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**Technical Standard for Control of Building Vibration with
Wind Load**

建筑结构风振控制技术标准

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Table of Contents

1 General Provisions	7
2 Terms and Symbols	8
2.1 Terms	8
2.2 Symbols	10
3 Basic Requirements	12
3.1 General requirements	12
3.2 Calculation of controlled structural responses subject to wind load	13
3.3 Design requirements of the wind-induced structural vibration control system	17
3.4 Testing of the wind-induced structural vibration control system	18
4 Wind Load	19
4.1 General requirements	19
4.2 Equivalent wind load of the structural along-wind direction vibration	20
4.3 Equivalent wind load for structural across-wind direction and torsional vibration ..	24
4.4 Fluctuating wind load of along-wind direction	28
5 Wind-Induced Structural Vibration Control Based on Viscous and Viscoelastic Damper	30
5.1 General requirements	30
5.2 Damping force model	31
5.3 Design specification	33
5.4 Testing	35
5.5 Connection and installation	37
6 Wind-Induced Structural Vibration Control Based on Tuned Mas/Liquid Damper ..	38
6.1 General requirements	38
6.2 Mechanical parameters of tuned mass/liquid damper	38
6.3 Design specification	41
6.4 Testing	44
6.5 Connection and installation	45
7 Wind-Induced Structural Vibration Control Based on Active-Passive Hybrid Tuned Mass Damper	47
7.1 General requirements	47
7.2 Design specification	47
7.3 Testing	55
7.4 Installation and acceptance requirements	56

8 Seismic Resistance Design Requirements for Wind Vibration Control System.....	57
Explanation of Wording in This Standard	58
List of Quoted Standards	59

2 Terms and Symbols

2.1 Terms

2.1.1 Controlled structure

The building structure installed wind-induced structural vibration control system.

2.1.2 Wind-induced structural vibration control system

Components and devices that are installed on the controlled structure to provide control force for the structure, increase structural damping or change the structural stiffness to reduce the wind-induced response of the structure.

2.1.3 Combined system of controlled building structures and wind-induced vibration control system

The system that is composed of controlled structure and wind-induced structural vibration control system.

2.1.4 Designed wind load

The wind load that is used in the wind vibration control design and wind vibration response checking calculation of the controlled structure, including equivalent wind load and wind load time-history.

2.1.5 Addition damping ratio

When the damping effect of the wind-induced structural vibration control system is equivalent to increasing the damping ratio of the controlled structure, the calculated damping ratio provided by the wind-induced structural vibration control system to the controlled structure.

2.1.6 Equivalent wind load

The standard value of equivalent wind load that is included in the wind-induced structural vibration control system to provide addition damping ratio effects to the controlled structure.

2.1.7 Viscous damper

A velocity-dependent damper that generates damping and consumes structural vibration energy through the viscous fluid motion inside the damper.

2.1.8 Viscoelastic damper

A velocity-dependent damper that produces damping and consumes structural vibration energy through the shear deformation of viscoelastic materials.

2.1.9 Tuned mass/liquid damper

It refers to the control system that absorbs and dissipates structural vibration energy by forming resonance with the structure to reduce the wind-induced response of the structure, including tuned mass dampers and tuned liquid dampers.

2.1.10 Effective mass of tuned mass/liquid damper

The part of the mass of the tuned mass/liquid damper that participates in the vibration to absorb and dissipate the vibration energy of the controlled structure.

2.1.11 Active-passive hybrid tuned mass damper

A wind-induced structural vibration control system consisting of a passive tuned mass damper and an active drive control device.

2.1.12 Active control algorithm

It is an algorithm for determining the active control force of structures online and in real time by taking structural response information or real-time load information as input.

2.1.13 Designed displacement of wind-induced structural vibration control system

The maximum displacement of the wind-induced structural vibration control system that is calculated according to the designed wind load and considers the amplification of the safety factor.

2.1.14 Designed velocity of wind-induced structural vibration control system

The maximum velocity of the wind-induced structural vibration control system that is calculated according to the designed wind load and considers the amplification of the safety factor.

2.1.15 Designed control force of wind-induced structural vibration control system

The maximum control force of the wind-induced structural vibration control system that is calculated according to the designed wind load and considers the amplification of the safety factor.

2.1.16 Allowable displacement of wind-induced structural vibration control system

The maximum displacement that is allowable to be withstood by the wind-induced structural vibration control system.

2.1.17 Allowable velocity of wind-induced structural vibration control system

The maximum velocity that is allowable to be withstood by the wind-induced structural vibration control system.

3 Basic Requirements

3.1 General requirements

3.1.1 The wind-induced structural vibration control system should be selected according to the following provisions:

- 1** The viscous and viscoelastic dampers should be used for the controlled structures with large relative displacement and relative velocity between stories;
- 2** The viscoelastic damper should be used die the controlled structure with a small temperature range of the damper;
- 3** The tuned mass/liquid damper should be used for the controlled structure with relatively small damping;
- 4** The active-passive hybrid tuned mass damper should be used for the controlled structure that requires high damping efficiency of the structural wind-induced vibration.

3.1.2 The wind-induced structural vibration control system should be installed separately along the two main axes of the structure according to the vibration reduction requirements; and the plane layout should not cause the structure to generate torsional response.

3.1.3 The vertical layout position of the wind-induced structural vibration control system should be optimized and determined according to the vibration characteristics of the controlled structure and the characteristics of the adopted vibration control technology.

3.1.4 The installation location of the wind-induced structural vibration control system shall be convenient for inspection, maintenance and replacement.

3.1.5 The wind-induced structural vibration control system shall meet the following requirements:

- 1** The wind-induced structural vibration control system shall work normally under the action of the wind load standard value; and its components should not be damaged in strength;
- 2** During the service period of the controlled structure, the components of the wind-induced structural vibration control system shall not have fatigue damage; the wind-induced structural vibration control system shall be able to work continuously for 4 hours without fatigue damage under the action of the wind load standard value; when the wind-induced structural vibration control system cannot meet the requirements of the fatigue strength, it shall be replaceable;
- 3** The wind-induced structural vibration control system shall not bear the self-weight of the structure;

- 4 Under the action of the standard value of wind load, the components of the wind-induced structural vibration control system shall not collide with the structural members; and anti-collision measures should be taken.

3.1.6 The response check of wind-induced structural vibration of the controlled structure shall meet the following requirements:

- 1 The influence of the addition damping ratio of the wind-induced structural vibration control system shall be considered in the calculation using the equivalent wind load method;
- 2 The control force transmitted by the wind-induced structural vibration control system shall be considered in the design of the connecting components between the wind-induced structural vibration control system and the controlled structure;
- 3 Under the action of the wind load standard value, the maximum vertex lateral displacement and the maximum story displacement angle of the controlled structure shall comply with the provisions of the current industry standards JGJ 3 *Technical Specification for Concrete Structures of Tall Building* and JGJ 99 *Technical Specification for Steel Structures of Tall Buildings*;
- 4 Under the action of the 10-year wind load standard value, the maximum acceleration of the apex of the controlled structure shall comply with the provisions of the current industry standards JGJ 3 *Technical Specification for Concrete Structures of Tall Building* and JGJ 99 *Technical Specification for Steel Structures of Tall Buildings*.

3.1.7 For controlled structures with seismic-resistance fortification requirements, the influence of wind-induced structural vibration control system on the structure's seismic response shall be considered. When the wind-induced structural vibration control system is also used for the seismic control of the controlled structure, the design of the wind-induced structural vibration control system shall be carried out according to the relevant provisions of Clause 8 of this Standard and the current national standard GB 50011 *Code for Seismic Design of Buildings*.

3.1.8 Design documents shall indicate the performance parameters of the wind-induced structural vibration control system, and the wind-induced structural vibration control system or its components shall be tested according to the requirements of this Standard.

3.2 Calculation of controlled structural responses subject to wind load

3.2.1 When the controlled structure is dominated by the along-wind direction vibration, the control design and calculation of the along-wind direction vibration of the structure can only be carried out. For the structures with obvious across-wind direction vibration and torsional wind vibration, the design and calculation of across-wind direction vibration control and torsional wind vibration of the structures shall be carried out.

3.2.2 The wind vibration response analysis of the controlled structure should adopt the

model of the wind-induced structural vibration control system;

- 2 The mechanical model of the combined system of controlled building structures and wind-induced vibration control system shall include the connected components such as the controlled structure, the wind-induced structural vibration control system and the support; and the force and working state of the wind-induced structural vibration control system should be able to correctly reflect.

3.2.8 The calculation of the displacement and velocity design values of the wind-induced structural vibration control system shall meet the following requirements:

- 1 When using the equivalent wind load method to calculate the wind vibration response of the controlled structure, the design value of the displacement and velocity of the wind-induced structural vibration control system shall take the maximum displacement and 1.4 times the maximum velocity of the wind-induced structural vibration control system calculated according to the provisions of 3.2.4~3.2.6 of this Standard;
- 2 When using the time history analysis method to calculate the wind vibration response of the controlled structure, the design value of the displacement and velocity of the wind vibration control system should take the maximum displacement and 1.4 times maximum velocity envelope value of the wind-induced structural vibration control system calculated by using multiple wind load time histories.

3.3 Design requirements of the wind-induced structural vibration control system

3.3.1 The allowable value of the control force of the wind-induced structural vibration control system should be greater than 1.2 times the design value of the control force; the allowable value of the displacement and velocity of the wind-induced structural vibration control system should be greater than 1.2 times the design value, respectively.

3.3.2 Structural components such as supports, walls, beams or beam-column joints set up for the installation of the wind-induced structural vibration control system shall be able to withstand the allowable value of the control force of the wind-induced structural vibration control system without damage; and shall meet the structural measure requirements of for the connection of steel members or the connection between steel and reinforced concrete members specified in the current national standard GB 50017 *Code for Design of Steel Structures*, and GB 50010 *Code for Design of Concrete Structures*.

3.3.3 The directly connected parts between the wind-induced structural vibration control system and the controlled structure shall be in an elastic working state under the action of the allowable value of the control force of the wind-induced structural vibration control system.

3.3.4 The wind-induced structural vibration control system and the controlled structure should be connected by bolts or pins; and welding can also be used. When using pins for connection, the connecting pins shall be closely matched; when using the welding, the welding workmanship and quality shall comply with the provisions of the current national standard GB

50661 *Code for Welding of Steel Structures*.

3.3.5 The wind-induced structural vibration control system should not be installed in places exposed to direct sunlight, rain, or where the temperature is too high or too low. When the environmental conditions cannot be met, measures shall be taken to avoid aging and rusting of the materials and components of the controlled system, and the leakage caused by the expansion of the viscous liquid of the viscous damper.

3.3.6 Measures shall be taken during the construction process to avoid damaging the anti-corrosion paint, and the anti-corrosion condition shall be checked after installation.

3.4 Testing of the wind-induced structural vibration control system

3.4.1 Before installing different types of wind-induced structural vibration control systems, the systems or components shall be inspected according to the provisions of the corresponding Clauses of this Standard.

3.4.2 The inspection of viscous and viscoelastic dampers shall comply with the provisions of Subclause 5.4 of this Standard.

3.4.3 The inspection of tuned mass/liquid dampers and active-passive hybrid tuned mass dampers shall meet the following requirements:

- 1** The stiffness element and damping element of the tuned mass damper should be inspected according to the provisions of Subclause 6.4 of this Standard before assembly;
- 2** When the mass block of the tuned mass damper or the active-passive hybrid tuned mass damper is too large to inspect the overall performance of the wind-induced structural vibration control system before installation, the inspection of the components of the control system shall be carried out according to the provisions of Subclause 7.3 of this Standard; and the overall debugging of the control system shall be carried out after the on-site installation;
- 3** The active-passive hybrid tuned mass damper shall be inspected in accordance with Clause 2 of this article, and the actuator shall be inspected and debugged in accordance with Section 7.4 of this standard before installation.

3.4.4 When the controlled structure encounters a wind load greater than that specified the current national standard GB 50009 *Load Code for the Design of Building Structures*, the wind-induced structural vibration control system and its connecting parts shall be inspected. When it is found that the components of the wind-induced structural vibration control system are damaged or the system is working abnormally, it should be repaired, strengthened or replaced.

4 Wind Load

4.1 General requirements

4.1.1 When the along-wind direction vibration of the controlled structure is dominated by the first-order vibration, the along-wind equivalent wind load can be calculated according to the relevant provisions in Subclause 4.2 of this Standard.

4.1.2 When the facade of the controlled structure is regular and the plane is circular or rectangular, the equivalent wind load of the across-wind and torsional wind vibration can be calculated according to the relevant provisions of Subclause 4.3 of this Standard.

4.1.3 When the facade of the controlled structure is complex or the high-order vibration mode has a significant impact on the wind vibration of the structure, the time history analysis method should be used to analyze the wind vibration response of the controlled structure; and the used wind load time history should be selected according to the following provisions:

- 1** When the aspect ratio of the controlled structure is greater than 6 or the torsional wind vibration response must be considered, it should carry out the rigid model wind tunnel test; and use the three-dimensional wind load time history measured by the wind tunnel test;
- 2** When the aspect ratio of the controlled structure is less than 6, and the torsional wind vibration response can be ignored, it should use the time history of wind velocity measured under similar landform conditions at the location of the structure to calculate the wind load. However, the measured wind speed amplitude shall be adjusted according to the requirements of the local design wind load. After adjustment, the 10min average wind velocity of the time history of the measured wind velocity at a height of 10m shall be consistent with the local design wind velocity;
- 3** When the aspect ratio of the controlled structure is less than 6, and the torsional wind vibration response is negligible, and there is no wind tunnel test results and local measured data, the fluctuating wind load in the along-wind direction can be calculated according to the relevant provisions in Subclause 4.4 of this Standard.

4.1.4 The wind load time history used in the design and check calculation of the wind vibration control of the controlled structure should meet the following requirements:

- 1** The basic wind pressure and site roughness category shall be determined according to the current national standard GB 50009 *Load Code for the Design of Building Structures*;
- 2** The duration of the wind velocity time history should be no less than 10min; and the sampling period should be no greater than 0.1s;
- 3** The power spectrum, coherence function and turbulence degree of fluctuating wind velocity time history shall be determined according to the current national standard GB

5 Wind-Induced Structural Vibration Control Based on Viscous and Viscoelastic Damper

5.1 General requirements

5.1.1 The performance of the viscous damper and viscoelastic damper controlled by wind vibration shall meet the following requirements:

- 1** Within the design ambient temperature range, the variation of the main mechanical performance indexes of the viscous damper and the viscoelastic damper shall not exceed 15%;
- 2** The viscoelastic material and the connecting steel plate shall have good bonding properties. When the control force of the damper reaches its allowable value, the damper should not have interface bond failure;
- 3** The viscous damper and viscoelastic damper should have good fatigue performance; and should comply with the provisions on the fatigue performance of the wind-induced structural vibration control system in Subclause 3.1.5 of this standard;
- 4** Under normal operating conditions, the design service life of the viscous damper should be no less than 30 years; the design service life of the viscoelastic damper should be no less than 50 years.

5.1.2 When the viscous damper and viscoelastic damper are used in the design of the wind-induced structural vibration control of the controlled structure, they shall meet the following requirements:

- 1** The installation quantity and position of the damper should be determined through scheme optimization;
- 2** The damper should be arranged at the position where the structural deformation and velocity are relatively large; and the plane layout should avoid eccentricity;
- 3** The dampers should be evenly arranged along the height of the controlled structure;
- 4** The wind vibration response analysis of the controlled structure shall take into account the addition damping provided by the viscous damper to the controlled structure;
- 5** The analysis of the wind vibration response of the controlled structure should take into account the addition stiffness and addition damping provided by the viscoelastic damper to the controlled structure.

6 Wind-Induced Structural Vibration Control Based on Tuned Mas/Liquid Damper

6.1 General requirements

6.1.1 The tuned mass/liquid damper should be arranged on the top layer of the controlled structure or at the peak of the controlled vibration mode. When controlling the torsional wind vibration of the controlled structure, Two tuned mass/liquid dampers should be arranged on the top layer of the controlled structure or at peak of the controlled vibration mode far away from the centroid; or one tuned mass/liquid damper is arranged eccentrically.

6.1.2 Equivalent wind load method or time-history analysis method can be adopted for the wind vibration control design of controlled structure using tuned mass damper. Equivalent wind load method should be adopted for wind vibration control design of tuned liquid damper.

6.1.3 In the wind vibration control design, only the wind load acting on the controlled structure may be considered, while the wind load acting on the tuned mass/liquid damper is not considered.

6.1.4 The structural members directly bearing the action of the tuned mass/liquid damper shall carry out the strength checking calculation under the action of the designed control force of the wind-induced structural vibration control system.

6.1.5 The structural components directly bearing the action of the tuned mass/liquid damper shall carry out the deformation checking calculations in the limit state of normal use; and the deflection of the flexural components shall meet the requirements for the normal use of the controlled structure and the normal operation of the tuned mass damper.

6.1.6 The damping element of the tuned mass damper should adopt an eddy current damper, or a viscous damper.

6.2 Mechanical parameters of tuned mass/liquid damper

6.2.1 The design documents shall indicate the following parameters:

- 1 The tuned mass damper shall indicate: mass of inertial mass, stiffness of connecting spring, damping coefficient of damper element, natural frequency, damping ratio, allowable value of stroke, allowable value of velocity and allowable value of control force, etc.
- 2 The tuned liquid damper shall indicate: the shape, size and water depth of the water tank; the liquid mass in the water tank; the mass participation coefficient; the natural frequency and the damping ratio, etc.

6.2.2 The natural circular frequency, damping ratio and mass participation coefficient of the tuned liquid damper with the rectangular water tank can be calculated according to the

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