Specification for Tunnelling

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Fourth edition

The British Tunnelling Society

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Foreword

The *Model Specification for Tunnelling* was produced by the British Tunnelling Society in conjunction with the Ground Board of the Institution of Civil Engineers in order to establish a common standard for tunnelling and first published in 1997. It was revised in 2000, published as the *BTS Specification for Tunnelling* and has become the standard Specification referred to in the majority of tunnelling contracts in the UK and in many worldwide. The third edition was published in 2010 and formed the basis of specifications for major infrastructure projects such as Crossrail, Thames Tideway and HS2.

This fourth edition consolidates the experiences gained on these landmark projects and presents the updated guidance emerging from practical application of the third edition. Like the earlier editions it relies heavily on the experience of individual and corporate members of the BTS. There have been too many contributors to name individually here.

Similar to the third edition, there are major changes in the section on sprayed concrete which reflect its growth in use and development as a technique. The sections dealing with then new techniques, such as sprayed applied waterproofing membranes, have been critically reviewed and likewise reflect practical experience. All sections have been updated to reflect best current practice, changes in national standards and the new Eurocodes. We trust that the fourth edition of the BTS Specification will retain its position as trusted standard for tunnelling contracts in coming years.

We recognise that change will continue to occur in the tunnelling industry and that it will always be possible to improve this specification. Any suggestions for improvements and amendments to future editions should be sent to the Secretary of the British Tunnelling Society at the Institution of Civil Engineers, Great George Street, London SW1P 3AA.

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1. General requirements

101. General notes

101.1. General

1. This Specification is a model document intended to serve as a basis for materials and workmanship quality requirements for all tunnel projects, including adits and shafts, in conjunction with the specification component of the Institution of Civil Engineers Specification for Piling and Embedded Retaining Walls, and the scope can be extended to include cut-and-cover tunnels and similar underground structures.
2. This Specification is written in modular form. It is intended that the whole document be incorporated into documents by reference, and additional, substituted or deleted clauses particular to the Project be included in a Particular Specification. References are made to the Particular Specification at various points in the text for the user to insert project-specific requirements. Where the Particular Specification is in conflict with the general text of the Specification, the Particular Specification shall take precedence.
3. The Specification indicates minimum standards of materials and workmanship, and is written so that the parties to the Contract are as free as possible to agree on methods of carrying out the work.
4. Any clauses relating to work or materials not required in the project are deemed not to apply.
5. Whenever possible, reference has been made to other industry standards and accepted quasi-standards. Except in this chapter and where specific to the text, references to Acts of Parliament and Statutory Instruments have not been made, as compliance with legislation is a statutory requirement.
6. This Specification reflects tunnelling practice as undertaken by UK clients, contractors and designers, but has been written to allow it to be used also in an international context with the minimum of modification.
7. This Specification has been written so that it may be used with a range of procurement methods and Conditions of Contract. The title ‘Engineer’ has been used throughout this Specification as the accountable party who is empowered to make decisions on design and technical matters and variations, but this title will vary between procurement methods and Conditions of Contract. The Contract Documents or Particular Specification should set out the roles and responsibilities for the particular project.
8. The title ‘Designer’ has been used where it is essential that supervision or specific input is provided that fully understands the design basis. The ‘Designer’ may be employed by the Employer or the Contractor depending on the particular project and procurement method.

9. Assessment of payment and sharing of financial risk have been specifically excluded from this Specification, this being deemed to be the province of other Contract Documents.
10. This Specification is written to be used in conjunction with other Specifications where several disciplines are involved in the works. The Particular Specification should establish the order of precedence where more than one Specification is referenced.
11. This Specification has been written on the basis that details of the Contractor's methods and temporary works will be submitted to the Engineer for agreement. The Particular Specification should clarify the requirements for the Engineer's agreement to methods and temporary works for the particular project, including timescales for review. Where the Engineer's agreement to methods and temporary works is not required, this shall be stated in the Particular Specification.
12. The planning and implementation of the works shall comply with the current version of the International Tunnel Insurance Group *A Code of Practice for Risk Management of Tunnel Works* 2006 (being revised).
13. The Contractor shall be the *user* in terms of BS EN 16191 and shall be responsible for providing all information on *intended use* required by that standard.
14. In this specification 'Employer' means the entity commissioning and paying for the tunnel works.

101.2. Carbon management

1. The Designer and the Contractor shall manage and minimise whole life carbon across the delivery of the Contract, in line with the principles of the BSI Publicly Available Specification (PAS) 2080 *Carbon Management in Infrastructure*.

   Note: Due to the rapid development cycle of carbon management it is recommended to review the requirements of Clause 101.2 and associated clauses and confirm their applicability in the Particular Specification.

2. The PAS 2080 carbon management hierarchy shall be applied for the management process as per Clause 101.2.1 to identify whole life carbon solutions for the asset and its components. In applying the carbon reduction hierarchy, all value chain members shall demonstrate they have considered the following

   (*a*) avoid: ensure the outcomes of the project/programme of work are aligned with the net zero transition and evaluate the basic need of an asset/network
   (*b*) switch: assess alternative solutions/options to reduce whole life emissions through alternative materials, technologies for operational carbon reduction, among

others, while satisfying the whole life performance requirements

(*c*) improve: identify solutions and techniques that improve the use of resources and design life of an asset/network, including applying circular economy principles to assess materials/products in terms of reuse and recycling potential after end of life as well as flexibility in being repurposed.

3. The Designer and Contractor shall identify carbon reduction opportunities at the earliest stage of the project or programme of work to enable the greatest carbon savings to be achieved. The baseline against which savings are measured shall be agreed in the Contract.

4. The definition of the goal and scope of greenhouse gas (GHG) quantification shall capture the elements listed in PAS 2080 Section 7.1.1 and shall be agreed with the Engineer.

5. Carbon management shall be captured in the Quality Management System as per Clause 108 of this specification.

6. For the use of non-standardised materials please refer to Clause 103.3 of this specification.

102. Definitions

102.1. General

1. Where definitions are not provided within the specification, they shall generally be those contained in BS 6100.
2. Definitions of tunnelling terms are contained in BS 6100-3: Section 6 (2007).
3. For terms not defined in BS 6100, reference shall be made to the ITA 'Glossary of tunnelling terminology' (https://tunnel.ita-aites.org/en/component/seoglossary/1-main-glossary).
4. 'Mechanised tunnelling' refers to tunnels excavated by some form of tunnel boring machine.
5. 'Conventional tunnelling' refers to tunnels excavated by means other than tunnel boring machine – for example, drill and blast in rock.
6. 'Permanent works' are works, the purpose of which extends beyond completion of construction and/or are left in place beyond the completion of construction.
7. 'Temporary works' are works, the purpose of which does not extend beyond completion of construction.
8. 'Carbon' is the short-hand colloquial term used for GHGs, typically the six covered by the Kyoto Protocol – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

103. References to Standards

103.1. Standards and alternative standards

Materials, equipment and methods shall comply with the Standards and Codes of Practice indicated in the text. Where references in this specification are dated, the dated version of that document shall be used. Where references are undated, then the versions current at the date for submission of tenders shall be used.

For BS EN 16191 and BS EN 12110, the version used shall be that current when the declaration of conformity is made by the manufacturer.

The Contractor may propose the adoption of alternative standards and shall provide explanations with any proposals. The use of such standards shall be subject to the agreement of the Engineer.

103.2. Alternative materials and equipment

The Contractor may propose alternative materials or equipment to those specified provided either

(*a*) they are of at least equal quality and performance or
(*b*) they are of like quality and performance and comply with approved alternative standards.

If alternative materials or equipment are proposed, the Contractor shall submit comprehensive details including technical descriptions, drawings and specifications to demonstrate that the alternative complies with either requirement of this Clause. The adoption of such alternative materials or equipment shall be subject to the agreement of the Engineer.

103.3. Design with non-standardised materials

Where proposed alternative materials are not standardised, or are used within the context of a design standard not specifically developed for use with these alternative materials, the design shall be undertaken as 'Design assisted by testing' to BS EN 1990:2002 +A1:2005 Annex D.

104. Eurocodes and European and British Standards

104.1. Eurocodes

The following design standards (Eurocodes) are relevant and are referred to in the text

BS EN 1990	Basis of structural design (Eurocode 0)
BS EN 1991	Actions on structures (Eurocode 1)
BS EN 1992	Design of concrete structures (Eurocode 2)
BS EN 1993	Design of steel structures (Eurocode 3)
BS EN 1995	Design of timber structures (Eurocode 5)
BS EN 1997	Geotechnical design (Eurocode 7)
BS EN 1998	Design of structures for earthquake resistance (Eurocode 8)

104.2. British, European and International Standards

The British designated version of the following European standards dual (BS EN) or dual triple numbered European and International standards (BS EN ISO) and their UK National Annexes are relevant and are referred to in the text

BS EN ISO 62	Plastics. Determination of water absorption
BS EN 196-1	Methods of testing cement. Determination of strength
BS EN 196-2	Methods of testing cement. Chemical analysis of cement
BS EN 197-1	Cement. Composition, specifications and conformity criteria for common cements
BS EN 206	Concrete. Specification, performance, production and conformity
BS EN 295-7	Vitrified clay pipe systems for drains and sewers – Requirements for pipes and joints for pipe jacking
BS EN 335	Durability of wood and wood-based products. Use classes: definitions, application to solid wood and wood-based products
BS EN 338	Structural timber. Strength classes
BS EN 450-1	Fly ash for concrete. Definition, specifications and conformity criteria
BS EN 471	High-visibility clothing
BS EN 480	Admixtures for concrete, mortar and grout. Test methods
BS EN ISO 527-3	Plastics. Determination of tensile properties. Test conditions for films and sheets
BS EN 681-1	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications – Vulcanized rubber
BS EN 681-2	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications. Thermoplastic elastomers