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General code for concrete structures

混凝土结构通用规范

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1 General

1.0.1 This Code is formulated to ensure the quality of concrete structural engineering, the safety of people's lives and property, personal health, and promote the green and high-quality development of concrete structural engineering.

1.0.2 This Code must be implemented for concrete structural engineering.

1.0.3 Whether the technical methods and measures adopted in engineering construction comply with the requirements of this Code shall be determined by the relevant responsible parties. Among them, innovative technical methods and measures shall be demonstrated and meet the performance requirements of this Code.

2 Basic regulations

2.0.1 Concrete structural engineering shall determine its structural design working life, structural safety level, seismic fortification category, structural action and action combination. Structural bearing capacity limit state, normal service limit state, and durability design shall be carried out. They shall meet the functional and structural performance requirements of the project.

2.0.2 The selection of strength grade for structural concrete shall meet the requirements for bearing capacity, stiffness, and durability of the engineering structure. For concrete structures with a design service life of 50 years, the strength grade of structural concrete shall also comply with the following regulations. For concrete structures with a design service life greater than 50 years, the minimum strength grade of structural concrete shall be higher than the following regulations.

1. The concrete strength grade of plain concrete structural components shall not be lower than C20. The concrete strength grade of reinforced concrete structural components shall not be lower than C25. The concrete strength grade of prestressed concrete floor structure shall not be lower than C30. The concrete strength grade of other prestressed concrete structural components shall not be lower than C40. The concrete strength grade of steel-concrete composite structural components shall not be lower than C30.

2. For reinforced concrete structural components subjected to repeated loads, the concrete strength grade shall not be lower than C30.

3. For reinforced concrete structural components with seismic resistance level not lower than grade 2, the concrete strength level shall not be lower than C30.

4. For reinforced concrete structural components using steel bars of 500 MPa and above, the concrete strength grade shall not be lower than C30.

2.0.3 Ordinary steel bars and prestressed steel bars used in concrete structures shall have strength and elongation that meet the requirements of engineering structures in the ultimate bearing capacity and normal service limit states.

2.0.4 The strength standard values of ordinary steel bars, prestressed steel bars, and structural concrete used in concrete structures shall have a guaranteed rate of not less than 95%. The strength design value shall comply with the following regulations:

1. The design value of structural concrete strength shall be determined by dividing its strength standard value by the material partial coefficient. The value of material partial coefficient shall not be less than 1.4.

2. The strength design values of ordinary steel bars and prestressed steel bars shall be determined by dividing their strength standard values by the partial coefficients of ordinary steel bars and prestressed steel bar materials. The material partial coefficients of ordinary steel bars and prestressed steel bars shall be determined based on the reliability requirements of the engineering structure, considering factors such as the mechanical properties, process performance, and surface shape of the steel bars.

3. The partial coefficient value of ordinary steel bar material shall not be less than 1.1. The partial coefficient value of prestressed reinforcement material shall not be less than 1.2.

2.0.5 Concrete structures shall take measures to ensure the durability of concrete structures based on their purpose, exposed environment, and designed service life.

2.0.6 Reinforced concrete structural components and prestressed concrete structural components shall adopt design and construction measures to ensure the synergistic performance of steel bars, prestressed steel bars, and concrete materials under various working conditions.

2.0.7 Mix design shall be carried out for structural concrete. Measures shall be taken to ensure the performance of concrete mixture, concrete mechanical performance and durability.

2.0.8 Concrete structures shall take measures to control concrete cracks from various aspects such as design, materials, construction, and maintenance. The calculation of stress cracks in concrete components shall comply with the following regulations:

1. For concrete components that do not allow cracks to occur, the concrete section shall be controlled to not generate tensile stress, or the maximum tensile stress shall not exceed the standard tensile strength value of the concrete according to the actual cleaning condition.

2. For concrete components that allow cracks to occur, the width of stress cracks shall be controlled based on the component category and environmental category,

with impermeability, frost resistance, corrosion resistance, wear resistance or other special requirements, the mud content and mud block content of the sand shall not exceed 3.0% and 1.0% respectively; and the firmness index shall not exceed 8%. The mud content and mud block content of the sand used for high-strength concrete shall not be greater than 2.0% and 0.5% respectively. The machine-made sand shall control the stone powder content according to the methylene blue value indicator of the stone powder and the flow ratio indicator of the stone powder.

2. Sea sand for concrete structures must be purified.

3. The chloride ion content of sand for reinforced concrete shall not exceed 0.03%. The chloride ion content of the sand used for prestressed concrete shall not exceed 0.01%.

3.1.3 The firmness indicator of coarse aggregate for structural concrete shall not be greater than 12%. For concrete with impermeability, frost resistance, corrosion resistance, wear resistance or other special requirements, the mud content and mud block content in the coarse aggregate shall not exceed 1.0% and 0.5% respectively. The firmness indicator shall not be greater than 8%. The mud content and mud block content of coarse aggregate for high-strength concrete shall not be greater than 0.5% and 0.2% respectively.

3.1.4 Admixtures for structural concrete shall meet the following requirements:

1. Concrete admixtures containing hexavalent chromium, nitrite and thiocyanate shall not be used in concrete that is in direct contact with drinking water after construction in drinking water projects.

2. Early-strength ordinary water reducers, early-strength agents, antifreeze agents and waterproofing agents containing strong electrolyte inorganic salts are strictly prohibited for the following concrete structures:

   1) Concrete structures in contact with galvanized steel or aluminum;

   2) Concrete structures with exposed steel bars and embedded parts without protective measures;

   3) Concrete structures using DC power;

   4) Concrete structures within 100 m from the high voltage DC power supply.

3. Early-strength ordinary water-reducing agents, early-strength agents, waterproofing agents and chloride-salt antifreezes containing chloride salts shall not be used in prestressed concrete, reinforced concrete and steel fiber concrete structures.

4. Early-strength ordinary water reducers and early-strength agents containing

ignored, the temperature effect and effect shall be calculated.

3. When the impact of shrinkage and creep on structural performance cannot be ignored, the impact of concrete shrinkage and creep on structural performance shall be calculated.

4. When the construction project requires to consider the accidental effect, the accidental effect and its effect shall be calculated according to the requirements.

5. For structures or structural components directly subjected to dynamic and impact loads, structural dynamic effects shall be considered.

6. The corresponding structural dynamic effects shall be considered during the fabrication, transportation, hoisting and installation of precast concrete components.

4.1.2 The seismic fortification objectives and anti-seismic measures of concrete structures shall be determined according to the seismic fortification intensity of the project location, site category, design earthquake grouping, project's seismic fortification category, and seismic performance requirements.

4.1.3 When the stress expression is used to calculate the limit state of the bearing capacity of concrete structural components, the following requirements shall be met:

1. The strength values of concrete and steel bars shall be determined according to the design conditions and component performance design objectives.

2. The design stress of the steel bar shall not be greater than the strength value of the steel bar.

3. The design stress of concrete shall not be greater than the strength value of concrete.

4.1.4 The prefabricated concrete structure shall determine the connection structure method and carry out connection and node design according to the structural performance and the convenience requirements of component production and installation construction.

4.1.5 The connection between concrete structural components and between non-structural components and structural components shall comply with the following requirements:

1. The stress and deformation performance requirements between the connected components shall be met.

2. The connection between non-structural components and structural components shall adapt to the deformation requirements of the main structure.

3. The connection shall not be broken prior to the connected component.

4.2 Structural system

4.2.1 The concrete structural system shall meet the load-bearing capacity, stiffness and ductility performance requirements of the project.

4.2.2 The design of the concrete structure system shall meet the following requirements:

1. The mixed load-bearing structural system of concrete structural components and masonry structural components shall not be used.

2. The building structure shall adopt a two-way lateral force resistant structure system.

3. For high-rise buildings with a seismic fortification intensity of 9 degrees, structures with transfer floors, structures with reinforced floors, split-level structures and conjoined structures shall not be used.

4.2.3 The concrete floor of the house building shall meet the requirements of vertical vibration comfort of the floor. Concrete structure high-rise buildings shall meet the vibration comfort requirements of the 10-year return period horizontal wind load.

4.3 Structural analysis

4.3.1 The structural analysis model that conforms to the engineering reality shall be used for the analysis of the effect of the concrete structure during the normal use stage and the construction stage.

4.3.2 The structural analysis model shall meet the following requirements:

1. The structural and component geometric dimensions, structural material performance indicators, calculation parameters, boundary conditions and calculation diagrams used in the structural analysis model shall be determined.

2. The possible structural effects and their combination, initial state, etc. shall be determined.

3. When using approximate assumptions and simplified models, there shall be theory, test basis and engineering practice experience.

4.3.3 Structural calculation and analysis shall meet the following requirements:

1. Satisfy the mechanical balance condition.

2. Satisfy the main deformation coordination conditions.

4. The ultimate tensile strain of longitudinal tensile steel bars is taken as 0.01.

5. The stress of the longitudinal reinforcement is taken as the product of the strain of the reinforcement and its modulus of elasticity. The stress of the steel bar shall not exceed the design value of the compressive and tensile strength of the steel bar. For axial compression components, the design value of the compressive strength of the steel bar shall not exceed 400 N/mm.

6. The stress of the longitudinal prestressed tendon is taken as the product of the strain of the prestressed tendon and its elastic modulus. The stress of prestressed tendon shall not be greater than its design value of tensile strength.

4.4.3 When performing stress analysis and design on concrete structural components with large volume or complex cross-sectional shape, the following regulations shall be met:

1. The strength values and checking calculations of concrete and steel bars shall comply with the provisions of Article 4.1.3 of this Code.

2. The amount of reinforcement shall be determined according to the projection of the resultant force of the design value of the main tensile stress in the direction of reinforcement. Determine the layout of the steel bar according to the distribution of main tensile stress. The corresponding construction requirements shall be met.

4.4.4 The minimum cross-sectional size of concrete structural components shall meet the following requirements:

1. The section width of rectangular section frame beams shall not be less than 200 mm.

2. The side length of the rectangular section frame column shall not be less than 300 mm. The diameter of circular section columns shall not be less than 350 mm.

3. The section thickness of the shear wall of a high-rise building shall not be less than 160 mm. The section thickness of the shear wall of a multi-storey building shall not be less than 140 mm.

4. The thickness of the cast-in-place reinforced concrete solid slab shall not be less than 80 mm. The thickness of the top and bottom slabs of cast-in-place hollow slabs shall not be less than 50 mm.

5. The thickness of the prefabricated bottom slab and the post-cast concrete of the prefabricated reinforced concrete solid laminated floor slab shall not be less than 50 mm.

4.4.5 Reliable reinforcement measures shall be taken for ordinary steel bars and prestressed bars in concrete structures. The value of the delineated solid length of ordinary steel bars shall meet the following requirements:

2. The eigenvalue of the stirrups of the converted column shall be increased by 0.02 compared with the value required by the ordinary frame column. The stirrup volume ratio shall not be less than 1.50%.

4.4.12 The structural design of high-rise buildings with reinforced floors shall meet the following requirements:

1. The seismic grades of the frame columns and core wall shear walls of the reinforced storey and its adjacent storeys shall be upgraded by one grade. It shall not be allowed to increase when it has reached the special grade.

2. For the frame columns of the reinforcement layer and its adjacent layers, the stirrups shall be densely configured in the entire column section. The limit value of axial compression ratio shall be adopted by reducing the value of frame columns of other floors by 0.05.

3. The reinforced layer and its adjacent core wall shear walls shall be provided with constrained edge components.

4.4.13 The design of the split-level structure of a building shall meet the following requirements:

1. The concrete strength grade of the frame column at the staggered level shall not be lower than C30. Stirrups shall be densely configured throughout the column. The seismic grade shall be raised by one grade. It shall not be allowed to increase when it is already a special grade.

2. The bearing capacity of the shear wall bearing force outside the plane at the staggered level shall be appropriately increased. The thickness of the shear wall section shall not be less than 250 mm. The concrete strength grade shall not be lower than C30. The reinforcement ratio of the horizontal and vertical distribution steel bars shall not be less than 0.50%.

4.4.14 Building connectors and structural components connected to connectors shall meet the following requirements:

1. For the connecting body and the structural components connected to the connecting body, within the height range of the connecting body and its upper and lower floors, the seismic grade shall be raised by one grade. Grade one shall be upgraded to special grade. It shall not be allowed to increase when it has reached the special grade.

2. The frame column connected with the connecting body shall be within the height range of the connecting body and its upper and lower floors. Stirrups shall be densely configured throughout the column. The limit value of axial compression ratio shall be adopted by reducing the value of frame columns of other floors by 0.05.

3. The shear wall connected to the connecting body shall be provided with constrained edge components within the height range of the connecting body and its upper and lower floors.

5 Construction and acceptance

5.1 General provisions

5.1.1 The construction of concrete structures shall ensure the realization of the design requirements and shall comply with the following regulations:

1. The construction organization design and construction plan shall be prepared and implemented.

2. Measures for resource conservation and environmental protection shall be developed and implemented.

3. The completed entities shall be protected. Loads acting on completed entities shall not exceed specified values.

5.1.2 Materials, components, utensils and semi-finished products shall be inspected and accepted at the site. They can only be used after they are accepted.

5.1.3 Acceptance of concealed works shall be carried out and records shall be made.

5.1.4 When the formwork is removed, the prefabricated components are lifted, and the prestressed tendons are stretched and released, the concrete specimens cured under the same conditions shall reach the specified strength.

5.1.5 The appearance quality of concrete structures shall not have serious defects and dimensional deviations that affect structural performance and use functions.

5.1.6 Physical quality inspection shall be carried out for representative parts involving the safety of concrete structures.

5.2 Template engineering

5.2.1 Templates and supports shall be designed according to various control conditions during the construction process. They shall meet the bearing capacity, stiffness and overall stability requirements.

5.2.2 Templates and supports shall ensure that the shape, size and position of each part of the concrete structure and components are accurate.

3. Bolted connections shall be subject to process inspection and installation quality inspection.

4. For the mechanical connection of steel bars, parallel processing test pieces shall be made. Performance tests shall be carried out.

5.5.2 The joint surface of prefabricated composite components and the joint surface of prefabricated component connection nodes shall be treated and cleaned according to the design requirements. Post-cast concrete shall be full and dense.

6 Maintenance and demolition

6.1 General provisions

6.1.1 For concrete structures, it shall establish a structure use and maintenance management system throughout the life cycle according to the structure type, safety level and use environment.

6.1.2 A maintenance database and information management platform shall be established for important concrete structures.

6.1.3 Demolition of concrete structure works shall be schematically designed. Measures shall be taken to ensure the safety of the dismantling process. The demolition of prestressed concrete structures shall still analyze the prestressing release procedure.

6.1.4 Demolition of concrete structures shall follow the principles of reduction, recycling and reusing. A waste disposal plan shall be developed.

6.2 Structure maintenance

6.2.1 Routine maintenance of concrete structures shall check the structural appearance and load changes. With regard to the appearance of structural components, inspections shall focus on cracks, deflection, freeze-thaw, corrosion, corrosion of steel bars, shedding of protective layers, water leakage, uneven settlement, artificial openings, damage and other damages. Regarding prestressed concrete components, it is important to check whether there are cracks and whether the anchorage end is loose. For concrete structures in coastal or acidic environments, the neutralization and corrosion condition of the concrete surface shall be checked.

6.2.2 For concrete structures in harsh environments, a targeted maintenance plan shall be developed.

6.2.3 When one of the following conditions is met, the structure shall be tested and identified:

1. Structures that are close to or reach the design working life and still need to be used;

2. Structures showing signs of endangering the safety of use;

3. Structures undergoing structural modification, changing the nature of use, damaging the bearing capacity or increasing the load;

4. Structures that have suffered damage after disasters such as earthquakes, typhoons, fires, floods, explosions, and impacts;

5. Structures affected by surrounding construction;

6. Structures that are determined to be inspected by daily inspection and evaluation.

6.2.4 When there is any objection to the cement stability of hardened concrete, the potential hazard of free calcium oxide in cement shall be tested.

6.2.5 The structural performance and safety of the following concrete structures shall be monitored:

1. High-storey and high-rise structures with a height of 350 m and above;

2. High-storey and high-rise structures where there is a large difference between the final configuration of the structure and the design target configuration during the construction process;

3. High-storey and high-rise or complex structures with seismic isolation systems;

4. Reinforced concrete shell structure with a span greater than 50 m.

6.2.6 Inspections and system maintenance shall be carried out during the monitoring period. During special circumstances such as typhoons and floods, the frequency of monitoring shall be increased.

6.2.7 Concrete structure monitoring shall set monitoring and early warning value. The monitoring and early warning value shall meet the requirements of engineering design and control of the monitored objects.

6.2.8 Bridge structures that have exceeded the structural design working life or have a service life of more than 50 years shall be inspected and evaluated. The testing and evaluation cycle shall not exceed 10 years.

6.3 Structure disposal

6.3.1 When one of the following situations occurs, measures to eliminate potential safety hazards shall be taken:

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