ID 6007

Local Reinforcement of Reinforced Concrete Frame Using Metal Fibers Recovered from Used Tire Steel

Talbi Nadia *[1], Nekmouche Aghiles [2], Ould Ouali Mohand [1]

[1] Laboratory Elaboration and Characterization of Materials and Modelling (LEC2M),University Mouloud Mammeri Of Tizi Ouzou, Bp17rp, 15000 Tizi Ouzoua, Algeria

[2] National Earthquake Engineering Research Center, CGS, Rue Kaddour Rahim,BP 252 Hussein-Dey, Algiers, Algeria

*Correspondent author email: nad_talbi@yahoo.fr

ABSTRACT

This work is dedicated to the study of the relevance of using recovered metal fibers from used tires, denoted as VSF, in civil constructions. The goal is to contribute to environmental protection by opening another avenue for recovery in a field known to be highly polluting. To achieve this, we have adopted a numerical approach, calibrating the parameters of the Concrete Damage Plasticity (CDP) model, available in the finite element analysis code Abaqus, with the results of experimental tests conducted on specimens containing VSF fibers. The obtained results demonstrate the relevance of our approach, highlighting the contribution of VSF fibers in improving the overall and local behavior of structures.

Keywords:. Recovery Fibers VSF, Abaqus, Reinforced concrete Frame, CDP, Environment.

1. Introduction

This study is part of the framework for strengthening existing buildings damaged by earthquakes. Its purpose is to enhance the capacity of (R+1) frames by introducing fiber-reinforced concrete into nodal zones with a reinforcement length. Two types of fibers are utilized: steel recovery fibers from used tires, known as 'VSF,' and industrial metallic fibers labeled 'ISF-1,' as studied by Tlemat and al [1]. Fiber-reinforced concrete is injected exclusively into the nodal zones of the frames, while the rest of the frame is constructed with ordinary concrete without fibers (CTV). The frames under investigation are derived from the experimental study conducted by Vecchio and al [2]. Subsequently, we employed the calibrated CDP model to simulate the response of an (R+1) frame reinforced with VSF fibers at the nodal zones. Our focus was primarily on monitoring the damages occurring in the nodal zones of the frames. For comparative purposes, we also utilized industrial metallic fibers (ISF-1) to qualitatively assess the contribution of recovery fibers.

2. Experimental

The modeling of the frames is carried out using the finite element model CDP in the Abaqus code [4]. The input parameters for the model are provided in the studies by Tlemat and al [1] and Vecchio and al [2] for the uniaxial loading case, and for the multi-axial loading cases, they are given in the study by Talbi and al [3]. See Figure 1.

Figure 1: Modeling of the frame using the Abaqus code.

DOI: 10.21467/abstracts.170 ISBN: 978-81-970666-1-0 (eBook)

3. Results and Discussion

The results of the study are presented in Figure 1. The behavior of the frames in FRM is very favorable towards earthquakes. For the reinforcement length value lr equal to 120% of beam height 'h', i.e. 48cm, the response of the frame coincides with that of the frame completely made with VCVSF6%. This shows that it is possible to reinforce only the nodal zones of the frames and have an optimal seismic behavior, identical to that of the frame completely made with fiber reinforced concrete (VCVSF6%). It is also observed that VSF fibers have practically the same positive influence as ISF-1 industrial fibers.

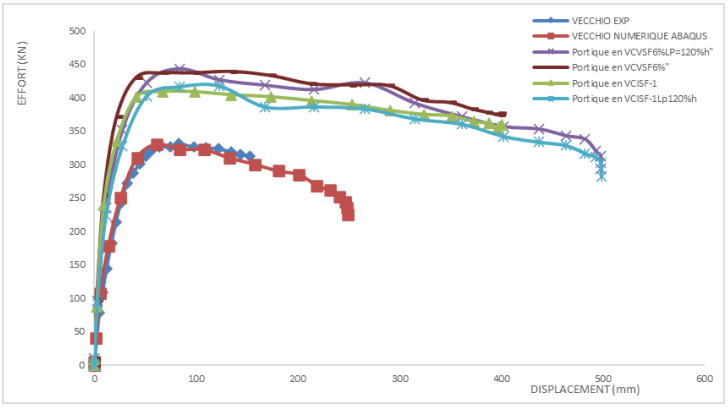

Figure 2: The capacity curves of frames created using the Abaqus software.

4. Conclusions

The introduction of metallic fibers into concrete helps reduce its fragility. Consequently, BFM frames react much better than ordinary concrete frames in terms of displacements and forces. BFM with VSF fibers at a 6% percentage exhibit a more favorable seismic response than BFM with ISF-1 fibers (at a 6% weight percentage), hence we recommend their use in structural concretes. The recovery of VSF fibers allows us to decrease waste pollution associated with the industry while ensuring environmental protection. Their use is more economical than ISF fibers as it helps limit steel waste. Therefore, there is an urgent need to develop markets requiring steel fibers as a secondary purpose. The interest in recovery fibers is twofold, contributing to the development of the construction industry as a potential market for steel fibers and eliminating illegal tire fire sites that pose a real threat to the environment. In conclusion of our study, we recommend incorporating VSF fibers into the composition of structural concrete, with the caveat of avoiding fiber clumping during mixing and implementation. It is a simple, secure, economical technique that contributes to environmental protection.

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ISBN: 978-81-970666-1-0

Series: AIJR Abstracts

DOI: 10.21467/abstracts.170