LOCAL STRAIN VARIATION IN THE PLIES OF A SATIN WEAVE COMPOSITE: EXPERIMENTAL Vs. NUMERICAL

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ABSTRACT

Along with the advantages of multi directional load carrying capabilities, the complicated interlacing pattern of the yarns in a textile composite produce large stress – strain gradients. The stress-strain behavior in a textile composite is influenced by: a) stacking sequence; b) number of plies in the laminate; c) distance of the ply to the surface [1]. From the numerical perspective, the investigation of the free edge and free surface effects in a textile composite unit cell [2] reveals that the local stress behavior changes considerably depending upon the finite/ infinite conditions used for the unit cell FE analysis. In the above context, to capture the variation in local parameters such as strain and damage profiles at different locations (inside/surface) of the satin weave composite under the tensile load, experimental techniques such as strain mapping, Fibre Brag Grating sensors (FBG’s) and the microscopic analysis is used. For the numerical validation, different unit cell stacking models with appropriate boundary conditions are used for the FE analysis. Comparison of the numerical and experimental results (Table 1) provides valuable information regarding the local strain variation (from edge to the centre) in a satin weave composite (Figure 1). In the similar guide lines, local damage variation is also studied using different unit cell stacks.

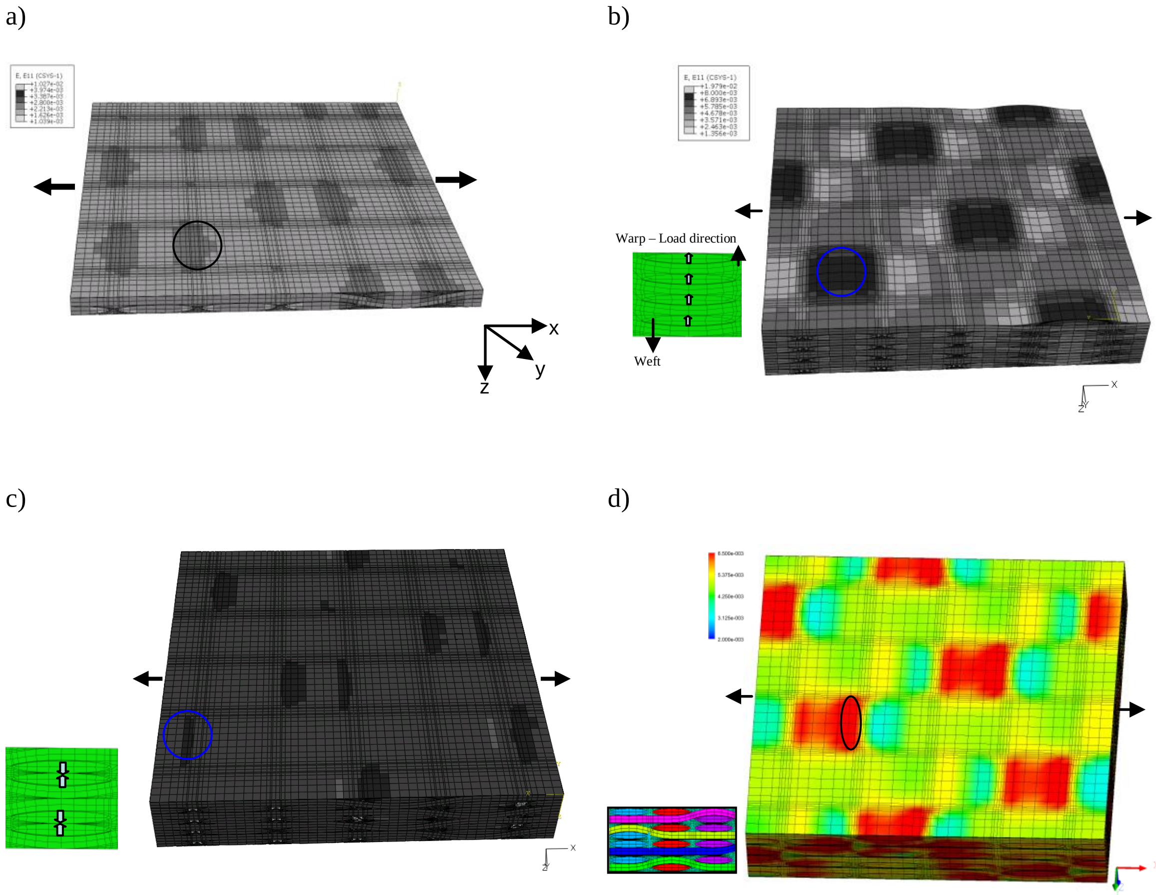

Figure1. **Variation in local strain locations on the weft yarn (infinite/ finite laminate FE analysis): a) Single unit cell with 3D PBC (Periodic boundary conditions); b) In-phase stacking of 4 unit cells with 2D PBC; c) out-of-phase stacking of 4unit cells with 2D PBC; d) Step stacking of 4unit cells with 2D PBC.**

Table 1. **Comparison of the local strain values: Experiment versus FE simulations.**

	Inside the laminate		*Laminate surface*	
	Max,%	*Min,%*	*Max,%*	*Min,%*
FBG's –strain inside the laminate - <0.2%>	*0.25*	*0.16*	*-NA-*	*-NA-*
Single unit cell -3D PBC <0.2%>	*0.27*	*0.17*	*-NA-*	*-NA-*
LIMESS (DIC) – Surface strain<0.5%>	*-NA-*	*-NA-*	*0.58-0.62*	*0.43-0.46*
4 Unit cells – out-of-phase stacking <0.5%>	*-NA-*	*-NA-*	*0.65*	*0.44*
4 Unit cells – step stacking <0.5%>	*-NA-*	*-NA-*	*0.65-0.69*	*0.32-0.44*
4 Unit cells – in-phase stacking <0.5%>	*-NA-*	*-NA-*	*0.73*	*0.35*

[1]. Ivanov, D.S., et al., *Stress distribution in outer and inner plies of textile laminates and novel boundary conditions for unit cell analysis.* Composites Part A: Applied Science and Manufacturing. **In Press, Accepted Manuscript**.

[2]. Owens, B.C., J.D. Whitcomb, and J. Varghese, *Effect of Finite Thickness and Free Edges on Stresses in Plain Weave Composites*. Journal of composite materials 2009. p. 0021998309347571.