



Boca de Briceño Approach Embankment

Briceño, Ecuador

The Impact® system effectively mitigated liquefaction on the foundation soils of an approach embankment, increasing its global stability during the April 16, 2016 Earthquake in Muisne, Ecuador, thus allowing the uninterrupted operation of the highway ensuing the earthquake.

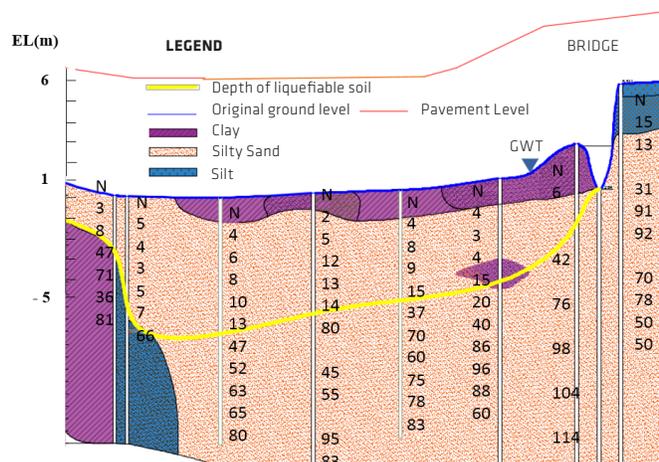
Project Description: The bridge overpassing the Boca de Briceño river is located near the municipality that carries the same name in Ecuador, 7km northwards from San Vicente. Its construction required an 800m long approach embankment of 4 to 6m in height. The highway was constructed between 2011 and 2012 with the objective of eliminating a “U” section, and to provide a scenic view throughout the coastal line. This artery constitutes a transportation project that goes from San Lorenzo (Esmeraldas Province) to Salinas (Guayas Province) and it is known as the Route of the Sun.

Geotechnical Conditions: The soil profile consists of 2 to 5m of loose silty sands underlain by dense silty sands with seams of hard clay and silts. The groundwater table was encountered at about 0.6m below ground surface.

Problem Statement: Due to the high seismicity in Ecuador, and the young nature of the foundation soils in Boca de Briceño, liquefaction as well as global stability issues were anticipated in case of significant ground motions and were considered for the design of the projected embankment.



Figure 1: Installation of the Impact® system on Boca de Briceño



Geopier Solution: The foundation soils of the approach embankment were reinforced with Rammed Aggregate Impact® Piers from Geopier. The Impact® piers were installed under the entire footprint of the approach embankment at varying spacing, depending on their location, at different depths according to the depth of the liquefiable layers. The company Pivaltec installed more than 6,000 Impact® pier elements with only one field crew. The pier elements were installed using a patented displacement system that avoids spoils and does not require groundwater abatement nor the use of casing, thus yielding high construction rates that allowed delivery in a timely manner.

Earthquake: In April 16th, 2016 a 7.8 magnitude earthquake struck the Pacific coast of Ecuador. The epicenter occurred in

Muisne, at about 112km from Briceño. Strong ground motions between 0.37 to 0.52g were recorded by the nearest strong motion stations. The natural disaster induced significant losses quantified in more than \$3,300 millions of dollars reflected in damage of infrastructure projects and at least 662 civilian casualties. Several embankments with similar foundation soil conditions, with no Impact® reinforcement, suffered damage due to liquefaction and eventual failure caused by global instability.

Results: After the earthquake, the integrity of the embankment supported with the Impact® system was not jeopardized whatsoever, displaying only negligible settlements and surficial cracks in the asphalt roadway that were not substantial enough to disrupt the traffic flow at any moment.

TYPICAL SECTION

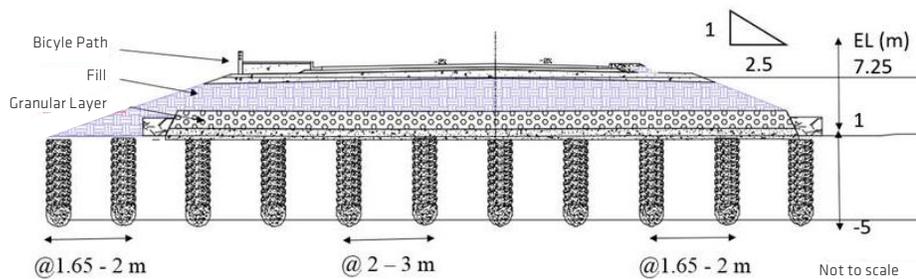


Figure 3: Typical cross section of the Impact® solution from Geopier Foundation Company



The Briceño embankment supported by Geopier Impact® piers.



The Mejía embankment that was not supported with Geopier ground improvement.