Critical failure was observed in the shear web of a wind turbine blade during a full-scale testing. This failure occurred immediately before the ultimate failure and was partly caused by buckling and non-linear cross-sectional strain. Experimental values had been used to compare and validate both numerical and semi-analytical results in the analysis of the shear webs in the reinforced wind turbine blade. Only elastic material behaviour was analysed, and attention was primarily focused on the Brazier effect. The complex, geometrically non-linear and elastic stress–strain behaviour of the shear webs and the cap in compression were analysed using a balance of experimental, numerical and analytical approaches. It was noted that the non-linear distortion was caused by the crushing pressure derived from the Brazier effect. This Brazier pressure may have a significant impact on the design of new blades, and an optimized box girder had been studied to show the importance of including Brazier pressure in the design process for future wind turbine blades.