effectively. APCC chose to build custom platforms which the Akkerman GBM systems could firmly attach themselves to while allowing full adjustability for slope correction. This configuration was like the Guided Auger Boring industry setup, however the custom skid allowed APCC to rapidly transfer the GBM to the next pilot hole location with onsite construction equipment.

Instead of a thrust reaction wall to counteract the thrust forces required to advance the pilot tubes, the front of the GBM frames were mechanically linked to the D-Walls and secured. During the installation of the pilot tubes, the mechanical linkage was placed in tension while pull-back operations reacted through the front adapter ring on the GBM frame itself. >

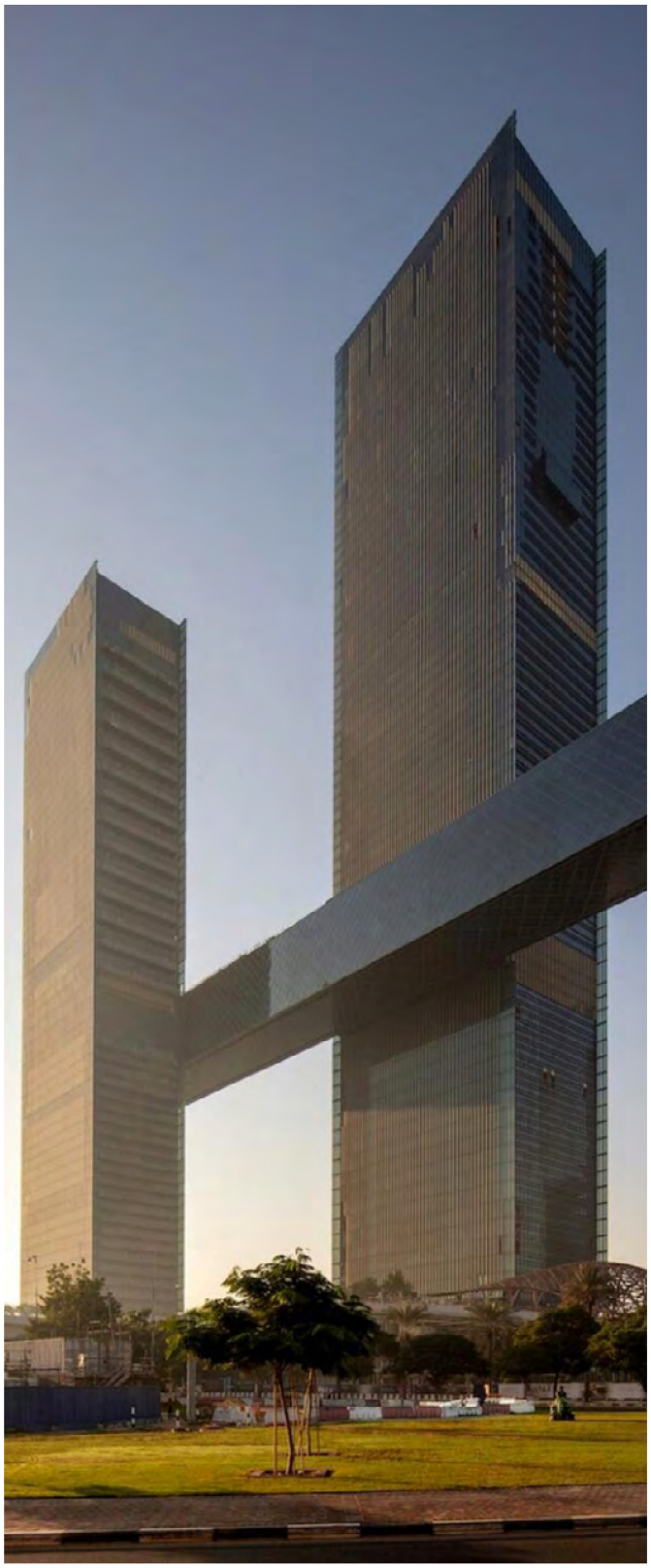


A detailed view of the bore site with tension cables shown protruding from previously completed bore holes

Preliminary Survey Points: Trenchless contractors understand the importance of jobsite set up and how any deviations in the initial survey will affect the accuracy of the final product. Typically survey points for critical line and grade bores are well-established and can be replicated with relative ease. In most cases, stringlines are dropped from predetermined points at the surface of the launch shaft to verify line, while elevation and grade are transferred. Due to the massive scale of the excavation, the construction team created mobile stringline stands to set up the guidance system. While this method was very functional once initially set up, the stands proved to be easily manipulated by anyone that accidentally bumped into it. If the incident was not reported immediately and the stand not resurveyed, the guidance system was set to an improper alignment causing borehole to be grouted and pilot tube to be re-installed at a later point.

Starter Casing Alignment

As mentioned earlier, every pilot tube shot started into an 8 in (200 mm) o.d. x 8 ft (2.4 m) long steel casing that was installed and pre-grouted into the D-Walls on both sides of the excavation. These starter casings were critical in the cable tensioning process to secure the D-walls on either side of the bridge structure. Since these casings were pre-installed into the D-Walls prior to the pilot tube installation, all 297 pilot tube shots needed to match existing casing installations earlier in the construction schedule. In many cases, this caused additional evaluation of the existing structure to properly set up the equipment. >



How the One Za'abeel will look once completed

During the pilot tube installation, it became apparent that some of the 297 crossings did not have starter casings that were concentric on both sides. If the starter casing on either side was installed at an acute angle, there was a risk of not intersecting the i.d. of the opposing side. In many cases, the pilot tube would intersect the 8 in (200 mm) i.d. casing with ample clearance to install the 6 in (150 mm) diameter HDPE, however in some cases the 8 in (200 mm) diameter steel casing had to be removed and re-installed. Every installation required inspection and evaluation prior to moving onto the next borehole.

Operational Training

With a tight construction schedule, it was important for APCC to install as many as 4 to 5 pilot shots per day. It was important to properly train the three teams to correctly operate the equipment as well as function as a unit to expedite the installation process. Even though the UAE often has a highly skilled labour force available, these teams can be comprised of members from multiple nationalities creating language barriers. To assist training efforts, multiple Akkerman technicians as well as experienced GBM operators from nearby regions worked with technical interpreters to ensure operations ran smoothly.

Results

With a milestone ceremony in November 2017, construction crews began pouring 26,000 cubic meters of concrete into the completed 7,600 square meter foundation that served as a launch shaft for the three Akkerman GBM systems a few short months earlier. Issam Galadari, Director and CEO of Ithra Dubai, announced at this time that: "With the appointment of ALEC Engineering & Contracting as the main contractor, the project entered an exciting phase of construction. After the pour, it is only a matter of time before One Za'abeel and its 'Linx', the panoramic sky concourse traversing the two towers, reshape the ever-exciting Dubai Skyline."

The recipient of several notable construction achievements such as the 'Iconic Project of the Year' at the Big Project Middle East Awards 2022 and 'Project of the Year at Innovation in Construction' at FM Awards in 2019 and 2020, One Za'abeel is a must-see destination when traveling to the region.

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