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Performance of textile reinforced concrete retrofitted RC beams under cyclic actions

21

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Project objectives and goals

In the past, many researchers conducted experimental and numerical studies in designing and retrofitting structural members and structures. Meanwhile, the upgrading of novel materials is another advantage because offers the potential for designing sustainable structures efficiently and cost effectively. The main idea of this project is to provide novel knowledge on how to retrofit existing structural beams under cyclic actions in order to upgrade existing structures and codes, with novel materials with potential to replace existing materials. The performance of most common strengthening methods, such as the carbon reinforced polymer (CFRP) method have some drawbacks, such as the high cost and non-friendly environmental behaviour. Meanwhile, even if fibre reinforced polymer (FRP) composites, are very desirable materials because of their properties, such as high strength-to-weight ratio, the adhesive material between FRP and the old substrate concrete is epoxy paste adhesive, which has some drawbacks; some of them are diffusion tightness, poor thermal compatibility with the base concrete, poor fire resistance and susceptibility to UV radiation. In order to avoid these problems, cement based composite systems consisting of FRPs and a cementitious mortar has been used. Meanwhile, the bond of FRP in the cementitious mortar is unable to penetrate and wet individual composite fibres, therefore alternative methods have been developed to improve the enhancement of the bond, by using fabric meshes into cementitious mortar.

One of the solutions proposed for designing cement based strengthening systems for concrete structures are Textile Reinforced Concrete (TRC), consisting multi-axial textile fabrics bonded to concrete surfaces with a fine-grained, high strength concrete. The effectiveness of TRC system was presented by authors such as Brückner et al. (2006), and is widely analysed in the literature. Although many researches were studied monotonic loading conditions, there is a lack in the literature regarding the behaviour of TRC-strengthened RC beams under cyclic loading. One of the main objectives is the evaluation of the performance of strengthened beams in terms of stiffness and strength by measuring the stiffness degradation after each cycle and by hysteretic testing. One of the parameters influencing the behaviour of reinforced members is the shear span-to-reinforcement depth (a/d) ratio which is the distance between the applied load and the support. Another important parameter is energy dissipation capacity, which will be used as a criterion for the measurement of the capacity of a structural member to cyclic inelastic loading or as a damage indicator. Energy dissipation is based on parameters such as reinforcement, configuration of reinforcement, geometrical characteristics of members and therefore empirical formulas are not accurate even if this parameter is important for economical purposes and seismic safety.

Description of methods and results

In this study experimental and numerical investigation will be conducted and the cyclic load will be imposed based on Protocol I-quasi static by FEMA-461 (2007). The size effect is considered by creating full scale rectangular beams with different shear span-to-depth ratio tested until failure. Four beams with a ratio of 2.8 (2m long, 150 mm beam width, 250 mm beam height) will be casted, strengthened by TRC and tested under four-point bending as simply supported beam. Two large beams with shear-span-to-depth ratio of 4.6 (4m long, 250 mm beam width, 350 mm beam height) reinforced with similar way will be compared in terms of size effects. The externally bonded TRC will be plated as a side bonded plate and the amount of TRC, layers and thickness are the same for all the beams. An un-strengthened control beam will be included for both large and short beams for comparisons in terms of energy dissipation. Meanwhile the transverse steel reinforcement will be remained constant in all cases. Regarding the instrumentation, two strain gauges will be placed to steel reinforcements and three will be placed on the concrete. There is a need to locate them in different positions across the section of the member in order to define the location of the neutral axis. More strain gauges will be located in the surface between TRC and concrete for estimating the bond between the materials and displacements will be measured by LVDT's at the middle of the beam. High definition camera will be used to record cracks, deflections and the flexure behaviour for the definition of mechanisms under which TRC strengthened beams reach the failure.

The nonlinear finite element analysis software ANSYS is used as a numerical tool to carry out further investigations such as a parametric study on flexural behaviour of RC beams by following methods known in the literature by Kachlakev and Thomas (2001). Numerical methods will take place in order to develop data useful for safe conclusions regarding the performance of TRC –strengthened beams in terms of energy dissipation.

Potential for application of results

This project will be the basis for conducting data for guidelines regarding TRC-strengthened reinforced concrete beams under cyclic actions. All these data will be useful for engineers who are willing to upgrade existing structures and codes by using knowledge on how to improve the performance of TRC-strengthened reinforced concrete beams. The accuracy of strain predictions of flexural performance of beams will provide the potential for improved design methods to avoid destructive forms caused by natural phenomena which can cause cyclic actions. Estimation of the transition actions from concrete, steel to TRC will be necessary for a better understanding of the strengthened system behaviour. The absence of guidelines on using TRC including the absence on cyclic loading is considered as an important reason for further research on this field.

References

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Further information

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