THE TENSION STIFFENING IN REINFORCED
CONCRETE BEAMS AND SLABS

By

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RAHIMAH MUHAMAD
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INTRODUCTION

In the design of reinforced concrete members, a well accepted full interaction moment curvature approach has been used for many years. This approach is only appropriate prior to cracking and once the cracks occur, it neglects the influence of slip between the concrete and the reinforcement. Hence, the partial interaction moment rotation approach, which takes into account the occurrence of these phenomena, has been used in this thesis. Subsequently, a new structural mechanics based partial interaction approach has been developed for quantifying the behaviour of flexural members under the effects of tension stiffening.

This thesis is a collection of manuscripts that are either submitted or accepted for publication in internationally recognised journals. The title of Chapters 1-3 reflects the overall research objectives and each chapter takes the following format: an introduction explaining the purposes of the chapter, a list of all the manuscripts presented in the chapter and finally the presentation of each manuscript.

Chapter 1 elaborates the limitations of the current moment curvature procedure and gives as a solution a newly developed approach that overcomes these limitations. This alternative solution has been discussed in broad terms, however, this thesis focuses exclusively on the tension stiffening mechanism of reinforced concrete beams and slabs using a partial interaction approach.

Chapter 2 discusses in detail the derivation of new generic structural mechanics solutions for quantifying the behaviour of a single and multiple cracks. In this chapter, the tension stiffening mechanism has been developed for quantifying the behaviour of cracks such as crack spacing, crack width and load to cause a crack. Later these models will be used in the next chapter for predicting the deflection of reinforced concrete beam and slabs.

Chapter 3 focuses on the application of the developed generic structural mechanics models for the discrete rotation deflection of reinforced concrete beams and slabs with steel bars. This generic model is further applied to simulating the deflection of reinforced concrete with FRP reinforcing bars as it is applicable for any type of material properties especially for different
ranges of reinforcement moduli, any shape of reinforcement and any type of bond stress slip characteristic.
LIST OF PUBLICATIONS

JOURNAL PAPERS

1. Our Obsession with Curvature in Reinforced Concrete Modelling
Oehlers, D.J, Haskett, M., Mohamed Ali M.S., Lucas, W., and Muhamad, R.

2. FRP Reinforced Concrete Beams – A Unified Approach Based On IC Theory
Oehlers, D.J., Mohamed Ali M.S., Haskett, M., Lucas, W., Muhamad, R., and Visintin, P.

3. Load-slip Relationship of Tension Reinforcement in Reinforced Concrete members
Muhamad, R., Mohamed Ali M.S., Oehlers, D.J., and Sheikh, A.H.

4. The Tension Stiffening Mechanism in Reinforced Concrete Prisms
Muhamad, R., Mohamed Ali M.S., Oehlers, D.J., and Griffith M.C
Advances in Structural Engineering 2011: submitted paper

5. Discrete rotation deflection of RC beams and slabs at serviceability
Muhamad, R., Oehlers, D.J., and Mohamed Ali M.S.
ICE Proceedings 2011: accepted paper

6. Simulating the deflection of RC flexural members with FRP reinforcing bars
Oehlers, D.J., Muhamad, R., and Mohamed Ali M.S.
ASCE Composites for Construction 2011: submitted paper
CONFERENCE PAPERS

1. *FRP Design using Structural Mechanics Models*

Oehlers, D.J., Haskett, M., Mohamed Ali, M.S., Lucas, W. and Muhamad, R.

*Keynote Paper, Proceeding CICE 2010 – The 5th International Conference on FRP Composites in Civil Engineering, Beijing, China, September 27th-29th*, pp. 37-44.

2. *Tension Stiffening Mechanism in Reinforced Concrete Structural Elements*

Mohamed Ali M.S., Muhamad, R., Oehlers, D.J., and Griffith M.C

*ICTACEM 2010 - The 5th International Conference on Theoretical, Applied, Computational and Experimental Mechanics, Kharagpur, India, December 27th-29th.*
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