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Bending strength of threaded connections for micropiles

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ABSTRACT

The bending strength of pin-box threaded connections for mortar-filled steel tubes used as micropiles is investigated in this paper. An experimental campaign has been carried out, including forty tests subjected to four-point bending until failure. The specimens consisted of mortar-filled steel tubes with a connection at the midsection. The results indicate that the failure mode of pin-box threaded joints is brittle and originates at the root of the last engaged thread of the pin end. Moreover, the bending strength of the connection is significantly smaller than the strength of jointless tubes. The analysis of the results suggests a considerable influence of the size effect, with the bending strength decreasing as the outer diameter of the tube increases. In addition, it is shown that, within the dimensions tested, the bending strength does not increase when the relative threaded length is increased.

1. Introduction

The use of steel tubular sections is widely extended in civil engineering structures, both in grouted or ungrouted elements. Concrete- or mortar-filled steel tubes used in geotechnical applications (e.g. deep foundations or pile walls) are known as micropiles when the outer diameter is smaller than 250 mm. In micropiles subjected to lateral loads, the bending strength is mainly given by the steel tube, while the concrete or mortar filling avoids local buckling of the compressed wall. Since the required length of micropiles is usually too long to be manufactured or transported, connections are needed to join shorter steel tubes, thereby allowing the micropile to reach the depth of competent layers. The most employed systems to join steel tubes in micropile walls consist of threaded connections, which may represent a point of weaker strength along the tube length. In the current engineering practice, the codes for metallic structures do not provide specific recommendations for such connections [1,2] and their design relies on a narrow knowledge based on few experimental results. For example, the Spanish guidelines for micropile design and construction suggest a 50% decrease of the bending strength with respect to the jointless tube unless specific tests for the joint employed are available [3]. In practice, a reduction of the bending strength of about 30% with respect to the elastic moment of the jointless steel tube has usually been considered in Spain, according to a study carried out 10 years ago [4].

A deep study of threaded connections for civil engineering structures is not found in the scientific literature. Most of the existing works deal with drillstring connections for the oil and gas industry and their results cannot be easily extrapolated. This is due to the fact that the loading conditions are significantly different. Drillstrings are mainly subjected to combined torsional and tension/bending loads [5,6]. Moreover, fatigue is commonly the governing design requirement due to the high number of load cycles applied to such elements [7,8]. Finally, the geometry of drillstring connections is more complex than that used in civil engineering. The use of stress relief geometrical details is usual in drillstring joints [9], which is in part due to the necessity of reducing stress concentration factors in order to enlarge the fatigue life.

In order to understand the response of threaded joints under lateral loads, bending tests are to be made focusing on the relevant parameters that may play a role on the in-service and ultimate behavior. A specific experimental study regarding the bending strength of threaded connections for micropiles, carried out at the Technical University of Madrid, Spain, has recently shown the different behavior of the two most extended connection types [10]. On the one hand, specimens assembled from pin- and box-ended tubes were tested, which showed brittle failure and strength reduction with respect to jointless tubes. On the other hand, a system consisting of an external coupling with inner box threads externally applied to join two pin-ended tubes was also tested, which did not show strength reduction but limited ductility dependent on the joint geometry. Even though the use of external coupling provides the full strength of the jointless tube, the pin-box system has other advantages, such as the lower weight or the ease and quickness of installation. A view of the on site installation of pin-box joints is given in Fig. 1. The whole tube length is achieved after subsequently screwing shorter sections to each other. Pin and box ends are joined together until their shoulders contact. The small place needed makes this system especially suitable for urban or difficult

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