A Generic Segmental Analysis of all types of RC Members

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Contents

Abstract ii
Statement of Originality iii
List of Publications iv
Acknowledgements v
Introduction and General Overview 1
Chapter 1 – Background 3
Introduction 3
List of manuscripts 3
FRP reinforced concrete beams – a unified approach based on IC theory 4
Chapter 2 – Cross Sectional Analysis 32
Introduction 32
List of manuscripts 32
A mechanics solution for hinges in RC beams with multiple cracks 33
A Mechanics Based Hinge Analysis for Reinforced Concrete Columns 58
Using shear-friction to simulate concrete softening in reinforced concrete flexural members 78
The Reinforcement Contribution to the Cyclic Behaviour of Reinforced Concrete Beam Hinges 104
Chapter 3 – Member Analysis 134
Introduction 134
List of manuscripts 134
A moment-rotation approach for analysing the behaviour of RC columns 135
Partial-interaction time dependent behaviour of reinforced concrete beams 161
Partial-interaction short term serviceability deflection of FRP RC beams 191
The fundamental mechanisms that govern the flexural ductility of all RC members 230
Chapter 4 – Concluding Remarks 262

Abstract

This thesis contains a series of journal papers in which a new segmental moment-rotation (M/θ) approach is developed for both instantaneous and long term loading. The analysis technique is based on the starting position of moment-rotation rather than moment-curvature and the assumption that plane sections remain plane, but not on the often applied corollary of a linear strain profile. Using the well-established mechanics of partial-interaction theory, the M/θ approach simulates the formation and gradual widening of cracks as well as tension stiffening, as the reinforcement slips relative to the concrete which encases it, and, using the mechanics of shear-friction theory, the approach simulates the formation and failure of concrete softening wedges. Moreover, being mechanics based, the M/θ approach can in theory be applied to any type of member, that is any cross section, with any concrete properties, and any reinforcement type with any bond characteristic. Hence using partial-interaction and shear friction theories, the M/θ approach obviates the need for both empirically derived effective flexural rigidities and hinge lengths. This leads to the establishment of a new equivalent flexural rigidity that accounts for both concrete cracking and concrete softening and can be applied to both instantaneous and long term loading.

Having established the equivalent flexural rigidity from segments of a member, it can then be used to predict the effective flexural rigidity of an entire member, and hence the load deflection behaviour through the application of a numerical segmental analysis procedure. It is further shown that with simplifying assumptions closed form solutions to describe the equivalent flexural rigidity of a segment can be obtained and member deflections described using standard analysis techniques.

Having established that the M/θ technique can be applied using both numerical and closed form solutions, it is used to predict a broad range of reinforced concrete behaviours. These behaviours include: the instantaneous deflection of beams reinforced with both ductile steel and brittle fiber reinforced polymer bars and the instantaneous deflection of laterally and eccentrically loaded columns, including those in which second order effects are considerable and the long term deflection of simply supported beams. Through these broad applications, it is shown that the M/θ approach represents a mechanics based solution to reinforced concrete analysis, capable of accurately predicting both instantaneous and long term deflections from serviceability through to peak loading and collapse, where the only empirically derived requirements are material properties. Hence, the M/θ approach can be considered an extension of traditional analysis techniques in that it removes the need to empirically define effective flexural rigidities and hinge lengths to determine member behaviour.

Statement of Originality

This work contains no material which has been accepted for the award of any other degree or diploma in any university or any tertiary institution to Phillip Visintin and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Phillip Visintin Date

List of Publications

Oehlers, D.J., Mohamed Ali M.S., Haskett, M., Lucas, W., Muhamad, R., and Visintin, P., (2011) "FRP reinforced concrete beams – a unified approach based on IC theory". *ASCE Composites for Construction*, May/June, Vol. 15, No. 3, pp293-303.

Visintin, P., Oehlers, D.J., Wu, C., and Haskett, M., (2012) "A mechanics solution for hinges in RC beams with multiple cracks". *Engineering Structures*, Vol. 36, pp 61-69.

Visintin, P., Oehlers, D.J., Wu, C., and Haskett, M., (2012) "A Mechanics Based Hinge Analysis for Reinforced Concrete Columns". Submitted to *Journal of Structural Engineering*

Visintin, P. Oehlers, D.J., Wu, C. and Griffith, M.C., (2012) "The Reinforcement Contribution to the Cyclic Behaviour of Reinforced Concrete Beam Hinges". Accepted for publication in *Earthquake Engineering and Structural Dynamics*.

Haskett, M., Oehlers, D.J., Visintin, P., Ali Mohamed, M.S., (2012) "Using shear-friction properties to simulate concrete softening in reinforced concrete flexural members" Submitted to: *Cement and Concrete Research*

Visintin, P., Oehlers, D.J., Haskett, M., Wu, C and Chen JF., (2012) "A moment-rotation approach for analysing the behaviour of RC columns". Submitted to *Computers and Structures*.

Visintin, P, Oehlers, D.J., Haskett M., (2013) "Partial-interaction time dependent behaviour of reinforced concrete beams". Submitted to *Magazine of Concrete Research.*

Visintin, P., Oehlers, D.J. Muhamad, R. and Wu, C. (2012) "Partial-interaction short term serviceability deflection of FRP RC beams". Submitted to *Engineering Structures.*

Oehlers, D.J., Visintin, P., Haskett, M. and Sebastian, W., (2013) "The fundamental mechanisms that govern the flexural ductility of all RC members". Invited paper for *Construction and Building Materials.*

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