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Flexural strengthening of concrete structures using prestressed fibre reinforced polymers

Fibre reinforced polymers (FRP) reinforcement has been used for flexural strengthening either as an externally bonded (EB) system in the form of FRP laminate (sheets, plates or strips) applied to the soffit tension side of the reinforced concrete (RC) members or as a near-surface mounted (NSM) system in the form of FRP strips or bars embedded inside a pre-cut groove into the concrete cover at the tension side of the RC member filled with epoxy adhesive. Although flexural strengthening using non-prestressed FRP reinforcement can remarkably increase the ultimate strength of a member, it does not significantly change the behaviour of the member under service loads or substantially increase the stiffness of the member. It should be noted that in non-prestressed FRP strengthening application only a portion of the strength of the FRP reinforcement is effective and the system is a passive strengthening technique that remains inactive until additional loads are applied. To achieve an increase in the stiffness of the member, the strengthening system must be active rather than passive. Thus, to improve the efficiency of the system, the FRP reinforcement should be prestressed before being bonded to the concrete. Therefore, by prestressing the FRP, the material is used more efficiently because a greater portion of its tensile capacity is employed, and it contributes to the load-bearing capacity under both service and ultimate conditions. Prestressing the EB and NSM FRP reinforcement requires a special anchorage system that should be practical in implementation. In general, prestressing is used to enhance the flexural behaviour of reinforced concrete members under service loads especially in bridges and (or) beams that have large spans and there is a limitation on the deflection and serviceability conditions. Because of their high tensile strength properties, FRP materials have great advantages for use in prestressing and post-tensioning strengthening applications. The specialized application of prestressing the FRP reinforcement for flexural strengthening of structures combines the noncorrosive and lightweight benefits of the FRP reinforcement with the advantages associated with external prestressing. However, the challenging part of the active FRP strengthening system is the application of the prestressing force to the FRP material using appropriate practical anchorage and prestressing system. A comprehensive review on the techniques and anchorage systems developed to prestress the EB and NSM FRP with the focus on the practicality of the prestressing systems where the FRP is prestressed against the member itself, and the performance of members strengthened using prestressed FRP reinforcement are discussed in this presentation.

Speaker Biography

Raafat El-Hacha is a Professor of Structural Engineering at the University of Calgary in the Department of Civil Engineering. His pioneer research has been recognized as pushing the boundary of knowledge in using innovative and smart advanced materials for strengthening existing structures and for new construction, such as fibre reinforced polymers (FRP), shape memory alloy, and ultra-high performance concrete for hybrid structural systems in bridge applications and other structures. He published over 220 journal and conference papers, co-authored 3 refereed design guidelines. Supervised and graduated 42 PhD and MSc students. Served as guest editor for 3 journals and edited/co-edited 8 conference proceedings. He is a Fellow of the International Institute for FRP in Construction (IIFC) and the Canadian Society of Civil Engineers (CSCE). He is the recipient of several awards and fellowships including the CSCE Casimir Gzowski Gold Medal, CSCE Excellence in Innovation in Civil Engineering Award, IIFC President's Award, Killam Professorship Award, Erasmus Mundus International Fellowship (twice) and many others for his outstanding academic and professional achievements.

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