I-A 368 CONNECTION STIFFNESS IN BRACED AND UNBRACED FRAMES

R. Hasan M. JSCE, Muroran Institute of Tech.
N. Kishi M. JSCE, Muroran Institute of Tech.
Y. Goto M. JSCE, Nagoya Institute of Tech.
W.F. Chen M. ASCE, Purdue University, U.S.A.

1. INTRODUCTION

Among all modern specifications, the most systematic connection classification system was introduced in Europe in EC3 (1992) code by providing explicit boundary lines among the three connection categories: (i) rigid, (ii) semi-rigid, and (iii) flexible connections. For demarcating boundary line between rigid and semi-rigid connections, EC3 recognizes a wide variation of semi-rigid action of connections depending upon the type of frames such as: braced and unbraced frames and provides two different boundary lines (Fig. 1.). The apparent logic used here is that the additional frame rigidity achieved by bracing an unbraced frame will have a significant contribution to a rigid connection's stiffness. From the geometrical representation, the initial connection stiffnesses for the corresponding frames can be easily calculated and are shown in Table 1. In the limiting case, as per EC3 classification system, a connection which serves the purpose of a rigid connection in a braced frame must be 25/8 times stiffer to serve the same in an unbraced one. This study is aimed to investigate the validity of this proposition.

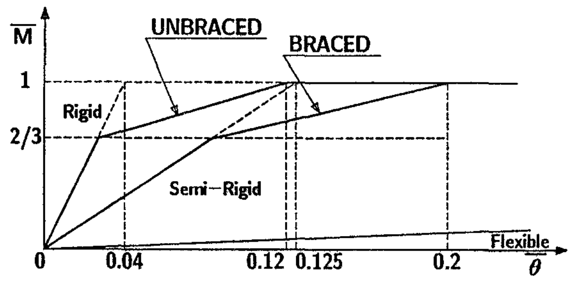


Fig. 1. EC3 classification system

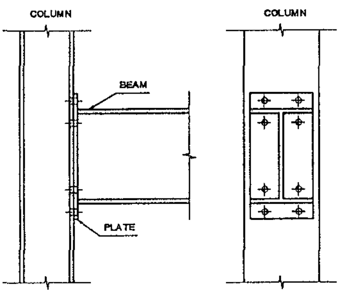


Fig. 2. End-plate connection

Table 1. Initial stiffness of connections

Initial Connection Stiffness (R_{ki})	Frame type	
	unbraced	braced
minimum R_{ki} of a rigid connection or maximum R_{ki} of a semi-rigid connection	$R_{ki} = \frac{25EI}{L}$	$R_{ki} = \frac{8EI}{L}$

2. FRAME ANALYSES AND RESULTS

Extended end-plate connections, a typical of which is shown in Fig. 2, are commonly used to sustain high moment and are generally regarded as rigid connections. A total of 112 experimental moment-rotation curves of this connection stored in the updated data base (Hasan et al., 1995) are utilized to determine the experimental minimum initial connection stiffness of a rigid connection both for braced and unbraced frames. A one-bay two-story frame is used for frame analyses (Fig. 3). Lateral wind forces (P) are applied for unbraced frame analyses, while for braced frame analyses, the wind forces are assumed not to be acting on the frame (i.e., P=0). Beam and column sections, floor heights and beam spans used in this study are shown in the figure. Element nos. are shown in boxes while node nos. are shown in circles. The frame is loaded with 68 and 40 psf load as floor dead (D) and live (L) load, respectively. The intensity of roof dead (D) and live (L), and wind (P) loads are of equal magnitude: 20 psf. Frame moments are obtained for factored load combination (1.2D+0.5L+1.3P), as per AISC-LRFD specification. The frame spacing is taken as 300 inch. Calculated frame responses for real connections are normalized by the corresponding values for fully rigid connections i.e.,

$$\text{normalized moment},\ m^* = \frac{\text{end moment for extended end-plate connection}}{\text{end moment for fully rigid connection}}$$

Normalized end moments m^* are then plotted against initial connection stiffness R_{ki}. Relative locations of the data correspond to EC3 classification systems are also shown in these figures by black star.

Two illustrative examples of braced and unbraced frame analyses are shown in Figs. 4(a) and (b), respectively and a tabulated interpretation is shown in Table 2. Even though, more dispersibility of m^*-$\log_{10}R_{ki}$ data is observed in case of unbraced frame than the case of braced one, no significant difference can be noticed. If the bracing effect on rigid connection's stiffness were significant, as EC3 asserts, there would have been an overall left-ward shifting of the distribution pattern from the case of unbraced to braced one. Rather, one common distinct observation in both figures can be made from the $m^*-\log_{10}R_{ki}$ distribution patterns is that: almost all data are clustered in the vicinity of $m^*=1$ when their $\text{Log}_{10}R_{ki} \geq 6$. This observation is found valid for all cases (i.e., for all nodes of both frames analyzed). Therefore, contradicting EC3 classification proposition, this leads to a general conclusion that: the minimum initial connection stiffness R_{ki} for a rigid connection in both braced and unbraced frames can be assumed to be the same (10^6 kip-inch/radian).

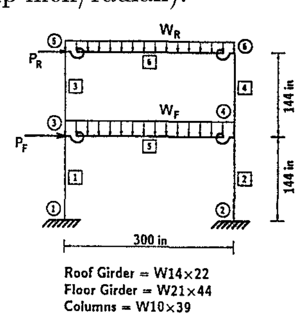
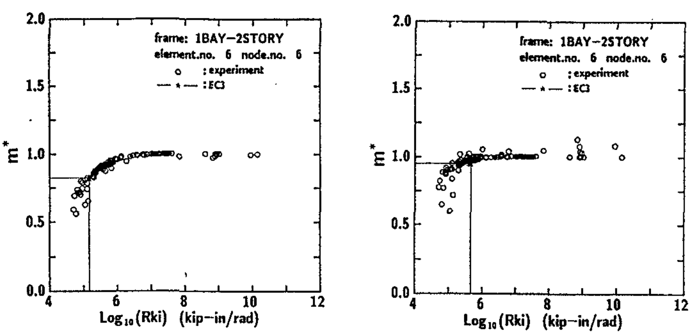


Fig. 3. 1-bay 2-story Frame



(a) braced frame (b) unbraced frame

Fig. 4. Result of Frame Analyses

Table 2. R_{ki} and m^* in the illustrative examples (Figs. 4(a) & (b)) for moment analysis

Frame Type	Node	Beam	Min. R_{ki} of a rigid conn. in kip-in/rad.		m^*	
			Present study	EC3	Present study	EC3
Braced	6	W14×22	1.0×10^6	0.1539×10^6	1.0	0.821
Unbraced	6	W14×22		0.4809×10^6	1.0	0.948

3. CONCLUSION

While EC3 recognizes significant frame bracing effect on the stiffness of a rigid connection, this study avers that EC3 proposition does not hold true and is an exaggeration.

4. REFERENCE

1. EC3 Code (1992), Design of Steel Structures, Part 1.1, European Committee for Standardization, CEN, Brussels.
2. Hasan, R., Kishi, N., and Matsuoka, K.G. (1995), "Updated data base: Study on end-plate connection's rigidity," Proceedings of ASCE-EMD Specialty Conference, University of Colorado at Boulder, USA, Vol. 2, 1350-1353.