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New Anchorage Technique for GFRP Flexural Strengthening of Concrete Beams Using Bolts-End Anchoring System

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Abstract

The concept of external glass FRP composite confinement is a current process for strengthening concrete beams subjected to static loads. End anchorage glass FRP composites of 80 mm width and 90–130 mm length with different thicknesses (2.4 and 4.8 mm) have been fixed at the bottom of beams with bolts of various diameters (6 and 10 mm). For this purpose, the behavior of beams strengthened with bolt-end anchoring glass fiber polymer composites (BEGFPC) has been analyzed. It is concluded that the load capacity of the BEGFPC beams is improved by increasing the end-anchorage glass FRP composite thickness (about 98–188%). In addition, the BEGFPC system with bolts of 6 mm diameter has significantly improved the flexibility of beams. In contrast, the 10 mm bolts in diameter give a high ultimate load, whatever their quantity. Therefore, combining bolts with diameters of 6 and 10 mm would be the best solution for increasing the ultimate load and ductility of the retrofitted beams. Depending on the number and bolts' arrangement, there is also an enhancement in the crack patterns by changing from intermediate flexural failure to shear failure in beams.

Keywords Tension zone, Bolts-end anchoring, Glass FRP, Bolts, Crack patterns, Failure modes

1 Introduction

Strengthening and rehabilitating degraded concrete structures by external bonding is a fruitful technique. Steel plates are popular due to their high strength, flexibility, and homogenous characteristics (Alasadi et al., 2019). However, steel plates corrode and lose thickness if exposed to open environments. Significantly, the influence of corrosion is limited by covering the concrete parts with anti-corrosive compounds, such as carbon fiber reinforced polymer (CFRP), glass FRP, aramid FRP, and basalt FRP (Al-Hamrani & Alnahhal, 2019; Norooz Olyaee & Mostofinejad, 2019; Yahiaoui et al., 2022). These FRPs are available in rebar, laminate, or sheet form. More importantly, the FRPs are lightweight, strong, and more cost-effective components to manufacture than metal plates. Therefore, the external FRPs bonding process has been widely used to strengthen concrete beams, because it makes the material more ductile (El Ghadioui et al., 2022; Pavithra et al., 2022). Prior studies reported that the FRP composites remained elastic until brittle debonding or FRP failure occurred (Salama et al., 2019; Zhou et al., 2018).

The effects of fiber direction and reinforcement ratio of glass fiber reinforced polymer (GFRP) sheets have been analyzed to examine the behavior of concrete beams. It is reported that the GFRP sheets strengthen the beam and improve the flexural deflection of the

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