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Investigation the Behavior of Beam to Column Connection with Flange Plate by Using Component Method

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Abstract: Study destructive earthquakes which have occurred in recent year's shows that beam to column connection are the main component of force transmission and also play a vital role in stability of structure; such failure of these connections could lead to the destruction of structures. In current study, the behavior of beam to column steel connection with flange plate was studied by using component method. The correctness of results was examined by comparing the moment-rotation curve of beam to column connection with flange plate under monotonic loading which was obtained by component method and experimental method. Studying the result shows that moment-rotation curve which was obtained by component and by experiments method are reasonably close to each other. Therefore, it could be concluded that this component method is an appropriate tool for studying the behavior of this connections.

Key words: Beam to column connection · Moment-rotation · Component method · Flange plate

INTRODUCTION

Structural connections moment-rotation curve represents an important feature of their responses. Because structural connections were designed more rigid or hinge in the past, necessity of the estimation of non-linear behavior of connections was not such important nowadays. There are reasonable methods for the evaluation of the connections strength and their initial hardness, but there are not suitable methods with same level for the other features of their responses such as rotational capacity or (M-θ) curve if these features could be estimated reliably, a series of significant advances would be achieved in structural design. Some suggestions in order to estimate these features are illustrated in references [1-4].

In component method, each of the deformation mechanisms in connection is specified and their rigidity is determined individually in each element by performing experiment or by regulations. The rigidity of these components is modeled by linear or non-linear springs and the set of these springs are assembled in series or parallel for determining the rigidity of connection. In this method, (M-θ) curve is obtained by computer programs and finite element software. Therefore, mechanical modeling selected in an acceptable from to estimate the non-linear response of connection and also to calculate (M-θ) curve. The advantage of this method is its flexibility in adaption with different connections. In these cases, the problems of connection response estimation are converted to correct components and then it is converted to calculate the unique responses [5-7].

Here, beam to column connection with flange plate is studied by component method. First, considered sample was modeled using component method and monotonic loading was also applied. Then for the evaluation of obtained results, an experimental sample was manufactured with similar specifications and in laboratory of Babol Noshirvani University of Technology, monotonic loading was applied to sample. The results of laboratory tests were used in order to determine the correctness of component method modeling. Main objective of component method is to simulate the behavior of moment-rotation curve of beam to column connection with flange plate under monotonic loading.

Component Method: Due to the problem in conducting empirical test on connection sample, an interesting method was recently proposed by European regulations for determination of the rigidity of connection, which is

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called component method. In this method each of the deformation mechanisms in connection is determined and also their rigidity is specified by conducting experiment or by regulations in each element. The rigidity of these elements is modeled by using linear or non-linear springs and this spring's set are assembled in series or parallel. In current method, (M-θ) curve is obtained by computer programs. Element-based modeling is a general agreement between overall modeling and finite element modeling.

In order to increase the accuracy and conformity, this method profit from the non-linear structural relations of element instead of too many elements. In element-based method, modeling is performed as a macro element with a combination of rigid rod and springs which represent and element constructive relation. Element-based methods used a combination of rigid elements and flexible spring which could show source of the deformation of an individual element. Elements are usually modeled mechanically by using geometric features and material properties. Eurocode3 was the first regulation for adapting components concept in order to determine the properties of connections deign. Although the prediction of complex response of hysteresis still has remained as a challenge. All of the mathematical models are idealized based on mechanical features in some parts. Idealization maybe leads to the elimination of some aspects of mechanical behavior which are maybe significant in mathematical presentation. Eurocode3 hardness model has been studied as main model [8, 9]. Nomenclature of each component is shown is Table 1. Considered model also is presented in Figure (1).

Because the model is used for estimation of initial hardness of connection, only hardness value is necessary for each of its components. Although model could be developed for estimation of the (M-θ) complete curve, but it is necessary to be presented a suitable F - Δ curve for each element [10, 11]. Due to slip components and being elliptical screw holes and some other reasons in cyclic loadings and complexity of modeling these components in component method, monotonic loading.Has been studied in this project. Beam to column connection response could be described using T-stubs connections which are used to model their tensile zones components.

In such connections, beam is connected to column by flange plate. These plates are welded to column but their connection to the beam occur using bolt screws. This welding has no contact consequence but screwing flange plate to the beam plate leads slip effect and displacing effects. In this connection, column plates

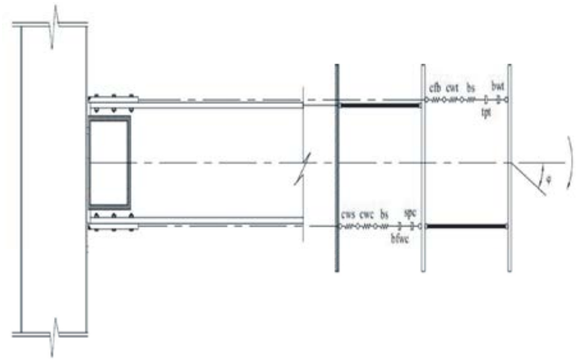

Fig. 1: Suggested Eurocode3 model for connection with flange plate

Table 1: Nomenclature the various components used in the component method

Abbreviation	Component	Abbreviation1	Component
Column web	cws	Seat plate in	spc
Panel in shear			Compression
Column web	cwc	Top plate	tpt
In compression			in tension
Column web	cwt	Bolts in	bs
In tension			Shear
Column flange	cfb	Beam web	bwt
In bending			In tension
Beam flange/web			bfwc
in compression			

welded to top plate both together constitute equivalent T-stubs. There are two kinds of equivalent T-stubs for the connections with flange plate:

- Equivalent T-stubs which composed of upper web sheet connection by welding to column web
- Equivalent T-stubs which composed of column plate and its web or column web with hardening plate in tensile zone.

First objective of T-stub model is simulating appropriate T-stubs component in beam to column connection tensile zone. In component method, various individual components are collected from connection in order to create a mechanical model. Each member is shown as a tensile spring which could connect to other springs or rigid element. In order to generate better deformation sources and forces transmission that occurs in real connection. Selecting the component and the way that they are connected are so important factors for the validity of each mechanical model and also for its ability to simulating plasticity and transmission forces. The main objective of modeling is calculation (M-θ) curve of connection or descriptive characteristics of resistance,

Fig. 2: Connection experimental model

Table 2: Consumed materials and geometric specification of model

Beam Section	IPE200
Column Section	IPB180
Beam Top-Flange Plate	PL160×100×15
Beam Bottom -Flange Plate	PL160×120×10
Doubler Plate	PL190×140×10
Stiffener Plate	170×130×8
Diameter Bolts	16

initial rotational hardness and rotational capacity. Various mechanical models were suggested for connections in the past. [3-5, 12, 13]

Experimental Studying: According to the obtained results by using component method, it was decided to study analytical results with conducting one test. Common method for determining (M-θ) curve is performing test on the connection. In order to plotting (M-θ) curve, bending moments were measured directly using applied static loading on the sample and rotational angles were measured according to the beams transmission toward its depth. For this purpose,

Model which was studied by component method was made in the laboratory of Babol Noshirvani University of Technology for conducting experiments in 1:1 scale. For making sample, first required sections were performed in laboratory. Due to non-reliability of welding in Laboratory required weld were conducted in factory. Flange plates were welded to the column flange by E7018 electrodes and also others were welded by E6013 electrodes. To investigate the moment-to-moment behavior of connection, incremental nodal load was applied in connection. This incremental modal load continues until weld cracked and also failure occurs in connection. Type of consumed materials and geometric properties of connection are both illustrated in Table 2. Experimental connection model is presented in Figure 2.

RESULT AND DISCUSSION

Here, performance of the component method for beam to column connections with flange plate was evaluated against experimental results. For the first time in order to prepare mechanical models, a specific program was developed which generate automatically. A model with sparing and rigid suitable elements. Final model was solved and (M-θ) curve of the connection was derived from obtained results. Matlab software package was used for analyzing. For springs in tensile zone corresponding to T-stubs components, F-Δ curve was calculated using T-stubs model. All of the required geometrical data for calculating are directly achieved from geometrical properties, expect equivalent width of T-stubs which was associated to non T-stubs elements also was evaluated in mechanical models. Elastic response for all hardness components was calculated for estimating initial hardness and their resistance by using Eurocode 3 relations. Figure 4, shows (M-θ) curve under monotonic loading and also suggested mechanical model. Generally mechanical models are reliable in order to predict (M-θ) curves and also they are able to estimate the initial hardness and connections resistance, effectively. The proposed model proves that is performance is quite satisfactory. Mechanical models performance shows a satisfactory prediction of actual (M-θ) curves. The existing deference's are due to defects and non-appropriateness and residual stress which are related to experimental setup which could not be easily imported in computational models. The effects of these factors could be very significant in initial hardness values [14-16].

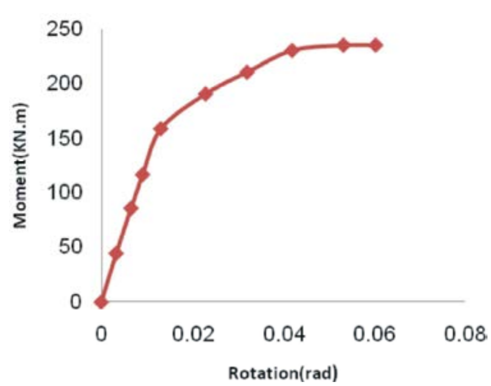

Fig. 3: Moment- rotation curve for component method

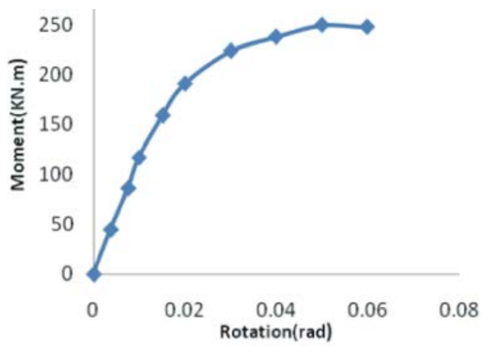

Fig. 4: Moment- rotation curve for experimental sample

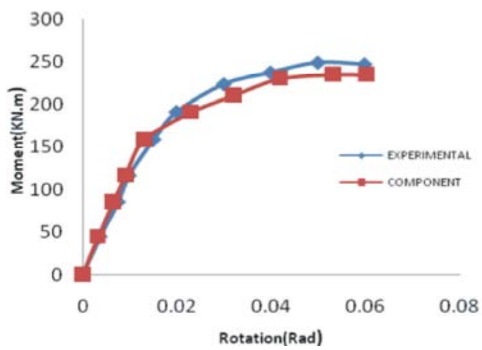

Fig. 5: Comparison of moment-rotation curve for component method and experimental sample

CONCLUSION

In this study, moment-rotation behavioral was of beam to column steel connection with flange plate was studied by component method and the correctness of component method was investigated by using experimental sample. Comparing obtained results from component method and experimental tests have shown that in elastic linear zone, adaption is in a large extent but with entering to non-linear zone, curves were separated from each other and component method resulted in a more conservative result that test method. With comparing obtained results, the derivation between component method and experimental sample could be justified as fallowing which do not considered in component method:

- Slip of screw bolts
- Elliptical screw holes
- Non-linear relation between materials

Consequently, it could be concluded that component method has an acceptable accuracy in behavior parameter making of these connections and also using this method could decrease heavy volume of calculations and also the experimental trial and error amount which finally, reduces the overall cost of study and project.

REFERENCES

1. Abdollahzadeh, G., S. Gharavi and S.M. Hashemi, Study the moment-rotation curve of beam to column connection with sheets using mathematical method and comparing with experimental results, 3th National Conference on Structure and Steel.
2. Shi, Y.J., S.L. Chan and Y.L. Wong, 1996. Modeling for moment rotation characteristics for end- plate connections.Journal of Structural Engineering ASCE, 122(11): 1300-1306.
3. Silva, L.S. and A.M.G. Coelho, 2001. A ductility model for connection Journal of Constructional Steel Research, 57(1): 45-70.
4. Coelho, A.M.G. and L.S. Silva, 2005. Ductility analysis of end plate beam -to-column joints. In: Hoffmeister B, Hechler O, editors. Eurosteel _ 4th European conference on steel and composite structures.
5. Frye, M.J. and G.A. Morris 1975. Analysis of flexibly connected steel frames. Canadian Journal of Civil Engineering. 2: 280-291.
6. Krishnamurthy, N., H. Hung, P.K. Jeffrey and L.K. Avery, 1979. Analytical M_ Curves for end - plate connections. Journal of the Structural Division ASCE. 105(1): 133-145.
7. Wu, F.H. and W.F.A. Chen, design model for semi-rigid connections. Engineering Structures 190(12): 88-97.
8. CEN _ Comite Euro peen de Normalisation. Euro code 3. 2003. Design of Steel structures-part 1.8. Design of joints. Stage 49 Draft.
9. Weynand, K.M., J.P. Jaspart and M. Steenhuis, 1995. The Stiffness model of revised Annex J of Eurocode3. In: Bjorhovde R, Colson A, Zandonini R, editors. Connections in Steel Structures III_ proceedings of the 3rdinternational workshop on connections in steel structures.
10. Minas, E. and C.J. Gantes, 2009. Mechanical modeling of the nonlinear response of beam to column joints. Journal of Constructional Steel Research, pp: 879-890.
11. Del Savio, A.A., D.A. Nether Cot, P.C.D.S. Vellasco, S.A.L. Andradec and L.F. Martha, 2009. Generalised component -based model for beam to column connections including axial versus moment interaction Journal of Constructional Steel Research, pp: 1876-1895.

12. Huber, G. and F. Tschemmernegg, 1998. Modeling of beam - to - column Joints. Journal of constructional Steel Research, 45(2): 199-216.
13. Krishnamurthy, N. and D.E. Graddy, 1976. Correlation between 2-and 3-dimenesional finite element analysis of steel bolted end-plate connections. Computers and Structures, 6(4-5): 381-389.
14. Bursi, O.S. and J.P. Jaspart, 1997. Calibration of a finite element model for isolated bolted end-plate steel connections. Journal of Constructions Steel Research, 44(3): 225-262.
15. Zoetemeijer, P., 1974. A design method for the tension side of statically laded, bolted beam to column connections. Heron, 20(1): 1-59.
16. Packer, J.A. and L.J. Morris, 1979. A limit state design method for the tension region of bolted beam column connections. The Structural Engineer, 55(10): 446-458.