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General specification for steel structures

钢结构通用规范

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General specification for steel structures

1 General

1.0.1 In order to ensure the quality and safety of steel structure projects, implement policies on resource and energy conservation and rational utilization, protect the ecological environment, ensure the safety of people's lives and property and personal health, prevent and reduce steel structure engineering accidents, improve the level of green development of steel structure projects, this specification is hereby formulated.

1.0.2 Except for the following projects, steel structure projects must implement this specification.

- 1 Highway and railway bridges;
- 2 Pressure vessels, chemical vessels, gas pipelines;
- 3 Water conservancy, hydraulic engineering, water transportation, waterway engineering.

1.0.3 The construction of steel structures shall follow the following principles:

- 1 Meet the requirements of applicability, economy, durability;
- 2 Improve project construction quality AND operation and maintenance level;
- 3 Comply with national policies on energy conservation, environmental protection, disaster prevention and mitigation, emergency management;
- 4 In line with the development direction of construction technology; encourage the application of new technologies.

1.0.4 Whether the technical methods and measures, which are adopted in the project construction, meet the requirements of this specification, shall be determined by the relevant responsible entities. Among them, innovative technical methods and measures shall be demonstrated AND meet the relevant performance requirements in this specification.

2 Basic requirements

2.0.1 For the steel structure engineering, it shall determine the design service life, based on factors such as use function, construction cost, use and maintenance cost, environmental impact. It shall adopt different safety levels,

according to the severity of the possible consequences of structural damage; reasonably determine the structural action and action combination, seismic action and action combination; adopt appropriate design methods, to ensure the safety, applicability, durability of the structure.

2.0.2 For steel structures, it shall select a reasonable structural system, according to the functional requirements of the building (structure), the on-site environmental conditions, etc.

2.0.3 Within the design service life, the steel structure shall meet the following requirements:

- 1** It shall be able to withstand various actions, within the design load range, that may occur during normal construction and use;
- 2** It shall be kept in normal use;
- 3** It shall have durability that can reach the design service life, under normal use and normal maintenance conditions;
- 4** It shall be able to function normally, within the specified time, under fire conditions;
- 5** When explosions, impacts and other accidents occur, the structure shall remain stable; there shall be no damage, that is not commensurate with the cause.

2.0.4 The use and maintenance of steel structures and components, within the design service life, shall meet the following requirements:

- 1** Without technical appraisal or design permission, it shall not change the functions and conditions of use, which are specified in the design documents;
- 2** For matters that may affect the safety and durability of the main structure AND cause public safety risks to the public, it shall establish a regular inspection and maintenance system;
- 3** The components, joints, supports, parts, etc., that must be replaced according to the design requirements, shall be replaced in time;
- 4** The fire protection and anti-corrosion protection layer on the surface of the components shall be maintained or replaced, in accordance with the design requirements and maintenance requirements;
- 5** When the structure, components, joints, bearings, etc. have deformation and durability defects, that exceed the design requirements, they shall be

the tensile force is small and the bending moment is relatively large, it shall prevent the overall instability of the tension-bending member.

4.2 Cold-formed steel components

4.2.1 For the axial tension members and tension-bending members, which are mainly under tension, shall be subject to the verification of strength and rigidity.

4.2.2 Axial compression members, bending members, compression-bending members, tension-bending members which are mainly subjected to bending, shall be checked for strength, stability, rigidity.

4.2.3 In the design of rigid frames, roof trusses, purlins, wall beams, it shall verify the strength, stability, rigidity of the members. Meanwhile, it shall also consider the adverse effects of changes in the internal forces of the members, due to wind suction.

4.2.4 For the cold-formed steel components, that have undergone heat treatment, such as annealing, welding, hot-dip galvanizing, shall not adopt the strength design value, which considers the cold-bending effect.

4.3 Stainless steel components

4.3.1 Stainless steel structural materials shall be selected, according to factors such as the safety level of the structure, design service life, working environment, corrosion resistance requirements, surface requirements, etc.

4.3.2 The design of stainless steel components shall meet the following requirements:

- 1** The tensile strength of stainless steel components shall be calculated, based on the net section; the compressive strength shall be calculated, based on the effective net section; the stable bearing capacity of the member shall be calculated, based on the effective section; the stability coefficient shall be calculated, based on the gross section.
- 2** The stainless steel axial tension members and tension-bending members shall be subject to the verification of strength and stiffness.
- 3** The stainless steel axial compression members, bending members, compression-bending members shall be checked for strength, stability, rigidity.
- 4** For stainless steel welded flexural members, that are directly subjected to dynamic loads OR whose buckling strengths are not considered, it shall

verify the local stability of the web.

4.3.3 When stainless steel components are connected to carbon steel and low-alloy steel components, by fasteners, it shall use the insulating gaskets to separate OR other effective measures, to prevent bimetallic corrosion; meanwhile, it shall reduce the mechanical properties at the connection. Stainless steel components shall not be welded with carbon steel and low-alloy steel components.

4.4 Steel structure connection

4.4.1 The calculation model of the connection and the connector shall be consistent with the actual bearing capacity of the connection; meanwhile, it shall respectively calculate and design a single connector, according to the bearing capacity limit state and the normal service limit state.

4.4.2 For ordinary bolted connections, rivet connections, high-strength bolted connections, it shall calculate the combined bearing capacity of bolts (rivets) under shear, tension, tension & shear, as well as the bearing capacity of the connecting plate. Meanwhile, it shall consider the influence of the weakened bolt holes and the prying force of the connecting plate, on the bearing capacity of the connection.

4.4.3 The processing accuracy of bolt holes, the pretension which is applied by high-strength bolts, the treatment process of the friction surface of connecting plate for the frictional connection of high-strength bolts, shall ensure the reliability of the bolt connection. For the high-strength bolts, to which pretension had applied, shall not be recycled as a force-bearing bolt, after removal.

4.4.4 The welding consumables shall be matched with the base metal. The welding seam shall adopt the groove form and structural measures, to reduce the welding shrinkage stress, which is perpendicular to the thickness direction.

4.4.5 During the design of steel structure, the weld quality level shall be determined, according to the importance of the steel structure, load characteristics, weld form, working environment, stress state.

4.4.6 When the steel structure is subjected to dynamic loads AND it requires fatigue calculations, it is strictly prohibited to use plug welding, slot welding, electroslag welding, gas-electric vertical welding joints.

4.5 Fatigue

4.5.1 For steel structural members and their connections, that directly bear the

greater than 0.2; the second-order effect coefficient of the multi-floor steel structures shall not be greater than 0.25;

- 3** In the first-order analysis, for the frame structure, it shall determine the calculated length coefficient of the frame column, according to the lateral stiffness, based on the mode of lateral buckling or no lateral buckling;
- 4** It shall consider the imaginary horizontal load, in the second-order analysis; the calculated length coefficient of the frame column shall be 1.0;
- 5** The direction of the imaginary horizontal load shall be consistent with the direction of wind load or seismic action. The load sub-factor of the imaginary horizontal load shall be 1.0. The combination factor shall be 1.0, for the load combinations which include wind load; the combination coefficient shall be 0.5, for the load combinations which include seismic action.

5.2.4 The seismic design of high-rise steel structures shall meet the following requirements:

- 1** It shall control the sequence of the plastic deformation of the structural members and joints; it shall use the capacity design method, for supplementary check calculations;
- 2** The slenderness ratio of steel frame columns and supporting members, the limits of the width-to-thickness ratio of beams, columns, supporting plates, shall be adapted to the seismic performance targets of different members.

5.2.5 For the reinforced layer of high-rise steel structure AND the vertical members and connecting parts of the upper and lower floors, the seismic structural measures shall be increased by one level, according to the specified seismic grade of the structure. As for the vertical members and connecting parts of the reinforced layer, the seismic strengthening measures shall also be designed, according to the calculation results.

5.2.6 Under normal conditions of use, multi-floor and high-rise steel structures shall have sufficient rigidity.

5.3 Large-span steel structure

5.3.1 When calculating the large-span steel structure, it shall determine the boundary conditions, according to the form of the lower supporting structure and the support structure. For the large-span steel structure with complex shape, it shall use the overall model, including the lower supporting structure, for calculation.

5.3.2 In areas with large snow loads, it shall also consider the adverse effects of uneven distribution of snow loads, when designing large-span steel structures. When the body shape is complex AND there is no reliable basis, it shall use wind and snow tests or special studies, to determine the design snow load.

5.3.3 For arch structures, single-layer reticulated shells, double-layer reticulated shells with relatively large spans, as well as other spatial grid structures that are mainly compressed, it shall carry out the nonlinear overall stability analysis. The stable bearing capacity of the structure shall be determined, through the whole process analysis of elasticity or elastic-plasticity, meanwhile it shall consider the influence of initial defects, in the analysis.

5.3.4 For the grid shell structure, which has a seismic fortification intensity of 8 degrees and above, AND the grid shell structure in the area, which has a seismic fortification intensity of 7 degrees and above, they shall be subjected to seismic calculation. When using the mode decomposition response spectrum method for seismic checking, the number of modes shall be calculated, so that the sum of the participating masses of each mode is not less than 90% of the total mass. For large-span steel structures, which have complex shapes, time-history analysis method shall be used in seismic check calculation; meanwhile the vertical and horizontal seismic effects shall be considered, at the same time.

5.3.5 For the cable-membrane structure or pre-stressed steel structure, it shall be respectively subjected to initial pre-tension state analysis and load state analysis. It shall consider the geometric nonlinear effects, in the calculation. Under the load combination, which is controlled by permanent load, the cables and membranes in the structure shall not be slack. Under the load combination, which is controlled by variable load, the structure shall neither cause structural failure nor affect the normal use function of structure, due to the relaxation of local cables or membranes.

5.4 Tower mast steel structure

5.4.1 For tower mast steel structures, which have complex terrain conditions or complex geometric shapes, the wind-resistant design parameters shall be determined, through wind tunnel tests or numerical simulations.

5.4.2 When designing similar structures such as TV towers, radio tower masts, power transmission towers, in ice-covered areas, it shall consider the effects of the increased load and wind-shielding area, which is caused by the icing of surface of structural members, overhead lines, ropes, as well as the unfavorable effects of uneven ice removal. For the structure of the transmission tower, it shall also consider the action of breaking tension, which is caused by icing.

- 1** It shall have a clear calculation diagram AND a reasonable transmission path of seismic action;
- 2** It shall be ensured that the connecting joints are not destroyed before the components;
- 3** It shall be avoided that the entire structure loses its anti-seismic capacity OR its bearing capacity for gravity loads, due to the destruction of part of the structure or components;
- 4** It shall have good deformability and plastic energy dissipation capacity;
- 5** Measures shall be taken to improve the seismic resistance of the weak parts, that may appear.

6.1.2 In addition to meeting the provisions of clause 3.0.2 of this specification, for the steel materials of the components or parts, that undergo plastic deformation, under the action of rare earthquakes, the super-strength coefficient shall not be greater than 1.35.

6.1.3 When calculating the seismic bearing capacity of steel structural members, the value of the seismic adjustment coefficient of bearing capacity shall comply with the requirements of current relevant national standards.

6.1.4 For the connection of the plastic energy dissipation zone of the seismic members of the steel structure, the ultimate bearing capacity shall be greater than the bearing capacity of the connected members, when they are fully plastically deformed.

6.2 Seismic isolation and damping design

6.2.1 In the design of seismic isolation and energy dissipation, the seismic isolation device and damping components shall meet the following requirements:

- 1** The performance parameters of the seismic isolation device and energy dissipation components shall be determined by tests;
- 2** It shall take measures, to facilitate inspection and replacement, for the installation positions of seismic isolation devices and energy dissipation and damping components;
- 3** The design documents shall indicate the performance requirements for the seismic isolation device and energy dissipation and damping components; it shall carry out sampling inspection, before installation.

7.2.3 All welds shall be visually inspected. The first-level and second-level welds, that require full penetration, shall be subject to non-destructive testing of internal defects. The flaw-detection ratio of first-level weld shall be 100%; the flaw-detection ratio of second-level weld shall not be less than 20%.

7.2.4 The judgement of results of the welding quality sampling inspection shall meet the following requirements:

- 1** Except for crack defects, when the unqualified rate of the number of welds, in the sampling inspection, is less than 2%, the batch is accepted. When the unqualified rate of the number of welds, in the sampling inspection, is greater than 5%, the batch is unqualified. When the unqualified rate, of the number of welds, in the sampling inspection, is 2% ~ 5%, other uninspected welds shall be randomly inspected, at a flaw-detection ratio of not less than 2%; meanwhile, it shall respectively add one place, along the extension line of the welds, on both sides of the original unqualified part; if the unqualified rate of all welds, under sampling inspection, is not more than 3%, this batch is accepted; if it is more than 3%, this batch is rejected.
- 2** When there is 1 cracking defect in the inspection, it shall double the number for inspection. If no cracking defect is found in the double sampling inspection of the weld, the batch shall be accepted. If the inspection finds multiple cracking defects or the double sampling inspection also finds a cracking defect, the batch shall be rejected, AND all the remaining welds of the batch shall be inspected.
- 3** When the batch acceptance is unqualified, all the remaining welds of the batch shall be inspected.

7.3 Acceptance

7.3.1 Steel structure's anticorrosive coatings, number of coating passes, coating thickness shall all meet the requirements of the design and coating product specification. When the design does not require the thickness of the coating, the total thickness of the dry paint film of the coating shall be 150 μm outdoor, 125 μm indoor, AND have an allowable deviation of -25 μm . The inspection quantity and inspection method shall meet the following requirements:

- 1** Randomly check 10% of the number of components; there shall be not less than 3 similar components;
- 2** Inspect 5 locations for each component; the value of each location is the average value of the dry paint film thickness of the coating, at 3 measuring

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