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**General code for seismic precaution of buildings and
municipal engineering**

建筑与市政工程抗震通用规范

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General code for seismic precaution of buildings and municipal engineering

1 General

1.0.1 This Code is formulated, in order to implement the national laws and regulations on earthquake prevention and disaster reduction of buildings and municipal projects, implement the principle of prevention first, so that buildings and municipal projects can achieve the target of reducing earthquake damage, avoiding casualties, reducing economic losses after seismic fortification.

1.0.2 All kinds of newly-built, expanded, reconstructed buildings and municipal projects, in areas which have a seismic fortification intensity of 6 degrees and above, must be seismically fortified. The survey, design, construction, use maintenance of engineering projects must comply with this Code.

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

2 Basic provisions

2.1 Performance requirements

2.1.1 For all kinds of buildings and municipal projects with seismic fortification, their seismic fortification objectives shall meet the following requirements:

- 1** In the event of frequent earthquakes, which are lower than the fortification intensity of the region, the main structures and municipal pipe network systems of various projects can continue to be used, without damage or repairs.
- 2** When encountering fortification earthquakes, which are equivalent to the fortification intensity of the region, buildings, structures, bridge structures, underground engineering structures, etc. in various projects may be damaged, BUT they can continue to be used, after general repairs. The damage to the municipal pipe network shall be controlled within the local scope AND shall not cause secondary disasters.

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2.3.2 The seismic fortification criteria of buildings and municipal works, which have each type of seismic fortification, shall meet the following requirements:

- 1** For the standard fortification category, the anti-seismic measures and seismic action shall be determined, according to the seismic fortification intensity of the local area, so as to achieve the seismic fortification target that it will not collapse or cause serious damage, that endangers life and safety, in the event of a rare earthquake that is higher than the local seismic fortification intensity.
- 2** For the key fortification category, the anti-seismic measures shall be strengthened, according to the requirement that the seismic fortification intensity of the region shall be increased by one degree. However, when the seismic fortification intensity is 9 degrees, anti-seismic measures shall be taken according to the requirements higher than 9 degrees. The anti-seismic measures for the foundation shall comply with the relevant provisions. At the same time, the seismic action shall be determined, according to the seismic fortification intensity of the area.
- 3** For the special fortification category, the seismic measures shall be strengthened, according to the requirement of increasing the seismic fortification intensity of the region by one degree. However, when the seismic fortification intensity is 9 degrees, the seismic measures shall be taken according to the requirements higher than 9 degrees. At the same time, the seismic action shall be determined, according to the results of the approved seismic safety evaluation AND higher than the requirements of the seismic fortification intensity of the area.
- 4** For the moderate fortification category, it is allowed to reduce the seismic measures appropriately, as compared with the requirements of the seismic fortification intensity in this area. However, the seismic fortification intensity shall not be reduced, when the seismic fortification intensity is 6 degrees. Under normal circumstances, the seismic action shall still be determined, according to the seismic fortification intensity of the area.
- 5** When the project site is category I, for the projects of special fortification category and key fortification category, seismic structural measures are allowed to be taken, according to the requirements of the fortification intensity of the region. For the projects standard fortification category, the seismic structure measures are allowed to be reduced by one degree; however, it shall not be lower than the requirement of 6 degrees.
- 6** For urban bridges, the frequent earthquake action shall be adjusted, according to the different seismic fortification categories multiplied by the

corresponding importance coefficient. For urban bridges with special fortification category, key fortification category, standard fortification category, moderate fortification category, THEN, their importance coefficients shall not be lower than 2.0, 1.7, 1.3, 1.0, respectively.

2.4 Engineering seismic system

2.4.1 The seismic system of buildings and municipal works shall be determined, by comprehensive comparison of technology, economy, use conditions, according to the engineering seismic fortification category, seismic fortification intensity, engineering space scale, site conditions, foundation conditions, structural materials, construction and other factors. Meanwhile, it shall meet the following requirements:

- 1** It shall have a clear and reasonable transmission path of seismic action.
- 2** It shall have the necessary stiffness, strength, energy dissipation capacity.
- 3** It shall have the ability to avoid the loss of seismic capacity of the whole structure OR the bearing capacity of gravity load, due to the failure of part of the structure or components.
- 4** Structural members shall have sufficient ductility, to avoid embrittlement failure.
- 5** The bridge structure shall also have reliable displacement restraint measures, to prevent falling beam damage during earthquakes.

2.4.2 The seismic system of construction projects shall meet the following requirements:

- 1** The structural system shall have sufficient firmness and seismic redundancy.
- 2** The floor and roof shall have sufficient in-plane stiffness and integrity. When using prefabricated floors and roofs, measures shall be taken, to ensure the integrity of the floors and roofs AND their connection with vertical lateral force-resistant members.
- 3** The foundation shall have good integrity and anti-rotation ability, so as to avoid the foundation rotation aggravating the earthquake damage of the building, during the earthquake.
- 4** The design and construction of member connections shall ensure that, the failure of joints or anchors does not precede the failure of members or connectors.

2.4.3 The seismic system of urban water supply & drainage and gas-fired thermal engineering shall meet the following requirements:

- 1 The same structural unit shall have good integrity.
- 2 The buried pipeline shall adopt the pipe material with good ductility OR set up flexible connection measures along the line.
- 3 The connection structure of the fabricated structure shall ensure the integrity of the structure AND the requirements for seismic performance.
- 4 When the pipeline is connected to the structure or the fixed equipment, the flexible connection structure shall be adopted.

2.4.4 Structural joints, such as expansion joints, settlement joints, anti-vibration joints, between adjacent buildings (structures) OR between different structural units of the same building, shall take effective measures, to avoid damage caused by collision or extrusion under earthquakes.

2.4.5 The special requirements of the seismic structural system, for structural materials (including special structural equipment) and construction technology, shall be indicated on the design documents.

3 Seismic requirements of site and foundation

3.1 Site seismic survey

3.1.1 The site seismic survey of buildings and municipal works shall meet the following requirements:

- 1 According to the geological environment and other conditions of the area, where the project site is located, the seismic performance of the area shall be evaluated as favorable, general, unfavorable or dangerous.
- 2 The category of the project site shall be evaluated and divided.
- 3 The seismic stability performance of the engineering site, such as liquefaction, seismic subsidence, lateral expansion, collapse and landslide, shall be evaluated; it shall give corresponding engineering prevention measures.
- 4 For unfavorable segments, such as strip-shaped protruding mountain openings, tall and isolated hills, steep slopes of non-rock and strongly weathered rocks, river banks and slope edges, it shall also provide the survey results of the parameters, such as the relative height difference,

4 Seismic action and structural seismic verification

4.1 General provisions

4.1.1 When calculating the seismic action of various buildings and municipal projects, the design ground motion parameters shall be determined, according to the relevant provisions of Article 2.2 of this Code, based on the fortification intensity. It shall be adjusted according to the following provisions:

- 1** When the engineering structure is within 10 km, on both sides of the seismic fault, the influence of the near-field effect on the design ground motion parameters shall be taken into account.
- 2** When the engineering structure is located in unfavorable areas, such as strip-shaped protruding mountain openings, towering and isolated hills, steep slopes of non-rock and strongly weathered rocks, river banks, slope edges, THEN, it shall consider the amplification effect of the unfavorable areas on the horizontal design seismic parameters. The magnification factor shall be determined, according to the specific conditions of the unfavorable area; its value shall not be less than 1.1 and not more than 1.6.

4.1.2 The seismic action of various types of buildings and municipal works shall be calculated, using an analysis model, that conforms to the actual working conditions of the structure; it shall meet the following requirements:

- 1** In general, the horizontal seismic action shall be calculated separately, along at least the two main axes of the structure. Where there are oblique lateral force-resistant members, which have an intersection angle with the main axis greater than 15° , THEN, the horizontal seismic action in the direction of the oblique members shall also be calculated.
- 2** When calculating the horizontal seismic action effect of each lateral force-resisting member, the influence of the torsional effect shall be taken into account.
- 3** For the large-span and long-cantilever structures, which have seismic fortification intensity not less than 8 degrees, AND the high-rise buildings, which have seismic fortification intensity of 9 degrees, water-containing structures, gas storage tanks, gas storage tanks, etc., it shall calculate the vertical seismic action.
- 4** For spatial structures and long-line structures, which have large plane projection scales, it shall consider the spatial and temporal changes of seismic ground motion, in the calculation of seismic action.

absorbing structure, shall not be lower than the total horizontal seismic action of the non-energy-dissipating structure, which has a fortification of 6 degrees; the horizontal seismic shear of each floor shall also meet the requirements of Article 4.2.3 of this Code.

- 2** The cross-section seismic check of the main structural members shall comply with the provisions of Article 4.3.1 of this Code. Among them, for the beams, columns, other structural members which are connected with the energy dissipation components, they shall be checked for the ultimate bearing capacity, by using the combination of standard effects, under rare earthquakes.
- 3** The energy-dissipating and shock-absorbing structures shall be checked for inter-floor deformation, under frequent earthquakes and rare earthquakes.
- 4** For the energy dissipation and shock absorption structure, its seismic measures shall be determined, according to the reduction range of the seismic action, after shock absorption.

5.1.12 For the non-structural components and ancillary electromechanical equipment of the building, as well as their connection with the main structure, they shall be seismically fortified.

5.1.13 In the main structure of the building, at the installation locations of non-structural components, such as curtain walls, enclosure walls, partition walls, parapets, awnings, trademarks, billboards, ceiling brackets, large storage racks, etc., it shall take reinforcing measures, to withstand the seismic action, which is transmitted by non-structural members.

5.1.14 The design and construction of non-load-bearing walls, such as enclosure walls, partition walls, parapet walls, shall meet the following requirements:

- 1** When masonry walls are used, tie bars, horizontal tie beams, ring beams, structural columns, etc. shall be provided, to reliably tie with the main structure.
- 2** The wall and its connection with the main structure shall have sufficient deformation capacity, to meet the interlayer deformation requirements of the main structure, in different directions.
- 3** The masonry parapet wall, at the entrance & exit and passage of people, shall be anchored with the main structure; the free end of the parapet wall at the anti-vibration joint shall be strengthened.

5.1.15 The design and construction of architectural decorative components

shall meet the following requirements:

- 1** The components of various ceilings and the connecting parts with the floor slabs shall be able to withstand the self-weight and earthquake additional action of the ceiling, suspended heavy objects, related electromechanical facilities. The bearing capacity of their anchorage shall be greater than the bearing capacity of the connecting parts.
- 2** For the cantilevered member OR the member supported by a column at one end, it shall be reliably connected to the main structure.
- 3** The seismic structures of glass curtain walls, prefabricated wall panels, cantilever members attached to the roof, large storage racks shall meet the requirements for seismic fortification category and intensity.

5.1.16 The mechanical and electrical equipment, which is attached to the building, shall not be installed in the position, that may cause secondary disasters, such as functional impairment. The auxiliary equipment, that needs to work continuously, under the fortified earthquake, shall be installed in the part of the building structure with less seismic response.

5.1.17 The openings for pipes, cables, ventilation pipes, equipment shall be set, so as to reduce the weakening of the main load-bearing structural members. The reinforcement measures shall be taken at the edges of the openings. The connection, between pipes, equipment and the building structure, shall have sufficient deformation capacity, to meet the needs of relative displacement.

5.1.18 The foundations or supports of the mechanical and electrical equipment, which is attached to the building, as well as the related connectors and anchors, shall have sufficient rigidity and strength; it shall be able to transmit all the seismic action, which is borne by the equipment, to the building structure.

In the building structure, for the parts, which are used to fix the embedded parts and anchors of the auxiliary mechanical and electrical equipment of the building, it shall be strengthened, to withstand the seismic action, which is transmitted by the auxiliary mechanical and electrical equipment to the main structure.

5.2 Concrete structure houses

5.2.1 The reinforced concrete structure house shall adopt different seismic grades, according to the fortification category, fortification intensity, structure type, house height. Meanwhile, it shall meet the corresponding requirements for internal force adjustment and seismic structure. The seismic grade shall meet the following requirements:

- 1** The seismic grade of category C buildings shall be determined, according

meet the following requirements:

- 1 A casing shall be installed on the wall or foundation, where the pipe passes through. The gap between the pipe and the casing shall be sealed with flexible anti-corrosion and waterproof materials.
- 2 When the traversing pipeline is embedded in the wall or foundation, a flexible connecting device shall be installed near the traversing pipeline.

6.2.10 In urban water supply & drainage and gas thermal engineering, when buried pipelines, such as water and gas transmission, cross the active fault zone, it shall take the following measures:

- 1 The pipeline shall be laid in the casing. The gap between the pipeline and the casing shall be sealed with flexible anti-corrosion and waterproof materials. Around the casing, it shall be filled with dry sand.
- 2 Pipes and casing shall be steel pipes.
- 3 On the pipelines on both sides of the fracture zone, emergency shut-off valves shall be set, at appropriate positions.

6.2.11 Emergency shut-off valves shall be installed, at the exits of gas plants and storage & distribution stations.

6.2.12 Valve wells shall be provided for all valves, on the pipeline network.

6.2.13 The sliding supports of overhead pipelines shall be provided with lateral baffles; the baffles shall be designed in coordination with the pipeline supports; the seismic action shall not be less than 75% of the standard value of the lateral horizontal seismic action of the pipeline supports.

6.3 Underground engineering structure

6.3.1 The general layout of underground works shall be simple, symmetrical, regular, smooth. The structural system shall be determined, according to the use requirements, site engineering geological conditions, construction methods, etc. It shall have good integrity, to avoid sudden changes in lateral stiffness and bearing capacity of the lateral force-resistant structure. For the slopes on both sides of the entrance and exit passages AND the upwards slope of the entrance, it shall select a reasonable type of opening structure, according to the terrain and geological conditions, to improve its seismic stability.

6.3.2 The seismic grade of the category C reinforced concrete underground structure shall not be lower than grade 4, for degrees 6 and 7; it shall not be lower than grade 3, for degrees 8 and 9. The seismic grades of reinforced

concrete underground structures of categories A and B shall not be lower than grade 3, at 6 degrees and 7 degrees; it shall not be lower than grade 2, at 8 degrees and 9 degrees.

6.3.3 Earthquake response analysis shall be carried out, for underground works, except for the following situations:

- 1 Category C and category D underground works, which are located in categories I and II fields, when the fortification is 6 degrees and 7 degrees.
- 2 Category C and category D underground works, which are located in categories I and II fields, when the fortification is 8 degrees (0.20g), which has not more than 2 floors, regular in shape, has a span of not more than 18 m.

6.3.4 The seismic response analysis model of the underground work shall be able to reflect the actual stress conditions of the surrounding earth retaining structures and internal components. For long-line underground work, which has uniform and regular distribution of surrounding strata and with a symmetrical axis, it is allowed to use the plane strain analysis model; in other cases, it shall use the spatial structure analysis model.

6.3.5 When the seismic response analysis of underground work is carried out, each design parameter shall meet the following requirements:

- 1 For the underground structure which uses the plane strain analysis model, only the lateral horizontal seismic action is allowed to be calculated.
- 2 For the underground work which uses the spatial structure analysis model, it shall calculate the lateral and longitudinal seismic action, at the same time.
- 3 When the soil layer-structure time history analysis method or the equivalent horizontal seismic acceleration method is used, the dynamic characteristic parameters of soil and rock shall conform to the actual engineering conditions.

6.3.6 The seismic check calculation of underground works shall meet the following requirements, in addition to the requirements of Chapter 4 of this Code:

- 1 It shall check the cross-section bearing capacity and structural elastic deformation of components, under the action of the first or second level earthquake, according to the expected fortification objectives.
- 2 It shall carry out the elasto-plastic deformation check, under the action of the third level earthquake, according to the expected fortification objectives.

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