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Serviceability and shear response of RC beams prestressed with a various types of FRP bars

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Abstract

The present study focuses on crack width prediction and shear response analysis of prestressed concrete (PC) beams with certain type of fiber-reinforced polymers (FRP) to be used. Recommendations are introduced taking into account the degree of bond between FRP bar and concrete interface considering a new type of FRP such as basalt FRP as well as glass FRP bars. Experimental program is presented in order to verify regulation formulae addressed for traditional steel applications. Further, a certain shear design model is proposed for PC beams consuming longitudinal basalt or carbon FRP concluding with a very accurate results.

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Keywords: basalt, glass fiber, width of crack, prestress, shear response.

1. Introduction

The research community has made a great progress quantifying the characteristics of composite materials used in infrastructure applications [1–5]. In comparison with conventional reinforcement fibre – reinforced polymers (FRP) do not corrode, have high strength–to–weight ratios, good fatigue properties, exhibit low relaxation losses and thus they might be used in lieu of steel, respectively. Taking into accounts said above, it delivers for a globe engineering infrastructure new and innovative design options and great potential benefits such as reduced maintenance and life cycle costs of the structures. FRP bars have smaller modulus of elasticity compared to that of steel and this makes RC

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members with FRPs more vulnerable to excessive deflection and wide cracks when the members are non–prestressed. The high strength of FRP can be more efficiently utilized when the FRP is employed as prestressing reinforcement [6-8].

Nomenclature

A	area of concrete symmetric with reinforcing bars/tendons divided by number of bars/tendons
a	shear span
a_f	force arm for pure bending scheme test
b	width of rectangular beam
b_w	width of the web
c	nominal concrete cover to the longitudinal reinforcement
d	effective depth
d_c	thickness of cover from the extreme tension face to centre of closest bar/tendon
E_f	modulus of elasticity of flexural reinforcement
E_s	modulus of elasticity of steel reinforcement
f_c	compressive strength of concrete
f_{ct}	tensile strength of concrete
f_f	stress in the FRP reinforcement
f_{fu}	tensile strength of FRP reinforcement
h	height of the beam
k_2	coefficient that accounts for strain distribution
k_b	coefficient that accounts for the degree of bond between FRP reinforcement and surrounding concrete
k_t	coefficient that accounts for the duration of loading
L	beam length
P_{eff}	pre-stressing force
s	spacing between bars/tendons
$s_{r,max}$	maximum crack spacing
V_c	concrete shear resistance
V_{exp}	experimental shear strength
V_f	FRP transverse reinforcement shear resistance
Φ	bar/tendon diameter
α_e	ratio between elastic modulus of FRP reinforcement and concrete
β	ratio of distance between neutral axis and tension face to distance between neutral axis and reinforcing bars
ε_{cm}	mean strain in concrete between cracks
ε_{sm}	mean strain in reinforcement
μ_x	average value
ν	coefficient of variation
ρ_f	longitudinal reinforcement ratio
$\rho_{p,eff}$	effective longitudinal reinforcement ratio
σ_s	stress in tensile reinforcement calculated using cracked concrete cross-section of the beam
σ_p	stress in longitudinal reinforcement caused by pre-stressing force after all stress loses
σ_x	standard deviation
φ_{c2}, φ_{c4}	coefficients which estimate concrete's properties
φ_f	coefficient which estimates the specific flexural FRP reinforcement's properties
φ_n	coefficient which estimates the effect of pre-stressing force