UNIVERSITI TEKNOLOGI MARA

PREDICTION OF SHEAR CAPACITY OF CONCRETE BEAMS REINFORCED WITH GLASS FIBRE REINFORCED POLYMER (GFRP) BARS

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ABSTRACT

Steel reinforcement bars are one of the most common reinforcement materials used in concrete structures for many decades due to their high tensile strength and modulus of elasticity. Moreover, its ability to withstand stress when subjected to high tensile loads leads to its high demand in the construction industry. However, the service life of steel reinforcement bars is often shortened due to corrosion especially when they are exposed to aggressive environmental conditions. Hence, the use of noncorrosive material such as Fibre Reinforced Polymer (FRP) as an alternative to reinforcement materials is recommended in this study. Compared to steel reinforcement, FRP reinforcement also offers excellent performance in terms of tensile strength and weight. Among the many types of FRP available, Glass Fibre Reinforced Polymer (GFRP) appears to be the most affordable compared to other types of FRP reinforcement such as Carbon Fibre Reinforced Polymer (CFRP) and Aramid Fibre Reinforced Polymer (AFRP). However, there is still a lack of information on the shear behaviour of concrete beams reinforced with GFRP bars. Furthermore, shear failure is more dangerous as it can occur abruptly without any warning. It has been reported that beams reinforced with longitudinal GFRP bars experienced lower shear strength compared to concrete beams reinforced with the same areas of longitudinal steel bars due to the low modulus elasticity of FRP bars. In addition, limited studies had reported the contribution of shear reinforcement in preventing sudden shear failure of concrete beams reinforced with GFRP bars. Thus, in this study, the investigation on the shear behaviour of concrete beams reinforced with GFRP bars was carried out. The study comprised of experimental and analytical investigation and numerical modelling. Eight concrete beams reinforced with steel bars (control beam) and sixteen beams reinforced with GFRP bars were tested. Three major variables namely tensile reinforcement ratio, shear span ratio and stirrup spacing were investigated. Analytical analysis using the ATENA software was used to simulate and analyse the response of the tested beams. The experimental results were also used to develop the shear strength design equation, V_c for concrete beams reinforced with GFRP bars. The results of this study showed that beams reinforced with GFRP bars which contained steel stirrups resulted in a higher shear load capacity and less brittle failure. Increasing the reinforcement ratio up to 0.8% in combination with closer stirrup spacing of 50 mm within a shear span ratio of less than 2.5 significantly increased the ultimate shear load of the beam up to 35%. In addition, higher tensile strain was clearly detected at the support of the beams reinforced with GFRP bars compared to the beams reinforced with steel bars. Based on numerical analysis results, reasonable accuracy in terms of ultimate shear load, load-deflection relationship, strain and crack patterns was obtained. Additionally, the new shear strength equations predicted the shear capacity of the beams reinforced with GFRP bars well. The mean ratio, standard deviation and coefficient of variation for the proposed equation were 1.13, 0.19 and 17% respectively.

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