

DOI:10.217672471-983810036

Strengthening of Pre-stressed Steel-Concrete Composite Beams Using Carbon Fiber Tendons – A Parametric Study

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Abstract

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Keywords Composite; Post-tensioning; Finite element modelling; CFRP; ANSYS

Citation: El-Shihy A, Shaaban H, Hassan H, El-Belbisi A (2018) Strengthening of Pre-stressed Steel-Concrete Composite Beams Using Carbon Fiber Tendons - A Parametric Study. Nano Res Appl Vol.4 No.2:7

Received: September 24, 2018; Accepted: October 10, 2018; Published: October 15, 2018

1. Introduction

Pre-stressed CFRPs in the strengthening of composite beams are used to increase the load capacity and ductility of the beams. This paper discusses the strengthening of pre-stressed steel-concrete composite beams using carbon fiber tendons. The study is a parametric study that aims to investigate the effect of the carbon fiber tendons on the load capacity and ductility of the beams. The study is conducted using the finite element method (FEM) using ANSYS software. The results show that the carbon fiber tendons significantly increase the load capacity and ductility of the beams. The study also shows that the carbon fiber tendons can be used to strengthen pre-stressed steel-concrete composite beams in a cost-effective manner.

This paper discusses the strengthening of pre-stressed steel-concrete composite beams using carbon fiber tendons. The study is a parametric study that aims to investigate the effect of the carbon fiber tendons on the load capacity and ductility of the beams. The study is conducted using the finite element method (FEM) using ANSYS software. The results show that the carbon fiber tendons significantly increase the load capacity and ductility of the beams. The study also shows that the carbon fiber tendons can be used to strengthen pre-stressed steel-concrete composite beams in a cost-effective manner.

Modeling of concrete: The concrete is simulated to be experimental outcomes. A parametric study is presented to inspect the impact of FRP tendons on strengthened composite steel-concrete beams. The reinforcing steel and post-tensioning steel tendons are modeled using the material non-linear behavior of the steel. FRPs have limited strain capacity and premature debonding. Three-dimensional index can be used as a major tool to avoid this phenomenon. By pre-stressing the FRP reinforcement, the stress in the internal

Methodology

Finite element model

Modeling of reinforcing steel bars and external pre-stressing steel tendons. As the reinforcing steel and post-tensioning steel tendons are modeled using the material non-linear behavior of the steel. FRPs have limited strain capacity and premature debonding. Three-dimensional index can be used as a major tool to avoid this phenomenon. By pre-stressing the FRP reinforcement, the stress in the internal

65) that is able to crack in tension and crush in compression. In each node is used to represent the shear connector's conduct to used to simulate the external tendons.

Figures 1 and 2. For prevent stress area.

Material modeling

Modeling is performed on ANSYS-15. The element damaged modeling all types of structures using concepts of isotropic steel-concrete beams. The choice of the suitable elements for Figure 2

Figure 3 is used in this study.

Real constants

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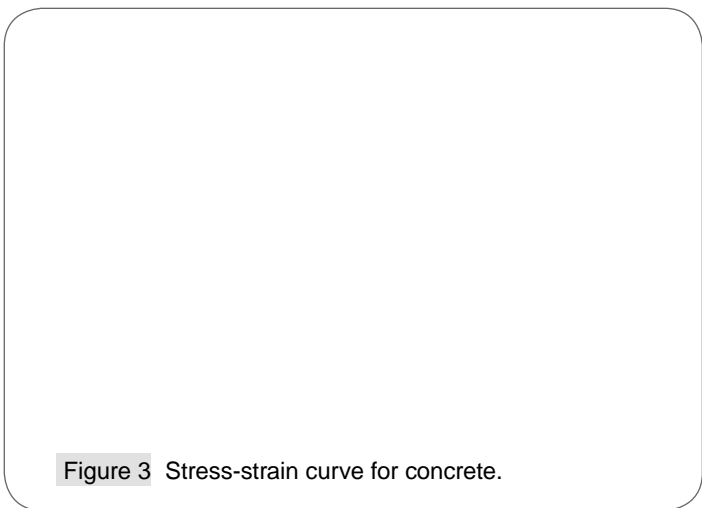


Figure 3 Stress-strain curve for concrete.

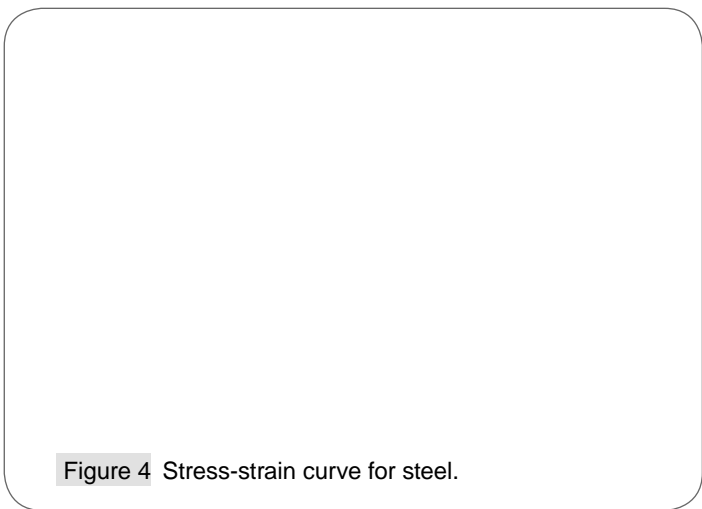


Figure 4 Stress-strain curve for steel.

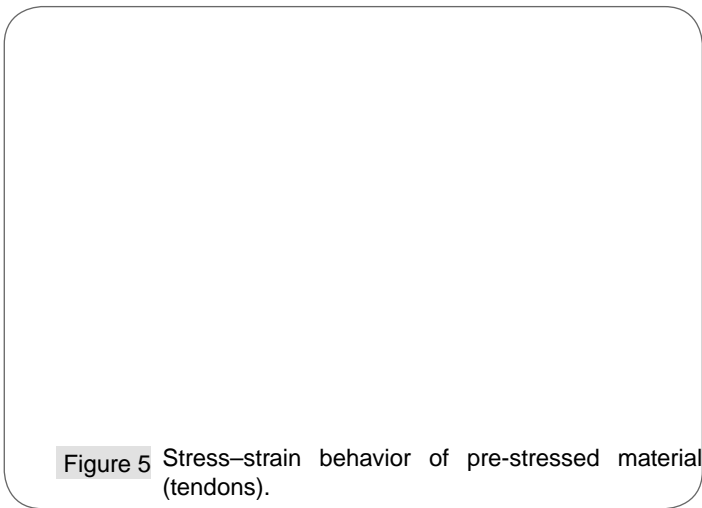


Figure 5 Stress-strain behavior of pre-stressed materials (tendons).

$$\sigma = \frac{E_s \epsilon}{1 + \frac{E_s \epsilon}{E_p \epsilon_p}} \quad (1)$$

The examined

The examined

Figure 6

are listed on Table 1

Pressing Tendons					f_y (MPa)		f_u (MPa)	
f_y (Mpa)	f_u (Mpa)	A_p (mm ²)	F (KN)	f_c (MPa)	Web	Flange	Web	Flange
1680	1860	137.4	112.6	40	327.7	406.5	327.7	406.5

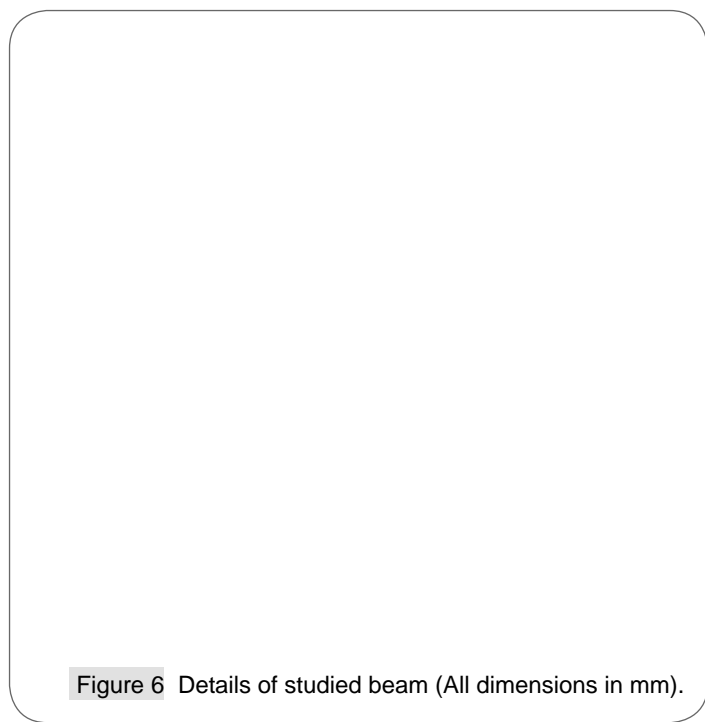


Figure 6 Details of studied beam (All dimensions in mm).

Figure 7 shows the stress-strain curves for the different models. The curves show that the models with FRP and CFRP tendons exhibit higher strength and ductility compared to the model with steel tendon. The FRP tendon model shows the highest strength, followed by the CFRP tendon model, and the steel tendon model shows the lowest strength and ductility.

Property	Prestressing Steel	AFRP Tendon	CFRP Tendon	GFRP Tendon
Nominal Yield Stress (MPa)	1860	N/A	N/A	N/A
Tensile Strength (MPa)	200	1200-2068	1650-2410	1724
Yield Strain (%)	1.4-2.5	N/A	N/A	N/A
Rupture strain (%)	>4	2-2.6	1-1.5	3-4.5
Density (kg/m ³)	7850	1250-1400	1500-1600	1250-2400

Table 3. Material properties of the different materials used in the models.

Strand Strength (MPa)	Modulus (Gpa)	Tendon Material	Model	No.
1860	200	Steel	ST	1
2410	165	CFRP	CT	2
2068	70	AFRP	AT	3
1724	62	'&ZW 'd	'd	4

Figure 7. Stress-strain curves for the different models.

Parametric study

The parametric study was conducted to investigate the effect of the different parameters on the behavior of the beam. The parameters studied were the tendon material, the tendon strength, and the tendon modulus. The results show that the tendon material and strength have a significant effect on the strength and ductility of the beam. The tendon modulus has a less significant effect on the behavior of the beam. The results also show that the FRP and CFRP tendons exhibit higher strength and ductility compared to the steel tendon. The FRP tendon model shows the highest strength, followed by the CFRP tendon model, and the steel tendon model shows the lowest strength and ductility.

Discussion

The results of the parametric study show that the tendon material and strength have a significant effect on the behavior of the beam. The tendon modulus has a less significant effect on the behavior of the beam. The results also show that the FRP and CFRP tendons exhibit higher strength and ductility compared to the steel tendon. The FRP tendon model shows the highest strength, followed by the CFRP tendon model, and the steel tendon model shows the lowest strength and ductility. The results of the parametric study are summarized in Table 3.

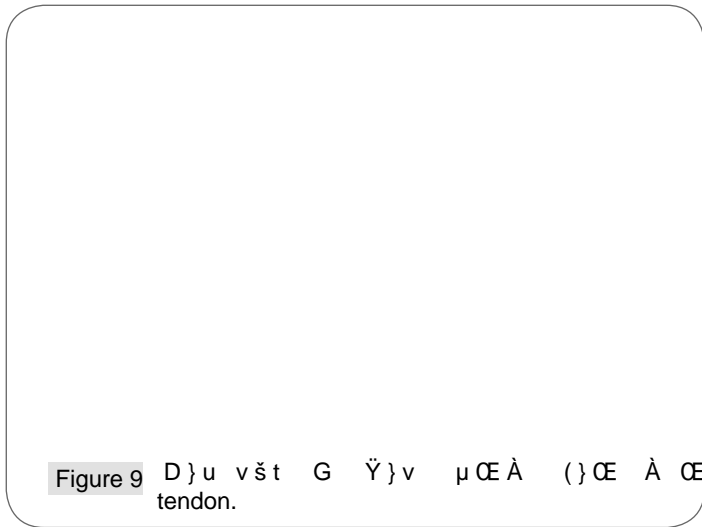


Figure 9 D}u všt G Ÿ}v μCEÀ (}CE À CE}]] tendon.

Figure 9 o CE]. • šZ u}u všt r G Ÿ}v CE}]] μCEÀ (}CE À CE}]] tendons. It is observed that CFRP tendon (model (CT)) had high strength compared to AFRP tendon (model (ST)) had high strength compared to others.

Modes of failure

dÁ} D} • } (& } μCE } μCECE]v šZ } u%} •]š uW } v CE š CEμ•Z]vP v &ZW CEμ%šμCE X &}CE u} o ~^d• šZ u} } (} μCE Á • } v CE š CEμ•Z]vPU ÁZ]o šZ u AE]umu u}u všt Á • iiñ IE u μ š} o}vP %o š • } (μ šZ u} } (} μCE Á • &ZW CEμ%šμCE U ÁZ]o šZ u AE]umu u}u všt Á • iöi IE uX &}CE u} o ~ d• šZ u} } (} μCE Á • &ZW CEμ%šμCE U ÁZ]o šZ u AE]umu u}u všt Á • iiö IE uX &}CE u} o ~ d• šZ u} } (} μCE Á • ' &ZW CEμ%šμCE U ÁZ]o šZ u AE]umu u}u všt Á • iiö IE uX

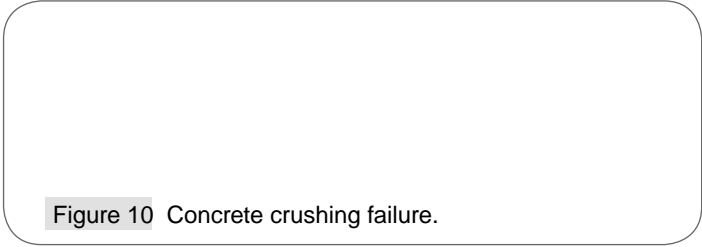


Figure 10 Concrete crushing failure.

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Prestress Level	Strand %strength (MPa)	o • Ÿ Modulus (Gpa)	Tendon material	Model	No.
20	2410	165	CFRP	CT1	1
30	2410	165	CFRP	CT2	2
40	2410	165	CFRP	CT3	3
50	2410	165	CFRP	CT4	4

From Figure 11 it is observed that :

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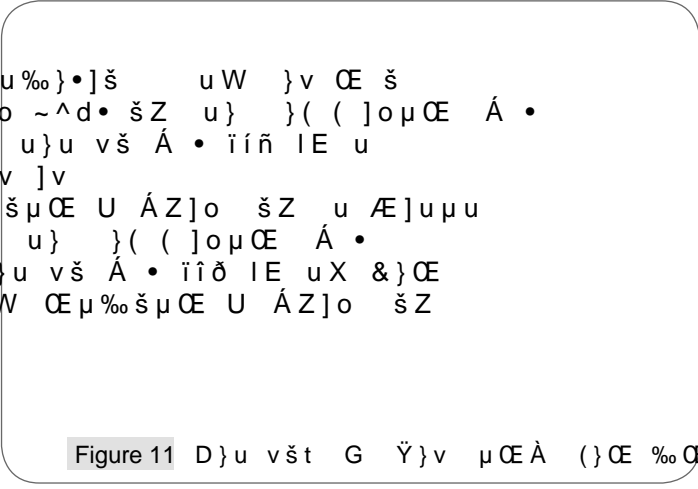


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he % of steel beam height	P.T Force (KN)	Model	No.
10	112.6	CH1	1
15	112.6	CH2	2
20	112.6	CH3	3
25	112.6	CH4	4

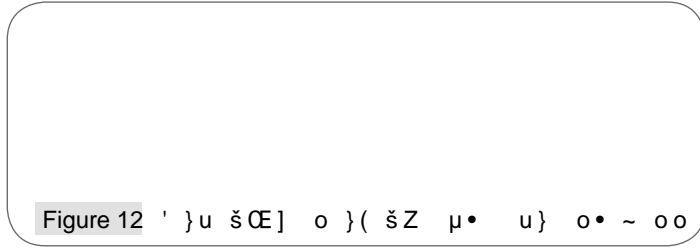
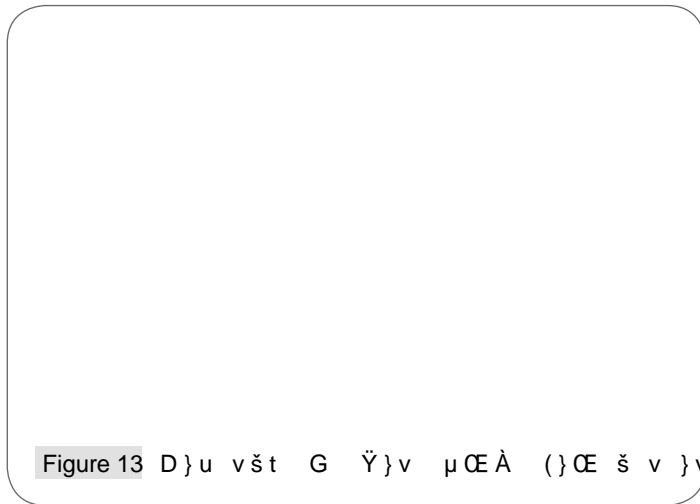


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From Figure 13 it is observed that :

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observed that model (CH1) had high strength compared to others.

Conclusion

In this research, a non-linear parametric analysis for composite
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lu evaluated. The FE model is validated using experimental results.
And, a parametric study is accomplished to survey the various
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in pre-stressed strengthened beams are concrete crushing for
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