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Punching behavior of strengthened and repaired RC slabs with CFRP

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HIGHLIGHTS

- We test rectangular RC slabs unreinforced or reinforced by carbon fiber reinforced polymer (CFRP).
- We test rectangular RC slabs with pre loading (60 and 80)% ultimate load.
- Compare reinforced slab repairing slabs with control slab and the role of CFRP.
- Compare reinforced slab with different orientation of CFRP.

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ABSTRACT

This study investigated the punching behavior of reinforced concrete slabs strength with carbon-fiber-reinforced polymer (CFRP). We tested a total of thirteen RC slabs, each having 965 mm length, 680 mm width, and 60 mm thickness, each slab was reinforced with two layers of CFRP of area ($40 \times 40\ cm^2$). The variables in the experimental program were: pre loading (60% and 80%) of ultimate load (load of control slab) and orientation of the fiber of CFRP (0°, 45°, (0°/90°) and (45°/135°)). Test results showed that the capacity of ultimate load of strength of the slabs is increase (23%–65%) compared with slab unreinforced. The results illustrate that carbon-fiber-reinforced polymer (CFRP) reinforcement is perfect in reducing the deflection (3%–48%). The CFRP strengthening is perfect in reducing the strain.

1. Introduction

The civil engineering field is in a constant evolution, despite this, we find a large number of civil engineering structures or buildings are found degraded for different reasons, such as damaged due to accidents, building redevelopment. More, there are also a large number of pathologies in civil engineering structures whose origins can be design errors, mechanical, physicochemical, accidental. To solve these problems, two main solutions available: demolition or repair, the latter solution is the perfect solution.

One of the applications that can successfully repair and reinforce structural elements made of reinforced concrete (such as columns) is the use of composite materials, such as external reinforcement (casing) [1] to plead to extreme mechanical actions (earthquake) where environmental (corrosion) [2]. This field of application is expanding more and more to other types of structures working mainly in flexion, such as slabs and beams [3,4]. With regard to this last type, more lines of research are expanding [5,6]. The slabs are generally reinforced on an important part of their surface) [7,8] by a reinforcement in the form of bands [9–12]. Composites are glued to their tension surfaces with the aim of repairing and improving their bearing capacity. This experimental work was carried out in the laboratory of Civil Engineering and Hydraulics (LGCH) and Architectural laboratory of the University of Guelma 8 May 1945(Algeria). In this paper, Its main purpose is to study the behavior under punching of reinforced concrete slabs, the work has been carried an experimental investigation on reinforced concrete slabs strengthened and repaired with Carbon fiber reinforced polymer. The slabs strengthen by surface of CFRP of 24% of the surface of the slab, with different orientations of composite layer (0°–45°–0°/90°–45°/135°). The second series, we repaired the RC slab after preload (60–80%) of ultimate load of control slab.

2. Experimental program

2.1. Material properties

The cement used is a Portland cement composed, CPJ-CEMII/A42.5, produced by Algerian company. Its mineralogical

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Table 1
Physical characteristics of aggregate.

Characteristics	Absolute density (g/cm^3)	Apparent density (g/cm^3)	Sand equivalent (visual) (%)	Fineness modulus
Gravel	2.47	1.41	–	–
Sand	2.56	1.53	82	2.28

Table 2
Characteristics of CFRP and the adhesive.

	Modulus of elasticity (MPa)		Tensile strength (Mpa)	Fracture elongation (%)	Thickness (mm)	Density (kg/l)
	Bending	Tension				
CFRP	–	>230000	>4000	1.7	0.129	–
Adhesive	3800	4500	30	0.9	–	1.30 ± 0.1

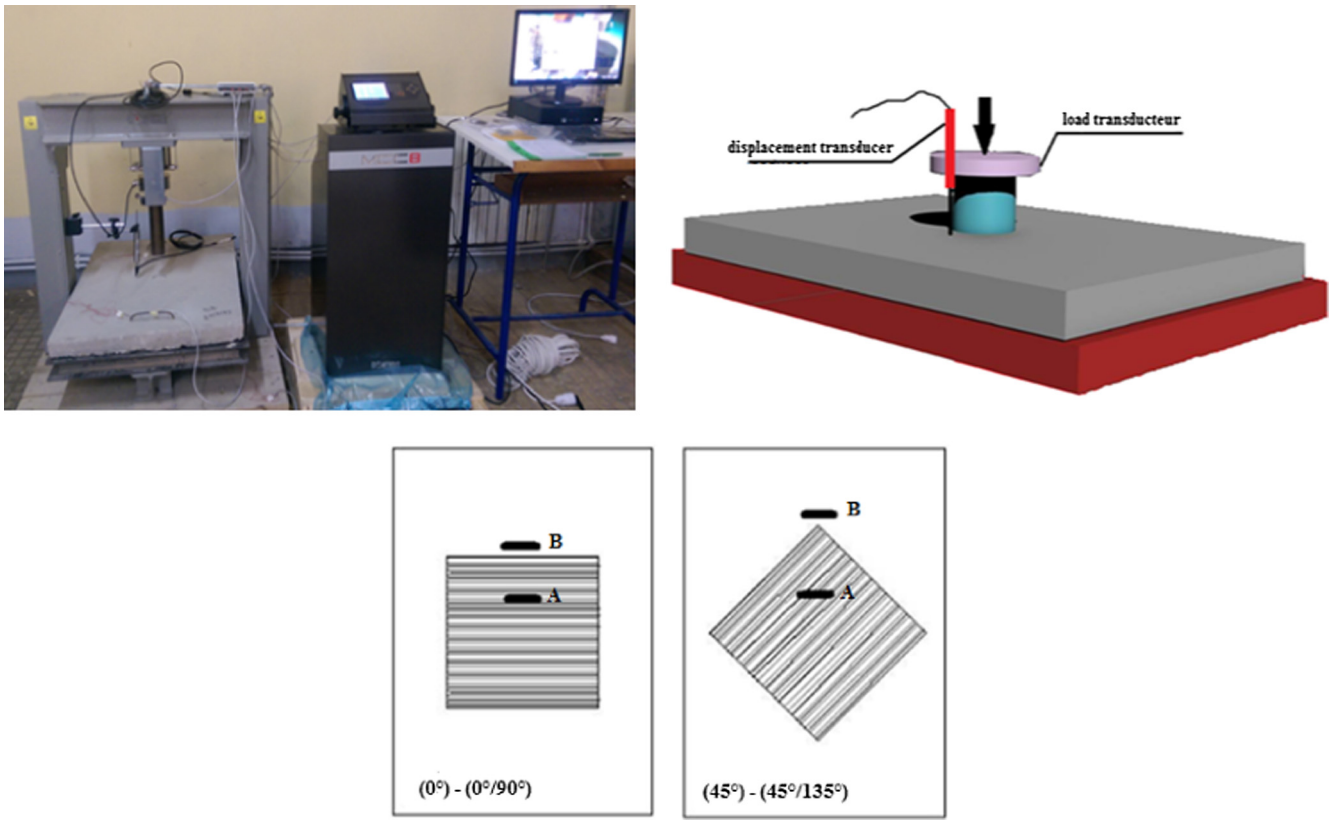

Fig. 1. Testing machine and positioning of the strain gages.

Table 3
Slab test descriptions.

Slab	Preload	Orientation of CFRP	
		1st layer	2nd layer
D1	–	–	
D2	–	0°	0°
D3	–	45°	45°
D4	–	0°	90°
D5	–	45°	135°
D6	60%	0°	0°
D7		45°	45°
D8		0°	90°
D9		45°	135°
D10	80%	0°	0°
D11		45°	45°
D12		0°	90°
D13		45°	135°

composition is CaO = 55–65%, SiO_2 = 22–28%, Al_2O_3 = 5–6% and Fe_2O_3.

The gravel used is a 5/15 gravel from the Bouslba-El-Fedjoudj quarry (Department of Guelma, northern Algeria). The sand used is a rolled sand (0/5) from Oum-Ali Department of Tebessa, northern Algeria) Table 1.

The composite material used in our experimental work is a unidirectionally woven CFRP produced by the Algerian company. Its mechanical characteristics are presented in Table 2.

The adhesive adapted to CFRP, according to the local society, is an epoxy resin with two components (A and B) according to its manufacturer. This glue complies with the requirements of the EN 1504-4 standard as a product for bonding reinforcement fabrics Table 2.

We used the Dreux-Gorisse formulation method for the composition of our concrete. The average compression strength of concrete is obtained from the compressive tests on cylindrical