An alternative method of assessing gas risk

CampbellReith re-assessed a Conceptual Site Model for housing on a landfill and adopted an innovative ground gas assessment resulting in detailed earthwork specifications which avoided land based gas protection and long term monitoring.

This project used an innovative method of ground gas risk assessment for residential development of a former landfill, which was based on assessment of the gas generation potential of soils rather than solely on gas concentrations. This resulted in the omission of land-based gas protection measures that had been specified as part of the original remedial strategy. In addition, it has removed the validation requirement for long-term post construction gas monitoring which thereby enabled rapid regulatory approval and site handover for development.

The project will eventually deliver 2500 houses for Crest Strategic Projects in Kilnwood Vale on the western outskirts of Crawley, together with a new school, commercial space, roads and infrastructure.

A large part of the 132ha development is on a former “inert” and fill, up to 16m deep. The development is being implemented in phases and Phase 2.1, which comprised up to 11m fill, has been completed and was the first to be subject to this alternative method of gas assessment. The fill soils were predominantly cohesive in nature but with variable amounts of organic and deleterious matter such as timber and alluvial soils, which required treatment to control both geotechnical settlement issues (particularly consolidation, creep and collapse compression). In addition, the significant methane concentrations rendered much of the landfill portion unsuitable for housing using conventional assessment.

As such, in order to “unlock” the site for development, an innovative engineering solution and reassessment of the Conceptual Site Model (CSM) were required that also considered the required time frame for development, cost benefit issues and complicated ground issues.

As the Design Engineer, CampbellReith assessed the range of design solutions available and following detailed negotiations with the client and technical stakeholders it was recommended that surcharging could provide a solution to the settlement issue; however, the previous remedial strategy for ground gas, designed by others and comprising a gravel venting trench, whilst appropriate for the assumed earthworks strategy at the time, could not now be accommodated. A fundamental re-appraisal of the CSM was therefore required and EPG were brought in to form a design partnership with CampbellReith to advise on the gas regime.

Earthworks design and implementation

Phase 2.1 comprised a large cut and fill operation to modify the irregular site profile. This involved net cut in the northern, historic landfill and net fill in the southern portion of site, which comprised natural ground. The maximum depth of residual Made Ground in the former landfill area, following earthworks, was 9m.

The geotechnical design of the surcharge solution relies on a low permeability layer beneath an engineered fill layer which ties into the underlying Weald Clay. This stops infiltration of rainwater into the underlying fill thereby preventing potential settlement. The previous gas remedial strategy comprised the installation of a granular venting trench beneath the engineered fill layer, together with stone
columns as part of the foundation solution. As such, this method was incompatible with the surcharge solution since it would allow water infiltration into the underlying fill materials.

**Reassessment of the conceptual site model**

During historical ground gas monitoring methane concentrations were regularly recorded above 20%, with several locations above 90%. Localised elevated flow rates were also recorded but carbon dioxide concentrations were below 10%.

Without a fundamental reassessment of the ground gas regime at the site it was likely that the gas results would be classified as CIRIA CS4 – CS6 / NHBC Red and therefore standard gas protection measures beneath the houses would not be sufficient and land based protection measures, such as a gravel blanket above the residual landfill material, would be required.

Standard concentrations at active landfills are of the order of 64% methane and 34% v/v carbon dioxide and this, together with historical assessments carried out by others, such as calculation of the biological and chemical oxidation demand ratios, indicated that the elevated methane concentrations and high flow rates were due to the way the landfill was constructed rather than the high organic load of the fill. Soils had been historically covered by cohesive clays and the ground gases generated from the organic portions were trapped. It was therefore proposed that gas generation was at a low rate and gas trapped in the soil pore spaces, which was released when the monitoring wells were installed.

**Forensic TOC vs traditional monitoring**

It was reasoned that measurement of ground gas in monitoring wells does not always give a suitable indication of the likely hazard because the gas concentration, pressure and flow rate measured in a well headspace may not be representative of conditions in the surrounding soils.

A more robust assessment of ground gas risk can be obtained by estimating gas generation from a source. The principal method incorporates determination of the percentage organic content of the fill material (not just the soil) via forensic total organic carbon (fTOC) analysis which is then used to calculate the potential emission rate of the soil. The emission rate can be converted to an equivalent borehole flow rate which therefore allows direct comparison against the CIRIA and NHBC classifications. For example, the upper threshold for CS3/Amber 2 sites, which is the maximum classification for standard gas protection measures, is 3.5l/hr.

The CIRIA and NHBC classifications are based on concentration and flow rate of ground gas in boreholes, which have been used to produce emission rate thresholds. These emission rate thresholds are, in turn, directly proportionate to the percentage fTOC of the soil and therefore it is possible to calculate fTOC thresholds for the CS/ NHBC classifications. For example, if the fTOC threshold is set at 4% for Made Ground soils less than 20 years old, then the site will be suitable for redevelopment if houses are provided with gas protection measures appropriate for CS3/Amber 2.

The use of fTOC in gas risk assessment was detailed by Steve Wilson (EPG) in publications such as the CL:AIRE research bulletin, RB17 and BS8485: 2015 and is compliant with current gas guidance, notably CIRIA C665.

Although RB17 was originally produced to allow simple screening of low risk sites, it has subsequently been used for high risk sites, including sites assessed under Part 2A of the Environmental Protection Act 1990. This is because the data collected for this method (fTOC, estimate of gas generation, etc.) enables a better understanding of soil chemistry, gas generation processes and the volumes of gas produced.

**Lines of evidence assessment and validation approach**

EPG provided advice on an appropriate validation methodology for the proposed remedial strategy and earthworks. This constituted a lines of evidence approach, comprising:

1. Sorting of soils excavated for re-use in accordance with the Specification for Highway Works (SHW), which was used to control the earthworks. This included removal of deleterious materials, including those with degradable content, followed by analysis of the soils to confirm <4% fTOC;

2. Trial pits across the surface of the residual landfill to visually observe the soils that would remain and take samples for fTOC analysis and drum tests;

3. Drum tests were undertaken to obtain actual gas generation rates from the soils on site. Large drums are sealed with a known mass of soil and then, through regular monitoring of the drums, a cumulative volume of gas is obtained and a gas generation rate calculated per volume of soil. The equivalent flow rate can then be calculated;

4. Surface emission monitoring via laser diode FID and flux chamber tests was carried across the excavated formation level of the surcharge area and the built up levels of the non-landfill reclaimed area; and

5. Short term validation borehole monitoring was carried out.

The results were assessed to provide an estimate of the likely emission rate potential of the soils and hence the gas protection measures required. Based on the results it was possible to divide Phase 2.1 into three areas according to their gas protection requirements: CS1, CS2 and CS3. The results categorically proved that land base protection measures were not required.

**Conclusions**

A methodology was developed which enabled a reassessment of a Conceptual Site Model via innovative guidance for ground gas assessment. This removed the need for site wide land based gas protection and instead enabled the development of housing with standard gas protection. Validation methods comprising forensic TOC, drum tests and emissions surveys were incorporated into the more familiar SHW method which enabled closure on completion of the earthworks. This brought significant programme benefits and by removing the need for post construction monitoring and obtaining rapid regulatory approval the Client went from outline design to completed development of Phase 2.1 in under 12 months with associated cost savings.

The key to the successful application of the works was a detailed, bespoke earthworks specification and significant liaison between CampbellReith, the designer and employer’s representative who had a full time on site presence, and Dunton Environmental Limited, the earthworks contractor.

The information from Phase 2.1, in terms of settlement parameters and ground gas risk, is now being fed into the subsequent phases of design and development in order to economise the design.

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