An experimental investigation on base-plate joints of steel storage pallet racks

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Abstract

Adjustable storage pallet racks are framed structures commonly made of cold-formed steel profiles. The performance of these structures is strongly influenced by the beam-to-column and the base-plate joints behaviour. The key role of joints is even more significant in seismic loading conditions. The complexity of their non-linear and non-symmetric behaviour calls for their experimental characterisation both in monotonic and cyclic range. In recent years, attention has been paid to the study of beam-to-column joints, while the knowledge on the base-plate joints response is still quite limited. This gap is even more evident when the cross-aisle (transversal) direction and the cyclic range are considered. The research presented in this paper focuses on the monotonic and cyclic experimental response of a typical rack base-plate joint, tested both in down-aisle (longitudinal) and cross-aisle direction. The main features and outcomes of the study are presented and discussed.

Keywords: Steel storage racks, cold-formed steel, uprights, base-plate joints, cyclic and monotonic tests, experimental tests, cross-aisle and down-aisle directions.

1 Introduction

Adjustable storage pallet racks, widely adopted in the logistic field, are framed structures commonly made of cold-formed steel profiles [1]. The racks behaviour is affected by some peculiar features, such as the use of slender mono-symmetric perforated columns (the so-called uprights) [2] and of semi-rigid non-linear joints (beam-to-column and base-plate joints) [3]. The global stability of storage racks in the down-aisle (longitudinal) direction is typically provided by the sole degree of continuity of joints. In fact, racks are usually braced only in the cross-aisle (transversal) direction, while, in the down-aisle direction, due to logistic reasons, the stability is guaranteed by the semi-continuity of the joints. The key role of the joints becomes even more significant in seismic loading conditions. The response of all joints is non-linear and non-symmetric. In addition, in case of base-plate joints, another issue to be investigated concerns the influence on the joints' global performance of the level of axial load acting on the uprights.

The great variability of joints' geometry and the complex phenomena affecting their behaviour limited the development of general analytical models able to predict the moment-rotation response. In recent years, attempts to apply the well-known "component method" developed for traditional steel connections were made [4]. Although promising results were obtained, it should be stressed that the effectiveness of the proposed formulations is limited to configurations similar to the ones used for the development of these models. As a consequence, the main standards for the design of racking systems [5], [6], [7] adopt the "design by testing" approach, i.e. a mixed experimental-analytical design procedure