

Reference	NR/L3/CIV/071
Issue	4
Publication date	4 th June 2011
Compliance date	3 rd September 2011

Level 3

Geotechnical design

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Published and Issued by Network Rail, Kings Place, 90 York Way, London. N1 9AG.



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Issue record

Issue	Date	Comments
1	August 2003	New standard
2	August 2004	Amended to agree with RT/CE/S/020, RT/CE/P/044, RT/CE/S/066, RT/CE/S/067 and RT/CE/S/141.
3	March 2010	Complete revision to accommodate the use of the suite of Structural Eurocodes
4	June 2011	Revision to 10.3.2 and 10.3.3 to correct the values of the partial factors; to 11.6 , 11.7 and 11.9 (new) to clarify the design requirements for unplanned excavations and passive pressures; and 12.3 to emphasise the requirements for producing a Ground Investigation Report. Editorial changes, to remove inconsistencies and improve the clarity of the text.

Compliance

This Network Rail standard is mandatory and shall be complied with by Network Rail and its contractors if applicable from 3rd September 2011.

When this standard is implemented, it is permissible for all projects that have formally completed GRIP Stage 3 (Option Selection) to continue to comply with the issue of any relevant Network Rail standards current when GRIP Stage 3 was completed and not to comply with requirements contained herein, unless stipulated otherwise in the scope of this standard.

Reference documentation

The Railways (Interoperability) Regulations 2006 (Statutory Instrument 2006 No. 397)

Health and Safety at Work Act 1974

Construction (Design and Management) Regulations 2007

Building Regulations

BS 1377 [various parts]	<i>Methods of test for soils for civil engineering purposes [various sub-titles]</i>
BS 5930	<i>Code of practice for site investigations</i>
BS 8006	<i>Code of Practice for strengthened/reinforced soils and other fills</i>
BS 10175	<i>Code of Practice on investigation of potentially contaminated sites</i>
BS EN 1990	<i>Basis of structural design</i>
NA BS EN 1990	<i>UK National Annex to Eurocode. Basis of structural design (2002) + A1 (2005)</i>
BS EN 1991 [various parts]	<i>Actions on structures [various sub-titles]</i>

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BS EN 1991-2	<i>Actions on structures. Part 2: Traffic loads on bridges</i>
BS EN 1997-1	<i>Geotechnical design: General rules</i>
BS EN 1997-2	<i>Geotechnical design: Ground investigations and testing</i>
BS EN ISO 14688-1	<i>Geotechnical investigation and testing. Identification and classification of soil. Identification and description</i>
BS EN ISO 14688-2	<i>Geotechnical investigation and testing. Identification and classification of soil. Principles for a classification</i>
BS EN ISO 14689-1	<i>Geotechnical investigation and testing. Identification and classification of rock. Identification and description</i>
BS ISO 5667-11, BS 6068.11	<i>Water quality. Sampling. Guidance on sampling of groundwaters</i>
GC/RT5212	<i>Requirements for defining and maintaining clearances</i>
NR/GN/CIV/801	<i>The application of the Observational Approach to the design of remedial works to Earthworks</i>
NR/L1/AMG/1010	<i>Policy on working safely in the vicinity of buried services</i>
NR/L1/TRK/05200	<i>Vegetation</i>
NR/L2/AMG/1020	<i>Buried services data provision</i>
NR/L2/AMG/1030	<i>Working safely in the vicinity of buried services</i>
NR/L2/AMG/1040	<i>Buried services data feedback</i>
NR/L2/CIV/003	<i>Engineering Assurance of Building and Civil Engineering Works</i>
NR/L2/INI/CP0047	<i>Application of the Construction Design and Management Regulations to Network Rail construction projects</i>
NR/L3/CIV/005	<i>Railway drainage manual</i>
NR/L3/CIV/037	<i>Managing the risk arising from mineral extraction and landfill operations</i>
NR/L3/CIV/038	<i>Managing the potential effects of coal mining subsidence</i>
NR/L3/CIV/140	<i>Model Clauses for Civil Engineering works</i>
NR/L3/CIV/151	<i>Technical Approval of Standard Details and Designs for Civil Engineering Works</i>
NR/SP/OHS/069	<i>Lineside facilities for personal safety</i>
Highways Agency	<i>Design Manual for Roads and Bridges</i>
CIRIA Report C580	<i>Embedded retaining walls - guidance for economic design</i>
The Federation of Piling Specialists	<i>ICE Specification for piling and embedded retaining walls (2nd Edition: 2007)</i>
D C Wyllie and C Mahe	<i>Rock Slope Engineering (published by Taylor and Francis)</i>

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1 Purpose

The purpose of this standard is to define the requirements for geotechnical designs undertaken for Network Rail.

2 Scope

This standard is applicable to all types of 'structure', which is defined in [BS EN 1990: Basis of structural design](#) as an 'organised combination of connected parts, including fill placed during execution of the construction works, designed to carry loads and provide adequate rigidity'. Thus this standard is applicable to the geotechnical design of all types of building and civil engineering works - such as Earthworks; retaining walls; the foundations, piers, abutments and wing walls of bridges; and foundations to buildings.

This standard does not apply to Track support systems.

3 Roles and responsibilities

Roles, responsibilities and competencies of those involved in the production and checking of geotechnical designs shall be in accordance with [NR/L2/CIV/003: Engineering Assurance of Building and Civil Engineering Works](#).

4 Definitions

characteristic value (of a geotechnical parameter)

A cautious estimate of the value (of a geotechnical parameter) affecting the occurrence of the limit state, which takes account of the volume and quality of the test results, the variability of the ground, and the type of structure.

comparable experience

Documented or clearly established information related to the ground being considered in design, involving the same types of soil and rock for which similar geotechnical behaviour is expected, and involving similar structures. Information gained locally is particularly relevant.

construction works

Everything that is constructed or results from construction operations.

design criteria

Quantitative formulations that describe for each limit state the conditions to be fulfilled.

design situations

Sets of physical conditions representing the real conditions occurring during a certain time interval for which design will demonstrate that relevant limit states are not exceeded.

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design value

The value of a variable used in the calculation of the dimensions, forces on or in the structure being designed. The design value for a geotechnical parameter (such as the strength of a soil) can (a) be derived by dividing the characteristic strength of the soil by the appropriate partial factor, or (b) be assessed directly.

design working life

Assumed period for which a structure or part of it is to be used for its intended purpose with anticipated maintenance but without major repair being necessary.

Earthwork

An Embankment, Cutting (soil or rock) or Natural Slope (soil or rock), or nailed or reinforced soil structure whose face angle is less than 70 degrees to the horizontal.

execution

All activities carried out for the physical completion of the work including procurement, the inspection and documentation thereof.

geotechnical action

Action transmitted to the structure by the ground, fill, standing water or ground water.

ground

Soil, rock and fill in place prior to the execution of the construction works.

Geotechnical Design Report

A presentation of assumptions, data, calculations and results of the verification of safety and serviceability of a geotechnical design. A Geotechnical Design Report will also contain a Ground Investigation Report and a plan for any monitoring work.

Ground Investigation Report

A presentation of all available geotechnical information (including geological features and relevant data) and a geotechnical evaluation of that information (including the assumptions made in interpreting the results of tests).

limit states

States beyond which the structure no longer fulfils the relevant design criteria.

serviceability limit states

States that correspond to conditions beyond which specified service requirements for a structure or structural member are no longer met.

ultimate limit states

States associated with collapse or with other similar forms of structural failure.

load case

Compatible load arrangements, sets of deformations and imperfections considered simultaneously with fixed variable actions and permanent actions for a particular verification.

method of construction

Manner in which the execution will be carried out.

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resistance

Capacity of a member or component, or cross-section of a member or component of a structure to withstand actions without mechanical failure.

stiffness

Material resistance against deformation.

strength

Mechanical property of a material indicating its ability to resist actions, usually given in units of stress.

Structural Assessment

The determination or confirmation of the stability or safe-load bearing capacity of a structure.

structural system

Load-bearing members of a building or civil engineering works and the way in which the members function together.

structure

Organised combination of connected parts, including fill placed during execution of the construction works, designed to carry loads and provide adequate rigidity.

Temporary works

Any works in place for less than twelve months.

Track support system

The structure that provides immediate support to the track; it includes the formation, capping layers, blanketing, ballast, geosynthetics that are integral with the support system, and Longitudinal Timbers.

5 Governing requirements

5.1 Regulations, legislation and standards

Design and construction works shall comply with the requirements of the following.

1. The Railways (Interoperability) Regulations 2006.
2. Relevant legislation, such as the Health and Safety at Work Act 1974, and the Construction (Design and Management) Regulations 2007.
3. Building Regulations (for example, regarding the minimum depth of a foundation).
4. Railway Group Standards (for example, [GC/RT5212](#): *Requirements for defining and maintaining clearances*).

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5. Network Rail standards (for example, [NR/L2/CIV/003](#), and [NR/L2/INI/CP0047](#): *Application of the Construction Design and Management Regulations to Network Rail construction projects*).
6. Standards governing design, methods of construction, product specifications etc: details of which are given in 9.

Any particular requirements, provisions, deviations from extant Railway Group Standards and Network Rail standards, or variations on standard industry practice shall be stated and justified on the Approval in Principle (AIP) submission. Furthermore, where appropriate, the Environmental Agency or the Scottish Environment Protection Agency shall be consulted and agreement for the design, construction work and the specifications for work and materials obtained and documented before finalising the AIP submission.

5.2 Planning and liaison

5.2.1 Railway infrastructure managers and operators

A design shall take account of the requirements for the safe and efficient operation of railway infrastructure during the construction and commissioning of the structure. Thus, as necessary, the designer shall liaise throughout the design process with those responsible for managing and operating that infrastructure.

5.2.2 External authorities and parties

A design shall take account of the requirements of authorities and interested parties external to Network Rail, and so liaison with representatives of these organisations might be required throughout the design process. Arrangements for liaising with such representatives shall be agreed with Network Rail prior to any consultation regarding the proposed works.

Unless the designer is specifically delegated or permitted to do so, Network Rail will liaise directly with the Office of Rail Regulation (ORR) and all Notified Bodies.

5.2.3 Planning authorities

Unless the designer is specifically delegated or permitted to do so, Network Rail will undertake all consultations with planning authorities, and all contact with such authorities shall be co-ordinated through Network Rail. Furthermore, without the prior approval of Network Rail, no communication shall be made to other parties regarding permitted development status or planning approval.

Where applicable, the following shall be considered in the design;

- permitted development status,

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- planning permission issues,
- materials and finishes,
- aesthetics,
- landscaping, and
- the possible effects of the proposed method of construction and the timetable of the construction works - for example, on road traffic and on those living or working close to the site.

5.2.4 Legal obligations and commercial liability issues

Unless specifically delegated to the designer, all legal obligation and commercial liability issues shall be addressed by Network Rail: these issues include;

- liabilities, easement and wayleaves,
- load-carrying obligations - with regard to both statutory and safety requirements,
- establishing requirements for carriageway widths etc, and
- existing agreements regarding the maintenance, replacement and renewal of infrastructure and services.

5.2.5 Mineral extraction and landfill

Planning and design issues regarding mineral extraction and landfill shall be dealt with in accordance with [NR/L3/CIV/037](#): *Managing the risk arising from mineral extraction and landfill operations*, and [NR/L3/CIV/038](#): *Managing the potential effects of coal mining subsidence*.

Arrangements for liaising with mine operators and the Coal Authority, and with landfill operators shall be agreed with Network Rail prior to the designer consulting these organisations.

5.2.6 Buried services

With regard to the identification, marking, recording, and working safely in the vicinity of buried services, the design shall meet the requirements of; [NR/L1/AMG/1010](#): *Policy on working safely in the vicinity of buried services*, [NR/L2/AMG/1020](#): *Buried services data provision*, [NR/L2/AMG/1030](#): *Working safely in the vicinity of buried services*, and [NR/L2/AMG/1040](#): *Buried services data feedback*.

The requirements of these standards shall be met when undertaking field investigations.

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5.3 Health and Safety

The design shall take account of all reasonably foreseeable effects of the construction, maintenance and operation of the structure on the health and safety of site operatives, railway passengers and personnel, and members of the public. Thus, for example, consideration shall be given to;

- the provision of positions of safety and walkways alongside the railway (as required by [NR/SP/OHS/069](#): *Lineside facilities for personal safety*), and
- specific requirements for maintaining railway infrastructure.

5.4 Environmental considerations

The design shall take account of all reasonably foreseeable effects of the construction, maintenance and operation of the structure on the environment. Thus, for example, consideration shall be given to;

- the effect on sensitive species,
- the generation and control of noise and dust during construction,
- the generation, re-use and disposal of waste materials - so far as is reasonably practicable the design shall aim to minimise the amount of material that is to be disposed of: the re-use of clayey soils and weak rocks (such as marls and shales) might require particular construction methods and expedients (such as treatment with cement),
- the management of water on the site - including the effect of water on (a) train control and other safety critical equipment, (b) the stability of existing Earthworks, and (c) the generation and control of contaminated run-off,
- managing vegetation in accordance with [NR/L1/TRK/05200](#): *Vegetation* - the design shall address the risks associated with allowing vegetation to grow unchecked, and
- the carbon footprint of the construction and use of the structure.

6 Design objectives and situations

The fundamental objectives of a design are that the structure will;

- throughout its intended design life (with appropriate degrees of reliability) remain fit for the use required, sustain all the actions and environmental influences likely to be imposed upon it during its construction and use - within acceptable deformation limits,
- have adequate stability, resistance, stiffness, serviceability and durability,

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- have sufficient resilience, robustness and structural redundancy to (a) withstand damage by accidents and events (such as vehicle impact, vandalism, and human error in design and use) disproportionate to their original cause, (b) have a low sensitivity to hazards that it might be subjected to, (c) withstand the accidental removal of a structural member, and (d) so far as is reasonably practicable, provide adequate warning of collapse - for example, by showing signs of structural distress or deformation,
- be economic to construct, use and maintain,
- be readily accessible for routine examination and maintenance, and
- in construction and use, generate only acceptable risks to (a) the safe use or performance of railway infrastructure and (b) the safety of the public at large; and cause minimal or no damage to property and the environment.

Both short-term and long-term design situations shall be considered, and the identification and definition of these situations shall take account of the following.

1. The types of action imposed on and by the structure.
2. The general suitability of the ground for construction.
3. The extent and nature of the various types of fill, soil, rock and structural members/elements/components that are modelled in any analysis.
4. The environment at the site, and the possible changes in the environment produced by the construction and use of the structure.
5. The possible effect of the construction and use of the structure on existing infrastructure.
6. The requirements for the safe and ready examination, maintenance, and repair of the structure - such as ease of access to the site, and the criticality and durability of hidden parts of the structure.

For each design situation, it shall be verified that no relevant limit state will be exceeded. In defining the limit states, consideration shall be given to the following.

1. The characteristics of the site (including the ground, ground water and environmental conditions).
2. The form, complexity and size of the structure and its members/elements.
3. The static, transient and dynamic loads that will be applied to and by the structure.
4. Potential failures of (a) the ground, and (b) structural members/elements (and connections between them) - singly, in combination and in sequence.