RC Beams Strengthened with FRP Systems – Results in Dapped-ends and Increase of Flexural Capacity

Tamás NAGY-GYÖRGY
Lecturer
Politehnica University of Timişoara, Romania
tamas.nagygyorgy@ct.upt.ro

Valeriu STOIAN
Professor
Politehnica University of Timişoara, Romania
valeriu.stoian@ct.upt.ro

Daniel DAN
Associate Prof.
Politehnica University of Timişoara, Romania
daniel.dan@ct.upt.ro

Cosmin DĂESCU
Assist. Prof.
Politehnica University of Timişoara, Romania
cosmin.daescu@ct.upt.ro

Dan DIACONU
PhD student
Politehnica University of Timişoara, Romania
dan.diaconu@ct.upt.ro

István DEMETER
PhD student
Politehnica University of Timişoara, Romania
istvan.demeter@ct.upt.ro

Summary

The paper presents a description of the theoretical studies and the results of the experimental tests carried out on reinforced concrete beams with specific strengthening systems. In the first part investigations made on pre-stressed concrete beams' dapped end retrofitted with various FRP systems were described. The second part is dedicated to RC beams flexural capacity increase by applying FRPs.

Keywords: RC beams; dapped-end; bending; strengthening; FRP composites; experimental studies.

1. Introduction

Strengthening with fiber reinforced polymer (FRP) composites is a widely used method for retrofitting or increasing load bearing capacity of structural members. In the Department of Civil Engineering of the Politehnica University of Timisoara, Romania, this technique of retrofitting is under study in a frame of several research projects. The elements under investigations are: unreinforced clay brick masonry walls subjected to in-plan shear loads; RC shear walls with monotonic, staggered and cut-out openings; columns with fiber wrapping and near surfaces mounted reinforcement; beams with dapped end and beams with composites applied with different anchorage systems. In this paper the experimental research results obtained in the last two subjects will be presented.

2. Studies Performed in Dapped Beam Ends Strengthened with FRPs

The research program was carried out in order to study the pre-stressed concrete beam support zone with dapped-ends, retrofitted with different externally bonded FRP composite systems, based on several specific theoretical and experimental investigations. The theoretical calculus for the un-retrofitted elements was made both in the linear and nonlinear ranges, correlated with the results of the strut-and-tie models. The strengthening was designed so as to increase the service load of the dapped-ends by 20%, in terms of displacement and strain level in steel reinforcement, without a significant modification of the stiffness. Within the experimental phase of the program, two full scale dapped-end beams with the same dimensions and internal reinforcement were manufactured for the experimental tests. The dapped-end was reinforced by using horizontal and vertical stirrups. Since the research focused on the dapped beam ends, the mid-span was over-reinforced.

Based on the studies performed, respectively on the behavior of the tested specimens, the following conclusions were drawn:

- The theoretical models used in the study approximate with sufficient accuracy the un-strengthened elements' behavior.

- The FRP systems used for retrofitting the elements proved to be viable for these kinds of

https://doi.org/10.2749/222137908796291903

applications, increasing the service load by 25% to 45% (compared with the reference strain in the steel reinforcement at 800kN), consequently demonstrating the effectiveness of the solutions used. The maximum load bearing capacity of the elements increased with 0% to 11%. Further increase of the ultimate load could have been reached by supplementing the fabric cross-sectional area and by using anchorages for plates.

- Elements strengthened with fabrics failed more ductile compared to those retrofitted with plates. The strengthened elements show a delay in cracking, the failure occurring by peeling-off the horizontal or inclined plates, or by fiber rupture along the main diagonal crack in the case of fabric strengthening.

- With respect to the baseline specimen, the maximum displacement had a very close value for fabric retrofitted elements, but a decreased value, by more than 30%, in the case of plate retrofitted elements.

3. Studies Performed in RC Beams Flexural Strengthening with FRPs

Flexural strengthening of RC beams with FRP composites is a well known field, researches being started in the 80's. Since then numerous theoretical and experimental studies have been carried out, recommendations and design guides were published, and also numerous applications were completed. The objective of this research was to clarify some aspects regarded to the influence of some special anchorage and there influences to the overall behavior of the RC beams subjected to flexure. For this reason several RC beam with different FRP composites retrofitting systems was tested in four point bending test, all designed to reach an appropriate ultimate load bearing capacity. Since the research focused on the flexural behavior, the stirrups was overdesigned to resist for the increased shear forces.

Preliminary dimensioning and detailing of the studied elements were performed according to the Romanian and European standards. The first reference beam (RB) was reinforced with 3ϕ16, while the second reference beam with 2ϕ16 (RB2). The rest of the beams were reinforced with 2ϕ16, and strengthened with different FRP composites systems, which were designed to reach an appropriate ultimate load bearing capacity as the first reference beam (RB).

Based on the performed experiments, respectively on the behavior of the tested specimens, the favorable effects of mechanical as well as chemical anchorage were experimentally demonstrated, both for bottom and laterally applied composites.

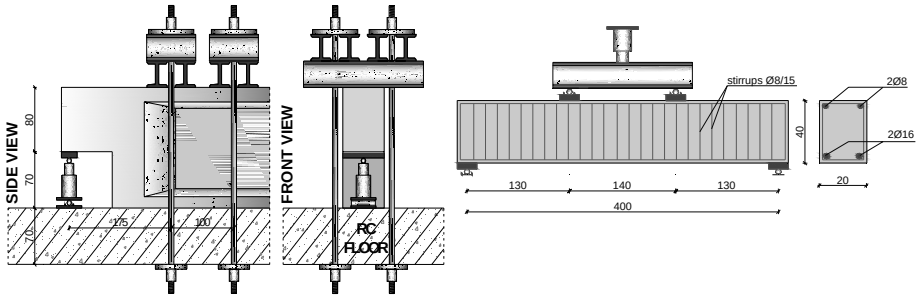

Fig. 1: The specimens loading scheme

4. Acknowledgements

The research works was granted to some extent by the National University Research Council, Romania. The authors would also like to thank SIKA Romania Corporation for the composite systems offered to be used in the experimental tests.