Two Maxibor personnel busy on site at a horizontal directional drilling job.

Maxibor drills to success with HDD

By developing and implementing a strong design and drilling methodology for HDD projects requiring maxi-rigs, Maxibor can ensure project success for even the most complex bores.

Asset owners are increasingly using more complex horizontal directional drilling (HDD) solutions to meet their infrastructure replacement and new installation needs.

With increased length, diameter and depth of bores, the importance of having the right expertise applied at the bore design and drilling methodology development stages has become more critical. Risk mitigation and opportunity optimisation must be achieved for all key stakeholders in the project to guarantee a successful installation and the broader objectives of the project.

Maxibor's methodology

Maxibor National Business Development Manager David Turner says Maxibor applies a procedure for each project that adapts accepted practices and then focuses on specifically solving the project issues through engineered design.

"Maxibor's HDD design and methodology development processes are highly iterative for the more complex bores," says Mr Turner.

"Each step in the design process feeds back to the previous parameters which causes an evolution in the design to get to a point that provides a pipeline installation solution which considers safety in design, constructability through engineering application and ultimately usable infrastructure."

Mr Turner says Maxibor's approach is developed within an integrated discipline framework, with the design and methodology development processes requiring a wide range of engineering, HDD operations and commercial knowledge to achieve successful installation.

The key steps in Maxibor's integrated discipline framework:

- **Pre-planning** – project objectives.
- **Build of initial bore plan** – design profile, preliminary hole, casing design.
- **Torque, drag and hydraulics** – friction factor analysis, maximum loads, maximum torque, pipe buckling.
- **Rig and equipment specification** – rigs, pipes, pumps, cleaning systems.
- **Case wearing** – will profile cause excessive wear?
- **Bore hole trajectory** – objectives to minimise tortuosity, target size, ellipse or collision analysis, survey and program design, target, anti-collision.
- **Bore hole stability** – fracture gradient analysis, collapse, rock mechanics, clay inhibition, swab and surge pressures, geotechnical investigation.
- **Product pipe design** – formation type, collapse pressures, tensile loading, floatation devices, safety factors, rig limitations, pipe wall force, coating type selection.
- **Bore hole assembly design** – drilling tendency, bending stress state, hole size evaluation, torque reduction tools, vibration, tooling layouts, bore hole assembly (BHA) analysis, stabiliser placement.
- **Fluids and hydraulics** – hole cleaning, density, rheology, flow rate and regime, maximum rate of penetration (ROP), pullback capacity, back reaming, fracture gradients, drag monitoring, drill pipe rotation speeds, BHA design, bit selection, cuttings volume, fluid volume displacement, lubricity, inhibition.
- **Torque and drag** – friction factors, sliding limits, pick up and slack off, buckling analysis, casing wall force, fatigue endurance, yield stress, tension, rig limits.
- **Risk and opportunity** – operational risks, corporate risks, opportunities, risk sharing.

The extent of factors to consider highlights the range of knowledge required to achieve a fit for purpose design and a drilling methodology.

In its development, Maxibor was able to draw upon its extensive internal experience of installing complex pipeline projects and its network of industry specialists, which have further facilitated the build of its internal knowledge bank.

This pool of knowledge can be applied to each project and provide significant confidence to clients that Maxibor's procedures will be successful.

Achieving desired outcomes for clients

Maxibor frequently puts forward alternative design solutions to clients to help achieve better outcomes and has applied its integrated design and drilling methodology development process to more complex projects, demonstrating the benefits of the disciplined and cooperative approach.

Mr Turner says by investing Maxibor's expertise and resources to undertake this additional work in the bidding stages, it helps clients have an achievable project.

An early design initiative of Maxibor on a recently completed Logan Water project was to combine two shorter bores into a 1.32 km bore, which reduced the cost to the client, impact on the local vegetation and noise and dust to nearby residents.

This outcome was achieved through a complete understanding of the project objectives before commencement of the detailed design and drilling methodology development activities. Mr Turner says good communication with the client and other key stakeholders is essential to ensure all HDD activity on a project is aligned with the objectives and needs of other parties.

"Our clients are increasingly appreciating the extent of our knowledge and our willingness to share that knowledge to help achieve better outcomes," says Mr Turner.

"If less informed decisions are made by clients, significant variations can arise. This is not necessarily to the benefit of the overall trenchless industry as it makes the infrastructure sector more reticent to use trenchless solutions."

The risks of complex projects

One of the major risks on the more complex HDD projects is 'frac out'. Maxibor's engineering design process considers fracture gradient modelling as a way of predicting the annular drilling fluid pressure compared to the ability of the formation to resist a crack or fracture forming from the annular drilling fluid pressure.

There are several factors that influence this calculation, including bore hole diameter; borehole depth of cover; drill pipe diameter; drilling fluid composition; drilling fluid flow rates; formation cohesion and plasticity; and formation ground water.

Maxibor says there are two principal models that are generally applied in the HDD industry to evaluate the fracture point – the overburden density model and the DELFT model. While

HDD

Maxibor's AA660 Rig is used on projects at all hours of the day, including at night.

both models each have their place, it is important that the mechanics of the complex models are fully understood since it is not a matter of simply plugging in numbers.

Therefore, while both models are usually considered, Maxibor notes that several university thesis studies have examined the DELFT model and generally conclude it overestimates the fracture resistance pressure of the formation by 100–150 per cent of the predicted pressures in more sandy type soils. Such soils are common in many of the near surface HDD bores in Australia and operators must question the application of a model that is more suited to heavy plastic clay.

Since the model itself is robust and the formulas readily available online, it is more often than not incorrectly selected and applied to the wrong soil types.

Real world testing shows the DELFT model is more accurate in more homogenous and highly plastic formations, so understanding the limitations of each of the technical modelling options is vital in making the right design and methodology decisions.

Another area where Maxibor is endeavouring to bring better practice to the trenchless industry is rock hardness measurement. Most geotechnical investigations utilise the unconfined compressive strength (UCS) tests to assess rock strength.

However, UCS tests are not considered to accurately reflect in-situ conditions experienced by the HDD drill head for the following reasons:

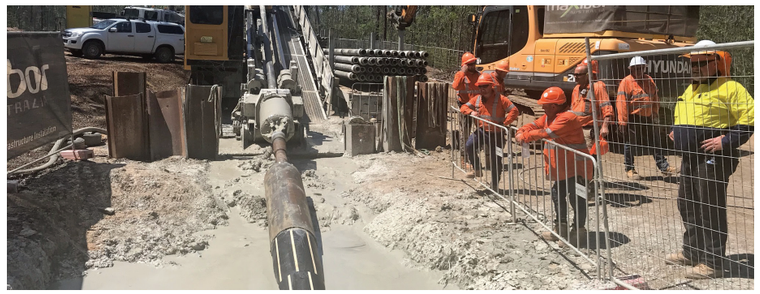
- UCS being unconfined does not apply or attempt to replicate the in situ confining pressures the rock mass experienced.
- UCS testing is greatly dependent on sample orientation when the rock is anisotropic.
- UCS tests often fail along existing defect planes within the rock which will therefore under-estimate rock strength.

Maxibor says UCS tests are therefore inherently subjective and highly dependent on the mode of failure and not necessarily representative of the actual intact rock strength.

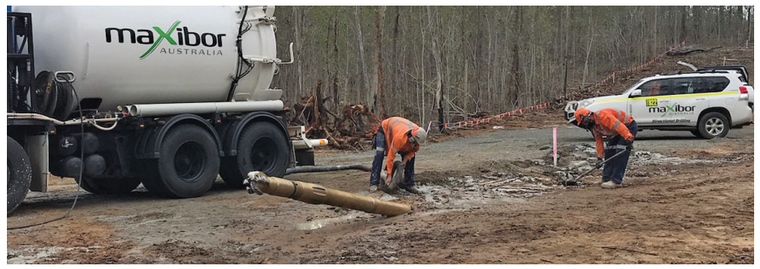
Instead, Maxibor considers that Hoek Triaxial testing is much more representative of the in situ ground conditions that are experienced during HDD operations.

Mr Turner says at a commercial level, Maxibor is supportive of assisting the industry to move to a ROP measure to determine commercial impacts on its maxi-rig projects.

"The traditional rock hardness measure is only one factor that affects the penetration rate. Other factors such as brittleness in situ fracturing, void, grain size, grain cementation all affect the drillability of the formation, while changes in formation along the bore alignment will also have an impact.



By collaborating with stakeholders and involved parties on the Logan HDD project, Maxibor could achieve the optimal outcome.



Maxibor utilised its thorough drilling methodology on an HDD project in Logan.

"We believe the fairest and most optimum way to apply the ROP measure is to consider average penetration rates amortised over the entire length of a bore as they account for the variable nature of the rock and other conditions," says Mr Turner.

However, rock hardness is not relevant to a significant proportion of the drilling operations such as site setup, casing installation, pipe welding, trenching and pit construction. The share risk for drilling operations is, therefore, best applied where geotechnical conditions largely dictate the speed of operations, namely pilot hole drilling and reaming passes.

"Under this option, the average penetration rates are measured for the pilot hole to reaming stages of the bore construction," says Mr Turner.

"Our detailed build-up of the drilling methodology and construction schedule provides a very sound basis for determining the expected average time to complete the works though these stages of the project.

"The ROP measure provides the option of developing a risk share between the parties. Under such an arrangement, the client would receive a benefit should the ROP be better than expected.

Additionally, use of the ROP measure also overcomes the need to obtain further core drilling samples to test the strength of the rock. Vertical core samples at even 50 m intervals will not necessarily be representative of the rock along the horizontal of the bore hole in between core samples; therefore, ROP measures will provide a much better indication of the drillability of the bore.

Comprehensive risk analysis

Maxibor has also compiled a comprehensive risk analysis for HDD operations that provides a point of reference to consider the risks associated with each project and identifies good practice actions that can be taken to mitigate those risks.

The risk analysis is relatable to the design and drilling methodology as well as broader operational areas around labour, plant, materials and HSEQ and corporate risks and opportunities. Mr Turner says this process makes both Maxibor and the client much more informed about the project.

As a knowledge sharing business, Maxibor is more than happy to discuss its design and drilling methodology development processes and related risk and opportunity activities with those interested. Contact Mr Turner on 0499 375 511 or **david.turner@maxibor.com.au.** •

For more information visit
www.maxibor.com.au