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Curtain walling — Inter-storey displacement resistance — Test method

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Foreword

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This document was prepared by Technical Committee ISO/TC 162, *Doors, windows and curtain walling*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Curtain walling — Inter-storey displacement resistance — Test method

1 Scope

This document specifies the test method to evaluate the inter-storey displacement resistance of curtain walling to three-directional seismic or wind actions when curtain walling is subjected to repeated movement.

The test method allows to determine, depending on the axes of the displacement imposed:

— horizontal inter-storey displacement in-plane resistance;

— horizontal inter-storey out-plane displacement resistance;

— vertical inter-storey in-plane displacement resistance;

— combined inter-storey displacement resistance.

The test method can be used to evaluate the inter-storey displacement either when it is a design requirement or to assess the relative displacement accommodated by the curtain walling assembly.

This test can be addressed manually or automatically depending on the size and/or the shape of the specimen.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3010, *Bases for design of structures — Seismic actions on structures*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

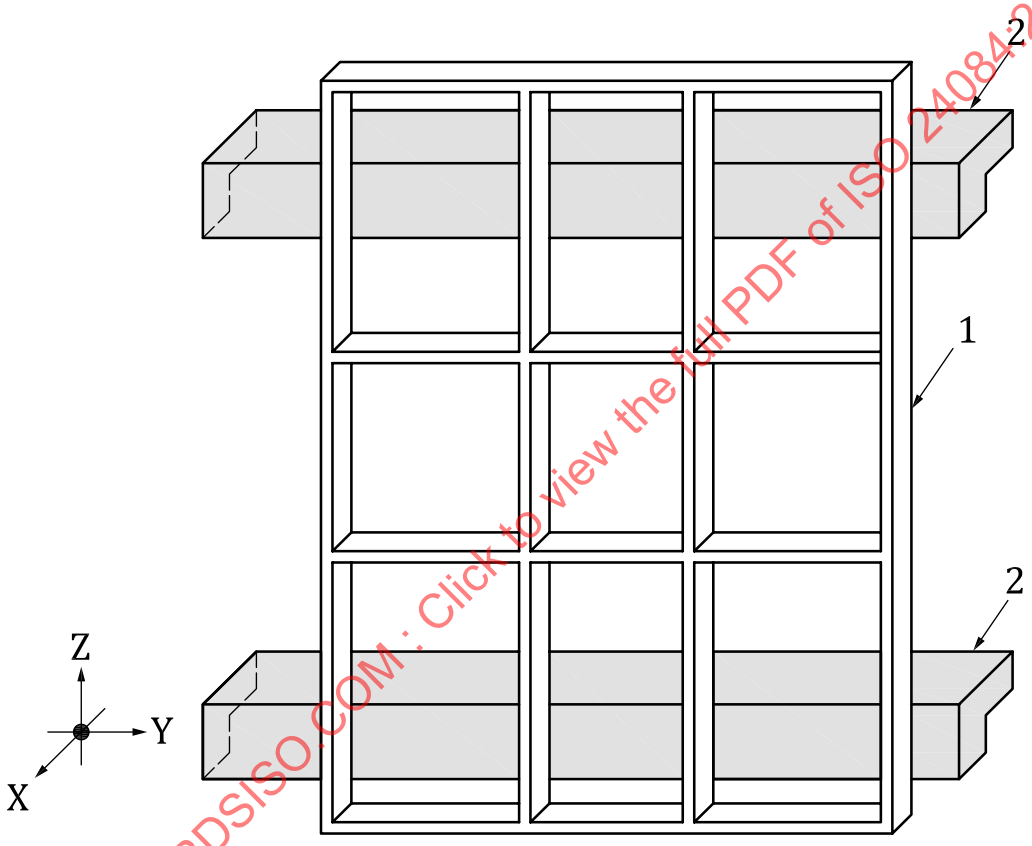
— IEC Electropedia: available at https://www.electropedia.org/

3.1
storey height
vertical dimension measured from the centre of a floor slab to the centre of the next consecutive floor slab, represented by the letter H in mm

3.2
inter-storey displacement
relative displacement caused for example by seismic actions or wind between two adjacent floor slabs in horizontal in-plane axis (Y-dir.), out-plane axis (X-dir.) and vertical in-plane axis (Z-dir.), as shown in Figure 1

Note 1 to entry: For the purpose of this standard the inter-storey displacement, which is the lateral displacement within a storey, is to be controlled. The inter-storey displacement should be limited to restrict damage to non-structural elements such as glass panels and curtain walling for moderate earthquake ground motions and to control failure.

Note 2 to entry: For control of life-threatening damage in occupied buildings at the ULS, the inter-storey displacement should be limited to certain values, depending on the materials of construction, the height of the building, and the use of the building (see ISO 3010).



Key
1 specimen
2 floor slab

Figure 1 — Schematic diagram of X-dir., Y-dir. and Z-dir.

3.3
inter-storey displacement resistance
capability of a specimen to comply with its design criteria when and after subjected to either single-axis *inter-storey displacement* (3.2) or a combination thereof, i.e. air permeability, watertightness and resistance to wind

3.4
horizontal inter-storey displacement in-plane resistance
capability of a specimen to comply with its design criteria when and after subjected to Y-dir. movement repeatedly, i.e. air permeability, watertightness and resistance to wind

Note 1 to entry: Positive displacement shall be defined as a rightward displacement of a specimen as seen from the outdoor side of the specimen. Reversely, negative displacement shall be defined as a leftward displacement of a specimen as seen from the outdoor side of the specimen.

3.5
horizontal inter-storey out-plane displacement resistance
capability of a specimen to comply with its design criteria when and after subjected to the X-dir. movement repeatedly, i.e. air permeability, watertightness and resistance to wind

Note 1 to entry: Positive displacement shall be defined as an outward displacement of a specimen as seen from the outdoor side. Reversely, negative displacement shall be defined as an inward displacement of a specimen as seen from the outdoor side.

3.6
vertical inter-storey in-plane displacement resistance
capability of a specimen to comply with its design criteria when and after subjected to the Z-dir. movement repeatedly, i.e. air permeability, watertightness and resistance to wind

Note 1 to entry: Positive displacement shall be defined as an upward displacement of a specimen as seen from the outdoor side. Reversely, negative displacement shall be defined as a downward displacement of a specimen as seen from the outdoor side.

3.7
combined inter-storey displacement resistance
capability of a specimen to comply with its design criteria when and after the movements in two or three axes repeatedly, i.e. air permeability, watertightness and resistance to wind

3.8
horizontal in-plane displacement
relative displacement δy measured in mm in Y-dir. (Figure 5) when subjected to Y-dir. movement

3.9
horizontal out-plane displacement
relative displacement δx measured in mm in X-dir. (Figure 7) when subjected to X-dir. movement

3.10
vertical in-plane displacement
relative displacement δz measured in mm in Z- dir. (Figure 8) when subjected to Z-dir. movement

3.11
drift angle
a ratio of the relative displacement between the two adjacent floor slabs to the *storey height* (3.1) in either X-dir. or Y-dir.

3.12
reliability
ability of a curtain walling to fulfil the specified requirements, during the working life, for which it has been designed

3.13
serviceability
ability of the curtain walling to perform adequately for a normal use under all expected actions

3.14
safety in use
ability of the curtain walling to avoid exceedance of ultimate limit state

3.15
serviceability limit state
SLS
limit state beyond which the serviceability criteria of curtain walling are no longer satisfied

3.16
ultimate limit state
ULS
limit state beyond which curtain walling collapse, may fall down or with other forms of mechanical failure which might endanger the safety of people

4 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviated terms apply.

X-dir.	Inter-storey movement direction in horizontal out-plane axis
Y-dir.	Inter-storey movement direction in horizontal in-plane axis
Z-dir.	Inter-storey movement direction in vertical in-plane axis
ULS	Ultimate limit state
SLS	Serviceability limit state
H	Storey height
δx	Horizontal out-plane displacement
δy	Horizontal in-plane displacement
δz	Vertical in-plane displacement

5 General and testing principle

This document is used to evaluate the safety in use performance under inter-storey displacement of curtain walling when subjected to a repeated movement caused by a simulating apparatus, e.g. seismic or wind actions.

This test can be also put in a serviceability sequence of testing, including some additional tests, if specifically required, see clause B.2.

For one single storey or two-storey building curtain walls, the "parallelogram" method or "symmetry" method can be used as shown in Figure 2. For the building curtain wall with a height more than two-storey height, the "parallelogram" method should be used.

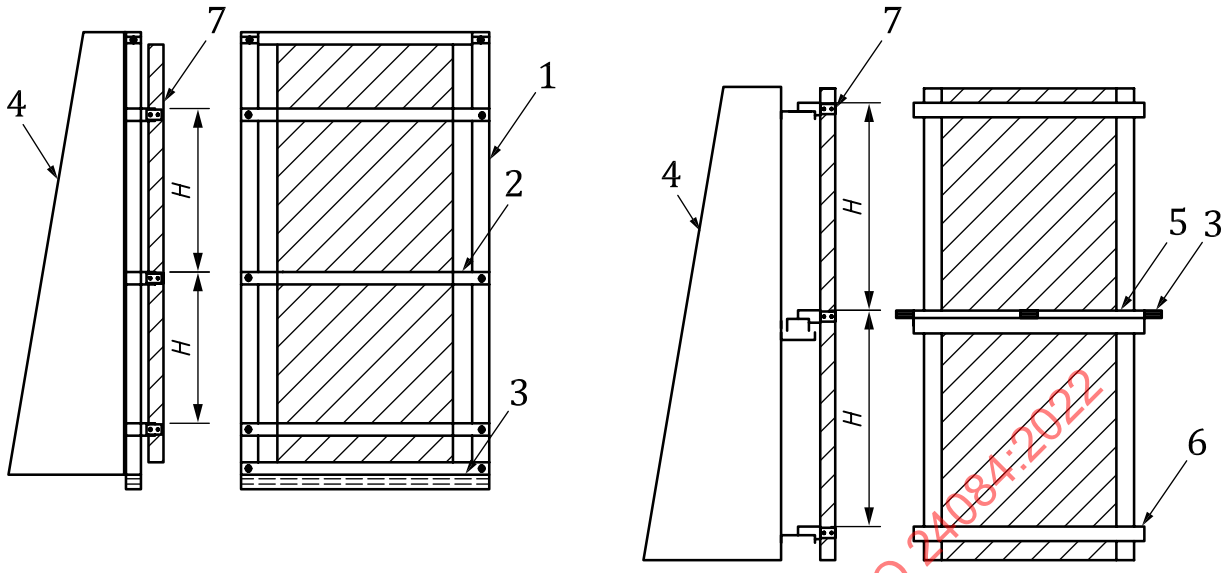
The most unfavourable condition shall be considered as the "symmetry" method is used.

The combined movement can be chosen according to Annex A.

6 Test apparatus and specimens

6.1 Configuration

The configuration of the test apparatus consisting of installation rig, static loading equipment and displacement measuring devices, is as shown in Figure 2.



a) Parallelogram method

b) Symmetry method

Key

1 vertical member
2 horizontal member
3 static loading apparatus
4 supporting structure
5 movable member
6 fixed member
7 fixings

Figure 2 — Schematic diagram of test apparatus and specimen

6.2 Installation rig

The installation rig consists of supporting structure, fixed member and movable member. The rig shall be capable of accommodating the test specimen with enough strength, rigidity and stability to avoid any additional deformations during the installation and testing. The vertical member and movable member shall meet the specified maximum drift angle or displacement for test.

6.3 Loading equipment

The loading equipment shall include a movable member of the rig to cause a movement of the specimen in three axes. The stroke of the movable member should be no less than 1,5 times the design requirement.

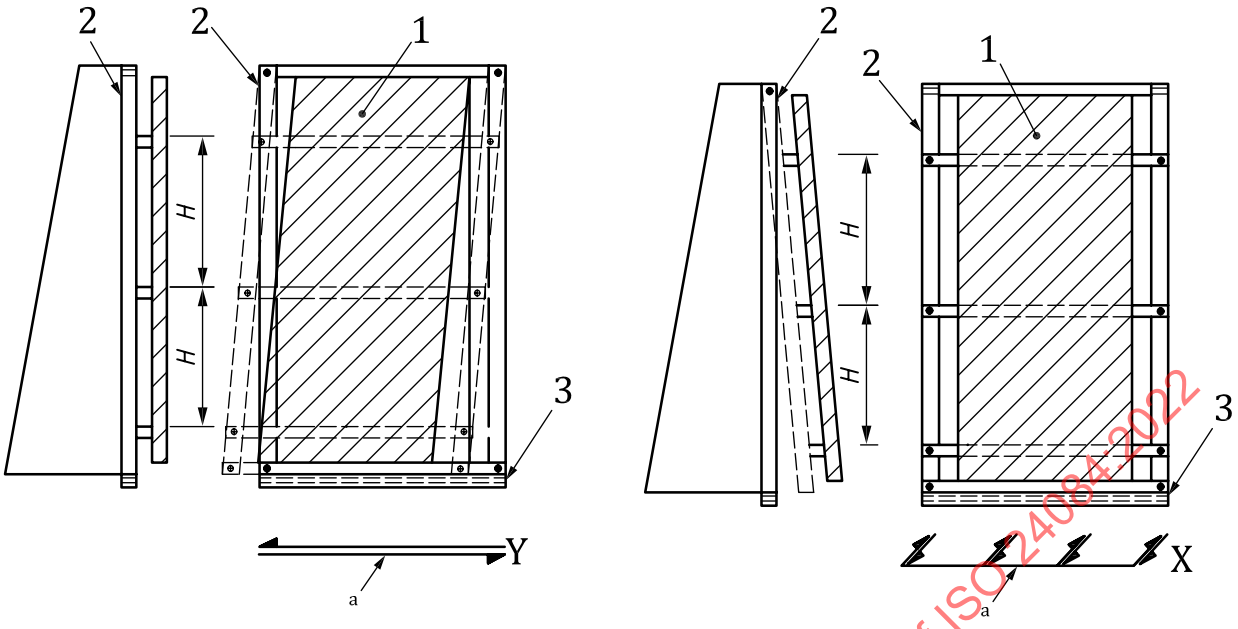
6.4 Displacement measuring device

The accuracy of displacement transducer shall not be more than ±1 % of its full range in the three axes.

7 Loading mode

7.1 Parallelogram method

As shown in Figure 3.



a) In Y-dir. b) In X-dir.

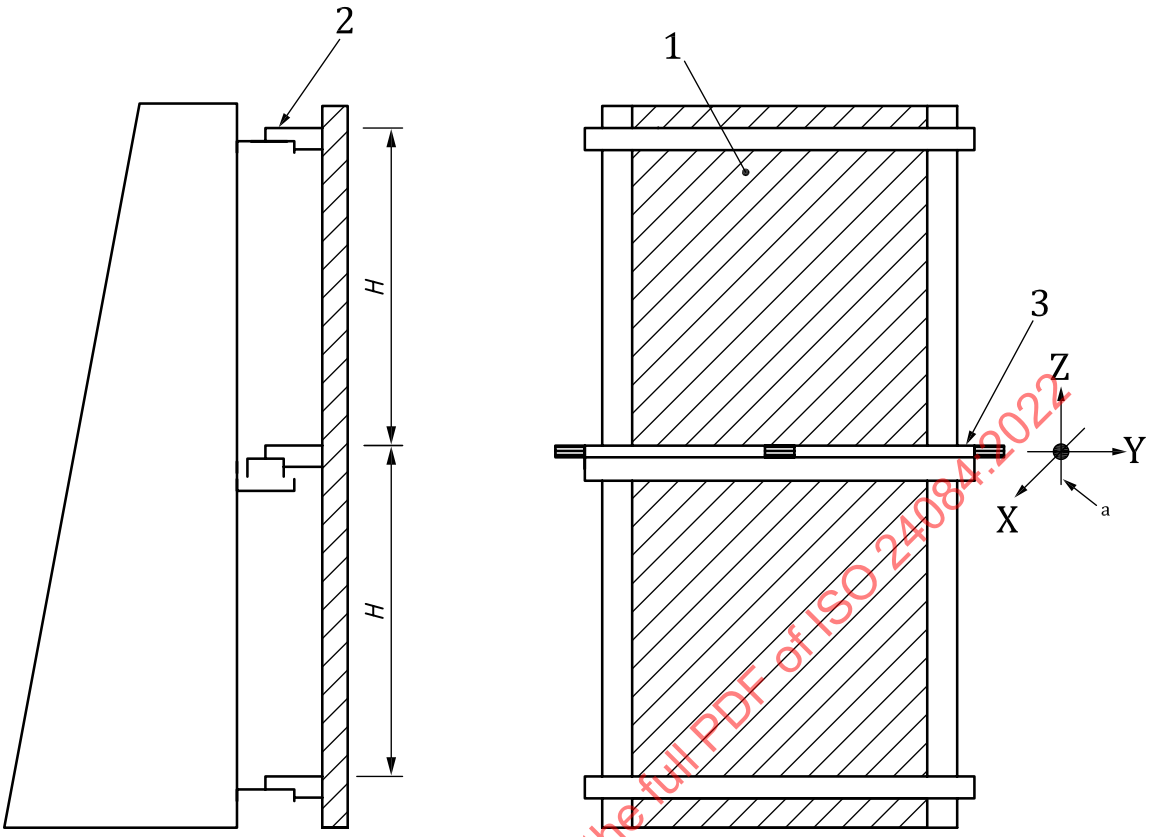
Key

1 specimen
2 vertical member
3 loading equipment
[a] Acting force in Y-dir. or X-dir..

Figure 3 — Schematic diagram of parallelogram method

7.2 Symmetry method

As shown in Figure 4.



Key

1 specimen
2 fixing
3 loading equipment
[a] Acting force in Y-dir., X-dir. or Z-dir..

Figure 4 — Schematic diagram of symmetry method

8 Specimen

Test specimen shall be erected as in practice and no additional fixing shall be used onto the specimen to affect the testing result.

9 Test procedure

9.1 Preparation

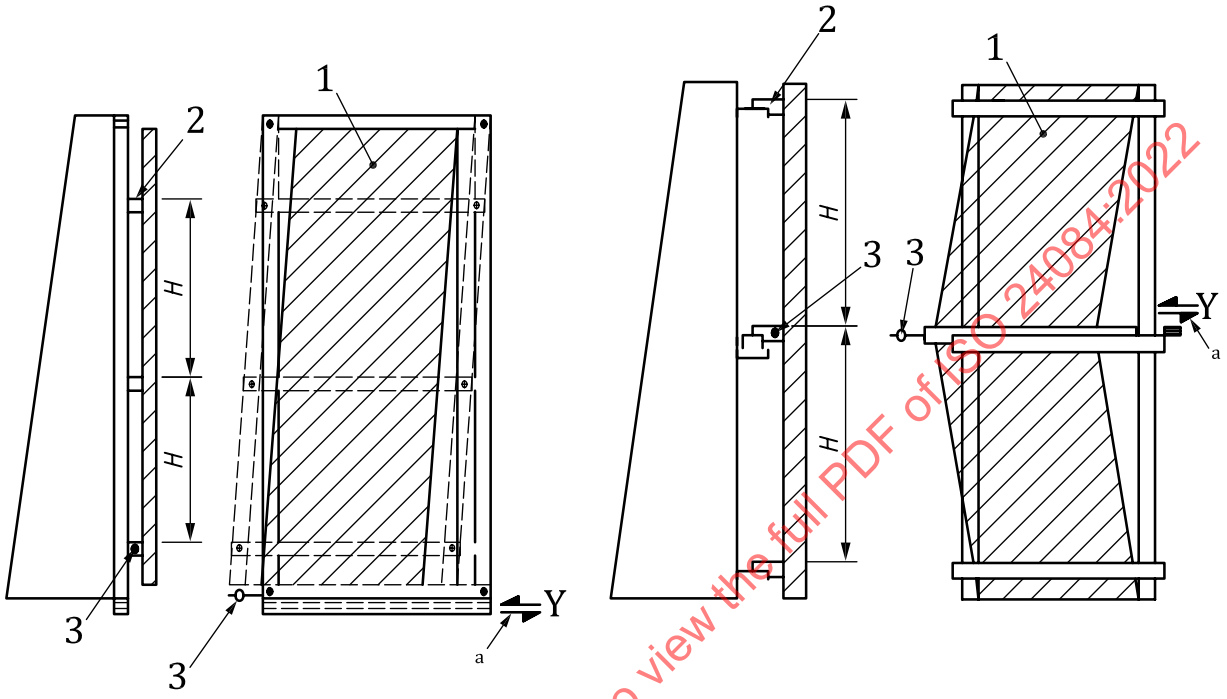
Inspect the specimen and open, close and lock the openable part for five times prior to test.

Make sure there is no restraints in the moving axis of the vertical or movable member. Any movement of the test specimen outside of the test axes shall be restrained.

9.2 Horizontal in-plane movement test

9.2.1 Displacement transducer

Place the displacement transducer on the bottom of the vertical member or the end of movable member as shown in Figure 5. The working condition of the transducers shall be checked. Also, it is recommended that the additional transducers should be placed on the fixings of specimen.



Key

1 specimen
2 fixing
3 displacement transducer
a Acting force in Y-dir.

Figure 5 — Displacement transducer placement in a horizontal in-plane movement test

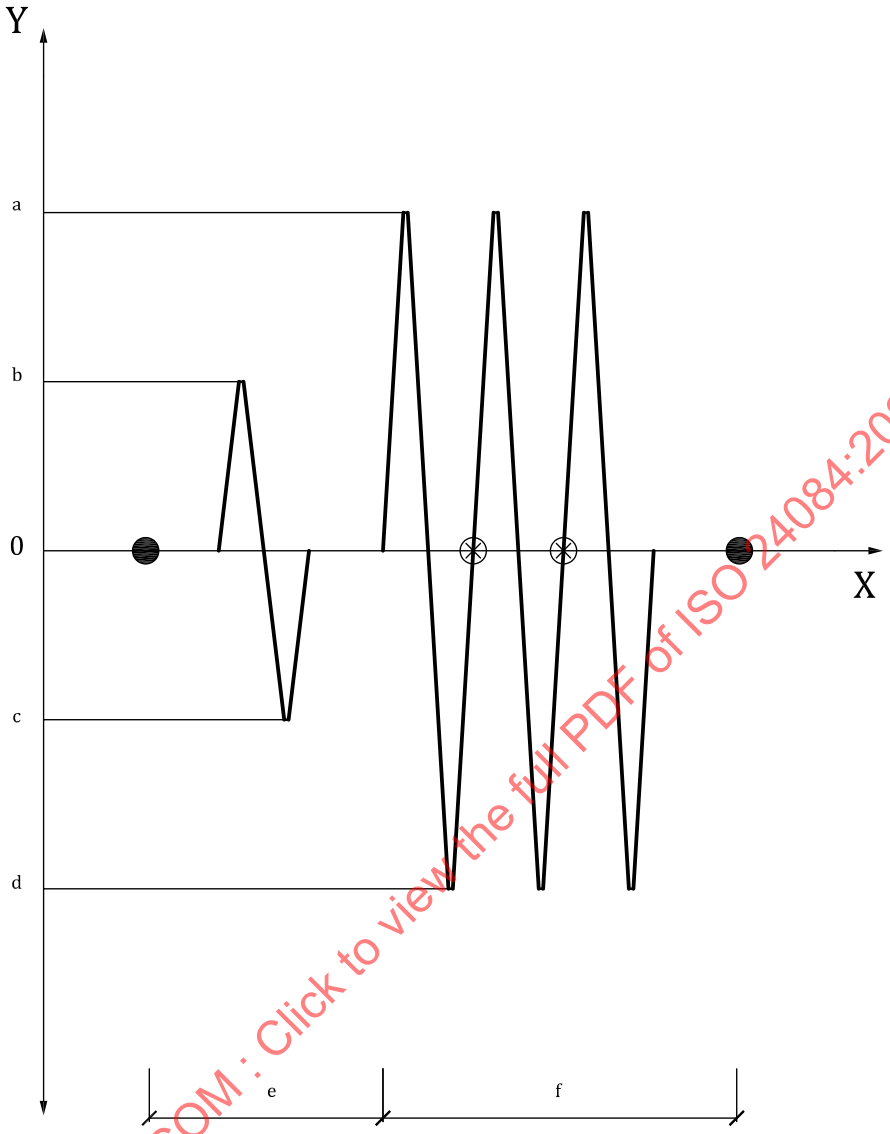
9.2.2 Pre-test

Start the apparatus to shift the movable member or vertical member, and the drift angle shall be 50 % of the maximum test displacement. One-cycle-test shall be completed and check whether there is any relative movement between the movable member and fixings. If any, adjust the fixings and repeat the preload test, as shown in Figure 6.

9.2.3 Displacement test

Start the apparatus to shift the movable member or vertical member. In the test, three cycles shall be completed at the maximum positive and negative displacement for each cycle, as shown in Figure 6. For each cycle of horizontal in-plane and out-plane displacement the duration should be no more than 10 s per (each) 10 mm of displacement. For vertical displacement the duration of each cycle should not be longer than 60 s. A minimum interval should be considered between positive and negative displacement within one cycle, depending on the kind of apparatus.

Inspect the specimen and, if present, open, close and lock the openable part for at least 5 times, as shown in Figure 6.



Key

X time in s

Y displacement in mm

a maximum positive displacement.

b 50 % maximum positive displacement.

c 50 % maximum negative displacement.

d maximum negative displacement.

e Preload test.

f loading test.

Note 1 Symbol ● means inspect, open, close and lock the openable part for no less than five times.

Note 2 Symbol ⊗ means the ending point of one test cycle and the beginning of the next one. It is recommended to have them continuous as much as possible in consideration of the test apparatus. However, the duration in between cycles may be extended due to the inspection of the test specimen, in case of damage occurring.

Note 3 The complete duration of the test shall be reordered for information purposes only

Figure 6 — Loading sequence

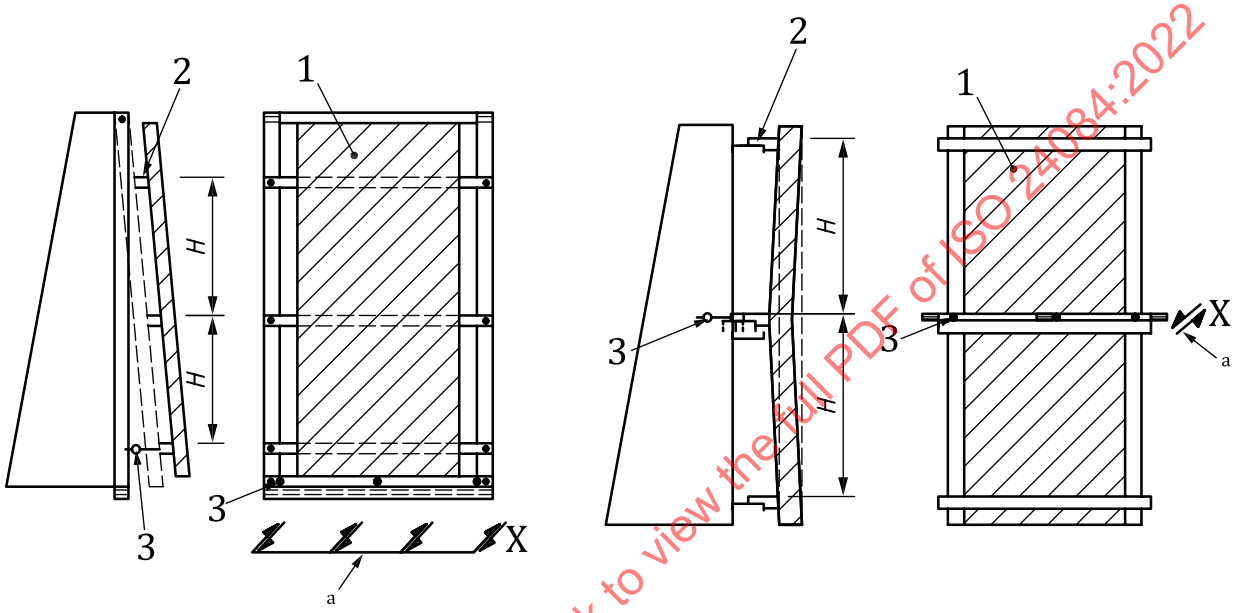
9.3 Horizontal out-plane movement test

9.3.1 Displacement transducer

Place the displacement transducer on the mid-span of the bottom of vertical member or the end of movable member as shown in Figure 7. The working condition of the transducers shall be checked. Also, it is recommended that the additional transducers should be placed on the fixings of specimen.

9.3.2 Load test

The test procedure shall follow the 9.2.2 to 9.2.3. The testing apparatus is shown in Figure 7.



Key

1 specimen
2 fixing
3 displacement transducer
a Acting force in X-dir..

Figure 7 — Displacement transducer placement in X-dir

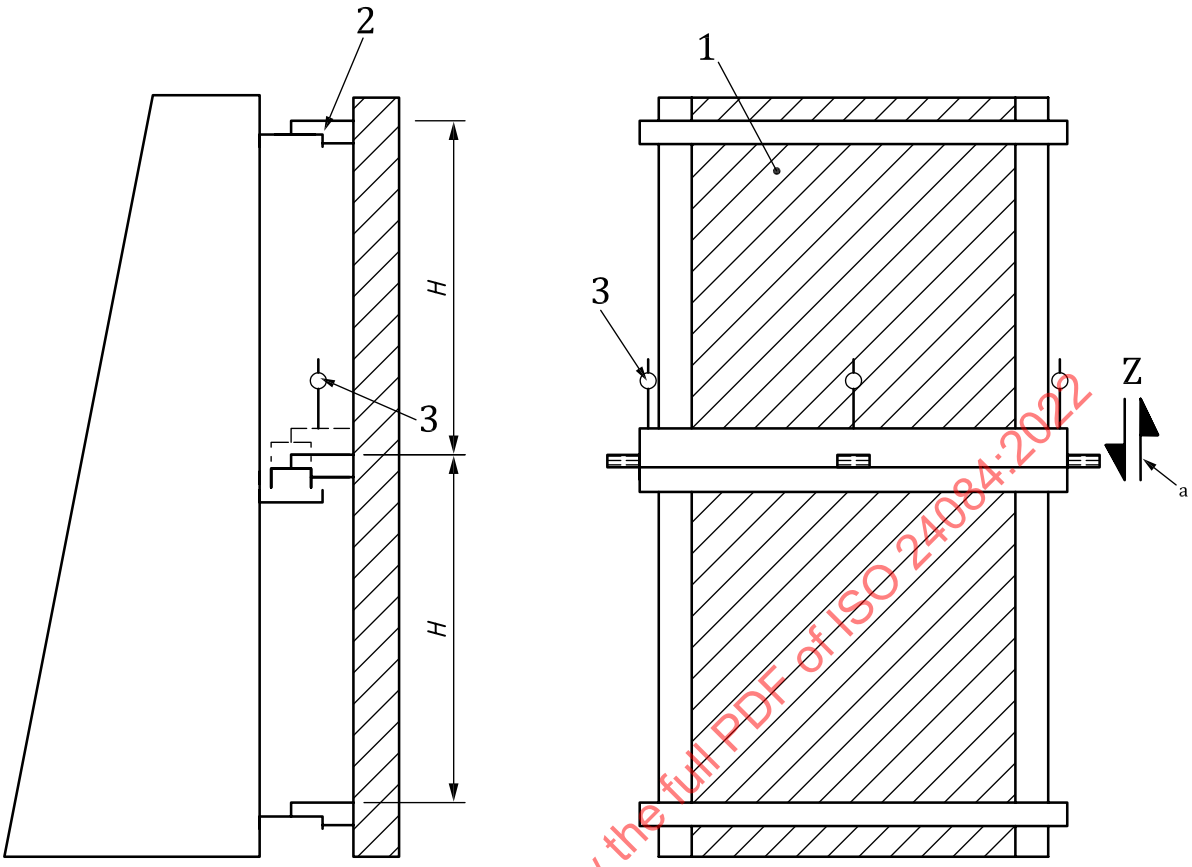
9.4 Vertical in-plane movement test

9.4.1 Displacement transducer

Place a displacement transducer at the mid-span of the movable member and a displacement transducer at each end of the movable member as shown in Figure 8. The working condition of the transducers shall be checked. Also, it is recommended that the additional transducers should be placed on the fixings of specimen.

9.4.2 Load test

The test procedure shall follow 9.2.2 to 9.2.3. The testing apparatus is shown in Figure 8.



Key

1 specimen
2 fixing
3 displacement transducer
[a] Acting force in Z-dir.

Figure 8 — Displacement transducer placement in Z-dir.

10 Test result and evaluation

10.1 Calculation

Drift angle in X-dir. shall be determined by Equation (1):

$$\gamma_x = \frac{\delta_x}{H} \tag{1}$$

where

H is the storey height of specimen, in mm;

δ_x is the absolute value of the displacement in X-dir., in mm.

Drift angle in Y axis shall be determined by Equation (2):

$$\gamma_y = \frac{\delta_y}{H} \tag{2}$$

where

H is the storey height of specimen, in mm;

δ_y is the absolute value of the displacement in Y-dir., in mm.

The magnitude of displacement in Z-dir. shall be represented by the absolute value of δ_z, in mm.

10.2 Evaluation

Specimen, at the specified drift angle or at vertical in-plane displacement, shall meet the following requirements, each with an adequate degree of reliability:

a) serviceability (i.e. damage limitation states, damage limitation requirement): that is withstanding a design action (e.g. seismic action or wind load) without the occurrence of damage and the associated limitations of use, the costs of which would be disproportionately high in comparison with the costs of the curtain walling itself. Damage limitation states are those associated with damage beyond which specified service requirements (i.e. air permeability, watertightness and resistance to wind load) are no longer met.

b) safety in use (i.e. ultimate limit states, no-collapse requirement): that is retaining its mechanical integrity and a residual load bearing capacity when subject for example to seismic action or wind load. Ultimate limit states are those associated with collapse or with other forms of mechanical failure which might endanger the safety of people.

The definition of criteria of evaluation for these two requirements, is part of national competency. However, Annex B reports information about the evaluation criteria for the serviceability requirement and safety in use requirement.

11 Report

The test report shall contain the following information:

a) Number and title of this document, i.e. ISO 24084:2022;

b) Identification of the organization performing the measurement;

c) Date of measurement;

d) All details necessary to identify the test specimen;

e) Specifications such as the name, type, width, height, thickness, material, colour, and other elements of the frame, glazing, shading device, opaque panel, or other components;

f) The technical drawing (elevations, sections), photograph, and others of the test specimen;

g) Results of test.

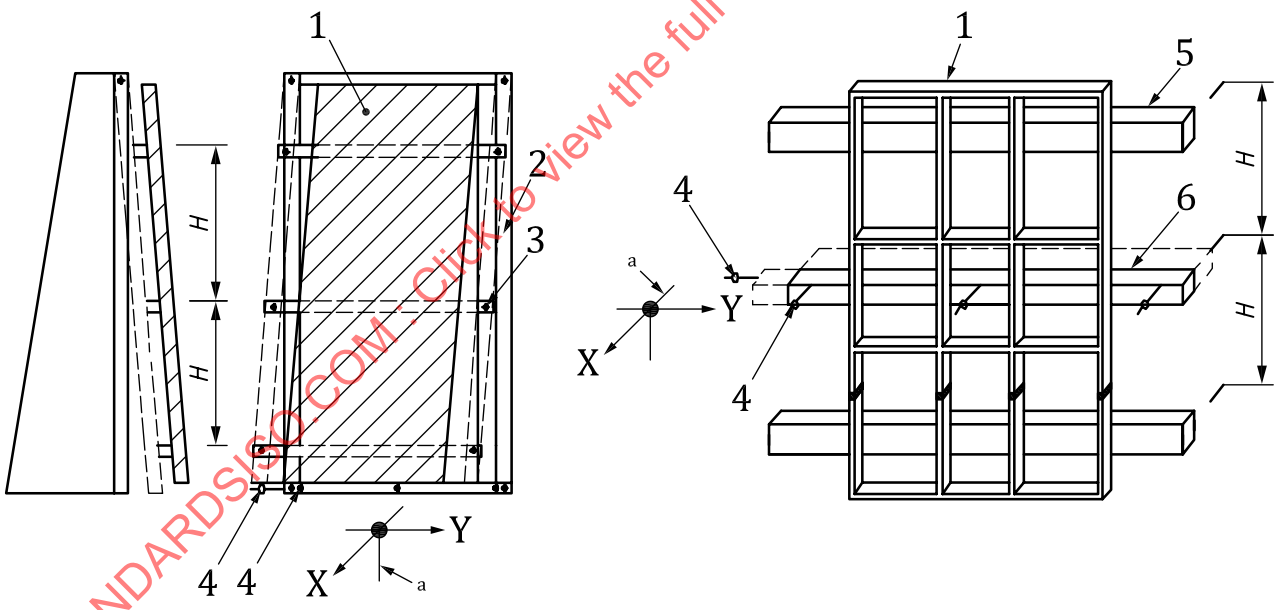
Annex A
(informative)

Combined movement test method

A.1 Combined movement test method in two axes

By operating the loading device, either the vertical movable member which is used for simulating main the structure actions, shall be driven to reach the specified drift angle γ_y along Y-dir. in positive axis, and maintain that reached displacement first. Then the vertical movable member shall be moved to the specified drift angle γ_x in positive axis as well, and be driven back to the previous position. At last, return the vertical movable member back to the initial position along the Y-dir. Repeat the above steps to complete the Y-dir. and X-dir. displacement in the negative axis for one cycle, and a total of three cycles shall be completed.

Also, it is allowable to drive either the vertical movable member at the same time to reach the specified drift angle in X-dir. and Y-dir. Loading mode and displacement transducer position in combined movement in both X-dir. and Y-dir. are shown in Figure A.1.



a) Parallelogram method

b) Symmetry method

Key

1 specimen
2 vertical member
3 horizontal member
4 displacement transducer
5 fix member
6 movable member
[a] Acting force in X-dir. and Y-dir..

Figure A.1 — Loading mode and transducer placement in X-dir. and Y-dir. test