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Design handbook for RC structures retrofitted with FRP and metal plates: beams and slabs

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PREFACE

Rehabilitating, strengthening, repairing, upgrading and retrofitting (herein collectively referred to as *retrofitting*) reinforced concrete beams and slabs by adhesively bonding or mechanically fastening plates to their surfaces is advancing very rapidly and has reached the stage where the serviceability and ultimate behaviours of plated beams or slabs are understood (Blashko et al 1998, Concrete Society Technical Report No. 55 2004, fib bulletin 14 2001, Teng et al 2002, ACI 440.2R-02 2002, Oehlers and Seracino 2004, CNR-DT 200/04 2005). This behaviour, which encompasses flexure, transverse shear, bond and ductility, is described in the following Handbook. It is described in generic terms and can be applied to all forms of plating. This document uses the output from research on steel and fibre-reinforced polymer (FRP) plated structures, but it applies to plates of any material encourage current and future developments in this rapidly advancing retrofitting technique.

This Handbook covers the retrofitting of both reinforced concrete beams and reinforced concrete slabs. It is the intention of the authors to eventually expand the document to include columns, joints and frames. The plating technique described can be applied to any type of plate (such as steel or FRP) and any cross-sectional shape of plate that can be attached to any surface of a reinforced concrete beam or slab at any inclination, such as longitudinal plates, transverse plates or inclined plates. These plates can be externally bonded to the concrete surface, near-surface mounted, in which a plate is adhesively bonded within a groove formed within or cut into the concrete cover, or bolted to the concrete surface. They can also be used in both reinforced concrete and prestressed concrete beams to increase the flexural capacity, the flexural ductility when the plate is applied to compression regions, the stirrup component of the transverse shear capacity and the concrete component of the transverse shear capacity.

Plated reinforced concrete structures are a relatively new and unique form of structure, which has similar failure mechanisms and behaviours as in both reinforced concrete structures and composite steel and concrete structures (Oehlers and Bradford 1995, 1999); however, plated structures also have many new failure mechanisms (Teng et al 2002, Oehlers and Seracino 2004) that are not covered in reinforced concrete and composite design manuals. As with all new forms of structures and because plating is a very efficient retrofitting technique, plating is being used in practice concurrently with the development of design rules. Hence, it is not possible at this stage of development of the technique to formulate prescriptive design rules that cover all situations. This should not hinder the application of plating but it does require a deep understanding of the behaviour of plated structures (Oehlers and Seracino 2004) to ensure a safe design. This in turn requires an understanding of the behaviour of both reinforced concrete structures and composite steel and concrete structures (Oehlers and Bradford 1995).

This Handbook consists of *Guidelines* and *Commentary* to *Guidelines*. The *Handbook* covers the generic and fundamental behaviour of both plated beams and plated slabs and it is these behaviours that have to be designed for. The more advanced design rules that quantify the fundamental behaviours in the *Handbook* are given in the *Commentary*. The *Commentary* is only meant to assist in the design and the designer is free to use any other approach that has been shown to be correct and safe and which satisfies the generic and fundamental principles outlined in the *Handbook*. It is recognised that design rules are improving and developing rapidly. In the long run, it is the intention of the authors to gradually transfer information from the *Commentary* to the *handbook* as design rules become established.

The Handbook includes a Commentary to the text (set in a box), the designation of which aligns with the clause numbering of the 'Handbook', is preceded by a 'C' and set in bold font. For ease of cross-referencing, additional subject headings in the Commentary are numbered in hierarchical order to follow initial numbering, preceded by a 'C' and set in light font.

In this document the term beam is used collectively to encompass all flexural members, both beams and slabs. The background and fundamental principles governing much of the *Handbook* is given in Oehlers and Bradford (1995 and 1999) and Oehlers and Seracino (2004).

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- Associate Prof Rudolf Seracino, Ph.D., M.A.Sc., B.A.Sc.
- Assistant Prof Scott Thomas Smith, Ph.D., B.E.

Prof Deric John Oehlers, D.Eng., Ph.D., M.Sc., B.Sc.
Chairman, Committee BD-101

The BD-101 Chairman also acknowledges the following International and Australian contributors:

Bank, Lawrence (University of Wisconsin, Madison, USA), Barros, Joaquim (University of Minho, Portugal), Chen, Jian-Fei (Edinburgh University, Scotland), De Lorenzis, Laura (University of Lecce, Italy), Hollaway, Len (University of Surrey, UK), Karbhari, Vistasp (University of California, San Diego, USA), Monti, Giorgio (University of Rome La Sapienza, Italy), Neale, Kenneth (University of Sherbrooke, Canada), Rizkalla, Sami (North Carolina State University, USA), Taljsten, Bjorn (Technical University of Denmark, Denmark), Teng, Jin-Guang (Hong Kong Polytechnic University, Hong Kong), Triantafillou, Thanasis (University of Patras, Greece) and Ueda, Tamon (Hokkaido University, Japan).

Al-Mahaidi, Riadh (Monash University), Beneke, David (Cardno Consulting Engineers (Sydney)), Boully, Geoff (VicRoads), Bradford, Mark (University of New South Wales), Foster, Stephen (University of New South Wales), Gilbert, Ian (University of New South Wales), Griffith, Michael (The University of Adelaide), Mohamed Ali, M. Sahib (The University of Adelaide), Molloy, Phillip (Department for Transport, Energy and Infrastructure, SA), Oehlers, Deric (The University of Adelaide), Paul, Alistair (Department for Transport, Energy and Infrastructure, SA), Prasad, Peter (Rail Infrastructure Corporation), Ronagh, Hamid (University of Queensland), Sarkady, Andrew (formerly Degussa (Australia) now BASF), Seracino, Rudolf (formerly with The University of Adelaide, now North Carolina State University, USA), Smith, Scott (formerly with University of Technology Sydney, now The University of Hong Kong, China), Van Erp, Gerard (University of Southern Queensland), Xia, Shaohua (formerly with The University of Adelaide, now TMK Consulting Engineers, Australia) and Zhao, Xiao-Ling (Monash University).

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