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Effects of various temperatures on the mechanical strength of GFRP box profiles

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HIGHLIGHTS

- The behavior of GFRP profiles was investigated at plus and minus degrees.
- The losses of strength for GFRP profiles were determined.
- Samples were tested with tensile and compressive tests in 13 different temperatures.
- GFRP profiles lose approximately half of tensile strength at 200 °C.

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ABSTRACT

Nowadays, Fiber Reinforced Profiles (FRP) are utilized as different sections in applications such as lightweight structures, pedestrian or vehicular bridges, towers, and ground reinforcement elements. Some of the advantages of FRP profiles are light weight, high tensile strength, corrosion resistance and performance against water and moisture. Glass Fiber Reinforced Profiles (GFRP) are preferred among FRP profiles due to economic reasons. In buildings where these materials are used at high temperatures such as fire or under the influence of freezing during the winter months, the loss of strength should be known.

In this study, tensile and compressive samples from GFRP box profiles measuring 74 × 74 × 4 mm produced with the pultrusion method were tested at different temperatures. Samples were tested with tensile and compressive tests at 13 different temperatures: −50, −25, −10, 0, +10, +25, +50, +75, +100, +125, +150, +175, +200 in severe cold and high temperatures under the influence of both tensile and compressive stress and losses of strength for GFRP profiles were determined.

1. Introduction

With the development of material technologies, new materials are used in many fields within the construction sector. FRPs are among these new materials. They are manufactured as fabric or profile and are widely used within the construction sector. As for the strengthening of structural elements which are part of the fabric, columns or beams are used. One of the primary uses of FRP composites in the construction sector is the strengthening of bar and beam elements and the wrapping of columns for the improvement of seismic resistance. They also have a very wide application area on walls, beams, slabs, and composite deck bridges, where strengthening of FRP composites is used in conjunction with traditional building materials formed from hybrid designs with composite profiles [1,2]. Among FRP materials, GFRP profiles are preferred more than other fiber types because they have many advantages such as corrosion resistance, light weight, high tensile strength, sealing against water and moisture, electrical and thermal conductivity, and not producing a magnetic field [3–6]. It is possible to see GFRP profiles with different section characteristics in many applications.

The building named Eyecatcher has five floors and was built in Basel in 1998 as a framework system using GFRP profiles (Fig. 1). High buildings can be constructed using GFRP profiles. The carrying systems in two-floor buildings constructed in Turkey are GFRP box profiles. Also, there is a greenhouse constructed using GFRP profiles in Turkey within the scope of a national project [7] (Fig. 1).

As the utilization of GRFP profiles increases, their behavior under the impact of different temperatures and fire should be known. So this issue is of great interest to researchers who conduct studies into the behavior of these profiles under the impact of temperature. Asaro et al. [8] studied the time-dependent performance of GFRP panels under the impact of fire and determined the temperature values of FRP panels' different points. Some researchers have studied fire protection systems in building upholstery constructed by pultruted GFRP, using experimental [9] and

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Fig. 1. GFRP structures.

thermo-mechanical reaction models [10]. Chowdhury et al. [11] studied the structural impact model of GFRP rectangle columns during fire and temperature transfer. Wong et al. studied the behavior of GFRP short columns at high temperatures in experimental and numerical models [12]. Davie et al. [13] studied polymer composite structural elements and numerical elements of compound performance subjected to various temperatures. Wong and Wang [14] have experimentally studied the twisting behavior of pultruted GFRP profile columns under high temperatures and the impact of compressive strength. Bai et al. have tried to model the thermal reaction [15] and rigidness [16] of GFRP composites under high temperatures. Correia et al. [17] have studied experimental and model evaluations of the mechanical behavior of pultruded GFRP composites under high temperatures. Correia et al. [18] have made a general evaluation of the fire impacted behavior of GFRP structural elements used in the field of civil engineering. They have compared and interpreted the conclusions reached by researchers on this issue. Russo et al. [19] stated that a compressive force is established with a scenario in which the behavior of circular FRP material at temperatures under the influence of the experimental and the finite element model was established.

Studies in the literature have focused on the behavior of GFRP profiles in different sections under high temperatures or the impact of tensile or compressive stress only. In this study, the tensile force of GFRP compressive stress on both box profile plus and minus degrees under the influence of the behavior of GFRP profiles was investigated. The behavior under compressive and tensile stresses in the GFRP profile at subfreezing temperatures and resistance losses has been identified.

2. Experimental studies

Experimental studies have determined the behavior of GFRP box profiles at different temperatures under the tensile and compression impact. 25 °C room temperature was the reference in tensile and compression tests and samples prepared at 13 different temperatures below and above 25 °C were tested. Strength and mass losses were determined on the tensile and compression force of GFRP profiles at low and high temperatures and the results were compared with similar studies in the literature.

2.1. Material properties

The physical characteristics of the glass fiber and matrix material that are the components of GFRP box profiles used in the tests are given in Tables 1–3.

2.2. Method

A total of 130 samples, 10 for each temperature, were prepared in order to determine the tensile strength losses of GFRP profiles at different temperatures and tested according to ASTM and TSE [20–22]. For this purpose, tensile test samples measuring