Technical Note

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Project title	Manchester Life - Loom Cotton (Murray's Mills)	Job number	235055-00
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Subject	Loom Cotton – Ground Gas Risk Assessment and Performance Specification		

1 Background

This technical note summarises the findings of a review of the available ground gas information for the Loom Cotton (Murray's Mills) site in Ancoats, Manchester, following the development of a scheme for redevelopment of the site for residential use.

The site is occupied by existing cotton mill buildings arranged around a central courtyard and former canal basin. It is proposed to convert all the existing buildings into several residential apartments. A new residential apartment block is proposed to be constructed along the Bengal Street side of the site, to be called 'Wing Mill'.

2 Available Ground Gas Data

The data for ground gas at the site was obtained as part of a ground investigation carried out by Structural Soils in 2013. Six rounds of gas monitoring were completed between 9th October 2013 and 30th October 2013 in nine standpipes (approximately weekly monitoring frequency). Atmospheric pressures during the monitoring ranged from 997 to 1016mb. The response zones of the monitoring wells were predominantly within the Made Ground, although three standpipes had response zones within the Glacial Till. The results of the gas monitoring are summarised in Table 1, below.

Table 1 Summary of Ground Gas Monitoring Data

Monitoring Well	Response Zone	Max CH4 % v:v	Max CO2 % v:v	Max CO ppm	Max H2S ppm	Max Flow l/hr	Maximum Characteristic Situation
BH101	Sand (Till)	0	14.1	4	0	-4	CS2
BH102	Made Ground/ Till	0	0.3	1	0	-5	CS1
BH103	Made Ground	0	8.6	6	0	0.5	CS2

Monitoring Well	Response Zone	Max CH4 % v:v	Max CO2 % v:v	Max CO ppm	Max H2S ppm	Max Flow l/hr	Maximum Characteristic Situation
WS101	Clay (Till)	0	1.8	4	0	0.2	CS1
WS102	Clay (Till)	0.1	1.6	5	0	-0.2	CS1
WS103	Made Ground	0.1	0.3	5	0	-0.1	CS1
WS104	Made Ground	0	0.7	0	0	0.1	CS1
WS106	Made Ground*	1.8	1.6	6	0	-0.5	CS2
WS108	Made Ground	0	0.3	5	0	0.1	CS1
*Made Ground had a hydrocarbon odour and a visible oily sheen at this location							

In addition to the data collected by on-site measurement, the UK Radon interactive map has been viewed to assess the potential for naturally-occurring radon gas within the site[1]. An extract of the radon map is shown in Figure 1, below, and indicates that the site is located in an area where between 1 and 3% of homes are affected by radon gas.

Figure 1 UK Radon Map Extract



2.1 Data Adequacy

2.1.1 Frequency of Monitoring

The guidance provided in CIRIA Report C665 recommends monitoring frequencies based on the potential gas generation of the source and the sensitivity of the proposed end-use. In the case of the Loom Cotton site, the only known potentially significant hazardous gas source within the site is the Made Ground (historical fill), which can be a source of methane, carbon dioxide and carbon monoxide. The site is underlain by bedrock of Triassic Sherwood Sandstone and no shallow coal mine workings are believed to be present beneath the site, which may otherwise be a potential

[1] http://www.ukradon.org/information/ukmaps/englandwales accessed 24th February 2015

source of ground gas. The Made Ground source is considered to be of low gas generation potential, as observations made during the ground investigation of the physical nature of the material did not indicate any significant quantities of degradable materials such as organic matter. The proposed end-use (residential flats) is considered to be of moderate sensitivity, in accordance with the CIRIA guidance.

For a site with low gas generation potential and moderate sensitivity of end-use, the CIRIA guidance recommends 6 gas monitoring visits carried out over a period of 3 months.

Atmospheric Pressure

The CIRIA guidance recommends that monitoring is carried out when atmospheric pressure is low or falling on at least two occasions. The gas monitoring records do not state whether atmospheric pressure was rising or falling on the days of monitoring, however, half of the rounds were carried out during periods of low pressure (around 1000mb or below).

2.1.2 Radon

The UK Radon interactive maps present a simplified version of the Radon Potential Dataset for Great Britain, in that the radon potential in each 1 km grid square is classed according to the highest radon potential found within it. The Loom Cotton site lies just within a 1km grid square in which between 1 and 3% of homes have radon concentrations above the action level. In order to investigate this further, a radon report was obtained from the British Geological Survey (BGS) which is specific to the site address. The report (see attached) confirms that no radon protective measures are required at the site. Therefore, the potential risks associated with radon gas have been discounted from further assessment.

2.2 Ground Gas Regime

Based on the available data and using the methodology set out in CIRIA C665, the majority of gas screening values calculated for the Loom Cotton site fall within Characteristic Situation 1. Two peak readings of carbon dioxide of 14.1% v:v (BH101) and 8.6% v:v (BH103) were recorded on one occasion which would result in a Characteristic Situation 2, but no gas flow was recorded in either standpipe during that monitoring visit. All other carbon dioxide readings were less than 5% v:v and typically much lower than this.

Two peak methane readings of 1.0 and 1.8% v:v respectively were recorded in WS106. Lower concentrations of methane (<1% v:v) were detected in this standpipe on all monitoring visits, together with low (<2% v:v) concentrations of carbon dioxide. Gas flows were typically negligible. The standpipe in WS106 was installed with a response zone in Made Ground. Hydrocarbon contamination was noted in the Made Ground during drilling of the borehole, comprising a hydrocarbon odour and an oily sheen on the soil and groundwater. It is very common for hydrocarbon vapours to give a ‘false positive’ methane reading, due to way the gas detection equipment operates. It is likely that the methane detected in WS106 is, in fact, vapour from a heavier hydrocarbon (e.g. oil/diesel). The presence of carbon dioxide would be expected as a by-product of the aerobic biodegradation of hydrocarbons in soil and groundwater. The ground conditions in WS106 are not typical of the remainder of the Loom Cotton site, and indicate some localised issue with hydrocarbon contamination, which requires further investigation. WS106 is located where the proposed Wing Mill block is to be constructed; therefore, investigation of this ‘hotspot’ can be carried out during the ground preparation works for this new building.

It is not standard practice to generate GSVs for gases other than methane and carbon dioxide, therefore no GSV has been generated for carbon monoxide (CO) which has been detected in all monitoring standpipes, but the results have been compared against the Workplace Exposure Limit (WEL) as an initial screen. The 8 hour WEL for carbon monoxide is 30ppm, compared to the maximum recorded concentration of 6ppm. Carbon dioxide, at concentrations substantially in excess of the relevant 8 hour WEL of 0.5% v:v, is therefore considered of most relevance.

Some strong negative gas flows (up to -5 l/hr) have been recorded in two standpipes which have response zones within the natural superficial deposits. Negative flows can sometimes result from falling groundwater levels, which can have a 'piston effect' within the monitoring well. The groundwater levels in all standpipes fluctuate slightly, but no correlation between strong negative flows and falling or rising groundwater levels has been identified. The strong negative flows do not occur in all standpipes sealed into the natural superficial deposits either. Negative flows indicate that gas is flowing into the ground, rather than out of it, but if gas can flow into the ground at this rate, it could also flow out at the same rate.

Based on the detailed interpretation of the data above, the overall gassing regime at the site is assessed to be borderline Characteristic Situation 1/2. Although the majority of gas measurements indicate Characteristic Situation 1, the lower than recommended frequency of monitoring for the proposed end-use, the fact that a peak carbon dioxide reading of 14.1% v:v has been detected and the occasional strong negative gas flows suggest that ground gas, particularly carbon dioxide, may pose a potential risk to the proposed residential development.

2.3 Requirements for Gas Protection

On the basis of the above assessment, gas protection measures will be required for all buildings, both existing and new.

The CIRIA guidance states that a typical scope of gas protection for a residential building in Characteristic Situation 2 should comprise either:

- a reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200g DPM (all joints and penetrations sealed) and underfloor venting, or
- Beam and block or pre-cast concrete and 2000g DPM/reinforced gas membrane and underfloor venting (all joints and penetrations through slab to be sealed).

2.3.1 Existing Buildings

The three existing mill buildings each have a basement level where residential apartments are to be located; therefore ground gas has the potential to enter the space through the walls as well as the floor. All existing buildings are to be provided with a new ground-bearing slab with a DPM, which can also serve as a gas membrane and will prevent gas from entering the building through the floor. It is recommended that a 2000g membrane (or equivalent proprietary reinforced membrane) is used in preference to a 1200g membrane in order to limit the potential for damage to the membrane during construction. The requirement for underfloor venting cannot be achieved given that the gas protection is to be retro-fitted inside existing structures. In addition, as the buildings are listed, no alterations such as external vents can be made to the façades and no holes can be made through the external walls for venting pipes to pass through.

With regard to the potential for gas ingress through the sub-basement walls, the design currently allows for a drained ventilated cavity against the external walls to deal with any groundwater ingress. Current proposals are to use 'Hydroduct' cavity former for this purpose, which is fixed to

the external walls using a proprietary fixing designed to seal the passage of gases. Therefore, the Hydroduct cavity former will function as a gas barrier on the external walls. It is proposed to seal the underslab gas membrane to the Hydroduct cavity former to provide a continuous seal so that ground gases cannot enter the cavity. This detail is shown on the attached drawings.

In addition, all habitable areas of the existing buildings and the bin store area will be mechanically ventilated with a combination of positive and extraction ventilation, which will limit the accumulation of ground gases in the sub-basement living areas. The circulation areas are to have natural ventilation only.

2.3.2 New Building (Wing Mill)

The Wing Mill building (Bengal Street block) is to be a new building with a cast in-situ reinforced suspended slab. There is a difficulty with providing ventilation beneath the slab due to architectural and archaeological constraints; the façade of the building facing Bengal Street is on the site boundary and therefore a venting trench cannot be provided as it would be within a public highway. The provision of periscope vents is not practicable as the façade is to be constructed of pre-cast concrete.

In accordance with the guidance provided in British Standard BS8485:2015, the building is considered to be a Type B structure (residential apartments within a managed development, small areas) which, for a CS2 gas risk would require 3.5 points of protection. Given the constraint with providing ventilation below the slab as described above, it is proposed to provide a 2000g membrane, which will include verification to the standards described in CIRIA Report C735 (see below), together with a cast in-situ well reinforced slab with minimal service penetrations. These measures will provide the required level of protection as set out in BS8485:2015, and will be enhanced by the fact that the ground floor contains only concierge space and circulation areas, with no residential accommodation, and mechanical ventilation is to be provided to many of the ground floor areas.

2.3.3 Validation requirements for gas protection

The Principal Contractor will be responsible for agreeing the detailed scope of validation with MCC Environmental Health, however, the validation procedures set out in CIRIA report C735 are to be adopted. This will include verification of the gas membrane installation by an independent third party Engineer, who shall be appropriately qualified and is to be appointed by the Principal Contractor.

The gas membrane is to be installed by Specialist Installation Contractors who are trained in the installation of the particular products being used, together with appropriate CQA procedures.

Details of the proposed membrane, ancillary products and proposed installation methods must be supplied by the Specialist Installation Contractor. Data sheets for the membrane should be supplied.

The independent third party verification Engineer shall be required to inspect the membrane installation at key stages, including immediately prior to all concrete pours, to ensure that the membrane has not become damaged by follow-on trades. All joints in the membrane, pipe penetrations and any other penetrations through the membrane shall be independently verified by air lancing to ASTMD4437.

Upon completion of the installation, as-built details of the gas resistant membrane, including an installation report, testing certificates and results of materials supplied, inspection records and as-

built drawings should be provided to the independent third party Engineer for inclusion in the verification report as specified in CIRIA C735. The content of the verification report should also be in line with GMPPP BN01:2008[2].

The verification documentation should document whether the measures pass or fail and should be supported by photographic evidence, membrane specification, integrity retesting and as built construction details. The verification report is required to be submitted to the local authority and the Principal Contractor for their approval and discharge of the relevant planning conditions.

3 Summary

The gassing regime at the site is assessed as borderline Characteristic Situation 1/2, in accordance with the guidance provided in CIRIA Report C665. This assessment is based on the results of on-site gas monitoring and a review of the adequacy of that data. A summary of the requirements for gas protection is provided in Table 2 below.

Table 2 Summary of Required Gas Protection Measures, Loom Cotton

Building	Requirements for Gas Protection
Existing mill buildings with sub-basements	Well-constructed cast in-situ ground bearing slab with minimum 2000g membrane (or equivalent proprietary membrane) Membrane installation to be completed by qualified installation contractor, with independent third party validation including visual inspections, CQA and air lance testing of all joints, service penetrations and other penetrations through the membrane. Mechanical ventilation to all habitable areas
Existing mill buildings without sub-basements	Cast in-situ ground bearing slab with minimum 2000g membrane (or equivalent proprietary membrane) Mechanical ventilation to all habitable areas
New building (Wing Mill)	Cast in-situ well reinforced slab with 2000g membrane (or equivalent proprietary membrane) and minimal service penetrations Membrane installation to be completed by qualified installation contractor, with independent third party validation including visual inspections, CQA and air lance testing of all joints, service penetrations and other penetrations through the membrane. Mechanical ventilation provided within main ground floor areas.

Given the borderline CS1/2 classification for the site, the combination of these measures together with robust third party validation of installation is considered adequate to deal with the potential risk of ground gas ingress into the new buildings. This detailing is subject to agreement with MCC Building Control and Environmental Health departments.

The hydrocarbon contamination identified previously within the proposed footprint area of Wing Mill, will be dealt with as detailed in the Outline Remediation Strategy prepared by Arup.

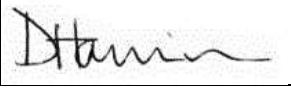
The D&B contractor will be required to install and validate the proposed gas protection measures. Further detail on the recommended gas protection measures and performance specification are included in Appendix A.

[2] GMPPP BN01/2008, Development on Land Potentially Affected by Hazardous Ground Gas

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Appendix A

Gas Protection Measures
Performance Specification

Subject Gas Measures Performance Specification

Date 14 August 2015 Job No/Ref 235055-00

1.1 Introduction

Guidance on the general development of the gas protection solution should be based on the following documents:

- CIRIA C665 Assessing Risks Posed by Hazardous Ground Gases to Buildings
- BS8485:2007, Code of Practice for the characterisation and remediation of ground gas in affected developments [1].
- CIRIA R149 Protecting Development from Methane
- BRE BR212 Construction of new Buildings on Gas-Contaminated Land.
- CIRIA R139 Water Resisting Basement Construction. A Guide
- BS 8102:1990 Protection of Structures Against Water from the Ground
- DETR Passive Venting of Soil Gases beneath Buildings. Guide for Design. Volume 1
- BRE BR414 Protective measures for housing in gas-contaminated land.

This note forms the appendix to the ground gas risk assessment and specification produced by Arup. The risk assessment was undertaken in accordance with CIRIA guidance document C665 [2] classified the site as borderline Characteristic Situation 1/2.

A Specialist Contractor is to undertake detailed design of the membrane and membrane detailing. Recommended scheme details, based on the current understanding of the gassing regime, are outlined in the following sections.

1.2 Membrane Properties

Gas resistant membranes are to be fitted by a specialist contractor. Where gas resistant membranes are to be used as part of the protection measures, the membrane will be continuous, and must be cut, laid and sealed in accordance with the specialist manufacturer's details.

Horizontal membranes will be laid on top of either a sand or aggregate blinding layer to prevent damage to the membrane. The area to be covered must be cleared of any sharp objects, stones etc and all steps protrusions and edges must be levelled and smoothed with appropriate materials.

Any concrete that requires the membrane to be adhered to it must be smooth and free from sharps and steps.

The membrane shall have sufficient mass/unit area to withstand the method of construction. The membrane for the existing buildings and Wing Mill shall be no less than 2000 gauge, and be effectively impermeable to carbon dioxide, methane and Volatile Organic Compounds (VOC) in vapour form. It is recommended that a 2000 gauge membrane is used in order to withstand potential damage during installation. The membrane should have a maximum methane permeability of 0.001 l/m²/day. The membrane is also required to act as damp proof membrane, and must have good tear and resistance properties.

Technical data sheets should be provided for all materials specified, including tensile strengths and gas resistance parameters. A full method statement and details should be provided regarding the installation of the protection measures to the Contract Administrator for approval prior to installation.

The membrane must extend across any cavity walls and encompass the entire floor footprint of structures.

1.3 Membrane Protection

The membrane must be carefully laid on a suitably prepared surface and sealed to manufacturer recommendations (sealing must be done with proprietary tapes or heat bonding).

The membrane should be protected against damage by follow on trades as soon as reasonably practicable. A visual inspection of the membrane should be conducted immediately prior to covering and any damage made good with repair patching in accordance with the manufacturer recommendations.

Protection boards should be used where the membrane is applied to vertical surfaces for protection against backfill material. The protection must remain fully in contact with the membrane and must not move during backfilling.

1.4 Membrane Detailing

The design should include details of measures required for the sealing of all joints and service entries and ducts, to ensure no leakage occurs e.g. overlapping, taping, welding and the use of proprietary preformed "top-hat", pipe collar and column cloak systems. The proposed design should also address details of the waterproofing properties of the membrane. Technical data sheets should be provided for all materials specified, including tensile strengths and gas resistance parameters. A full method statement and details should be provided regarding the installation of the protection measures to the Contract Administrator for approval prior to installation.

1.5 Integrity Testing

Integrity testing is to comprise installation by specialist installation contractors with appropriate CQA procedures and verification (see **Section 2**). The Contract Administrator should be notified at when inspection are taking place so an engineer can be made present if required. The contractor is responsible for agreeing the scope of this validation with MCC Environmental Health. Details of the specialist contractor's proposed inspection sheets and inspection method statements are to be provided to Manchester City Council Environmental Health for approval.

1.6 Regulatory Consultation and Approvals

The Principal or Specialist Contractor is responsible for obtaining approval of all gas protection measures design and detailing from Manchester City Council Environmental Health and Building Control prior to commencement of installation, and approval of the installation and verification of those measures post construction. Copies of all regulatory approvals and correspondence must all be issued to the Contract Administrator.

2 Quality Assurance

2.1 Installation

Installation of the gas protection membrane should be carried out by methods approved by the manufacturer and to the instructions and recommendations provided, and installed by an Accredited Installation Contractor approved by the manufacturer. The installation should be of suitable quality as to pass the verification process detailed in Section 5.3 below.

Installation of the membrane should be to an internationally recognised quality assurance procedure, such as ISO 9002, and should extend to such items as seals to penetrations, services and structural steel work etc.

The installation should be subject to a site specific method. This should describe the proposed methods of installation and achieving seals, which should be made part of the quality assurance procedure.

Certificates of conformity to the above should be supplied.

Details on proposed methods of jointing of membrane strips and sealing of the membrane at penetrations should be submitted for approval to the Contract Administrator.

Jointing and sealing work should be covered under the quality assurance procedures described above. All joints will be checked by the operative and by a qualified installation technician. A photographic record of joints and seals should be kept for inclusion in the verification report.

All installations will be carried out in accordance with standard working procedures and/or site instructions and logged on the ISO 9002 documentation.

The installation of the membrane should allow for shrinkage and movement of the slab along the construction joints.

2.2 Damage

Any damage caused to the gas protection membrane by the activities of the subsequent trades should be logged and advised to the gas protection measures installation contractor, who will then effect appropriate repairs according to the nature of the damage. Once damage is located the area should be cleaned and dried off.

Any defects which occur as result of construction process must be repaired prior to pouring concrete. At least 12 hours before concrete pouring, a CQA inspection of the membrane should to be carried out. Defects must be repaired and the membrane re-inspected. The results of the inspection are to be submitted to the Contract Administrator.

2.3 Verification Information Required

The Specialist Contractor must prepare a verification report in line with GMPPP BN01:2008 [3] for submission to both the regulators and Contract Administrator for approval. Details of the proposed

membrane, ancillary products and proposed installation methods must be supplied by the specialist sub-contractor. Data sheets for the membrane should be supplied.

Upon completion of the installation, as-built details of the gas resistant membrane, including an installation report, testing certificates and results of materials supplied, inspection records and as-built drawings should also be provided for inclusion in the verification report as specified in GMPPP guidance document BN01:2008 [3]. Details of any commissioning testing should also be included.

The verification testing and documentation should be undertaken by an independent specialist contractor. The report should document whether the measures pass or fail and should be supported by photographic evidence, membrane specification, integrity retesting and as built construction details.

Independent third party verification, with supporting verification records and reporting, is also required (see **Section 1.5**)

2.4 Warranties

Warranties for the overall design and construction of the gas protection system will be required. Details of the level and duration of the warranty cover should be confirmed with the Contract Administrator.

References

[1] BS8485:2007, Code of practice for the characterization and remediation from ground gas in affected developments

[2] CIRIA (2007) Guidance Document C665, Assessing Risks Posed by Hazardous Ground Gases to Buildings.

[3] GMPPP (2008) BN01: Development on Land Potentially Affected by Hazardous Ground Gas