

## **Development of a Triple-Scale Analysis Method for Plain-Woven Laminates Based on a Homogenization Theory for Time-Dependent Composites**

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In this study, a triple-scale elastic-viscoplastic analysis method for plain-woven laminates is newly developed based on a homogenization theory for time-dependent composites. For this, triple-scale modeling of plain-woven laminates is performed by considering a plain-woven laminate as a macro structure, plain fabrics and a matrix in the laminate as a meso structure, and fibers and a matrix in the plain fabrics as a micro structure. Then, the boundary value problems for macro/meso and meso/micro scales are derived based on the homogenization theory for time-dependent composites, and the relationship between these problems are discussed. Using the relationship, a triple-scale elastic-viscoplastic analysis method for plain-woven laminates and its computational procedure are developed. It is shown that the present method is successful in taking into account the effects of elastoviscoplasticity of a epoxy matrix in plain fabrics on the elastic-viscoplastic behavior of plain-woven GFRP laminates.

**Keywords:** Plain-woven laminate, Triple-scale analysis, Homogenization, Viscoplasticity