Comparative Study of a Moderate Story Steel Structure based on Chinese, Japanese, European and American Building Codes

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Abstract

Following the author's previous study, four design codes, Japanese (ASD-2005), Chinese (GB50017-2017), European (Eurocode 3) and American (AISC 360-16) codes, are compared on the regulations and corresponding seismic provisions of steel structures. The allowable stress design method is adopted in the Japanese code, while the limit state design method is adopted in the other three codes. In Japan, two-phase design procedures were adopted from 1981. In the first phase design, to the medium seismic event, the members are checked elastically to the allowable strength against the gravity load and the seismic load. In the second phase design, to the severe seismic event, story drift, vertical stiffness distribution, horizontal eccentricity and ultimate lateral load carrying capacity are confirmed by the static push-over analysis. The design methods, load combinations, beam and column strength calculation formulas and weak beam/strong column (WBSC) philosophy check procedures are compared first. Then, a H-shaped beam and a cold-formed box column selected from a six-story steel moment-resisting frame designed according to the Japanese code, are analyzed to investigate the difference among the design codes. The earthquake spectra in Eurocode 8 and ASCE7, having a return period of 475 years are considered the same as those in Japanese and Chinese codes after considering the Response Modification Coefficient *q* or *R*. For the given design example, the ratios of load to resistance by Japanese code give the most severe result for both beam and column. Results by European and American codes are almost same. In the weak beam/strong column (WBSC) philosophy check procedures, the beam moment strength calculated by American code has the maximum value. Thus, one beam-column connection judged OK by the other three codes, was judged NG by American code.

Keywords: Steel structure, Design code, Design strength, weak beam/strong column, connection

1. Introduction

With the activity in the overseas construction market, Japanese structural designers are required to understand European and American design standards more and more. Continuous efforts on the international standards and guidelines, international standardization of construction materials, and mutual approval of engineer qualification systems (APEC Engineer etc.) have been paid persistently. The structural designers have to understand the design code well to make a judgement by considering what the performance target is and if the design procedures follow the design code appropriately.

In the previous studies [1,2], the authors have compared Japanese (ASD-2005)[3], Chinese (GB50017-2017)[4] building codes where the members' (column and beam etc.) strength is checked by a small seismic event having about 50 years return period. In this paper, European (Eurocode 3) [5] and American (AISC 360-16) [6] codes are compared together, where the members' stress is checked by a large seismic event having about 475 years return period. Only by considering the Response Modification Coefficient *q* or *R* in European and American codes, can the four codes be compared together. At first, design methods, formulas and load combinations of gravity load and seismic load are summarized. Then, design formulas for beams in flexure and shear and columns in axial compression and bending are compared. The strength reduction factors of the column in axial compression are summarized then. The weak beam/strong column philosophy is one of important concepts in aseismic design of buildings. The check procedures are compared together, although only Cold-Formed Square Steel Columns structure in Japanese code has to be applied. The same building introduced in the previous papers are used to demonstrate design procedures of column and beam. The weak beam/strong column (WBSC) philosophy check procedures are shown at last.

2. Design methods, load combinations and strength formulas

2.1 Design methods and load combinations

The design methods, formulas and typical load combinations are summarized in Table 1. In the structural design, there are usually members' strength check and story drift check. This paper will focus on the members' strength check, which is conducted on the gravity load and seismic load, respectively. By considering the Response Modification Coefficient q or R used to consider the ductility property in European and American codes, the four codes can be compared together. To consider the different seismic action level, following lateral acceleration response spectra relation is assumed in the design study.

$$S_{a,jp,50} = S_{a,cn,50} = S_{a,EU,475}/q = S_{a,US,475}/R \tag{1}$$

In the allowable stress method, the strength is directly compared with the load without any load factor. The strength safety factor in the seismic load is 2.0 and 1.5 times of that in the gravity load for concrete and steel, respectively in Japan. In the limit state method, there are many safety factors for material strength and load combinations by considering load factors statistically as shown in Table 1.

Table 1 – Comparison of the design methods, formulas and typical load combinations

Design code	**Design method**	**Design formulas**	**Load combination**	
			gravity load	**seismic load**
Japan[7]	Allowable stress method	$S_\mathrm{d}(\square) \le R_\mathrm{d}(f_\mathrm{y}, a_\mathrm{d})$	D+L	D+L+E
China[8]	Limit state method	$\gamma_0 S_\mathrm{d}(\square) \le R_\mathrm{d}(f_\mathrm{y}/\gamma_\mathrm{M}, a_\mathrm{d})$ seismic:$\gamma_0 S_\mathrm{d} \le R_\mathrm{d}/\gamma_\mathrm{RE}$	1.3D+1.5L	1.2(D+$\gamma_\mathrm{EG}L$)+1.3E_{50}
Eurocde[9]		$\gamma_\mathrm{I} S_\mathrm{d}(\square) \le R_\mathrm{d}(f_\mathrm{y}, a_\mathrm{d})/\gamma_\mathrm{Mi}$	1.35D+1.5L	1.0D+$\psi_{2\mathrm{i}}L$+1.0E_{475}/q
America[10]		$I_e S_d(\square) \le \emptyset R_\mathrm{d}(f_\mathrm{y}, a_\mathrm{d})$	1.4D 1.2D+1.6L	1.2D+f_1 L+ψE_{475}/R

Formula in $S_\mathrm{d}(\square)$: $\gamma_\mathrm{D} D + \sum_{i=1}^{n} \gamma_{\mathrm{L}_i} L$; γ_0, γ_I, I_e :important factor; γ_M: partial factor for a material property; γ_RE, γ_Mi, ϕ:partial factor for strength of members or joints; D:dead load E:seismic action, where subscript 50 or 475 means return period; L:live load γ_{EG}, ψ_{2i}, f_1: combination factor.

2.2 Column and beam's strength

Comparison of design formulas for beams in flexure and shear is shown in Table 2. The formulas are almost same in all codes. But in Japanese and Chinese code, the elastic section modulus Z_e is used comparing with the plastic section modulus Z_p used in European and American codes. In Chinese code, there is a plastic adaption coefficient γ accounting for the plastic developing state. In AISC, ϕ_b=0.9 (resistance factor for flexure) and ϕ_c=0.9 (resistance factor for compression) are used to reduce the material strength in flexure and compression, respectively. In AISC and EC3, C_v(web shear coefficient) is used to consider the strength reduction depending on the slenderness in shear.

Comparison of design formulas for columns in axial compression and bending is shown in Table 3. Two parts formulas are used in all codes, accounting for axial compression and bending, respectively. The strength reduction in axial compression is expressed as a function of the non-dimensional slenderness $\bar{\lambda}$ shown in Table

4 and Fig.1. It can be seen from Fig.1, there is only one formula in Japanese and American codes, while there are several formulas in Chinese and European codes, which are classified by width-to-thickness ratio, section direction and manufacturing process etc. Class EC3_a is almost same with class GB50017_a, which are slightly larger than AISC360. Class EC3_b is almost same with class GB50017_b and AIJ-ASD.

Table 2 – Comparison of design formulas for beams in flexure and shear

Design code	**In flexure**	**In shear**
AIJ-ASD	$M_\mathrm{x}/(fZ_\mathrm{ex}) \leq 1.0$	$\sqrt{3}\,Q_\mathrm{x}/(ht_\mathrm{w}f) \leq 1.0$
GB50017	$M_\mathrm{x}/(\gamma_x fZ_\mathrm{ex}) \leq 1.0$	$\sqrt{3}Q_\mathrm{x}S/(It_\mathrm{w}f) \leq 1.0$
EC3	$M_\mathrm{x}/\left(f/\gamma_\mathrm{M0}\,Z_\mathrm{px}\right) \leq 1.0$	$\sqrt{3}\,Q_\mathrm{x}/(A_\mathrm{w}fC_\mathrm{v}\gamma_\mathrm{M0}) \leq 1.0$
AISC360	$M_\mathrm{x}/\left(\phi_b fZ_\mathrm{px}\right) \leq 1.0$	$Q_\mathrm{x}/(0.6A_\mathrm{w}fC_\mathrm{v}) \leq 1.0$

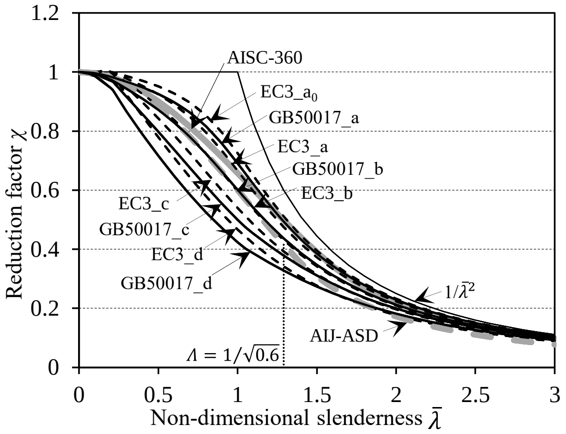
Herein: t_w: thickness of web, Z_ex: elastic section modulus, Z_px: plastic section modulus.

Table 3 – Comparison of design formulas for columns in axial compression and bending

Design code	**Columns in axial compression and bending**
AIJ-ASD	$N/(f_\mathrm{cr}A) + M_\mathrm{x}/(Z_\mathrm{ex}f) + M_\mathrm{y}/(Z_\mathrm{ey}f) \leq 1.0$
GB50017	$N/(\chi_\mathrm{x}fA) + \beta_\mathrm{mx}M_\mathrm{x}/\left(\gamma_\mathrm{x}Z_\mathrm{ex}(1-0.8N/N'_\mathrm{Ex})f\right) + \eta\beta_{ty}M_y/(\chi_{by}Z_{ey}f) \leq 1.0$ where $N'_\mathrm{Ex} = \pi^2EA/(1.1\lambda_\mathrm{x}^2)$ for seismic load: f needs to be multiplied by γ_RE
EC3[11]	$N/\left(\chi_\mathrm{y}fA/\gamma_\mathrm{M1}\right) + M_\mathrm{x}/(\chi_\mathrm{LT}Z_\mathrm{ex}f/\gamma_\mathrm{M1}) + 1.5\,M_\mathrm{y}/\left(Z_\mathrm{py}f/\gamma_\mathrm{M1}\right) \leq 1.0$
AISC360	$N/(\chi_\mathrm{c}\,f_\mathrm{cr}A) + (8/9)\left(M_\mathrm{x}/(Z_\mathrm{px}f) + M_\mathrm{y}/(Z_\mathrm{py}f)\right) \leq 1.0, \quad N/(\chi_\mathrm{c}\,f_\mathrm{cr}A) \geq 0.2$ $N/(2\chi_\mathrm{c}\,f_\mathrm{cr}A) + \left(M_\mathrm{x}/(Z_\mathrm{px}f) + M_\mathrm{y}/(Z_\mathrm{py}f)\right) \leq 1.0, \quad N/(\chi_\mathrm{c}\,f_\mathrm{cr}A) < 0.2$

Table 4 – Comparison of reduction factor formulas for strength of columns in axial compression

Design code	Columns in axial compression $(\bar{\lambda} = \lambda\sqrt{f/E}/\pi,\ \chi = f_{cr}/f)$
AIJ-ASD	$\chi = \begin{cases} 1.5\left\{1-0.4\left(\sqrt{0.6}\,\bar{\lambda}\right)^2\right\}/\left\{3/2+2/3\left(\sqrt{0.6}\,\bar{\lambda}\right)^2\right\}, & \bar{\lambda} \leq 1/\sqrt{0.6} \\ 0.277/(\sqrt{0.6}\,\bar{\lambda})^2, & \bar{\lambda} > 1/\sqrt{0.6} \end{cases}$
GB50017	$\chi = \begin{cases} 1-\alpha_1\bar{\lambda}^2, & \bar{\lambda} \leq 0.215 \\ (\alpha_2+\alpha_3\bar{\lambda}+\bar{\lambda}^2) - \sqrt{(\alpha_2+\alpha_3\bar{\lambda}+\bar{\lambda}^2)^2-4\bar{\lambda}^2}, & \bar{\lambda} > 0.215 \end{cases}$ where $\alpha_1, \alpha_2, \alpha_3$: factor influenced by the type of sections
EC3	$\chi = 1/\left(\phi+\sqrt{\phi^2-\bar{\lambda}^2}\right)$ where $\chi \leq 1.0$; $\phi = 0.5\left[1+\alpha\left(\bar{\lambda}-0.2\right)+\bar{\lambda}^2\right]$ where α: factor influenced by the type of sections
AISC360	$\chi = \begin{cases} 0.658^{\bar{\lambda}^2}, & \bar{\lambda} \leq 1.5 \\ 0.877/\bar{\lambda}^2, & \bar{\lambda} > 1.5 \end{cases}$



Cross section	GB 50017			EC 3			
	Limits	Buckling about axis	Buckling curve	Limits	Buckling about axis	Buckling curve	
						S235 S275 S355 S420	S460
b t	$b/t \leq 20$	any	c	hot finished	any	a	a$_0$
	$b/t > 20$	any	b	cold formed	any	c	c
rolled t h b	$h/b \geq 1.25$	strong axis	a	$h/b > 1.2$	strong axis	a	a$_0$
	$t_f < 40$mm	weak axis	b	$t_f \leq 40$mm	weak axis	b	a$_0$

Strength ranking ($\bar{\lambda} \leq \Lambda$)

〈1〉	EC3_a$_0$		
〈2〉	GB50017_a	EC3_a	
〈3〉	AISC-360		
〈4〉	GB50017_b	EC3_b	AIJ-ASD
〈5〉	EC3_c		
〈6〉	GB50017_c		
〈7〉	EC3_d		
〈8〉	GB50017_d		

Fig. 1 – Comparison of column strength reduction curves

2.3 The weak beam/strong column (WBSC) criterion

The weak beam/strong column (WBSC) philosophy is one of important concepts in aseismic design of buildings. The check procedures are summarized in Table 5. Except effect of the axial compression load, the WSBS is checked by the nominal strength of the column and the beam.

Table 5 – The weak beam/strong column (WBSC) philosophy check procedures

Design code	**Weak beam/strong column (WBSC) criterion**
BCJ-CFST [12]	$\sum M_{pc} \geq 1.5 \sum M_{pb}$ $\sum M_{pc,b} = \sum \nu_c \sigma_{yc,b} Z_{pc,b}$ $\nu_c = \begin{cases} 1 - 4n^2/3, & n = N/(\sigma_{yc}A) \leq 0.5 \\ 4(1-n)/3, & n = N/(\sigma_{yc}A) > 0.5 \end{cases}$
GB50017	$\sum W_{Ec}(f_{yc} - N_p/A_c) \geq \eta_y \sum W_{Eb} f_{yb}$
EC8	$\sum M_{Rc} \geq 1.3 \sum M_{Rb}$
AISC341 [13]	$\frac{\sum M_{pc}^*}{\sum M_{pb}^*} > 1.0$ $\sum M_{pc}^* = \sum Z_c\,(F_{yc} - \alpha_s P_r/A_g)$ $\sum M_{pb}^* = \sum (M_{pr} + \alpha_s M_v)$ $M_{pr} = C_{pr} R_y F_y Z_e$

In Japanese code, this criterion only applies to the structure using Cold-Formed Square Steel Columns. If the material is STKR(carbon steel square and rectangular tubes)[14], the criterion must be strictly applied. But if the material is BCP(box column pressed) or BCR(box column rolled) [15], when this criterion is not satisfied, one can confirm the ultimate lateral load carrying capacity at the second phase design procedure [2].

The factor, column to beam moment strength ratio 1.5, is known from following considerations, which may not occur all together [12]. a) seismic load acts diagonally: $\sqrt{2}$; b) diagonal section property: 1/0.94; c) strength increasing due to the restraint effect of slab: 1.25; d) high mode effect: 1.3; e) strength variation of the steel material: 1.15.

In Japanese, Chinese and American codes, the axial compression reduction factor is considered. The formulas in Chinese and American codes are almost same, except the additional moment due to the beam's plastic hinge to the column centerline. In American code, there are two factors, C_{pr} and R_y, introduced in calculating the moment strength of the beam which increase the moment strength remarkably. C_{pr} is the factor to account for peak connection strength, including strain hardening, local restraint, additional reinforcement and other connection conditions. R_y is the ratio of expected yield stress to specified minimum yield stress. R_y is also adopted in Japanese code which applies to steel material, thus to both columns and beams. In Chinese, European and American codes, there is one common exception where the check procedure shall not apply: columns used in a one-story building or the top story of a multistory building. Some other exceptions in both Chinese and American codes are summarized in Table 6.

Table 6 – Exceptions in both Chinese and American codes for WSBC check

GB50017	**AISC341**
(a) Columns used in a one-story building or the top story of a multistory building. (b) Columns in any story that has a ratio of available shear strength to required shear strength that is 25% greater than the story above. © The sum of the available shear strengths of all exempted columns in the story is less than 20% of the sum of the available shear strengths of all moment frame columns in the story acting in the same direction (d) A brace connects to the joint. (e) $N_p/(A_c\sigma_y)<0.4$, and the slenderness satisfies the class S3； (f) The column capacity satisfies the ductility class V.	(a) Columns with $P_{rc}<0.3P_c$ for all load combinations other than those determined using the overstrength seismic load and that satisfy either of the following:(1) Columns used in a one-story building or the top story of a multistory building.(2) Columns where (i) the sum of the available shear strengths of all exempted columns in the story is less than 20% of the sum of the available shear strengths of all moment frame columns in the story acting in the same direction, and (ii) the sum of the available shear strengths of all exempted columns on each moment frame column line within that story is less than 33% of the available shear strength of all moment frame columns on that column line. (b) Columns in any story that has a ratio of available shear strength to required shear strength that is 50% greater than the story above.

3. Design comparison

3.1 Common parameters and load values

The same six-story steel moment-resisting frame structure designed upon Japanese code was used here [1,2]. The column, expressed by □-700x700x28, with height of 3.7m was designed as cold-formed square steel column, whose material was BCP325 (SN490B). The beam, expressed by H-900x300x16x28, with span of 8.5m was designed as H-shape beam, whose material was SN490B. The section size and load values (dead, live, seismic) were the same ones shown in the references [1,2].

As shown in Eq. (1), the same lateral acceleration response spectra were assumed for all codes. In Chinese code, the effective mass may take 85% of the representative value of gravity load for a multi-story building, 85% was used to reduce seismic action from the Japanese code. 85% was used for EC8, since the period was 0.769s less than 2s. In ASCE7, only dead load is considered in the seismic action. In this study case, dead load was about 70%. In ASCE7, the vertical seismic action has to be included too, 0.2D was used here. The seismic combination used is shown in Table 7. The calculation results of gravity load and seismic load are shown in Table 8.

Steel material was selected as SN490B for all codes. In Chinese code, the design strength has been reduced by a reduction factor 0.9 to comply with the code. Following Japanese engineering practice, to design the beam, the bending moment is considered to be borne by the flange plats, and the shear force borne by the web plate. Same parameters were used to calculate member's stress values in all codes. Other parameters used in the design study are summarized in Table 9.

Table 7 – Seismic load combination used in the design study

Design code	Seismic load	Note
Japan	$D+L+E$	
China	$1.2(D+0.5L)+1.3E_{\mathrm{cn},50}$	$E_{cn,50} = 0.85E_{jp,50}$: effective mass
Eurocde*	$1.0D+0.3L+1.0E_{\mathrm{EU},475}/q$	$E_{EU,475}/q = 0.85E_{jp,50}$: T=0.8s<2T_c
America	$1.4D+0.5L+1.0E_{\mathrm{USA},475}/R$	$E_{USA,475}/R = 0.7E_{jp,50}$; $E_v = 0.2D$ dead load counting, vertical seismic load

*: Design rules for moment resisting frames required by Eurocode 8[9] was not considered.

Table 8 – Gravity load and seismic load calculated according each code

Member	Code	Japan		China		Europe		America	
		gravity	seismic	gravity	seismic	gravity	seismic	gravity	seismic
Column	M_x (kN m)	19.0	1727.0	25.8	1906.8	26.5	1467.0	25.0	1217.3
	M_y (kN m)	124.0	124.0	168.4	127.2	172.8	98.8	163.2	141.2
	N (kN)	4853.0	4961.0	6590.4	5098.5	6762.7	3959.6	6386.6	5603.1
	Q_x (kN)	9.0	1129.0	12.2	1246.8	12.5	959.2	11.8	794.3
Beam	M (kN m)	179.0	1841.0	243.1	2020.2	249.4	1555.4	235.6	1367.3
	Q (kN)	108.0	534.0	146.7	581.6	150.5	448.2	142.1	421.2

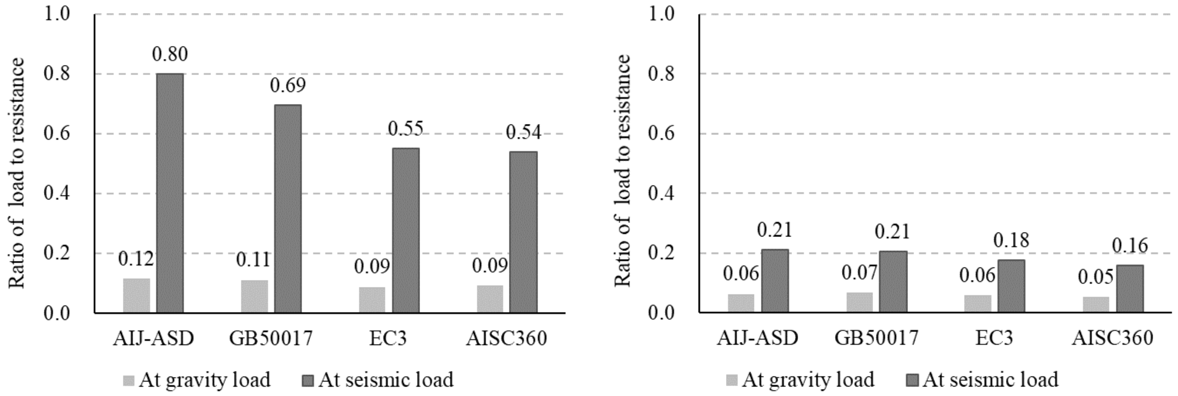
Table 9 – Parameters used in the design study

Design code	Parameters
Common parameters	f_y=325MPa, f_u=490MPa
Japan	design strength $f = f_y$, $f_{y\_gravity}$=208MPa, $f_{y\_seismic}$=312MPa
China	design strength f=0.9f_y section type b γ_x=1.05, β_{mx}=1.0, η=0.7, b_{ty}=1.0, φ_x=0.95
Eurocde	α=1.0, χ_y=0.96, γ_{M0}=γ_{M1}=1.0, χ_{LT}=1.0
America	ϕ_b=0.9, ϕ_c=0.9

3.2 Comparison of ratios of load to resistance of the beam and the column

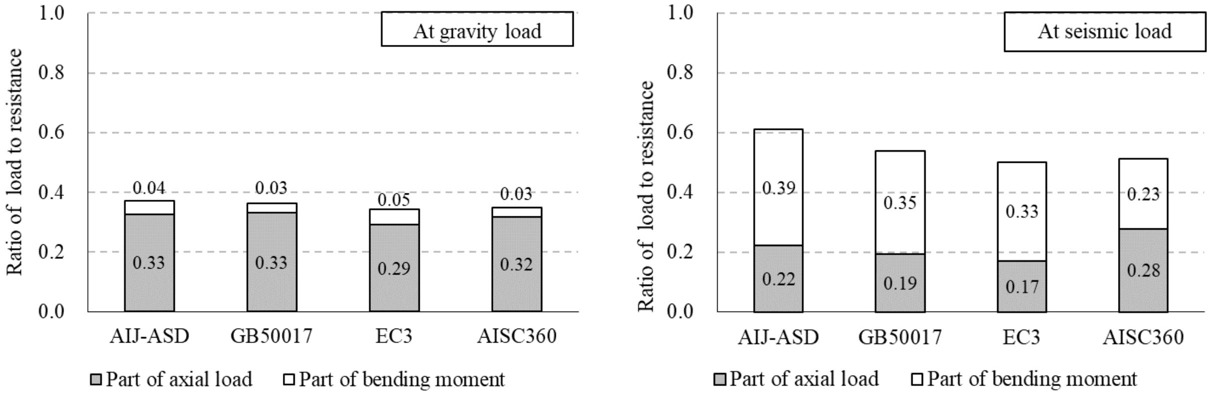
Comparison of ratios of load to resistance of the beam is shown in Fig.2. Japanese code gave the most severe result for the ratio of load to resistance (σ/f) in bending. Chinese code had 2nd large value although it had the largest seismic load. The results by Eurocode and American codes are almost same. In shear, results from all codes were so small.

Comparison of ratios of load to resistance of the column is shown in Fig.3. At gravity load, results from all codes were almost same. At seismic load, Japanese code gave the slight large value but diffed not some much like the beam in bending. The results by Chinese, Eurocode and American codes were almost same. It is interesting, the percentage between the contribution from axial load and bending moment was different. The vertical seismic load was considered in American code, such as the contribution from the axial load was largest.



(a) in bending (b) in shear

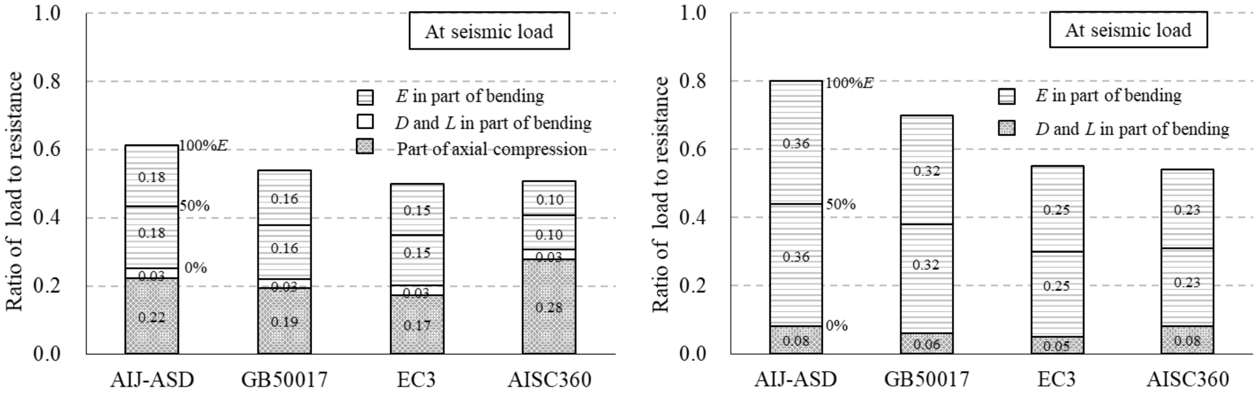
Fig. 2 – Comparison of ratios of load to resistance of the beam



(a) at gravity load (b) at seismic load

Fig. 3 – Comparison of ratios of load to resistance of the column

Since the seismic load in Japanese code is usually larger than the other codes, we change the seismic action to confirm the influence of seismic action on ratios of load to resistance shown in Fig.4. For column, the ratio was divided into three part: axial load, dead load with live load in bending and seismic action in bending. For beam in bending, the ratio was divided into two part: dead load and live load and seismic action in bending. 50% seismic action was also shown in the same figure. For column, since the percentage of axial load was larger in American code due to the vertical seismic action, if the seismic action is reduced to the half, the ratio of load to resistance will be almost same with Japanese code. For beam, since the percentage of gravity load was almost same in all codes, the ratio of load to resistance kept the same tendency. More cases should be investigated to give serious conclusions.



(a) column (b) beam

Fig. 4 – Influence of seismic load on ratios of load to resistance

3.3 The weak beam/strong column (WBSC) criterion

The weak beam/strong column (WBSC) philosophy check procedures are summarized in Table 10. The seismic load shown in Table 8 was used as the axial load in all codes. The axial load in the upper and lower column was taken as the same value for convenience. In Japanese code, the steel strength was amplified by factor 1.1 in both column and beam. In Eurocode, since same steel was chosen for both beam and column, the moment ratio was simply expressed by the ratio of their section modulus. As stated before, the beam moment strength calculated by American code had the maximum value, while its column moment strength was almost same with Chinese code. Thus, the beam-column connection judged OK by the other three codes, was judged NG by American code.

Table 10 – The weak beam/strong column (WBSC) philosophy check process

Design code	**Weak beam/strong column (WBSC) check process**
Japan	$n=4961.0/(1.1*325*7.123*10)=0.195$ $\nu_c=1-4*0.195^2/3=0.949$ $\Sigma M_{pc}=2*(0.949*1.1*325*17.6*10^6/10^6)=11942.2$ kNm $\Sigma M_{pb}=2*(1.1*325*10.3*10^6/10^6)=7364.5$ kNm $\Sigma M_{pc} \ / \ 1.5\Sigma M_{pb} = \mathbf{1.08} > \mathbf{1.0}$ **OK**
China	$\Sigma W_{Ec}(f_{yc}-N_p/A_c)=2*17.6*(325-5098.5*10^3/71230)=8920.5$ kNm $\eta_y \Sigma W_{Eb} f_{yb}=1.15*2*10.3*325=7699.3$ kNm $\Sigma W_{Ec}(f_{yc}-N_p/A_c) / \ \eta_y \Sigma W_{Eb} f_{yb} = \mathbf{1.16} > \mathbf{1.0}$ **OK**
Eurocde	$\Sigma M_{pc} \ / \ \Sigma M_{pb}=17.6/10.3 = \mathbf{1.7} > \mathbf{1.3}$ **OK**
America	$\Sigma M_{pc}=2*17.6*(325-5603.1*10^3/71230)=8671.1$ kNm $M_{pr}=C_{pr}R_y F_y Z_e=1.2*1.1*325*10.3*10^6/10^6=4418.7$ kNm $M_v=2M_{pr}/L*d_c/2=2*4418.7/(8.5-0.7)*0.7/2=396.6$ kNm $\Sigma M_{pb}=2*(4418.7+396.6)=9630.5$ kNm $\Sigma M_{pc} \ / \ \Sigma M_{pb} = \mathbf{0.9} < \mathbf{1.0}$ **NG**

4. Conclusions

Four design codes, Japanese (ASD-2005), Chinese (GB50017-2017), European (Eurocode 3) and American (AISC 360-16) codes, were compared on the regulations and corresponding seismic provisions of steel structures. The design methods, load combinations, beam ad column strength calculation formulas and weak beam/strong column (WBSC) philosophy check procedures were summarized. Comparison of ratios of load to resistance of the beam and the column was carried out following previous study. Japanese code gave the most severe result in all cases for both beam and column. If the seismic load is small, the ratio by American code may be severe for column. In the weak beam/strong column (WBSC) philosophy check process, the beam moment strength calculated by American code had the maximum value. Thus, the beam-column connection judged OK by the other three codes, was judged NG by American code. In American code, there are two factors, C_{pr} and R_y, introduced in calculating the moment strength of the beam which increase the moment strength remarkably.

5. References

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