A Generic Mechanics Approach for Predicting Shear Strength of Reinforced Concrete Beams

by

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ABSTRACT

This thesis includes a series of journal articles in which a mechanics based segmental approach is developed for simulating shear behaviour of reinforced concrete (RC) beams. Using the well-established theories of partial interaction and shear friction, the generic mechanics approach simulates the formation and widening of diagonal cracks and shear sliding failure for RC beams. Being mechanics based, the proposed approach can be generally applied to various kinds of structures, that is any cross section, with any type of concrete and reinforcement and with any bond properties. Moreover, no component of the proposed approach relies on empiricism to account for the mechanics of shear failure, and the approach can accommodate any material characteristics which with time can be refined and revisited to improve the accuracy of shear strength simulation.

In developing the mechanics of the segmental approach for prestressed RC beams, it is shown how the approach is applied to analyse shear behaviour and simulate shear failure of prestressed beams. Parametric studies are conducted to explain the effect of prestress on shear behaviour. For verification, the proposed approach is applied to 102 specimens and the analytical and experimental results are in good agreement.

The generic nature of the mechanics approach is shown by its application to steel and fibre-reinforced polymer (FRP) reinforced beams and one-way slabs without stirrups. From the mechanics of the segmental approach, closed form solutions are derived for shear design and validated by comparisons with test results and code predictions of 626 steel and 209 FRP reinforced specimens.

Having developed closed form solutions for beams without stirrup, the approach is extended to incorporate shear reinforcement. Significantly, the partial interaction analyses of longitudinal and transverse reinforcements are directly linked. Furthermore, simple solutions are derived through mechanics for tension stiffening and can be applied for shear and flexure analysis in the segmental approach. The numerical and closed form solutions are applied to 194 specimens and validated with good correlation of predicted and measured results.

The generic mechanics approach is further extended to accommodate the effect of axial load on shear strength. The proposed approaches are applied to 61 specimens and simulation results show good agreement with test data.

A series of push-off tests are conducted to investigate the shear friction parameters for initially uncracked concrete under low levels of confinement. In addition, it is shown that the concrete shear friction properties can be extracted from simple confined cylinder tests and then applied in the segmental approach to predict shear sliding capacity. Thus this research highlights the potential to reduce the significant cost of empiricisms in terms of time and money when developing innovative RC products and generic design guidelines.

The broad application of the mechanics based segmental approach presents a general solution to simulate shear strength of RC beams. Thus the generic mechanics approach is a good extension of traditional shear analysis techniques as it obviates the necessity of empiricisms through huge amount of testings to determine shear strength of RC members.

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LIST OF PUBLICATIONS

Journal Papers

Oehlers, D. J., Visintin, P., Zhang, T., Chen, Y., and Knight, D. (2012). “Flexural rigidity of reinforced concrete members using a deformation based analysis.” *Concrete in Australia*, 38(4), 50-56.

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Conference Paper

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