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PRESTRESSED POLYMERIC COMPOSITES: AN ALTERNATIVE APPROACH

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Summary: Although prestressed concrete is an established structural material, interest in the use of prestress within polymeric matrix composites, to improve mechanical properties, is comparatively recent. Elastically prestressed polymeric matrix composites (EPPMCs) exploit prestressed concrete principles, in that fibres within the composite are stretched to maintain an elastic strain during matrix curing. On matrix solidification, compressive stresses are produced within the matrix, which are counterbalanced by residual fibre tension. Research with unidirectional glass fibre EPPMCs has shown increases in impact resistance, strength and stiffness of 25–50% compared with control (unstressed) counterparts. Although such improvements can be achieved without increasing section dimensions or weight, the need to apply fibre tension during matrix curing can impose limitations on processing and product geometry. Also, as the matrix is polymeric, fibre-matrix interfacial creep may cause the prestress to deteriorate. An alternative approach is to consider viscoelastically prestressed polymeric matrix composites (VPPMCs): here, polymeric fibres are subjected to tensile creep, the applied load being removed before the fibres are moulded within a matrix. Following matrix curing, the strained fibres impart compressive stresses (through viscoelastic recovery) to the surrounding matrix. Since fibre stretching and moulding operations are separate, VPPMC production offers great flexibility; also, any potential for deterioration through fibre-matrix creep would be offset by active responses from longer term viscoelastic recovery mechanisms. Research has shown that VPPMCs can be produced from fibre reinforcements such as nylon 6,6, UHMWPE and bamboo. Compared with control (unstressed) counterparts, these VPPMCs have shown improvements in mechanical properties comparable to those from EPPMCs. Of major importance however, is longevity: accelerated ageing techniques have demonstrated that VPPMCs (based on nylon fibre) show no deterioration in impact performance over a duration equivalent to ~25 years at 50°C ambient. Potential applications include crashworthy and impact-resistant structures, dental materials, prestressed precast concrete and shape-changing (morphing) structures.