


Designing quality buildings

a BRE guide

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Foreword

Today's building industry has no shortage of information: indeed, the challenge is in selecting and using what is really important. Construction technology is constantly developing, and the regulatory framework within which decisions are made about design, materials, construction, costs, maintenance and so on, is changing too, as clients become more demanding and as pressures for construction to become more sustainable increase.

I am delighted to welcome and endorse this BRE guide both personally and on behalf of BRE Trust. The Trust's mission is:

'to promote and support excellence and innovation in the built environment for the benefit of all.'

This book contributes to these aims in three ways.

- It brings together in a single volume, the most important aspects of the accumulated knowledge and experience of a team of BRE's most experienced architects, engineers, surveyors and scientists in a concise format that sets out key principles and advice.
- The guide provides a route map through the maze of standards, regulations and guidance that circumscribe our industry.
- Sustainable construction can only be achieved by applying lessons about successful performance of materials and techniques over time: this guide will enable clients and designers to make sound decisions that will contribute to sustainable construction based on a thorough understanding of the fundamental physical, chemical and environmental characteristics of buildings.

For generations of building professionals, the book *Principles of modern building* was a trusted companion to those needing authoritative guidance on the application of building science and technology. I believe that *Designing quality buildings* is a worthy successor to that classic book, and I commend it to you.

Sir Neville Simms
Chairman, BRE Trust
January 2007

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Preface

'The highest available knowledge of pure science and the most effective methods of research are needed in building as in any other field of research. Building research as a whole, however, is concerned with the principles of an exceptionally wide range of science… … Results of past scientific research are not at present fully utilised in building because there is no suitable bridge between the research worker and the architect or designer'.

(DSIR 1919)

Then as now! These observations from nearly a century ago highlight what has proved to be a continually recurring problem for the construction industry in the UK. In spite of the nearly instant availability of information (some might argue that the most relevant information has become buried in an avalanche of virtually useless data), there is still a need for considered overviews to aid the busy designer. That is one of the main purposes of BRE's *Digests* and other leaflets and reports, and it is to update, enhance and consolidate that effort that this book has been produced.

There are perhaps as many interpretations of the meaning of the word 'quality' as there are designers. For the purposes of this book, however, it is the technical excellence of a building that underlies our central theme, rather than its aesthetic excellence, in accordance with the BRE tradition of adopting a non-controversial approach to matters of aesthetics. Technical excellence includes sustainable construction, which means designing buildings that are fit for purpose, adaptable and durable. When short-life components are used, they should be safe and easy to look after and replace, and at the same time have a minimal impact on the environment and be affordable.

Many of the chapters have been based on construction elements but this should not be allowed to hide the fundamental fact that an holistic approach, developed in the earlier chapters, is required to improve both the design and construction processes if we are to achieve improved quality in our finished buildings.

The scope of the book has been restricted to low-rise construction, if only in order to keep the book to a manageable size. It is also primarily about new construction, where opportunities for application of sustainability principles are perhaps greatest, but many of these principles, if not the practices set out in the following pages, apply in equal measure to refurbishment of the existing stock of buildings. It gives the construction professional a solid understanding of many key design and specification principles and a good starting point when talking to specialists.

The past few years have radically changed the national framework for the construction industry as well as the research which underpins it, and new challenges and opportunities are shaping the form and content of our buildings. Our homes, offices, schools, factories, hospitals (in fact all types of public and private building) will need to reflect and respond to:

- a changing age structure in the population,
- changing family structures and patterns of living,

- new materials technologies,
- new dispersed working patterns following IT developments,
- new control technologies (eg allowing lower energy use and increased water conservation),
- better security and fire protection,
- recycling of land and building materials,
- greater use of natural energy sources,
- better structural assessment and repair technologies,
- improved protective finishes for timber, metals and concrete,
- rapid and economical replacements for items that are life-expired,
- new insulation materials and better heating and lighting products, to cut energy consumption,
- climate change,
- a more demanding and articulate building user.

These, in summary, form the background to our chosen topics.

There are many references to building regulations in the following pages. Buildings constructed meticulously in accordance with these regulations should ensure that minimum standards of performance and safety are met. However, in many cases, higher standards than those cited in building regulations will be both justifiable and affordable when measured against long-term sustainability criteria. That is the real meaning of 'quality'.

Key points have been added to draw the reader's attention to important design information.

When selecting products, systems, installers or maintenance companies BRE strongly recommends that you choose those that have been independently approved by a third-party certification body. The performance of an excellent product can be severely undermined by poor installation or maintenance. BRE produces lists of approved products and services which can be viewed free of charge at www.RedBookLive.com.

Readers' feedback for the next edition is of course welcome. It can be addressed to:
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Mike Clift
Stephen Garvin
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January 2007

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1 Introduction

Good designers have always sought to provide functional, cost-effective and pleasing buildings for their clients. BRE first published *Principles of modern building* in 1938-9. In the introduction to the 3rd edition in 1959, the Director of Building Research stated the objective as:

'to help the reader to grasp principles, to sense the interconnection of requirements, and to appreciate their relative importance in particular circumstances….There is relatively little change, however, in the basic requirements that a building must satisfy; strength and durability, exclusion of the weather, admission of light and air, control of noise, and so on, at reasonable cost….What materials, put together in what ways, what methods of design, will meet these requirements?'.

The book went on to deal with the following topics:

- Strength and stability,
- Dimensional stability,
- Exclusion of water,
- Heat insulation,
- Ventilation,
- Sound insulation,
- Daylighting,
- Fire protection,
- Durability, composition and maintenance,
- Building economics,
- Principles of use of materials.

Each of these issues is still highly relevant to designers of buildings, but perhaps we would query the statement that there is relatively little change in the basic requirements. The process of design now takes place in the context of changing expectations and constraints, in a world where information is available almost instantly, but knowledgeable overviews are few and far between. The designer (of whatever discipline or background, within whatever form of contract) has the role of interpreting the client's requirements to turn them into a building that meets both the immediate need and the foreseeable future requirements. This entails translating functional issues into technical and practical designs and specifications, which can be built effectively, using available and cost-effective materials, labour and techniques.

In the process of design many legislative and regulatory requirements must be met — these changing requirements are summarised in each chapter. There is also a requirement to comply with good or best practice — key aspects of these are highlighted and sources of further guidance are listed at the end of each chapter.

We now recognise that we are living in the context of a rapidly changing and evolving social and technological age, with new concerns about the planet we live on and the sustainability of our society. This introductory chapter on sustainable design deals with the context of building design in the early 21st century. It covers some of the enduring and current issues and relates them to the basic concepts of design.

Guidance has not been explicitly tailored to 'traditional' or 'modern methods of construction' as each will be required to meet the same performance requirements. The main difference lies in the fact that where a whole system or kit is selected as the basis of design, the predetermined selections should still be tested against the basic design criteria. In principle, either can be the basis of sustainable design and specification.

Sustainable design and specification

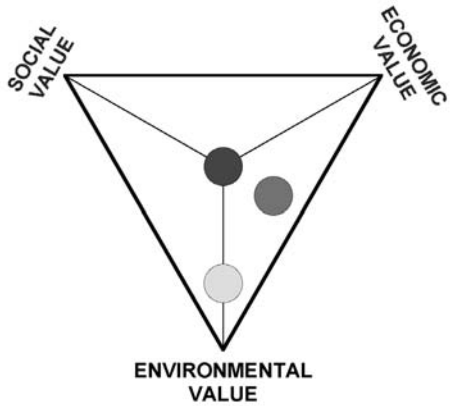
'Sustainable construction is the set of processes by which a profitable and competitive industry delivers built assets (buildings, structures, supporting infrastructure and their immediate surroundings) which:

- enhance the quality of life and offer customer satisfaction,
- offer flexibility and the potential to cater for user changes in the future,
- provide and support desirable natural and social environments,
- maximise the efficient use of resources.'

(Source: OGC 2000)

The 'triple bottom line' of sustainability (Figure 1.1) is the successful balancing of social, economic and environmental issues. Sustainability is almost always context-dependent; what improves a problem in one area can exacerbate it in others, depending on the circumstances. It also follows that a fundamental rule of sustainable construction is that there must be an identified need for the development in the first place. The built environment has a key role to play in sustainability and appropriate building design is one of the key tools to improve sustainability in construction.

Real-world design is not about 'absolutes'; this becomes abundantly clear when trying to deal with more than one aspect of design at a time, and where interdependent alternatives might have competing or conflicting priorities. This makes the 'perfect' optimisation of a design difficult to achieve since



KEY

- Project with perfect balance of Social, Economic and Environmental Value
- Project with high Environmental Value but little Social or Economic Value
- Project with equal balance of Economic and Environmental Value but little Social Value

Figure 1.1 Projects have varying balance between the triple bottom-line values of sustainability

there is often no common function against which alternatives can be measured. Different aspects of a design will be measured against different functions, with perhaps a large gain or loss in one being needed to compensate for a small loss or gain in another.

For example, increasing an area of glass to achieve an increase in the level of natural light within a building (eg to exceed the measure of a specific minimum daylight factor) may lead to significant increases in the amounts of solar gain on some elevations and an unavoidable need for mechanical cooling. In this context, the desire for natural light and the need to avoid overheating can be seen to be in conflict and to be difficult to resolve.

However, the issue can be resolved if considered at a higher level, one where the questions of 'how much glass' and 'what temperature' can be balanced against each other. Examining the cost of installing and running a cooling system as opposed to the cost of artificial lighting would be one way of doing this, as well as considering other factors. The designer needs to be mindful of functionality. For example, people generally prefer daylight to artificial light and are thought to be more productive and perform better in daylight. This should make it more

Office of Government Commerce (OGC). *Achieving sustainability in construction procurement.* 2000. 12 pp. Available as a pdf from www.ogc.gov.uk

worthwhile investing in shading devices, although it is not easy to demonstrate payback.

All this illustrates the crucial importance of the notion of hierarchy when dealing with the many uncertainties and conflicts that surround the types of problems that designers have to deal with all the time, and which lie at the heart of the concept of any design and especially sustainable design. Otherwise, it would be impossible to make design decisions that are both reasonable and, within limits, objective.

In any project, the designer(s) will need to recognise the balance sought by their clients between cost, environmental value and social value. Generally, not all aspects will have exactly equal value: it is relatively rare for social or economic values to be sought at any price. It is, however, part of the expertise of the designer to seek to strike an optimum balance within the constraints of the budget. Maximising sustainability is best achieved by considering it from the outset of the design process.

Box 1.1 gives a brief overview of each of the key values of sustainability. More detail is given in the following sections when they are described in

Box 1.1 Key values of sustainability

Environmental concerns and principles

Environmental sustainability (in relation to the built environment) considers the local, national and global environment and the impacts of development on them.

This means:

- Using land wisely and protecting areas of natural beauty, scientific interest, etc.
- Using the least amount of energy and finding more environmentally friendly forms of energy, with less damaging emissions to the environment and people.
- Limiting the amount of water treated for human consumption and increasing the use of environmentally friendly (grey) water supply and drainage systems.
- Reducing the amount of road traffic to alleviate congestion, reducing air pollution and limiting the land required for roads and car parks.
- Reducing the amount of raw materials used for construction, and considering appropriate means of extraction and/or processing for materials that are plentiful.
- Encouraging local sourcing of materials, thereby reducing transport costs and impacts.
- Providing safe disposal of used materials that cannot be re-used or recycled.
- Protecting and enhancing wildlife and biodiversity.

Social concerns and principles

Social sustainability in relation to the built environment entails providing a healthy, attractive and desirable place for people to live and work.

Consider, wherever possible:

- A high quality built environment (one that the majority of people find attractive, safe and comfortable).
- A mix of housing (types and tenures) and land uses (housing, employment, health, education and leisure).
- An appropriate density of buildings for the type of area.
- Provision of facilities locally (shops, schools, chemists, health centres).
- High accessibility throughout the area with good public transport and provision for walkers and cyclists, and recognition of different individuals' changing mobility.
- A reduction in the domination of the car, particularly in residential areas.
- Measures to improve air quality.
- Provision of a high standard of urban design with sufficient public green space and areas of beauty.
- Designs that reduce the opportunities for and fear of crime.
- Designs that reduce noise nuisance and provide some quiet spaces.

Economic concerns and principles

Economic sustainability varies depending on the nature of the community, but it is linked to the economic health of the surrounding region.

Within the urban situation some of the factors needed to make an area economically viable for the future include:

- Providing employment sites to meet projected needs.
- Providing an appropriate intensity of land use to ensure viability of local business.
- Providing good infrastructure links to key trading centres by both public and private transport.
- Supporting local trades and businesses during construction and regeneration activities.
- Ensuring that owners and occupiers will be able to afford running costs, foreseeable maintenance and repair activity, and anticipation of likely timing and cost.
- Ensuring that buildings have some flexibility to meet changing requirements without sacrificing cost effectiveness in the short term.

relation to specific issues, such as climate change, together with an overview of some key tools for balancing the competing values of sustainability.

The principles of space planning

What do buildings provide for us? At the most basic level they provide space protected from the elements so that we can carry out our intended activities. This can be developed into more detailed descriptions of:

- the type of spaces,
- the services,
- the interrelationship of spaces, and
- the relationship to the environment outside,

but essentially they should meet the needs of people and organisations.

Clearly, some buildings make a greater contribution than others to the efficiency and profitability of the business operations carried out within them, ie their functional performance.

Functional performance has a natural life cycle. It should typically be at a maximum on or shortly after completion of a new building. It will then decline as the building fabric starts to wear and the occupants' requirements change.

In each sector for which the building industry constructs buildings, there are different drivers for the construction and different functional requirements placed on the building. In some, the need to measure functional performance is more obvious than in others.

For some other buildings that are more closely integrated into a manufacturing or logistics process, the functional performance is even more critical. For example, the floor of a high rack automated warehouse has to perform to a high standard to ensure the racks are able to function. Passenger interchange buildings not only need to provide reliable mechanical equipment (escalators, lifts, baggage handling, etc.) but the planning must avoid cross-flows on main thoroughfares. The building may need to operate 24 hours a day throughout the whole year.

Constructing and running office buildings is such a small proportion of the cost of employing the staff over the design life of the building, that it is clearly important to understand and optimise the contribution of the building to their activities that take place within it. In commercial buildings there is clearly a link between how well a building supports the activities taking place within it and the profitability of that operation. The exact relationship of these factors is not simple because so many of the factors which determine profitability have nothing to do with the building(s) housing the operation. Separating out the non-building factors would require considerable research.

There is, however, a factor which links function and profitability and that is productivity. Some industry sectors and some existing research have addressed this. In the manufacturing sector, productivity is usually expressed as output per person (because even here people costs are such a large proportion of overall costs). However, it can be expressed by building. In other building types though, the concentration has been on the impact of indoor environmental factors. Productivity is quite difficult to measure, even in environments such as call centres because of the impact of non-building factors.

Away from commercial buildings decision-making is usually based on other factors. In the case of houses, most residents make decisions based on their own functional performance assessment as only they can.

The functionality of every form of built facility, including roads, railways, retail outlets, houses, hospitals, schools, offices, can be expressed in terms of the flow of added value. Figure 1.2 shows how objects, information or people flow in, something is done within the physical realm of the building and objects, information and people flow out with value added to them. Smooth flow equates with high functionality and high added value, while interrupted flow equates with low functionality and waste.

For instance, in a railway station, the continuous flow of passengers to and from trains adds value to journeys for as long as people can move freely. The continuous progress made by passengers in their journeys is a 'smooth flow'. On a motorway, the flow of traffic adds value to journeys even if

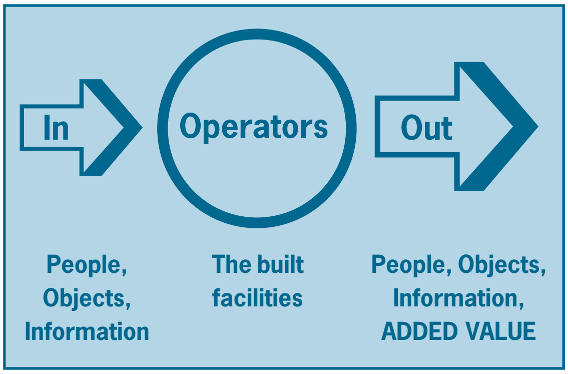


Figure 1.2 Flow chart of added value through a building

movement is slow, but any unplanned stoppage causes delay, frustration and waste. This is an example of interrupted flow, where progress towards the goal is not continuous. Time passes without value being added to the journey.

Smooth flow does not necessarily require continuous physical movement of people and objects themselves. Smooth flow is about continuously adding value or progressing towards a goal. For instance, in a shop, people who stand still to examine goods on a shelf, continue to progress smoothly towards their goal so long as they are:

- able to look at the goods and decide whether or not to buy, and,
- they are not in the way of other shoppers or staff.

As soon as shoppers find that they have been interrupted through being unable to see or reach goods, waste is generated. Time passes without value being added, and worse (for the business), the shoppers may be sufficiently frustrated that they leave the shop to make their purchase elsewhere.

Guidance and toolkits

There are a number of tools that help establish how well a building is going to perform and provide guidance on good practice design. Box 1.2 describes some of the available toolkits.

Principles and application of environmental sustainability in design

In the UK, construction activity is responsible for around:

- 72 million tonnes of waste from sites and demolition (17% of the total waste produced in the UK),
- 10 million tonnes of unused materials,
- 260 million tonnes of quarried materials,
- 20% of water pollution incidents,
- 60% of timber used in the UK.

(Source: Sustainable Construction Task Group 2002)

Whether at site, building or component level of design and specification, taking account of environmental issues can change typical or default behaviour and have a long-term impact on issues of national or global importance. Over the last decade, climate change has emerged as one of the most pressing environmental issues. Concerns about its wide implications are now leading to changes in both legislation and building regulations in the UK. In the next section on *BRE sustainability tools*, some of the tools to measure the environmental impact of buildings are described. In the section on climate change, the changes to construction practice required as a result of climate change are reviewed.

SCTG. *Reputation, risk and reward.* Report prepared by BRE and Environment Agency. 2002