Abstract: The application of data-driven methods in assessing and modelling extended endplate connections

Zizhou Ding

University of Southampton

Project objectives and goals

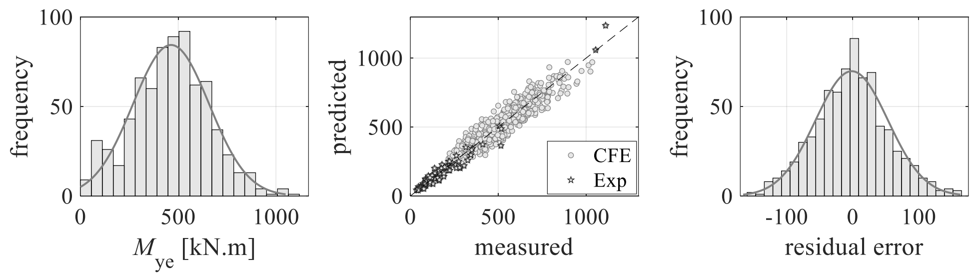
Extended endplate connections (EEPCs) are widely used in practice to connect beams and columns as part of the wind/seismic design of moment-frame buildings. These connections are designed as either fully rigid (FR) or semi-rigid (SR). The moment-rotation response and deformation mode behaviours of EEPCs are complicated. This is mainly dependent on the rigidity classification and the complex interactions between each component, such as the endplate, column flange, and column web panel zone. Several studies have investigated EEPCs' moment-rotation response and deformation modes (CEN, 2005, Kozlowski et al., 2008, Eatherton et al., 2021). However, these existing models do not always provide reliable predictions and cannot predict the full-scale EEPCs' behaviour. This is mainly attributed to the limited numbers of predictors, small datasets (limited applicability range), or non-generalised assumptions. This paper aims to address the problems above using a comprehensive database and advanced numerical methods. The research's objectives are as follows:

- Develop a comprehensive multi-attribute experimental database for the bare steel EEPCs.
- Develop robust numerical models for predicting the full-scale moment rotation response and deformation mode of EEPCs.

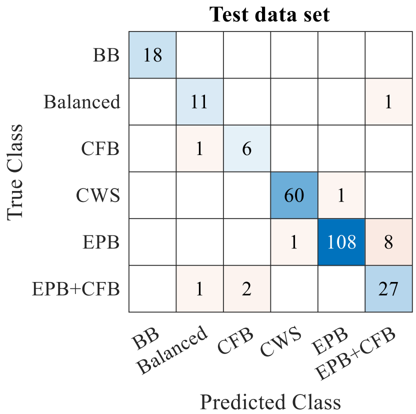
Description of method and results

A comprehensive database with over 800 specimens was established as the data resource for developing the predictive models for EEPCs. This database includes multi-attribute parameters, mainly the test/specimen attributes, geometrical properties, material properties, and reported deformation modes. For EEPC's moment-rotation response, several targeted parameters need to be predicted, which are the elastic stiffness (K_e), plastic strength (M_{ye}), ultimate strength (M_u), and maximum rotation (θ_c). A bilinear curve was used to present the full-scale EEPC's behaviour with the target predicted parameters. The target response parameters were predicted by training the multiple linear regression (MLR) and artificial neural network (ANN) models. The developed models can provide an accurate and robust prediction with a P_{20} larger than 0.9, see an example of the unstiffened EEPCs in **Fig. 1 (a)**.

Several primary deformation modes were determined for EEPCs, which include endplate bending (EPB), column flange bending (CFB), panel zone in shear (CWS), and beam buckling (BB). The random forest (RF) model was trained to predict the determined primary deformation mode of EEPCs. The trained RF model can reach an accuracy of over 90%, see the performance of the testing set in **Fig. 1 (b)**. To ensure the robustness and reliability of the developed RF model, the probability of each primary deformation mode was also predicted. This can address the issues caused by material uncertainty and geometrical imperfection.



(a) Example of M_{ye} prediction of the MLR model for unstiffened EEPCs



(b) Confusion matrix of the RF model for the EEPCs with the testing set

Fig. 1 Model performance of the MLR and RF model for EEPC

Potential for application of results

The developed models can effectively predict the moment-rotation response and corresponding deformation mode of an EEPC. This can be used as the part of the performance-based design to assess the acceptable design criteria.

References

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