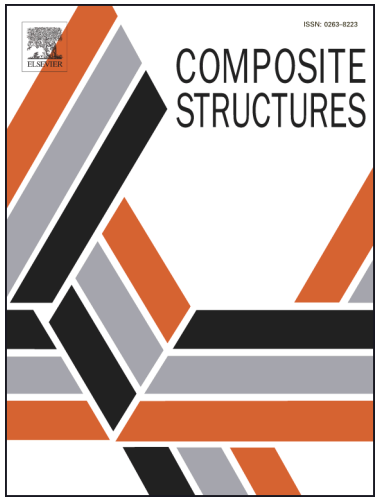


# Evaluation on material behaviors of pultruded glass fiber reinforced polymer (GFRP) laminates

Haohui Xin, Yuqing Liu, Ayman S. Mosallam, Jun He, Ao Du

PII: S0263-8223(17)31977-3
DOI: http://dx.doi.org/10.1016/j.compstruct.2017.09.006
Reference: COST 8869

To appear in: *Composite Structures*

Received Date: 28 June 2017
Revised Date: 21 August 2017
Accepted Date: 12 September 2017

Please cite this article as: Xin, H., Liu, Y., Mosallam, A.S., He, J., Du, A., Evaluation on material behaviors of pultruded glass fiber reinforced polymer (GFRP) laminates, *Composite Structures* (2017), doi: http://dx.doi.org/10.1016/j.compstruct.2017.09.006

# EVALUATION ON MATERIAL BEHAVIORS OF PULTRUDED GLASS FIBER REINFORCED POLYMER (GFRP) LAMINATES

**Haohui Xin[a], Yuqing Liu[a,*], Ayman S. Mosallam[b], Jun He[c], Ao Du[d]**

[a] Department of Bridge Engineering, Tongji University, Shanghai, China

[b] Department of Civil and Environment Engineering, University of California, Irvine, California, USA

[c] School of Civil Engineering and Architecture, Changsha University of Science & Technology, Hunan, China

[d] Department of Civil and Environment Engineering, Rice University, TX, USA

* *Corresponding author. Tel.: +86 21 65983116; fax: +86 21 65983450*

E-mail: yql@tongji.edu.cn

**Abstract:** In order to extend the use of pultruded glass fiber reinforced polymer (GFRP) composite materials in civil engineering, a systematic study on pultruded GFRP laminate is important and realistic for the design and construction of GFRP structures in bridge engineering. A practical method to evaluate the fiber volume fractions and the equivalent thickness of each lamina is proposed considering that a typical pultruded FRP profile is not truly laminated structure in rigorous sense. The elastic modulus and ultimate strength of each lamina were predicted based on micromechanics. In terms of that the facts that lack of knowledge of the majority of bridge engineers on the behavior of composites, an innovative carpet plots with different fiber volume fraction are adopted to finish the laminate design procedure without much complicated calculation. In addition, a continuum damage model considering lamina shear nonlinearity, lamina damage along thickness direction, innovative damage evaluation methods, loading/unloading strategy and viscous methods to alleviate the convergence difficulties is proposed and implemented via user material subroutine. Three different types of pultruded GFRP laminate were fabricated, and material properties have been tested to validate the numerical and theoretical models. The Finite element simulation results agreed well with tests and could provide reference for the design and construction of GFRP structures.

**Keywords:** Glass fiber reinforced polymers (GFRP); Laminates; Finite element analysis; Pultrusion