Alternate load path method for robust design by ductile steel and composite joints

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Summary

The paper reports briefly on the experimental and numerical investigations of steel and composite joints aiming at the development of semi-rigid and partial-strength joint solutions allowing large deformations and rotations for redistribution of internal forces in the structural system when local damage e.g. “column loss” occurs. Investigations of steel and composite joints with highly ductile behaviour are presented. Thereby special focus is given to the adjustment of the single joint components to ensure a high deformation capacity during pure bending as well as combined bending and membrane exposure.

Keywords: alternate load path method, robustness, redundancy, joint ductility, plastic material reserves, over-strength effects

1. Introduction

The paper highlights the ductility demand of beam-to-column connections in the framework of progressive collapse assessment of framed steel or composite structures considering sudden column loss due to e.g. impact, blast, etc. Depending on the public or commercial relevance of a building today it is no longer sufficient for engineers to consider only basic design criteria for planning of structural framework. Engineers are increasingly being required to consider progressive collapse mitigation as additional design criteria. The new ductile joint solutions are contributing to the redundancy of steel or composite frame structures improving the collapse resistance of the whole structural system due to their beneficial properties concerning energy absorption capacity and ductility supply. The highly ductile and partial-strength joint solutions allow placing the plastic hinges into the joints instead of the former concept to strengthen the joints in order to achieve a development of the plastic hinges in the beams. These ductile joint configurations allow for redistribution of internal forces within the structural system by enabling large deformations so that they are suitable to follow the design strategy of the alternate load path method for progressive collapse mitigation. The alternate load path method is realized in this case by activating plastic system reserves by transition from flexural load to tensile load in the members and joints and initiating of catenary action. Therefore the joints have to be designed in detail and all single joint components have to be adjusted in such a manner that under bending and tensile loading at each time of loading the weakest component has to be always ductile. This is feasible with only small additional effort by using the inherent plastic reserves of the material steel.

2. Alternate load paths as design strategy

2.1 General

There are different design approaches to achieve the mitigation of progressive collapse [14]. One method of achieving this goal effectively is the redundancy approach (alternate load path method).

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