

NUMERICAL FINITE ELEMENT MODELLING OF A BOLTED JOINT

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ABSTRACT

Steel connections are an important component of any structural steel building as they provide links between the principal structural members. The steel structure collapse may be consequence of failure of the joints; therefore the evaluation of steel connections is an important topic.

The experimental investigation in laboratory is expensive and it takes a long time to carry out an experiment, furthermore the real conditions are difficult to reproduce with enough accuracy. Therefore the numerical modelling using advanced software is a vital resort to study the steel connections. The comparison between numerical models and available experimental data let us validate the models to do analytical and parametric studies of the joints investing less time and cost.

Particularly, the bolted lap joints are easy to fabricate and install; as a result, they have gained popularity because of their economy. The symmetric double lap joint subjected to double shear has been investigated in this research; therefore a highly detailed 3D finite element model has been created using the ABAQUS software. This is a complex model accounting for material nonlinearity, large deformation and contact behaviour. Contact is critical to model the shear behaviour of the joint. The connection model has been analysed through the elastic and plastic behaviour.

Comparison of the numerical model results with the available experimental data shows high level of accuracy and it has been used to reproduce the steel connection behaviour to do a parametric study. Furthermore, a comparative study between the numerical model and the regulations has been done. The regulations DB-SE-A, EAE and EN 1993 were studied during the creation of the finite element model.

The parametric study consists of analysis the influence of the bolt ductility and the steel plate strength and thickness in the global behaviour of the steel connection. Therefore, an external load is applied until the failure of the model for every case. Bolt shear and bending, and plate and web bearing have been observed as failure modes.

The comparative study between the regulations and the numerical finite element model have shown a high affinity between both methods, in the failure load of the steel connection and in the failure mode observed in any case. The results show that bolt ductility is an important parameter for joints with large thickness of the plates because the bolt shear and bending is the failure mode. Nevertheless, steel strength of the plates is more relevant in steel connections with small thickness of the plates because the failure mode of the joint is the plate and web bearing.

Although the affinity between the results of the regulations and the numerical model is high, the regulations do not use some parameters which influence in the global behaviour of the steel connection because they are limited for their equations, nevertheless with the finite element models is possible to assess the influence of any parameter. Therefore, the use of validated and calibrated numerical finite element models is a useful tool to study the steel connections and improve the regulations, because a better knowledge of the behaviour of the joints would let reduce the safety coefficients to optimize their use.