Amendments to Code of Practice for the Structural Use of Steel 2011

(November 2016)

Legends:

Revision/Addition

(3/2023)

Major amendments to the Code of Practice for the Structural Use of Steel 2011 in November 2016 included:

(a) updating the characteristic strength of reinforcement bar from 460 N/mm^2 to 500 N/mm^2 in accordance with the latest reinforcement bar standard CS2:2012 and the parameters of characteristic resistance of headed shear stud in different grades of concrete shown in Table 10.7;

(b) including an additional Table l2.2e on strength reduction factors for hot rolled reinforcing bars at elevated temperatures and Chinese standard GB/T 700-2006 in the Acceptable Standard List in Annex Al.1.3;

(c) explicating the need on second-order direct analysis for members in bending and sensitive to buckling in Equation 6.14 and the term of restrained beam mentioned in Clause 8.2 for consideration of lateral torsional buckling;

(d) standardizing the two similar terms of "oscillation" and "vibration" to the latter to remove ambiguity and tally with that in the Chinese version; and

(e) correcting the typo errors on expression of the reduction factor in Equation 9.23 and designation of buckling curves for S460 hot-finished structural hollow section in Table 8.7.

Amendments to the Code of Practice for Structural Use of Steel 2011 (November 2016)

<table>
<tr><th>Item</th><th>Clause/ Annex</th><th>Current Version</th><th>Amendments</th><th>Remarks</th></tr>
<tr><td>1</td><td>Clause 1.1 – para. 9</td><td>Section 5 contains particular requirements and guidance for deflection control and structural dynamics including serviceability criteria for wind induced oscillation of tall buildings. The section also covers durability and protection against corrosion attack.</td><td>Section 5 contains particular requirements and guidance for deflection control and structural dynamics including serviceability criteria for wind induced vibration of tall buildings. The section also covers durability and protection against corrosion attack.</td><td rowspan="2">The terms “oscillation” and “vibration” are collectively read as “vibration” for consistency.</td></tr>
<tr><td>2</td><td>Clause 1.2.5 – para. 3</td><td>Serviceability limit states correspond to limits beyond which specified in-service criteria are no longer met. Examples are deflection, wind-induced oscillation, human-induced vibration and durability.</td><td>Serviceability limit states correspond to limits beyond which specified in-service criteria are no longer met. Examples are deflection, wind-induced vibration, human-induced vibration and durability.</td></tr>
<tr><td>3</td><td>Clause 2.2 - Table 2.1</td><td>Table 2.1 - Limit states<table><tr><th>Ultimate limit states (ULS)</th><th>Serviceability limit states (SLS)</th></tr><tr><td>Strength (including general yielding, rupture, buckling and forming a mechanism)</td><td>Deflection</td></tr><tr><td>Stability against overturning, sliding, uplift and sway stability</td><td>Vibration</td></tr><tr><td>Fire resistance</td><td>Wind induced oscillation</td></tr><tr><td>Brittle fracture and fracture caused by fatigue</td><td>Durability</td></tr></table>Note:- For cold-formed steel, excessive local deformation is to be assessed under ultimate limit state.</td><td>Table 2.1 - Limit states<table><tr><th>Ultimate limit states (ULS)</th><th>Serviceability limit states (SLS)</th></tr><tr><td>Strength (including general yielding, rupture, buckling and forming a mechanism)</td><td>Deflection</td></tr><tr><td>Stability against overturning, sliding, uplift and sway stability</td><td>Human induced vibration</td></tr><tr><td>Fire resistance</td><td>Wind induced vibration</td></tr><tr><td>Brittle fracture and fracture caused by fatigue</td><td>Durability</td></tr></table>Note:- For cold-formed steel, excessive local deformation is to be assessed under ultimate limit state.</td><td>The terms “Vibration” and “Wind induced oscillation” stated in Table 2.1 are amended to “Human induced vibration” and “Wind induced vibration” respectively.</td></tr>
<tr><td>4</td><td>Clause 2.3.3 – para. 3</td><td>Situations where fatigue resistance needs to be considered include the following:
Where there are wind-induced oscillations due to aerodynamic instability. Normal fluctuations in wind loading need not be considered.
Structural members that support heavy vibratory plant or machinery.
Members that support cranes as defined in clause 13.7.
Bridge structures, which will normally be designed to a bridge design code.</td><td>Situations where fatigue resistance needs to be considered include the following:
Where there are wind-induced vibrations due to aerodynamic instability. Normal fluctuations in wind loading need not be considered.
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Bridge structures, which will normally be designed to a bridge design code.</td><td rowspan="2">The terms “oscillation” and “vibration” are collectively read as “vibration” for consistency.</td></tr>
<tr><td>5</td><td>Clause 2.4 – para. 1</td><td>SERVICEABILITY LIMIT STATES (SLS)
Serviceability limit states consider service requirements for a structure or structural element under normally applied loads. Examples are deflection, human induced vibration, wind induced oscillation and durability. They are described in section 5.</td><td>SERVICEABILITY LIMIT STATES (SLS)
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</table>

6	Clause 5.2 - Table 5.1	Note: Exceedance of the above limit is not acceptable unless a full justification is provided. Precamber deflection can be deduced in the deflection calculation. Ponding should nevertheless be avoided in all cases. Long span structures should be checked against vibration and oscillation.	Note: Exceedance of the above limit is not acceptable unless a full justification is provided. Precamber deflection can be deduced in the deflection calculation. Ponding should nevertheless be avoided in all cases. Long span structures should be checked against vibration.	The terms "oscillation" and "vibration" are collectively read as "vibration" for consistency hence the word "oscillation" is deleted.
7	Clause 5.3	**WIND-INDUCED OSCILLATION** Vibration and oscillation of a structure should be limited to avoid discomfort to users and damage to contents. For special structures, including long-span bridges, large stadium roofs and chimneys, wind tunnel model tests are recommended for their wind resistant design to meet serviceability limits.	**WIND-INDUCED VIBRATION** Vibration of a structure should be limited to avoid discomfort to users and damage to contents. For special structures, including long-span bridges, large stadium roofs and chimneys, wind tunnel model tests are recommended for their wind resistant design to meet serviceability limits.	
8	Clause 5.3.2	**Serviceability limit state** The serviceability limit states on oscillation, deflection and acceleration should be checked to ensure serviceable condition for the structure.	**Serviceability limit state** The serviceability limit states on vibration, deflection and acceleration should be checked to ensure serviceable condition for the structure.	The terms "oscillation" and "vibration" are collectively read as "vibration" for consistency.
9	Clause 5.3.3.1	*Natural frequencies* Structural analysis programmes should be used to determine the natural frequencies of vibration of buildings and structures to mitigate excessive horizontal oscillation and vertical vibration. Empirical formulae can also be used for approximated vibration analysis of typical and regular buildings.	*Natural frequencies* Structural analysis programmes should be used to determine the natural frequencies of vibration of buildings and structures to mitigate excessive horizontal and vertical vibration. Empirical formulae can also be used for approximated vibration analysis of typical and regular buildings.	The terms "oscillation" and "vibration" are collectively read as "vibration" for consistency hence the word "oscillation" is deleted.
10	Clause 5.3.5	**Serviceability criteria for communication and broadcasting towers** Communication and broadcasting services demand minimal disruption to transmission. The serviceability limits for communication and broadcasting towers are selected to meet the performance specifications of antennae and other transmission devices to be mounted on those towers. Excessive oscillation and vibration of towers should be avoided. For design, reference should be made to specialist literature.	**Serviceability criteria for communication and broadcasting towers** Communication and broadcasting services demand minimal disruption to transmission. The serviceability limits for communication and broadcasting towers are selected to meet the performance specifications of antennae and other transmission devices to be mounted on those towers. Excessive vibration of towers should be avoided. For design, reference should be made to specialist literature.	
11	Clause 6.8.3 – equation 6.14	Member lateral-torsional and torsional buckling checks are carried out separately or alternatively by replacing M_{cx} in the above equation by the buckling resistance moment M_b in Equations 8.20 to 8.22. If moment equivalent factor m_{LT} is less than 1, both Equation 6.12 or 6.13 and Equation 6.14 are required for member resistance check. $\frac{F_c}{A_g p_y} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} = \frac{F_c}{A_g p_y} + \frac{m_{LT}[\overline{M}_x + F_c(\Delta_x + \delta_x)]}{M_b} + \frac{m_y[\overline{M}_y + F_c(\Delta_y + \delta_y)]}{M_{cy}} \le 1 \quad (6.14)$ The equivalent uniform moment factor m_{LT} for beams and the moment equivalent factor m_y for flexural buckling can be referred to Tables 8.4 a & b and Table 8.9.	Member lateral-torsional and torsional buckling checks are carried out separately or alternatively by replacing M_{cx} in the above equation by the buckling resistance moment M_b in Equations 8.20 to 8.22. If moment equivalent factor m_{LT} is less than 1, both Equation 6.12 or 6.13 and Equation 6.14 are required for member resistance check. $\frac{F_c}{A_g p_y} + \frac{M_x}{M_{cx}} + \frac{M_y}{M_{cy}} = \frac{F_c}{A_g p_y} + \frac{m_{LT}[\overline{M}_x + F_c(\Delta_x + \delta_x)]}{M_b} + \frac{m_y[\overline{M}_y + F_c(\Delta_y + \delta_y)]}{M_{cy}} \le 1 \quad (6.14)$ The equivalent uniform moment factor m_{LT} for beams and the moment equivalent factor m_y for flexural buckling can be referred to Tables 8.4 a & b and Table 8.9. For members in bending and sensitive to buckling, imperfection on both axes should be considered if effective length has reduction in capacity about buckling in both axes.	For second-order direct analysis, imperfections in both axes should be considered for members in bending about strong axis and sensitive to lateral torsional buckling.

<table>
<tr>
<td>12</td>
<td>Clause 8.2 – para.1</td>
<td>

RESTRAINED BEAMS

Restrained beams refer to beams provided with full lateral restraint to their top flanges and with full torsional restraint at their ends. In such a case, lateral-torsional buckling should not occur before plastic moment capacity.

</td>
<td>

RESTRAINED BEAMS

Restrained beams refer to beams provided with full lateral restraint to their top flanges and with nominal torsional restraint at their ends. In such a case, lateral-torsional buckling should not occur before plastic moment capacity.

</td>
<td>Torsional restraint requirement of beams at the ends to prevent lateral torsional buckling is revised from full restraint to nominal restraint</td>
</tr>
<tr>
<td>13</td>
<td>Clause 8.7.6 - Table 8.7</td>
<td>

Table 8.7 - Designation of buckling curves for different section types

<table>
<tr><th rowspan="2">Type of section</th><th rowspan="2">Maximum thickness (see note1)</th><th colspan="2">Axis of buckling</th></tr>
<tr><th>x-x</th><th>y-y</th></tr>
<tr><td>Hot-finished structural hollow sections with steel grade > S460 or hot-finished seamless structural hollow sections</td><td></td><td>a_0)</td><td>a_0)</td></tr>
<tr><td>Hot-finished structural hollow section < grade S460</td><td></td><td>a)</td><td>a)</td></tr>
<tr><td>Cold-formed structural hollow section of longitudinal seam weld or spiral weld</td><td></td><td>c)</td><td>c)</td></tr>
<tr><td>Rolled I-section</td><td>≤ 40 mm
> 40 mm</td><td>a)
b)</td><td>b)
c)</td></tr>
<tr><td>Rolled H-section</td><td>≤ 40 mm
> 40 mm</td><td>b)
c)</td><td>c)
d)</td></tr>
<tr><td>Welded I- or H-section (see note 2)</td><td>≤ 40 mm
> 40 mm</td><td>b)
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d)</td></tr>
<tr><td>Rolled I-section with welded flange cover plates with 0.25 < U/B < 0.80 as shown in Figure 8.4)</td><td>≤ 40 mm
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b)</td><td>b)
c)</td></tr>
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c)</td><td>c)
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<tr><td>Rolled I or H-section with welded flange cover plates with U/B ≥ 0.80 as shown in Figure 8.4)</td><td>≤ 40 mm
> 40 mm</td><td>b)
c)</td><td>a)
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<tr><td>Rolled I or H-section with welded flange cover plates with U/B ≤ 0.25 as shown in Figure 8.4)</td><td>≤ 40 mm
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d)</td></tr>
<tr><td>Welded box section (see note 3)</td><td>≤ 40 mm
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c)</td><td>b)
c)</td></tr>
<tr><td>Round, square or flat bar</td><td>≤ 40 mm
> 40 mm</td><td>b)
c)</td><td>b)
c)</td></tr>
<tr><td>Rolled angle, channel or T-section
Two rolled sections laced, battened or back-to-back
Compound rolled sections</td><td></td><td colspan="2">Any axis: c)</td></tr>
<tr><td colspan="4">NOTE:
1. For thickness between 40mm and 50mm the value of p_c may be taken as the average of the values for thicknesses up to 40mm and over 40mm for the relevant value of p_y.
2. For welded I or H-sections with their flanges thermally cut by machine without subsequent edge grinding or machining, for buckling about the y-y axis, strut curve b) may be used for flanges up to 40mm thick and strut curve c) for flanges over 40mm thick.
3. The category “welded box section” includes any box section fabricated from plates or rolled sections, provided that all of the longitudinal welds are near the corners of the cross-section. Box sections with longitudinal stiffeners are NOT included in this category.
4. Use of buckling curves based on other recognized design codes allowing for variation between load and material factors and calibrated against Tables 8.8(a_0), (a) to (h) is acceptable. See also footnote under Table 8.8.</td></tr>
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</table>

</td>
<td>Typo error on designation of buckling curves for the grade of hot-finished structural hollow section less than or equal to S460 is rectified.</td>
</tr>
</table>

<table>
<tr>
<td>14</td>
<td>Clause 9.3.6.1.6 – equation 9.23</td>
<td>Bolts through packing
When a bolt passes through packing with thickness t_{pa} greater than one-third of the nominal diameter d, its shear capacity P_s should be reduced by multiplying a reduction factor β_p obtained from:
$$\beta_p = \left(\frac{9d}{8d + 3t_{pa}}\right) \le 10 \quad (9.23)$$
For double shear connections with packing on both sides of connecting member, t_{pa} should have the same thickness; otherwise, the thicker t_{pa} should be used.
This provision does not apply to preloaded bolt (friction-type) connections when working in friction, but does apply when such bolts are designed to slip into bearing.</td>
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<td>Typo error on the upper bound of equation 9.23 in calculating the reduction factor β_p is rectified.</td>
</tr>
<tr>
<td>15</td>
<td>Clause 10.1.3</td>
<td>Reinforcement
Reinforcement shall comply with HKCC, and the characteristic strength, f_y, shall not be larger than 460 N/mm^2. The elastic modulus shall be taken as 205 kN/mm^2, i.e. same as that of structural steel sections.
Different types of reinforcement may be used in the same structural member.</td>
<td>Reinforcement
Reinforcement shall comply with HKCC, and the characteristic strength, f_y, shall not be larger than 500 N/mm^2. The elastic modulus shall be taken as 205 kN/mm^2, i.e. same as that of structural steel sections.
Different types of reinforcement may be used in the same structural member.</td>
<td>The characteristic strength of reinforcement bar is changed to 500N/mm^2 to meet with the latest reinforcement bar standard CS2:2012</td>
</tr>
<tr>
<td>16</td>
<td>Clause 10.3.2.2 - Table 10.7</td>
<td>Table 10.7 - Characteristic resistance P_k of headed shear studs in normal weight concrete
<table>
<tr><td colspan="11">Characteristic resistance of headed shear studs P_k (kN)</td></tr>
<tr><td colspan="2">Dimensions of headed shear stud</td><td colspan="9">Cube compressive strength of concrete, f_{cu} (N/mm^2)</td></tr>
<tr><td>Nominal shank diameter (mm)</td><td>Nominal height (mm)</td><td>Minimum as-welded height (mm)</td><td>C25</td><td>C30</td><td>C35</td><td>C40</td><td>C45</td><td>C50</td><td>C55</td><td>C60</td></tr>
<tr><td>25</td><td>95</td><td>95</td><td>111.4</td><td>126.9</td><td>141.7</td><td>155.9</td><td>169.7</td><td>176.7</td><td>176.7</td><td>176.7</td></tr>
<tr><td>22</td><td>95</td><td>88</td><td>89.9</td><td>102.4</td><td>114.3</td><td>125.8</td><td>136.8</td><td>136.8</td><td>136.8</td><td>136.8</td></tr>
<tr><td>19</td><td>95</td><td>76</td><td>67.1</td><td>76.3</td><td>85.2</td><td>93.8</td><td>102.1</td><td>102.1</td><td>102.1</td><td>102.1</td></tr>
<tr><td>16</td><td>70</td><td>64</td><td>47.5</td><td>54.1</td><td>60.5</td><td>66.5</td><td>72.4</td><td>72.4</td><td>72.4</td><td>72.4</td></tr>
</table>
Note: For cube compressive strength of concrete greater than 60 N/mm^2, the values of P_k should be taken as those with f_{cu} and E_{cm} limiting to those of concrete grade C60.</td>
<td>Table 10.7 - Characteristic resistance P_k of headed shear studs in normal weight concrete
<table>
<tr><td colspan="10">Characteristic resistance of headed shear studs P_k (kN)</td></tr>
<tr><td>Dimensions of headed shear stud</td><td colspan="9">Cube compressive strength of concrete, f_{cu} (N/mm^2)</td></tr>
<tr><td>Nominal shank diameter (mm)</td><td>Minimum as-welded height (mm)</td><td>C25</td><td>C30</td><td>C35</td><td>C40</td><td>C45</td><td>C50</td><td>C55</td><td>C60</td></tr>
<tr><td>25</td><td>100</td><td>116.1</td><td>133.1</td><td>147.6</td><td>162.4</td><td>176.7</td><td>176.7</td><td>176.7</td><td>176.7</td></tr>
<tr><td>22</td><td>88</td><td>89.9</td><td>102.4</td><td>114.3</td><td>125.8</td><td>136.8</td><td>136.8</td><td>136.8</td><td>136.8</td></tr>
<tr><td>19</td><td>76</td><td>67.1</td><td>76.3</td><td>85.3</td><td>93.8</td><td>102.1</td><td>102.1</td><td>102.1</td><td>102.1</td></tr>
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</table>
Note: For cube compressive strength of concrete greater than 60 N/mm^2, the values of P_k should be taken as those with f_{cu} and E_{cm} limiting to those of concrete grade C60.</td>
<td>(a) The column “Nominal height” is deleted.
(b) The minimum as-welded height of 25mm shank diameter shear stud is amended.
(c) The corresponding characteristic resistances of headed shear stud for various concrete cube strengths are revised.</td>
</tr>
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<table>
<tr>
<td>17</td>
<td>Clause 12.1</td>
<td>DESIGN PRINCIPLES
This section aims to provide guidance on fire resistant design in steel and composite structures which deals primarily with minimising the risk of structural collapse and restricting the spread of fire through the structure.
The fire resistant design method is applicable to steel and composite structures with the following materials:
Structural steel: Hot rolled steel sections with design strengths equal to or less than 460 N/mm^2.
Cold formed steel sections with design strengths equal to or less than 550 N/mm^2.
Concrete: Normal weight concrete with cube strengths equal to or less than 60 N/mm^2.
Reinforcement: Cold worked reinforcing bars with design strengths equal to or less than 460 N/mm^2.
For steel materials other than those listed above, refer to specialist design recommendations. Alternatively, passive fire protection method should be adopted.</td>
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The fire resistant design method is applicable to steel and composite structures with the following materials:
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Concrete: Normal weight concrete with cube strengths equal to or less than 60 N/mm^2.
Reinforcement: Cold worked reinforcing bars with design strengths equal to or less than 500 N/mm^2.
For steel materials other than those listed above, refer to specialist design recommendations. Alternatively, passive fire protection method should be adopted.</td>
<td>The design strength of reinforcement bar is changed to 500N/mm^2 to meet the latest reinforcement bar standard CS2:2012</td>
</tr>
<tr>
<td>18</td>
<td>Clause 12.1.4 - Table 12.2e (added)</td>
<td>-</td>
<td>Table 12.2e - Strength reduction factors for hot rolled reinforcing bars at elevated temperatures
<table>
<tr><th>Temperature (°C)</th><th>Strength reduction factors</th></tr>
<tr><td>20 °C</td><td>1.00</td></tr>
<tr><td>100 °C</td><td>1.00</td></tr>
<tr><td>200 °C</td><td>1.00</td></tr>
<tr><td>300 °C</td><td>1.00</td></tr>
<tr><td>400 °C</td><td>1.00</td></tr>
<tr><td>500 °C</td><td>0.78</td></tr>
<tr><td>600 °C</td><td>0.47</td></tr>
<tr><td>700 °C</td><td>0.23</td></tr>
<tr><td>800 °C</td><td>0.11</td></tr>
<tr><td>900 °C</td><td>0.06</td></tr>
<tr><td>1000 °C</td><td>0.04</td></tr>
<tr><td>1100 °C</td><td>0.02</td></tr>
<tr><td>1200 °C</td><td>0.00</td></tr>
</table></td>
<td>A table extracted from BS EN 1992-1-2:2004 showing the strength reduction factors for hot rolled bars at elevated temperatures is added.</td>
</tr>
<tr>
<td>19</td>
<td>Clause 13.2.5</td>
<td>Serviceability issues
The following serviceability issues shall be addressed for towers and masts:
(a) Wind induced oscillations of antennas, structural elements and cables.
(b) Access for maintenance of steelwork can be very difficult, therefore a high quality protective system should be specified.
(c) Required stiffness for purpose (e.g. microwave alignment).
(d) Access facilities for routine maintenance and inspection shall be designed to take into account of the availability and likely competence of staff trained to climb such structures but should normally include ladders fitted with a fall arrest system and regular platforms to rest and safely place work equipment.</td>
<td>Serviceability issues
The following serviceability issues shall be addressed for towers and masts:
(a) Wind induced vibrations of antennas, structural elements and cables.
(b) Access for maintenance of steelwork can be very difficult, therefore a high quality protective system should be specified.
(c) Required stiffness for purpose (e.g. microwave alignment).
(d) Access facilities for routine maintenance and inspection shall be designed to take into account of the availability and likely competence of staff trained to climb such structures but should normally include ladders fitted with a fall arrest system and regular platforms to rest and safely place work equipment.</td>
<td>The terms “oscillation” and “vibration” are collectively read as “vibration” for consistency.</td>
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</table>

20	Clause 13.2.6	**Design issues for steel chimneys** In addition to the guidance given in clauses 13.2.1 to 13.2.5, special attention should be given to the following in the design of steel chimneys and flues: (a) Wind-excited oscillations should be considered and analyzed by aerodynamic methods. For circular chimneys the simplified method in clause 13.2.8 may be used. (b) Design should be in accordance with the appropriate provisions of the Code and in the acceptable references in Annex A2.1. (c) To control buckling in the case of a thin walled chimney with effective height to diameter ratio of less than 21 and diameter to thickness ratio of less than 130, the ultimate compressive stresses in the chimney structure arising from the three principal load combinations shall be limited to a value calculated in accordance with Table 12.2 of clause 12.1.4 which allows for reduced steel strength at elevated temperatures. If this value exceeds 140 N/mm^2, then a value of 140 N/mm^2 shall be used. The value should be reduced further for higher aspect ratios.	**Design issues for steel chimneys** In addition to the guidance given in clauses 13.2.1 to 13.2.5, special attention should be given to the following in the design of steel chimneys and flues: (a) Wind-excited vibrations should be considered and analyzed by aerodynamic methods. For circular chimneys the simplified method in clause 13.2.8 may be used. (b) Design should be in accordance with the appropriate provisions of the Code and in the acceptable references in Annex A2.1. (c) To control buckling in the case of a thin walled chimney with effective height to diameter ratio of less than 21 and diameter to thickness ratio of less than 130, the ultimate compressive stresses in the chimney structure arising from the three principal load combinations shall be limited to a value calculated in accordance with Table 12.2 of clause 12.1.4 which allows for reduced steel strength at elevated temperatures. If this value exceeds 140 N/mm^2, then a value of 140 N/mm^2 shall be used. The value should be reduced further for higher aspect ratios.	The terms "oscillation" and "vibration" are collectively read as "vibration" for consistency.

21	Clause 13.2.8	**Wind-excited oscillations of circular chimneys** Flexible slender structures are subject to oscillations caused by cross wind and along wind action. Structures with a circular cross section, such as chimneys, oscillate more strongly across than along wind. The following simplified approach may be used for across wind oscillation, see also clause 5.3: (a) The Strouhal critical velocity V_{crit} in metres per second for the chimney is to be determined by: $V_{crit} = 5\, D_t\, f$ (13.1) where f (in Hz) is the natural frequency of the chimney on its foundations. This may be calculated analytically or from the following approximate formula for the case of a regular cone: $f = \dfrac{500(3D_b - D_t)\left[\dfrac{W_s}{W}\right]^{\frac{1}{2}}}{h^2}$ (13.2) and h is the height of chimney (in m) D_t is the diameter at top (in m) D_b is the diameter at bottom (in m) W is the mass per metre height at top of structural shell including lining or encasing, if any (in kg) W_s is the mass per meter height at top of structural shell excluding lining (in kg) (b) If V_{crit} exceeds the design wind velocity in metres per second given by the following formula $V = 40.4\,(q)^{0.5}$ (13.3) where q is the design wind pressure in kN/m^2, severe oscillation is unlikely and no further calculation is required. (c) If V_{crit} is less than the design wind velocity, the tendency to oscillate C may be estimated by the following empirical formula: $C = 0.6 + K\left[\dfrac{10\,D_t^2}{W} + \dfrac{1.5\Delta}{D_t}\right]$ (13.4) where Δ is the calculated deflection (in m) at the top of the chimney for unit distributed load of 1 kPa. K is 3.5 for all welded construction, 3.0 for welded with flanged and bolted joints and 2.5 for bolted and riveted or all riveted. (d) If C is less than 1.0, severe oscillation is unlikely. If C is between 1.0 and 1.3 the design wind pressure for the chimney should be increased by a factor C^2. If C is larger than 1.3 stabilizers or dampers should be provided to control the oscillations.	**Wind-excited vibrations of circular chimneys** Flexible slender structures are subject to vibrations caused by cross wind and along wind action. Structures with a circular cross section, such as chimneys, oscillate more strongly across than along wind. The following simplified approach may be used for across wind vibration, see also clause 5.3: (a) The Strouhal critical velocity V_{crit} in metres per second for the chimney is to be determined by: $V_{crit} = 5\, D_t\, f$ (13.1) where f (in Hz) is the natural frequency of the chimney on its foundations. This may be calculated analytically or from the following approximate formula for the case of a regular cone: $f = \dfrac{500(3D_b - D_t)\left[\dfrac{W_s}{W}\right]^{\frac{1}{2}}}{h^2}$ (13.2) and h is the height of chimney (in m) D_t is the diameter at top (in m) D_b is the diameter at bottom (in m) W is the mass per metre height at top of structural shell including lining or encasing, if any (in kg) W_s is the mass per meter height at top of structural shell excluding lining (in kg) (b) If V_{crit} exceeds the design wind velocity in metres per second given by the following formula $V = 40.4\,(q)^{0.5}$ (13.3) where q is the design wind pressure in kN/m^2, severe vibration is unlikely and no further calculation is required. (c) If V_{crit} is less than the design wind velocity, the tendency to oscillate C may be estimated by the following empirical formula: $C = 0.6 + K\left[\dfrac{10\,D_t^2}{W} + \dfrac{1.5\Delta}{D_t}\right]$ (13.4) where Δ is the calculated deflection (in m) at the top of the chimney for unit distributed load of 1 kPa. K is 3.5 for all welded construction, 3.0 for welded with flanged and bolted joints and 2.5 for bolted and riveted or all riveted. (d) If C is less than 1.0, severe vibration is unlikely. If C is between 1.0 and 1.3 the design wind pressure for the chimney should be increased by a factor C^2. If C is larger than 1.3 stabilizers or dampers should be provided to control the vibrations.	The terms “oscillation” and “vibration” are collectively read as “vibration” for consistency.

22	Clause 13.5.5	**Serviceability issues** The following serviceability issues shall be addressed for long span structures: (a) Vibration from crowds. Refer to section 5 of the Code. (b) Wind induced oscillations of roof elements and cables. Fatigue may need to be checked. (c) Access for maintenance of roof steelwork can be very difficult therefore a high quality protective system should be specified for the steelwork. (d) Deflection limits for long span trusses under live and wind loads depend on circumstances. A value of span/360 may be used for preliminary design in the absence of other requirements. Significantly smaller deflection limits will be required for applications such as: aircraft hanger doors and stadia opening roofs.	**Serviceability issues** The following serviceability issues shall be addressed for long span structures: (a) Vibration from crowds. Refer to section 5 of the Code. (b) Wind induced vibrations of roof elements and cables. Fatigue may need to be checked. (c) Access for maintenance of roof steelwork can be very difficult therefore a high quality protective system should be specified for the steelwork. (d) Deflection limits for long span trusses under live and wind loads depend on circumstances. A value of span/360 may be used for preliminary design in the absence of other requirements. Significantly smaller deflection limits will be required for applications such as: aircraft hanger doors and stadia opening roofs.	The terms "oscillation" and "vibration" are collectively read as "vibration" for consistency.
23	Paragraph 13.6.4	**Vibration and oscillation** Pedestrians can be adversely affected by the dynamic behaviour of footbridges. In addition to the criteria specified in section 5 on Human-Induced Vibration, the natural frequency of a footbridge shall not be less than 3 Hz. If the natural frequency of a footbridge is less than 3 Hz which may lead to unpleasant vibration, the maximum vertical acceleration, a_v, shall be limited to an appropriate value as given in recognized design guidelines in Annex A2.3 in order to avoid unpleasant vibration.	**Vibration** Pedestrians can be adversely affected by the dynamic behaviour of footbridges. In addition to the criteria specified in section 5 on Human-Induced Vibration, the natural frequency of a footbridge shall not be less than 3 Hz. If the natural frequency of a footbridge is less than 3 Hz which may lead to unpleasant vibration, the maximum vertical acceleration, a_v, shall be limited to an appropriate value as given in recognized design guidelines in Annex A2.3 in order to avoid unpleasant vibration.	The terms "oscillation" and "vibration" are collectively read as "vibration" for consistency hence the word "oscillation" is deleted.
24	Annex A1.1.3	*Chinese standards* GB/T 247 - 1997 Rules of acceptance, package, label and certification for plate, strip and wide flat in structural steel GB/T 709 - 2006 Dimension, appearance, weight and tolerance of plate, strip and wide flat in hot rolled structural steel GB/T 1591 - 2008 High strength structural steel GB/T 5313 - 1985 Through thickness properties of steel plates YB 4104 - 2000 Steel plate for high rise building structure GB 50017 - 2003 Code for design of steel structures GB 50205 - 2001 Code for acceptance of construction quality of steel structures	*Chinese standards* GB/T 247 - 1997 Rules of acceptance, package, label and certification for plate, strip and wide flat in structural steel GB/T 700 – 2006 Carbon structural steel GB/T 709 - 2006 Dimension, appearance, weight and tolerance of plate, strip and wide flat in hot rolled structural steel GB/T 1591 - 2008 High strength structural steel GB/T 5313 - 1985 Through thickness properties of steel plates YB 4104 - 2000 Steel plate for high rise building structure GB 50017 - 2003 Code for design of steel structures GB 50205 - 2001 Code for acceptance of construction quality of steel structures	The Chinese standard GB/T 700-2006 is added in the Acceptable Standard List.