

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

ICS 91.040.01; 91.060.01

Confirmed December 2011

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee B/500/3, upon which the following bodies were represented:

- Building Research Establishment (BRE)
- British Board of Agrément (BBA)
- British Institute of Facilities Management (BIFM)
- Building Services Research and Information Association (BSRIA)
- Chartered Institute of Building (CIOB)
- Civil Engineering Contractors Association (CECA)
- Construction Confederation
- Construction Products Association
- Consumer Policy Committee of BSI
- Defence Estates
- Home Office
- Institution of Civil Engineers (ICE)
- Institution of Structural Engineers
- Office of the Deputy Prime Minister (Building Regulations Division)
- Royal Institute of British Architects
- Royal Institution of Chartered Surveyors
- Scottish Office (Construction and Building)

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- Association of Building Component Manufacturers
- Federation of Civil Engineering Contractors

This British Standard was published under the authority of the Standards Policy and Strategy Committee on XX July 2003

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First published March 1992

The following BSI references relate to the work on this British standard:
Committee reference B/500/3
Draft for comment 87/15323 DC

ISBN 0 580 38789 5

Amendments issued since publication

Amd. No.	Date	Comments

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Foreword

This British Standard has been prepared under the direction of the Basic Data and Performance Criteria for Civil Engineering and Building Structures Standards Policy Committee. It supersedes BS 7543:1992 which is withdrawn.

This new edition of BS 7543 incorporates technical changes only. It does not reflect a full review or revision of the standard, which will be undertaken in due course.

An International Standard, ISO 15686, *Buildings and constructed assets — Service life planning*, was first published in 2000. The provisions of 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 ISO 15686. This edition of this standard incorporates the complementary elements, while those elements of the standard replaced by ISO 15686 have been removed from this edition.

Instances of the premature failure of buildings have highlighted the need for more attention to be paid to all aspects of durability. This British Standard will assist the communication of information on durability between the parties involved in a building project, i.e. clients, designers, manufacturers, contractors and specialists. It is intended to discourage unrealistic expectations of service life of buildings and parts of buildings.

Annex A gives information on the prediction of durability for buildings and parts of buildings and guidance on the way agents can affect service life. Annex B describes some common examples of construction failure that have occurred in the last 20 years where expectations of durability have not been met. Annex C is an annotated bibliography giving further reading on topics covered in this guide.

NOTE Users are encouraged to investigate the possibility of applying the most recent editions of the bibliographic references given.

Although BS 5760 “Reliability of systems, equipment and components” deals comprehensively with reliability and durability, in all industries, it was considered necessary to provide a separate publication specifically for the construction industry [1]. However, some of the terms used in BS 5760 and the techniques that it recommends are relevant.

This British Standard has been written for all members of a building team who provide information on durability, that is: clients, designers, manufacturers and those responsible for maintenance. It is also relevant to the preparation of information in standards and technical approvals for products.

For simplicity the term “parts” has been used throughout to cover building elements, products and components.

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 C. It should also be remembered that the design life of parts of a building will often need to be less than the design life of the whole building and that this can be perfectly compatible with the usage and refurbishment cycles of normal building occupancy.

In using this guide it should be remembered that predicting durability is not an exact science. It is essential to be aware that periods arrived at for the predicted life of a building and its parts will sometimes be no more than an informed estimation and that it will usually be helpful to state the facts, assumptions and references on which the periods are based.

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 does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 28, an inside back cover and a back cover.

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Section 1. General

0 Introduction

0.1 General

To predict durability and building life many factors need to be considered. These include experience, results of assessments and tests and the effect of the actions of agents on different parts of the building. It is also important that this information is communicated clearly. Adherence to the forms of expression and terms defined in Clause 2 will help to avoid misunderstandings.

0.2 Experience

Prediction has to take into account the variability of conditions, workmanship and maintenance and the practical problems of handling, installing and inspection of components on a building site. The maintenance, repair and replacement of buildings and parts of buildings provides a wealth of experience on durability. However, in all but a few cases, there is a lack of systematically collated data that can form a basis from which durability can be predicted with any certainty.

0.3 Assessment techniques and life cycle costing

Techniques are being developed to assess when items should be replaced. For example life cycle costing can be used to predict the limit of durability which is reached when it is no longer economical to maintain and repair an item rather than when it is no longer possible to do so. Life cycle costing can help to predict the limit of durability of some items on economic grounds [1] [2]. Other items, in particular mechanical services, may need to be replaced before they fail in order to avoid interrupting the use of a building. Hazard analysis techniques can help to identify such items.

0.4 Agents

Agents that cause deterioration in buildings, such as driving rain and foot traffic, can each be measured. An agent's action may vary nationally (for example the velocity and direction of driving rain varies from one part of the country to another) but local variations and variations from one side of a building to another may be just as significant.

0.5 Communications

To avoid misunderstandings that can lead to construction failures each member of a building-team should have a clear understanding of what is possible, what is required and what is provided in terms of durability. They may then need to communicate this information to others. This guide makes recommendations that will help with the communications of information about durability.

1 Scope

This British Standard gives guidance on durability, required and predicted service life and design life of buildings and their components and/or parts. It applies primarily to new buildings and their components and/or parts rather than to alterations and repairs. It also gives guidance on presenting information on the service and design life of buildings and their components and/or parts when a detailed brief is being developed.

This British Standard applies to civil engineering projects involving buildings, but only partially to other civil engineering projects such as roads, bridges and dams.

This British Standard does not deal with many aspects of obsolescence, i.e. when buildings or parts of buildings are replaced or altered either to suit different needs and changing conditions including change of use, mandatory requirements or when new products offer better performance without a corresponding increase in cost. It should also be borne in mind that a decision to replace or alter obsolete buildings or their parts may be influenced by a reassessment of their predicted service lives.

NOTE 1 The titles of the publications referred to in this standard are listed on the inside back cover.

NOTE 2 The numbers in square brackets in the text of this standard refer to the numbered references in Annex C.

2 Definitions

For the purposes of this British Standard the definitions in BS ISO 15686 apply together with those given in BS 6100.

Section 2. Expression of durability

3 Design life

A badly stated requirement for design life, can lead to misunderstanding at a later date. When a period for required service life is given the following information is essential:

- a) time (or a time measure such as running time or cycles of use) against which durability is to be assessed;
- b) conditions in which the item will have to perform (i.e. environmental conditions and levels of maintenance and usage);
- c) performance point at which functions become unsatisfactory (for example the light transmission through a glass reinforced plastics (GRP) rooflight decreases over the period of use. A decision has to be made on when to change the rooflight for a new one that will give a greater light transmission).

The required service life for a building should be qualified by additional information on conditions of use and maintenance levels. Table 1 lists three levels of maintenance based on the types of inspection described in 4.2.3 of BS 8210:1986.

When seeking predicted service life statements from manufacturers the required service life for parts of buildings should also be qualified by information of the following two types.

- a) *Information on exposure.* This is particularly important where the required service life is part of a performance specification presented to a manufacturer supplying external components for use in a building that is not known to him.
- b) *Details of adjacent materials and fixings.* The 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 required life is given to a manufacturer of components in a performance specification. General statements and schematic details may not be enough to identify risks. It is essential that the allowances made for thermal and moisture movement and for isolating incompatible materials are fully described.

Very durable, long lasting construction is usually more expensive and may restrict the design to a limited range of materials. Consequently a long required service life is likely to increase the cost of the project and can limit the design solutions that meet the brief.

Funding of building construction often implies a required service life at least as long as the period of the loan used to finance the building.

Table 1 — Maintenance levels (other than daily and routine cleaning)

Level	Description	Scope	Examples
1	Repair only	Maintenance restricted to restoring items to their original function after a failure	Replacement of jammed valves; reglazing of broken windows
2	Scheduled maintenance plus repair	Maintenance work carried out to a predetermined interval of time, number of operations, regular cycles etc. (see Note),	Five yearly external joinery painting cycle. Five yearly recoating of roof membrane with solar reflective paint
3	Condition based maintenance plus repair	Maintenance carried out as a result of knowledge of an item's condition. [The condition having been reported through a systematic inspection (procedure)]	Five yearly inspections of historic churches etc. leading to planned maintenance

NOTE The length of the regular maintenance cycle is an important factor. It may be stated in the brief or agreed while the design is being developed.

BS 8210 recommends systematic inspections as follows:

- a) continuous, regular observation by the building user as part of the occupancy of the building; and
- b) annual visual inspection of the main elements under supervision of suitably qualified personnel; and
- c) full inspection of the building fabric by suitably qualified personnel at least every 5 years.

There may be statutory requirements for more frequent inspections.

Annex A (informative)

Agents that cause deterioration

A.1 General

A.1.1 This appendix provides basic data on the action of the principal agents that affect the durability of building materials; see Table 2 and Table 3. Where possible there are examples to illustrate the data and, in some cases, there is an explanation of the process that takes place. In many instances deterioration is not the result of action by a single agent but the effect of a combination of agents. It is therefore important to consider each type of agent and the extent to which their combined effects are likely to affect a particular form of construction. Frequently the action of one agent is dependent on the presence of others, for example an increase in temperature of 10 °C can double the rate of a chemical reaction causing deterioration. Moisture is probably the agent with the greatest influence on the durability of building materials. Many types of deterioration, such as corrosion of ferrous metals, can take place only if moisture is present.

A.1.2 Although there is a great deal of data available on climate it tends to be in a generalized form such as a contour maps. Designers also need to consider the local climate conditions and conditions in the immediate surroundings of a building (known as the microclimate), in addition to generalized data on climate [3].

A.2 Temperature

All external construction materials experience both diurnal and annual temperature variations (see Figure 1 and Figure 2) [4] [5]. These are most pronounced when the construction is exposed to an unobstructed sky, e.g. high level roofing, cladding and external structural members of buildings.

Changes of temperature are relevant when assessing the consequences of thermal expansion and contraction, e.g. due to stresses within materials when changes of size are restrained, and to strains imposed on jointing materials when components are free to change size. The actual temperatures reached can lead to temporary or permanent changes in physical or chemical properties, e.g. embrittlement at low temperatures, accelerated oxidation or loss of volatiles at high temperature. In some cases the distribution or gradient of temperature within a material or constructional element may be critical; for example in the case of assessment of interstitial condensation risk, or in the control of excessive temperatures due to heat of hydration during setting and initial hardening of concrete.

Properties that can be altered by changes of temperatures are:

- a) shape or dimensions;
- b) strength;
- c) rheological (flow) properties;
- d) resistance to solvents;
- e) electrical resistance.

As a consequence of change of viscosity or solvency two adjacent materials may blend together at a high temperature; a reaction that would not have occurred had a lower ambient temperature been maintained.

Increases of temperature may accelerate irreversible consequences such as chemical action, creep and biological decay. Fluctuations of temperature may influence moisture content, crystallization and leaching actions.

A.3 Radiation

A.3.1 Solar radiation

A.3.1.1 General

The energy that reaches the earth's surface from solar radiation is concentrated in certain wavebands. Figure 3 shows the variation in the energy received at different wavebands from direct sunlight. A portion of solar radiation is absorbed or reflected by the earth's atmosphere. This portion varies from one waveband to another and is affected by cloud cover. The degree of shading from direct sunlight also affects the quantity of the radiation received in each waveband [6].

A.3.1.2 Infra-red radiation (approximately 700 nm to 3 000 nm)

Infra-red radiation is absorbed to some extent by all forms of matter and this causes an increase in temperature, thus creating surface temperatures greater than that of the surrounding air (in some cases markedly so). The opacity, texture and colour of the surface involved has a considerable effect on the amount of radiation that becomes absorbed. The absorbed radiation will raise the temperature of a material by an amount dependent upon the specific heat and thermal conductivity of the material and the structure behind. In clear sunny weather in the United Kingdom black mastic asphalt roofing can reach a temperature of 80 °C. Similar figures have been reported for black bituminous roofing. If a reflective coating is applied the maximum temperature rise can be reduced by 20 % to 35 % [7].

For a given surface texture the colour of a surface considerably affects the absorption of solar radiation. Assuming a perfect black to have an absorptivity of 100 %, the absorptivities for the following colours are:

- | | |
|------------------------|--------------|
| a) ordinary black | 85 % |
| b) dark green or grey | 70 % |
| c) light green or grey | 40 % |
| d) white | 12 % to 20 % |

NOTE This research did not identify these colours with the BS 5252 colour code reference.

Table 2 — Agents relevant to building performance

Nature	Origin			
	External to the building		Internal to the building	
	Atmosphere	Ground	Occupancy	Design consequences
<i>Mechanical agents</i>				
Gravitation	Snow loads, rain water loads	Ground pressure, water pressure	Live loads	Dead loads
Forces and imposed or restrained deformations	Ice formation pressure, thermal and moisture expansion	Subsidence, slip, heave	Handling forces, indentation	Shrinkage, creep, forces and imposed deformations
Kinetic energy	Wind, hail, external impacts, sand-storm	Earthquakes	Internal impacts, wear	Water hammer
Vibration and noises	Wind, thunder, aeroplanes explosions, traffic, machinery noises	Traffic and machinery vibrations	Noise and vibration from music, dancers, domestic appliances	Services noises and vibrations
<i>Electro-magnetic agents</i>				
Radiation	Solar radiation, radioactive radiation	Radioactive radiation	Lamps, radioactive radiation	Radiating surface
Electricity	Lightning	Stray currents	—	Static electricity, electrical supply
Magnetism	—	—	Magnetic fields	Magnetic fields
<i>Thermal agents</i>	Heat, frost, thermal shock	Ground heat, frost	User emitted heat, cigarette	Heating, fire
NOTE This table is based on Table 4 of ISO 6241.				