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Work Report:
Restoring the grout on the footings of the HTF Tanks.

Customer: UTE Andasol 3

Location: Autopista A-92 Km 312 CP. 18514 Aldeire-La Calahorra, Granada

Project: Restoring the grout on the footings of the HTF Tanks.

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Date: February 2015

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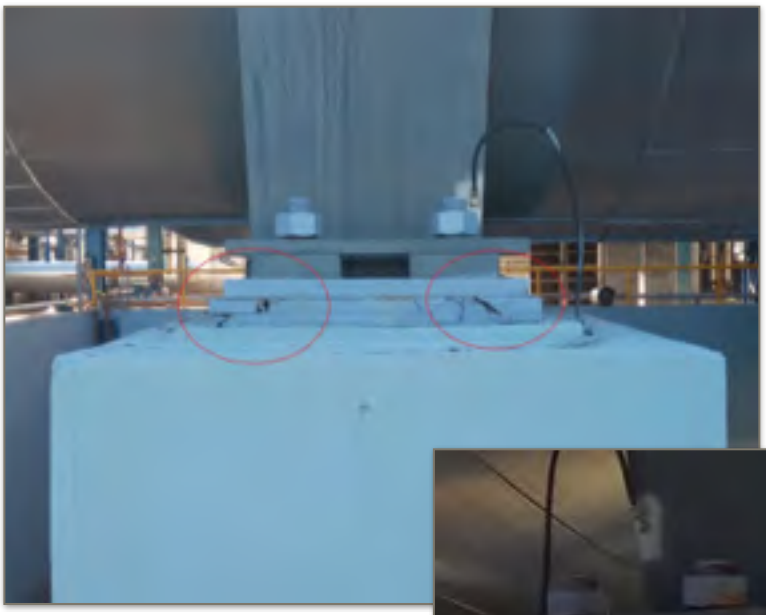
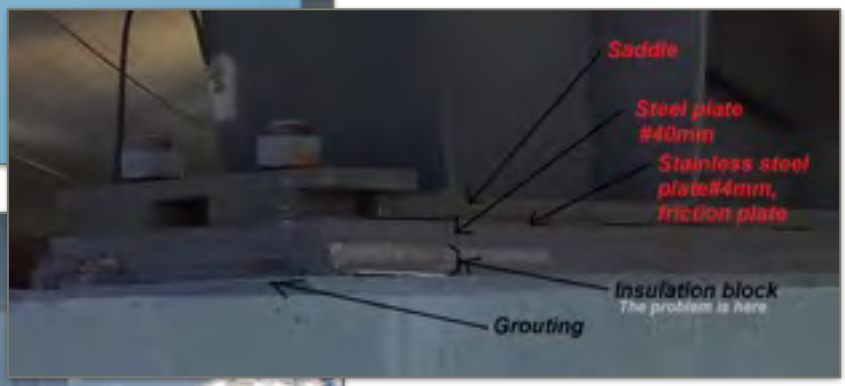
Previous situation, before repairs:

HTF tanks continuously move slightly due to a contraction/dilatation cycle, originated by its temperature changes, along with great changes in the HTF level which combined, exert considerable loads in the footings.



The anchoring+insulation system used for the moving supports is thoroughly deteriorated. The insulation part was designed and built using two different materials: two insolation plates and one cement grout which add up to approximately 110mm in thickness. There are also four M64 anchor bolts per footing, grade unknown, the saddle and the steelplate+friction plates.



The expansion of the tanks is approximately 2 cm on each side and if you add its contraction, you have roughly 4 cm of possible movement on each footing.

Assuming a friction coefficient for a steel-steel interface μ=0,7 (usual values in between 0,5 y 0,8) and a net weight of P= 170 tonnes, then τ= Fr/A= P·μ/A =0,35MPa . This calculation doesn't bring into account the effect of stress concentrators such as sharp corners or defective surfaces.

Any good cementitious grout upholds a shear stress resistance within the adhesion surface of 1.75 MPa, supposed ideal conditions (which *slightly* differ from in as built conditions). This shear forces, together with a laminated disposition installed without any bonding agent and the loose anchor bolts, was enough to induce a progressive cracking on the isolating material.

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In situ our team observed that the saddle, the steel plate and the isolation layers moved conjointly. This fact added dynamic friction to the crack party, degrading further and faster the isolating material.

After 40 years working experience, we recommend the use of epoxy grouts when high shear stress, compression/tension load cycles, adherence failures and vibration problems are expected, such as in this case. Our specially developed AT800 is the best choice because of his advanced technical properties (shear stress resistance 37.9 MPa, Compressive strength 100 MPa, Flexural strength 26,1MPa)

The steel baseplates were installed without rounded corners and act as stress concentrators.

The isolation plates under the central footings were in good condition, but it was decided to remove them and use AT800 instead for safety reasons.

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Repairing procedure:

The repairs were carried out to restore the integrity of the interface between the grout and the sliding plates, situated beneath the footings on both HTF Tanks. This repairs were designed for both tanks, our team working on parallel and for all the footings: six in total.

On February the 10th, our team arrived to Andasol 3 facility to check on the scaffolding, review the operations and coordinate activities for the following day.

Wednesday, February 11th:

We centred our first efforts on the footings facing south. Using pneumatic chippers, we got rid of enough material form underneath the sliding plate to be able to place the first Alphapad sized D2. The quantity of material removed was sufficient to ensure a proper levelled surface with healthy concrete, and not enough to change in any way the position of the saddle.

Three D2 Alphapads where installed on each foot.

After installing the alphapads, we situated a dial gauge on each anchor bolt to detect any relative movement between the saddle and the concrete below.

Once the Alphapads where installed, the pressure on all three of them was raised

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enough to lift the saddle, along with the foot of the tank, just enough to facilitate our job eliminating the rest of the defective material.

This procedure was carried out in due time on each of the footings. The biggest displacement observed was not bigger than 0.5mm, and it was compensated changing pressures on the alphapads, restoring the saddle to its proper height.

Thursday, February 12th:

It was a rainy day, pouring our AT800 on the first footings was out of the question. We continued placing Alphapads on the other side of both tanks, designed the formwork parts and tried them.

Friday, February 13th:

All surfaces that will be in contact with the resin were prepared:

- Clean saddle from paint and oils.
- All corners sufficiently rounded.
- Clean all surfaces, including the concrete from dust and any other pollutant.

Anchor bolts were also isolated from any contact with the epoxy grout using PE foam and duct tape, to allow its stretching while tightening them.

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Finished cleaning, formwork was installed in place and, once guaranteed water-tight conditions, we mixed and poured enough AT800 to cover up both saddle plates reaching a level 5 mm below the upper surface.

Saturday, February 14th:

The resin is sufficiently cured for taking out the formwork.

The rest of the defective material was eliminated from underneath the north footings in both tanks, and all surfaces are prepared as it was done in the first ones. anchor bolts were also covered in PE foam and another formwork was set in place.

It was possible to pour both footings early in the afternoon.

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While doing this, the dial gauges were always kept as a reference on the anchor bolts, to compensate any movement detected on the plates and correct them using the Alphapads.

All saddle plates where adjusted to have as much contact with the footings as possible.

Sunday, February 15th:

The formwork was removed and alphapads where placed in position for the middle footings. Once installed and pressurised, the rest of the isolation material and cement grout was removed.

Monday, February 16th:

The rest of the defective material was removed, surfaces cleaned, corners rounded, and formwork prepared and installed. When we were sure that no resin was able to leak, we poured the rest of the AT800.

Tuesday, February 17th:

The formwork of the central footings was removed, the corners of the resin were polished to create chamfers and filled all major hollows in the surface of the plinths.

A Shore hardness test was carried out in order to check if the resin had already cured. After ensuring that the curing process was above 90% (hardness was above 80 in multiple places), the pressure on the alphapads was relieved. Now the saddle plates rest on the grout and not on the hydraulic pistons.

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The forms were taken off and the team proceeded to take care of blemishes and other surface ind plinth imperfections:

- Polishing grout corners.
- Refilling holes, leaving the smoothest surface possible .

After taking off the pressure on the alphapads, the whole of the tank weight rested on the epoxy grout.

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About tightening requirements of the anchor bolts

Alphatec team was requested to take over the tightening process of the anchor bolts. The tools required for this job didn't came on time and were not available, so it was decided that this was going to be carried out by in-house personnel.

Alphatec advocates, for reciprocal or rotatory machinery, a tightening torque equivalent to in between 50-70% of the yield. Thus, the torque depends on the grade of the steel with which the anchor bolts are made.

- The HTF tanks are almost static, being the only movement the expansion/contraction due to temperature changes, so the condition 50-70%yield is an overestimation.
- Looking the in-built plans and *in situ* observations, we're certain that there is not enough free length for the bolts to stretch when tightened (they should have at least 400 mm free).
- Our works freed and protected at least 120 mm of the upper part of the bolts.

After this considerations, Alphatec's recommendation is to tighten the bolts up to 25% of the yield.

In Valencia, February 24th, 2015

Written by:

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Approved by :

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