Ductility Increasing for Concrete Columns. Experimental Results

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Summary

The research program presented here contains a short theoretical and experimental study upon the reinforced concrete columns retrofitted using composite materials. The aim is to clarify some of the aspects regarding the ductility of these types of elements. One part of the study is that it aims to establish the type of interaction between two methods of retrofitting, namely in bending and by confinement. The actual codes present only the computational methods for each individual situation, but not for the superposition of the two retrofitting methods.

Keywords: concrete, columns, retrofit, FRP

1. Introduction

The FRP composite materials are widely used to retrofit structural elements such as beams, columns or slabs. In the European or American codes, each retrofitting procedure is presented individually, not taking into consideration the superposition of two or more retrofitting procedures.

The main interest was to develop a retrofitting method for reinforced concrete columns that will allow the use of additional steel reinforcement and confinement with FRP wrapping.

Consequently, a testing program was proposed in which all the different parts of the retrofitting system were applied on the reinforced concrete columns in a certain order. This meant that there were tested two reference specimens, one monotonically and one cyclically. The next phase of the program referred to two columns retrofitted in bending only, using additional steel reinforcement. This was followed by another set of two columns strengthened by base confinement of the columns with CFRP wrap. The final part, at least up to this date, consisted of two columns strengthened both in bending and by confinement, thus realizing the final retrofitting system.

2. Finite element modelling

The finite element modelling was done using the ABAQUS and the AxisVM programs. The Abaqus model simulates the theoretical behaviour of the specimens. A T-shaped model was subjected to both vertical and lateral loading. Figure 1 presents the distribution of isostresses in the initial unstrengthened model. Further refinement of this model was also done to include the retrofitting system.

3. Experimental tests

Six experimental tests were performed in various configurations. The goal was to obtain an efficient retrofitting method for the concrete columns and to make a comparison between different test

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procedures and their influence in increasing the columns' ductility and load bearing capacity. Carbon fabrics or glass fabrics were used for confinement and additional NSM steel rebars for lateral retrofitting in bending.
Similar studies were done in the past regarding only retrofitting RC columns by confinement and by mounting near surface reinforcement. Research programs that involved retrofitting both by confinement and by NSM rods for bending were also carried out, but none of them went through a step-by-step study on the superposition of the two strengthening procedures.
In this testing program, the retrofitting systems used were divided into their main components, each one being tested individually on an individual RC column. The benefits arising from the different parts of the retrofitting systems were studied. In total three different types of retrofitting systems were used and at least 2 experimental tests were performed for each type.
Figure 2 presents the test set-up scheme. The concrete used had a mean cube compressive strength of 27.5 N/mm^2. The yield strength of the reinforcement was equal to 500N/mm^2, both for the initial reinforcement and for the steel rebars used for lateral retrofitting.

Fig. 1: Isostresses

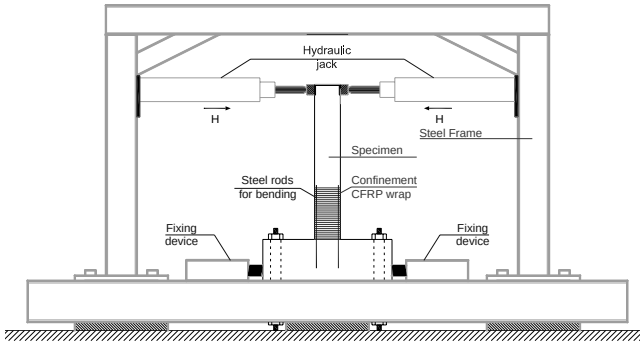

Fig. 2: Testing Stand Set-up

4. Conclusions

After this series of six experimental tests, the following conclusions can be drawn:
- the retrofitting method studied can lead to a significant increase in the ultimate horizontal load;
- the ductility increase ranges between 8.5% and 75% for the monotonically tested specimens and between 26% and 46% in the case of the cyclically tested columns.

The experimental program is in progress. Future tests are planned in which other types of composite wraps will be used as well as composite materials instead of steel rebars.