Book review

Ageing of Composites

Rod Martin (ed.). Woodhead, Cambridge, 2008, ISBN 978 1 84569 352 7, £155, 544 pp.

Although composite materials are a growth area in construction, being increasingly seen in bridge and building applications for both strengthening/repair and new construction applications, their long-term behaviour is not well characterised. This is manifested in the very large partial factors in some applications to cover uncertainty with ageing (for example material factors of 4.5 at ULS and 2.5 at SLS in Highways Agency BD90/05 'Design of FRP Bridges and Highway Structures', with additional factors on top of these for variability arising from fabrication methods). BD90/05 states that 'these factors take into account effects such as creep, stress rupture, moisture uptake, temperature variation, and general degradation'. This book is squarely targeted at these (and similar) phenomena.

The book is a compendium of chapters, typically 20 or 30 pages per topic, with a worldwide roll-call of contributors (throughout Europe plus Canada, Korea, Taiwan and the USA).

It is predominantly concerned with fibre reinforced polymers, principally glass fibre reinforced materials. However, more exotic composites (not yet found in the construction industry) are also covered. For example, a chapter is dedicated to composites with silicon carbide reinforcement and either metal or ceramic matrix. The behaviour of this material is interesting from a scientific point of view, but will probably not yet be troubling any civil engineers. The material is claimed to be finding increasing acceptance in other industries, and it may be added to the civil engineer's armoury in due course.

Similarly, some other chapters are rather more scientific than of direct relevance to practising engineers – molecular diagrams are found throughout the first part of the book and both spectroscopy and gas chromatography results put in an appearance. A lot of this will be hard for civil engineers to apply directly, although it does build a picture of the breadth and depth of study that the book is trying to compress into one volume.

While the first half of the book (nine chapters) is dedicated to the science and especially to the modelling and prediction of ageing processes, the second half comprises reports of industrial applications. These chapters are probably of more interest (and certainly more directly applicable) to most civil engineers.

Even here, however, they are typically drawing on scientific work derived from the aerospace, chemical and petrochemical industries and will need extrapolation to apply to civil engineering. The chapter 'Ageing of

composites in the rail industry', for example, is confined to the application within rail vehicles. This particular chapter is predominantly concerned with train carriage body panels and structure, so the issues of environmental exposure while under structural loads can potentially be extrapolated (the train is exposed to substantially the same environment as the bridge that it passes over), but that extrapolation is necessary for the civil engineer to apply information from the book.

Critically to such extrapolations, the service lives for such applications are likely to be much lower than for bridge or building applications, and a figure of 50 years is occasionally referenced in the book as a long design life ('A design life of 10–50 years is required for important areas of application of reinforced polymers', 'the average lifetime of a composite pleasure boat is 30 years. This clearly indicates the excellent ageing performance of these materials' and 'Records of lifetime lengths of 50+ years have not been unique', all taken from different chapters). This is not a criticism of the book per se, but a function of the extent of real-world experience, since the materials have had commercial applications from around the 1950s. This constraint probably does not allow a work such as this book to challenge directly the inherently conservative approach of civil engineering design standards and guidance such as BD90/05.

Chapter 15 is 'Ageing of composites in the construction industry', and is written by S. Halliwell of NetComposites Ltd in the UK. These 20 pages clearly are of direct interest to the civil engineer, and within the constraints of the space available provide a brief summary of current construction industry applications, highlighting the particular ageing and deterioration issues of concern in civil engineering. The chapter highlights the issue of fundamentally different service life expectation for civil engineering structures compared to the applications in the rest of the book, but has little detail or guidance to resolve the issue.

Overall, this book is an interesting read about a complex field in which there is still a significant degree of uncertainty. Unfortunately, much of the scientific work reported is apparently predicated on the assumption that a service life of 50 years is outstanding, and having achieved that, no further work is required. The one chapter specific to the construction industry is limited by the space available to being little more than a slightly elaborated list of the issues of concern. As such, a civil engineer already active in the field will probably not find anything new in that chapter, and one that is not will probably not have the expertise to extrapolate much of use from the rest of the book. For most, it may well prove an interesting read (with a spirit of scientific enquiry), but this book is not a must-have or essential reference for the vast majority of civil engineers.

Ian Smith