25m³ Geotextile Bags and Geotextile Tubes used to protect a 42" pipeline against scouring, 30m deep on the sea bed, Coveñas, Colombia, S.A

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ABSTRACT
The buoy that is part of the offshore terminal for tanker ships loading oil off the Colombian coastline is anchored to a submerged pipeline 42" in diameter that sits 30m over the seabed. Underwater currents have caused localized scouring along the pipeline, creating voids underneath it and additional strain on the pipe. To provide a definitive solution, it is key to understand that loading of the ships is the number one priority of the facility, therefore very specific windows of operation are open to install or build any solution.
With this restriction in mind, the project opted to fill onshore large Geotextile bags, 25m³ in capacity each, that would be loaded onto a barge using a lifting harness made of polyester geogrid and a PVC coating. The geotextile bags would be lowered into position using a large crawler crane which would be fixed on to the barge and set into position with the help of deep-sea divers. With the bags in place, resting on each side of the pipeline, a geotextile tube would be installed in between the bags and under the pipeline and filled from the surface with a sand and water slurry.
The geotextile bags are 5.0m long x 2.5m wide x 2.0m high and each has a filled capacity of 25m³ and weighs in approximately 40 tons. Once the Geotextile bag and Geotextile tube are in position, a final Geotextile tube type-of - mattress would be placed overlapping the bags and the geotextile tube and filled with a sand slurry to fill in voids so that it can provide the support required to keep the submerged pipeline stable and in place. This geosynthetic system will provide a long-lasting solution for this scouring problem for good.

1. INTRODUCTION

1.1 Project Background

The crude oil pipeline stretches from the south eastern plains in Colombia, in Cusiana and runs nortwest to Coveñas, on the Caribbean coast of Colombia, covering a total length of 850km on land and 12km underwater, lying on the bottom of the sea bed, 30m deep, where it connects to a manifold and valve system known as "TLU buoy" where super tanker ships are loaded, and the crude oil is exported or sent to the refinery in near-by Cartagena. Figure 1 – Project Location.

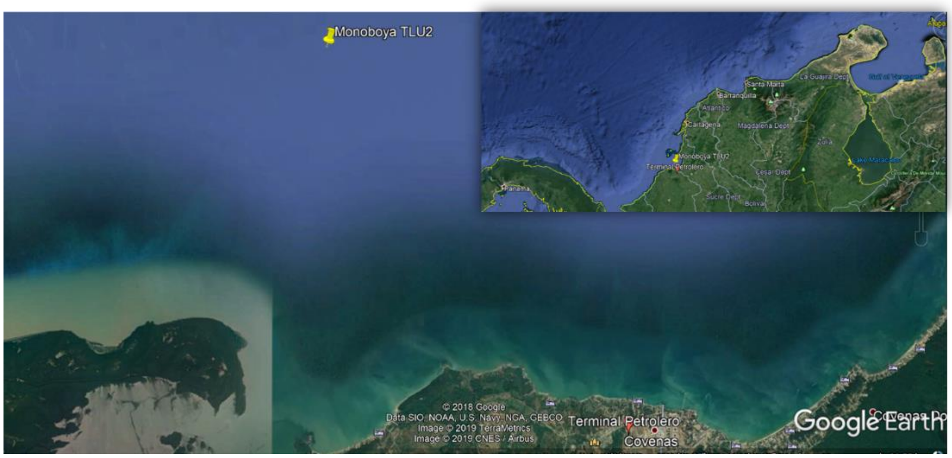


Figure 1 – Project Location

The submerged pipeline is 42" (1.06m) in diameter, it seats on the seabed and undergoes constant electronic monitoring and scuba diving supervision. Localized scouring along the pipeline has been detected in the past, mainly caused by underwater currents and several attempts to stop it have been made, with partial success.

An inquiry was brought to our attention on finding a way to solve this scouring problem for good and a solution utilizing a combination of geosynthetics was chose: large Geobag units would be placed along each side of the pipeline; then, Geotextile Tubes and a Geotextile tube type-of-mattress would be installed. Figure 2 – Condition Prior to Geotextile Tube Solution

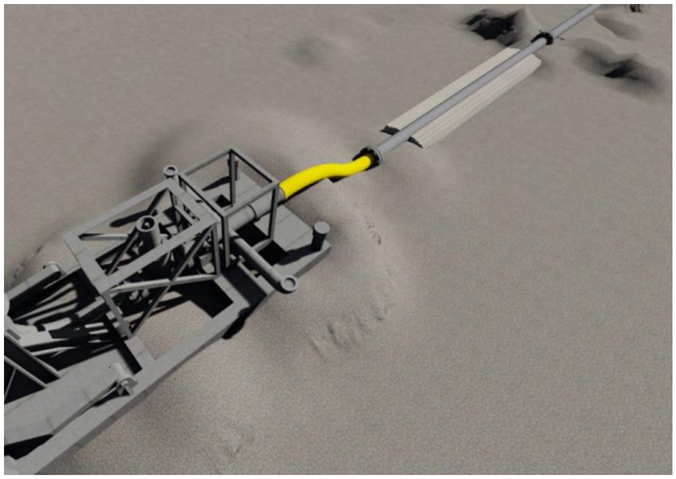


Figure 2 – Condition Prior to Geotextile Tube Solution

1.2 The Challenge

One of the constraints to carry out the installation of the Geotextile Bags and Tubes, was the time frame allowed to move near the buoy and carry out field maneuvers, as the priority of operation of the buoy consists in exporting crude oil, therefore any attempt to work around the site, would have to be done in between tankers approaching the buoy. Any schedule overrun, could mean thousands of dollars in liabilities.

To reduce such risk, it was decided to split the construction process into two phases: the first phase would be carried out onshore, with the deployment of the Geogrid Lifting Harness and the Geobag units. Initially, these bags were designed with a capacity of 35m^3 but it was later decided to bring them down to 25m^3. The bags would be deployed over the geogrid lifting harness, filled and then loaded on to a barge. A total of 21 Geobag units would be required for this project, containing over 525m^3 of coarse grain material.

Once the Geobag units were lowered into position, all crane and additional vessels would no longer be required, thus reducing construction risks to manual deployment of the Geotextile tubes and mattresses.

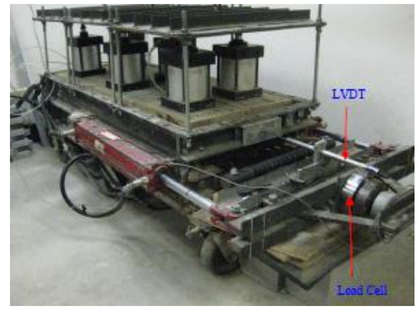
2. LABORATORY TESTS

2.1 Geogrid Pullout Testing

To determine the Geogrid Lifting Harness Factors of Safety, we carried out Pullout tests, as per ASTM D 6706, using a 400kN/m geogrid as pullout specimen overlying by a 200kN/m x 200kN/m geotextile sample, so as to simulate the behavior of the geogrid – geobag system interaction.

Geogrid Setup

Geotextile Setup



Complete Test Setup

Image 1 – Pullout Tests

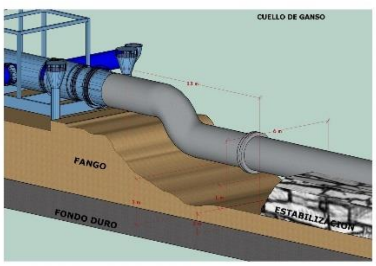
2.2 Test Results

2.2.1 Apparent Friction Coefficient

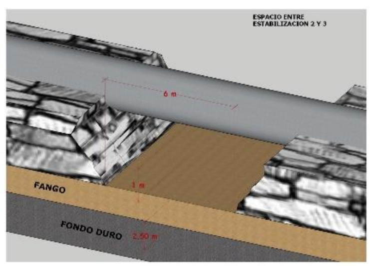
Pullout tests allowed us to determine the apparent coefficient of friction of Geogrid – Geotextile system, which would be used to calculate the geogrid's lifting harness factors of safety against rupture and pullout resistance, based on the Geobag's geometry and weight.

3. GEOBAG AND GEOTEXTILE TUBE DIMENSIONING

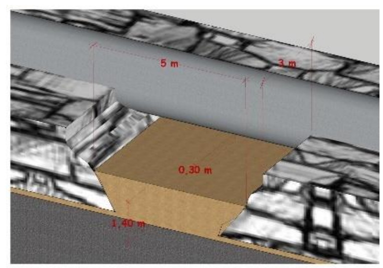
Several factors were taken into consideration for the design of the Geobags and Geotextile Tubes used on this project. Although geotechnical information was not made available, a recent survey and bathymetric report were used to determine the fill height and capacity of all units, as shown on Figure 3 – Localized Scouring.



Sector 1



Sector 2



Sector 3

Figure 3 – Localized Scouring

Three sectors were identified that would require stabilization. As there was no geotechnical data, information provided by the diving team was used to determine the size of Geobags. A layer of fine grain material, approximately 1.2 to 1.5m in thickness was present. Therefore, Geogag units that would be placed along the side of each sector should be as heavy as possible so that they would sink through this layer and become stable reducing future settlements. Initially, Geobag units were designed to contain 35m^3 but were later reduced to 25m^3 each. Fabrication and lifting would have been possible; however, this decision was made in stake of risk management on behalf of the client. Final Geobag design was a unit made of a woven geotextile, 200kN/m x 200kN/m and 5.0m long, 2.5m wide and 2.0m high. Finally, each Geobag was 30m lowered into position with the use of a crawler crane and the Geogrid lifting harness. Figure 4 – Geobag Lifting Harness and Installation.

Figure 4 – Geobag Lifting Harness and Installation

Geotextile Tubes were designed with a fill height of 2.0m also, having Flat-Ends on each end so that they would snug fit between Geobag units. These Geotextile tubes were lowered and secured into position by divers and pumped from the surface using electric submersible pumps from a sand box located on board of the service tug. Figure 5 – Sand Box

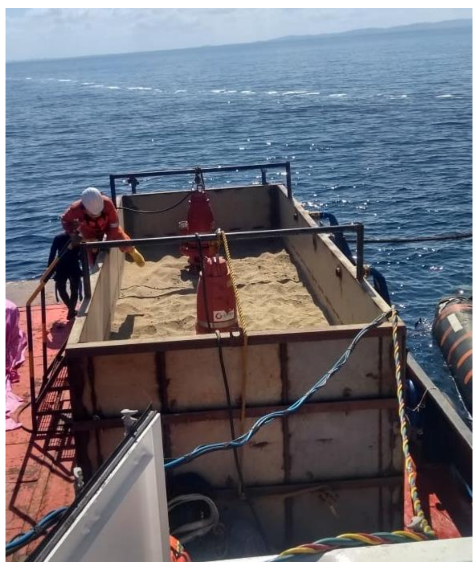


Figure 5 – Sand Box

4. RESULTS AND CONCLUSIONS

All Geobag units and Geotextile tubes were installed successfully and have provided support to all scoured sections. Installing the Geotextile tubes on the seabed by divers proved difficult as time was limited during each dive, yet it was achieved. Also, pumping the sand slurry 30m to the bottom was accomplished successfully.

Project was completed in 2019 and first monitoring will be made during the first quarter of 2020.

4.1 REFERENCES

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