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Mechanical Properties of Pultruded GFRP WF, Channel and Angle Profiles for Limit State/Permissible Stress Design

by

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Abstract

Coupon test data from five pultruded GFRP profiles is used to generate longitudinal/transverse, tensile/compressive ultimate stresses, elastic moduli, minor/major Poisson's ratios and ultimate strains (some of which are not in the pultruders' design manuals). Characteristic ultimate stresses/elastic moduli are compared to design manual minimum values. The former depend on profile size/shape, whereas the latter are shape-/size-independent. Limit state design stresses are shown to be larger than permissible stress design stresses. However, most of the limit state longitudinal design elastic moduli are smaller and all of the transverse design elastic moduli are larger than the permissible stress values.

Keywords: A. Polymer-matrix composites (PMCs); B. Mechanical properties; D. Mechanical testing; E. Pultrusion

1. Introduction

Pultruded GFRP *structural grade* profiles have been used for many years in a wide variety of secondary structures such as staircases, walkways and raised platforms. Their use in these and other applications continues to grow as awareness of their potential amongst the structural engineering community increases.

In order to promote the use of their GFRP profiles and assist structural engineers engaged in the design of GFRP structures, several pultruders began to publish *design manuals* about 40 years ago. During the intervening years they have continued to update the manuals and have made them accessible online [1 – 3]. In 1996 these manuals were supplemented with the *EUROCOMP Design Code and Handbook* [4], which was the first *limit state* design guidance for Fibre-Reinforced Polymer (FRP) composite materials/structures used in infrastructure. More recently, limit state design guides have been published in Europe and Japan (see for example, [5 – 8]). Perhaps the most up-to-date design guides for FRP composite structures are those published under the auspices of the ASCE [9] and the EU's CEN Technical Committee 250 [10].

The aforementioned pultruders' manuals and design guides provide useful and reasonably comprehensive information for the design of pultruded GFRP structures. In the pultruders' manuals there is a particular focus on the ultimate stress and elastic modulus properties of their standard structural profiles, whereas in the design guides the focus is on how ultimate stress and elastic modulus data are used in the design of FRP components and structures so that they comply with the specified serviceability and ultimate limit state criteria. However, it is important to appreciate that the basic mechanical properties (ultimate stress, elastic modulus etc.) of the GFRP standard structural profiles, given in the pultruders' manuals, are described as *typical* or *minimum* values of these properties and, therefore, are not applicable to limit state design, even though they were established by tests carried out in accordance with early versions of the relevant ASTM standards. They are, however, frequently used in *permissible stress* design in conjunction with relatively large factors of safety. Because the pultruders have not disclosed full details of the mechanical properties of the pultruded GFRP standard structural profiles their typical/minimum status remains to be independently and rigorously verified.

In the light of the foregoing comments and the fact that the pultruders manufacture standard structural profiles which are deemed to comply with the E17 and E23 requirements, i.e. have flexural elastic moduli of 17 and 23GPa, given in [11], it would be useful to undertake (independent of the pultruders) more comprehensive mechanical testing of pultruded GFRP standard structural profiles to verify the status of the minimum properties, particularly ultimate stress and elastic modulus, and obtain characteristic values which may be used in limit state design.