Welcome to…

Site Investigation:

Cost vs Risk… How To Make The Right Choice

ROGER BULLIVANT

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RBL'S
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Marketing & Events Coordinator

ROGER BULLIVANT

Contents

ROGER BULLIVANT LIMITED
AT A GLANCE

Total employees.

500+

Linear metres of precast beam manufactured annually.

>250,000 LM

Providing piling and foundation solutions in the residential sector.

Residential

RBL has the capacity to manufacture over 1 million metres of precast pile every year.

1M

Fleet of piling rigs.

50+

100% of precast products manufactured with low carbon concrete.

100%

Providing piling and foundation solutions for various commercial projects.

Commercial

ROGER BULLIVANT

OUR PRODUCTS
WHAT WE DO

PILING

- Driven Precast Concrete Piles
- Driven Steel Tubular Piles
- RB Combipile
- Continuous Helical Displacement Piles (CHD)
- Continuous Displacement Auger Piles (CDA)
- Continuous Helical Auger Displacement Piles (CHAD)
- Continuous Flight Auger Piles (CFA)
- Contiguous Piled Retaining Walls

GROUND IMPROVEMENT

- Vibro Stone Columns
- Helical Displacement Inclusions (HDI)

FOUNDATION SYSTEMS

- RBeam Precast Concrete Ground Beams
- Precast Caps

RESTRICTED ACCESS

- Sectional Flight Auger (SFA)
- Bottom Driven Minipiles
- ODEX Piles
- Jack Piles & Jack Pile Raft
- Grundomat Piles
- Drill Bar Piles
- Underpinning

LOCAL KNOWLEDGE
NATIONAL SUPPORT

International expertise

Introduction


Legacy Probe Holes
Relevant Boreholes
Historical Data
Interpratative Report
Interpretative Report
Deeper
Asbestos
Obstructions
Trial Pits
Consistency
PSD
Dogger Risk
Environmental
Lab Testing
Design Lines
Cu
Heave
Soil Profile
Wet Sieve
Levels
Triaxial
Photos
CPT
SPT
Chalk
Window Samples
Mining Report
Summary
Top Soil
Dissolution
Rotary Core
Site Plan
Insitu Tests
Contamination
Water Monitoring
Coordinates
More Boreholes
Rock Strength
Drillers Description
Chemical Data
Rock Sampling
Clear Results
SI
Cable Percusive
Design Parameters
Limestone

SITE INVESTIGATION:
THREE PHASES

Ground Investigation Reports

Phase 1
Desk Study

Phase 2
Intrusive Investigation

Phase 3
Remediation

Geotechnical Design Report

SITE INVESTIGATION:
PHASE 1

- Dominated by a desk study
- Previous history and use giving insights on contamination and obstructions.
- Identifies potential pathways for contamination migration.
- Simple geological and contamination model.
- First stage of the risk register.
    - Subsidence, potential contamination sources, mining, archaeology, invasive plants etc.
- May involve a site walkover.
- Determines the broad extent of the invasive work and not detailed enough to proceed with a robust design.

SITE INVESTIGATION:
PHASE 2

- Dominated by intrusive work
  - Trial pits
  - Boreholes
  - Remote sensing/ Geophysics
- Provides detailed categorisation and description of the site, both for geotechnics and contamination.
- Sample testing and characterisation. (laboratory and field)
- Details the geotechnical model as well as the associated design.
- Hotspot characterisation, water and gas sampling.
- Refines the risk register.
- May result in further intrusive information with significant variation.

SITE INVESTIGATION:
PHASE 3

- Completes the risk register.
- Uses the risk register, geotechnical and contamination information.
- Provides remediation measures for safe development of the site.

SITE INVESTIGATION:
GEOTECHNICAL REPORT

GROUND INVESTIGATION REPORT (GIR)

- Forms part of the Geotechnical Design Report
- Includes:
  - Appropriate geotechnical information
  - Evaluation of the information
  - Propose further work

GEOTECHNICAL DESIGN REPORT (GDR)

- Two most important parts:
  - GIR
  - Plan to any requisite supervision and monitoring during & after construction

SITE INVESTIGATION:
GEOTECHNICAL REPORT

Table 1: Summary of report types and contents

Report Type	Ref	Site description, scope, rules of engagement	Historical Search	Walkover	Field Results	Lab Results	Ground Conditions/ Parameters	Derived Values	Characteristic Values	Design Values	Design calculations, drawings and recommendations	Supervision, monitoring and maintenance requirements	Comments
Desk Study Report	BS, BS15, EC7, UK Spec	●	●	○									
Factual Report	BS, EC7	●	○	○	●	●							
Field Report	BS, BS15 EC7, UK Spec	●		○	●			○ (EC7 only)					Sign off by responsible person/ Responsible Expert (BS15) required to comply with EC7
Interpretative Report	BS	●	○	○	○	○	●	○			○		
GIR	BS15, EC7, UK spec	●	●	●	●	●	●	●					GIR can be in separate parts or a single report
GDR	EC7, UK Spec	●	●	●	●	●	●	●	●	●	●	●	
GBR	BS15	●					●						To be agreed with contracted parties and risk allocation defined
GFR	BS15												Contents as specified or to BS8002 and BS8004

Key ○ optional requirement ● mandatory requirement

BS - BS5930:1999+A2:2010, Code of Practice for Site investigation (Withdrawn).

BS15 – BS5930:2015 Code of practice for ground investigations

UK Spec- UK Specification for Ground Investigation, 2nd Ed, Site Investigation Steering Group ICE,2006

EC7- BS EN 1997-1:2004+A1:2013 Eurocode 7. Geotechnical design. General rules./ BS EN 1997-2:2007 Eurocode 7. Geotechnical design. Ground investigation and testing. (Including UK National Annexes to EC7)

AGS Guide to Ground Investigation, 2017

SITE INVESTIGATION:
CURRENT STATUTORY REQUIREMENTS

Eurocode (BSEN1997-2, appendix B.3)

Noted as examples the section gives guidance as to frequency.

- High rise, using a grid pattern with spacing of 15-45m.
- “large “ structures again a grid of no greater than 60m spacing.
- Roads, bridges, machinery bases and other linear structures, 20-200m.
- “special structures, 2-6 investigation points.

SITE INVESTIGATION:
CURRENT STATUTORY REQUIREMENTS

Eurocode (BSEN1997-2, appendix B.3)

The section also gives specific recommendations for depth of investigation based on the type of structure, usually as a function of the width/breadth of the foundation.

Unfavourable ground conditions such as competent over less competent strata should increase these minimum depths.

Bedrock or consistent strata curtail the depth.

In summary, for foundation piles, this should be three times the pile group width or 5m beyond the depth of the foundation.

How can this be achieved if the foundation has yet to be designed? Early Contractor Engagement

SITE INVESTIGATION:
CURRENT STATUTORY REQUIREMENTS

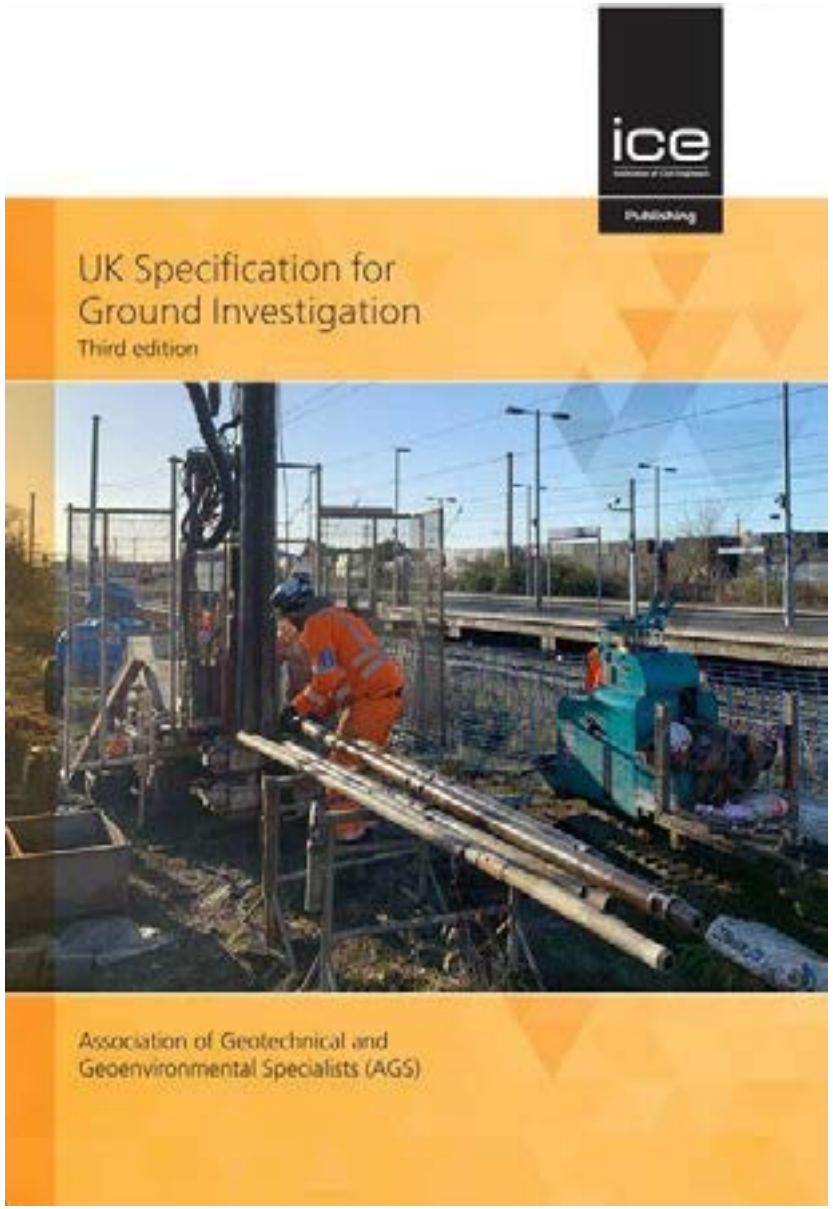
ICE specification of ground investigation (2022)

Known as the “yellow book”, it covers all common aspects of site investigation.

Produced by the Association of Geotechnical specialists, with support from the Federation of piling specialists.

Appendix A gives details of best practice from the perspective of piling and is authored by practitioners.

Compliant with Eurocode, expands giving detail and recommendations for coverage in some circumstances not expressly considered in code.



Geotechnical Risk	Bearing Piles		Embedded retaining walls	
Low	Borehole frequency (minimum)	1 borehole with maximum of 50m spacing	Borehole spacing (maximum)	50m
	Minimum depth	The largest of: 5m beyond the pile toe ,3 times pile base size or the breadth of the overall foundation, but limited by the zone of influence	Minimum depth	Full height of retaining structure, plus the depth equivalent to the zone of influence of the foundation element. As a minimum, boreholes at the end and midpoints for the wall
Medium	Borehole frequency (minimum)	3 boreholes maximum 25m spacing	Borehole spacing (maximum)	30m
	Minimum depth	As Low for bearing piles	Minimum depth	As Low for embedded retaining walls
High	Borehole frequency (minimum)	3-5 boreholes maximum 15m spacing,	Borehole spacing (maximum)	15m
	Minimum depth	As Low for bearing piles	Minimum depth	As Low for embedded retaining walls

SITE INVESTIGATION:
NEW STATUTORY REQUIREMENTS

Depth requirements remain unchanged.

Subject to authoring changes, the requirements for site investigation have been clarified and further quantified related to risk.

Table NA.1 – Table H.1 Maximum spacing and minimum number of investigation locations for structures in Geotechnical Category 2

Structures		Maximum spacing (per structure) X_{max}	Minimum number (per structure) N_{min}
Low-rise structures with plan area A	$A \leq 300\ m^2$	30 m	3
	$A > 300\ m^2$		$A / 100\ m^2$
High-rise structures	4-10 storeys	25 m	3-4[b]
	11-20 storeys	20 m	4-5[b]
	>20 storeys	15 m	5-6[b]
Estate roads, parking areas and pavements		40 m	2
Silos and tanks		15 m	3
Shafts		1 per shaft <10 m deep 2 for shafts >10 m deep, located either side of shaft[c]	
Bridges, piers and abutments with plan area A	$A \leq 50\ m^2$	10 m	2
	$A > 50\ m^2$	10 m	$A / 25\ m^2$
Power lines		1 per pylon	

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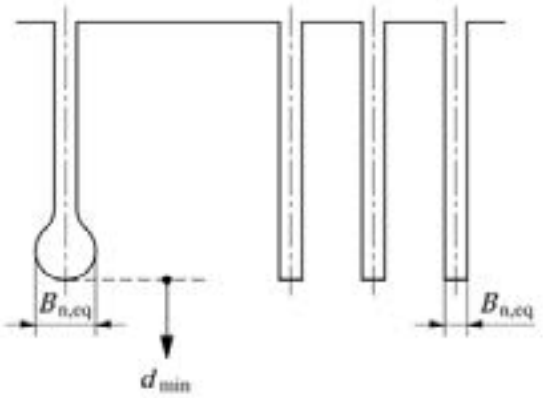
SITE INVESTIGATION:
NEW CODE REQUIREMENTS

Table 6.2 (NDP) — Minimum depth of field investigation for piled foundations

Application	Minimum depth	Illustration
Single piled foundation	$d_{min} = \max\{5\ m; 3B_{n.eq}\}$	
Pile groups or piled rafts in soils and in very weak and weak rock	$d_{min} = \max\{5\ m; 3B_{n.eq}; p_{group}\}$	
Pile groups or piled rafts in strong rock	$d_{min} = \max\{3\ m; 3B_{n.eq}\}$	

$B_{n.eq}$ is the equivalent size of the pile base, equal to B_b (for square piles), D_b (for circular piles), or p_b/π (for other piles)

B_b is the base width of the pile with the largest base (for square piles)

D_b is the base diameter of the pile with the largest base (for circular piles)

p_{group} is the smaller dimension of a rectangle circumscribing the group of piles forming the foundation, limited to the depth of the zone of influence

SITE INVESTIGATION:
NEW CODE REQUIREMENTS

Table 12.2 (NDP) — Minimum depth of field investigation for ground improvement

Ground Improvement Class	Minimum depth, d_{min}
AI	treatment depth + 5 m
AII	treatment depth + 5 m
BI	treatment depth + max{5 m; $3B_i$}
BII	treatment depth + max{5 m; $3B_{ri}$}

d_{min} is the minimum depth of field investigation from the ground surface

B_i is the equivalent diameter of a non-rigid inclusion (Class BI)

B_{ri} is the equivalent diameter of a rigid inclusion (Class BII)

The equivalent diameter of an inclusion is determined from, $B = 2\sqrt{A/\pi}$, where A is its horizontal cross sectional area.

(2) The minimum depth may be reduced if a shallower investigation combined with comparable local experience allows the ground properties to be determined below the treatment depth in accordance with EN 1997-2:2024, 5.4.3(4).

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SITE INVESTIGATION:
HIDDEN BENEFITS

Early contractor engagement is essential to optimise these benefits.

The minimum requirements should not be the maximum delivered.

SITE INVESTIGATION:
EXAMPLE: COST ANALYSIS

Simple Continual Flight Auger (CFA) example

- Cohesive ground conditions.
- 350mm Diameter, 200 pile project.

Foundation Costs

- 22% additional pile length.
- 26% contract (time and value) increase.
- 25% increase in contract duration

Typical site investigation Costs

- £1750-£10000

SITE INVESTIGATION:
CONCLUSIONS

- First step guidance is available in specifications and code
- The recommended values are the minimum required and not the maximum.
- It may be necessary to repeat the investigation process as the project evolves.
- New codes enhance the link between risk and detail of investigation.
- The costs of the any extended site investigation are always exceeded by the additional foundation costs managing the excessive unknown.
- Early contractor engagement is smart and essential.

Q&A