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Second edition

Cracking in buildings

Ron Bonshor, Lesley Bonshor and Roger Sadgrove

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Preface to the first edition

Cracks are inevitable in virtually all types of construction because of the kind of materials we use, the ways in which we use or misuse them and the service conditions that our buildings experience. Nevertheless, cracks are often unsightly and, to the uninitiated, may be a sign of serious problems. Whether a crack is cause for concern or not, of course, depends on circumstances, and whether subsequent action is needed depends on correct diagnosis of the nature of the problem that brought it about.

Accordingly, this book sets out basic information on the science of materials behaviour, which is relevant to understanding how and why cracks occur. Given that understanding, much can be done to avoid their occurrence, and to diagnose their cause and repair them so that they do not recur.

It is hoped that readers will find merit in the book in that it collects relevant but scattered information into one source, treats cracking in buildings as a subject in its own right and provides a systematic approach to whatever is the reader's role in the building business. Its content should therefore be of interest to all who own, occupy, design, build and maintain buildings.

Architects need to design to avoid or at least to minimise cracking. They need to be aware of the behaviour of materials and components in response to environmental or other changes, and to be able to assess the consequences of that behaviour for the performance of buildings. The significance of those consequences may determine how much design effort and money should be invested in minimising the risk of cracks developing.

Builders will wish to avoid cracking that might be attributed to their mishandling of materials and components on site (in storage or in the course of construction), to their mistranslation of design requirements or to the quality of their work.

Surveyors undertaking building surveys need to be able to locate and determine the causes of cracks, and to advise on their significance in relation to overall structural integrity and building worth.

Building failure investigators, loss adjusters and expert witnesses in litigation need to consider all possible causes of cracking in buildings so that sound and robust cases can be made for discounting those causes that do not apply and for supporting those that do.

Building owners and maintenance staff wish to be sure that causes of cracking have been correctly identified and their significance correctly assessed, so that time and money are not wasted on unnecessary, irrelevant or in some cases even damaging remedial work.

Besides the interest that members in each of the above groups have in relation to their particular role, it is important that they also have a general appreciation of the subject and some understanding of the interests of the other parties in the building process. Surveyors or maintenance staff, for example, will be better equipped to account for a crack in an existing building with knowledge of what designers or builders may or may not have done. This book seeks to meet this generality of interests in two ways.

Firstly, it deals in Part I with the underlying science: the physics (and in some cases the chemistry) underlying the changes of size in materials and components. Part I includes the basic data quantifying size changes and distortions in building materials. Other data include ranges of conditions that are likely to be experienced by parts of buildings in service and that determine the size changes occurring in particular circumstances. These data are essential both in designing to avoid cracking damage and in the diagnosis of the causes of damage in existing structures. Part I describes the mechanisms by which the size changes potentially produce intolerable strain, and consequent distortion or cracks. It deals also with the way in which unavoidable inaccuracies in building construction modify or negate the design provisions made to accommodate changes of size in components and structures. Thus, Part I provides essential and fundamental information relevant to all, whatever their role in building.

Secondly, in Part II, it deals with the causes of cracking covered in principle in Part I, but sets them in real building contexts, taking each building element in turn. Here the common interests of the various parties are met by presenting the information in a common format, typically:

- design principles
- practical detailing
- site practices
- diagnostic principles
- remedial work or repairs.

Under 'Design principles', the factors operating in each case are identified. In 'Practical detailing', design solutions are described for particular cases. The 'Site practices' section deals with the ways in which site activities influence subsequent behaviour of materials and components in service. The 'Diagnostic principles' section explains what factors must be present for any particular conclusion about causes to be valid – and how to confirm their presence. (Appendix B shows a suggested approach to crack investigation.) Finally, under 'Remedial work' or 'Repairs', the need for action and its nature are described. Thus, the interests of all roles are brought together in each successive package of information.

All of the information presented in both Part I and Part II already exists elsewhere, though scattered among a considerable number of different sources. But the information is not only scattered; much of it appears under headings that do not give an immediate impression that the content might be relevant to cracking or distortion – alkali–aggregate reaction and re-covering old timber roofs, for example – so that it might easily be missed in a library search for information and guidance on the causes and consequences of cracking. The extensive bibliography provided should also help in this respect.

In the UK, there are three separate sets of Building Regulations: for England and Wales, Scotland and Northern Ireland. There are many common provisions between the three sets, but there are also differences. The fact that references to Building Regulations are to those for England and Wales should not make the book inapplicable to Scotland and Northern Ireland.

One aspect of cracking in buildings is intentionally omitted: the design of structural members to control cracking under service loads, or under handling stresses, is both too specialised and too well covered in books on structural design to warrant it being included here. Nevertheless, there should be sufficient information in this book for readers to distinguish between cracking due to service loads and to other causes.

We are immensely grateful to the following members and former members of BRE staff who have contributed to, or commented on, the preparation of this book: R N Cox, Dr N Crammond, Dr R C de Vekey, R M C Driscoll, M A Halliwell, H W Harrison and Dr P J Nixon. We also extend our thanks to Dr A J Wadge of the British Geological Survey for his advice on the content of the tables on sources of information and methods of investigation relating to topography, vegetation, drainage and ground conditions.

Ron and Lesley Bonshor

Preface to the second edition

Cracking in buildings, first published in 1996, has become essential reading for architects, builders and surveyors. This is essentially due to the job that Ron and Lesley Bonshor did in bringing together such comprehensive and relevant information on cracking, and then presenting it in an easy-to-follow style. The book has stood the test of time, and amendments to the first edition have been limited to updating references and any aspects of the methodology that have changed in the intervening years.

One of the strengths of this book is that it references a large number of guidance documents (many authored by BRE), which may themselves now be ageing but remain a valid source of reference. All of the referenced BRE documents have been checked and are currently available as a download from www.brebookshop.com.

The guidance contained in this book has been prepared to align with the Approved Documents that support Building Regulations for England and Wales. While there are slight differences between the English and Welsh requirements compared with those contained in the Technical Handbooks that support Building Regulations in Scotland and the Technical Booklets that support Building Regulations in Northern Ireland, the technical guidance remains applicable to all parts of the UK.

Roger Sadgrove

Introduction to Part I

In most artefacts a crack indicates that the item has failed – or will do so shortly, no matter whether that item is a turbine blade or a teacup handle – and that urgent repair or replacement is essential.

Cracking in buildings does not follow this general conception. The total collapse of a building may indeed be preceded by an observable, apparently innocuous hairline crack in its fabric; but total or even partial collapse of a building within its expected service life is fortunately rare indeed, barring acts of war, earthquake and similar catastrophic events.

Virtually all parts of buildings are subjected to continuing size changes, expanding or perhaps contracting as the materials used in their construction respond to changes in temperature or moisture content. Buildings are comparatively large, complex and rigid structures, constructed from disparate materials with component parts subjected simultaneously to differing environmental conditions. It is not surprising that cracks are inevitable, though only some impair the serviceability of a building or may do so if they widen further. (Appendix A presents a method of classifying visible damage to walls.) Such cracks may justify repair or require measures to ensure that they do not develop further. Distinguishing these from the remainder, the vast majority, requires an adequate understanding of the various factors involved: the materials technology, the causes, the mechanisms and the performance consequences of cracks. To that extent, one of the aims of this book is to discourage any automatic assumption that a crack is necessarily significant – diminishing the building's integrity and worth, and demanding urgent remedy – and to substitute overreaction with calm and reasoned appraisal based on sound knowledge.

This report has been funded by BRE Trust

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Given that understanding, much can be done to avoid the occurrence of cracks, to diagnose their cause and to repair them so that they do not recur.

This second edition updates references and any aspects of the methodology that have changed since the first edition was published. It is hoped that readers will find merit in this book in that it collects relevant information into one source, treats cracking in buildings as a subject in its own right and provides a systematic approach to whatever is the reader's role in the building business. Its content should therefore be of interest to all who own, occupy, design, construct and maintain buildings.

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2 Cracks in buildings are common occurrence Cracks in buildings are common occurrence. It develops when the stress in a component exceeds the strength. Stress is caused by either externally applied or internally generated force.Â Vertical cracks in a long building or boundary wall, without expansion joint, is an example of non structural crack. 4. 5 Non structural cracks do not endanger the safety of building, but they create an impression of faulty work or instability.