

M9 Spur Extension/A90 Upgrading. Consolidation of Mine Workings

Client: The City of Edinburgh Council
Engineer: Scott Wilson Scotland Ltd
Value: £6.9million

The scheme required the treatment of oil shale workings beneath part of the proposed 'M9 Spur Extension/A90 Upgrading' road scheme on the approach to the Forth Road Bridge. Multiple seams of oil shale have been extensively worked beneath this part of the site as confirmed by old mine plans. The seams were each up to 2.6m thick, steeply dipping across the site from outcrop to 60m. A mixture of broken ground, large voids and open workings were treated.

The new road scheme design included the construction of embankments and bridge structures at this location which will produce high ground loadings, and therefore the specification for the consolidation works was developed to ensure the complete treatment of each seam and areas of migrated collapse. This included the requirement to treat the lowest seam first, followed by the successive treatment of the upper seams. To ensure this was properly achieved all boreholes were required to be cased concurrently with drilling, initially for the full hole depth, thus guaranteeing a sealed primary casing and the insertion of grouting tremmie into the correct position to treat the working. The primary casing was subsequently withdrawn to the level of the next seam which was then treated. **We were in a unique position amongst tendering contractors of being able to guarantee that this specification requirement could be met by utilising our Casagrande C6S & M9 'dual head' drilling rigs. The rigs have 2 high torque drilling heads which allows simultaneously drilling with rods & casing ensuring a one pass, clean, fully cased hole is achieved.**

Brief description of work;

- Site clearance and topsoil strip to the 6.8ha site.
- Construction of 1km surface access road to the site area including provision of wheelwash. Also construction of 1km of hardcored site access and treatment area service roads.
- Establishment of large site compound, office and welfare set up.
- Provision of 60m x 60m surfaced materials storage and mixing compound. The compound was container surrounded to provide material containment, dust suppression and noise reduction. The mixing compound was situated 500m from the treatment area.
- Establishment of high capacity grout batching plant and pumping equipment to cater for the expected 85,000 tonnes of grout. This consisted of a Bellmix twin shaft pug-mill mixing unit of 130m³/hr output with feed hoppers & conveyors, twin 50t cement silos and screw feeders. Mixed grout was discharged into the hoppers of Schwing BP3000 static concrete pumps.
- Grout was pumped 500m to a 9m³ mobile grout agitation/pumping unit situated in the treatment area where it was distributed to boreholes by 4 no Gardner Denver grout pumps.
- Grout for the 300m long barrier was pfa/sand/cement. Any significant voids were filled with pea gravel which was injected via the drill casing. Infill grout was pfa/cement



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- Drilling work involved the completion of 3500 boreholes, up to 60m deep, for consolidation works which included probe holes, monitoring, barrier and infill holes. Drilling work was carried out to an agreed sequence with barrier holes completed first at the lowest point of the mine.
- 10 drilling rigs, including 8 'dual head' rigs were resourced to site. Holes were drilled with 139mm OD casing using down-hole hammer and eccentric drilling systems with air/water mist as the flushing medium. The dual head system allowed returned drill flush/cuttings to be piped directly to enclosed skips ensuring a completely clean drilling process. The chosen casing size allowed the hole to be immediately used for any purpose including gravel injection without the need for any re-drilling or enlargement.



- Grout injection was carried out to strict specification requirements, hole and stage sequences with limits on grout quantity and pressure to ensure full treatment of each working. Continuous monitoring and recording of injected quantity and pressure was carried out together with extensive quality control and testing of mixed grout.

A broad range of protection measures were established to ensure there was no pollution to the existing brook courses which ran adjacent to both the mixing plant and the treatment areas, either from displaced mine water, surface water or run off from the grouting compound. Cuttings collection skips, ditches, transfer pumps, settlement tanks and 'siltbuster' units provided the necessary protection. Cleaned site water was either re-circulated for mixing or drilling purposes or was discharged to brook course under a consent from SEPA.

Discussions were held with SEPA prior to works commencement to agree the surface water protection measures and regular liaison took place throughout the contract. Part of this regime included QA procedures for water testing to ensure the discharge consent was met. The siltbuster units were also set up with dosing facilities to ensure quality targets were met.



The oil shale seams outcropped on the southern edge of the site and this area of geotechnically unsuitable material was excavated and replaced with engineered imported clean fill following the completion of the consolidation works.