Vortrag

Freitag, 10. Oktober 2025, 12:15 Uhr

Horizontal Directional Drilling (HDD) in High-Complexity Subsoil: Case Study of the Rio Grande Crossing

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Lecture

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Carlos Eduardo Chaves, Drillcon

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The Rio Grande crossing, executed using Horizontal Directional Drilling (HDD), formed part of an emergency rehabilitation project for one of Brazil's most strategic multiproduct pipelines: the São Paulo–Brasília Pipeline (OSBRA). Spanning 964 km, the system transports gasoline, diesel, jet fuel, and ethanol, and is operated by Transpetro, a wholly owned subsidiary of Petrobras. The rehabilitated section, approximately 810 meters in length, comprised an API 5L X65 carbon steel pipeline, 20" in diameter with a 0.375" wall thickness, installed under geotechnical and geological conditions of high complexity, whose specific characteristics could not be fully characterized during the pre-construction site investigation.

The primary objective of this case study is to present the technical challenges encountered throughout execution and the engineering solutions implemented, emphasizing the importance of adaptive approaches supported by continuous re-evaluation of the geological–geotechnical model. Despite the lithological variability detected, the pilot bore was completed as planned. The major challenge emerged during the reaming phase, when the Bottom Hole Assembly (BHA), comprising a Ø26" reamer and drill pipe string, became stuck. A range of release procedures and resources were mobilized, including simultaneous push and pull forces applied from both ends of the bore, mobilization of an additional drill rig from the pipe side, deployment of a 50-ton pneumatic hammer, circulation of high-viscosity drilling fluid, and wash pipe operations to the reamer.

Despite the application of multiple techniques, immediate release could not be achieved, necessitating a comprehensive reassessment of the geological conditions. The analysis incorporated data from the basic engineering design, operational parameters recorded during drilling and reaming, and specific technical and bibliographic references. This investigation identified the probable presence of the Uberaba, Botucatu, Piramboia, and Serra Geral formations in the region of interest, with clay-rich intervals containing expansive clay minerals, particularly smectite. The interaction between these clays and the drilling fluid, combined with changes in in situ stresses induced by drilling, was found to be a decisive factor in the sticking incident.

To confirm this hypothesis, samples collected from downhole tools and shakers were analyzed via X-ray diffraction (XRD), confirming the presence of expansive clay minerals in all specimens. Based on this diagnosis, the bentonite-based fluid was replaced with a polymeric fluid containing clay inhibition additives, pumped simultaneously from both ends of the bore. After approximately two days, return fluid properties indicated significant incorporation of clay material, resulting in the successful release of the drill string.

However, on the opposite side, the wash pipes remained irretrievable, likely due to the combination of the clays' high swelling potential and the reduced annular clearance, which hindered effective fluid action. As a contingency measure, a sidetrack was executed only in the affected section, after which reaming to Ø26" and then Ø34" was performed, conditioning the bore for pipeline installation.

During the pullback phase, when only 100 meters remained for completion, the pipe string encountered an obstruction. After the pipe string complete removal, a backsurvey revealed a geometric deviation precisely at the soil–rock interface, where reamers had followed the rockhead relief without top-side support to allow proper cutting. A second sidetrack was ruled out due to the risk of buckling in a bore already reamed to Ø34”. Instead, an intercept bore was drilled from a new entry point to intersect the original bore and bypass the problematic section. This operation, which required multiple BHA changes to accommodate soft soil and hard rock drilling conditions, confirmed the complex lithology of the region and enabled successful completion of the pipeline installation.

The experience highlighted the importance of an iterative approach to geological-geotechnical modeling, with continuous updates based on field data and laboratory analysis. The presence of a highly specialized in-house engineering department was critical for enabling real-time assessment of encountered conditions, proposing technically sound solutions, and conducting advanced analyses to support rapid, well-founded decision-making.

The contractor’s robust operational structure and equipment fleet, including complete HDD spreads, diverse downhole tooling, and self-sufficient logistical capability, ensured immediate resource mobilization and uninterrupted operations, mitigating the impact of unforeseen events. This case reinforces that, in HDD projects in stratigraphically complex environments, risk management, operational flexibility, and integrated engineering application are essential elements for success.

Beyond exemplifying the overcoming of significant technical barriers, the Rio Grande crossing provides valuable insights for future HDD projects in challenging geological settings, establishing itself as a reference in planning, risk mitigation, and the application of advanced engineering solutions in works of high geotechnical complexity.