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Editorial

The previous editorial referred to the role and influence of shear on the flexural behaviour of RC beams, and the punching shear failures of slab-column connections. From a theoretical point of view, shear is always an integral component of flexural loading and bending behaviour. Many tests reported in published literature, as well as numerous structural failures in the field, confirm this without a shadow of doubt. Indeed, the major lesson to be learnt from all this evidence is that there is a sound and indisputable technical argument to develop an integrated approach for the design of flexural and shear behaviour of RC structural members. In practice, no RC structural member can escape from having to resist shear forces whether under static loading or under dynamic forces arising, for example, from seismic effects or storm surge. An integrated design approach is thus critical to RC beams for their long-term stability, safety and ductile service-life performance.

The problem of shear becomes much more critical when RC beams have to be strengthened for flexure and/or shear. Structural strengthening and retrofitting have now become a world-wide need. Plate Bonding Technology—the technique of bonding external reinforcement to the tension faces of the beams is now widely recognised as a cost-effective, structurally sound and practically efficient method of strengthening and rehabilitating deteriorated, damaged or otherwise structurally deficient RC beams. However, an increase in the flexural capacity of a RC beam automatically enhances the shear forces acting on the beam so that a beam strengthened for flexure, by bonding external reinforcement at the tension face, may not be safe in shear. There is now conclusive experimental evidence to emphasize that for RC beams weak in shear, the bonded external reinforcement will not enhance their shear load capacity when exposed to a predominantly shear loading regime, and the mode of failure will remain extremely brittle. These studies prove that there is a close, synergistic interaction between flexural strengthening and shear strengthening. Strengthening structures separately for flexure and for shear can then mask inherent structural weaknesses in ductility and shear, and can lead to premature failures of the strengthened beams. A holistic design approach integrating flexural and shear reinforcement will ensure structural integrity and adequate load capacity under both flexural and shear loading regimes to which a strengthened member could be exposed during its service life. Such an unified approach will clarify the intricacies and inter-relationships between flexural and shear behaviour.

There is now again overwhelming evidence that Truss Analogies can offer an effective way forward for a combined and holistic design for flexure and shear. The strut-and-tie model is a powerful tool in this respect, because it enables the engineer to understand the physics and mechanics of the structural system considered. Based on this strut-and-tie approach, it is possible to develop a unified analytical model to predict the failure loads of reinforced concrete beams strengthened with externally bonded reinforcement for flexural and/or shear. The uniqueness of the truss analogy is that it can be used in conjunction with the theory of plasticity to take into account the non-linear behaviour of materials and of the structural member. In addition, the model can be developed to incorporate the load transfer mechanism by bond to reflect the debonding phenomena and the associated cracking of concrete cover, both of which can have a dominant influence on the failure process of externally bonded plated beams. The great advantages of the strut-and-tie model are that it is based on sound engineering principles, and it can reflect the physical behaviour of the strengthened members. Further, the model is capable of describing all possible failure modes, and in particular, identity the weakest link in the resistance of the member. This model has been validated against a large number of beam tests strengthened for flexure and/or shear reported in the literature, involving a large number of structural variables, and steel, carbon and glass fibre reinforced polymer laminates as reinforcing medium. The results show that the model gives a consistently good correlation with test data, and that is represents a valid holistic design tool, integrating material characteristics with structural integrity and ductility.

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