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Numerical Analysis of reinforced concrete beams pre cracked reinforced by composite materials

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Abstract - To ensure a relatively more ductile behavior for armed reinforced concrete elements, the reinforcement technique for composite materials, causes a reduction in the ductility of elements reinforced by bending and without significant containment. Knowing that the ductility is a desirable element, the addition of the glass fibers could be considered as an alternative, since they are relatively more deformable and cheaper than the carbon fiber. In this sense, the present work aims to evaluate the effectiveness of external reinforcement on beams reinforced with fabric FRP (glass-carbon). Different reinforced concrete beams were strengthened in bending and shear, and loaded under bending load to four points in the static case. Strains and stresses fields strain were evaluated using Ansys. Software the results were analyzed in terms of strength, stiffness, ductility and fracture mode. The study presented here was to make a qualitative comparison between the different configurations of strengthening and particularly on their ductility. This technique reinforcement's glued composite material is becoming increasingly important in the field of building structures.

Keywords: Reinforced concrete; Beams; Glass fibers; Carbon fiber; FEM; Bending and shear; Ductility.

Analyse numérique des poutres en béton armé pré-fissurée renforcé par des matériaux composites

Résumé - Pour assurer un comportement relativement plus ductile pour les éléments de béton armé, la technique de renforcement des matériaux composites entraîne une réduction de la ductilité des éléments renforcés par flexion et sans confinement significatif. Sachant que la ductilité est un élément souhaitable, l'addition des fibres de verre pourrait être considérée comme une alternative car elles sont relativement plus déformables et moins chères que la fibre de carbone. Dans ce sens, le présent travail vise à évaluer l'efficacité du renforcement externe sur des poutres renforcées avec du tissu FRP (verre-carbone). Différents faisceaux de béton armé ont été renforcés en flexion et cisaillement, et chargés sous charge de flexion à quatre points dans le cas statique. Les déformations et le champs des contraintes ont été évalués par le logiciel Ansys. Les résultats ont été analysés en termes de résistance, de rigidité, de ductilité et de mode de rupture. L'étude présentée ici était de faire une comparaison qualitative entre les différentes configurations de renforcement et en particulier sur leur ductilité. Ce matériau composite de technique de renforcement collé devient de plus en plus important dans le domaine des structures de construction.

Mots-clés: Béton armé ; Poutres; Fibres de verre ; Fibre de carbone ; FEM ; Flexion et cisaillement ; Ductilité.

I. Introduction

The technique of reinforcement's glued composite materials is becoming increasingly important in the field of building structures. It proves especially advantageous for the reinforcement and repair of concrete structures, carpentry or masonry. However apart from the benefits it provides, the building technique composite materials, causes a reduction in ductility of the elements reinforced by bending and without significant containment, knowing that the ductility is a desirable element.

The introduction of the technique called reinforcement (NSM) [2] to strengthen the structural elements of reinforced concrete (RC) flexural using polymer-reinforced carbon fiber - (HFRP) has become very attractive in these last years. It involves the insertion of flat or polymer rods reinforced with carbon fibers (HFRP) with channels in previously performed in the coating concrete strained surfaces and filled with epoxy resin for fixing. However this reinforcement system has been widely used, experimental research, analytical and numerical is increasingly justified to understand the effect of various parameters on strengthening performance in bending of reinforced concrete elements.

The goal of the numerical program developed in this work is to study the possibility of using carbon rods and plates to strengthen reinforced concrete beams, and deal a practical problem with limiting the depth of engravure, which is generally regarded as the thickness of concrete cover, these points are examined in this study.

Triantafillou and Plevris [4] have demonstrated that strengthening facets of reinforced concrete beams with glass fibers or aramid, improves their shear strength and ductility. And recently Camata Guido et al, [5] have shown experimentally and analytically the effectiveness of the contact surface of the composite reinforcement on ductility. In this sense the present study evaluates the influence and effectiveness of the external strengthening of reinforced concrete beams, by a reinforcing fiberglass and carbon, and that by an appropriate reinforcement configuration. Different solutions are tested; they combine the separate use of carbon fibers and unidirectional glass with an anchor in U. Under the same conditions a bidirectional glass-carbon hybrid fabric is tested. And in this context and to reduce the cost and ensure a relatively ductile behavior for reinforced concrete strengthened, the addition of glass fiber may be considered as an alternative, since are relatively more deformable and cheaper than carbon fiber [9].

To achieve these objectives, bending simulation four points were made on a reinforced concrete beams strengthened by HFRP according Attari [3]. The simulations were carried out by varying the following experimental parameters: type reinforcing HFRP; size and type of reinforcement; mounting types (flat composite fully inserted without cutting frames).

This paper presents the results of the numerical simulations using similar rates of reinforcement HFRP. Unreinforced samples were also tested to serve as a control. Substantial increases in terms of stiffness and ultimate strength were obtained. Furthermore, strengthening HFRP resulted in a decrease in both the ductility and arrow. The flexural breakage arrangements discussed load on the database, arrow, and recorded deformation. The numerical results show that the strengthening of beams by this technique is very satisfactory.

II. Loading and boundary conditions

The numerical tests were carried out on a four-point bending device with a capacity of 250kN (Fig.1), the applied load was static cyclic type with a speed of 0.02 mm.

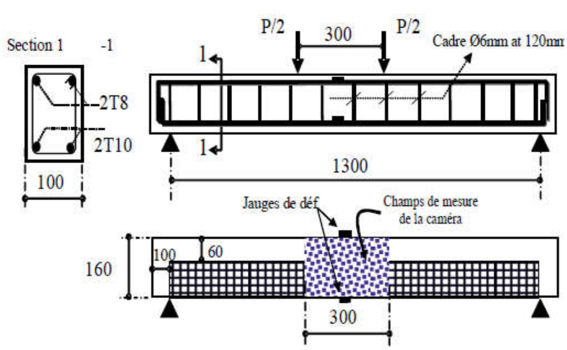

Fig. 1. Details of specimen [mm].

III. Experimental aspects

III.1. Features of the beams

The characteristics of the beams are summarized in table 1 below.

Materials	Modulus E Gpa	Strength Mpa	Ultimate load Kn/mm	Thikness mm	Elongation %
CFRP	43.5	403	0.644(1 layer)	1.6	**0.95**
GFRP	19.2	325	0.650(2 layers)	2	**1.7**
CFRP+GFRP	28	400	0.640(2 layers)	1.6	**1.45**
Hybrid fabric	27	218	-	2	**0.85**

Tab. 1. Features of the beam.

III.2. Characteristics of fiber

A total of seven rectangular beams were manufactured for the purposes of this study, all the beams are identical, they have a 100×160 mm^2 and a length of 1500mm, they are armed with two lower HA10 bars and two HA8 bar higher 13 HA6 frames spaced 12cm were used for reinforcement to shear and to avoid premature rupture shear (Fig. 2).

There are two sets of building configuration, the A series where the beams are reinforced by a unidirectional fiber reinforcement U-shaped, the B series includes reinforcement with a bi-directional hybrid carbon glass fiber fabrics (Table 2).

III.3. Characteristics of materials

The characteristics of the fibers used are given as follows (Tab.1)

Materials	Modulus E Gpa	Strength Mpa	Fiber Orientation	Thicknessmm	Elongation %	Mass g/m^2
CFRP fiber (Sika Wrape 230C)	238	3650	Unidirectionnel	0.13	1.7%	**225**
GFRP (Sika Wrape 430G)	19.2	325	Unidirectionnel	0.17	2.8%	**430**
Hybrid Fiber	**Not available**					

Tab. 2. Materials Characteristics.

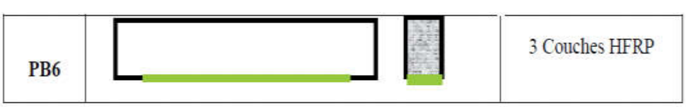

Fig. 2. Configuration tested specimen.

In this study, the value of the desired strength of the concrete was taken equal to 30 MPa. The longitudinal and transverse reinforcement used are deformed steel having a Young's modulus of 200 GPa, and an average value of 500 MPa as elastic limit.

III.4. Instrumentation

Several types of measurements were performed: displacement and strain measurements. The displacements were used for the deflection measurements, and to judge the relevance of the results of gom-aramis camera, a comparison was made between the results of the traditional measures of trips by lvdt, as we see a perfect correlation between the two measurements (Fig. 4).

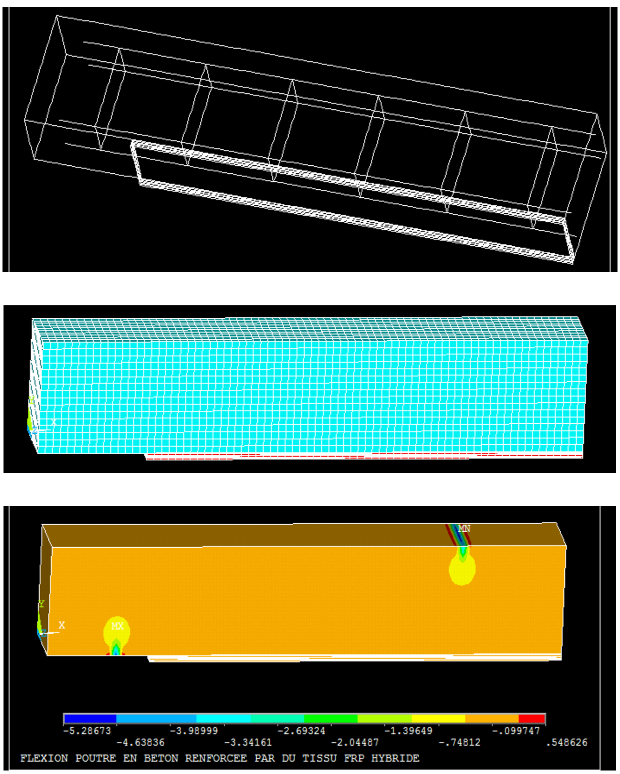

Fig. 3. Geometric features, mesh and reinforcement schemes.

IV. Results and discussion

Deflection curves as a function of the load for different beams (beam + superimposed 3 nappes with and without cracks, beam + 3 nappes shelf with and without cracks, beam + a FRP layer with and without crack) (adhesive = 1, FRP layer = 2).

During the study (representation) of the variation of the applied load F [kN] according to the bending U [mm] of the beams under the following conditions:

P: 3 ply staircase cracked beam (FRP).

P0: beam staircase without crack three ply (FRP).

P01: cracked beam shelf 3 ply (FRP).

P02: crack without beam shelf 3 ply (FRP).

P03: beam without crack a layer (FRP).

P04: beam cracked + layer (FRP).

P-EXP: Attari et al. [3,9].

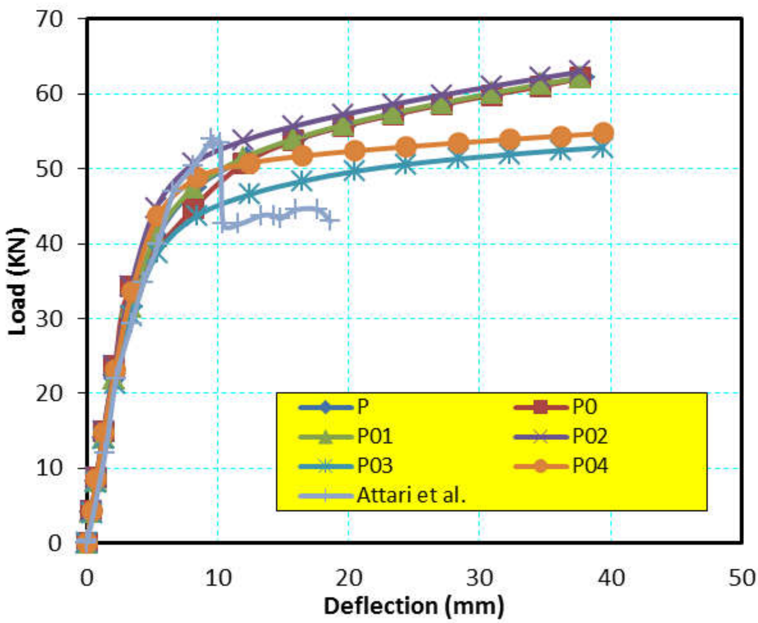

Fig. 4. Details of specimen [mm].

This configuration was selected to study the reinforcing effect on the behavior of the beams, remarks that can be done on the response of the beams is that the strengthening of a beam increases a substantial load rupture, with increased rigidity and reduced deflection.

This representation currency (3) parts as follows: Part (1) of (0 to 6 mm) same speed in all curves in the form of a straight line Y = ax where all the graphs are completely combined with each other a non-linear variation of the beams (p, p01) which are both cracked beams reinforced with three layers.

Curves P02, P04 have the same variation between them and closer to that of the experimental values [3]; in the moment to note that the figure P03 keeps the same with values far from that of [3].

Part (03) to (10 to UMAX) compared to the beam P-EXP [3] witness, there was an increase in the load of 5 to 20% respectively, this part is explained as follows:

1- P03 curve: variation greater than 5%.

2 curve P04: Variation 8% higher.

3- P0 curve, P01, and P: these curves are confused them totally exceeds

15% of the experimental, it explains that the three solution have the same role therefore can be replaced by each other.

4- P02 curve keeps the same shape parallel with the three beams reinforced P0, P01 and P with maximum values of about 20% contribution to Attari et al. [3]. That shows the ineffectiveness of this solution (adding 3 nappes shelf).

Indeed, the beam P01 curve show a slight addition to the P02 and especially a better beam deflection. This is due to the influence of reinforcement and way of provision (Shelf), which gives to this way of disposal better performance against the performance of a beam has graduated arrangement.

V. Conclusion

We can deduce from this study that some solutions (P03) can be effective and rendable in solving cracking problem.

The behavior of most of the reinforced beams, has been accompanied by a significant improvement in stiffness.

It can also be deduced from this study that the number of reinforcing layers and its provisions have an influence on the structural response.

References

[1] Kim, S. F., and Low, F., 1997, Liquid Film Cooling at High Temperature, J. Film Cooling, 122, pp. 21-26.

[2] Schlichting H., 1979, Boundary-Layer Theory, 7th edition, McGraw-Hill, New York

[3] Attari N., Amziane S. et Chemrouk M., Efficacité du renforcement des poutres en béton armé par des matériaux composites, MATEC Web of Conferences 2, 02005, EDP Sciences, 2012.

[4] DOI: 10.1051/C _Owned by the authors, published by EDP Sciences, 2011/2012 MATEC 02005 (2012) matecconf 0202005
[5] Abdelghani Merdas, Bruno Fiorio, Nasr-Eddine Chikh Etude de poutres en beton arme renforcees par materiaux composites selon la technique NSM. Rencontres Universitaires de Genie Civil, May 2015, Bayonne, France. <hal-01167580>
[6] Ansys 14 WORK BENCH 2014
[7] Triantafillou, T. C. "Shear Strengthening of Reinforced Concrete Beams Using Epoxy-Bonded FRP Composites" ACI Structural Journal, V.95, N°2, Mar-Apr (1998), PP.107-115.
[8] Guido Camata; Enrico Spacone.Roko Zarnic "Experimental and nonlinear finite element studies of RC beams Strengthened with FRP plates. Composites: Part B 38(2007)277-288.
[9] Attari N., Amziane S., Chemrouk M. "Efficiency of Beam–Column Joint Strengthened by FRP Laminates" Advanced Composite Materials Journal (ACM), Vol: 19 (2010), P 171–183. Brill Publication (2010).
[10] S. M. Metev and V. P. Veiko, Laser Assisted Microtechnology, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.
[11] J. Breckling, Ed., The Analysis of Directional Time Series: Applications to Wind Speed and Direction, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.
[12] S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," IEEE Electron Device Lett., vol. 20, pp. 569–571, Nov. 1999.
[13] M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, "High resolution fiber distributed measurements with coherent OFDR," in Proc. ECOC'00, 2000, paper 11.3.4, p. 109.
[14] R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, "High-speed digital-to-RF converter," U.S. Patent 5 668 842, Sept. 16, 1997.
[15] http://www.ieee.org/
[16] M. Shell. (2002) IEEEtran homepage on CTAN. [Online]. Available: http://www.ctan.org/tex-archive/macros/latex/contrib/supported/IEEEtran/
[17] FLEXChip Signal Processor (MC68175/D), Motorola, 1996.
[18] PDCA12-70 data sheet, Opto Speed SA, Mezzovico, Switzerland.
[19] A. Karnik, "Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP," M. Eng. thesis, Indian Institute of Science, Bangalore, India, Jan. 1999.
[20] J. Padhye, V. Firoiu, and D. Towsley, "A stochastic model of TCP Reno congestion avoidance and control," Univ. of Massachusetts, Amherst, MA, CMPSCI Tech. Rep. 99-02, 1999.