Dune Sand Mortar Effects on Deflections of Repaired Steel Bars-Reinforced Concrete Beams

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ABSTRACT

This paper presents theoretical and experimental investigations to analyze the flexural behavior of reinforced concrete beams repaired with mortars based on dune sands. The beams supposedly damaged were repaired using mortars based on dune sand varying the mortar cover thickness and the reinforcement ratio. After a suitable cure of beam specimens in the laboratory, they submitted to progressive loading until failure. The results obtained show that the repaired dune sand mortar could be used to enhance the flexural capacity and the ductility of damaged reinforced concrete beams, repaired with dune sand mortars. Comparisons between theoretical and experimental results in terms of deflections are also presented.

Keywords: Dune sand mortar; Repaired concrete beam; Theoretical and experimental deflections; Reinforcement ratio

1 INTRODUCTION

Several works were conducted for strengthening reinforced concrete structures (Prabhat et al., 2015; Attari et al., 2012; Carlo et al., 2011; ACI, 2008; Park & Yang, 2005; Dong-Suk Yang & Sun-Kyu Park, 2002; Hollaway & Leeming, 1999). However, to valorize the local materials such as the dune sand, which covers 60% of the Algerian territory at one hand, and to develop the new repair mortar based on the dune sand on other hand because of the high cost of reparation and rehabilitation of concrete buildings. An experimental study is carried out to investigate the flexural behavior of concrete beams reinforced with steel bars repaired with mortars based on the dune sand varying the mortar cover thickness and the reinforcement ratio. Comparisons between experimental and theoretical results in terms of deflections of repaired reinforced concrete beams are presented.

2 EXPERIMENTAL INVESTIGATION

2.1 Parameters

The present research examines the flexural behavior of reinforced concrete beams repaired with cementitious repair materials using the normal Portland cement mortar

based on the dune sand applied in the tensile zone. The studied parameters of reinforced concrete beams are the steel reinforcement ratio and the repair mortar cover thickness as shown in Table 1.

Table 1: Studied parameters of steel bars-reinforced concrete beams.

Reinforcement ratio	Series Beam	Cover thickness
ρ= 0.0122	PTA1	1.5 cm
	PRA1	
ρ= 0.0125	PTA2	2 cm
	PRA2	
ρ= 0.0085	PTB1	1.5 cm
	PRB1	
ρ= 0.0087	PTB2	2 cm
	PRB2	
ρ= 0.0056	PTC1	1.5 cm
	PRC1	
ρ= 0.0058	PTC2	2 cm
	PRC2	

2.2 Materials

The mechanical properties of concrete used to fabricate concrete beams were determined experimentally on concrete cylinders 16 cm x 32 cm according to French Standards (NFP 18-406 and NFP 18-408). The compressive strength and the tensile strength of concrete at 28 days (f_{c28}) were found to be equal to 30 MPa and 3 MPa, respectively. The different rates of the normal Portland cement and fine aggregates used for the repair mortar are shown in Table 2. The mechanical properties of the repair mortar such as the compressive strength and the tensile strength at 28 days of curing were found equal to 18.13 MPa and 5.82 MPa, respectively.

Table 2: Composition of cement repair mortar (MSDA4)

Cement (Kg/m^3)	Water (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)
400	200	623.57	1148.71

2.3 Beams description

A total of 12 reinforced concrete beams were cast having overall dimensions of 150 mm in width, 200 mm depth, 1500 mm length, and 1300 mm span between supports. Two types of 12 and 10 mm diameters of steel bars were used as tensile and compression reinforcements. 6 mm diameter of steel bar was used as stirrups. Shearing bars were arranged with an interval of half of the effective depth to minimize the effect of the shearing force.

The beams after casting were removed from their moulds after 1 day, and stored in water cured at ambient temperature of 20°C for 28 days.

3 RESULTS AND DISCUSSION

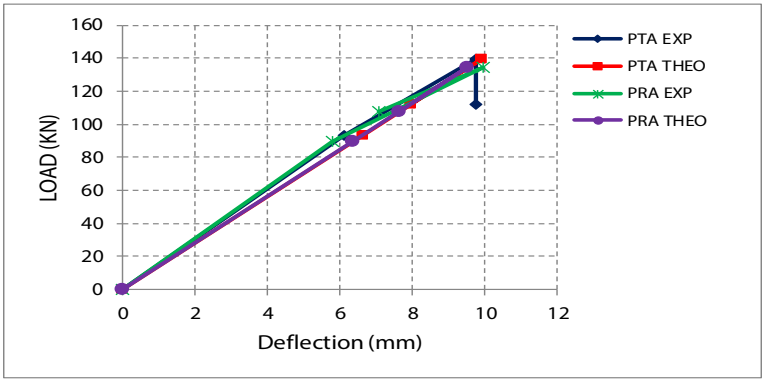

Figure 1: Load-Deflection curves of A-type beams- Comparison between theoretical and experimental results.

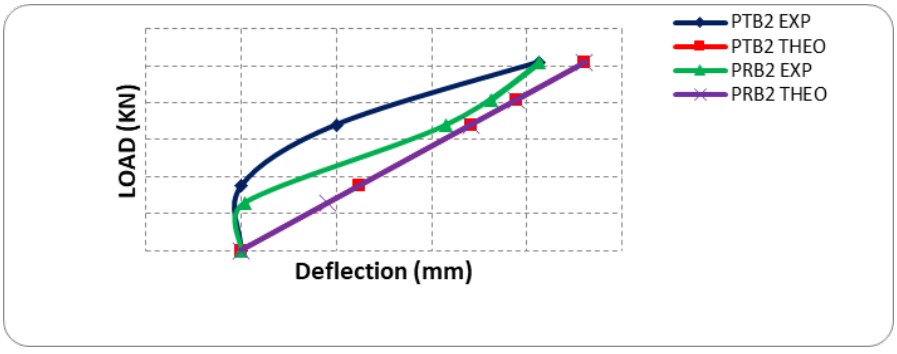

Figure 2: Load-Deflection curves of B-type beams- Comparison between theoretical and experimental results.

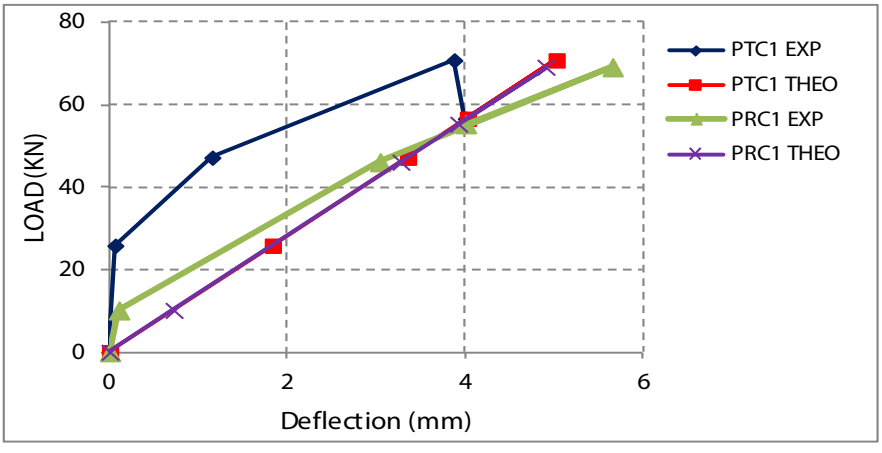

Figure 3: Load-Deflection curves of C-type beams- Comparison between theoretical and experimental results.

As shown in figures 1 to 3, the theoretical and experimental deflections are almost

similar for A-series beams (over reinforced section) because the cracks in this series did not reach the reparation mortar. B2 and C1-series beams show in general experimental values relatively close to those predicted from theoretical models (Jean-Pierre Mougin, 2004; Lim & Hong, 2016; Smarzewski, 2019). However, certain B2 and C1 beam specimens (under reinforced section) show disturbance in deflection results because probably of the lack of the sensibility of certain LVDTs (displacement instrument).

4 CONCLUSION

Analysis results in terms of deflections of concrete beams reinforced with steel bars repaired with cementitious mortar based on dune sand, permit to draw the following conclusions:

- The cementitious mortar based on the dune sand can be used to enhance the flexural capacity of damaged concrete structures reinforced with steel bars.
- Deflections of reinforced concrete beams repaired with the mortar based on the dune sand are generally reduced compared to those of control beams, and consequently the beam stiffness is increased.
- The ductility of reinforced concrete beams repaired with the mortar based on the dune sand is 20% greater than that of the control beam for under-reinforced beams (with low reinforcement ratio). However, for over-reinforced beams, the ductility of repaired beams is close to that of the control beams. This proves that the concrete beam repaired with the dune sand mortar is able to absorb the load during deformation after the appearance of the first crack. As a consequence, the ductility enhancement particularly for under-reinforced beams is due to the repair dune sand mortar contribution.
- Deflections of reinforced concrete beams predicted from theoretical models are in general close to those obtained from experimental tests.

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