Midland Metro - Wednesbury to Brierley Hill Extension Mine Workings and Mine Shaft Location & Treatment

Project Profile

Client: Midland Metro Alliance

Designer: Johnson Poole & Bloomer

Value: Phase 1 - £712k
Phase 2 - £1.7M

The 11km Wednesbury to Brierley Hill Midland Metro extension branches off the current West Midlands Metro line just east of the Wednesbury Great Western Street Metro stop, before heading through Tipton and Dudley on its way to Brierley Hill. The route, which mainly follows a section of disused rail line, includes 16 Metro stops and is being constructed for Transport for West Midlands (an executive body of West Midlands Combined Authority).

Desk Studies and Phase 1 Investigation works had identified a number of areas affected by shallow coal workings and mine shafts affecting the scheme footprint (see page 3 for details) and the Phase 2 Mine Workings Stabilisation contract was carried out to stabilise the shallow workings under structures and to locate and treat the mine entries along the route.

Treatment designs, specifications and drilling grids were determined by the Client MMA and designer Johnson Poole and Bloomer. Treatment of the shallow workings was undertaken by drilling and grouting on a 6m grid with centre secondary holes, to a maximum depth of 35m. Shaft probing was completed on a 1.0m spiral grid.

The scheme was split into 7 main sections within which there were 42 potential shaft locations and 2 areas of shallow mine workings requiring treatment.

In summary the work completed included:

- **Shallow Mine Workings treatment**
  - ◊ 221 boreholes drilled (8,700 metres of drilling).
  - ◊ 365 tonnes grout injected (10:1 PFA:OPC).
- **Mine shaft location and treatment**
  - ◊ 42 mineshaft locations were probed involving 15,174 probe holes (195,200m of drilling).
  - ◊ Over 40% of probe holes were angled at up to 45°.
  - ◊ 14 shafts were located and treated to depths up to 76m requiring 52 treatment holes (2,184m of drilling).
  - ◊ 2 void shafts were filled with 580 tonnes of 10mm gravel.
  - ◊ 651 tonnes of grout injected (10:1 PFA:OPC).
  - ◊ Grout caps were completed to stabilise the fills above the treated shafts with 1,646 holes drilled (15,924m of drilling) and 205 tonnes grout injected (10:1 PFA:OPC).

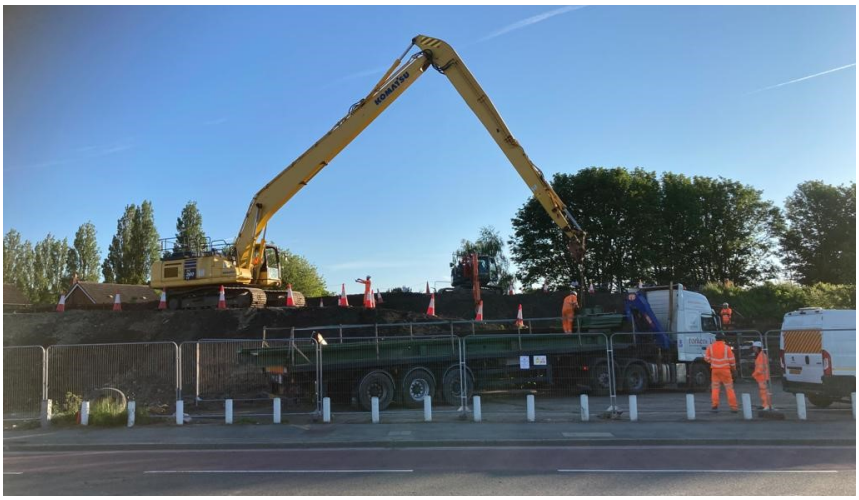
Midland Metro - Wednesbury to Brierley Hill Extension Mine Workings and Mine Shaft Location & Treatment (Cont'd)

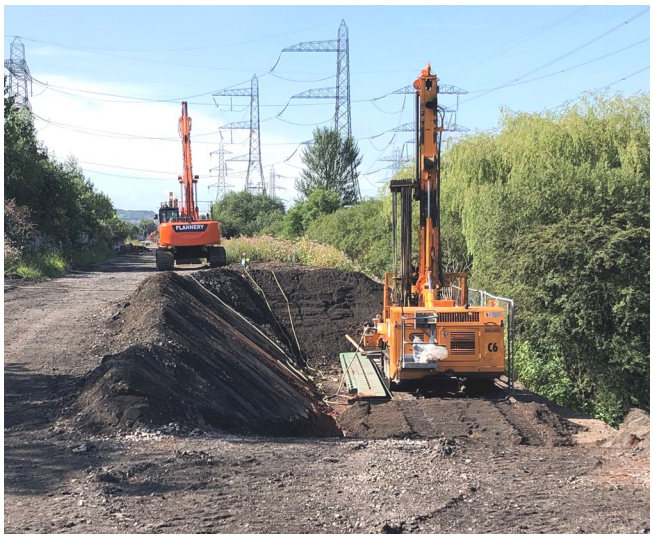
Project Profile

Client: Midland Metro Alliance

Designer: Johnson Poole & Bloomer

Value: Phase 1 - £712k
Phase 2 - £1.7M





- Grouting compounds were set up in each treatment area along the line of the route. The set up included provision of water storage tanks, water feed and grout pipelines to service the whole of each area.
- Preparation of working areas was completed by MMA and included installation of drill flush and surface water collection trenches & sumps, silt fencing and creation of drilling platforms.
- Shallow mine workings treatment boreholes were drilled with 101mm OD rotary percussive steel casing (a specified requirement), drilled and sealed into rockhead followed by drilling a 75mm open hole to full depth.
- Treatment of shallow mine workings areas was commenced from the down-dip side of the treatment area.
- Due to the location of identified shaft positions and constraints on available working areas, a significant amount of inclined drilling was required (>40%) to complete probing of all shaft locations. Inclined probe holes were cased to rockhead to prevent hole collapse.
- Our Klemm KR904 and Casagrande C6 geotechnical drilling rigs have versatile kinematics and extending guard arrangements to allow a full range of drilling angles and positions to be achieved.
- Treatment of all shafts was carried out from purpose built drilling safety platforms to ensure protection should a collapse occur during drilling (see photos).
- Filling the void shafts utilised a conveyor system to feed gravel to the shaft platform to avoid loading the collapse risk zone
- Grout caps were constructed above treated shaft positions due to the depth of overlying fills
- Water flush was used for all drilling with water piped to drilling rigs via a delivery main along the treatment areas. The rigs are also equipped with on board water pumps to ensure optimum hole flushing.
- Grout was mixed in 2.5m^3 hydraulically driven batch mixers then distributed directly to treatment area grout holes using peristaltic hose pumps.
- The grout mix used for mall applications was 10:1 PFA/cement and recording of injected quantity and pressure was carried out together with quality control and testing of mixed grout (flow, bleed and cube tests).
- During the workload peak up to 12 drilling rigs were resourced to site, together with 7 grout mixing set ups requiring over 30 personnel.
- All drilling and grouting plant and equipment was resourced from our specialist in-house plant fleet.
- Our works programme was co-ordinated and phased carefully with MMA to ensure that there was no impact upon other concurrent or programmed works.

Midland Metro - Wednesbury to Brierley Hill Extension Mine Workings and Mine Shaft Location & Treatment (Cont'd)

Project Profile

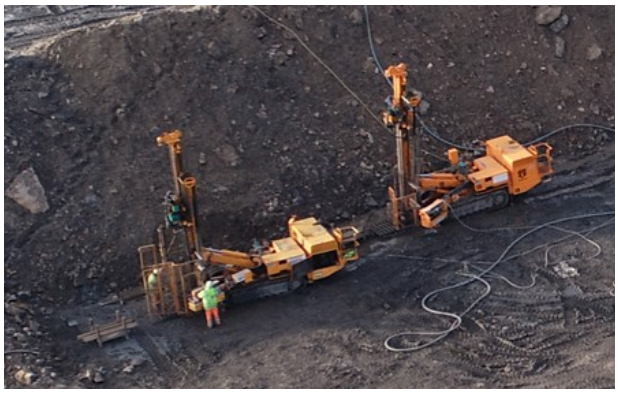
Client: Midland Metro Alliance

Designer: Johnson Poole & Bloomer

Value: Phase 1 - £712k
Phase 2 - £1.7M

In advance of the mineshaft location and treatment works, Forkers were engaged by MMA to undertake a series of site wide site investigation works, carried out in 6 sections primarily to help inform elements of structural design, but also to identify historical mining legacy issues that could impact the progress of the enabling phase of the works. Investigation works commenced at Delta Junction in Wednesbury during April 2019 and progressed along the proposed corridor towards Merry Hill over a period of 12 months in the stages identified below:

- Phase 1 Delta Junction.
- Additional investigation Wednesbury section.
- Mineshaft probing Danks Way.
- Sedgley Road East shaft treatment.
- Delta Junction mineshaft treatment.
- Track monitoring (Delta Junction shaft treatment).



The site investigation work consisted of:

- Rotary drilling including open hole and coring – 17no boreholes (800m) with core logging and photographs.
- Mineshaft probing – 200no probe holes (2,200m).
- Cable percussive boreholes – 16no (150m) with sampling.
- Cone penetration tests – 13no (120m).
- Dynamic Probing - 6no (60m).
- Window sampling – 4no (20m) with sampling.
- Mechanical trial pitting – 4no with samples taken for soils analysis.
- Location and treatment of 3no previously located mineshafts to 50m depth, drilled twice, 30 tonnes of 10:1 PFA/Cement grout injected, no capping.
- Logging and reporting was carried out by our in-house geotechnical engineering staff.
- 3 no. Casagrande C6S dual-head rotary drilling rigs were deployed to undertake both open holed and cored boreholes.

Specialist track monitoring was also implemented to the existing Metro infrastructure at Delta Junction to enable probing and subsequent treating of mineshafts within influence of the track. These works were undertaken successfully at night during limited shutdown windows. The 2 phases of track monitoring required were:

1. During the first SI phase when drilling in close proximity to structures - 11 weeks.
2. For treatment of 3 mineshafts on the metro embankment - 10 weeks.

Significant stakeholder liaison and traffic management was required throughout to enable the successful completion of these investigation and treatment works.