

BS 7543:2015



BSI Standards Publication

Guide to durability of buildings and building elements, products and components

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Contents

Foreword *ii*

Introduction 1

- 1 Scope 1
- 2 Normative references 2
- 3 Terms, definitions and abbreviations 3
- 4 Requirements for durability 5
- 5 Researching and calculating durability 8
- 6 Service life assessment 8

Annexes

- Annex A (informative) Climatic agents affecting durability 18
- Annex B (informative) Guidance on materials and durability 24
- Annex C (informative) Examples of UK material or component failures 33
- Annex D (informative) Design life data sheet: Worked example for facade components 35
- Annex E (informative) Further Reading and sources of information on durability 38

Bibliography 40

List of figures

- Figure 1 – Degradation of a component and its relation to service life distributions and physical modelling (Method 2) 9
- Figure 2 – Approaches to service life planning (based on BS ISO 15686-2) 12
- Figure 3 – Decision process in support of categorization of design life 13
- Figure 4 – Phases of the life cycle 17

List of tables

- Table 1 – Categories of design life 5
- Table 2 – Categories of effects of failure 6
- Table 3 – Examples of effects of failure in different categories 14
- Table 4 – Expression of durability (summary of guidance) 15
- Table B.1 – Untreated timber durability hazards 28
- Table C.1 – Examples of UK material or component failures 33
- Material or component 0
- Table D.1 – Design life data sheet 36

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 42, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 April 2015. It was prepared by Technical Committee CB/101, *Service Life Planning*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 7543:2003, which is withdrawn.

Information about this document

This is a full revision of the standard, and introduces the following principal changes.

- Terms and definitions have been updated to reflect the BS ISO 15686 series.
- The basis of risk assessment for estimating durability has been revised (see Clause 5).
- The data on climate have been revised to reflect current understanding, in particular in respect of climate change (see Annex A).
- Annex A gives guidance on the way agents can affect service life.
- Annex B gives guidance on standards and good practice for major building materials.
- Annex C describes some common examples of construction failure that have occurred reasonably recently where expectations of durability have not been met.
- Annex D is an example of a completed design life data sheet showing application of the principles of this guidance to a specific system (building facades).
- Annex E is an annotated list of further reading giving information sources on topics covered in this guide.
- There is also a bibliography updated to reflect the current guidance.

This revision of BS 7543 updates and reinstates certain areas covered in the 1992 version. A series of International Standards, BS ISO 15686, *Buildings and constructed assets – Service life planning*, have been published since 2000. The provisions of BS ISO 15686 have replaced many of the provisions of the previous edition of this standard. However, there are a number of elements of this standard which are complementary to BS ISO 15686. This edition of the standard incorporates the complementary elements.

As a guide, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

In order to predict the durability and the possible overall life of buildings, many factors need to be considered. These include practitioners' experience of component or material durability in practice, results of assessments and tests, and the possible effects of the actions of agents on different parts of the building or civil engineering structures. It is also important that this information is communicated clearly to the client and the project team so that the long-term performance implications of proposed designs can be understood and agreed.

For simplicity the term "parts" has been used throughout to cover both whole buildings and building elements, products and components.

Predicting durability is not an exact science, but a risk-based approach to the consideration of failure and acceptable service life. Values calculated for the predicted service life of a building and its parts can sometimes be no more than an informed estimation (for example, for novel materials or for unusual combinations of specific project circumstances). It is usually helpful to state the facts, assumptions and references on which the values are based.

Predictions of the durability of buildings have to take into account the variability of operating conditions, environment, workmanship, the quality and frequency of maintenance and the practical problems surrounding the storage, handling, installing and inspection of materials or components on a construction site. Maintaining, repairing and replacing buildings and assets across many sites or projects can provide a wealth of experience(s) on durability. However, there is a lack of systematically collated data that can form a basis from which durability can be accurately predicted for future projects.

NOTE 1 Although BS 5760 dealt comprehensively with reliability, maintainability and availability, in all industries, it was considered necessary to provide a separate publication specifically for the construction industry. Many of the parts of BS 5760 (but not all) have been superseded by applicable CEN standards, and one in particular is relevant which is BS EN 60812 which describes failure mode effect and criticality analysis (FMECA). Specific guidance on the durability of particular parts of buildings is given in many other British Standards, some of which are referred to in Annex B and Annex C. The design life of parts of a building will often need to be less than the design life of the whole building and this can be perfectly compatible with the usage and refurbishment cycles of normal building occupancy. However, achieving adequate durability without excessive expenditure or consumption of scarce resources is essential for achieving sustainability.

NOTE 2 Attention is drawn to the Construction Products Directive [1].

NOTE 3 Further guidance on improving the collection of data from buildings during their in-use phase can be found in BS ISO 15686-7.

1 Scope

This British Standard gives guidance on durability, design life and predicted service life of buildings, constructed assets and their parts. It applies to both new and existing buildings.

This standard also gives guidance on communicating and recording information on the service and design life of buildings, infrastructure and their components and/or assets when a detailed brief is being developed.

The principles of this British Standard are applicable to civil engineering projects and the guidance is written for all members of a construction project or facilities management team who provide or require information on durability, including clients, designers, contractors, specialists, manufacturers and those responsible for maintenance. It might also be relevant to funders, insurers and those undertaking due diligence assessments for investment purposes. It also applies to situations when new products offer better performance without a corresponding increase in cost.

This British Standard does not cover aspects of obsolescence and fashion, i.e. when buildings, infrastructure or assets are replaced or altered either to suit different needs and changing conditions including change of use and mandatory requirements.

NOTE 1 A decision to replace or alter obsolete buildings or their assets might be influenced by a reassessment of their predicted service lives. BS ISO 15686-1:2011, Clause 8 gives further guidance on obsolescence.

NOTE 2 More durability guidance specific to individual sectors is available from bodies such as the Highways Agency and engineering institutions.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 15643-1, *Sustainability of construction works – Sustainability assessment of buildings – Part 1: General framework*

BS EN 15643-2, *Sustainability of construction works – Assessment of buildings – Part 2: Framework for the assessment of environmental performance*

BS EN 15643-3, *Sustainability of construction works – Assessment of buildings – Part 3: Framework for the assessment of social performance*

BS EN 15643-4, *Sustainability of construction works – Assessment of buildings – Part 4: Framework for the assessment of economic performance*

BS ISO 6707-1, *Buildings and civil engineering works – Vocabulary – Part 1: General terms*

BS ISO 6707-2, *Buildings and civil engineering works – Vocabulary – Part 2: Contract terms*

BS ISO 15686-2:2012, *Buildings and constructed assets – Service life planning – Part 2: Service life prediction procedures*

BS ISO 15686-5, *Buildings and constructed assets – Service life planning – Part 5: Life cycle costing*

BS ISO 15686-7, *Buildings and constructed assets – Service life planning – Part 7: Performance evaluation for feedback of service life data from practice*

BS ISO 15686-9:2008, *Buildings and constructed assets – Service-life planning – Part 9: Guidance on assessment of service life data*

BS ISO 15686-10:2010, *Buildings and constructed assets – Service life planning – Part 10: When to assess functional performance*

BS ISO 15686-11:2014, *Buildings and constructed assets – Service life planning – Part 11: Terminology*

3 Terms, definitions and abbreviations

For the purposes of this British Standard, the terms and definitions given in BS ISO 15686-11, BS ISO 6707-1, BS ISO 6707-2, and the following apply.

3.1 agent

whatever acts on a building or its parts to adversely affect its performance

EXAMPLE Person, water, load, heat.

[SOURCE: BS ISO 15686-2:2012, 3.1.4]

3.2 asset

whole building structure or unit of construction works, or a system or component or part thereof

NOTE Component has been used to include both materials (e.g. sand or cement) and assemblies (e.g. cladding).

[SOURCE: BS ISO 15686-10:2010, 3.1]

3.3 component

product manufactured as a distinct unit to serve a specific function or functions

[SOURCE: BS ISO 15686-2:2012, 3.1.6]

3.4 degradation

process whereby an action on an item causes a deterioration of one or more properties

[SOURCE: BS ISO 15686-2:2012, 3.1.7]

3.5 design life (DL)

DEPRECATED: intended service life; expected service life

service life intended by the designer

NOTE As stated by the designer to the client to support specification decisions.

[SOURCE: BS ISO 15686-1:2011, 3.3]

3.6 durability

ability of a building and its parts to perform its required function over a period of time and under the influence of agents

3.7 durability limit

point at which loss of performance leads to the end of the service life

3.8 environment

natural, man-made or induced external and internal conditions that can influence performance and use of a building and its parts

[SOURCE: BS ISO 15686-1:2011, 3.4]

3.9 estimated service life (ESL)

service life that a building or parts of a building would be expected to have in a set of specific in-use conditions, determined from the reference service life data after taking into account any differences from the reference in-use conditions

[SOURCE: BS ISO 15686-1:2011, 3.7]

3.10 failure

loss of the ability of a building or its parts to perform a specified function

[SOURCE: BS ISO 15686-1:2011, 3.9]

3.11 life cycle

consecutive and interlinked stages of the object under consideration

NOTE 1 The life cycle comprises all stages from construction, operation and maintenance to end of life, including decommissioning, deconstruction and disposal.

NOTE 2 Adapted from the definition of "life cycle" contained in BS EN ISO 14040, 7.1.

[SOURCE: BS ISO 15686-5:2008, 3.3.4]

3.12 maintenance

combination of all technical and associated administrative actions during the service life to retain a building, or its parts, in a state in which it can perform its required functions

[SOURCE: BS ISO 15686-1:2011, 3.13]

3.13 performance

DEPRECATED: performance in-use

qualitative level of a critical property at any point in time considered

[SOURCE: BS ISO 15686-1:2011, 3.15]

3.14 performance requirement

DEPRECATED: performance criterion

minimum acceptable level of a critical property

[SOURCE: BS ISO 15686-1:2011, 3.19]

3.15 predicted service life

service life predicted from performance recorded over time in accordance with the procedure described in BS ISO 15686-2

[SOURCE: BS ISO 15686-1:2011, 3.20]

3.16 reference service life (RSL)

service life of a product, component, assembly or system which is known to be expected under a particular set, i.e. a reference set, of in-use conditions and which can form the basis for estimating the service life under other in-use conditions

[SOURCE: BS ISO 15686-1:2011, 3.22]

3.17 service life

period of time after installation during which a building or its parts meets or exceed the performance requirements

NOTE Adapted from BS ISO 6707-1.

[SOURCE: DD ISO/TS 15686-9:2008, 3.4]

3.18 usage conditions

in-use conditions due to users of a building/constructed assets, and human activity adjacent to a building/constructed assets

NOTE In BS ISO 15686-7:2006, the factor class (3.1.39) F is designated "usage conditions" rather than "in-use condition" as used but not defined in BS ISO 15686-1. This is called for in order to distinguish the factor class from the term "in-use condition" as defined in BS ISO 15686-2:2001 as "environmental condition under normal use".

[SOURCE: BS ISO 15686-7:2006, 3.15]

4 Requirements for durability

4.1 General

Requirements for durability vary from project to project and from one asset to another. Requirements can be related to intended use, to the financing of a project and to scheduling/carrying out periods of maintenance, repair or replacement of a building or its parts.

Very durable, long lasting construction is usually more expensive and might restrict the design to a limited range of materials. Consequently a long design life is likely to increase the initial cost of the project, but not necessarily the life cycle cost, and can limit the design solutions that meet the brief. Therefore the designer might challenge excessive design life requirements as well as other aspects of the brief, such as the initial budget.

Financing of building construction often presumes a design life at least as long as the period of any loan used to finance the building, which might be secured on the building value.

4.2 Communication of requirements for durability (client to designer)

The client should define the design life of the building in the initial brief, which should reflect the overall requirements. Design life categories for parts are given in Table 1 and categories for effects of failure are given in Table 2. In addition the client might wish to specify the design life for specific assets. An example of reference service lives for specific components is given in Annex D. The design life or reference service life should be given in years and can be related to the categories of building design life.

Table 1 Categories of design life

Category description	Life	Typical examples
Short-term	Shorter life than the building and readily replaceable	Door actuators and motors, taps
Replaceable	Shorter life than the building and replacement can be envisaged at design stage	Most floor finishes and services installation components
Maintainable	Lasts, with periodic treatment, for the life of the building	Most external cladding, doors and windows
Lifelong	Lasts for the life of the building	Foundations and main structural elements

Table 2 Categories of effects of failure

Category	Effect	Example
A	Danger to life (or injury)	Sudden collapse of structure
B	Risk of injury	Loose stair nosing
C	Danger to health	Serious damp penetration
D	Costly repair	Extensive scaffold required. Durability critical component failure (see note below)
E	Costly because repeated	Window fastening replacement
F	Interruption to building use	Heating failure
G	Security compromised	Broken door latch
H	No exception problems	Replacement of light fittings

NOTE Individual failures can be in two or more categories.

When a period for design life is given by or on behalf of the client the following information is essential:

- time (or a time measure such as running time or cycles of use) against which durability is to be assessed;
- usage conditions in which the item will have to perform (i.e. environmental conditions and levels of maintenance and usage); and
- performance requirements to allow the durability limit to be assessed (i.e. the point at which performance becomes unsatisfactory).

NOTE 1 Annex A gives guidance on relevant environmental conditions. Annex B gives some details of specific materials and relevant durability considerations.

NOTE 2 For example the light transmission through some materials decreases over the period of use depending on the surface finish and levels of cleaning/planned maintenance. A decision has to be made on when to change the roof light for a new one that will give a greater light transmission.

NOTE 3 The maintenance of thermal performance is achieved by ensuring that thermal conductivity characteristic of the material along with its dimensional stability (especially thickness in the direction of heat flow) is maintained. Before specifying a product the designer should be satisfied that the aging method required by the product standard is appropriate for the intended use.

NOTE 4 When designers receive a clear statement of requirements for durability from a client, they are more likely to be able to specify appropriately for all assets and avoid disappointments where, for instance, assets require early replacement. However, the process of agreeing the design lives with the client might involve the designer challenging competing client requirements (such as very long design lives against very low costs or short design periods or low fees), or indicating where design life requirements cannot be reasonably met by available design options.

Where the client has not specified the usage conditions or performance requirements that apply to the assets, the designer should record and agree with the client which conditions or requirements have been assumed.

The design life for a building should be qualified by additional information on future maintenance activity, based on the level of accessibility and feasibility for replacement of parts.

NOTE 5 Further guidance on maintenance can be found in BS 8210. There are three groups of maintenance approaches described in BS 8210:2012, Annex A. BS EN 13306 has definitions of corrective maintenance, maintenance plans, etc.

When a designer is developing a performance specification containing requirements for durability, it might be necessary to consult the client to ascertain their requirements. Any assumptions or cycles implied should be discussed and agreed with the client. For example, certain parts of the building might only be required to last until the first major refurbishment, in which case this timescale should be agreed.

For most parts or components it is clear how they are required to perform throughout the specified required service life. Some reduction in performance during the life cycle is generally acceptable (e.g. prior to replacement or maintenance), provided the performance requirements continue to be met. However, in the case of cosmetic appearance, some change might be acceptable. If changes in appearance are to be avoided this should be discussed at the briefing stage.

NOTE 6 For example the weathering of external claddings might be acceptable or even desired. A gradual change in the appearance of many floor finishes in trafficked areas is inevitable.

4.3 Communication of requirements to manufacturers and suppliers

The designer, or the person responsible for maintenance, should give requirements for durability when ordering a product from a supplier. Design life requirements should be given in years, and be related to design life categories in Table 1 and building design life.

When seeking predicted service life statements from manufacturers, designers or the person responsible for maintenance should give the following information on the design life for parts:

- a) information on exposure to agents; and

NOTE 1 More detailed advice on specific agents and their effects on durability is given in Annex A.

- b) details of adjacent materials and fixings.

NOTE 2 Information on exposure to agents is particularly important where the design life is part of a performance specification presented to a manufacturer supplying external components.

NOTE 3 The extent of cyclical movement of adjacent components and the chemical compatibility of materials is often critical to the durability of an assembly. These details are particularly important when the design life is given to a manufacturer of components in a performance specification. General statements and schematic details might not be enough to identify risks.

Allowances made for thermal and moisture movement, and methods of isolating incompatible materials should be fully described to the manufacturer.

A predicted service life from a supplier or manufacturer should indicate the service life environment (the specific or generic set of in-use conditions), as described in BS ISO 15686-2:2012, 5.1.2.1.

5 Researching and calculating durability

A designer needs information on durability in order to be able to meet the client's requirements and assess the adequacy of intended durability of the whole building under construction. Information on durability of buildings and building components can be obtained from various sources, including:

- a) codes of practice, text books and trade association publications;

NOTE 1 Such sources often embody experience in the use of traditional methods and materials.

- b) national or international construction product certification bodies;

NOTE 2 For resources such as certificates assessing the performance of products.

- c) publications from research bodies, professional institutions, or authoritative bodies;

- d) manufacturers, providing predictions or warranties of the service life of their products.

NOTE 3 Such predictions or warranties can include details of the method of assessment, the variability of test results, the assumed conditions of use, and maintenance requirements as described in BS ISO 15686-2:2012, Clause 5.

NOTE 4 Relevant test certificates are not always available from manufacturers and might have to be obtained by testing for a specific project. This is time-consuming and expensive to do properly and might not be possible for smaller or for fast-track projects.

Predicted service life should be expressed in accordance with Table 4 (an example is shown in Annex D).

6 Service life assessment

6.1 General

The predicted service life is an expert judgement by the designer or supplier based on:

- a) available information on service life;
- b) site conditions;
- c) expected quality of workmanship; and
- d) the expected maintenance levels.

A cautious interpretation (avoiding too much optimism in interpretation) of available information is justified where:

- 1) the usage of parts of the building cannot be foreseen;
- 2) unfamiliar or novel products or products that are unfamiliar to the designer or supplier are to be incorporated; and
- 3) exceptionally large assemblies of components are involved.

6.2 Modelling of degradation of components

6.2.1 General

There are three main methods of modelling degradation of components for use in probabilistic analysis.

- a) **Method 1** (see 6.2.2): The use of past performance data to provide probability information regarding the service life of the building and/or

parts: e.g. time to repair, replacement or failure. When complete data are unavailable, theoretical considerations and laboratory tests can be used to complement them.

- b) **Method 2** (see 6.2.3): Physical modelling of the degradation of material properties and dimensions under the environmental conditions expected or specified. The knowledge for developing and calibrating these models can come from past performance data, laboratory tests and theoretical considerations.
- c) **Method 3** (see 6.2.4): Use of national data sets of typical reference service life estimates. These are expert judgements, often by a panel of experienced professionals. They might be published or available only within an organization, based on the previous experience of the professionals concerned. They can also include a range of values with guidance on which aspects of environment might influence selection on a single value estimate within the range.

Figure 1 shows a simple case of a single component with various possible service lives due to different environmental and load conditions.

Figure 1 **Degradation of a component and its relation to service life distributions and physical modelling (Method 2)**

