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# COMPRESSIVE FAILURE BEHAVIOR OF UNIDIRECTIONAL GFRP COMPOSITE UNDER THE INFLUENCE OF IN-PLANE FIBER WAVINESS

**N. Swaroop[1,2], C.Y. Yue[2(*)], A. Dasari[3]**

[1]ERI@N/Interdisciplinary Graduate School, Nanyang Technological University, Singapore
[2]School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore
[3]School of Material Science and Engineering, Nanyang Technological University, Singapore
[(*)] *Email:* mcyyue@ntu.edu.sg

## ABSTRACT

The study focuses on the failure modes and failure behavior of unidirectional glass fiber reinforced polymer (GFRP) composites under the influence of an intentionally induced uniform in-plane fiber waviness throughout the thickness of the laminate. A uniform single sinusoidal fiber waviness with different level of wave severity ($W_s$) values were considered for the coupon level experimental study. Based on ASTM D6641, a compression experiment was conducted on a set of specimens with and without fiber waviness defects. Comparison studies with non-defected specimens showed that along with a drastic reduction in compressive strength a transition in failure behavior and failure modes were observed with increase in fiber wave severity.

***Keywords:*** GFRP, fiber waviness, compressive strength, wind turbine blade.

## INTRODUCTION

The future of power generation more relies on renewable energy resources for a friendly environment and clean energy. Wind power industry is one among them with a promising contribution of 10% to 20% towards the future global energy consumption. The manufacturing defects found in the wind turbine blades were unavoidable and the increasing size of the turbine makes those defects more critical towards the life expectancy of the whole turbine unit. Fiber waviness is one of the common manufacturing defect found in the sparcap of composite wind blades. Sparcap is the back bone of the wind turbine blades which is made up of unidirectional fiber reinforced composites.

The term fiber wave severity (Ws) is a measure of intensity of the defect introduced by (Adams and Hyer 1993) and it is the ratio of the fiber wave amplitude and the wave length. Four sets of fiber wave severity were prepared by varying the wave amplitude value with a constrained wavelength due to standard specimen size. A static compressive experiment was done using Zwich Hydraulic Composite Compression Fixture (HCCF). As per previous study, more reduction in compressive strength was observed with 0º ply having fiber waviness (Mandell, Samborsky et al. 2003). As for the compression failure mechanism, (Pinho, Iannucci et al. 2006), fiber failure reportedly occurred due to the small misalignment of the fibers which lead to kink-band formation during the matrix failure. Hence, fiber waviness assisted the fiber failure mechanism which led to a visible kink band formation at a lower load range compared to an original specimen without any defect.

## RESULTS AND CONCLUSIONS

Fig.1 shows the reduction in compressive strength with increase in fiber wave severity ($W_s$) and a failed specimen with an average fiber wave severity 0.025. The kink band formed was clearly visible to the naked eye.

There was a transition in the failure mechanism at the 0.01 wave severity range where both crushing and kink band formation failure were observed.

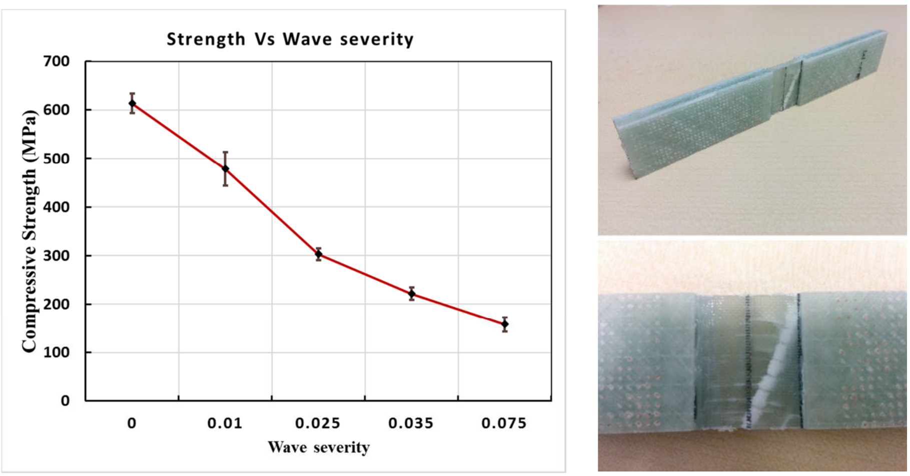


Fig. 1 - Compressive test results and the failed specimen

The study shows that through thickness in-plane fiber waviness had an adverse effect on the compressive behavior of the unidirectional composite. Further investigations are being conducted on the effect of fiber waviness on other mechanical properties of the composites including fracture toughness and the flexural properties.

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