

## Case Study

### Foundation Design Inco Europe Ltd.



Phone: 01639 775293

Website: [www.geotechnology.net](http://www.geotechnology.net)

Email: [info@geotechnology.net](mailto:info@geotechnology.net)



Geotechnology Limited  
Ty Coed Cefn-Yr-Allt, Aberdulais, Neath, SA10 8HE  
Registered in England and Wales No. 6497727

# Foundation Design

Inco Europe Ltd.

---

Many of the geotechnical commissions undertaken by Geotechnology support development proposals and largely concern foundation design. Geotechnology is therefore experienced in undertaking specific ground investigations to examine the reaction of the ground to the proposed imposed loading. The practice uses 3D software packages to provide estimates of the capacity of the ground to accept the proposed foundation loads, and the resulting settlement.

Geotechnology was recently commissioned by Inco Europe Ltd to undertake a ground investigation at the location of a proposed EST facility at its Clydach plant. Two tanks were proposed, each 14m in diameter and 9m high, weighing 2500 tonnes and equating to an average bearing pressure, when fully loaded, of  $159.6 \text{ kN/m}^2$ .

An initial investigation comprised two deep boreholes to rockhead, and during this investigation considerable variability in ground condition was noted. Made ground had been placed directly onto alluvial clays and silts, which rapidly became softer with depth. Significant thicknesses of gravels, sands and silts were encountered below the upper alluvium which was found to be highly variable in their nature, density and lateral extent. Soil samples were taken during the investigation for classification, consolidation and chemical laboratory testing.

Settlement assessment using the 3-dimensional settlement simulation software Settle3D was used to quantify expected settlements arising from elastic deformation and consolidation beneath the proposed tanks. Settle3D is a software tool for the analysis of settlement beneath flexible foundations, embankments, surface excavations and pile groups. Whilst the model is able to accommodate complex vertical soil profiles its principal limitation is that it assigns the same parameter to each depth.



# Foundation Design

Inco Europe Ltd.

The variable ground conditions encountered at the Inco site were responsible for producing significant differences in the amount of settlement experienced beneath each of the tanks and undermined the basic assumption of the model.

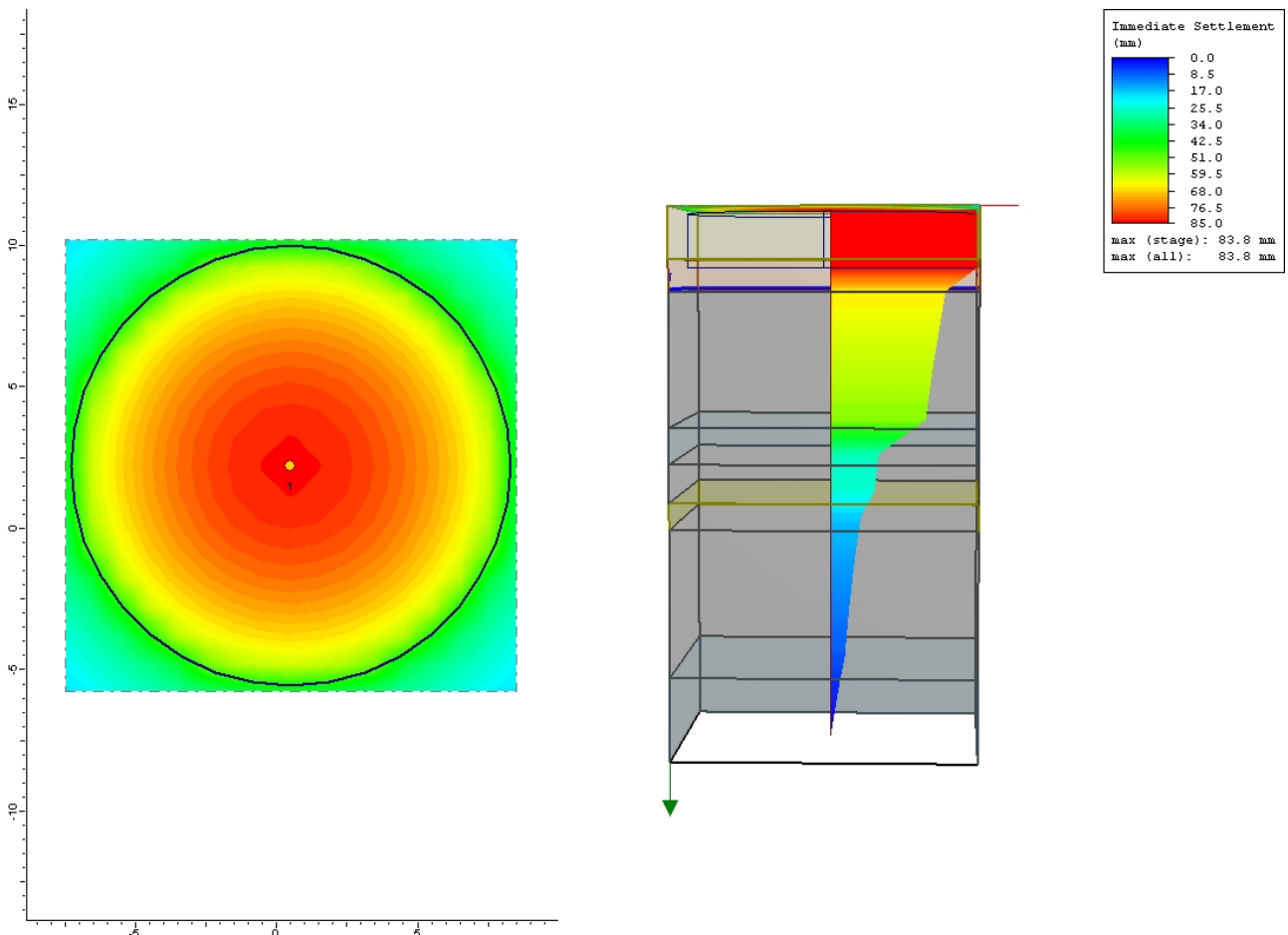
A supplementary investigation was commissioned, with the objective of refining the geological model, taking a more sophisticated approach to the settlement calculations and considering piles placed at an intermediate depth.

The second phase of investigation gathered a significant amount of additional data. Geotechnology used a sophisticated finite element model called Plaxis to evaluate the response of the ground to the tanks, and considered several possible foundation options including piles at

various depths. The simpler model used in the previous assessment was also used for validation purposes.

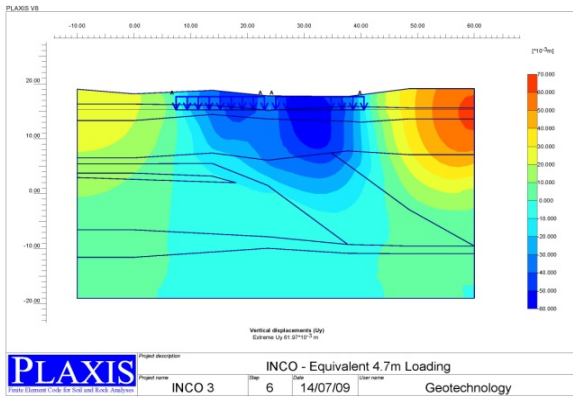
Plaxis allows geological sections to be input as they are encountered, and properties can be assigned to any shape on the section, allowing laterally variable ground conditions to be analysed. By applying loads from the structures at any part of the model the response of the ground to shallow or deep foundations, retaining walls and slopes can all be simulated.

The geotechnical behaviour of the various layers was established using a combination of laboratory and in-situ tests. To simulate the influence of pile groups the “Equivalent Raft” concept was used to calculate the depth and bearing pressure of a raft



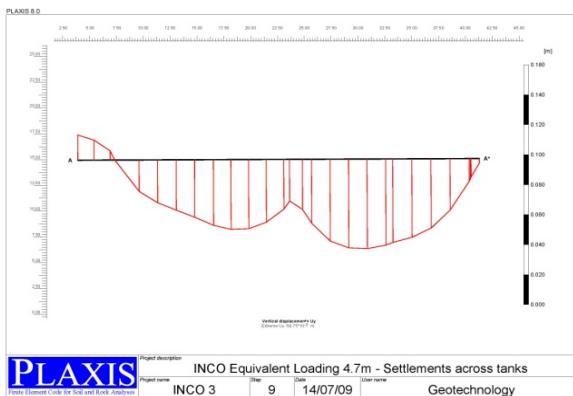
# Foundation Design

Inco Europe Ltd.



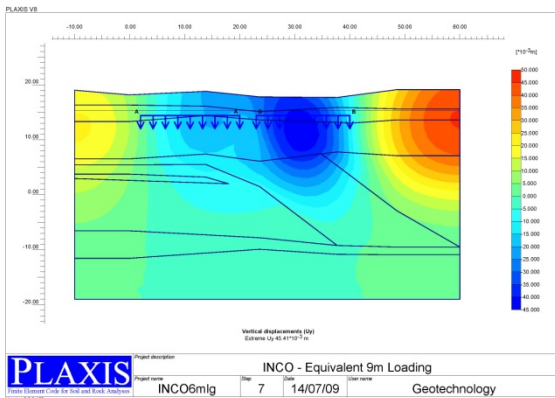
with equivalent settlement behaviour as the proposed pile group.

The result of the assessment showed that tanks would be subject to very large total and significant differential settlements if constructed on either shallow foundations or a pile group placed at an intermediate depth. Settlements varied within the assessment but typically settlements of 50 to 100mm were calculated.



It was considered that deep piles offered the only certainty to overcome the problem of total and differential settlements caused by both cyclical loadings of the tanks and varying ground conditions.

During the investigation an upper gravel horizon containing cobbles and boulders proved extremely difficult to pierce because of its very high density and the presence of cobbles and possibly boulders. This would also be a significant constraint on piling works.



It was considered that the only assured way of placing piles through the gravel band and down to rock would be to bore the piles. This would be more costly but offered assurance that the piles would be positioned correctly and that the tanks would not suffer from settlement upon filling or rebound upon emptying. Without settlement the integrity of the tanks and the associated pipework would be assured.

