



BRE
Design life of buildings
A scoping study

January 2007

Report prepared by: Dr D J Kelly, Senior Consultant, BRE
BRE Scotland
Kelvin Road
East Kilbride
Glasgow
G75 0RZ
T +44 (0) 1355 576200
F +44 (0) 1355 576210

E eastkilbride@bre.co.uk
www.bre.co.uk

The opinions expressed in this report are those of the author.

Report commissioned by:
Scottish Building Standards Agency
Denholm House
Almondvale Business Park
Livingston
EH54 6GA

Tel: 01506 600 400
Fax: 01506 600 401
e-mail: info@sbsa.gsi.gov.uk
web: www.sbsa.gov.uk

© Crown Copyright 2007

Applications for reproduction of any part of this publication should be addressed to:
SBSA, Denholm House, Almondvale Business Park, Livingston, EH54 6GA

This report is published electronically to limit the use of paper, but photocopies will be provided on request to the Scottish Building Standards Agency

1	Executive Summary	
2	Introduction	1
2.1	Scope of the study	1
2.2	Research methodology	2
3	Regulation 8	3
4	Relevant Standards	5
4.1	Construction Products Directive	5
4.2	British Standard BS 7543 (2003)	5
4.2.1	British Standard BS 8000	6
4.3	BS ISO 15686-1 (2000)	7
4.4	BS ISO 15686-2 (2001)	7
5	Lifetime approach to building design	9
5.1	Initiatives and legislation	9
5.1.1	Whole Life Cost techniques	9
5.2	Sources of information	10
5.3	CDM Regulations	10
6	Methodology	12
6.1	Definition of terms	12
6.2	The design service life assessment	13
6.3	Buildings to be included	14
6.4	Durability and maintenance	15
6.5	Critical issues	15
6.6	Assessment procedure	16
6.6.1	Assessment form	17
6.6.2	Factor method for predicting design service life	17
6.7	Alternative method	18
7	Technical Handbook guidance	20
7.1	Information required	20
7.2	Carrying out the assessment	20
8	Examples of design life assessment	22
8.1	Private dwelling	22
8.1.1	Structural elements	22
8.1.2	Non-structural elements	23
8.2	Concrete frame	24
8.3	Softwood window	24
9	Discussion	25
9.1	Current levels of design service life assessment for buildings	25
9.2	Assessing the design service life	25
9.3	Design service life methodology	26
9.4	Assessment criteria	27
9.5	Alternative assessment method	27
9.6	Possible areas of conflict	28
10	Conclusions	29
11	References	31
	Appendix 1 – Estimated design service life for regulation (<i>EDSL-R</i>) assessment form	

1 Executive Summary

BRE has carried out a scoping study for the Scottish Building Standards Agency (SBSA) into the possibility of including a statement of 'Design service life' into Regulation 8 of the Scottish Building Standards. This study has looked at possible methodologies for assessing design service life and what the assessment criteria would include. This work was undertaken as a desk-based study, although this has been supplemented by meeting with Building Standards Officers. This provided valuable feedback on how the design service life of buildings could be assessed and how the methodology could be developed.

The definition of design service life was described in a previous BRE Report 228293 (June 2006). This stated that design service life should be defined as follows:

"... the assessment of a structure, both as a complete building and individual components, which predicts its potential lifetime based on levels of design, workmanship, maintenance and the environment."

This statement has been developed by BRE throughout the course of this study and encapsulates all of the criteria which design service life should represent. The statement has been used as the focus for the development of a design service life assessment methodology which has also been developed in this work.

The following points are concluded:

- There are limited means available for the building owner, designer or verifier to test the design of a building against its intended design service life. Whole life cost techniques can be utilised to this end, however the availability of accurate information may limit the effectiveness of the assessment.
- A factoring method for assessing the design service life of buildings and components has been developed by BRE for SBSA. This is based on the method of BS ISO 15686-1 and allows all of the criteria affecting the lifetime of the building or component to be assessed.
- The factoring assessment method lists the criteria which affect the durability and performance of materials and components throughout their lifetime. However, standardised assumptions must be made during the assessment process with regard to workmanship, in-use conditions and levels of maintenance, in accordance with the requirements of Regulation 8 of the Building (Scotland) Regulations 2004.
- The design service life assessment may have some implications to insurers or mortgage providers. This is particularly relevant where the design service life of the building lies beyond the terms of the mortgage repayment schedule, or the building cannot be insured due to the vulnerability of the materials and components.
- A simplified method for assessing the design service life of buildings and components has also been developed. This is based on a 'lifelong', 'replaceable' or 'maintainable' assessment criteria and also states the minimum service life of the building or component. This may be used as an alternative approach to the factoring method if required.

The information required in the assessment of design will encourage designers and specifiers to select materials and components, not only on their thermal performance, but also their interaction with the

environment. This could encourage specifiers and manufacturers to be more aware of their products and the materials they are using within their buildings. It should be noted that there are many whole life cost and sustainability tools being implemented in a percentage of construction projects being carried out within the industry.

2 Introduction

BRE has been carrying out a scoping study for the Scottish Building Standards Agency (SBSA) into the possibility of including a statement of 'Design service life' into Regulation 8 of the Scottish Building Standards ^[1]. This study has looked at possible methodologies for assessing design service life and what the assessment criteria would include. This work has been undertaken as a desk-based study, although this has been supplemented by meeting with Building Standards Officers. This provided valuable feedback on how the design service life of buildings could be assessed and how the methodology could be developed.

Design service life should be defined as follows:

"... the assessment of a structure, both as a complete building and individual components, which predicts its potential lifetime based on levels of design, workmanship, maintenance and the environment."

This statement has been used by BRE throughout the course of this study and encapsulates all of the criteria which design service life should represent.

This report describes the methodology and assessment criteria identified during this work. The scope of the study, relevant background material and guidance will also be provided.

2.1 Scope of the study

The research is a feasibility study of extending Regulation 8 of the Building (Scotland) Regulations to require a statement of design service life in building warrant applications. It is hoped that such a statement would further promote and enforce the need for consistent practices to achieve sustainable development. It is also hoped that including a statement of design service life will promote a whole life approach to building design and development. This is in keeping with the key issue of sustainability which is at the forefront of construction at this time.

Regulation 8 requires:

"(1) Work to every building designed, constructed and provided with services, fittings and equipment to meet a requirement of regulations 9 to 12 must be carried out in a technically proper and workmanlike manner, and the materials used must be durable and fit for their intended purpose."

The scope of the work was to undertake a study to explore the issues that are relevant to the extension of Regulation 8 to include a description of design service life of non-domestic buildings. The work involved the following aspects:

- Determining current levels of design specification that are provided at the point of building warrant submission.
- Developing a means for the building owner, designer or verifier to assess the design service life (the intended service life).
- Recommending a simplified methodology for assessing design service life for whole buildings, building elements, components and products, based on product information from BBA Certificates, BRE Certificates and TRADA.
- Describing the criteria involved in assessing and determining the service life of buildings using information sourced in the UK and worldwide.

- Identifying any conflicts with including current contractual practice, including contract warranties and impact on PFI projects.
- Identifying potential implications for building owners when they wish to replace, sell or demolish parts of the building and any additional impact on indemnity insurance.

This report describes the findings of the scoping study and makes recommendations on whether or not an amendment to Regulation 8 concerning the design service life of buildings, materials and components would be as follows:

- a) worthwhile, in terms of assessing the design service life of buildings, materials and components,
- b) practicable, in terms of ease of use and understanding for building owners, designers and verifiers.

2.2 Research methodology

The approach to this work involved setting out the research into separate work items that were staged throughout the project. These work items effectively reflected the five aspects set out in the scope of work.

The research was undertaken through the following:

- Desk study research, including the examination of existing information on the level of design and specification information available. This included the current situation regarding the amount of information being presented in a building warrant.
- Desk study of current methods of determining design or service life and how these can be adapted for non-domestic buildings. This included a simplified statement of design service life and how it can be implemented for individual buildings.
- Discussions with Building Standards Officers to identify possible conflicts with existing practice and any further impact for the building owner. This included an assessment of how maintenance, renovation and adaptation of buildings will impact on the design service life.
- Use of research previously undertaken by BRE into whole life costs and performance. This included previously published research in BRE documents and as appropriate unpublished research. Information was also sought from organisations in other parts of the world who have adopted a similar approach to the design service life of buildings.

This work has been completed as part of a desk-based study and has utilised the expertise and knowledge of individuals with BRE and other relevant agencies or organisations.

3 Regulation 8

Regulation 8 of the Scottish Building Standards (2005) states:

“(1) *Work to every building designed, constructed and provided with services, fittings and equipment to meet a requirement of regulations 9 to 12 must be carried out in a technically proper and workmanlike manner, and the materials used must be durable and fit for their intended purpose.*

“(2) All materials, services, fittings and equipment used to comply with a requirement of the regulations 9 to 12 must, so far as *reasonably practicable*, be sufficiently accessible to enable any necessary maintenance or repair *work to be carried out.*”

The durability of building materials and products is a key element in the building design and lifetime performance^[2]. The selection and installation of materials and construction systems will have a direct impact on the durability of the building. In the UK materials and products are often exposed to periodic driving wind and rain and this can affect the performance over the lifetime of the building. These ‘service conditions’ should be accounted for in the design and specification process and installed correctly subject to manufacturers guidelines.

There are a large number of environmental and chemical factors which can affect the durability of a material or component during its service life. These include the following:

- Moisture
- Humidity
- Temperature
- Driving wind and rain
- Chemical pollutants
- Solar radiation
- Site conditions.

The durability of a material or component will be affected by some, or a combination of, these factors. Their resistance and, therefore, suitability for use should be based on accepted test methods for determining durability. These tests are described in various UK and European Standards for materials and products used in the construction industry. There is a large number of product standards relating to the full range of construction products, from bricks and blocks to glass and aluminium cladding.

As Building Standards are amended to reflect the need for greater energy efficiency, more and more new products are becoming available within the construction industry. Many of these materials include greater thermal efficiency and/or space saving features, and it is these innovative features that can leave them outwith traditional material ‘groupings’. New materials, as well as more established products, should still be assessed in relation to their durability and performance. Guidance to Regulation 8 recommends that fitness of materials is met by using materials, fittings, and components, or parts thereof which comply with any of the following standards:

- a. the standard (whether British Standard or otherwise) specified in the Technical Handbooks;
- b. a relevant code of practice of a national standards institution or equivalent body of any member state within the European Economic Area;

- c. a relevant international standard recognised in any Member State within the European Economic Area;
- d. a relevant specification acknowledged for use as a standard by a public authority of any Member State within the European Economic Area;
- e. traditional procedures of manufacture of a Member State within the European Economic Area where these are the subject of written technical description sufficiently detailed to permit assessment of materials, fittings, and components, or parts thereof for the use specified; or
- f. for materials, fittings, and components or parts thereof, of an innovative nature subject to an innovative process of manufacture and which fulfil the purpose provided for by the specified standard, a European Technical Approval or specification sufficiently detailed to permit assessment.

Of equal importance to the durability and fitness of materials is workmanship during their installation, repair and maintenance. Guidance to Regulation 8 also recommends methods of establishing the level of workmanship that should be achieved. This is particularly important when the quality of installation has a direct impact on the durability and performance of the material. It is practically difficult to ensure that installation procedures have been adhered to in all situations and instances, however where performance is important, checks against the relevant Standard(s) should be made.

4 Relevant Standards

Guidance to Regulation 8 gives a large amount of information and Standards which can be used as guidance, to assess workmanship and assist with product selection. A selection of some relevant policy and standards is given in the following sections.

4.1 Construction Products Directive

Since 1989 it has been possible for the first construction products to be placed on the UK and European Economic Area (EEA) market with CE marking based on a harmonised European Standard (Construction Products Directive 89/106/EEC) ^[3]. This directive provides for common methods of performance evaluation of the product across the EEA and these methods are described in the relevant EN standards.

Products which are covered by the Construction Products Directive (CPD) are those which are "produced for incorporation in a permanent manner in works". In this case "works" include buildings, roads, bridges and other civil engineering and building works. The categories of products covered are included in a separate list of product areas.

The Directive also contains essential requirements for the performance of works, as follows:

- Mechanical resistance and stability.
- Safety in the case of fire.
- Hygiene, health and the environment.
- Safety in use.
- Protection against noise.
- Energy economy and heat retention.

It is important to remember that the works must be those covered under the regulations in a member state (in the UK these are the various building regulations, including the Building (Scotland) Regulations). Where no such regulations exist, the CPD does not apply.

4.2 British Standard BS 7543 (2003)

British Standard BS 7543 (2003) 'Guide to durability of buildings and building elements, products and components' ^[4] gives guidance on durability, required and predicted service life and design service life of buildings and their components and/or parts. It applies primarily to new buildings and their components rather than repair and maintenance. It also gives guidance on presenting information on the service and design service life of buildings and their components when a detailed brief is being developed.

This Standard expresses durability as 'design service life' which aligns well with the possible inclusion within Regulation 8. There is important information which is required in order to determine the possible lifetime of a material or component:

- a) time against which the durability is to be assessed.
- b) conditions in which the material or component will have to perform.
- c) Performance level at which the material or component is not to the required standard.

In addition to these factors, issues such as maintenance levels and conditions of use should be estimated. Three levels of maintenance are described in BS 7543 (2003) and these are shown in Table 1. This Standard also includes detailed information relating to factors which can cause deterioration. Many

examples of premature deterioration are also listed in addition to agents that can affect the service life of building components and materials.

Information on the predicted service life can be supplied by manufacturers. This should be qualified by considering additional information as follows:

- 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 allowances are made for thermal and moisture movement and for isolating incompatible materials are fully described.

Providing a long-lasting and durable building often involves the use of high specification components and expensive materials. This can raise the cost of the project, however careful detailing and good workmanship can also provide long-term performance in some cases.

4.3 British Standard BS 8000

British Standard BS 8000 'Workmanship on building sites' has a number of 'Codes of Practice' ^[5] which describe the various building practices. These include the following:

- Code of practice for excavation and filling (Part 1: 1989).
- Code of practice for concrete work. Mixing and transporting concrete (Part 2.1: 1990).
- Code of practice for concrete work. Site work with in situ and pre cast concrete. (Part 2.2: 1990).
- Code of practice for masonry (Part 3: 2001).
- Code of practice for waterproofing (Part 4: 1999).
- Code of practice for carpentry, joinery and general fixings (Part 5: 1990).
- Code of practice for slating and tiling of roofs and claddings (Part 6: 1990).
- Code of practice for glazing (Part 7: 1990).
- Code of practice for plasterboard partitions and dry linings (Part 8: 1994).
- Cementitious levelling screeds and wearing screeds. Code of practice (Part 9: 2003).
- Code of practice for plastering and rendering (Part 10: 1995).
- Code of practice for wall and floor tiling. Ceramic tiles, terrazzo tiles and mosaic (Part 11.1: 1989).
- Code of practice for wall and floor tiling. Natural stone tiles (Part 11.2: 1990).
- Code of practice for decorative wall coverings and painting (Part 12: 1989).
- Code of practice for above ground drainage and sanitary appliances (Part 13: 1989).
- Code of practice for below ground drainage (Part 14: 1989).
- Code of practice for hot and cold water services (Part 15: 1990).

The information contained within each of these parts of the standard gives guidance on construction details and methods for all aspects of building. This guidance gives details on the quality of workmanship required which is also described in Regulation 8. Codes of practice for the installation of materials and components are a vital part to ensuring the completed building is fit for purpose and can meet the lifetime requirements of the occupants.

Many of the sections within BS 8000 are up to fifteen years old, however they are still applicable in today's construction industry as they describe all of the 'traditional' building methods used in the UK. The parts of the standard describing structural elements may be of greater importance when estimating the design service life of a building. These are often viewed as the elements which will govern how long a building will perform to its design level and how the durability of the materials will be affected during the lifetime of the structure.

4.4 BS ISO 15686-1 (2000)

BS ISO 15686-1 (2000) 'Buildings and constructed assets – Service life planning: Part 1 – General principles' ^[6] provides a methodology for forecasting the service life of buildings and estimating the necessary maintenance and replacement of components. A major factor in the development of this standard was concern over the industry's need to forecast and control the cost of building ownership, as a high proportion of the life cycle costs of a building may be set by the time the building is complete. Where there is a large stock of older buildings, more than half of all construction expenditure will be spent on maintenance and refurbishment. For countries currently developing their building stock, the risk is that a similar pattern will occur if long-term performance is not taken into account at the outset.

The standard states that service life planning aims to reduce the cost of building ownership. An assessment of how long each part of the building will last, helps to decide the appropriate specification and detailing. When the service life of the building and its parts are estimated, maintenance planning and value engineering techniques can be applied.

BS ISO 15686-1 provides a means of comparing different building options. It also allows checking that performance is not unacceptably reduced to meet financial constraints during the stages of development and planning. The standard is primarily intended for the following:

- Building owners and users.
- Design, construction and facilities management teams.
- Manufacturers who provide data on the long-term performance of products.
- Maintainers of buildings.
- Valuers of buildings.
- Technical auditors of buildings.
- Those who develop of draft product standards.

4.5 BS ISO 15686-2 (2001)

British standard BS ISO 15686-2 (2001) 'Buildings and constructed assets – Service life planning: Part 2 – Service life prediction procedures' ^[7] describes the principles for service life predictions (SLPs) of building components. The SLP methodology has been developed to be universally applicable to all building types. It can be used in the planning of SLP studies regarding new products or components where the knowledge of their performance may be limited.

This part of BS ISO 15686 is intended for the following:

- Manufacturers who wish to provide data on the performance of their product(s).

- Test houses, laboratories and technical approval organisations.
- Those who develop or draft product standards.

This part of the standard can be used as a stand alone document, however it is recommended by BSI that the other parts of BS ISO 15686 are considered (particularly BS ISO 15686-1) before implementation.

5 Lifetime approach to building design

A key element of this work was to identify current practices for assessing the lifetime performance of buildings. This involved a desk-based review of recent legislation, standards, guidance and good practice that have been implemented to allow the long-term performance of buildings to be estimated. This has seen the introduction of whole life performance and costing techniques that have had a major impact on the construction industry.

5.1 Initiatives and legislation

Initiatives within the construction industry such as the Egan Report ^[8] and the Latham Report ^[9] have set targets for cost savings which are assessed using Whole Life Cost (WLC) techniques. The Egan report states that,

“design needs to encompass whole life costs, including costs of energy consumption and maintenance costs. Sustainability is equally important. Increasingly, clients take the view that construction should be designed and costed as a total package to include costs in use and (through to) final decommissioning.”

A whole life costing approach encourages decision making that takes account of durability, future running costs, maintenance and refurbishment requirements ^[10]. It can, therefore, encourage the design of buildings that are more compatible with the concept of sustainable construction.

The UK has also led the international development of standardisation within the sector of service life planning. Several trial and demonstration projects have been carried out for various Government agencies and this has led to an increase in the popularity and use of WLC techniques. This included the publication of international standard BS ISO 15686-1 (2000) ‘Buildings and constructed assets – Service life planning. This standard was published in five parts and 1 and 2 are described in Sections 3.3 and 3.4 of this report . Part 3 describes the approach and procedure to be applied to prebriefing, briefing design, construction and, where required, the life care management and disposal of buildings and constructed assets to provide a reasonable assurance that the measures necessary to achieve performance over time will be implemented.

Part 4 of the standard describes the range of data requirements that will allow the service life to be determined, and Part 5 will provide guidance on the assessment of the life cycle costs of a building.

5.1.1 Whole Life Cost techniques

Whole life costs techniques are usually employed at the planning stage as a method of option appraisal and is not often considered after a construction project is underway. It can be used to assess the merits and costs of various elements of the building such as windows, cladding systems, roofing or flooring. The costs of purchasing, installing and maintaining the element can then be estimated over an agreed lifetime.

Recent studies by BRE have developed a concise definition of WLC as ^[11],

“the systematic consideration of all relevant costs and revenues associated with the acquisition and ownership of an asset”

Within the construction industry this was likely to account for procurement costs such as the following:

- Initial construction or major refurbishment
- Purchase or leasing
- Interest
- Fees.

In addition to this, costs for the continued use or occupancy of the building should also be considered as follows:

- Rent and rates
- Cleaning and refurbishment
- Maintenance, repair, replacement and renewal
- Energy and utilities
- Dismantling, disposal or demolition
- Security and management.

Fundamental to the success of the WLC approach is the availability of accurate material data. This data should indicate the service life of the material, its maintenance schedule and future removal, renovation or demolition cost. If this information is not available then some estimation of the cost will be used. This can introduce an error into the WLC calculation which will accumulate if applied to a whole building.

5.2 Sources of information

The Housing Association Property Mutual (HAPM) 'Component Life Manual' ^[12] provides lifespan assessments for a wide range of building components. It was developed as an insurance tool for providers of UK social Housing and offers indicative benchmarks against which new or alternative specifications can be assessed. The approach is intended to be easy to use, reflecting current knowledge and placing no restrictions on the choice of components. The approach was developed specifically for insurance purposes although the data can be adapted for other purposes through the use of appropriate adjustment factors. Similar data on the durability and maintenance of building components, materials and assemblies used in commercial, industrial and public building types are also available within 'Building Performance Group (BPG)' publications.

BRE has a number of publications relating to the lifetime performance of building materials and products ^[13] ^[14] ^[15]. This ranges from research and test work carried out on specific materials and components, to an overview of materials, their durability and whole life performance. The development of whole life performance techniques is dependent on the material performance and lifetime data that is available. This can only be determined by research into the performance of materials, something which BRE has a long experience in carrying out through Government sponsored research and consultancy work. These findings and material data are available from BRE publications.

Certification schemes and manufacturers' literature are also sources of information that may prove useful in identifying material information that can be used in a design service life assessment. British Standards Institution (BSI), British Board of Agrément (BBA) and BRE Certification provides quality 'marks' for materials and products which may include information relating to lifetime performance. This data is often related to material properties such as thermal conductivity and density, however, more and more products are having a lifetime performance assessment included in the certification process.

5.3 CDM Regulations

The Construction (Design and Management) Regulations ^[16] have imposed statutory duties on clients, designers, planning supervisors and contractors with the specific aim of improving the health and safety of people in the construction industry. The Regulations came into force on 31 March 1995 and apply to all construction work as follows:

- Lasts more than thirty days or will involve more than 500 person days of work.
- Requires five or more people on site at any one time.

- Includes any demolition.

These Regulations apply to construction projects and all those associated with them. Anyone who appoints a designer or contractor has to ensure that they are competent for the work and will allocate resources for health and safety.

There are five key parties who have been identified who have specific duties in the implementation of requirements of CDM Regulations:

1. The client: who should be satisfied that only competent people are appointed as planning supervisor and principal contractor. This also applies to making arrangements for the appointment of designers and contractors. They should also ensure, as much as they can, that sufficient resources, including time have been or will be allocated to enable the project to be carried out safely. Duties on clients do not apply to domestic householders when they have construction work carried out.
2. The designer: who should ensure, as much as they can, that structures are designed to avoid or where this is not possible, to minimise risks to health and safety while they are being built and maintained. Where risks cannot be avoided, adequate information has to be provided. Design includes the preparation of specifications, it is not limited to drawings.
3. The planning supervisor: who has overall responsibility for coordinating the health and safety aspects of the design and planning phase and for the early stages of the health and safety plan and the health and safety file.
4. The principal contractor: who should take account of health and safety issues when preparing and presenting tenders or similar documents. The principal contractor also has to develop the health and safety plan and coordinate the activities of all contractors to ensure they comply with health and safety legislation. Principal contractors also have duties to check on the provision of information and training for employees and for consulting with employees, and the self-employed on health and safety.
5. Contractors and the self-employed: who should cooperate with the principal contractor and provide relevant information on the health and safety risks created by their work and how they will be controlled. Contractors also have duties for the provision of other information to the principal contractor and to employees. The self-employed have similar duties to contractors.

These Regulations will have an obvious impact on the design of a building, the material specification and workmanship issues. These are all important considerations within Regulation 8 and the development of a design service life statement.

6 Methodology

Some of the regulations and standards relating to Regulation 8 and the development of a design service life statement have been described in the previous sections of this report. In this work, one of the main objectives was to derive a methodology that could be used to assess the design service life of a building. This methodology has been developed throughout the duration of the work and has involved feedback from Building Standards Officers and the SBSA.

6.1 Definition of terms

There is a list of terms which can be used to describe lifetime of buildings, components and materials. In some cases the definition of these terms and how they differ from one another is unclear.

Many factors in the construction process can determine whether or not a structure will meet its design service life. There have been numerous examples of durability problems due to poor design detailing, poor workmanship, inadequate cover to vulnerable components and lack of proper maintenance. BS EN 1990 (2002) 'Eurocode. Basis of structural design' ^[17] defines *service life* as 'the 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'.

The actual end of life can be determined by a number of factors including changes of use and economics. Consequently, a number of alternative types of service life have been defined as follows:

Required (service) life	The minimum period during which the structure or a specified part of it should perform its design functions (subject to routine servicing and maintenance) to meet the users' requirements.
Design (service) life	The period of intended use by the designer.
Technical (service) life	The actual time in service until a defined minimum acceptable state is reached.
Functional (service) life	The time in service until the structure is obsolete due to changes in functional requirements.
Economic (service) life	The time in service until replacement is economically more advantageous than continued maintenance in service.

These definitions have been developed to assess the lifetime performance of buildings, materials and components, from the perspective of different stakeholders who have an interest in a building. For instance, the owner or user of the building may only be concerned with the required service life as this describes the period for which the building should perform to the user's requirements. On the other hand, the technical service life may only be the concern of the owner and the facilities team as they will have to pay for and manage any maintenance issues in non-domestic buildings. Lastly, the economic service life is one of the main concerns of the building owner. Managing the building as a resource and ensuring adequate return on the investment made in its purchase and use will be assessed in line with the economic service life predictions.

Individual components of a structure will have different expected service lives. Structural members are generally expected to perform their intended function for at least the service life of a structure whereas it may be acceptable for non-structural components to be repaired or replaced.

When estimating the design service life of a structure or element, it is important to consider what constitutes the end of the service life. It may even be possible that the building becomes obsolete within its service life. There are, therefore, many principles on which the end of the service life of a structure might be based, which could go as far as delapidation, as in the following examples:

- Deterioration of 'protective' materials or components.
- The point at which corrosion is initiated.

The actual limits of required service life used at the design stage will depend on the nature of the structure and the client's requirements. The required service life may also depend on the type of structure or its elements, its performance (including safety) requirements, and on the maintenance regime that is adopted.

BS ISO 15686-1 (2000) 'Buildings and constructed assets – Service life planning: Part 1 – General principles' uses an approach where components are characterised as replaceable, maintainable or lifelong. Decisions regarding the critical nature of the structure and the need for replacement, repair and maintenance must be made by the client and the designer during the design process. An appropriate approach to achieving the required service life, which depends on the critical nature of the element or structure, can then be undertaken. This could include, for instance, critical elements or components being provided with increased protection to prolong their lifetime.

In less critical areas it may be more appropriate to plan for regular remedial work or replacement. BS ISO 15686-1 gives suggested minimum design (service) lives for elements based on their ease of replacement and the required service life of the structure.

6.2 The design service life assessment

In order to develop the design service life assessment methodology, a clear understanding of what is being assessed is required. The design service life is defined as the period of use intended by the designer and agreed with the building owner. This is removed from the warranties life which would be an indication of the insured life of the product. The differences in these terms can be illustrated visually in Figure 1.

Here the warranties (service) life, design (service) life and real (service) life are compared. This illustration is for information only and could be affected by a number of parameters. The warranty life is the period of the guarantee given by the manufacturer during which they will be willing to replace the product. This could be twenty-five years for a window for example. The design service life of a component or structure is the period for which the building will be designed to perform the function for which it has been constructed and to the standard at the time of construction. This may be sixty or seventy years depending on its design, use and exposure. This. The real life situation is different again from the warranty life and the design service

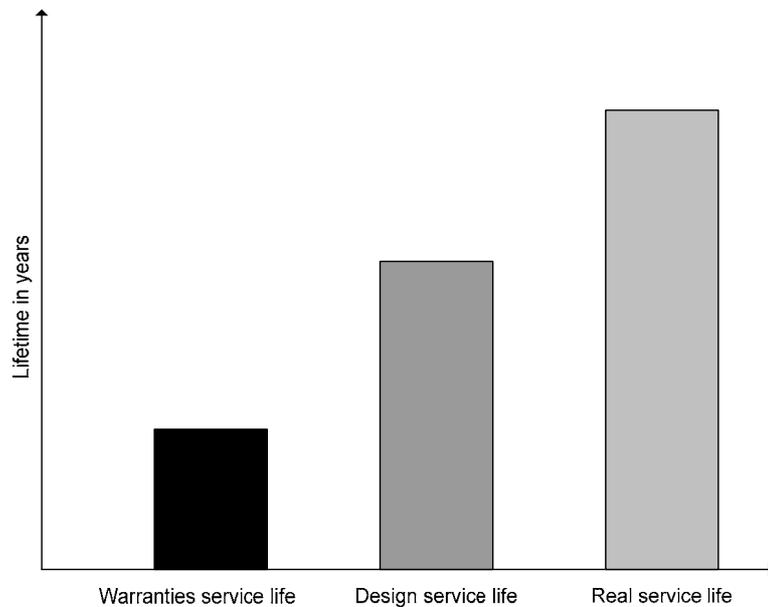


Figure 1. Illustration of the differences between the terms associated with the lifetime of a building or component.

life. Structures or components have the ability to last far beyond their warranties life or design service life. The ‘real’ life cannot be estimated easily but in many cases this is beyond the design service life.

The statement of ‘design service life’ is therefore an assessment of the building based on the period of time the building should perform to its original performance specification. This ‘design service life’ will be decided, perhaps unwittingly, by the designer through his detailing, specification of materials and methods of construction. During the design service life of the building issues such as maintenance and repair will be important factors in ensuring the design service life is met. Failure to carry out such regular maintenance checks will affect the long-term performance of the building. However, the assessment of ‘design service life’ must make assumptions about maintenance schedules.

6.3 Buildings to be included

The assessment of design service life of buildings could be applied to a variety of buildings from private extensions to dwellings, garages, new-build houses and non-domestic buildings. Each of these constructions need to comply with existing Building Regulations and Standards and could theoretically be assessed under the design service life procedure. For smaller buildings such as extensions and garages, this process may not be economically viable due to the extent of the information required and time taken to complete a design service life assessment.

It may be practical, therefore, to use the design service life assessment for buildings above a certain size or function. The lower limit could be a floor area of a certain size and all buildings above this limit should be assessed under the design service life procedure.

New buildings that meet the floor area requirements could be assessed using the design service life procedure. Existing buildings that are due to be converted, altered, or extended could also be subject to a design service life assessment, but the collation of information may be more difficult if the design and specification of the original structure is unknown. A design service life assessment can be undertaken for the conversion, alteration or extension work, but the design service life assessor would need to make an informed judgement on the how the design service life of the building will be affected by these works.

6.4 Durability and maintenance

As well as the materials aspects of designing for durability, the following issues are also critical in designing durable buildings:

- The impact of the design detailing, especially on the service life of high and medium 'classed' structures and elements.
- The 'buildability' of the design and good workmanship.

These will have a direct impact on the design service life of the building. Detailing and design are important factors in order to maximise the properties, performance and lifetime of the materials and components to be used in a building. High grade materials and components will not achieve their performance potential if they are fitted incorrectly or not to the manufacturers guidelines. Vulnerable materials are also at risk if design detailing is not carried out correctly. Many insulation materials, for example, will deteriorate rapidly if they are exposed to moisture and UV radiation. Therefore, protection and detailing surrounding these, and similar materials is important.

The issue of 'buildability' is equally important. Careful design and detailing would be rendered useless if the intricacies of the design could not be reproduced on site. Careful consideration should always be given to site conditions, the availability of skilled labour and the practical implications of carrying out the work.

Workmanship issues are, of course, important to ensure the design service life of the building is achieved. Minimal accepted levels of workmanship are described in BS 8000 although more detailed instruction may be required for new or innovative materials. If these instructions are not available, or unusual construction methods are required without adequate information being provided, the lifetime of the building may be compromised.

Maintenance schedules are also important when assessing the design service life of buildings. Periodic treatment or repair of elements within the building will help to maintain their performance over its intended lifetime.

Regulation 8 requires that materials, fittings and components should be suitable for their purpose, correctly used or applied, and sufficiently durable, taking account of normal maintenance practices, to meet the requirements of the regulations. Accordingly, it must be assumed that design detailing, workmanship, durability, and maintenance meet a satisfactory minimum standard and therefore these aspects need not be addressed in a design service life assessment for the purposes of any new building regulations requirement.

6.5 Critical issues

The critical nature of components and structures has been assessed and described in Table 2. This classification allows designers to specify the service life of the elements and components within the building. The prediction of design service life is a complex issue as it involves dealing with a large number of factors which will affect the prediction. Some of these factors will be unique to the building itself, others will directly relate to the quality of the material or component, and some will reflect the in-service conditions.

There are, however, a number of common features that can be identified that may affect the design service life of materials and components. These can be structured or analysed in terms of the stage of design or construction at which they occur, or in terms of what they tell us about the weak links in performance for the particular material or component. Some of the most critical areas have been identified as follows^[19]:

- The combination of the exposure level experienced by the material or components, and its resistance to these levels. This will determine the rate of deterioration and therefore the service (design) life.
- To identify the likely performance, the basic properties of the material or component should be identified. This will allow the likely performance to be assessed more easily.

- Often the most vulnerable area of a material or component is where it meets another material or joint. These areas are often the centre of deterioration patterns that can cause early failure to occur.
- Any moving parts of a material or components will undoubtedly be prone to wear and tear. The more intensively or the longer they are used, the more likely they may be to deteriorate. The tolerances for movement will also be critical for performance, and therefore will be critical for long-term durability. Lubrication or adjustment may be required in order to achieve the required lifetime of the product.
- Protective coatings can often be sacrificed in order to access to materials or components that may need servicing or replacing. Materials or components protected by coatings or cladding will only be as durable as the material protecting them.
- The position of the material or component on the building is important in respect to the level of exposure it will face during its lifetime.

All of these issues and factors should be considered when assessing the design service life of a building or component.

6.6 Assessment procedure

BRE has proposed that the assessment of design service life for the purpose of a building warrant application should be based on a combination of the two approaches, as follows:

- A factoring method as described in BS ISO 15686-1 (2000) 'Buildings and constructed assets – Service life planning: Part 1 – General principles'.
- Dividing the components of a building under the headings of 'structural' and 'non-structural' and carrying out an assessment of design service life for each grouping, but with a standardised assumption of satisfactory design detailing, workmanship, durability, and maintenance.

By dividing the building into structural and non-structural elements, their lifetime may be more easily estimated. Structural walls may be made up of masonry, steel or timber frame whose durability and lifetime in most cases would be a minimum of sixty years. The durability and performance of these structures is often well researched and documented. Consequently, information on the potential lifetime of the structural system should be readily available in most cases.

The non-structural elements may be seen as more likely to be replaced or requiring maintenance during their lifetime. These elements would include cladding, windows, internal finishes and services. Many non-structural elements will have a maintenance schedule that could be sourced from the manufacturer. This information could be used as a source of evidence for the likely lifetime of the product if it is maintained correctly.

The provision of information is often the stumbling block when carrying out an assessment. If the building is divided into structural and non-structural elements, sourcing this information may not be such an onerous task. The method by which the information is presented will also have an impact on the likelihood of it being provided. A simple form for regulation purposes is essential if the information required for a design service life statement is to be provided. The form should also provide an easily transferable information source so that the assessment of design service life can be made.

The factoring method used within the standard BS ISO 15686-1 involves a detailed assessment. It may be feasible for the guidance to the building regulations in the Technical Handbooks to allow applicants to submit information that fully meets the standard, but with no assessment for design detailing, workmanship, durability or maintenance of less than 1 in order to meet the minimum requirements of Regulation 8. However, the minimum requirement to satisfy the regulations and associated mandatory functional standard should allow a reduced assessment method.

This reduced approach would be more practical for smaller construction projects or even large scale house building where issues such as whole life performance costing are not currently taken into account to the same degree as for larger office or commercial properties.

6.6.1 Assessment form

A prerequisite of the assessment of design service life is that it should be straightforward and not incur an unrepresentative amount of effort to complete. The assessment form has been developed so that it can be used to evaluate the component parts of a building. These components can be categorised into structural and non-structural elements as follows:

- Structural components
 - Roofs (including structural components and tiles)
 - Ground floor
 - Other floors
 - External walls (structural)
 - Internal walls (structural)
 - Foundations
- Non-structural components
 - Windows and rooflights
 - Doors
 - External walls (cladding)
 - Internal walls (partition)
 - Services.

An assessment form can then be completed for each component. A suitable form is shown in Appendix 1 and includes the reduced factoring system. This system uses a nominal value of 1 to show a factor which will neither increase or decrease the lifetime of the material or component. If the factor improves the likely performance, durability and lifetime of the component, this can be factored up to a maximum of 1.2. If the factor reduces the lifetime of the component it can be factored down to a minimum of 0.8.

The design service life can, therefore, be estimated by multiplying together all of the relevant factors. The reference service life of the element or component should be estimated from an accurate source at all times e.g. manufacturer or certification. This statement holds true for all factors to be assessed and manufacturers should be the primary source of this information. Where information is lacking, other sources may be used such as the HAPM Manual or BPG publication.

The estimated reference service life is, perhaps, the most important factor to accurately determine. This value will have greatest influence on the estimated design service life and effort should be made to source accurate information. Manufacturers literature, research publications and British and European Standards should provide the majority of this data.

The form provided in this report is a 'first draft' of a possible assessment procedure. This should be trialled and amended where necessary through consultation and appraisal from industry representatives and verifiers.

6.6.2 Factor method for predicting design service life

Based on the initial literature survey carried out and described in BRE Report 228290.1, a factoring method for assessing the design service life of buildings has been proposed. This approach would adopt a standard service life for components with assumptions made for their quality and their use in a building.

BS ISO 15686-1 uses the following approach to categorising the factors influencing the estimated design service life:

$$EDSL = RSLC \times A \times B \times C \times D \times E \times F$$

Where; *EDSL*: estimated design service life

RSLC: reference service life

A: quality of materials factor

B: design level factor

C: work execution level factor

D: environmental conditions factor

E: in-use conditions factor

F: maintenance conditions factor.

The 'reference service life' refers to the time that the component or building can be expected to last under normal conditions. 'Normal' conditions, in this sense, are related to the building being used to the purpose for which it was designed and not exposed to any extreme loading from the weather or other unnatural events. The reference service life may be derived from modelling, experience, accelerated testing, data from the manufacturer or from product standards. *A* to *F* represents factors from BS ISO 15686 that can affect the estimated design service life under circumstances where they do not meet the levels specified in manufacturers recommendations or in the Codes and Standards. Appropriate values for these factors need to be judged by the designer and based on the particular circumstances of the project, previous experience and information available on the effects of factors on design service life (e.g. design concept, structural detailing, environment, workmanship and maintenance).

For Building Standards purposes, it may only be practical to assess factors *A* and *D*. Regulation 8 has requirements relating to *B*, design level factor, and *C*, work execution level factor and it makes assumptions relating to *E*, in-use conditions factor, and *F*, maintenance conditions factor.

The reduction of the number of factors would therefore result in an estimated design service life for regulatory purposes, as follows:

- **Estimated Design Service Life for Regulation (*EDSL-R*)** = reference service life x quality of materials factor (*A*) x environment factor (*D*).

The factors that applied will be between 0.8 and 1.2.

6.7 Alternative method

The information provided in BS ISO 15686 has been the basis on which the assessment of design service life has been based. Within part 1 of the Standard, components are characterised as "replaceable, maintainable or lifelong", as described in Section 5.1 of this report. This classification of components could be the basis of a more simplified approach to the factoring method described in Section 5.6. This method would include a division of components into structural and non-structural elements as previously. The difference, however, would be in the assessment process. Instead of using factors to identify the possible design service life of each material or component, the item would be classed as either replaceable, maintainable or lifelong.

Using this simplified approach each material or component could be given a minimum period over which it should either be replaced or maintained. If it was an element that was viewed as integral to the building and likely to remain unchanged for its lifetime, this 'lifelong' element could be assigned a minimum design service life.

This simplified approach can help to overcome some of the ‘unknowns’ which may be a problematic feature of the factoring method. The factoring method also places an emphasis on the knowledge of the assessor and the information provided, areas which could leave room for some errors when assessing the design service life. The simplified approach, although basic in its concept, may help to overcome some of these problems.

The simplified approach would also include a simplified form for assessing design service life. This would simply list the components, allow them to be categorised as replaceable, maintainable or lifelong. An example of this assessment form is given in Figure 2. The form also allows the maximum lifetime of the component to be stated, as well as its maintenance and replacement characterisation. This simplified approach may not provide as much detail as the original form illustrated in Appendix 1, however it may allow the design service life of a component to be completed in a relatively straightforward manner.

This method could also be used as the first approach with a move to more detailed method in future regulation revision.

Element:		Structural	Non-structural
		Please tick:	Please tick:
Description:			
Maximum lifetime of element: (years)			
	Replaceable	Maintainable	Lifelong
Characteristics of element			
Details	<i>Information on replacement schedule to be given here</i>	<i>Information on maintenance schedule to be given here</i>	

Figure 2. Simplified method assessment form.

7 Technical Handbook guidance

This section of the report offers recommendations on the possible incorporation of design service life assessment in the building standards system.

Regulation 8 could be amended to require applicants to supply a design service life statement, along the following lines:

- **“The design service life of structural and non-structural components within a building should be assessed.”**

Guidance could be given in either the Technical Handbooks or the Procedural Handbook on the procedure for carrying out the design service life assessment, with details of what information is needed and how that information is to be provided. There would also be a need to give information on the methodology and how this was derived, with the option of meeting the requirements of BS ISO 15686-1 as an alternative to the assessment form set out in Appendix 1.

However, the success of the assessment is dependent on two main factors, as follows:

1. the provision of information
2. the skill and interpretation of the assessor.

Manufacturers of components and materials may not have the information required for their products or may be unwilling to provide it for reasons of confidentiality. However, the quality of the assessor's interpretation could be assured by a system of accreditation.

7.1 Information required

The minimum information required to carry out the design service life assessment is as follows:

- The predicted design service life of the element (reference service life).
- Quality of materials (by reference to conformity with standards, CE Marking or third party Certification).
- Exposure of the site (environmental conditions).

The assessor, whose role it is to identify the products and their characteristics, should in the first instance supply information in the application form from manufacturers information or from third party certificates that relate to the actual product being proposed. Where information is not forthcoming the assessor can use other sources of information such as British Standards, BRE Guidance, Housing Association Property Mutual (HAPM) and Building Performance Group (BPG) publications^[20].

When information has been used from a source outside the applicant's own assessment then this should be noted on the assessment form. This may be the result of detailed specifications of materials not having been prepared, or more than one type of product has been proposed for use by a specifier, but that tenders have not yet been sent out or received.

7.2 Carrying out the assessment

The design service life assessment should be carried out by the applicant when the building warrant application is made to the Verifier.

The assessment may be reviewed at a later date once work has started on site. The 'relevant person' should ensure that the materials and components described in the building warrant application, as granted, have in fact been used in the building.

8 Examples of design life assessment

These case studies has been provided as a means of illustrating how the design service life of a building could be assessed. They have been included for information purposes only and is not based on any 'real-life' examples. Note that the factor B is not mentioned it is assumed to be 1 as it describes the design level factor. This assumption is based on the fact that the building being assessed should already meet the requirements of Regulation 8.

8.1 Private dwelling

The main factors affecting the estimated design service life of a private dwelling will be particular to the structural and non-structural elements. The structural elements are a timber frame system, brick cladding and concrete roof tiles. The non-structural elements are made up of timber windows and doors, plasterboard partition walls and the electrical and plumbing services.

8.1.1 Structural elements

The main factors affecting all of the structural elements will be moisture ingress and movement in the building. These are a feature of the site and its exposure to the weather conditions.

Using the factoring method described in Section 2.1 and Section 5.6, the estimated design service life of the timber frame system for regulation purposes can be estimated as follows:

$$EDSL-R = RSLC \times A \times D$$

Where; EDSL: estimated design service life.

RSLC: reference service life – structural component, not accessible: value 60 years.

The factors should vary by no more than 0.2 from 1.0.

A: quality of materials factor – Certified timber: value 1.1.

D: External exposure – suburban location, elevated and exposed: value 0.9

Therefore, $EDSL-R = 60 \times 1.1 \times 0.9 = 59$ years

Using the factoring method described in Section 2.1 and Section 5.6, the estimated design service life of the brick cladding system for regulation purposes can be estimated as follows:

$$EDSL-R = RSLC \times A \times D$$

Where; EDSL: estimated design service life.

RSLC: reference service life – structural component, not accessible: value 60 years.

The factors should vary by no more than 0.2 from 1.0.

A: quality of materials factor – Frost resistant bricks: value 1.1.

D: External exposure – suburban location, elevated and exposed: value 0.9

Therefore, $EDSL-R = 60 \times 1.1 \times 0.9 = 65$ years

Using the factoring method described in Section 2.1 and Section 5.6, the estimated design service life of the concrete roof tiling system for regulation purposes can be estimated as follows:

$$EDSL-R = RSLC \times A \times D$$

Where; EDSL: estimated design service life.

RSLC: reference service life – structural component, not accessible: value 50 years.

The factors should vary by no more than 0.2 from 1.0.

A: quality of materials factor – BBA Certified product: value 1.1.

D: External exposure – suburban location, elevated and exposed: value 0.9

Therefore, $EDSL-R = 50 \times 1.1 \times 0.9 = 54$ years

8.1.2 Non-structural elements

The main factors affecting the non-structural elements will be the ingress of moisture and water damage.

Using the factoring method described in Section 2.1 and Section 5.6, the estimated design service life of the timber windows for regulation purposes can be estimated as follows:

$$EDSL-R = RSLC \times A \times D$$

Where; EDSL-R: estimated design service life.

RSLC: reference service life – non-structural component, accessible: value 25 years.

A: quality of materials factor – non-durable redwood, fully machined and pressure treated with a solvent based preservative: value 1.

D: environmental conditions factor – internal environment, low risk; external environment, sheltered from wind, rain and particulates: value 1.1.

Therefore, $EDSL-R = 25 \times 1.1 \times 1.1 = 30$ years.

Using the factoring method described in Section 2.1 and Section 5.6, the estimated design service life of the internal plasterboard partitions for regulation purposes can be estimated as follows:

$$EDSL-R = RSLC \times A \times D$$

Where; EDSL-R: estimated design service life.

RSLC: reference service life – non-structural component, accessible: value 30 years.

A: quality of materials factor – foil-back plasterboard: value 1.

D: environmental conditions factor – internal environment, low risk; external environment, sheltered from wind, rain and particulates: value 1.1.

Therefore, $EDSL-R = 30 \times 1.1 \times 1.1 = 36$ years.

Using the factoring method described in Section 2.1 and Section 5.6, the estimated design service life of the services for regulation purposes can be estimated as follows:

$$EDSL-R = RSLC \times A \times D$$

Where; EDSL-R: estimated design service life.

RSLC: reference service life – non-structural component, accessible: value 30 years.

- A: quality of materials factor – wiring and plumbing using quality materials: value 1.
- D: environmental conditions factor – internal environment, low risk; external environment, sheltered from wind, rain and particulates: value 1.1.

Therefore, $EDSL-R = 30 \times 1.1 \times 1.1 = 36$ years.

8.2 Concrete frame

The main factors affecting the estimated design service life of the reinforced concrete structure are the grading of the material, reinforcement and protection. The environment and exposure to possible corrosive compounds, such as salt spray, will also be important to consider.

Using the factoring method described in Section 2.1 and Section 5.6, the estimated design service life for regulation purposes can be estimated as follows:

$$EDSL-R = RSLC \times A \times D$$

Where; EDSL: estimated design service life.

RSLC: reference service life – structural component, not accessible: value 60 years.

The factors should vary by no more than 0.2 from 1.0.

- A: quality of materials factor – Portland blast furnace slag cement (to British Standards) with good coverage of reinforcement: value 1.1.
- D: External exposure – inner city location away from coast and significant frost, frame covered by cladding: value 1.2

Therefore, $EDSL-R = 60 \times 1.1 \times 1.2 = 79$ years

8.3 Softwood window

The main factors affecting the estimated design service life of the softwood window are the inherent timber quality and the quality of the timber treatment, together with the quality of maintenance of any coating. The window design and its orientation and position within the building are also important factors to consider.

Using the factoring method described in Section 2.1 and Section 5.6, the estimated design service life can be estimated using the factorial approach as follows:

$$EDSL-R = RSLC \times A \times D$$

Where; EDSL-R: estimated design service life.

RSLC: reference service life – non-structural component, accessible: value 25 years.

- A: quality of materials factor – non-durable redwood, fully machined and pressure treated with a solvent based preservative: value 1.
- D: environmental conditions factor – internal environment, low risk; external environment, sheltered from wind, rain and particulates: value 1.1.

Therefore, $EDSL-R = 25 \times 1.1 \times 1.1 = 30$ years.

These examples are not given as an indicative guide to reinforced concrete structures or softwood windows. Their purpose is to serve as an illustration of the assessment procedure that can be carried out for structural and non-structural components.

The main focus of this study was to evaluate the feasibility of extending Regulation 8 of the Building (Scotland) Regulations 2004 to require a statement of design service life in building warrant applications for buildings. This has been carried out by developing the concept of design service life for building and a methodology for its assessment and use. The concept has also been presented to a selected number of Building Standards Officers to obtain feedback and comments on the design service life principal and the assessment procedure.

9.1 Current levels of design service life assessment for buildings

The initial part of the work was concerned with identifying what information is currently submitted in building warrants. The warrant will have a wide ranging level of information contained within it. This is dependant upon the project and the amount of detailing supplied within the warrant application. There is a minimal requirement for the amount of details supplied by the applicant. This can vary significantly and results in differences in the amount of information provided.

The verifier will deal with this variation in information by assessing the details provided in a site inspection that not only verifies these, but ensures that the construction work has been carried out to the required levels for compliance with the Building Standards. Engineering details are often also included to complement the warrant application and more detailed information is often provided.

What is apparent from the work carried out during this study is that design service life statements and the lifetime of materials or components are not often provided by manufacturers unless they are specifically requested. This may change in the years to come as the energy performance and sustainability of buildings become increasingly important issues for owners, designers and users of buildings. The inclusion of a design service life statement within Regulation 8 of the Building (Scotland) Regulations could prompt this type of information to become more readily accessible, but the lack of such information would make such statements impractical.

The incorporation of a statement or assessment of the design service life of the key components of a building will add significantly to sustainable development; in short if the materials of the building are not durable then the building cannot be sustainable. At present there is no requirement for design service life assessment and at the same time there are a considerable number of building failures that can be attributed to lack of durability of the materials and components used. This lack of durability may be a result of poor quality materials or of poor workmanship. However, an assessment of design service life for building regulation purposes will bring into focus the issues of design service life and may encourage the use of better quality materials, improved specification and more attention to detail in workmanship.

The use of a design service life assessment in building regulation would not require specific lifetime limits to be reached.

9.2 Assessing the design service life

Theoretically, the inclusion of such as statement of 'Design service life' could be undertaken on a number of levels. The amount of information required to fully assess the design service life of a building could consider all materials, components and fittings. This is an onerous task as the number of components and materials within a building could be significant depending on the size of the construction project.

A methodology has been developed as the proposed best route for inclusion within the remit of Regulation 8. As the amount of information provided in building warrants is variable, a detailed approach to whole life costing and a statement of 'design service life' may be difficult to implement. A simplified factoring method could be used to identify the 'design service life' based on the information available. It should take into consideration the lifetime of the material and components and the building's location.

Based on these criteria the statement of design service life was defined as follows:

“... the assessment of a structure, both as a complete building and individual components, which predicts its potential lifetime based on the quality of materials and the environment, assuming normal use and satisfactory levels of design, workmanship, and maintenance.”

This description encapsulates all of the criteria which should be assessed to evaluate the design service life of a building.

The full prediction of design service life is a complex issue as it involves dealing with a large number of factors which will affect the prediction. Some of these factors will be unique to the building itself, others will directly relate to the quality of the material or component, and some will reflect the in-service conditions. There are, however, a number of common features that can be identified that may affect the design service life of materials and components. These can be structured or analysed in terms of the stage of design or construction at which they occur, or in terms of what they say about the weak links in performance for the particular material or component.

An accurate assessment of design service life depends on the information available. Verifiers will have some knowledge of how the elements of the building will perform over a period of time and any obvious areas of concern should be quickly identified. Where the lifetime of a component cannot be easily determined from the usual information sources, the onus will be placed on the manufacturer to provide the required data. There are some immediate concerns with this as follows:

- a) the manufacturer may not have any relative information for their product, or
- b) the manufacturer does not wish to share the information with other parties.

The lack of any ‘back-up’ regulations to ensure all relevant data is provided may limit the accuracy of the design service life assessment in some cases. In recent years, however, manufacturers have become increasingly aware of the need to provide such information in a market where energy efficiency and sustainability are key issues for all those involved in construction.

9.3 Design service life methodology

The assessment of design service life has been developed from a combination of the two approaches, as follows:

- A factoring method as described in BS ISO 15686-1 (2000) ‘Buildings and constructed assets – Service life planning: Part 1 – General principles’.
- Dividing the components of a building under the headings of ‘structural’ and ‘non-structural’ and carrying out an assessment of design service life for each grouping, but with a standardised assumption of satisfactory design detailing, workmanship, durability, and maintenance.

By dividing the building into structural and non-structural elements, their estimated design service life may be more easily estimated. Structural elements may be made up of masonry, steel or timber frame whose durability in most cases would be a minimum of sixty years. The durability and performance of these structures is often well researched and documented. Consequently, information on the potential lifetime of the structural system should be readily available in most cases.

An assessment form has been developed which allows the information relating to the component to be evaluated. The scoring system, although simple to follow, relies on the opinion of the assessor and not on definite performance limits. The interpretation of the assessor is therefore critical in the design service life process. Another limitation of the BS ISO 15686-1 (2000) methodology is that the factoring method may not be fully completed in all instances. It would be difficult for the assessor to comment on the level of workmanship, for instance, if the building is not inspected during and post-completion. It is not practical to carry this out in all circumstances. Other factors such as the level of maintenance and ‘in-use’ factors are also difficult to determine unless they are followed up by periodic site visits. These limitations, together with

the requirements and assumptions of Regulation 8, have led to the development of the simplified form described in Section 5.7. It may be relevant, however, to ask if the simplified method is, in itself, worthwhile. The details provided through the simplified form may not provide any useable data that could be used in the assessment of design service life. This could only be determined through some trials and comparison of the two assessment procedures.

9.4 Assessment criteria

The design service life assessment has adopted a method which uses the standard service life for components with assumptions made for their quality and their use in a building. BS ISO 15686-1 uses the following approach to categorising the factors influencing the design service life:

$$EDSL-R = RSLC \times A \times B \times C/D$$

Where; EDSL-R: estimated design service life.

RSLC: reference service life.

A: quality of materials factor.

B: design level factor.

C/D: environmental conditions factor.

The 'reference service life' refers to the time that the component or building can normally be expected to last under specified service conditions. It may be derived from modelling, experience, accelerated testing, data from the manufacturer or from product standards. *A* to *F* represents factors that can affect the design service life under circumstances where they do not meet the levels specified in manufacturers recommendations or in the Codes and Standards. Appropriate values for these factors need to be judged by the designer and based on the particular circumstances of the project, previous experience and information available on the effects of factors on design service life (e.g. design concept, structural detailing, environment, workmanship and maintenance).

In reality, however, it may only be possible for the assessor to determine factors A, B and D (quality of materials, design level and environmental conditions, respectively) as well as the reference service life. The other factors C, E and F (work execution, in-use conditions and maintenance conditions, respectively) are difficult to determine without site work and periodic inspection of the building. This would be an onerous undertaking for most buildings, however it could be considered where the lifetime of the building was particularly sensitive to maintenance, levels of workmanship and its day-to-day usage. An example of this could be the use of treated timber cladding, where periodic treatment and maintenance is essential to provide the service life of the product. A further example is related to the in-use conditions within the building. This may be particularly relevant where the building changes ownership and rooms are converted into computing suites, for instance. The increased heating and moisture loads provided by the equipment and human occupancy levels may cause long-term deterioration of the internal finishes and/or structural system.

9.5 Alternative assessment method

A simplified assessment method has been developed as an alternative to the factoring method developed from BS ISO 15686. This simplified approach allows the material or component to be classified as 'maintainable, replaceable or lifelong'. This approach allows the applicant to consider any replacement or maintenance issues and highlight these as being important factors when considering the lifetime and durability of the material or component. This allows an assessment of the design service life to be made without considering any factors such as the environment in which the building is situated and what its 'in-use' conditions may be.

The simplified approach may be the first stage in implementing the design service life assessment. It is simple in that it does not have a scoring system to deal with and would not be too onerous for the applicant to complete. A possible drawback, however, maybe that the information supplied in this simplified method is not detailed enough to provide any meaningful conclusions to be drawn regarding the design service life of the building. This can only be determined through application and assessment of the methodology.

9.6 Possible areas of conflict

The design service life assessment could, in some instances, lead to conflict between building owners, insurers and mortgage providers. The design service life statement will inform the owner of the possible future value of the building. The possible deterioration in materials and components will be a key factor in estimating the current or future values. This will also be useful in determining what upgrading or remedial work may be necessary to ensure that future value is maintained or improved. Design service life information may also be made available to potential purchasers to inform them of the level of work required and the materials and components used in the building.

These factors may also account for changes in the levels of insurance cover required for the building throughout its lifetime. As the building and its components age over time, the requirement for insurance cover may vary accordingly. This may require a schedule of repair or maintenance work to be agreed with the building owner and the insurers.

10 Conclusions

BRE has carried out a scoping study on behalf of the Scottish Building Standards Agency (SBSA) into the possible inclusion of a design service life statement within Regulation 8 of the Building (Scotland) Regulations. This has involved a desk-based study and the development of a methodology for assessing the design service life of buildings. Feedback has also been received from Building Standards Officers at various stages of this work. The following points are concluded:

- There are limited means available for the building owner, designer or verifier to test the design of a building against its intended design service life. Whole life cost techniques can be utilised to this end, however the availability of accurate information may limit the effectiveness of the assessment.
- A factoring method for assessing the design service life of buildings and components has been developed by BRE for SBSA. This is based on the method of BS ISO 15686-1 but takes account of the requirements and assumptions of Regulation 8.
- The factoring assessment method lists the criteria which affect the durability and performance of materials and components throughout their lifetime. However, standardised assumptions must be made during the assessment process with regard to workmanship, in-use conditions and levels of maintenance, in accordance with the requirements of Regulation 8 of the Building (Scotland) Regulations 2004.
- The design service life assessment may have some implications to insurers or mortgage providers. This is particularly relevant where the design service life of the building lies beyond the terms of the mortgage repayment schedule, or the building cannot be insured due to the vulnerability of the materials and components.
- A simplified method for assessing the design service life of buildings and components has also been developed. This is based on a 'lifelong', 'replaceable' or 'maintainable' assessment criteria and also states the minimum service life of the building or component. This may be used as an alternative approach to the factoring method if required.

The information required in the assessment of design will encourage designers and specifiers to select materials and components, not only on their thermal performance, but also their interaction with the environment. This could encourage specifiers and manufacturers to be more aware of their products and the materials they are using within their buildings. It should be noted that there are many whole life cost and sustainability tools being implemented in a percentage of construction projects being carried out within the industry.

Table 1. Maintenance levels (Quoted from BS 7543(2003) ^[4]).

Level	Description	Scope	Examples
1	Repair only	Maintenance restricted to restoring items to their original function after 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.	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 inspection of historic churches etc leading to planned maintenance

Table 2. Criticality of service life of structures and elements of structures.

High criticality	Lifelong: durability failure would cause cessation of function or major disruption and unacceptably high costs during remedial work.
Medium criticality	Efficiency of operation reduced, but remedial work or replacement can be done during normal working hours at acceptable cost.
Low criticality	Not critical. Maintenance and remedial work or replacement can be done without inconvenience and for an acceptable cost.

Table 3. Alternative design service life assessment form (example).

Component	Category	Minimum lifetime
Timber frame	Lifelong Maintainable	60 years
Windows (PVC-U)	Replaceable Maintainable	25 years
Concrete frame	Lifelong	60 years
Roof tiles	Replaceable Maintainable	50 years

11 References

- [1] The Scottish Building Standards Technical Handbooks (Domestic and Non-domestic), Scottish Building Standards Agency, 2005.
- [2] Rebecca Hooper and Frederico Rizzi (2001). 'Durability and assessment of buildings and structures: consultation exercise results', BRE Report 428, Garston Watford.
- [3] Construction Products Directive 89/106/EEC.
- [4] British Standard BS 7543 (2003). 'Guide to durability of buildings and building elements, products and components', BSI, London.
- [5] British Standards BS 8000. 'Workmanship on building sites' (various parts). BSI, London.
- [6] British Standard BS ISO 15686-1 (2000) 'Buildings and constructed assets – Service life planning: Part 1 – General principles', BSI, London.
- [7] BS ISO 15686-2 (2001) 'Buildings and constructed assets – Service life planning: Part 2 – Service life prediction procedures', BSI, London.
- [8] Sir John Egan (1998) 'Rethinking construction', The report of the construction task force to the Deputy Prime Minister, John Prescott, on the scope for improving the quality and efficiency of UK construction.
- [9] Sir Michael Latham (1994) 'Constructing the team', Final report of the Government/industry review of procurement and contractual arrangements in the UK construction industry. Department of the Environment.
- [10] K C Quillin (2001). 'Corrosion of steel in concrete – Service life design and prediction', BRE Digest 455, CRC Ltd, Watford, UK.
- [11] Mike Clift and Kathryn Bourke (1999) 'Study on whole life costing', BRE Ltd.
- [12] Housing Association Property Mutual (HAPM) 'Component Life Manual', London, E & F N Spon, 1992.
- [13] BRE Digest 429 (1998). 'Timbers: their natural durability and resistance to preservative treatment', BRE, Garston, Watford.
- [14] BRE Digest 420 (1997). 'Selecting natural building stones', BRE, Garston, Watford.
- [15] B K Marsh (1996). 'A review of service life design of concrete structures', BRE Report 316, BRE, Garston, Watford.
- [16] The Construction (design and management) Regulations (1994). <http://www.opsi.gov.uk/>
- [17] British Standard BS EN 1990 (2002). 'Eurocode. Basis of structural design'. BSI, London.
- [18] British Standards BS 8210 (1986). 'Guide to building maintenance management'. BSI, London.
- [19] Kathryn Bourke & Hywel Davies (1997). 'Factors affecting service life predictions of buildings: a discussion paper', BRE Report 320, CRC Ltd, Watford, UK.
- [20] Building Performance Group (BPG) 'BPG Building fabric component life manual', London, E & F N Spon, 2000.

Appendix 1 – Estimated design service life for regulation (EDSL-R) assessment form

Element:	Structural	Non-structural
	Please tick: <input type="checkbox"/>	Please tick: <input type="checkbox"/>
Description:		
Reference service life (RSLC): _____ (years)		
Factor: scale 0.8 to 1.2 (1.0 the nominal value for normal levels of quality, design and exposure)		
	Factor	Explanation
A: quality of materials		
D: environmental exposure (internal and/or external)		
Estimated design service life for regulation (EDSL-R) = RSLC x A x D = _____ years		
Notes:		

Factoring information

The factoring system is based on the following details. A nominal value of 1 should be entered if :

- the information provided does not have a positive or negative effect on the overall design service life of the building.
- information relating to the factor is unknown or cannot be adequately assessed.

The factoring approach is based on a certain amount of judgement by the applicant. The following table gives guidance on how to determine which factor to apply. The assessor can also apply a factor of, for example, 1.05 if this is considered more acceptable. The factor applied should be justified in the assessment form set out above.

Factoring system

Factor	Description
0.8	Presents a significant adverse effect on the lifetime of the material or component.
0.9	Presents an adverse effect on the lifetime of the material or component.
1	Presents no effect on the lifetime of the material or component.
1.1	Presents additional benefit to the lifetime of the material or component.
1.2	Presents increased benefit to the lifetime of the material or component.