1.

Ground Conditions

Contents

Introduction

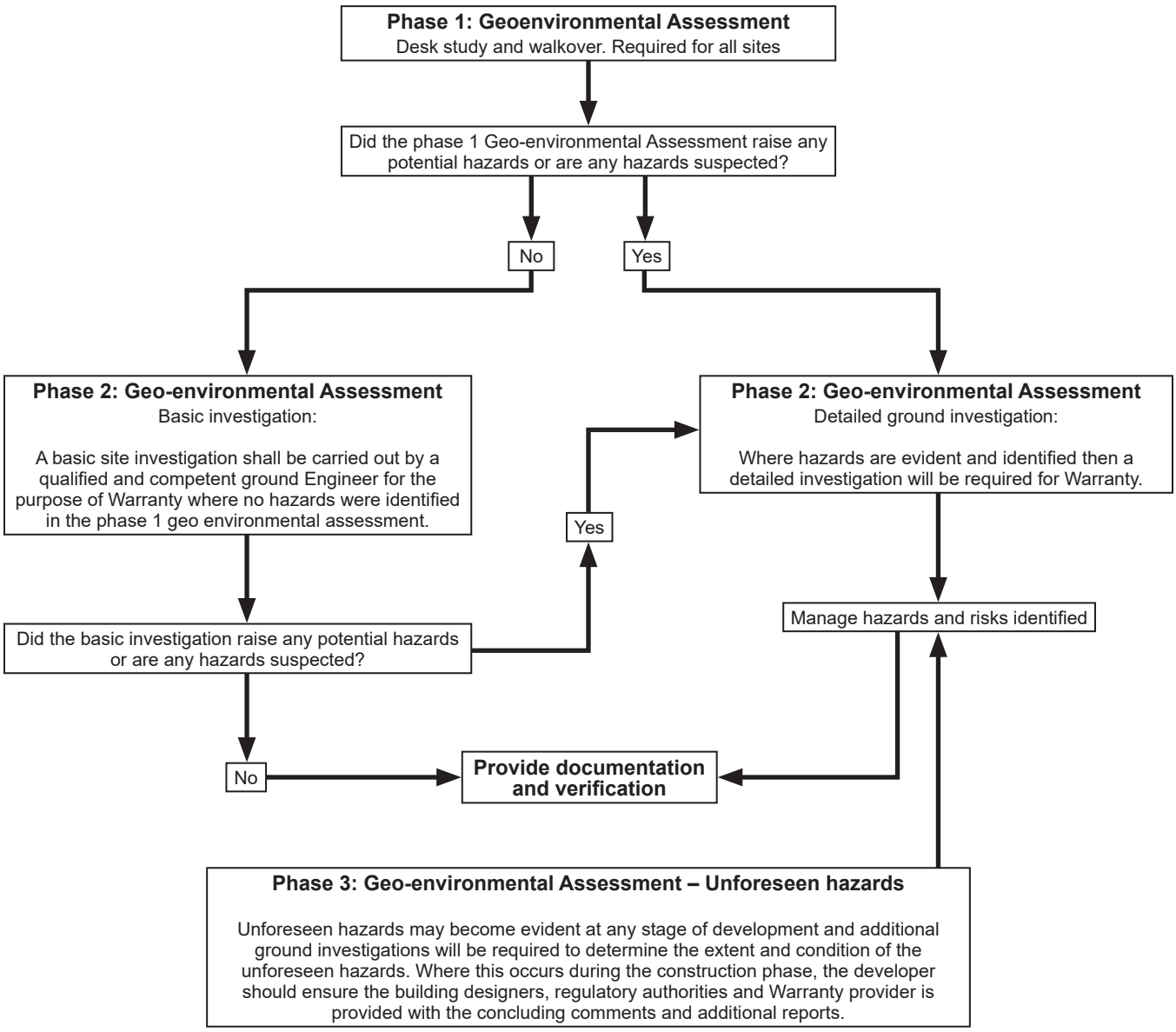
This section provides guidance on meeting the performance requirements for an acceptable site and ground investigation.

1.1.1 Compliance

All sites shall have an appropriate level of site investigation which accurately assesses and investigates potential hazards which may affect the development.

To ensure a consistently high standard, all stages of the work should be carried out by an Engineer or Geologist with at least five years' experience of ground and soil engineering. Specifying and using competent qualified personnel will considerably increase the overall industry standard.

Site investigation procedures flow chart



1.1.2 Information to be provided

The developer shall provide an appropriate level of site investigation for the specific site which accurately assesses and investigates potential hazards which may affect the development.

Please note, historical reports greater than 5 years may be used as a reference document for the desk study but investigative reports of ground conditions must be undertaken and dated within 5 years of construction starting on site.

A full set of site investigations should be made available to the Warranty provider and all other interested parties prior to the associated works starting on site. This should include:

1. Phase 1: Geo-environmental Assessment – Desk study and walkover
2. Phase 2: Geo-environmental Assessment – Basic and detailed ground investigation
3. Phase 3: Geo-environmental Assessment – Unforeseen hazards (where applicable)

The Warranty surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

1.1.3 Phase 1 Geo-environmental Assessment – Desk study and walkover survey

A Phase 1: Geo-environmental Assessment shall be provided and shall consist of a desk study and walkover survey undertaken by a competent person who has experience with ground investigations.

The phase 1 assessment shall be sufficiently thorough as outlined within the guidance to highlight any potential hazards.

The collation of information from the phase one assessment shall be evaluated and recorded. The resulting initial assessment report shall include sufficient details appropriate to the site.

Desk study

The desk study is essential for all sites. The contents of the report highlights the site location, the geology, hydrogeology (ground water), surface water and flooding, topographical features and past investigations undertaken on or close to the site.

It is an overall collection and examination of existing data brought together from a wide variety of sources. The purpose of the assessment is to indicate the potential hazards at the very early stage of the development and provide the guidance for more detailed exploratory investigations.

The following headings are what to expect within a Phase 1 - Geo-environmental assessment – Desk Study report. A listing of the contents of a Phase 1: Geo-environmental report along with their sources of the data can also be found in the checklists within this section.

Site description

The description should outline the exact extent of the site, and should include the site address the grid reference and elevation above sea level. The boundaries topography of the site should be clearly defined.

Geology and mining

The bedrock geology, any overlying superficial deposits and the effects of weathering should all be described, together with any geological faults that may affect the site. An explanation of the likely ground conditions should be given, together with reference to any other mapped geological features, particularly if there are likely to be any natural cavities or solution features.

In former coalfields, or other areas of mineral extraction, the maps may not always record the presence of old or active workings particularly shallow or surface workings. The likelihood of shallow coal workings affecting surface stability should be established in conjunction with a Coal Authority report. Such reports also record areas that have been affected by the extraction of brine, which is particularly prevalent in the Cheshire area of the UK. Other forms of mineral extraction will require site-specific research possibly requiring investigative or exploratory work.

Solution (soluble) features

Solution features (such as pipes, swallow holes and solution cavities, sometimes loosely infilled with drift deposits) are commonly found in chalk, caused by water draining through the chalk and dissolving it. They can also be found in Limestone and other soluble rocks. The British Geological Survey categorises the five main soluble rocks found in the UK as Chalk, Limestone, Gypsum, Dolomite, and Salt.

The risk of solution features should be addressed in the Phase 1 Geo-environmental assessment (commonly from an Envirocheck or GroundSure report on geological hazards, both on-site and locally).

Hazard maps are available with different coloured areas representing different levels of risk. Where the risk is moderate or high, special precautions should be taken, which for strip foundations would include careful inspection of the excavation, probing and use of reinforcement to span potential voids.

Ground gases and radon

Potential naturally occurring ground gases and where sites previously used for the industrial, commercial and social use will need to be identified for the purpose of building and environmental protection.

The need to incorporate radon protection measures should be determined by reference to risk maps produced by the Health Protection Agency. Such information is also usually included within commercially available datasets.

Geo-environmental risk assessment and the conceptual site model

A quantitative health and environmental Risk Assessment should be carried out as part of the assessment. The process of a Risk Assessment is set out in Part IIA of the Environment Protection Act 1990, and amended in subsequent legislation.

This act introduces the concept of a pollution linkage, which consists of a pollution (contaminative) source or hazard and a receptor, together with an established pathway between the two. For land to be contaminated, a pollution linkage (hazard-pathway-receptor) must exist; this forms a so-called 'conceptual model' of the site.

Hydrology and hydrogeology

A significant part of the desk study will consider an assessment of flooding risk to the site. The presence of surface water features and drainage should be described, and the overall risks of flooding to the site should be determined, primarily with reference to the Environment Agency flood map data and Local Authority-commissioned strategic flood risk assessments. Flood risk data is continually being updated by the Environment Agency and Local Authority.

The hydrogeology of the site provides an understanding of the transpiration of water below the surface of the ground. Sites where a principle or secondary aquifer and Source Protection Zones are identified are susceptible to pollution of the ground water.

Any ground water or surface water abstraction points 'downstream' of the site, particularly any potable (drinking water) abstraction points, should be recorded, as this may have liability implications should the development cause any pollution.

Site history

The history of the site and the surrounding areas is extremely important when assessing the likelihood of contamination or geotechnical hazards.

The influence or impact of off-site past industrial use, (e.g. agricultural use, below ground mining, landfill and quarrying) will depend upon the type of industry, the underlying geology and the topography. However, consideration should normally be given to any such features within a 250m radius of the site (or further where appropriate) with the potential to affect it.

It should be remembered that historical maps only provide a snapshot in time, and care must be taken when interpreting what may have occurred in the intervening years.

Environmental setting

The question as to whether a site poses an actual or potential environmental risk, or is at some external risk from pollution, will be determined by its environmental setting. This will in turn depend upon the site's topography, geology, hydrogeology and hydrology, amongst other site-specific considerations.

It is necessary to consider other potential sources of contamination, such as pollution control licenses, discharge consents, hazardous sites (COMAH, NIHHIS), pollution incidents, landfills, waste treatment sites and past and current industrial sites.

Geotechnical assessment

Although no intrusive investigation may have been undertaken it should be possible to give preliminary indications in respect of the geotechnical matters.

Desk study Checklist for Phase 1: Geo-environmental Assessment

Site Description (and surrounding area of relevance)

- Location, O.S. grid reference and plans
- Topography, levels
- Site layout and main features
- Site infrastructure
- Site description and topography
- Made ground, erosion, cuttings or quarries
- Slope stability
- Evidence of faulting or mining
- Watercourses, seepages or sinks
- Marshy or waterlogged ground
- Type and health of vegetation
- Existing structures and condition
- Existing on-site processes
- Demolished structures/old foundations
- Visual evidence of contamination
- Existing site operations
- Underground and overhead services
- Trees
- Previous site conditions and current use
- Site proposals

Mining

- Past, present and future mining
- Reference to geological sources
- Coal Authority Mining Report
- Register of abandoned mine plans and opencasts
- Shaft register
- Other mining, e.g. sand, sandstone, limestone, brine, etc.

Geology

- Geological maps (1:50,000 and 1:10,000 scale)
- Memoirs
- Technical reports
- Previous site investigations
- Previous laboratory results – Soil sampling
- Engineering geological maps
- Existing trial pit or borehole logs and reports
- Subsidence features

Hydrogeology and hydrology

- Ground water vulnerability
- Aquifer status
- Abstraction licences (within 1km)
- Flood risk, drainage and watercourses (within 1km)

Local Authority consultation

- Building Control, Planning and Environmental Health/Contaminated Land Officer
- Petroleum Officer

Archival research

- Past O.S. mapping and previous on-site and off-site usage possible contaminants associated with former use(s)
- Town plans
- Local history records, books and photographs (where relevant and practicable)
- Aerial photographs (where relevant)
- Archaeological register (where relevant)

Contamination

- Likely contaminants based on past history
- Hazard-Pathway-Receptor scenario
- Preliminary Conceptual Site Model

Environmental database

- Operational and former landfill sites, scrapyards and waste processing sites
- Radon protection measures

Walkover survey

This survey is undertaken to identify and verify the potential hazards for construction based upon the findings of the desk study assessment of the site and surroundings.

The walkover should be always undertaken by a competent person who can interpret the desk study and relate it to the actual site conditions. Photographs are an essential means of recording the potential hazards.

Potential Hazards that will require further investigation include:

Topography (physical features)	Significant and abrupt changes in slope and site depressions Overburden on slopes Excavation at the bottom of slopes Landslip and subsidence Contamination – tipped or imported harmful material Species, height and spread of tress hedges and scrub Tree and vegetation condition
Geology (soils and rocks)	Ground Conditions – basic soil types and classifications Below surface compressible materials Surface cracking Sudden changes in soil types
Hydrology (surface water)	Waterlogged ground Signs of flooding Aquatic plants and grasses Ponds, water courses and springs Discoloured water - source
Hydrogeology (ground water)	Tree and vegetation – water demand on sub-surface soils Hedgerow and scrub – Dying or sparse
Historic (local buildings)	Damage to buildings or structures - cracking Building movement - tilting Below ground services
Local Information	Local knowledge – mining, landfill, localised flooding Past uses – local history, place and street names

1.1.4 Phase 2 Geo-Environmental assessment

Where no hazards are identified in the phase one geo environmental assessment, a basic ground investigation shall be carried out by a competent person who has experience with ground investigations.

A detailed ground investigation shall be provided where:

- The initial scope of the ground investigation reveals potential hazards.
- The basic investigation reveals anomalies not previously raised in any site investigation.
- There are any doubts about the condition of the ground.
- The basic investigation reveals potential hazards.

Introduction

The outcome of the desk study and the walkover survey will provide the scope for the Phase 2 Geo-Environmental assessment and involves using a combination of various intrusive techniques depending on the risks identified.

The investigation must be designed to provide the appropriate level of information on ground and ground water conditions on the site, together with identifying potential areas of contamination. The investigation should be undertaken in accordance with the principles of:

- BS EN 1997-1: Eurocode 7 - Geotechnical design - Part 1: General rules.
- BS EN 1997-2: Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing.
- BS 5930 and BS 10175.

The dates of the investigation and the methods used should be stated, with the exploratory trial pit or borehole positions clearly being shown on a drawing.

Basic ground investigation

A basic ground investigation should:

- Be carried out by a qualified and competent Engineer.
- Be carried out where no hazards were identified in the phase one geo environmental assessment.
- Include an assessment of observations specific to the site.
- Include ground material testing to provide assurance to the Warranty provider that sites are free from potential hazards that can influence the design of the building.

Trial pitting

This method enables:

- Soil conditions to be closely examined at any specific point and samples to be taken.
- It gives useful information on the stability of excavations and water ingress.
- Material and any other required ground tests can easily be undertaken in the open trial pit.

The following should be considered where trial pits are proposed:

- They should be at least three times the anticipated foundation depth where possible, or sufficient to prove a founding formation material suitable to support the design loads of the developments structure.
- They should be excavated outside of the proposed foundation area where possible.
- The distance from the edge of the trial pit from a foundation should be at least the proposed foundation depth plus 250mm.
- On completion excavations are normally backfilled.

Detailed ground investigation

Where hazards are evident, an intrusive investigation will be required. A detailed ground investigation will be required where hazards are evident and identified from:

- The initial scope of the ground investigation.
- Phase 1 Geo-environmental assessment (desk study and walkover survey).
- Basic ground investigation.

In addition, a detailed ground investigation will be required:

- Where the basic investigation reveals anomalies not previously raised in any site investigation.
- If there are any doubts about the condition of the ground.

The detailed Phase 2 Geo-environmental assessment should adopt a clearly defined structured and detailed approach to the investigation for gathering site information and testing and include:

- Basic ground investigation.
- Changing development proposals – Usage.
- Ground conditions – complexity of materials and stratum.
- Influence of foundations on the bearing strata.
- Presence of contaminants and ground gases.
- Surface and ground water.
- Geology, topography and site history.

On site intrusive investigation and soil sampling is required for foundation and basement designs which extend further into the ground. Investigations require the use of deeper boreholes and the use of rigs and different sampling will need to be specified.

In order for the development of the site to succeed the liabilities and site hazards will need to be managed and communicated in the detailed Phase 2 Geo-environmental ground investigation report. Further assessment of ground conditions through Investigation may be required to fully address the development objectives.

Mining areas - Key requirements for foundations

Any foundations must be designed to clearly demonstrate that design loads are transferred to known soil strata capable of supporting those loads.

Foundations should not settle more than what is specified within the 'Foundations' section. For piled foundations, settlement should not be more than what is specified by the Engineers design.

The potential for mine workings and mine entries within an influencing distance of the proposed development should be addressed by an Engineer prior to commencement of works, and in accordance with CIRIA guidance (including CIRIA C758D Abandoned mine workings manual), Coal Authority Technical Guidance Notes (including TGN01/2019) and our "Mining - Structural Requirements" document.

Reference should be made to reports on geological hazards, such as Envirocheck or GroundSure reports, both on-site and locally.

For further guidance on foundation proposals in mining areas, please refer to the Warranty Good Practice Guide: 'Mining - Structural Requirements' available on the Warranty website.

The dates of the investigation and the methods used should be stated, with the exploratory trial pit or borehole positions clearly being shown on a drawing.

Soluble geology - Key requirements for foundations

The foundation scheme should be designed to clearly demonstrate that the foundations are capable of supporting and transferring the design loads safely to known soil strata that can be demonstrated from the appropriate project Site Investigation report to be capable of carrying the load, using the appropriate soil properties obtained from geotechnical testing.

Where there is a moderate to high risk of voids being present, the foundations should be designed in the first instance to span across a void of at least 5 metres without settlement greater than what is specified within the 'Foundations' section. For piled foundations, settlement should not be more than what is specified by the Engineers design.

Soakaways and soluble geology

The potential effects of soakaways, leaking drains, run off, etc. on the chalk will need to be considered and addressed in the design.

CIRIA C574: Engineering in Chalk, 2002 gives the following recommendations:

Concentrated ingress of water into the chalk can initiate new dissolution features, particularly in low-density chalk, and destabilise the loose backfill of existing ones. For this reason, any soakaways should be sited well away from foundations for structures or roads, as indicated below:

- In areas where dissolution features are known to be prevalent, soakaways should be avoided if at all possible but, if unavoidable, should be sited at least 20m away from any foundations.
- Where the chalk is of low density, or its density is not known, soakaways should be sited at least 10m away from any foundations.
- For drainage systems, flexible jointed pipes should be used wherever possible; particular care should be taken for the avoidance of leaks in both water supply and drainage pipework.
- As the chalk is a vitally important aquifer, the Environment Agency and Local Authority must be consulted when planning soakaway installations where chalk lies below the site, even where it is mantled with superficial deposits.

Checklist for Phase 2: Geo-environmental Assessment

Trial pits

- Strata profile and description
- In-situ gas testing for methane, carbon dioxide and oxygen
- Landfill gas, marsh gas and mine gas
- In-situ shear strength testing
- In-situ Mexe Cone Penetrometer for CBR/in-situ shear strength
- Full description of ground and ground water conditions
- Soakaway testing
- Geotechnical contamination laboratory testing

Boreholes

- Cable percussive, window sampling, dynamic probing or rotary drilling to BS 5930
- Use of British drilling association accredited drillers
- Full description of ground and ground water to BS 5930
- Installations for long-term gas and water monitoring (if required)
- Geotechnical laboratory testing (BS 1377) and contamination testing if suspected by accredited laboratories

Other methods of investigation

- Geophysics
- Cone penetrometer

Recommendations for reports:

Foundations and retaining walls

- Foundation type, depth, bearing capacity and settlement
- Ease of excavation
- Sulphate/acidity/concrete class
- Shrinkage/heave
- Effect of vegetation, including building Near trees
- Buoyancy or flotation effects
- Ground improvement options, e.g. Piling, Vibro, compaction, etc.

Mining

- Precautions for foundations in respect of past or future mining
- Treatment of shallow mine workings
- Capping of shafts

Landfill/mine gas/Radon

- Requirements for long term monitoring
- Protection measures for structure
- Venting measures

Road construction

- CBR of subgrade and its preparation
- Sub-base type and thickness
- Excavation of unsuitable material
- Soil stabilisation
- Frost susceptibility

Drainage and excavations

- Ground water regime including de-watering
- Use of soakaways
- Support and ease of excavation
- Rock levels
- Use of sheet piling, diaphragm, bored piles and ground anchors

Earthworks

- Compaction characteristics
- Surcharging and self-settlement
- CBR at formation level
- Slope stability and slope stabilisation
- Suitability of excavated material for re-use

Contamination

- Full assessment of contamination testing
- Hazard-Pathway-Target scenarios/Conceptual Site Model
- Risk assessment and liability
- Precautions or remediation of contamination

Further investigation

- Is further investigation needed?
- Nature of further investigation

1.1.5 Phase 3 Geo-Environmental assessment - Unforeseen hazards

Where unforeseen hazards are encountered, a phase three assessment shall be carried out by a competent person who has experience with ground investigations.

In some cases of intrusive investigations reveal hazards which are unforeseen where further investigation may be required or where the earlier Phase 2: Geo-environmental assessment has been preliminary. The requirement for additional ground investigation is required to determine the extent and condition of this unforeseen hazard.

Unforeseen hazards may also become evident during construction. When such occurrence happens the developer is to ensure that the building designers are notified of the potential hazard. A scope for the additional investigative works is established. The concluding comments of the additional report and the management of the unforeseen hazard is conveyed to the regulatory authorities, designers and the Warranty provider.

1.1.6 Site and laboratory testing

Where site and laboratory testing is required as a part of the phase 2 or 3 Geo-Environmental assessment, it shall be undertaken by testing laboratories who:

- Have an appropriate quality assurance programme in place, **and**
- Are accredited to carry out such tests by bodies such as UKAS or MCERTS.

Where in-situ testing is required, it shall be undertaken by a competent person.

In all circumstances, soil testing shall be undertaken to recognised standards.

All samples shall be stored and kept in such a way that will not cause inaccuracy when soils are tested.

Site and laboratory testing such as those in the following list should be undertaken to recognised standards and be completed by a competent geologist or Engineer:

- Gas monitoring
- Soil strength
- Soakaway testing
- Contamination testing/monitoring
- Natural or in-situ moisture content testing
- Liquid and plastic limits
- Particle size distribution
- Bulk density
- Permeability
- Consolidation characteristics
- Strength characteristics
- Compaction
- California Bearing Ratio (CBR) test
- Chemical tests

References

British Standards Institution

- BS 1377: Methods of test for soils for civil engineering purposes (Parts 1 to 8)
- BS 3882: British Standard specification for topsoil
- BS 5930: British Standard Code of Practice for Site Investigations
- BS 8485: British Standard Code of Practice for the characterization and remediation from ground gas in affected developments
- BS 10175: British Standard Code of Practice for the investigation of potentially contaminated sites
- BS EN 1997-1: Eurocode 7 - Geotechnical design - Part 1: General rules
- BS EN 1997-2: Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing
- BS ISO 14688-1: Geotechnical investigation and testing - Identification and classification of soil - Part 1
- BS ISO 14688-2: Geotechnical investigation and testing - Identification and classification of soil - Part 2
- BS ISO 14689-: Geotechnical investigation and testing – Identification, description and classification of rock.
- BS8004: British Standard Code of Practice for Foundations

BRE

- Radon: Guidance on protective measures for new dwellings, BR 211
- Protective measures for housing on gas-contaminated land, BR 414, 2001
- Cover systems for land regeneration, 2004
- Concrete in aggressive ground, Special Digest SD1, 3rd Edition, 2005
- BRE IP 5/97: Building on Fill – collapse compression on inundation

CIEH

- The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment (2nd Edition)

CIRIA

- Assessing risks posed by hazardous ground gases to buildings, CIRIA C665
- Shaft friction of CFA piles in chalk 2003, CIRIA PR 86
- Engineering in chalk 2002, CIRIA C574
- CIRIA C758D Abandoned Mine Workings Manual

DoE

- CLR Reports 1-4
- Waste Management Paper No. 26A, Landfill Completion: A technical memorandum…
- Waste Management Paper No. 27, Landfill gas: A technical memorandum…

DEFRA

- Contaminated land report CLR 11, 2002 (7-10 withdrawn)
- R & D Publications TOX 1 - 12, 14, 16 - 25
- R & D Publications SGV 1, 3, 4, 5, 7, 8, 9, 10, 15 and 16 (withdrawn)
- Improvements to contaminated land guidance - Outcome of the “Way Forward”, 2008
- Exercise on soil guideline values, 2008
- Guidance on the legal definition of contaminated land, 2008

DETR

- Circular 02/2000. Contaminated land, 2000
- Guidelines for environmental Risk Assessment and management, 2000

Environment Agency
- Guidance for the safe development of housing on land affected by contamination, 2000
- Guidance for waste destined for disposal in landfills, Version 2, 2006
- Protective measures for housing on gas-contaminated land remediation position statements, 2006
- Guidance and Monitoring of Landfill Leachate, Groundwater and Surface Water
- Human Health Toxicological Assessment of Contaminants in Soil (Science Report SC050021/SR2), 2008
- Updated Technical Background in the CLEA Model (Science Report SC0520021/SR3)
- Using Soil Guideline Values, 2009

HMSO
- Environmental Protection Act 1990
- Environment Act 1995
- UK Water Supply (Water Quality) Regulations 2000
- The Water Act 2003

Institution of Civil Engineers
- Contaminated Land: Investigation, Assessment and Remediation (2nd Edition)
- Specification for Piling and Embedded Retaining Walls

Joyce, M.D.
- Site Investigation Practice, 1982

London District Surveyors Association
- Notes for the design of straight shafted bored piles in London Clay

OPDM
- Planning Policy Statement 23: Planning and Pollution Control Annex 2: Development on Land Affected by Contamination

Introduction

This section provides guidance on meeting the performance requirements for managing ground contaminants.

The term ground contaminants is used throughout this section. For the purposes of Warranty, ground contaminants refers to gases and/or vapours in the ground, including, methane, carbon dioxide, volatile organic compounds (VOC's) and radon. Ground contaminants can occur on their own, or in combination.

1.2.1 Compliance

Hazardous ground contaminants[1] shall be effectively managed under the supervision of a consultant or specialist acceptable to us.

Historical reports greater than 5 years may be used as a reference document for the desk study but investigative reports of ground conditions must be undertaken and dated within 5 years of construction starting on site.

[1] For the purposes of Warranty, ground contaminants refers to substances that pose significant health and environmental risks include those that can cause cancer, are poisonous, or can lead to suffocation, as well as substances that can, catch fire, explode, be corrosive or emit harmful radiation where a statutory notice could be given if the hazard isn't effectively managed. Ground contaminants can occur on their own, or in combination.

1.2.2 Information to be provided

The Designer shall provide sufficient design details to demonstrate it meets the requirements of this section.

A full set of design drawings, specifications, investigations and reports should be made available to the Warranty provider and all other interested parties prior to the associated works starting on site. This may include:

1. All sites must have an appropriate level of site investigation in accordance with:
   a. The 'Ground Conditions – Site Investigation' section of this Technical Manual.
   b. BS 8576 - Guidance on investigations for ground gas. Permanent gases and Volatile Organic Compounds (VOCs).
   c. BS 10175 - Investigation of potentially contaminated sites. Code of practice.
2. A remediation strategy which also incorporates a plan for verification and testing of the protection measures prior to any works starting on site. This should be completed by a suitably qualified professional.

The Warranty surveyor, at their discretion, may also request supporting information that demonstrates suitability for use of any materials or systems contained within the above.

1.2.3 Site Investigation and assessment of ground contaminants

The developer shall provide an appropriate level of site investigation for the specific site which accurately assesses and investigates potential ground contaminants which may affect the development.

A site investigation should be carried out in accordance with:

- The 'Ground Conditions – Site Investigation' section of this Technical Manual.
- BS 8576 - Guidance on investigations for ground gas. Permanent gases and Volatile Organic Compounds (VOCs).
- BS 10175 - Investigation of potentially contaminated sites. Code of practice.

The findings from the site investigation/s should be used to formulate a detailed remediation strategy as detailed within this section. This should be completed by a suitably qualified professional.

Carbon dioxide and methane

Where the site investigation reveals the presence of carbon dioxide and/or methane, they should be characterised and assessed in accordance with BS 8485.

Residential buildings should not be built on CS4 or higher sites (as characterised in BS 8485) unless the type of construction or site circumstances allow additional levels of protection to be incorporated.

VOC's

CIRIA report C682 should also be referred to for guidance on investigating and assessing the risks posed by VOC's.

Radon

The United Kingdom Health Security Agency (UKHSA) has published maps which highlight the radon potential on 1km grid squares, these should be reviewed by the designer prior to any works commencing on site. The level of protection required is site specific.

1.2.4 Remediation strategy

The findings from the site investigation shall be used to formulate a detailed remediation strategy report which shall be completed by a suitably qualified professional.

Remediation techniques may include:

- Risk avoidance by changing the pathway or isolating the target, by adjusting the layout and/or by building protective measures into the construction.
- Engineering-based treatments that remove or isolate contaminants or modify the pathway by excavation, providing ground barriers or covering and capping.
- Process-based treatment to remove, modify, stabilise or destroy contaminants by physical, biological, chemical or thermal means.

As a minimum, the following should be included in the remediation strategy report:

- Remediation objectives for ground, groundwater and ground gas/contaminants.
- Summary of ground contaminants present in accordance with the cited site investigation report.
- Site plan showing effected plots/areas of site.
- Detailed remediation techniques to be employed.
- Installation plan including method statements.
- Design drawings for remediation techniques where applicable.
- Details of all materials to be used along with installation guidance.
- Proposed plan for the supervision and monitoring of works.
- Proposed plan for verification and testing. Verification of gas protection systems is about more than gas membranes – it covers inspection of underfloor voids, ventilation, oversite capping and venting layers etc that may not be the responsibility of the gas membrane installer.

Carbon dioxide and methane

BS 8485 should be used by the designer to determine an appropriate remediation strategy. 3 forms of protection are defined in BS 8485 and these include:

- The floor structure (referred to as the structural barrier in BS 8485).
- A gas resistant membrane.
- Sub-floor ventilation.

The remediation strategy should incorporate at least 2 forms of protection as a single element should not be solely relied upon to provide effective protection as there would not be redundancy to allow for defects in the component.

BS 8485 uses a scoring system to determine what level of protection is required in different situations; the designer should use this system to determine the forms of protection required.

VOC's

CIRIA report C716 provides an overview of the techniques available for treating or managing the risk presented by VOCs and this should be used by the designer to formulate a detailed remediation strategy report to base their proposals on.

Radon

The designer should provide an appropriate design where basic and full radon protection is required in accordance with BRE report BR 211.

Basic radon protection

Where basic radon protection is required, a radon barrier should be provided in accordance with BRE report BR 211.

The radon barrier can be installed at high level (above or below the ground floor construction), or at low level (solum level). Where the radon barrier is installed at high level is should be lapped with the cavity tray in the cavity wall construction. Care should be taken to maintain the integrity of the radon barrier.

The DPC to a cavity wall should be in the form of a cavity tray to prevent radon entering the building through the cavity.

Where radon protection is required for a framed structure, the radon protection should not impede on drainage and/or ventilation of the framed structure and its sole plate. For further guidance, please refer to our 'External Walls – Timber Frame' and 'External Walls – 'Light Gauge Steel Frame' sections.

Full radon protection

Where full radon protection is required, additional protection can be provided to that of basic protection in the form of a radon sump or a ventilated sub-floor void.

Where sub-floor ventilation is required, the designer should determine the amount of ventilation and the number of air bricks required. Ventilation must be cross-flow on two opposing sides of the building. Any obstructions such as sleeper walls, beams etc., should have adequate provision to allow for cross-flow ventilation. Landscaping and other external works should not block the air bricks.

Where periscope subfloor ventilators are used, the joints between the upper and lower halves should be taped to reduce the risk of radon entering the cavity.

Where a radon sump is required, guidance on the number and specification of sumps should be sought from BRE report BR 211.

Other considerations for radon protection

- Where a radon barrier is specified, the guidance on gas resistant membranes within this section should also be followed.
- Whilst thicker radon barriers may be more robust, they may be difficult to bend or fold around edges and corner details. As such, preformed components should be used where possible.
- The cavity tray in the external wall should be supported with concrete or other suitable material.
- Manufacturer's instructions should be followed for jointing details and sealing of service penetrations for radon barriers. Some materials may be difficult to seal in adverse weather conditions and this should be taken into account prior to works starting on site.

1.2.5 Gas resistant membranes

Gas resistant membranes shall:

- Be capable of providing a complete barrier and be impervious to the relevant ground contaminants specific to that development.
- Have a third party product conformity certificate.
- Be installed in accordance with the manufacturers recommendations.

Where a gas resistant membrane is required, a DPM should not be specified or used instead, as they are thinner and made from lower grade materials; this may allow the transmission of ground gases/contaminants.

Please note, gas membranes manufactured from recycled products are not acceptable for Warranty purposes.

Penetrations

Where elements of construction require fixing through the membrane (such as curtain walling systems, stud walls etc.), a sealing gasket should be used. This should be part of the membrane system (see manufacturer's data sheet) and its third party product conformity certificate. The recommended detail should be clearly outlined in the remediation strategy report and construction drawings.

Services

Care should be taken around service penetrations, stanchions and columns with pre-fabricated top-hats and corner seals the preferred method of providing a robust and complete barrier around these elements. The sealing of service penetrations, stanchions and columns should be carefully considered during the design phase and these elements should be avoided very close to walls due to difficulties in providing a robust seal.

Service ducts should be sealed between the duct internal wall and the utility pipe. Sealing of individual flexible cables and/or ducted cable bundles can be difficult to achieve and specialist systems should be used. The method chosen should also be a part of the third party product conformity certificate.

Sealing

Membranes can either be tape sealed or welded, the method of sealing and all associated components should be part of the membrane system (see manufacturer's data sheet) and its third party product conformity certificate. The jointing strategy should be clearly outlined in the remediation strategy report and construction drawings.

Installing gas resistant membranes on a beam and block floor

There should be consideration for where gas resistant membranes are specified with beam and block floor constructions. The specialist designer should provide a suitable design proposal in such circumstances.

Gas resistant membranes and external walls

Where gas membranes bridge the external cavity wall, a cavity tray should be provided above the gas membrane. Cavity trays should be sealed to the gas membrane in accordance with the manufacturer's instructions to prevent capillary damp ingress at the joint.

Where gas membranes bridge the cavity between the external cladding and a framed structure, detailing should not impede on drainage and/or ventilation of the framed structure and its sole plate. For further guidance, please refer to our 'External Walls – Timber Frame' and 'External Walls – 'Light Gauge Steel Frame' sections.