SA HB 84:2018

Handbook

Guide to concrete repair and protection

STANDARDS Australia

acra

This Handbook was prepared by Committee BD-002, Concrete Structures. It was approved on behalf of the Council of Standards Australia on 6 April 2018.
This Handbook was published on 6 June 2018.

The following are represented on Committee BD-002:

- Bureau of Steel Manufacturers of Australia
- Cement Concrete and Aggregates Australia—Cement
- Cement Concrete and Aggregates Australia—Concrete
- Concrete Institute of Australia
- Consult Australia
- Engineers Australia
- Master Builders Australia
- National Precast Concrete Association Australia
- Steel Reinforcement Institute of Australia
- University of Melbourne
- University of New South Wales
- University of Sydney

Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Handbook through their representation on the Committee.

Keeping Standards up-to-date

Australian Standards® are living documents that reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued.

Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments that may have been published since the Standard was published.

Detailed information about Australian Standards, drafts, amendments and new projects can be found by visiting www.standards.org.au

Standards Australia welcomes suggestions for improvements, and encourages readers to notify us immediately of any apparent inaccuracies or ambiguities. Contact us via email at mail@standards.org.au, or write to Standards Australia, GPO Box 476, Sydney, NSW 2001.

Handbook

Guide to concrete repair and protection

Originated as HB 84—1996.
Previous edition 2006.
Revised and designated as SA HB 84:2018.

Published by SAI Global Limited under licence from Standards Australia Limited, GPO Box 476, Sydney, NSW 2001, Australia

ISBN 978 1 76072 070 5

PREFACE

This Handbook was prepared by Standards Australia Committee BD-002, Concrete Structures, to supersede HB 84—2006.

The original 1996 edition of this document was prepared by the CSIRO Division of Manufacturing and Infrastructure Technology at the request of the Australasian Concrete Repair Association (ACRA), who also provided the technical, editorial and funding input.

This Handbook is intended for those engaged in the maintenance, repair and production of concrete structures, and provides an overview of the typical methods and practices in the industry. It is not to be used as a Standard or as part of any contract relating to the repair of concrete.

This Handbook aims to provide guidance and information that can be read and understood by a diverse group of persons, ranging from professionals engaged in specifying or carrying out repairs to concrete structures, to those involved in the management of buildings and structures.

Previously available publications on investigatory and repair technologies for concrete are of overseas origin. The development and support of this document by ACRA was based on the perceived need for a document on local techniques and materials.

In the preparation of this Handbook, reference was made to RILEM Technical Recommendation 124-SRC, *Draft Recommendation for Repair Strategies for Concrete Structures Damaged by Reinforcement Corrosion*, 1994.

The 2018 edition of this document has now been updated and modified to reflect the advances in the industry as well as aligning more closely with International Standards.

AUSTRALASIAN CONCRETE REPAIR ASSOCIATION (ACRA)

The Australasian Concrete Repair Association (ACRA) was incorporated in 1991 with the aim of providing a forum to promote excellence in all spheres of concrete repair and protection work.

The Association is fundamental to the ongoing nationwide development of a professional industry whose key objectives include providing the highest levels of expertise, experience, training and quality. ACRA demands a continuing commitment from its members to maintaining the quality standards it has set for the concrete repair industry.

Through its membership base, which includes manufacturers, specialist contractors, consultants and owners, ACRA provides stakeholders with confidence in the remedial concrete repair process. This insistence on quality and best practice underpins ACRA's role in the concrete repair market.

ACRA has established a scheme of awards for excellence in concrete repair which are open to Corporate Members of the Association. These awards, which have been run every two years since 1998, showcase the work of the member companies. ACRA is committed to ongoing training of its members in the latest developments in both the technology and practical application of concrete repair and protection. Training courses have been developed by ACRA including a One Day Course on Concrete Repair and Protection, which is based on SA HB 84.

ABN 41 059 791 374

Tel: 61 2 9903 7733
Fax: 61 2 9437 9703
Email: info@acrassoc.com.au
Website: www.acrassoc.com.au

THE COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION (CSIRO)

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is Australia's national science agency and one of the largest and most diverse scientific research organizations in the world. CSIRO has more than 6500 staff carrying out research in a wide range of areas including construction, materials, energy, minerals, agriculture and natural resources.

Materials and Infrastructure Services is a division of CSIRO that supports the building, construction and engineering industries with research, consulting and testing. The division's science spans building materials—including concretes, timbers, polymers and tiles—to heating and cooling, air quality, urban planning and infrastructure, IT applications for construction, fire testing, and water systems and products.

CSIRO Manufacturing and Infrastructure Technology

Telephone: 1300 363 400
International: +61 3 9545 2176
Fax: +61 3 9545 2175
Email: enquiries@csiro.au
Web: www.csiro.au

CONTENTS

STANDARDS AUSTRALIA

Handbook

Guide to concrete repair and protection

CHAPTER 1 CONCRETE PROPERTIES

1.1 CONCRETE

1.1.1 Introduction

Concrete is a very durable material which can be used for most types of construction. Its properties and performance are influenced by the selection of mix ingredients, mix design, placing, compaction, curing conditions, design and detailing, and interaction with the service environment.

The processes of degradation, such as corrosion of steel reinforcement, are dependent on concrete quality as well as exposure conditions. This Chapter gives an overview of factors affecting quality and performance of concrete.

1.1.2 Benefits and limitations

Concrete is probably the most versatile material used in modern construction and is likely to remain so for many years to come. It has been in service as a structural material for over a century. Today, reinforced concrete structures are designed to be durable, to be serviceable and to have low life-cycle cost.

In addition to its constituents being readily available, concrete can be formulated in any quantity and fabricated in any desired shape or configuration. Its handling is amenable to sophisticated or relatively simple equipment, both under factory-controlled operations (as in the production of precast building elements) or in cast-in-place site situations. Fresh concrete is transportable and the time required for it to harden can be regulated.

An important asset of concrete is that it can provide a non-corroding environment for steel reinforcement embedded in it. Thus, well-designed and properly placed, compacted and cured steel-reinforced concrete is highly durable and provides satisfactory performance under varying service conditions.

These distinct benefits of concrete are not; however, always achieved in practice. The design life of many concrete structures around the world has not been realized, primarily because of aggressive environments, combined with deficiencies in design, detailing, supply or construction, leading to corrosion of steel reinforcement which substantially reduces the service life of many structures. The integrity of the concrete is subsequently impaired, resulting ultimately in structural distress in severe cases.

Certain material properties of concrete also exert significant influence on the service life performance of concrete structures Distress arising from material characteristics is often related to service conditions.

Other forms of distress arise because concrete is basically a brittle material. Though strong in compression, it has relatively low tensile properties. Under normal service conditions, concrete may undergo irreversible shrinkage due to moisture loss and may creep under applied load. However, suitable design and construction practices are usually employed to control some of the properties of concrete which tend to diminish structural durability.

The persistence of structural degradation regularly found in concrete structures is often due to the interaction between concrete and its service environment. The diversity and complex nature of the environmental interactions, combined with factors such as poor workmanship, inadequate structural design, construction defects and the material limitations of concrete, act against the ideal of a maintenance-free service life.

Regular inspection and condition assessment of concrete structures is essential and it is desirable that this is more than a visual inspection. Preventive maintenance can then be performed before degradation becomes advanced and the remedial work will be less extensive and less expensive. The fundamental factors that govern concrete durability need to be well understood to enable practices that ensure satisfactory asset maintenance and enhanced service life performance.

It is imperative to incorporate durability requirements into new structures and provide guidance on repair strategies for existing ones, thereby reducing the life-cycle cost of structures.

Dutch engineer Reinhold DE Sitter first postulated the 'Law of Fives' in 1984, that in terms of the life of a concrete structure, concrete durability problems can be divided into four phases:

- Phase A: Design, construction and concrete curing.
- Phase B: Corrosion initiation processes are underway, but propagation of damage has not yet begun.
- Phase C: Propagating deterioration has just begun.
- Phase D: Propagation of corrosion is advanced, with extensive damage manifesting.

The 'Law of Fives' states that $1 extra spent in Phase A is equivalent to saving $5 of remedial expenditure in Phase B, or $25 remedial expenditure in Phase C, or $125 remedial expenditure in Phase D.

Whilst the ratios may differ between structures it is now well understood that the compounding effects of untreated deterioration results in rapidly escalating costs over time.

The law demonstrates that quality design and construction, along with early intervention or preventative maintenance throughout an asset's life cycle, saves substantial money in the long-term. This law is illustrated in Figure 1.1 below. The graph illustrates the propagation of deterioration in a concrete structure over time until its repair, followed by the post-repair phase where the concrete repair and protection methods selected influence the rate of ongoing deterioration.

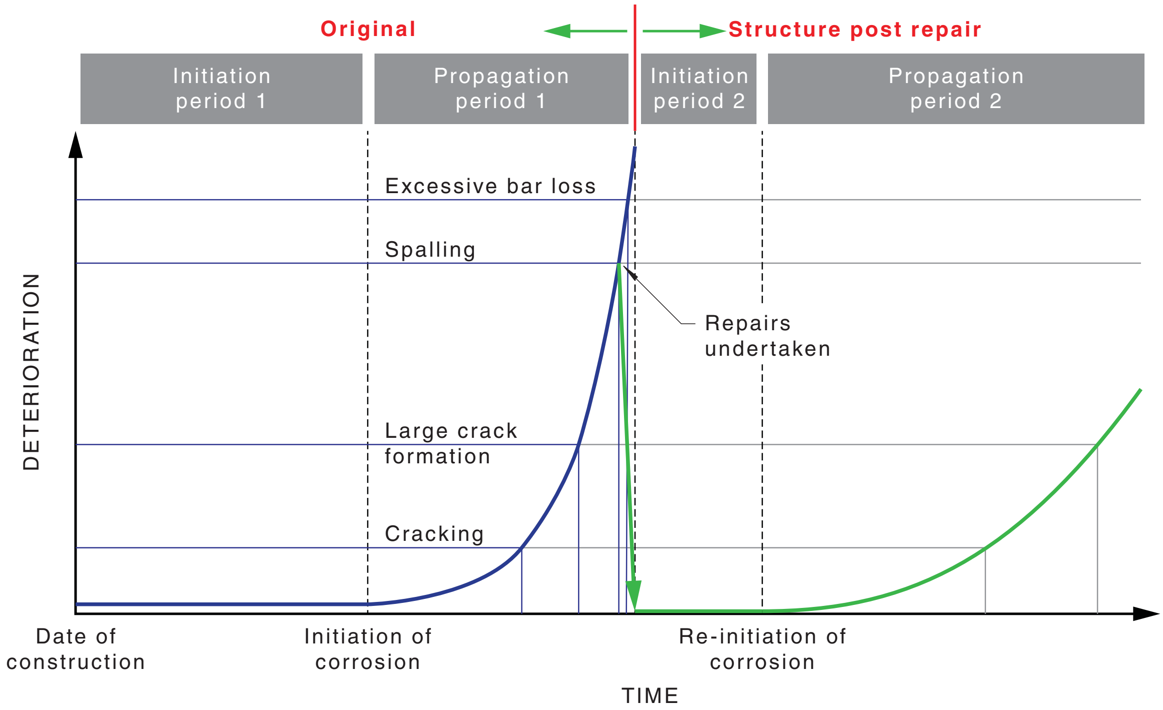

FIGURE 1.1 PROPAGATION GRAPH

1.2 MATERIAL PROPERTIES

1.2.1 Introduction

Concrete is a composite material. Its basic constituents are coarse aggregate, fine aggregate, cement (the binder) and water. The coarse aggregate fraction comprises the bulk of the mix, with the fine aggregate (typically <5 mm size) and cement paste filling the spaces between the particles.

Concrete derives its strength from the reaction between the binder (i.e. cement) and water. This reaction is referred to as ‘hydration’. The products of hydration progressively form a gel which surrounds and binds the aggregate particles together into a solid monolithic mass.

The binder system is, perhaps, the most important single constituent of concrete that determines durability and the nature of concrete deterioration. Both the chemistry of the binder system and its physical characteristics are important.

The most widely used binder system consists entirely of Portland cement and is generally referred to as Type GP cement. Blended cement systems have gained significant usage over recent years. The latter group of binders contains a proportion of Portland cement; the remainder being, for example, blast furnace slag, fly ash, silica fume or similar supplementary cementitious materials. The rapid growth in the usage of blended cements stems from the well-recognized durability characteristics they can offer under various conditions.

Table 1.1 shows the classification of binder systems as specified by AS 3972.

1.2.2 Concrete quality

The quality of concrete is generally related to its strength and permeability, which, in turn, are governed by the amount of water used in the mix.

The water/binder ratio together with the total binder content of the mix and the amount of curing given to the concrete, are the key factors controlling permeability and, hence, concrete durability.