PLASTIC DESIGN OF STEEL ELEMENTS REINFORCED BY CFRP STRIPS

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Summary. Bonding between the adherends represents a key point when dealing with the reinforcement of steel structures by using FRPs [1]. The interface behaviour between the steel and the CFRP and in particular the interaction between the inelastic deformation and the delamination process is worth to be studied. In practical application it is important not only to recover the local strength but also a certain degree of ductility in particular in the seismic design [2]. In this paper methods for plastic design of steel elements reinforced by CFRP strips are then presented and validated experimentally and through numerical analyses.

1 INTRODUCTION

In this paper experimental and numerical results related to steel beams and joints reinforced by CFRP plates are first presented. Experimental tests have been simulated taking into account the elastic-plastic behaviour of the steel and the delamination between the steel substrate and CFRP plates by a cohesive approach. Design criteria are finally proposed for both steel joints and beams reinforced with CFRP strips.

2 MATHEMATICAL MODELLING AND NUMERICAL MODELS

In this paper elasto-plastic debonding strength of double shear lap specimens is first investigated from both the numerical and analytical point of view. An elasto-plastic fracture mechanics approach is used to derive a design formulas taking into account the energy dissipated through plastic deformation in steel joints. A numerical model (cohesive approach) is also proposed and validated through experimental results to simulate the debonding process.

Elasto-plastic analysis are then performed for steel beams reinforced with CFRP strips. An analytical procedure for the evaluation of the tensile stress in the CFRP strips and shear stress in the adhesive layer is proposed. Moreover, failure criteria based on fracture energy is proposed to evaluate the debonding load. Finally, a numerical model (cohesive approach)
similar to the one used for steel/CFRP joints was implemented to simulate the debonding process.

Parametric analysis was also performed to investigate the influence of materials and geometrical parameters on the debonding process.

3 RESULTS

Numerical, analytical and experimental results are presented in Fig. 1 in terms of load-displacement curves. It is shown that analytical and numerical results agree very well also with the experimental findings.

![Figure 1: Typical results for steel joints (on the left) and steel beams (on the right) reinforced by CFRP strips.](image)

4 CONCLUSIONS

Analytical formulas are derived to design steel elements reinforced with CFRP strips. These analytical models are used to evaluate the debonding load in steel/CFRP joints and beams. Results were successfully validated through experimental data and numerical analyses.

Parametric analyses clearly show the influence of the adhesive quality (fracture energy) and stiffness of the CFRP strips on the debonding load of both steel joints and beams reinforced by CFRP strips.

REFERENCES
