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Innovative materials and repairing of composite steel-concrete structures

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Project objectives and goals

Using my previous experience with regard to this particular PhD project, the author initially intends to continue to contribute as a student in a dynamic research environment related to strengthening and seismic retrofitting of concrete structures with advanced materials. The author plans to do an extensive study regarding new methods of reinforcing and undertake investigations via experimental work to develop new novel applications of advanced materials. A repair method using composite patches (Rachid et al., 2012) should be used to extend service live and ultimate conditions of composite steel-concrete members, i.e. beams, slabs and columns (Ranzi et al., 2013). As it is known, composite materials have many advantages against the conventional materials. Composite materials have properties like high strength-to-weight ratio and high corrosion resistance, and because of their properties they are desirable materials for most existing applications as retrofitting but also as reinforcing materials. In this research area some parameters could be investigated, including: steel surface preparation for adhesive bonding, which is one of the most common type of repairs carried out with composite materials (Hosseini-Toudeshky et al., 2013); selection of suitable adhesive; bond behaviour between the composite material and the steel-concrete beam and its appropriate modelling; flexural strengthening of steel-concrete beams; fatigue strengthening of steel-concrete beams; and strengthening of thin-walled steel-concrete structures against local buckling (Teng et al., 2012). Most of the above mentioned research areas of the project could be confirmed by experimental data that will verify the arithmetic models. Tools that could be used for this research include software like ANSYS, in order to have an estimation of the interaction of the two materials due to the nonlinear Finite Element Analysis method and also the distribution of damage in adhesive layer under static and cyclic loading. Some expressions should be developed and some comparisons should be done with the wide range of experimental data.

Description of method and results

Bonded composite repairs are preferred because they provide enhanced stress transfer mechanics, joint efficiencies and aerodynamic performance (Katnam et al., 2013). Bonded CFRP (Carbon Fibre Reinforced Polymer) patches provide advantages for fatigue strengthening of steel-concrete structures. There are two types of bonded patches that can be used for repairing a structural damage: the external bonded patches and scarf-type bonded patches. External bonded patches can provide some recovery with respect to the beam's strength and it is an easily implemented method, but scarf repairs offer many advantages compared to external patch repairs. They provide higher stiffness when adapted to the structure by reducing stress distribution in the repaired region, and this method is very common where surface smoothness is essential. It is important that the performance of bonded repair techniques should be assessed under uniaxial tensile loading into specimens with different characteristics and different kinds of repairing materials. A 3D Finite Element Analysis should be performed to determine the field of the stress distribution in the optimum repaired configuration and the results should be compared with the experimental observations (Caminero et al., 2013).

Potential for application of results

The produced test results could indicate the utility of this method, based on the experimental response of steel-concrete members repaired with patches and the experimental data which should be validated by the analytical models. The results of both techniques should be performed and some conclusions about the recovered strength through the scarf repair and damage evolution should be exported in order to identify damage location and extent after loading. It should also be observed that severe degradation of the adhesion leads to failure and it is possible to examine the different kinds of failure modes.

There are also some topics and issues of great importance and special interest for the future including durability of the bonding adhesive, fire resistance of FRP-strengthened steel-concrete structures, strengthening of steel-concrete structures against blast and impact loading, and the use of external FRP reinforcement for combined strengthening and corrosion protection (Teng et al., 2012). The following should be examined: how the long-term composite behavior is affected by the self-compacting and high performance concrete, the identification of the time-dependent properties of the interface between concrete and steel, the influence of time effects on the ultimate composite behavior, the determination of the shrinkage on the long-term deformations and the stiffness of different composite materials and the influence of time effects of the whole structural system (Ranzi et al., 2013).

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