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NUMERICAL STUDY OF THE ROBUSTNESS OF STEEL STRUCTURES WITH FRICTION JOINTS

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ABSTRACT

This paper presents finite element analysis on *Abaqus Software* of a steel frame equipped with friction joints subjected to a static load and to a vehicle impact, in one of its external columns. The force-time histories were determined considering the loading patterns found on the experimental impact tests conducted on the joint and on the friction damper (Santos, *et al.* 2017).The behaviour of the friction joints was included in the model by a slot-rotation spring. For the impact analysis, the effect of high strain rates on the materials constitutive model. The numerical simulations are used to predict the structural robustness of a steel frame under exceptional loading conditions with the studied connections types. Furthermore, the behaviour of the frame with friction joints is compared with the behaviour of the same frame with rigid joints.

Keywords: impact load, robustness, friction joints.

INTRODUCTION

The interest on the study of robustness of structures subjected to accidental loads (as blast or impact) have grown after the collapse of the Ronan Point apartment tower in 1968. After the World Trade Centre disaster in 2001, the behaviour of beam-to-column connections have been highlighted as a critical parameter in maintaining structural integrity when subjected to severe loads. Since then, several research works have been developed on the robustness design of structures and on the behaviour of steel beam-to-column joints when subjected to extreme loads, as blast and impact (Ribeiro *et al.*, 2016), (Fu *et al.*, 2016), (Yang and Tan 2012), (Nethercot, 2011).

In this paper, the static and dynamic structural robustness of a steel frame equipped with friction joints is studied. Furthermore, its behaviour is compared with the behaviour of the same frame with rigid joints. These analyses are carried out with the ABAQUS software (Abaqus, 2011).

As a first analysis, two-storey 2D frame equipped with friction joints and with rigid joints have been subjected to a static load in one of its external columns. The beams are IPE220 and the columns HEB220, all in S275JR steel.

The beams and columns are modelled using B31-two-node linear beam elements available on ABAQUS library. The friction joint and rigid joint are modelled using a slot connector and a tie connector, respectively, via the ABAQUS library. Furthermore, the load has been applied by means of a smooth amplitude function to ensure a quasi-static loading using a dynamic explicit procedure.

PRELIMINARY RESULTS

In Table 1 is reported the maximum horizontal displacement, maximum beam deflection and maximum stress found for the frame with rigid joints and semi-rigid friction joints. The results underline the importance of a correct modelling of the beam-to-column connection behaviour in the assessment of the structural behaviour of a frame. Moreover, at the end of the analysis, stresses in the beam are less for the frame with friction joints. On the other hand, the maximum horizontal displacements are significantly higher.

This behaviour is due to the particular behaviour of the friction joints. The slippage of the friction damper up to the stroke end makes possible to obtain an increase of the vertical component of the beam axial forces resulting from the catenary actions after column loss due to the ability of the friction damper in accommodate the required displacements without any damage. In this way, an improvement of the structural robustness of the frame under exceptional actions can be expected.

Table 3 - Maximum displacements and stress

Joint type	**Maximum horizontal displacement [mm]**		**Max Beam stress [Mpa]**
	1st story	**2nd story**	
Friction joint	8	16	36
Rigid	3.2	4.48	137

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